Use of agriculture for biodiversity purposes; an analysis of the effects of agri-environmental management and its contribution to the Dutch biodiversity network ‘ecologische hoofdstructuur’.

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Abstract

The decline in biodiversity is considered to be one of the most important environmental problems of the moment. To stop this, the UN made agreements to preserve biodiversity. Each country must implement this and design a policy to stop the decline. The focus of this paper is on The Netherlands, where a national ecological structure (EHS) is the main way to stop the degradation of biodiversity by supporting animal migration and habitat possibilities. An increasingly more important aspect of this policy is the use of agricultural land. The goal of this paper is to investigate what the role of agriculture is within the EHS. Therefore, this paper looks only at the effects of agriculture on the undomesticated biodiversity. The findings in this paper are projected on the Natura2000 network to search for overlapping possibilities.

The increasing importance of agricultural land for the EHS is due to policy changes: instead of buying land, farmers are subsidized for taking precautions to prevent the negative effects of agricultural actions on biodiversity. These precautions include the restriction of the emission of NH_3 and pesticides, delayed mowing of fields where birds breed, extensive mowing of field margins and the (re)introduction of semi-natural elements (such as hedgerows, ditches and tree lines) to improve habitat,- and migration possibilities. This agri-environmental management is insufficient due to several factors. The deposition of nitrogen from background NH_3 is too high. The use of pesticides in adjacent farms can still harm animals who have a relative large habitat (more than one field). Because farmers can choose which precautions they want to take, mostly a few are taken only. This makes them less effective and it might cause an ecological trap in which several protective bird species are negatively affected. Biodiversity is still decreasing, so agri-environmental managed lands are not contributing to the EHS goal.

However, the use of agri-environmental farms as buffer around EHS areas might be a possibility to increase biodiversity inside the EHS, provided that these farms take all necessary precautions. This can protect animals with relative large habitats living inside the EHS from pesticides in adjacent fields and increase the migration and habitat possibilities around the EHS. More research should be conducted to investigate the economic and social feasibilities of such a buffer.

As for the Natura2000 network, many uncertainties make it difficult to compare the EHS with this network. This is mainly caused by the differing abiotic conditions (soil conditions, (ground)water levels, landscape) between EU lands. However, the creation of a buffer of agri-environmental farms around the Natura2000 network might be worth looking into further: pesticides and fragmentation are problems in other countries as well.

Samenvatting

De afname van de biodiversiteit wordt gezien als een van de belangrijkste milieuproblemen van deze tijd. Om deze afname te stoppen heeft de UN afspraken gemaakt. Elk land dient de biodiversiteit in dit land te beschermen door een eigen beleid te ontwerpen. De focus van deze paper ligt op Nederland, waar de Ecologische Hoofdstructuur (EHS) de migratie van dieren en habitatmogelijkheden moet ondersteunen. Agrarisch gebied is in toenemende mate van belang voor de EHS. Het doel van deze paper is het onderzoeken van het gebruik van deze gebieden voor het verbeteren van de biodiversiteit en na te gaan hoe dit overeen komt met het doel van de EHS. De focus ligt op ongedomesticeerde biodiversiteit. Hiernaast wordt gekeken in hoeverre de bevindingen in deze paper bruikbaar zijn voor het Natura2000 netwerk.

Door recente beleidsveranderingen is agrarisch natuurbeheer belangrijker geworden voor de ontwikkeling van de EHS; voor deze veranderingen werd er vooral land gekocht. Nu worden boeren gesubsidieerd als ze maatregelen nemen om de biodiversiteit te ontzien. Een aantal belangrijke maatregelen ter behoud van biodiversiteit zijn het beperken van de emissies van pesticiden en NH_3, uitgesteld maaibeheer en het (her)introduceren van seminatuurlijke elementen. Dit blijkt echter niet

genoeg om verschillende redenen: stikstofdepositie door hoge achtergrond niveaus NH_3 is te hoog, het gebruik van pesticiden in naastgelegen velden is schadelijk voor dieren met een relatief groot habitat (groter dan één akker) en daarnaast kunnen deelnemers kiezen welke maatregelen ze nemen, waardoor de meeste boeren er slechts enkelen nemen. Dit gaat ten koste van de effectiviteit en kan leiden tot een ecologische val: beschermde vogelsoorten bouwen hun nest in habitatsmet een tekort aan prooi, waardoor de overlevingkans van hun jongen afneemt. Het doel om de biodiversiteit te stabiliseren is hierdoor niet gehaald in gebieden met agrarisch natuurbeheer. Deze maatregelen dragen dus niet voldoende bij aan het volbrengen van de EHS doelen.
Een buffer van ecologische boerderijen rond de EHS kan van toegevoegde waarde zijn voor het behouden van de biodiversiteit, mits deze boerderijen alle nodige maatregelen treffen. Dit zou bescherming kunnen bieden aan soorten met een groot habitat binnen de EHS en bevorderd de migratie,- en habitatmogelijkheden aan de rand van de EHS. Meer onderzoek is nodig om de economische en sociale uitvoerbaarheid na te gaan.
Door verschillende abiotische omstandigheden in de EU landen is er veel onzekerheid bij het vergelijken van de EHS met het Natura2000 netwerk. Pesticiden en fragmentatie zijn echter ook problemen voor de biodiversiteit in andere EU landen. Daarom is het wellicht de moeite waard om de mogelijkheden voor een buffer van ecologische boerderijen rond het Natura2000 netwerk te onderzoeken.

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1 Introduction

1.1 Biodiversity

Biodiversity is the diversity in ecosystems, species and genes (Mace et al., 2005; Miller, 2007; Butchart et al., 2010). Biodiversity is of utmost importance for the very survival of life itself; without ecosystems, the earth would be a barren wasteland (Mace et al., 2005). Species themselves are important with regard to the stability of these systems; when species disappear from the system, the stability of the whole system will be influenced (Gilbert, 2009). The genetic diversity (diversity within species) is important from an evolutionary perspective; a low diversity causes homogenization in traits of the species (Kellenberg, 1994; Miller, 2007). Next to this, several species have esthetic value and biodiversity itself has an intrinsic value (Lockwood, 1999).

Due to human activities, this diversity is declining: the rate at which people manipulate environmental processes and change natural habitats to cultural lands has decreased the possibilities of species to adapt and survive (Mace et al., 2005; Miller, 2007; Buchart et al., 2010).

In an attempt to stop the decline, the United Nations made agreements; since states have the sovereign right to exploit their natural resources, each state has to implement its own plan of action. The developed countries have more responsibility since they have more influence on the biodiversity due to an higher environmental pressure (UN, 1992). In 2002, world leaders agreed on the Convention on Biological Diversity to significantly reduce biodiversity loss by 2010 (Butchart et al., 2010; www.cbd.int 8-6-2010). The goal of the EU is to stop the decline in biodiversity in 2010. To achieve this, the EU has started to develop an ecological network: Natura2000 (see fig. 1 in Appendix I for all Natura2000 areas in Europe). The network consists of Special Protection Areas, protected under bird directives, and Special Conservation Areas, protected under the habitat directive (http://ec.europa.eu, 19-6-2010).

1.2 The Dutch situation

This paper focuses on the situation in The Netherlands, where the main policy to protect the biodiversity and stop its decline is a national ecological network: the ecological main structure (Dutch: ecologische hoofdstructuur; I will refer to it as the EHS). It is the Dutch man way to implement the EU goal to stop biodiversity loss in 2010 and to increase biodiversity after that (Grootproject EHS, 2007; Natuurbalans 2009; http://ec.europa.eu, 19-6-2010). The national goal is to have the biodiversity restored to the 1982 situation in 2020 (Grootproject EHS, 2007; Natuurbalans 2009).

The network consists of natural preservation areas which are interconnected, and has an almost complete overlap over all the Dutch Natura2000 areas (Grootproject EHS, 2007; see fig. 2 in Appendix I). According to the island theory, the fragmentation of populations is causing extinction rates to increase; connecting natural areas increases the possibilities to migrate and disperse and thus improves chances of survival and (re)colonization (Grootproject EHS, 2007; MacArthur & Wilson, 1969). The construction of the EHS started in 1990. This was done by buying land (mostly agricultural) and convert them to natural areas, protected by EU directives (Grootproject EHS, 2007). In 2002, this policy changed because of the rise of ground prices and the unwillingness of farmers to sell their lands (Tweede Kamer, 2002; van Oostenbrugge et al., 2003; Grootproject EHS, 2007). This new policy leads to an increase in importance for agri-environment schemes: agreements with farmers (and other landowners) are made to take measures with regard to biodiversity decline. Participating farmers receive a subsidy for lost income (Kleijn et al., 2001; van Oostenbrugge et al., 2003; Grootproject EHS, 2007; Henle et al., 2007).

1.3 Goal of this study

The main goal of this study is to investigate the effectiveness of the use of agricultural areas in the protection of the undomesticated biodiversity within the EHS. It will focus on the effects of emissions and the effect of the landscape diversity on biodiversity and on the possibilities of ecological farming as buffer around EHS areas. The effects on biodiversity due to global warming caused by CH_4 and N_2O emissions from livestock are not taken into account, because of the complexity of the relation between the quantities emitted in The Netherlands and the loss in biodiversity. The research question is: what are the effects of agri-environment schemes on the biodiversity and how does this fit into the biodiversity goal of the EHS? Secondary, the findings for the EHS will be discussed in the light of the Natura2000 network; how far are the situations comparable?

The goal of this study is relevant since the use of agri-environment schemes is of increasing importance in biodiversity policy and the effects are debatable (Kleijn et al., 2001; Primdahl et al., 2003; Kleijn et al, 2007; Stortelder, 2009; Breeuwer et al., 2009; Natuurbalans, 2009).

The first paragraph will give an overview of the negative impact agriculture has on the biodiversity. The second paragraph will look into the effectiveness of agri-environment schemes. Here the emissions of pesticides and NH_3 will be analyzed in an emission effect approach. The fragmentation due to homogenization will be treated in the next subparagraph in a landscape-habitat approach. After that, the possibilities for ecologically sound farms to form a buffer around EHS areas will be investigated in a third subparagraph.

The third paragraph will project the findings of this paper on the Natura2000 network to search for overlapping possibilities.

2 Material & method

The method used to write this paper was a literature research. Several documents were found on the website of Alterra, a research institute specialized in agriculture and environment, which is situated in Wageningen, The Netherlands. Most of these documents are about agri-environment schemes. Some are about the effectiveness of the EHS as a mean to preserve biodiversity.

Several other documents were found on the OMEGA database of the Utrecht University library. These documents give a perspective on biodiversity and the role agriculture plays and should play in a more broad way. The influences of agriculture on biodiversity in The Netherlands and Europe are important aspects found in these documents.

Next to these scientific papers, some policy documents were looked into. This was necessary for the research because of the information on the aim of the EHS, the plans the government has on protecting biodiversity and the plans on the use of agriculture for that purpose. Also, one policy document from the European Commission on agri-environment schemes was studied.

This thesis was worked out in an academic set-up represented in the syllabus Academic Skills for environmental science (Academische vaardigheden voor milieuwetenschappen).

3 Biodiversity and agriculture

The influence agricultural activities have had on biodiversity has changed over the past 150 years. The invention of artificial fertilizers and pesticides, the increase in scale and intensity of land use, the changes in water tables and the use of pesticides have caused stress on several species and ecosystems. The effects of these activities still have a negative influence on the biodiversity (Lahr et al., 2005; MEA, 2005; Miller, 2007; Mozumder & Berrens, 2007; Stortelder, 2009). Several EU-documents stress the importance of farmlands for the protection of biodiversity, since 50% of all species are found there, but these claims seem debatable. Most species found in agricultural land are not living only on here; their habitats lie only partly in the agricultural land. Additionally, the species which are living partly in agricultural lands are not dependent on these lands (Lahr et al., 2005). Although the part of the biodiversity that is exclusively dependent on agricultural land in Holland is not known, one study shows that for vascular plants and carabids less than 10% of the species is found exclusively in these areas (Lahr et al., 2005). A more important aspect of these lands with regard to the biodiversity is their influence on nearby habitats and thus they play an important role in the attempt to stop the decline in species which live around and partly in agricultural land (Lahr et al., 2005; Stortelder, 2009).

For the EHS, the most important contributions of agricultural landscapes to the biodiversity is the complexity of the landscape: semi-natural aspects, such as ditches, tree lines, hedgerows etc. form a gradient rich landscape with diverse habitats. The increasing size of lands by adding several parcels to one homogenizes the land and thereby destroys microclimate, habitats and migration possibilities (Lahr et al., 2005; Concepción et al, 2007; Breeuwer et al., 2009; Stortelder, 2009).

The emission of several chemicals used in agriculture are also an important factor in the decrease of biodiversity. The use of artificial fertilizer and the related NH_3 emissions, and the use of pesticides all contribute to the loss of species (Lahr et al, 2005; Stortelder, 2009; Geiger et al., 2010).

Agri-environment schemes aim at both reducing the emissions and improve the heterogeneity of the landscape to support the biodiversity by inter alia delaying mowing, extensive mowing of the field margins, keeping the size of the parcel relative small and (re)introducing semi-natural elements (Kleijn et al., 2001; Concepción et al., 2007; Kleijn et al., 2007; Breeuwer et al., 2009; Geiger et al., 2010).

4 Effect of agri-environment schemes

4.1 Emission approach

The study of Geiger et al. (2010) compares conventional use of pesticides with agri-environmental managed fields in Europe. It shows that the use of pesticides leads to a decrease in plants species, carabid species and bird species. Agri-environment schemes led to improvements in diversity of plant species and carabid species but not in bird species. This can be due to the larger habitats birds have in comparison to insects (and plants). Birds can be influenced by the negative effects of pesticides which are used on other lands (Geiger et al., 2010). Another study, conducted in Italy, also shows a relation between the decline of species, the size of their habitat and the use of certain pesticides. Although in this study the scale seems to have a positive effect on species richness, it shows the relevance of adjacent areas; the study suggests that species with a large habitat suffer less from pesticides because of their ability to reach pesticide free habitats (Brittain et al., 2009). Because The Netherlands use between 55-70% of their lands for agricultural purposes (Lahr et al., 2005; http://www.cbs.nl, 27-5-2010), which is averaged 2625000 ha., and only 59.415 ha. (which is about 2.3%) of this is used for agricultural nature management (Grootproject EHS, 2007), the rate of biodiversity loss due to pesticides is probably not declining: there are very few pesticide free areas. The goal is to have 97.685 ha. of agricultural nature management areas inside the EHS by 2018

(Grootproject EHS, 2007), but this is still only a fraction of the total (about 3.8%). To prevent decline in biodiversity, it is insufficient to restrict emissions of pesticides only on certain farms (Brittain et al., 2009; Geiger et al., 2010). However, in The Netherlands, about 2/3 of all agri-environment schemes are carried out inside the EHS (Grootproject EHS, 2007), which might improve the condition for large-habitat pesticide sensitive species inside the EHS.
The use of inorganic or artificial fertilizers has a negative impact on the biodiversity as well (Kleijn et al., 2001; Kros et al., 2008; de Vries, 2008; Stortelder, 2009; Berendse, 2010). In agricultural nature management, agreements are made with respect to the emission of NH_3. The use of artificial fertilizers leads to the dispersal of NH_3, through both air and (ground)water, which has an negative effect on biodiversity through eutrophication (or nitrification) and acidification. When it deposits in an area with low nitrogen availability, N-limited plants prosper well, but less-competitive species cannot survive (van Tol et al., 1998; Stortelder, 2009). The process of nitrification releases H^+ and also lead to acidification (Kros et al., 2008). This is an advantage for some common species that can withstand low pH-levels only. Another important problem with fertilizers is transportation through groundwater to natural areas. This also causes eutrophication and acidification. Both phenomena cause perfect conditions for some (mostly) common species to grow and outcompete others what leads to homogenization of the plant diversity (Kros et al., 2008; Stortelder, 2009).
Therefore, emission restrictions are needed: in 2010 the emission of NH_3 must be decreased to 128 kiloton per year (Kros et al., 2008). However, Kleijn et al. (2001) and Kleijn et al. (2007) show that restriction of fertilizers can lead to a decrease in prey organisms for wader species, including the important Oystercatcher and Black-tailed Godwit, which breed only in The Netherlands. In combination with delayed mowing to increase the quality of the field for bird reproduction, this might lead to a so called 'ecological trap': the birds prefer sufficient conditions to reproduce (fields which are not mowed yet) over the conditions to nest (such as food availability). When the eggs hatch, there are too few prey organisms (Kleijn et al., 2001). Klein et al. (2001) also shows that the decrease in fertilizers used on field margins to improve soil conditions for less-competitive plant species is not enough: the amount of fertilizer in combination with nitrogen deposition might still be too high. Moreover, when background levels of NH_3 decrease so far that soil conditions improve, this still will be insufficient because sees sources are scarce (Kleijn et al., 2001).

4.2 Landscape-habitat approach

Since agricultural activities are intensified and the scale is increased, agricultural landscapes lost their heterogeneity in habitat richness. The loss of semi-natural elements, such as hedgerows and tree lines, and a smaller field margin to field size relation leads to a biodiversity decline (Lahr et al., 2005; Concepción et al., 2007; Henle et al., 2008). The semi-natural elements have several functions that facilitate diverse species to live in agricultural areas; without these elements, species able to survive in agricultural land would be restricted to a few (Lahr et al., 2005; Stortelder, 2009). An increase in areal scale means a loss of these elements (Lahr et al., 2005; Henle et al., 2008).
The study of Wassmuth et al., 2009, shows that certain plant associations are preferable for less-competitive species. Common species in field margins that are not disturbed are all high competitive; less-competitive species do not survive (Geertsema, 2002). In agri-environment schemes, agreements are made involving the field margins: they are mowed extensively, so wild plant species can develop with low competitive stress on the less-competitive species. The composition will be favorable for the biodiversity (Geertsema, 2002; Wassmuth et al., 2009): this leads to the creation of diverse natural habitats for several insect species, which are prey for other insects and birds (Lahr et al., 2005). Additionally, plant species composition should be managed actively to increase the survival chance of less-competitive species (Wassmuth et al., 2009). This might also provide a solution for the scarce seed sources, if sowing is included in active management.

Ditch banks are important for plant and insect species too, but also for several amphibians and the banks are mowed extensively to increase the chances of survival for less-competitive plant species (Lahr et al., 2005; Stortelder, 2009).
Semi-natural elements, such as hedgerows and tree lines, are also important for the biodiversity; mammals use them to rest and migrate, birds use them to build nests. They also provide habitats for insect species (Lahr et al., 2005; Stortelder, 2009). Therefore, these linear elements are important with regard to the connection function of the EHS network: species can migrate from one hot spot to another through these semi-natural paths and these connections themselves are hosts of several ecosystems (Grashof-Bokdam et al., 2007; Stortelder, 2009).
So the role of a more gradient rich agricultural area in the EHS is to increase the biodiversity by means of passage ways, habitat diversity, a more diverse plant composition, and an increase in diversity of lower trophic levels and by that an increase in predator diversity (Geertseman, 2002; Lahr et al., 2005; Stortelder et al., 2009; Wassmuth et al., 2009). However, the effectiveness of agricultural management is uncertain. Several studies indicate that the diversity of target species is not stopping to decline (Kleijn et al., 2001; Kleijn et al., 2007; Breeuwers et al., 2009).
Next to the already mentioned measures, fields are mowed later than is used in conventional farming. By doing this, insect and bird species have a temporary habitat. This measure should especially increase survival rate of the chicks of several protected bird species (Kleijn et al., 2001; Kleijn et al., 2007; Breeuwers et al., 2009).
Kleijn et al. (2001) compared the amount of specific species of birds, plants, hover flies and bees in conventional farm lands with areas with management agreements and found that agri-environment schemes were not sufficient in improving the amount of plants and bird species. This might be due to the already mentioned ecological trap for birds and the deposition of background nitrogen for plants (Kleijn et al., 2001; Kleijn et al., 2007). Hover flies were found in slightly increased numbers in May only, probably due to the delayed mowing: hover flies feed on plants found in these fields. In June, when the breeding season is over, these fields are mowed and the food supply becomes insufficient (Kleijn et al., 2001). Bees increased in numbers on managed fields. It is not clear what causes this (Kleijn et al., 2001).
The study of Breeuwers et al. (2009) investigated the effects of agri-environmental management on changes in density of four bird species. It shows that the delayed mowing of fields does not contribute to an increase in these birds. The Oystercatcher and the Black-tailed Godwit did not significantly increase in numbers. The densities of Lapwing and the Redshank decreased after the management agreements were implemented. A possible explanation for this is that the Dutch farmers can choose between packages of measures. Most take the easiest measures like postponing the mowing date and most do not agree harder ones, like higher water levels. Higher water levels are important for amount of prey organisms. Also, the still too high concentration of fertilizer is mentioned as an important factor for the lack of effects of agri-environmental management on bird densities. This is because the high concentration makes the swards very dense, which makes it difficult to find move and collect prey (Breewers et al., 2009).
There seems to be an contradiction between the decline of birds and their prey and the use of only some environmental precautions: Kleijn et al. (2001) and Kleijn et al. (2007) found that the reduction of fertilizer is causing a decline in prey organisms for the Oystercatcher and the Black-Tailed Godwit, while Breeuwers et al. (2009) found the high concentration of fertilizers is decreasing the ability of the birds to collect prey. Next to that, the low water levels lead to a decline in prey (Breeuwers et al., 2009). Additional research should be conducted to investigate what the major cause of prey decline is and how to stop this.
Kleijn et al. (2001), Klein et al. (2007) and Breewers et al. (2009) all agree that the need to reduce fertilizers is also important to create a more gradient rich landscape by decreasing eutrophication and acidification.

4.3 Ecological farming as buffer

The study of Stortelder (2009) shows that farms with low pesticide and NH_3 emissions and that have much semi-natural lines and elements could be used as buffer around protected EHS nature areas. This study uses an optimized type of farm, where all relevant protective actions are taken.
NH_3 from (conventional) farms that lie higher than the adjacent natural areas is dispersed through the groundwater and causes eutrophication and acidification in nearby areas (Stortelder, 2009). This is disastrous for the biodiversity because only few plants can live in these conditions (Geertsema, 2002; Stortelder, 2009). When (conventional) farms lie below the natural areas, these areas get drier. Because farmers keep the water levels in their fields low, (ground)water flows from the natural habitats to these fields (Stortelder, 2009). This causes drought and has a negative effect on biodiversity through mineralization caused by aeration; mineralization increases nitrogen, so N-limited species spawn relentlessly (van Tol, 1998; Strotelder, 2009). Next to that, mineralization leads to a decrease in basic cations, so the pH drops (van Tol, 1998). The effects of deposited nitrogen and NH_3 is studied by van Tol et al. (1998). The dispersal of NH_3 through the air and the accompanying nitrification is different from dispersal by groundwater, but the substance is the same. Therefore, the same effects can be expected, but they will be more localized when dispersed by (ground)water (van Tol et al., 1998; Kros et al., 2008; Stortelder, 2009). Higher water levels and local bans on use of fertilizers in agri-environmental managed farms prevent both effects on adjacent areas (Stortelder, 2009). A study to investigate the concentration differences in comparison to the effects between aerial distribution and dispersal by groundwater should be carried out to ascertain these findings, because deposition of background NH_3 might still be too high for the low competitive species inside the EHS.
As indicated before, the effects of pesticides seem to affect all species, but localized bans on usage can prevent local species to decline (Brittain et al., 2009; Geiger et al., 2010). Therefore, the local effects of pesticides related to conventional farming can be limited. Additionally, a buffer of agri-environmental farms would help pesticide sensitive species with a larger habitat inside the EHS to survive because the adjacent fields are then pesticide free (Brittain et al., 2009; Stortelder, 2009; Geiger et al., 2010).
The gradient richness of agri-environmental managed lands is also important for nearby nature areas. The semi-natural elements help animals (especially mammals) to migrate. They also provide habitats for several more localized species, such as spiders and insects, and for some territorial bird species (Lahr et al., 2005; Stortelder, 2009).
Thus, agri-environment management seems to have potential as a buffer around the EHS. This is especially for pesticide sensitive species with large habitats, local species that are specifically dependent on extensive agricultural habitats and species that migrate through semi-natural elements.

5 Possibilities for Natura2000

Since the abiotic conditions (such as soil condition, groundwater levels and landscape type) differ between EU countries, some of the effects of the measures analyzed in this paper are not translatable to the Natura2000 network. Besides, all countries can design their own schemes, which makes it difficult to compare the Dutch situation with any other European country (Primdahl et al., 2003).
However, the findings with regard to pesticide restriction and semi-natural elements are relevant for other countries, since these findings are partly based on areas outside The Netherlands (Concepción et al., 2007; Henle et al., 2007; Brittain et al., 2009). Because migration and habitat,- and species protection are important goals of the Natura2000 network, agri-environment precautions might be useful for this network.

Additionally, the overall contribution of agri-environment schemes to the biodiversity are seen as positive (except for Holland, where the effects are seen as debatable) (European Commision, 2005). A report of the European Commission on agri-environment schemes tells that the effects on species diversity, genetic diversity and ecosystem diversity are positive. The document also states that the different landscapes make it difficult to analyze the effects of agri-environment management on biodiversity by improving the landscape gradient richness. The effects of agri-environment schemes in relation to the Natura2000 are not investigated very well (European Commission, 2005). Because of the uncertainties, only the findings regarding the use and restriction of pesticides are useful to project on the Natura2000 network. This implies that a buffer of (ecologically sound) pesticide free farms might be of interest. However, since the effects of agri-environment schemes on the overall biodiversity in other countries is seen as positive, they might have more potential for the Natura2000 network.

6 Discussion

Only a fraction of the agricultural land in The Netherlands is used for agri-environment schemes; this will increase only a little bit by the time the EHS is finished. The background levels of NH_3 coming from conventional farms is still too high. Aside from that, NH_3 is not the only acidifying chemical; other sectors such as transport and energy also cause acidification. The agri-environment schemes therefore, might be insufficient to decrease the acidification and eutrophication and the related biodiversity loss caused by these emissions. Additional research is necessary to investigate the necessity to restrict all emissions to decrease the background levels of acidifying and eutrophying substances.

The small fraction of agri-environmental managed lands might also be insufficient to prevent the negative effects of pesticides. There are not much pesticide free areas, so species with a large habitat might still be affected. The effects of pesticides on local species in conventional farmland is also still a problem, but the ban on usage in agri-environment schemes has a positive effect on the local species.

Extensive mowing to increase diversity in the field margins and ditch banks seems to be effective, but there can be more gain by managing the plant associations. This can increase the chances of survival for less-competitive species. It will also improve the chance for some plants to be reintroduced in places where they are extinct. Nevertheless, which plant associations are best different situations in The Netherlands is not investigated yet.

The combination of delayed mowing and fertilizer restriction might have negative effects: it may lead to an ecological trap for several protected bird species through decline of prey due to the restriction of fertilizers while conditions for reproduction are improved. However, the continued use of fertilizers might increase the sward density in the breeding fields, which causes birds to be restricted in their movements and hinders prey collections. Additionally, the decline in prey might also be caused by the low water tables in agricultural fields. What causes the decline in bird species must be investigated further, especially because of the contradictory character of the problem with regard to the use of fertilizers.

For bees, delayed mowing seems to be effective, but the cause is uncertain. Some studies show that the use of pesticides in adjacent fields is increasing bee mortality, which contradicts the increase in bees. More research should be conducted to compare the increase in numbers of bees caused by delayed mowing and the decrease in bee diversity by pesticides.

For the use of ecological farms as buffer, the direction of the groundwater should be investigated: if water flows out of the farms into the natural area, the precautions should be different than in the reverse situation. When water flows into the farmland, the water tables should be risen to stop dehydration and the related acidification and eutrophication of the natural areas and the biodiversity

loss caused by that. If groundwater flows out of the farmland, NH_3 and pesticides will be introduced to the adjacent nature areas; therefore, emission restriction is important for these farms to prevent acidification and eutrophication. How the background emission levels influence these natural areas is not certain; further research should be done. Also, the ecological trap which might be caused by agri-environment management must be investigated in the lights of ecological farms as buffer.
Additionally, the study showing the possibilities of a buffer of ecological farms uses farms that take all relevant agri-environment precautions. Most farmers do not agree the to take all precautions. Next to that, the financial aspect is uncertain; how much subsidy is to be paid and is this possible? Because of these uncertainties, the social and economic feasibility of this perspective must be looked into.
The projection of the findings of this paper on the Natura2000 network is difficult because there are more uncertainties due to differing abiotic conditions, landscapes and policies in different countries. Aside from this, the contribution of agri-environment schemes to the Natura2000 biodiversity goal is not investigated very well. The European Commission states that there is an improvement in biodiversity caused by agri-environment schemes in most countries (except Holland), but how this is related to the Natura2000 network is yet to be investigated; it might shed a light on more potential for agri-environment schemes on biodiversity protection within the Natura2000 network.
Additionally, the European Commission states that the differences in landscape and their different functions make it difficult to analyze the effects of semi-natural elements on biodiversity. Since the findings of this paper are partly based on foreign situations which showed a positive relation between semi-natural elements and the biodiversity, the contribution of these elements on the biodiversity must be investigated further.

7 Conclusion

The use of agricultural nature management in the EHS seems to be improving diversity of some species. Other species are not increasing in numbers or species richness; some are even declining. This is probably partly due to the high background emission levels in The Netherlands. The option for farmers to choose the measures they want to take is a cause too; the management which is easiest in practice will be applied. This might lead to a decrease in prey organisms and even to an ecological trap. A study to investigate the effects of the implementation of only several precautions should be conducted.
The return of semi-natural elements in agri-environmental managed farms seems to have an overall positive influence on biodiversity: it makes the landscape more gradient rich and thus increases the amount of habitats. Organisms of lower trophic levels increase, and by that, their predators do too. Aside from that, fragmentation becomes less by the help of linear paths such as hedgerows, creating more passageways for migrating animals. This increases the survival rate according to the island theory and therefore it has a positive effect on biodiversity. These passageways consist of several habitats, which increases the gradient richness of the landscape even more. Because this is all important for the EHS goal, the use of semi-natural elements is a positive addition to the effectiveness of the EHS.
The use of agri-environment schemes on farms around the EHS as buffer seems to be an effective mean to protect the adjacent nature areas. Especially the semi-natural elements and the restriction of pesticides are useful in stopping the decline of Dutch biodiversity. Effects of groundwater (dispersion of NH_3 and pesticides, and dehydration) can also be effectively reduced by such a buffer. However, the emission restriction might be insufficient due to the high background NH_3 level. More research is necessary.
The research question (what are the effects of agri-environment schemes on the biodiversity and how does this fit into the biodiversity goal of the EHS?) can be answered as follows: the effects of

optimal managed ecological farms can improve biodiversity conditions, especially when used as a buffer. However, the most agri-environmental managed farms are not optimally managed. Therefore, the effects on biodiversity are less positive than was anticipated and the goal to stop the biodiversity loss in 2010 is not met by the measures taken. Still, agri-environmental managed fields have potential: semi-natural elements, active management of plant associations and pesticide restriction contribute to biodiversity, but the possibility to implement only a few measures makes them less effective. A buffer of optimal managed ecological farms around EHS areas has the highest potential to stop the biodiversity decline. The economic and social feasibility of this option should be investigated further.
Because of the different abiotic conditions, landscapes and policies in other EU countries and because the effects of agri-environmental management on Natura2000 areas are not investigated well, only the findings regarding pesticides are useful for the Natura2000 network. A buffer of pesticide free farms around Natura2000 areas can help to stop the effects of pesticides on species living inside Natura2000 network. Such a buffer might also improve migration and habitat possibilities through semi-natural elements, but because of the differences in landscape, more research is needed.

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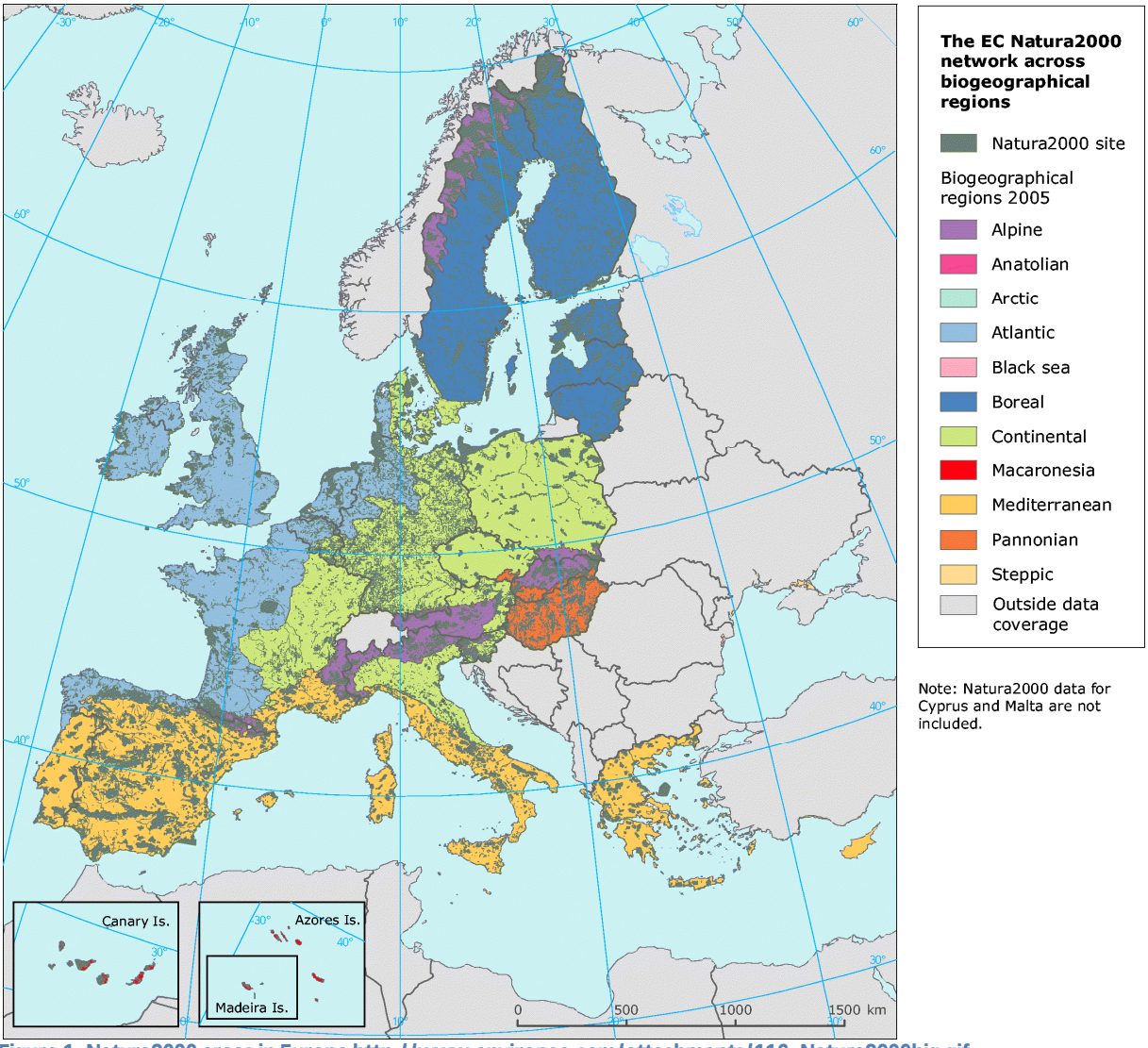
Appendix I – Figures



Note: Natura2000 data for Cyprus and Malta are not included.

Figure 1; Natura2000 areas in Europe http://www.enviropea.com/attachments/116_Natura2000big.gif

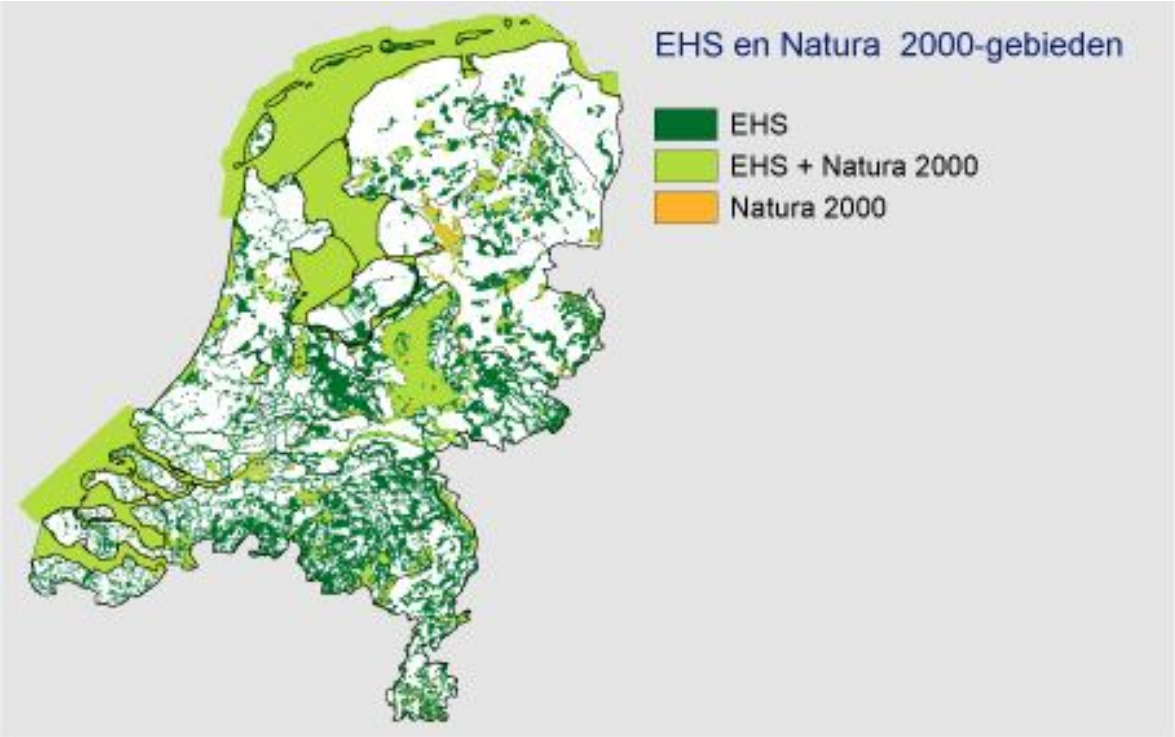


Figure 2; EHS, Natura2000 and overlapping areas in The Netherlands (http://www.pbl.nl/images/033k_nb06_72_tcm60-31058.jpg - 28-06-2010)