Chapter 1

General introduction
The nature reserve vs. agri-environment scheme debate

Despite the fact that many ecologically interesting biotopes in Europe result from agricultural practices, there is an ongoing debate about the best way to manage and conserve their biodiversity (de Boer & Reyrink 1988; Udo de Haes 1999; Baldock 1999; van Elsen 2000). Should the management on modern farms be changed so that high biodiversity is possible, or should habitats currently used for agriculture be converted into nature reserves?

Historically, much of the biodiversity in semi-natural ecosystems was created by low-intensity farming practices (Bignal & McCracken 1996; van Elsen 2000). In Western and Northern Europe, these practices gave rise to a multitude of different biotopes including heathland, dry hay meadows, chalk grasslands, lowland wet grasslands, blanket bogs and moorlands (Bignal & McCracken 1996); all dependent on (extensive) regular management. However, during the last century, changes in agricultural practices, including intensification and land abandonment, led to a rapid decline in both habitat and species diversity (Ruuska & Helenius 1996; Delbaere 1998; Bouma et al. 1998; Wilson et al. 1999; Tikka 2001; Stoate et al. 2001; Robinson & Sutherland 2002). Subsequent biodiversity conservation measures in response to this decline can be divided into two main groups: the creation of nature reserves and the implementation of agri-environment schemes on modern farms (van Strien 1991; Kleijn & Sutherland 2003).

Traditionally, conservationists have emphasised the role of nature reserves (including the conversion of former agricultural land into reserves), for protecting agricultural biodiversity. However, both socio-economical and ecological obstacles often interfere with the creation and maintenance of nature reserves (Melman & van Strien 1993). High land prices and conflicting land user interests are a problem, especially in densely populated areas. Moreover, since valuable biotopes with an agricultural origin are dependent on regular management, management costs must also be taken into account. Ecologically, maintenance and increase of biodiversity is hampered by the fact that that nature reserves tend to be small and that many dispersal processes have been disrupted in the increasingly fragmented landscapes of today (van Dorp et al. 1997; Poschlod & Bonn 1998; Kalkhoven 1998; Debinski & Holt 2000).

Agri-environment schemes were introduced in many European countries in the 1990’s (with forerunners in the 1980’s). The goals of these schemes include, not only the protection of diversity of (agricultural) species and habitats, but also the restoration of landscapes, the maintenance of a viable countryside and the reduction of nitrogen and pesticide loads (Carey et al. 2002; Kleijn & Sutherland 2003). Clearly there are many potential advantages to the integration of nature conservation into modern agriculture. These include the possibility to enlarge the total area available for nature and potential corridor functions of different landscape elements (but see van Dorp 1996 and Harrison & Bruna 1999). At the same time, since production remains the primary objective, important restrictions are present. In addition to various economical restrictions, a
number of ecological objectives, such as the protection of very rare species with very specific habitat and management requirements, may be difficult to realise on farms.

After a decade of agri-environment schemes, the actual ecological effectiveness of these schemes for conserving and restoring the diversity of flora and fauna remains controversial (Kruk 1993; Kleijn et al. 2001; Musters et al. 2001; Carey 2001; Carey et al. 2002; Feeham et al. 2002; Kleijn & Sutherland 2003; Critchley et al. 2003; Kleijn et al. 2003). This again adds fuel to the old ‘nature vs. agriculture’ debate, often resulting in an unnecessary ‘either-or’ deadlock. Unnecessary, not because questions related to the effectiveness of agri-environment schemes are unimportant - on the contrary - they are equally important as questions related to the ecological effectiveness of (management in) nature reserves (van der Meijden et al. 2000). The deadlock is unnecessary because we should realise that it is impossible to conserve all agricultural (biodiversity and cultural) values only in nature reserves or only on modern farms. Especially in light of problems with fragmentation and isolation, the aim should be to increase the biodiversity of the whole landscape as far as possible. A combination of both approaches is therefore not only desirable, but also necessary.

Ditch bank vegetation on modern dairy farms in the Netherlands

In modern agricultural landscapes, most of the former biodiversity is currently being maintained in small-scale landscape elements, such as ditch banks, field margins, hedgerows and road verges (Baudry 1988; Wratten 1988; van Strien 1991; Fry 1994; Joenje & Kleijn 1994; Bunce & Hallam 1998; Geertsema 2002). In order to protect the biodiversity of the agricultural landscape as a whole, we need to preserve both the diversity of these landscape elements as well as the species richness in them.

Especially in densely populated areas, such as the Netherlands, small-scale landscape elements are extremely important. The Western Peat District is particularly rich in these elements. Colonisation of these fenlands started in the 10th century, followed by large-scale reclamation efforts, through the creation of a network of drainage ditches, in the centuries that followed (van der Linden 1982; van der Molen 1982). Initially the land was used for arable farming. However, the fenlands gradually subsided due to dehydration and mineralization, making arable agriculture impossible. As a consequence, dairy farming has been the most important activity in this region since the 15th century. Currently, a network of 300 000-400 000 km ditches cuts through this landscape (Higler 1994).

The agricultural landscape of the Western Peat District harbours species from many different vegetation types, ranging from dry grasslands to wet fenlands (de Boer 1982). Originally, these vegetation types were maintained on pastures and fields. However, as a result of the agricultural intensification process during the 20th century, with continuously lowered water levels and high fertilisation rates, the original vegetation types largely disappeared from the landscape. Outside nature reserves, fragments of these vegetation types are currently almost exclusively found in ditch
banks, which - due to the gradient from dry to wet in combination with a large total area - function as a very important refuge for many plants (Ruthsatz & Haber 1982; Melman & van Strien 1993). These include previously common grassland species, such as *Caltha palustris* and *Lychnis flos-cuculi* (Clausman & van Wijngaarden 1984; Westhoff & Weeda 1984) and also some internationally interesting species, like *Cirsium dissectum* and *Myosotis discolor* (Verkaar et al. 1992; Schaminée et al. 1992). In terms of rarity, most ditch bank species are currently classified as ‘common’ species in the Dutch Red List (van der Meijden et al. 2000). However, considering the fact that these species are largely dependent on the ditch bank habitat and that species richness still appears to be decreasing in this refuge habitat, there is cause for concern (Provincie Zuid-Holland 2002).

**Ditch bank management and agri-environment schemes**

Due to intensive farming methods, the ecological possibilities for an increase in floristic richness on modern dairy farms are far greater in the ditch banks than on the fields. With a careful fertilisation regime, it is possible to maintain nutrient-poor ditch banks next to nutrient-rich pastures (van Strien 1991; Melman 1991). This is further made possible by the fact that leaching, infiltration and run-off are unlikely to add any significant amounts of nutrients to the ditch bank system (Melman et al. 1990; Melman & van Strien 1993). Ditch banks are also suitable for conservation purposes from an economical viewpoint, since ditch bank grass production is unimportant on a total farm scale.

Until the year 2000, two main types of agri-environment schemes were applied in ditch banks in the Netherlands: ‘management agreements’ (Regeling Beheersovereenkomsten en Natuurontwikkeling and forerunners; (LNV 1995)), and ‘direct payment schemes’ (Natuurproductiebetaling; (Kruk et al. 1994; Musters et al. 2001)). The management agreements imposed restrictions and then compensated farmers for their losses. In direct payment schemes the farmer was free to choose his own management, and was only rewarded for his ecological results (an increase in ‘target’ species). In 2000, a new agri-environment system (Subsidieregeling Agrarisch Natuurbeheer; (DLG 2000)) was introduced, combining management restrictions with minimum numbers of ditch bank species. In essence, very similar management is recommended or applied within all types of agri-environment schemes. Nature-friendly ditch bank management involves no fertilisation, lower ditch cleaning frequencies, no deposition of ditch sediment or plant parts in the ditch bank and extensive mowing and grazing regimes (Melman & van Strien 1993); (although the newest schemes have less clear mowing and grazing recommendations (DLG 2000)). Agri-environment schemes promoting these recommendations have been implemented since the beginning of the 1990’s, and participation has been growing steadily (RIVM & DLO 2003; RIVM 2003). Still, the species richness of ditch banks does not seem to increase (Kleijn et al. 2001; Kleijn & Sutherland 2003).
Why is ditch bank species diversity not increasing despite agri-environment schemes?

Looking to restoration projects in grasslands for answers, we see that many restoration projects have focused on restoring soil conditions by adapted mowing and grazing regimes, sod cutting and / or rewetting (Bakker 1989; Olff & Bakker 1991; Marrs 1993; Pfadenhauer & Klötzli 1996; Oomes & van der Werf 1996; Berendse et al. 1999; van Duren & Pegtel 2000). In general, however, these measures have not been enough to restore species richness. Although restoration of soil conditions is a necessary prerequisite for restoring species richness, in itself it is not enough: limited dispersal and the absence of (target) species form the seed bank often form a serious obstacle (van der Valk & Pederson 1989; Marshall & Hopkins 1990; Hutchings & Booth 1996; Strykstra et al. 1998; Bekker 1998; Prins et al. 1998; Pärtel et al. 1998; Bakker & Berendse 1999).

In other words, to restore species richness, not only is it important to reduce local extinction by creating suitable conditions for survival, but colonisation (either through dispersal or from the seed bank) and initial establishment must also be possible. How does this apply to ditch banks?

So far, studies of these ditch banks were primarily aimed at understanding the relationship between management and plant species diversity (van Strien 1991; Melman 1991). Van Strien compared hundreds of ditch banks with different management regimes at one point in time, treating ecological mechanisms as a black box. Melman carried out more ‘traditional’ field experiments and focused on changes in time (during three years) in the vegetation in response to different management. The ultimate goal in both cases was to develop ‘nature-friendly’ management guidelines that could be implemented immediately, in order that no more time would be lost in scientific debates about the finer points related to the responsible mechanisms (while the species richness continued to decline). Still, although subsequent implementation did seem to result in the maintenance species richness, the management apparently did not have the desired effects of increasing species richness.

Interestingly, if we re-examine the ecological foundation of these studies, we find that the investigated management factors and final management recommendations (see above) were almost exclusively related to local (a)biotic factors related to survival (reducing nutrients) and reproduction (allowing late flowering species to set seed) and were thus in effect aimed at preventing extinction. Processes and factors related to colonisation (in this thesis defined as dispersal, presence in the seed bank, germination and early establishment) were hardly included at all in the studies (but see sod cutting experiments by Melman & van Strien (1993)). This could be an important explanation why species richness in ditch banks is not increasing and this will therefore be the focus of this study.
Aims and outline of the thesis

The aim of my project is to investigate the possibilities of increasing the floristic richness of ditch banks. The focus is on grassland ditch banks on modern dairy farms in the Western Peat District in the Netherlands. Floristic richness is low in the fields and there appears to be an overall trend of declining species richness also on the ditch banks. So far, research has largely focused on creating optimal (a)biotic conditions in ditch banks. Still the species richness does not seem to increase. There are two possible (not mutually exclusive) explanations: 1) conditions have not improved as expected, reducing the survival of existing plant populations or 2) (re-)colonisation is insufficient. The (re-)colonisation of a species is dependent on the presence of source populations and dispersal vectors or on the presence in the seed bank. In addition, abiotic and biotic factors must be suitable for germination and establishment. See Fig. 1 for a schematic representation of the life-cycle of a plant, a number of ecological constraints and the most relevant management factors in ditch banks.

Fig. 1. Fictive life-cycle of a ditch bank plant, key ecological constraints and the most relevant management factors in ditch banks.
The central research questions addressed in this thesis are (Fig. 2):

1. **Are (target) species able to (re-)colonise and maintain themselves in ditch banks?** (Chapter 2)

   Changes in species richness in ditch banks were studied in a 25 year long dataset, specifically whether ditch bank species have tended to decline in occupancy. A method was developed for investigating the relative importance of colonisation and extinction for determining species increase and decline in multi-species assemblages. This was followed by regression analyses of ecological species traits (such as nutrient requirements, seed bank type and germination time) associated with trends, colonisation and extinction. The results from these analyses yield an overall picture of the relative importance of different ecological factors and processes in ditch banks. Tentative management recommendations are formulated.

2. **What is the potential of the soil seed bank for restoration?** (Chapter 3)

   If the seed bank is to be potentially useful in restoration, the seed bank needs to be species-rich, or in case of a species-poor seed bank, target species must be present. The species richness and composition, including the presence of target species were studied in the vegetation and the seed bank at species-poor and species-rich sites. Furthermore, the relative importance of different ecological species traits and biomass at species-rich and species-poor sites were investigated and interpreted in terms of management.

3. **What are the effects of agri-environment schemes on ditch bank productivity and diversity?** (Chapter 4)

   First, the effect of 10 years of agri-environment schemes on plant diversity were investigated. Since ditch bank management recommendations are mainly focused on reducing productivity, the focus was then shifted to effects of these schemes on productivity. The development in ditch banks with agri-environment schemes was compared to that in ditch banks mostly without management schemes. Finally, the relationship between productivity and diversity in ditch banks was studied. If productivity is important, theory predicts a negative relationship between these two parameters. Spatial productivity-diversity patterns and changes in time in productivity and diversity were investigated, including the possible effects of a high starting productivity. Possible dispersal constraints and consequences for agri-environment schemes are discussed.
4. Can germination, establishment, survival and reproduction be enhanced by different management regimes in conditions differing in productivity? (Chapter 5)

To improve management guidelines, we need to pinpoint the most important ecological constraints currently hampering an increase in species diversity in ditch banks. Nine target species were sown and transplanted into artificial gaps in ditch banks differing in productivity and subsequently subjected to different mowing and grazing regimes. Germination, establishment, survival and reproduction were monitored during two years. The (interactive) effects of productivity and management on these variables were tested, focusing on the question whether a more intensive grazing / mowing regime is better in high productive situations and whether a more extensive regime is better in low productive situations. The relative importance of seed, microsite and site limitation in ditch banks are discussed.

This thesis concludes with a summary of the most important ecological and practical results followed by a general discussion about the importance for (restoration) management and agri-environment schemes (Chapter 6).
Are target species (re-)colonising and maintaining themselves in ditch banks?
- occupancy, trends, colonisation & extinction.
Chapter 2

Are viable diaspores available?
- seed limitation? Chapter 5

In the surroundings?
- isolation
Chapters 2, 4 & 5

Are conditions suitable for dispersal?

In the soil seed bank?
- which species?
- depth?
Chapter 3

Are (a)biotic conditions suitable for seed germination and seedling establishment?
- microsite limitation? Chapter 5

Are (a)biotic conditions suitable for survival, growth, flowering and seed-set?
- site limitation? Chapters 4 & 5

Management considerations:
No problem

Seed introduction

Which factors?
- presence vectors

Which factors?
(actual transport by vectors)

Which activation measures?
- sod cutting?
Chapter 6

Which factors?
- productivity?
Chapter 5

Regional solutions

Potential of seed bank for restoration

Mowing and grazing regime optimising initial establishment

Mowing and grazing regime optimising flowering and seed-set
Reference List


