Farmland Biodiversity – in the Hands and Minds of Farmers

Effects of Landscape Structure, Management and the Farmer's Interest in Nature

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Abstract

Recent declines in farmland biodiversity have been attributed to agricultural intensification. Organic farming and other Agri-Environmental Schemes have been implemented to counter the biodiversity decline. Decisions concerning farming systems and farm management are taken by the farmer and since these decisions have consequences for biodiversity the motivations behind them need to be understood. The main aim of this thesis is to study how farmers relate to biodiversity on their farm, how biodiversity depends on farmers' perspectives of nature and the direct effects of farm management practices.

A meta-analysis was conducted comparing biodiversity and abundance on organically and conventionally managed land. Organic management on average resulted in 30% higher species richness and 50% higher abundance, but the effect varied greatly between studies, organism groups and study scale.

To empirically study how farmers relate to nature and how this affects biodiversity interviews were conducted with 16 farmers in south-central Sweden, and inventories made of species richness on their fields and farmsteads. The relation between species richness, local management and the surrounding landscape was explored.

Bird species richness on the farmsteads was positively affected by the area of houses and animal production on the farm. Species composition was also associated with composition of the surrounding landscape. Biodiversity, represented by the proportion of the regional richness found on single fields summed over the five organism groups, increased significantly with farmers' interest in nature and decreased with local farming intensity, measured as crop density.

Interest in nature is the social relationship of farmers with their ecological context, and their personal feelings and perceptions of nature. The main conclusion from this thesis is that farmers' interest in nature matters for biodiversity but exactly how and by what means needs further study. In any case, this factor needs to be included when designing and studying future agricultural landscape management, for sustainable production and maintaining biodiversity and ecosystem services.

Keywords: attitudes, perceptions, nature conservation, species richness, biodiversity, farmers, agri-environmental schemes, management, interviews

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I want to live in a great, white house
à la fin de siècle
with a wrought-iron gate
that creaks benignly
and roses around the door
I shall have a swing
in an old apple tree
and in the spring
apple blossom will fall like snow around me
and there'll be lilacs to remind me of the cruellest month and honeysuckle spreading a sweet, intense, sensuous scent in soft summer evenings
I want a garden full of mystery
a garden full of dreams
with snails stubbornly carrying their fragile hiding-places leaving shiny traces of their paths in curious patterns and birds with black, bead-like eyes, twittering and butterflies fluttering and dragonflies darting through the air, glittering and bumblebees tumbling and fumbling and rumbling amusing and confusing me and possibly foxes with pointy noses or secretive badgers hiding amongst the roses
and I will befriend anonymous hedgehogs with their pin-cushion bodies but leave the wild rabbits to roam free only from a distance loving their attentive ears and soulful eyes lest I scare them
and in the winter
the supposedly dead roses
will still breathe
and sing a wordless lullaby about life slumbering in frosty buds and frozen roots and the naked trees will stand boldly enduring the cold hibernating secretly harbouring hopes of growth knowing that growth is in their nature and in the summer I will have coffee beneath their leafy boughs saluting them their faith and endurance
I will prune and potter about
in white flannel trousers or ball gowns
I will tread the ground softly, softly on naked feet and there'll be room for everything that I am
I will stand in awe of God
humble before His creation
honoured to be a part of it
blown away by His goodness
in the fire of the fall
in the white stillness or whipping storms of winter in the bubbly frenzy of spring and in the green heat of the summer

Poem written by my sister Malin

Contents

List of publications

This thesis is based on the work contained in the following papers, referred to in the text by Roman numerals:

I Bengtsson, J., Ahnström, J. & Weibull, A-C. 2005. The effects of organic agriculture on biodiversity and abundance: a meta-analysis. *Journal of Applied Ecology* 42, 261-269.

II Ahnström, J., Höckert, J., Bergeå L, H., Francis, C.A., Skelton, P. & Hallgren, L. 2009. Farmers and nature conservation: What is known about attitudes, context factors and actions affecting conservation? *Renewable Agriculture and Food Systems*. 24, 38-47.

III Ahnström, J., Berg, Å. & Söderlund, H. 2008. Birds on farmsteads – effects of landscape and farming characteristics. *Ornis Fennica* 85, 98-108.

IV Ahnström, J., Hallgren, L. & Boonstra, W. Are you interested in nature? Farmers' perception and experience of nature and nature conservation in Sweden. Submitted manuscript

V Ahnström, J., Bengtsson, J., Berg, Å., Hallgren, L., Boonstra, W. & Björklund, J. Farmers' interest in nature enhance biodiversity in arable fields. Submitted manuscript

The contribution of Johan Ahnström to the papers included in this thesis was as follows:

I Data collection and writing

II Original idea, data collection, and main author

III Idea development and statistical analysis together with Åke Berg and main author

IV Original idea, data collection, interpretations in cooperation with the other authors and main author

V Idea together with supervisors, data collection, statistical analysis and main authors

1 Introduction

1.1 Biodiversity in agricultural landscapes

Farmland biodiversity is decreasing in Sweden and in general througout Europe (Wretenberg *et al.*, 2006; Donald *et al.*, 2001; Krebs *et al.*, 1999). Intensification of farming is the main cause of this biodiversity decrease (Kleijn *et al.*, 2009; Donald *et al.*, 2001). The intensification has lead to the desired increased yields but also to lower farmland heterogeneity, a switch from spring to winter sown crops and from hay to silage, a decrease in the number and area of semi-natural habitats, increased use of agrochemicals etc. (Benton *et al.*, 2003; Robinson & Sutherland, 2002; Stoate *et al.*, 2001). These changes occur on both local, e.g. crops on fields, and regional, e.g. farmland heterogeneity, scale (Tscharntke *et al.*, 2005). In ecological terms this has lead to loss, fragmentation and decreased connectivity of habitats and changes in the temporal and spatial distributions of habitats, thus affecting population dynamics of species and in several cases has lead to local and regional extinction of species, an example from Sweden is White Stork *Ciconia ciconia*. The effect of the landscape changes on organisms depend on their life history traits e.g. size, mobility, trophic level (Rundlöf *et al.*, 2008b; Rundlöf, 2007).

The intensification of agriculture has created a landscape matrix, i.e., the background cover type in the landscape that covers a large highly connected area (Turner *et al.*, 2001), that is unsuitable for many organisms and simultaneously the area of suitable habitats, e.g., semi-natural habitats has decreased considerably (Benton *et al.*, 2003). The suitable habitats or patches can often be seen as islands or patches in unsuitable matrix and thus there is a low connectivity among the ‘good’ habitats. Metapopulation theory examines the survival of populations in a landscape with island habitats or patch distribution of habitats (Hanski, 1998). Based on this theory survival of populations is increased by increasing the connectivity between good habitats via corridors (Bennett, 1999, 2003) or by making the matrix less unsuitable (Vandermeer & Carvajal, 2001).

Organic farming has been suggested to ameliorate the status of farmland biodiversity (Bengtsson *et al.*, 2005; Hole *et al.*, 2005). The decreased intensity, i.e., abandonment of chemical fertilisers, herbicides and pesticides, often mixed farms and a diverse crop rotation, that make the matrix more suitable are among the suggested reasons (Perfecto & Vandermeer, 2008; Vandermeer & Perfecto, 2007). Organic farming has been included in agri-environmental schemes within EU but the benefits of AES in general and of organic farming in particular have been questioned by (Goklany, 2002; Kleijn *et al.*, 2001; Trewavas, 2001).

The effect of organic farming on biodiversity is landscape dependent (Bengtsson *et al.*, 2005; Weibull *et al.*, 2000). Rundlöf has shown in several studies that organic fields have a higher biodiversity than conventional fields in homogeneous landscapes but there is little difference in heterogeneous landscapes (Rundlöf *et al.*, 2008a; Rundlöf *et al.*, 2008b; Rundlöf & Smith, 2006). Thus the organic fields are 'good' habitats or they make the matrix less hostile in the homogeneous landscape but in the heterogeneous landscape there are other habitats that are better and the suitablility of the matrix is already higher.

In Sweden the agricultural area represents 8% of the land area but still half of the threatened species (red-listed species) are connected to the agricultural landscape (Gärdenfors, 2005). The most important areas for farmland biodiversity in Sweden are semi-natural pastures (Lindborg *et al.*, 2008). However, semi-natural pastures have decreased considerably during the last 100 years. While much research in Sweden has focused on biodiversity in semi-natural pastures (Stenseke, 2009; Hessle *et al.*, 2008; Sjödin, 2007; Öckinger & Smith, 2007; Öster *et al.*, 2007; Lenoir & Pihlgren, 2006; Stenseke, 2006), have fewer studies, like this thesis, had their focus on biodiversity in the agricultural fields (Rundlöf, 2007; Öberg, 2007; Weibull *et al.*, 2000). The conflict between production and conservation is pronounced in agricultural fields and therefore an excellent study area for this interdisciplinary thesis.

1.2 Farming in change

The number of farm holdings (both arable and livestock farms) has decreased by almost 40% since 1980 and the recruitment of young farmers is low, i.e. a

50% reduction of farmers between 25-34 years old since 1996. The size of the farm holdings are also increasing rapidly from 29ha/company 1990 to 36ha/company 2005. Also the number of really large companies (over 100 ha) is increasing rapidly meaning that a few managers have a large impact on large areas of the landscape (Statistical Sweden, 2008). Thus each individual farmer's decisions regarding production and nature conservation become more and more important. Furthermore, the farm holdings without livestock have increased by 20% 1980 to 2007, and the farm holdings with livestock are unevenly distributed in the country (Statistical Sweden, 2008). Thus there are agricultural areas with low numbers and other areas with high numbers of grazing animals.

1.3 Farmers as actors

Farmers have been acknowledged as keystone actors in the appearance of the agricultural landscape and the environmental effects of farming and thus the literature studying actions and attitudes of farmers has grown over the last 40 years, from 12 published in 1970 to 96 published 2008 (Web of Knowledge; keyword farmer attitudes). The explanatory variables used to describe attitudes have been, e.g., age (Vanslembrouck *et al.*, 2002), farm size (Featherstone & Goodwin, 1993), economy (Siebert *et al.*, 2006) and education (Pyrovetsi & Daoutopoulos, 1999). There is critique of using simplistic variables like age to explain complex and non-static attitudes (Gravsholt Busck, 2002).

As a response to the critique there are several sociological studies which analysed differences in farm management practices in relation to landscape development, nature management and biodiversity, based on the concept of van der Ploeg (1993) called 'style of farming' (Swagemakers, 2008; Schmitzberger *et al.*, 2005; Gerritsen, 2002; Gravsholt Busck, 2002). These studies argue that farm practices are irreducibly linked with local ecological systems. Thus, different farming styles result in different forms of co-production and consequently have a diverse impact on the rural landscape and farmland biodiversity.

1.4 Landscape issues are interdisciplinary

The appearance of landscape we see around us is co-constructed by society and nature (Bürgi *et al.*, 2004), based on interactions between social, economic, historic and environmental factors (Moss, 2000) and evolves constantly based on social and economic needs (Antrop, 2006). Thus nature conservation is a multidisciplinary, interdisciplinary or transdisciplinary task. Multidisciplinarity use knowledge from different disciplines but the result stays within respective discipline. Interdisciplinarity links disciplines and try to build and coordinate a coherent whole. Transdisciplinarity integrates disciplines and transcends their traditional boundaries and involve multifold of stakeholders (Moss, 2000).

However, difficulties for social and natural scientists to interact and integrate their studies are partly based on the fact that different credibility is given to quantitative and qualitative data (Bürgi & Russell, 2001). Fry (2001) describes the barriers to interdisciplinary research as academic traditions, the merit system and the lack of theory.

2 Aims of the thesis

The main aim was to study how farmers relate to biodiversity on their farm and how biodiversity is dependent on the farmers' perspectives of nature and farm management. I want to contribute to the question how and by what means biodiversity can be enhanced in agricultural landscapes, with special focus on the role of farmers as actors in biodiversity related issues.

2.1 Specific aims of the different studies

2.1.1 Paper I

- Evaluate if organic farming, one of many agri-environmental schemes in Europe, enhances biodiversity and abundance based on literature data.
- Study if the effect of organic farming differs between organism groups and spatial scales.

2.1.2 Paper II

- Provide an overview and critical examination of the current knowledge about farmers' perceptions of nature and nature conservation.
- Discuss the factors that influence farmers' perceptions and actions related to nature conservation.

2.1.3 Paper III

- Study a farmland habitat that is mainly influenced by individual farmer decisions, namely the farmstead.
- Study how farmstead habitat structure, farm production type (livestock and arable production) and landscape structure affect the bird fauna in farmsteads.

2.1.4 Paper IV

- Study how farmers talk and think about their relation to nature and biodiversity.
- Understand the role, motivations and sentiments of farmers to nature and nature conservation using farmers' interest in nature as a tool.
- Discuss how "interest in nature" can influence willingness to promote biodiversity and nature conservation.

2.1.5 Paper V

- Examine to what extent "interest in nature" can explain farmland biodiversity in comparison with commonly measured ecological variables like local farming intensity and landscape composition.
- Interdisciplinary synthesis of Papers II-IV.

2.2 Interdisciplinarity

I wanted to combine methods and concepts from natural and social sciences, since farming and nature conservation within the agricultural landscapes is a socio-ecological system. This thesis is interdisciplinary but the Papers I-IV are disciplinary with interdisciplinary discussions and only Paper V is truly interdisciplinary. Thus I want to state that disciplinary research is needed as well as interdisciplinary research to understand farmland biodiversity and motivations and actions of farmers; there is no need for an either/or position regarding disciplinary or multidisciplinary research (multi-, inter- or transdisciplinary).

3 Farming and nature conservation context in Sweden

3.1 Nature conservation

I will in this section briefly describe different important nature conservation related agreements, directives, schemes and rules that are part of the governance of biodiversity and nature conservation in different ways.

3.1.1 Multiple use of nature conservation

Nature conservation is a term and a concept that is used by many stakeholders, e.g., governmental bodies, farmer federations and local nature interest groups. However, the meaning of nature conservation and the methods of conserving nature differ between stakeholders.

The Swedish term for nature conservation is *naturvård* i.e. to take care of nature. However, this often means conserving, preserving or protecting nature – rather as though it's in a museum. But caring for nature should involve getting close to it, and should include active management. The words used are important because they appeal differently to different stakeholder groups (Carr & Tait, 1991).

3.1.2 Convention of Biodiversity

The Convention of Biological Diversity (CBD) was discussed at the UN meeting in Rio de Janario, Brazil, in 1992. Today 191 countries have signed the treaty. Sweden ratified it in 1993 and by that we committed ourselves to stop the loss of species within our country. CBD defines biological diversity thus:

> "Biological diversity" means the variability among living organisms from all sources including, inter alia, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part; this includes diversity within species, between species and of ecosystems. (CBD, 2009b)

The main aim of CBD is to conserve biodiversity, sustainably use our natural resources and equitably share the resources. Traditional and indigenous knowledge about nature is raised as important to cherish. The reasons to conserve biodiversity are concrete values, i.e., utilitarian values, consumption values, scientific values, production values, and abstract values, i.e., ethical values, intrinsic values of species and habitats and symbolic values (Lisberg Jensen, 2000). The concrete values are today often called ecosystem services, i.e., services that sustain human life (Daily, 1997).

The parties of the convention agreed to

> achieve by 2010 a significant reduction of the current rate of biodiversity loss at the global, regional and national level as a contribution to poverty alleviation and to the benefit of all life on Earth (CBD, 2009a).

To achieve this biodiversity loss reduction protected areas are seen as the foundation. The protected areas are seen as the back bone for the stability (for a more comprehensive view of the role of reserves and non-protected areas see Bengtsson *et al.* (2003)) and functioning of ecosystems (Secretariat of the Convention on Biological Diversity, 2009).

3.1.3 EU directives

In 1979 the first nature conservation related directive was established within EU; the bird directive (Council Directive 79/409/EEC). The bird directive was developed to protect, manage and regulate all wild bird species naturally living European territory of the Member States. Furthermore, bird habitats should be maintained, restored and new habitats created if lacking. The bird directive was complemented, in 1992, with the Council Directive 92/43/EEC on the conservation of natural habitats and of wild fauna and flora, often called the species and habitat directive. Each member state is responsible for certain habitats and species so that they can persist in the future. The purpose of the directive is to promote biodiversity with regard to economic, social, cultural, and regional needs. The directive acknowledges that in order to promote biodiversity it can be necessary to keep or even promote human activities, i.e. mowing of a hay meadow. The

Natura2000 network is a way to implement theses two directives within EU by connecting protected areas to each other.

3.1.4 Environmental objectives

Sweden have had, since 2005, 16 environmental objectives (Gov Bill. 2004/05:150), the first fifteen came in 1999 (Gov. Bill 1998/99:183). The aim is to reach the environmental objective within a generation i.e. 2020-2025. The environmental objectives should be considered in all activities and decisions at national, county, municipality, and company level to ensure nature and environmental sound behaviour. Within each objective there are interim targets and these are supposed to be precise and easy to understand. They can be monitored and thus serve as a basis for regional and local efforts to achieve the objectives (Gov. Bill 2000/01:130). The objective with the strongest connection with farming is 'A varied agricultural landscape'. The interim targets for this objective include maintaining a certain amount of area of managed pastures and meadows, planning how to increase the number of uncultivated habitats in intensive agriculture areas and developing action programs for threatened species. The intentions behind the objectives are indeed ambitious and sound but the objectives differ in the degree of how practical they are to put into operation; and there are goal conflicts between the objectives (Edvardsson, 2004).

3.1.5 CAP and Agri-Environmental Schemes

The Common Agricultural Policy (CAP) was first established in 1957 in The Treaty of Rome and since then farming in the growing EU has been governed within the same framework. The aims of the CAP have changed over the years going, from the aim of increasing the yields to producing in an environmentally sound way (Table 1).

Table 1. *Aims of the CAP*

Aims 1957-2005	Aims 2005-onwards
Increased yields	Reasonable incomes for farmers
Ensure a fair standard of living for the agricultural Community	Fair prices and safe food to consumers
Stabilise markets	Acceptable costs for taxpayers
Secure availability of supplies	Fair possibilities for world food to enter EU
Provide consumers with food at reasonable prices	A competitive food industry

To achieve this environmentally sound production Agri-Environmental Schemes have been developed in the EU, with specific national designs to counteract the loss of biodiversity. The integration of agriculture within EU nature conservation has been described as a prerequisite for success (Siebert *et al.*, 2006). The first AES came in 1992 (with regulation 2078/92) with the focus of making agricultural production methods compatible with the requirements of the protection of the environment and the maintenance of the countryside. Each AES period is five years and the current one runs from 2007 to 2013.

The effect of AES on biodiversity has been questioned (Berendse *et al.*, 2004; Kleijn *et al.*, 2004; Kleijn & Sutherland, 2003; Kleijn *et al.*, 2001). Furthermore, the expected change in farmers' attitudes to more nature- and environmental-friendly attitudes has not occurred (Burton *et al.*, 2008). The whole design of the schemes is also questioned since the outcome of the schemes cannot be evaluated because of unclear ecological aims. The attempts of national self-evaluation regarding the schemes have been lacking in scientific and statistical rigor. The design, administration and control function, and the aims of the schemes, are a delicate balance between different interests e.g. ecological, socio-economical, administrative and political (Kleijn *et al.*, 2006).

Participation in AES is voluntary for farmers. Thus the fields under the schemes are not always where they would benefit biodiversity the most. Furthermore the fields that are included in the AES are often low-yielding peripheral fields (Kleijn *et al.*, 2004; Kleijn & Zuijlen, 2004). These fields may already hold a high biodiversity and the evaluation process is therefore even harder to do.

3.2 Farming in Sweden

The Swedish arable field area was in 2007 was almost 2 650 000 ha and that is a decrease of 10% since 1981 (data is taken from Statistical Sweden and the Yearbook of statistics 2008 if not indicated otherwise). The two most grown crops in 2007 were winter wheat and spring barley with 300 000 ha each i.e. 12% each of the total arable field area. The winter wheat area in 2007 had more than doubled since 1981. The winter wheat area might differ substantially over the years depending on the weather during the sowing time of late August to early October. In contrast to winter wheat the area of oats in 2007 is less than half that in 1981. The fallows have increased from 2 % of the field area to 10 % in 2007, but are likely to decrease due to changes in the use of fallows. I will later use fallows as an example of effects of subsidies.

The yields have increased considerable since 1965 e.g. winter wheat by 70% and spring wheat and oats by 50%. This is due to higher yielding cultivars and the use of external inputs like fertilisers and crop-protection chemicals.

I will use dairy production as an example of how the development of farming includes both closure of farms and intensification of farming from 1980-81 to 2007. The number of dairy holdings has decreased by 80%, the number of cows by 44% and the total milk production by 10% (Svensk mjölk, 2009; Statistical Sweden, 2008). The relative small loss in total milk production is caused by two things: the holdings have increase in size from 15 to 52 cows per holding, and each cow produces 36% more milk. The distribution of the farms is also uneven in the country, with 30% of the dairy cows are in the two counties of Skåne and Västra Götaland. This shift in dairy production has of course changed the appearance of the landscape. There are few or no grazing animals in some areas with implications on biodiversity, and many animals in other areas with high grazing pressure and nutrient loads. Thus biodiversity is threatened both by intensification and abandonment of farming.

The changes in dairy production affect other parts of the production chain. There are fewer calves for other farmers producing bulls and steers, and the dairies and slaughter houses are bigger and fewer and also placed where there are most animals. The whole food chain is becoming even larger and thus small-scale farming has to either try to fit into the large-scale production or break free and start to find new alternative methods to process their raw materials into sellable units.

The number of farm holdings (both arable and livestock farms) have decreased by almost 40 percent since 1980 and the total numbers of farmers have decreased from 85 000 to 67 500. There are some age classes that have decreased more than others and those are the young farmers below 40 years old. The reduction in the number of farmers in age class 25-34 years old is almost 50 percent.

The decisions of each individual farmer regarding production and nature conservation becomes more and more important as numbers of farmers and farm holdings become fewer and as a result of this each farmer still in production in Sweden has a larger farm, 29ha/company 1990 and 36ha/company 2005. Also the number of really large farm holdings (over 100 ha) is increasing rapidly meaning that a few managers have a large impact on large areas of the landscape.

3.2.1 Agri-Environmental Schemes in Sweden

The current rural development program with biodiversity and environmental measures is valid though 2007 to 2013. The aim of the program is to support a sustainable economic, ecologic and social development of the rural areas. The program is divided into four parts: Enhance competitiveness of agriculture and forestry, Environment and field management, Diversified economy and good quality of life in rural areas and the LEADER dimension. This thesis will focus on Environment and field management part of the AES but the other parts that affect farmers management and economy and thus indirectly biodiversity. The current program holds the traditional five year agreements for management of certain habitats or structures, e.g., semi-natural pastures and green field border zones, but there is also project financing, e.g., pasture restoration.

The previous AES-period has been evaluated and the main conclusion for biodiversity is that even though the payments to for example management of semi-natural pastures and an open agricultural landscape, seem to have been allocated to land with high quality this is no reassurance that it promoted biodiversity (SLU, 2009).

3.2.2 Fallows as an example of effects of agriculture regulations

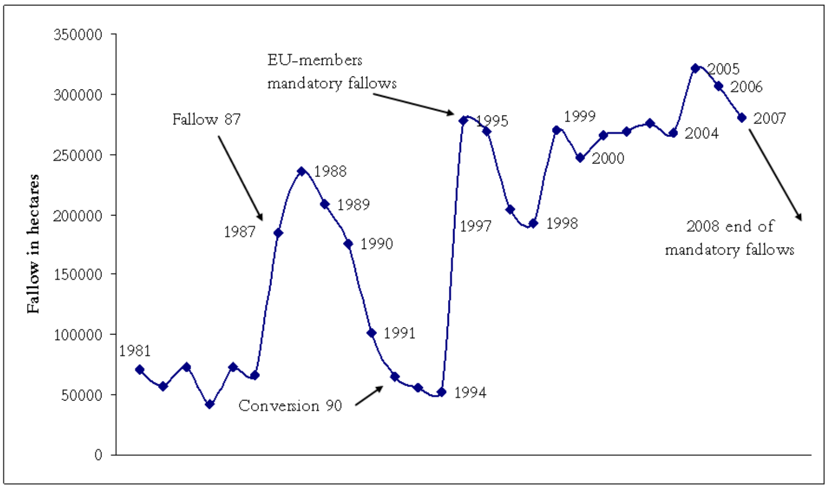

Figure 1. Area of fallows in hectares in Sweden from 1981 to 2007 and important agricultural regulations affecting the area of fallow (Statistical Sweden, 2008).

The area of fallow in Sweden has varied considerably during the last 30 years (Figure 1). The variation is highly connected to the introduction of different agricultural policies and regulations. The appearance and placement of the fallows has also differed over time. In figure 1 four sudden changes of fallow are clearly shown. In 1987 Sweden introduced a scheme called Fallow 87 that promoted fallow to decrease the overproduction of cereals. However, the decrease was not considered enough. Therefore, a new scheme called Conversion 90 was introduced. This scheme compensated farmers who used their arable land for other things than producing cereals, e.g. planting trees. The arable land was thus taken out of production for a long time, longer than just a fallow. This scheme had a marked effect and the overproduction decreased with 50%. The third important event was the entry into the EU. In the EU 1995 there was a mandatory fallow of 12% of the arable land for all farmers producing more than 92 000 kg of cereals. The proportion of the land that should be fallowed has changed over the years; see the decrease to 5% of the arable land on the farm 1997-1998 and an increase to 10% 1999. The increase of fallow between 2004 and 2005 depends on that the mandatory fallow increased again but it was also possible to fallow all arable land on the farm (previously only 50% of the land area could be fallowed). (Jordbruksverket, 2006)

In 2008 the EU decided to leave the mandatory fallows and let farmers themselves decide if they wanted a fallow or not. The area of fallow in 2008 was not available when figure 1 was made: however, it is well known that the area of fallow has decreased considerable and in some areas more or less disappeared totally (Jordbruksverket, 2008).

The effect on biodiversity of the ending of mandatory fallows in Sweden has been discussed by the board of agriculture (Jordbruksverket, 2008). It was discussed that the farming intensity in already intense areas of Sweden would increase ever more and this would of course be negative for biodiversity in theses regions.

In 2005 there was a decoupling of subsidies from production to land area. In practice that meant that the farmers got the same amount of money per hectare of land no matter what they did on their land as long as certain basic criteria were met (Jordbruksverket, 2008). This made it possible to use fallow to change the shape of fields, e.g., to straighten a field border, and fallow the shaded parts of a field. In figure 2 the shape of a field is discussed based upon different agricultural regulations and schemes. The green borders in figure 2 makes a smooth transition from neighbouring habitats, to the fallow and then the crop and that ought to be beneficial for biodiversity.

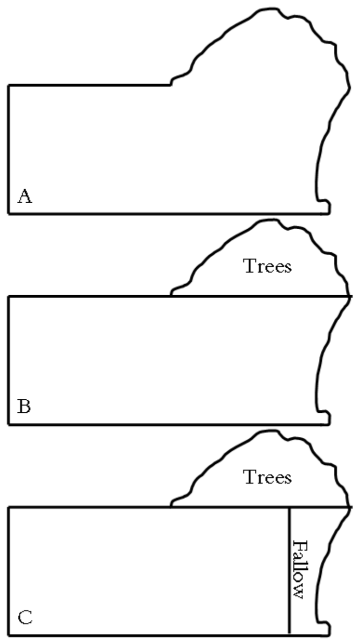

Figure 2. The shape of a field based upon different fallow regulations. A) This is how the field looked originally. B) Through support of Conversion 90 part of the field that was heavily shaded by the surrounding forest was planted with birch (*Betula pendula*). C) In accordance with 2005 years change in agricultural support system, that crop and fallow are equally rewarded in the subsidy system, the borders of the field were made straight to make ploughing easier. The strip of fallow is also makes excellent headland.

4 Theories and concepts

I will now briefly describe theories and concepts that my work is based on. First I will discuss the epistemological foundations of my work, i.e. my view of knowing and learning, by using hermeneutics. This view of knowledge development applies how I have worked with both my ecological data and interview data. My data collection methods and my interpretation of data was based on what I knew at the time for the collection and interpretation; knowledge development needs knowledge (pre-understanding) (Hallgren, 2003).

4.1 Hermeneutics

Hermeneutics is an epistemological view on how human knowledge is created and shaped. Hermeneutics deals with how we interpret, understand and know about the world around us (Ödman, 1979). Hermeneutics deals with how we always relate our new experience to what we have experienced before, i.e. our pre-understanding. The pre-understanding is crucial for how we understand and interpret e.g., a situation and a question. For example how an interview transcript is understood is based on the pre-understanding which is formed by previous knowledge and experience. Furthermore, the pre-understanding is redefined and/or extended in the process of understanding (Bos & Tarnai, 1999). My pre-understanding or rather a description of my experience will be given in chapter 5 to help the reader and myself to understand my point of departure in the interpretation process of social and natural science data. Moss (2000) stated that it would be useful for researchers of all disciplines to state their background and experience to help the reader to understand how different interpretations were reached. Furthermore, hermeneutic-based research should be explicit about what the interpretations were based on and thus motivate the interpretation. However, this may become a circular discussion since an interpretation is needed to understand a interpretation, which then in turn should be interpreted (Hallgren, 2003). This thesis has certainly changed my understanding regarding many different issues.

The hermeneutic view on knowledge development is that understanding is always a dialectic process between parts and whole. The parts cannot be understood without understanding the whole picture and the whole picture cannot be understood without knowing about the parts. The process of putting together a puzzle is a good example of the hermeneutic approach (Ödman, 1979). Trying to put together a puzzle by just looking at the parts, the single puzzle bits, is hard - not to say impossible. However, if the parts are looked at as being parts of a whole and put together in larger subunits of the puzzle then it is easier. These units and how they go together need knowledge about the small parts as well as an idea on how the full picture will look. Thus it is important to go back and forth between the parts and the whole to be able to put together the puzzle e.g. data help to explain theory and theory help to explain data. For example, in my study I have studied carabid beetles as part of biodiversity (whole), but also how biodiversity correlates with species richness of carabid beetles. Biodiversity studies in farmland are not complete if carabid beetles are excluded and carabid beetles are affected by the surrounding biodiversity, i.e. species that are food or carabid beetle predators.

It should be noted that hermeneutics is a description of the knowledge development and results in criteria for good research. However, to follow these criteria is difficult, i.e., it is easier to talk and describe hermeneutics than it is to work in a truly hermeneutic way.

4.2 Ecological theory and terminology

This chapter deals with ecological theory and terminology used in the thesis.

The loss of farmland biodiversity is an ongoing process that will affect ecosystem services and the stability of farmland ecosystems (Tilman *et al.*, 2002). This will ultimately also affect farming but also factors such as recreational values of farmland. Biodiversity on farmland is also affected by land-use and landscape composition, on both local and regional scale (Tscharntke *et al.*, 2005). Landscape ecology embraces spatial variation but also interdisciplinary work (Moss, 2000), see 4.2.2 for definition of landscape ecology. Studies of biodiversity in a landscape need to be based on a fundamental theory and in my case that is metapopulation theory (Hanski, 1998) and its subsequent development into metacommunity theory (Leibold *et al.*, 2004). However, I have not explicitly worked with it in my thesis – but the theory is fundamental for nature conservation issues in farmland, where the fields are often seen as a 'bad' matrix and uncultivated habitats as good 'patches'.

4.2.1 Biodiversity, ecosystem functioning and stability

Biodiversity has been an accepted term ever since 1988 when Edward Wilson edited and released a book with the title Biodiversity. Biodiversity can be defined (Hooper *et al.*, 2005; DeLong, 1996) and measured in many ways (Hamilton, 2005). The term may mean many things not only in different research disciplines but also in the non-scientific literature, e.g. in policy and planning (Zetterberg, 2009). In order to be able to use biodiversity in discussions on nature conservation, ecosystem stability and ecosystem function, must be clearly defined and described (Purvis & Hector, 2000), for example as species richness, relative abundance of species, species composition, evenness of species or traits of species (Hooper *et al.*, 2005). Furthermore, biodiversity encompasses several different levels, i.e., genes, species and ecosystems (Purvis & Hector, 2000).

If biodiversity is defined as the total number of species of all organism groups in a specific area then it is more or less impossible to study (Fleishman *et al.*, 2005; Simberloff, 1998). Therefore, most studies have addressed only parts of the biodiversity, for example as species richness of one or several species groups (Wolters *et al.*, 2006) that can be considered as being indicators of the total biodiversity. Alternatively, some other indicators for biodiversity have been used, e.g., landscape structure (Dauber *et al.*, 2003). However, although the correlation between species richness of one taxon and species richness of other taxa is often positive, the correlations are often quite low (Wolters *et al.*, 2006), indicating that good indicator groups for overall species richness will be difficult to find.

There is a debate among scholars how ecosystem stability and ecosystem functioning are related to biodiversity (Loreau *et al.*, 2001; Lehman & Tilman, 2000). To be able to discuss this, the meaning of stability must be explicitly defined (Gunderson, 2000). Ecosystem stability can be described as resilience. The term resilience has two major definitions in the literature. A systems return time to a stable state after a perturbation (Neubert & Caswell, 1997; Ives, 1995) or a systems resistance to, ability to recover and adapt to disturbances by remaining within the same stability domain (Folke, 2003; Holling, 1973). Alternatively ecosystem stability can be defined as ecosystem integrity, i.e., the ability for a system to retain all its components and the functional relationships among the components under disturbance (De Leo

& Levin, 1997). Ecosystem integrity thus includes dynamics and changes within ecosystems and furthermore it includes the system's capability to produce ecosystem functioning (De Leo & Levin, 1997).

Ecosystem functions support the whole ecosystem including humans (Hooper *et al.*, 2005). The functions that support humans are often treated separately and are then called ecosystem services (Daily, 1997).

The production of ecosystem services as well as biodiversity has been negatively affected by the intensification of agriculture, e.g., maintenance of fertile soils, biotic regulation, nutrient recycling, assimilation of wastes, sequestration of carbon dioxide, and maintenance of genetic information (Hooper *et al.*, 2005; Tilman *et al.*, 2002). Many of these services are of fundamental importance for agricultural production, e.g., mineralisation, erosion control, pest regulation and pollination, are of great importance for rural life and rural development, e.g. aesthetics, viable bird and fish populations and flower-rich meadows. External agricultural inputs, such as chemical fertilisers, herbicides and pesticides, have both replaced lost services and been drivers of their decrease (Björklund *et al.*, 1999).

It is common species that support and create the substantial part of the ecosystem services that humans rely on (Kremen *et al.*, 2007; Bianchi *et al.*, 2006). Ecosystem services are extensively studied, however, most studies have not (contrary to what is often claimed) directly studied an ecosystem service, but the potential for the ecosystem service. To study bumble bee species richness and abundance is to study parts of the potential for the ecosystem service pollination, but it is not a direct study of the service.

There are only a few studies that actually have studied ecosystem services; seed production (Morandin & Winston, 2005), aphid removal (Ameixa & Kindlmann, 2008; Östman, 2004) and soil aggregation (Rillig *et al.*, 2002). The studies of ecosystem services are important since they might provide good arguments for conservation of different species that are easily understood by farmers and the rest of the society.

Ecosystem functioning is connected with biodiversity (Hooper *et al.*, 2005), or rather the species that build up the biodiversity are connected to ecosystem functions (Bengtsson, 1998). Ecosystem functions depend on species richness but also on species composition and interactions between species (Hooper *et al.*, 2005). The abundant or common species are the ones most likely to affect the rate of a function, i.e., the abundant honey bees (*Apis mellifera*) pollinate a rape-seed field more efficiently than rarer solitary bee species. However, also rare keystone species could affect a function, such as a brown bear (*Ursus arctos*) eating and destroying bee colonies.

‘The more species the higher the stability’ has been an hypothesis since the time of Darwin (Hector & Hooper, 2002) and demonstrated in many studies, e.g. (Tilman *et al.*, 1996). The ways that biodiversity or species relate to stability and function has been described with the biodiversity-stability hypotheses, rivet hypothesis, the redundant species hypothesis, hypothesis of passengers and drivers and more recently discussions about response diversity.

The rivet hypothesis (Ehrlich & Ehrlich, 1981) describes species as rivets holding together an airplane and all rivets are equally important. If a few rivets are lost due to a perturbation does not matter because there are other rivets still holding the airplane together. But eventually there are not enough rivets and the airplane will fall apart and crash.

In the redundant species hypothesis the ecosystem will remain intact as long as each functional group has at least one representative but if one function is lost the system will be unstable and enter another state (Walker, 1992). A special case of the redundant species hypothesis is called passengers and drivers (Walker, 1992). The more passengers the higher likelihood that one of them can become a driver if a driver is lost, i.e. the function is not lost only a producer of the function. In some cases the driver also creates the very foundation for that for example beavers (*Castor fiber*) that created the pond and thus the prerequisites for that ecosystem.

Response diversity refers to the situation when species contributing to a function have different responses to environmental conditions or disturbances ((Elmqvist *et al.*, 2003) but see also (Loreau *et al.*, 2003)). In times with predicted higher spatial and temporal variations and negative impacts on ecosystems by pollution, climate change and human disturbance preserving response diversity is crucial to maintain resilient systems (Folke *et al.*, 2004).

Today, the conclusion seems to be that some individual species are as good performers of specific ecosystem function as a species rich mix (Hooper *et al.*, 2005), but these systems are less resilient (Folke *et al.*, 2004; Elmqvist *et al.*, 2003). However, biodiversity in relation to multifunctional ecosystems functioning has been surprisingly little studied. Multifunctional ecosystem functioning requires higher species richness than single functions (Gamfeldt *et al.*, 2008; Hector & Bagchi, 2007). An explanation of this is that species become more unique when many functions are added to a multivariate index of functional diversity (Petchey & Gaston, 2002). This means, according to (Gamfeldt *et al.*, 2008), that species loss is more likely to affect overall function of an ecosystem, rather than single functions.

In recent literature the relative importance of local management and landscape context on biodiversity or rather species richness of specific groups of species have been debated, e.g. (Tscharntke *et al.*, 2005). In this thesis I study both the local appearance and the management of winter wheat fields and farmsteads and the surrounding landscape. I will now discuss local-regional effects on biodiversity mainly based on literature comparing organic and conventional farming. The effect of organic and conventional farming on biodiversity has been suggested to be dependent on landscape heterogeneity (Rundlöf *et al.*, 2008a; Rundlöf *et al.*, 2008b; Holzschuh *et al.*, 2007; Rundlöf & Smith, 2006; Purtauf *et al.*, 2005; Roschewitz *et al.*, 2005; Schmidt *et al.*, 2005; Weibull *et al.*, 2000). The effects of local management of a field (organic and conventional) were greater in homogeneous landscapes than in heterogeneous landscapes. In heterogeneous landscapes there are many alternative habitats, 'good' habitats, to cereal fields and thus the management of these fields are relatively less important for biodiversity, i.e. the quality of the matrix is of less importance. However, in homogeneous landscapes where there are few 'good' habitats the importance of the matrix quality is higher for biodiversity.

Furthermore, local and regional contexts have been shown to influence species richness and species abundance differently. Species richness may be mostly affected by the landscape but species abundance was mostly affected by the local factors (Schmidt *et al.*, 2005).

4.2.2 Landscape ecology

There are thus strong relations between biodiversity and landscape structures and their spatial distributions. This implies that studies of landscapes are of crucial importance for biodiversity related issues in the agricultural landscapes.

There are two major views and definitions of landscapes and landscape ecology (Zetterberg, 2009; Moss, 2000). One is the more natural science oriented definition that deals mostly with how landscape elements are spatially distributed within a matrix and how landscape structure influences ecological patterns and processes (Wiens & Milne, 1989), and how landscape structure changes over time (Forman, 1983). Moss (2000) calls this view unidirectional interdisciplinarity, i.e., the perspectives originated more or less solely from natural sciences and especially a biological ecosystem perspective.

The other is the multidisciplinary or interdisciplinary definition where human activities are considered and included within the definition and use of landscape ecology. Furthermore, there is often a focus on solving management questions through applied research. Moss (2000) calls this either goal-oriented interdisciplinary or transdisciplinary landscape ecology. Thus landscape ecology covers spatial distribution of landscape structures on different scales and includes biophysical as well as socio-economic parameters. From my point of view both are valid and needed in different situations.

4.2.3 Metapopulation theory

The study of biodiversity and landscape demands a clear theoretical background and my work is based on metapopulation and metacommunity theory.

Metacommunity theory actually dates back to the work by MacArthur and Wilson (1967) and was formulated for single species by Levins (1969) who coined the term meta-population for a collection of local poulations. In metapopulation theory populations within in a landscape are divided into discrete local populations in patches (habitats) connected by species individuals that disperse between patches. The quality of the patches is considered equal and the matrix surrounding the patches considered as 'hostile', i.e., a non-habitat. In the early days of metapopulation theory the patches were either occupied or not and survival depended on stochastic events of extinctions and recolonisation, i.e. the distance to other patches (e.g. Hanski 1998).

The landscape changes within the agricultural landscape (Björklund *et al.*, 1999; Ihse, 1995) have lead to decreased amount of habitat and increased isolation of suitable patches, e.g., semi-natural pastures, and made the non-habitat areas, the matrix, more hostile. According to metapopulation theory this increases the probability of extinction of local populations and a lower recolonization rate but the metapopulation itself will persist until a threshold level of suitable or occupied patches is reached and then the whole population becomes extinct (Andrén, 1994).

Conservation of metapopulations is directly linked to dispersal possibilities and abilities. Therefore the use of corridors (Bennett, 1999, 2003) and stepping stones (Fischer & Lindenmayer, 2002) have been suggested as important conservation measures. However, the general benefit of these structures has been questioned (Hannon & Schmiegelow, 2002; Simberloff *et al.*, 1992) since the characteristics of a 'good' corridor are species specific, i.e. the requirements of a lichen, snail and a bird, are fundamentally different (Roy & Blois, 2006). However, the dispersal of most taxa are promoted by corridors (Haddad *et al.*, 2003). Furthermore, the effects of the corridors and stepping stones are dependent on the surrounding matrix with a more positive effect in landscapes where interpatch dispersal is high ('good' matrix) compared to landscapes where interpatch dispersal is low ('bad' matrix) (Baum *et al.*, 2004). The use of matrix itself has been shown to be both matrix quality dependent and life history trait dependent (Jauker *et al.*, 2009).

In reality patches differ in habitat quality. Thus the survival of populations in a patch is dependent on habitat quality as well as dispersal possibilities. Metapopulation survival depends on 'source' patches, i.e. 'good' patches with a high realized rate of increase that produces a surplus of individuals that can disperse to low quality patches' termed 'sinks' (Pulliam, 1988). The populations in 'sink' patches cannot survive without the immigration of individuals from other habitats.

In conservation related issues two special cases of 'sinks' are important; ecological traps and remnant populations. An ecological trap is a habitat that initially fulfils the basic habitat criteria for a species that rapidly changes and population survival is decreased. Remnant populations are often composed of long-lived species that remain or return to the same area year after year but do not have a positive growth rate. For instance, many long-lived grassland plants are surviving in abandoned pastures decades after abandonment, but in the long run the population will become extinct (i.e. an extinction dept) (Helm *et al.*, 2006; Lindborg & Eriksson, 2004).

4.3 Sociological theories and terminology

Here I will first briefly describe three epistemological concepts; social construction, grounded theory and objective hermeneutics, and then turn to describe three ontological concepts; identity, attitudes and social norms. Epistemology deals with how knowledge is seen and ontology deals with how the world is viewed, explained and understood.

In this thesis I have used qualitative interview sociological methods. Qualitative social methods try to develop theories and discover the unexpected in contrast to quantitative social science methods which focus on detecting significant causal relations and measuring frequencies (Mann, 2007). Through these qualitative interviews I discovered *interest in nature* as an interesting and useful concept to understand why the farmers and I differed in how we thought about different issues.

4.3.1 Social construction of reality

> Everyday life presents itself as a reality interpreted by men and subjectively meaningful to them as a coherent whole…//…It is a world that originates in

their thoughts and actions, and is maintained as real by these (Berger & Luckmann, 1967).

Hence, reality is constructed by our perceptions, i.e. everything that we perceive is given a meaning and content based on our previous experiences and thoughts. This holds for everything that we perceive, e.g., people and nature. In research, and everywhere else, the social reality is constructed and we cannot just picture it (Alvesson & Sköldberg, 1994). Thus nature is inescapably social (Castree, 2001) as we, each and every one of us, construct how we perceive but also define nature. There are of course physical and chemical processes going on independent of human perceptions and interpretations and thus something exist even without us humans. However, it is humans who call this something nature and humans who construct the meaning of the "something" they call nature and the frames and boundaries of its definition. What nature is – is decided in inter-human interactions and this of course lead to that different stakeholders have different definitions of nature (Hansen *et al.*, 2006), so has for example within the scientific community biodiversity been agreed on as a meaningful representation of nature. Biodiversty as a concept has added and changed the meaning of nature and in communities in which "biodiversity" is not a meaningful concept, nature will be (perceived) differently. The unperceived nature we can not even imagine.

How nature is constructed within our minds will affect how we act. Therefore, the understanding of other peoples' constructions of nature will be a guide to explain their behaviour. For example, if a person does not believe that pesticides will percolate thorough the soil, to the water and into his well then his action of using pesticides next to his well is understandable. It does not mean that he is right but for us to understand his actions we need to know about his construction of this situation.

In this thesis farming and nature conservation are seen as social processes, similarly to (Pickel, 2005; Emirbayer, 1997; Elias, 1978). Such a process-sociological (Elias, 1978) or relational approach (Emirbayer, 1997) assumes that persons and things are inseparable from the social contexts in which they are embedded via social relations. These social relations are dynamic, unfolding and ongoing social processes (Emirbayer, 1997), which enable and restrict specific patterns of feeling, thinking, wanting, doing and interacting (Pickel, 2005; Zijderveld, 2000). Using such an approach, farming and nature conservation can be conceptualised as a social process, i.e. a process that unfolds through (and is thus dependent on) social relations, which are both informal and formal; both vertical and horizontal; both direct and indirect. These social relations include, besides relations between people, relations between people and non-humans (biotic and abiotic) (Murdoch, 2001). The social relations of farming exist between three components: a) the physical and ecological context in which farmers find themselves b) the social relations of which farmers are part and c) the personal emotions, feelings, senses, perceptions and desires of farmers. In social reality these components are always intimately interlinked, and can therefore only be separated analytically.

4.3.2 Grounded theory

In this thesis I do neither work with nor try to relate to big social science theories, e.g. Marxism and Psychoanalyse. Instead I have focused on to try to understand and interpret what the farmers are saying and why they are saying it. By doing that I construct an empirically based theory based on the tension between previous and new experiences (Hallgren, 2003).

Grounded theory is a systematic research method to go from data to theory thus not to confirm theory but to generate theory (Alvesson & Sköldberg, 1994). Grounded theory was developed by Glaser and Strauss (1967). They put forward that each and every one of us can create a theory that is not only for the big scientists like Marx and Durkheim. The theory needs to be tested, and that can lead to changes but not to destruction of the theory.

Grounded theory was developed as a purely inductive approach, i.e., the researchers are supposed to ignore everything that is known about the study situation to ensure that the theory is not 'infested' with previous knowledge (Glaser & Strauss, 1967). Thus grounded theory is in its pure form a radical contradiction to hermeneutics since the pre-understanding is totally ignored (Alvesson & Sköldberg, 1994).

Grounded theory is epistemologically impossible but good as a method to interpret interviews. Grounded theory is the most used method to interpret qualitative interviews and it is an inductive approach meaning that the theory or hypothesis is developed simultaneously with the data collection and the interpretation process (Bryman, 2002). Furthermore, it is an iterative process and thus collection and interpretation of data goes hand in hand. The coding of interviews is an important part of the theory development within grounded theory. The interview is divided into categories with different properties not mainly to gather data but to be a part of the understanding and theory building process. The step going from categories to theory involves (PM-)writing, finding the main category and model building (Strauss, 1987). We have worked in a similar manner for example in this thesis Paper IV has been written and re-written several times since the writing process has been an interpretation process and we did construct models in several steps of this process. All of these models were discarded from the written text but they are still present as they were a part of the interpretation process. In paper IV interest in nature appeared as the main category during the interpretation process.

4.3.3 Objective hermeneutics

In the process of using grounded theory to interpret my interviews I found that my thoughts and ideas of some parts of an interview were not visible in the text. Grounded theory cannot interpret anything outside data but that is possible with objective hermeneutics.

In German speaking countries grounded theory is often replaced with objective hermeneutics (Mann, 2007). Objective hermeneutics are focused on reconstruction of the reality i.e. trying to understand why things were said and what would have been the expected answer to a particular question in an interview situation. The transcribed interview is dissected in every detail trying to reason about the form of the dialogue, words used and words not used. The paper of Mann (2007) was an eye-opener for me on how to (and daring to) interpret interview quotes. Objective hermeneutics takes the interpretation process to its extreme and that was important for my development as a qualitative interview interpreter.

4.3.4 Reflections on identity, social norms and attitudes

To be able to understand the motivations for certain actions and kinds of behaviour a conceptual framework for how the world is viewed, explained and understood is needed. Ontological concepts used in this thesis are identity, social norms and attitudes.

These reflections, with reasoning about identity, social norms and attitudes by relating to myself and my own behaviour, are intended to shed light on the fact that each and every one of us has several identities, while the people around us have expectations on what we are and how we are supposed to act, i.e. social norms, based on the situations and perceived or expected pressure from society. We express our attitudes but expressing an attitude and putting that attitude into action are completely different things.

I am a biologist. I identify myself as a biologist and want the people around me to see me as a biologist. However, this also depends on who I am talking with at any particular moment. For example, I often tend to show more of my farming connections when I am with biologists and I tend to be more like a biologist when I am with farmers that I know well. But when meeting the farmers in the study for the first time I tried not to fulfil what I thought would be their idea of a biologist. I always wore my Blundstone boots (boots often used by farmers) and avoided my Fjällräven trousers (trousers often used by biologists) to try to question their image of me as a biologist. Furthermore, I always tried to engage in discussions about farm machinery and animal husbandry and tried to bring up my own experience of soil cultivation, work with hay and straw, and tending to pigs and cows. I did not want to be dismissed as just another biologist. I was and always will be a biologist in these farmers' eyes, but I hope and think that I called into question their picture of biologists.

I have discussed pasture management with more than one hundred students, biologists and landscape architects, in my pasture and how this management is influenced of rules and regulations, the demands of society and personal feelings. As a biologist I want dead wood in my pasture because that is an important substrate for many species. But I also want a nice view from my house and dead trees are not always beautiful. I heat my house with wood, and therefore I tend to find trees to cut down and process for firewood. These are only three identities that I relate to and these identities and different situations give rise to different attitudes.

When asked about dead wood in the pasture I would say that it should be there, but when sitting in the garden looking out on the pasture I might think that the dead trees look ugly. I have been out in the pasture with the chainsaw and I have cut down several medium sized dead rowans (*Sorbus aucuparia*). During the cutting-down I regret that I am not keeping the dead tree and I know that I am acting against the social norm of a biologist. I feel bad because I do not fulfil my biologist identity. I realize in stressing that I cut down only medium sized rowans, I am excusing my behaviour since I know that other biologists will know that the biological values connected with dead medium sized rowans are limited.

4.3.5 Identity, social norms and attitudes

Identity

Identity does not exist as an object in or of itself but are in constantly redefined through negotiations between participative experience and reificative projections (Wenger, 1998). Thus we constantly relate our self to fulfil our self image but also to fulfil the image we believe that other have of us. In the literature farmer identity has been described as a social construct which exists as both an ideal type that farmers pursue to realise and as narratives or labels, held within society, indicating what (both real and imagined) farmers are like and what they do (Vanclay *et al.*, 2006).

Social norms

Social norms are standards of behaviour based on shared beliefs about how individuals should act (Fehr & Fischbacher, 2004) and are constituted when members in a group, in these case farmers, have expectations of how other members in the group think, believe, know and act. In line with social norms is social identity (Tajfel, 1982) -- what social group the actor identifies with and thus what norms should be followed. In the review we find a general, however vague, farmer identity but there are probably many farmer identities defined either by the farmers themselves (e.g. milk producers, cereal growers, organic farmers, efficient farmers, traditional farmers) or defined by the surrounding society (e.g. old farmers (>60 years), large scale farmers (>200 ha of arable land), small scale farmers (<5ha of arable land).

The norms in the group are developed and maintained through interactions between the group members, and between groups and the rest of the context. The mindset of a farmer and feelings as a member e.g. of the dairy farmers' group is developed through comparison with other farmers in the group, other farmers outside the group, and people outside the farming community.

Attitudes

Attitudes has been defined as *the probability of recurrence of behaviour forms of a given type or direction* (DeFleur & Westie, 1963), i.e. a certain stimuli leads to a certain behaviour. The direct relation between attitudes and behaviour has for a long period of time been questioned (Wicker, 1969) and current literature question the overwhelming emphasis on attitude as the main motivational determinant of behaviour (Burton, 2004). Furthermore, the use of attitudes seem to be flawed and simplistic due to lack the of theoretical considerations and the believes of attitudes as static (Burton, 2004). Attitudes are neither permanent nor static and they are recreated each time responding to a question, a behaviour or a specific occurrence (Eagly & Chaiken, 1993) and therefore attitudes has also be defined as readiness to act (Jung, [1921] 1971). Because of the nonstatic nature of attitudes the fruitfulness of the very concept of attitudes has been debated by scholars (Siebert *et al.*, 2006).

5 My pre-understanding and the background of the thesis

In this chapter I will describe my understanding of my pre-understanding. My pre-understanding is of course developed and change as I write. However, this text is written to give the reader an insight in my background and experiences that are the basis for my research and especially then the interpretation of data and results.

Close to my home, where I was raised, the local nature conservation group had a very conservative conservation agenda. They said NO to any change that included any measure that did anything to nature. I remember them fighting for an oak in a garden, without looking just outside the garden where there were several oaks on municipality land, and where the oaks needed more space by thinning other trees around them. Instead of saying NO they could have said YES IF we can help these oaks in the vicinity. Their actions, as I recall it, did not save the oak, the oaks that needed help did not receive help and many people were angry with nature conservation. Nothing good at all came out of their struggle. Thus this is why I did not become a NO-saying biologist but a Yes-if biologist because I thought that both nature and society would gain from this approach. With this in mind I started biology studies at the Swedish University of Agricultural Sciences on the Natural Resource Program.

During my studies I met my wife. She was raised on a farm. My connection with farming has grown a great deal since the then thanks to her and her family.

I was also lucky enough to work two summers in a row at the organic experimental farm Ekhaga with projects regarding how to integrate nature conservation measures on farmland. Thus I have dealt with both arable farming and animal husbandry.

After finishing my master thesis I was employed at the Centre for sustainable farming to write a report about organic farming and biodiversity. Paper I is based on data from this report. While working with the report and Paper I realized that the impact of farming on biodiversity was very farmer-dependent. I applied for funds and together with a grant from FORMAS there was enough money for me to be hired as a PhD student.

For half a year I worked half time with the PhD-project and half time on starting an agricultural network within the Swedish Nature conservation union.

During my studies we have renovated a house and moved out to the countryside 50 km west of Uppsala. We also have in, January 2009, 13 head of cattle and graze more or less 10 hectares of rented land. We own 2.5 ha of land. We heat our house with wood and thus I have to work in the forest, my father-in-laws forest, to produce firewood. My wife and I are members in the local farmers' federation (LRF). I have a very direct connection to farming and the rules and regulations coming with having animals, apply for subsidies and owning land. We have a private firm and within that firm we sell meat but we also sell education days about nature conservation in general in farmland and nature conservation and management of pastures in particular.

I am a farming biologist and that have substantially influenced the design of this study and my interpretations.

6 Methods

6.1 Area and farm selection

The 16 studied farms are situated in south-central Sweden in the county of Uppland. Eight of the farms are found in an intensively managed agricultural area within a radius of 14 km around the city of Uppsala (59º50'N 17º38'E). The other eight farms are situated in the mixed (forest-farmland) landscape within a radius of nine km around the small town of Heby (59º56'N 16º51'E) 60 km west of Uppsala. The two areas mainly differ in the proportion of forest and agricultural land surrounding the farms (56 % forest in Heby and 30 % in Uppsala at the 2400 m scale). In both areas the landscapes are quite level, with other habitats than crop fields mainly occurring on low moraine islands, rocky outcrops, river banks and as field margins. The soils contain high proportions of clay, derived from sedimentation when the areas were covered by the Baltic Sea until 2-4000 years ago.

The farm sizes varied from 34 to 600 ha and the main production activity on the farms ranged from conventional piglet production to organic dairy production and from intensive cereal production to part-time farming with some cereal production. However, all farms grew winter wheat during the growing season of 2004. Winter wheat is the most common cereal crop in Sweden (Statistical Sweden, 2008). Choosing this crop thus made the selection of farms easier but winter wheat is also regarded to hold a low biodiversity (Berg & Kvarnbäck, 2005; Mason & Macdonald, 2000). Thus it can be considered to represent base-line diversity with respect to the crops occurring in the region. Furthermore, there is a marked conflict between production and biodiversity conservation in this crop, making the study of this extreme very interesting.

The studied farms were selected from suggestions by the local chairman of the Federation of Swedish Farmers (LRF) in the two regions. In one of the areas (Uppsala) we also asked the farmers we visited for further respondents. We consider this selection as randomized with respect to the location of the farm in the landscape and the production type and intensity of the farm. We are aware of the fact that our respondents might not represent the typical Swedish farmer, for example they agreed to collaborate in a study of farmland biodiversity. Still, our primary aim here was to examine whether, e.g., interest in nature had an effect on farmland biodiversity, not to make any generalizations for Swedish farming as a whole. As in all qualitative research we do not want to generalize to a population but to a theory (Bryman, 2002).

I have chosen to be very restrictive in describing the farms because I do not want to expose the farmers who have agreed to take part in this study. If I had described the farms even in general terms it would have been possible to recognize specific farms and that cannot be tolerated since the farmers who have taken part in the study have been assured that their identities would not be revealed.

6.2 Biodiversity inventories

We conducted inventories in the largest winter wheat fields on each farm (in 2004) and in the farmsteads (in 2005) on 16 selected farms. We studied vascular plants (i.e. weeds), carabid beetles, solitary bees and wasps (later called solitary bees), bumblebees, and birds on the fields. Only birds were studied on the farmsteads. Species richness per farm for different organism groups is presented in Appendix 1-5.

These organism groups were selected because they are easy to study, they are likely to respond to agricultural activities, and they have previously been used as indicators for biodiversity.

As stated previously the study habitat, winter wheat, was chosen because it is a common crop, it holds a low biodiversity according to the literature (Berg & Kvarnbäck, 2005; Mason & Macdonald, 2000), and can thus be seen as part of the 'bad' matrix.

6.2.1 Weeds (Paper V)

Weeds were recorded in seven 0.25 m^2 squares evenly distributed from two meters from the field border to the centre of each field. All individuals were determined to species level twice during the growing season (25 May - 4 June and 20 July - 5 August 2004), see Appendix 1.

6.2.2 Carabid beetles (Paper V)

Carabid beetles were sampled using three pitfall traps; one placed 2 m from the field border, one in the centre of the field and one half-way between these two points. The pitfall traps were placed in the field from mid May (17-19 May) until early August (30 July - 5 August) and during that time they were emptied 5-6 times at regular intervals. The mid-July collection was not possible to use because the traps were completely filled with rainwater. All carabid species were determined to species level, see (Appendix 2).

6.2.3 Solitary bees (Paper V)

Solitary bees were studied by placing three trap-nests at the field border. The trap-nests consisted of a bundle of paper cylinders constructed to suit the red mason bee, *Osmia rufa* (Oxford Bee Company Ltd., 40 Arthur Street, Loughborough, Leicestershire LE11 3AY). Each of these trap-nests contained 29 150 mm-long paper cylinders of three different diameters, 7, 8 and 9 mm and was placed on a pole at a height of 1.5 meters. The nests were placed out on 28 April and collected 23 October 2004. They were stored outdoors, but sheltered from rain and snow. In March the nests were taken inside (20°C) and the hatching started 18 days later. All hatched individuals were determined to species level (for details on methods see (Sjödin, 2007)(Appendix 3).

6.2.4 Bumblebees (Paper V)

Bumblebees were recorded along one transect (length 45-300 m) from the border to the centre of each field and one equally long transect along the border of each field. Large fields had longer transects, but species richness and field size were not significantly correlated with each other, and there was no bias in species richness due to transect length. The transects were surveyed at normal walking pace and all bumblebees within 3 m were recorded. In cases where direct species identification was not possible the individuals were caught and determined to species level later in the field or in the laboratory (Appendix 4).

6.2.5 Birds (Paper III and Paper V)

Birds were studied by point counts from the centre of the field. All birds seen or heard within 300 m during five minutes were noted to species level. All fields were visited between 06.00-10.00 three times from early May to mid June (13-19 May, 26-29 May and 7-17 June 2004), see Appendix 5.

Birds were also studied on the farmsteads. Birds were surveyed four days (between 08.00 and 14.00) at each farmstead from late April to mid June in 2005. The rather late start hour of the inventory was possible since most of the birds on the farmsteads could easily be observed throughout the whole day, and we wanted to respect the privacy of the farmer's family. The census consisted of a one-hour, slow walk covering the whole farmstead area. The farms were visited in different order and time of day to avoid bias. All adult birds, heard or seen, were noted and the total number of individuals for each species was added up for each visit. However, due to the low number of visits, in the analyses the visit with the highest number of individuals per species was used as an estimate of the abundance of different species (Berg 2002b), see Appendix in paper III.

6.2.6 Biodiversity measure (Paper V)

To be able to combine species richness of the selected organisms we constructed a biodiversity measure. First, the proportion of the regional species pool (total number of species on all fields) occurring on each farm was calculated for each of the five organism groups. Thereafter the sum of the proportions of the regional species pools (i.e. the sum for the five organism groups) was calculated for each farm and used as biodiversity index. This produces an index that is independent of the species number of the different organism groups, and does not give more weight to any of the groups.

6.3 Landscape analysis

The landscape surrounding each farmstead and each field was analyzed with ArcGIS 9.1 (ESRI) using (a) the terrain map (vector map) from the Swedish Land Surveying Authority, and (b) the map of subsidized agricultural fields (given in field units) and the corresponding crop data from the Swedish Board of Agriculture. The GIS analysis was done within circles with different radii (100-2400 m), but only data from 300 m was used in the statistical analysis due to the strong correlation between the different scales. Furthermore, we consider 300m as an appropriate scale for all studied organisms. All measured variables are presented in Appendix 6.

6.4 Farm management data

Farm management data was collected directly in the wheat field e.g. crop density, but also through the interviews with the farmers, e.g., yield, N-application and weed management strategies such as herbicides used and active doses.

6.4.1 Crop density (Paper V)

Crop density (measured as per cent cover of the crop in $0.25m^2$ squares) was recorded in the same squares and on the same dates as the weeds, but only data from the first inventory was used in the analysis. Crop density is here considered to be a measure of farming intensity, and correlates strongly with other measures of agricultural intensification (Lindström, 2008).

6.5 Farmstead characteristics (Paper III)

The habitat composition of the farmstead was initially described by many habitat variables: number of buildings, trees and nest boxes per hectare of farmstead. The area covered by buildings, lawn, gravel yard, shrubs, manure heap or slurry pit, storage and pasture was estimated.

6.6 Variable selection (Paper III and V)

Due to the moderate number of study farms it was necessary to reduce the number of variables. I wanted to have variables that corresponded to local factors, e.g., crop density in the field or areas of buildings on the farmstead, and landscape characteristics such as the proportion of annual crops. The variable selection process was based on PCA and correlation analyses to identify variables that best represented local and landscape factors. In Paper V the best predictor of landscape composition was the first axis of a PCA. The axis represented a gradient from large proportions of annual crops to areas with high landscape heterogeneity. All variables measuring proportions of areas were Arcsine-transformed. No other habitat variables were transformed.

6.7 Statistical analysis

The statistical analyses are presented briefly below. More detailed explanations are found in the different papers.

6.7.1 General statistics

In this thesis we have used general descriptive statistics, i.e., standard multiple regressions with stepwise selection (Paper III & IV).

In Paper III the abundances of the most common farmland bird species (occurring on $\geq$ 7 farmsteads) were analyzed by log-linear regressions with stepwise selection of variables (software JMP 6.03) by using generalized linear models with a Poisson distribution and a log link.

In Paper V the differences between organism groups in their relationships to the selected variables were examined using the test for significant differences between correlation coefficients outlined in Sokal & Rohlf (1981), p. 583-591).

6.7.2 Multivariate statistics

In multiple regressions one variable (i.e. the dependent variable) is predicted or explained by the independent variables. However, multivariate methods such as PCA, DCA, RDA, examine the interrelationship between variables.

In Paper III multivariate techniques (Ter Braak & Ŝmilauer, 2002; Ter Braak & Ŝmilauer, 1998) were used to analyze bird community composition in relation to the selected habitat variables. First, a detrended correspondence analysis (DCA) was done in order to estimate the compositional gradient length of the bird species data. The short gradient length (1.3) suggested that redundancy analysis (RDA) should be used for further analyses. In the RDA analysis a manual forward selection of environmental variables and a Monte Carlo test (unrestricted; full model; 999 permutations) were used for identifying significant variables.

6.7.3 Meta-analysis

Meta-analysis is a method to analyse data from different sources with different quality and account for these differences in order to answer a clearly defined question (Gurevitch & Hedges, 2001; Osenberg *et al.*, 1999; Zandt & Mopper, 1998; Arnqvist & Wooster, 1995; Gurevitch *et al.*, 1992). The statistical procedures allow quantitative analyses of treatment effects, and account for the fact that all studies are not equally reliable. Meta-analysis is especially useful for examining general patterns of treatment effects, such as, for example, the evidence for interspecific competition in field experiments (Gurevitch *et al.*, 1992). The usefulness of meta-analysis has sometimes been questioned (Blinkhorn, 1998). Nevertheless, it is regarded as an appropriate method for examining the general evidence for or against a specific hypothesis, and to suggest further studies explicitly testing the patterns found in the meta-analysis, and it has been used extensively in ecology in recent years.

6.8 Qualitative interview methods

6.8.1 Qualitative interviews

In this thesis qualitative interviews have been used but within these interviews traces of naturalistic inquiries/narratives can be found. The interviews have been semi-structured. This means that it was more important to cover different discussion areas than to put specific questions, and that the order of the topics and questions depended on the interview situation. The interviews were also open-ended meaning that follow-up and clarification questions could be asked and new topics explored. I had only one question that I tried to formulate in the same way during all interviews and that was how they defined nature conservation.

Qualitative interviews should not be generalized to population but to theory (Bryman, 2002) e.g. this research does not try to explain the attitudes and actions of all Swedish farmers but tries to develop a theory of how farmers might respond to different stimuli.

Recordings of the interviews were made with the farmers consent, and the identity of the farmers will not be revealed.

A pilot interview with a farmer not included in the study was performed as training in interview technique, testing the interview guide and dealing with the recording equipment.

All except one, of the farmers were interviewed three times. The first interview, in spring 2004, was focused on getting to know the farmer, the farm, farm management and farm history. Other topics dealt with were agricultural politics, subsidies, heirs to the farm, crop management, and the economic situation. However, my intended focus was discussion about nature, nature conservation and nature conservation administration. The first interview lasted between 50-120 minutes and was later fully transcribed.

The second interview performed in summer 2005 was intended as a follow-up of the cropping season 2004 and other issues that the farmers wanted to talk about. I also presented the results from the field inventories of the crop, weeds, carabid beetles, solitary bees, bumblebees and birds but also the bird inventory performed on their farmstead. The presentation was designed so that they could see the results from the other farms, not knowing which the other farms were, and could thus compare and discuss possible reasons for these farm differences.

The letter I sent out prior to the second interview contained request that they should think about a place at their farm that they like to visit and that we together could visit this place. The walk there or in some rare cases a short car ride was a nice way to talk about things we passed in his or neighboring fields. At the chosen place we talked about why he chose this place and what we saw there.

The third interview had the focus to grasp the farmer's sense for nature and environmental issues and compare that with French famers in Brittany (Javelle, 2007). The interview was lead by Aurelie Javelle, at the time PhD-candidate, from France. The interview was conducted in English and translated when needed by me. The interview also included aspects we had dealt with earlier but the questions were posed from a French context and that forced the farmers to think and give answers in a totally different way from when I asked questions.

6.8.2 Transcription of interviews

Interview one and three were fully transcribed while just parts of interview two were transcribed. The quotes were written down carefully and dialects, hesitations etc. were noted. I transcribed all interviews except seven of the first interviews. When someone else had transcribed it was important for me to be careful and thoroughly read through to find errors.

6.8.3 Coding of transcripts

I used Atlas.ti (ATLAS.ti Scientific Software Development GmbH, Berlin), a workbench for the qualitative analysis of large bodies of text, to code and categorize the interviews. This program and my work with the coding is clearly influenced by grounded theory.

In total I have worked with 47 transcripts covering more than 50 hours of interview. In total 172 categories were created and 2595 quotes were assigned to these categories. All categories, except one, were formulated *in vivo*, i.e., from the actors themselves or rather from the transcribed interview. The exception was the *in vitro*, i.e., predefined by me as researcher, category dealing with their definition of nature conservation. The categories were created from the first to the last interview. However, the rate of new categories was of course lower by the last interview. This means that the coding process involves go back and forth within each transcript but also go back and forth between transcripts.

I tried to make the categories as specific as possible to help the interpretation process. For example a category 'Cropping' covers way to many different aspects while 'Cropping-pesticides' are more specific and thus more helpful in later stages of the interpretation. Important is to assign properties to each category to test whether different quotes fit within in an existing quote or if a new should be created. While coding memos assigned to different quotes were created to remember thoughts and ideas while coding.

6.8.4 Interpretation of the interviews

Already from the beginning of the thesis project it was decided that one paper should be based in the interviews, aiming to thick descriptions of attitudes and perceptions of farmers to nature. However, the main question was unclear. While working with the quotes and assigning categories to the quotes some codes and categories was appealing to me. They were appealing because they were opposing my own or others expectations or because I realized that I and the interview person had misunderstood each other, or just because they were amusing. I shared the best quotes with colleagues and we discussed and we tried different interpretations.

For example 'Interest in nature' was created during the coding process as an in vivo category. Some of these quotes are interesting and I have discussed with colleagues and supervisors and thus interest in nature appeared to be an important term to use in the continued and deepened interpretation process of the interview transcripts. Using the perspective of interest in nature increased my understanding of some of the misunderstandings, statements and comments encountered in the transcribed interviews. In the creation of this thesis, the writing in itself has indeed been an very important vehicle for the interpretation process, see also (Hallgren, 2003). Through the writing, my interpretations and their consequences, opportunities and in-consistencies have become clearer. With the task of explaining an interpretation for a potential unknown reader, I have been able, or forced, to distance myself from my own taken for granted understanding. As all text producers, I have been shifting from the position of the writer to the position of the reader which is a shift from being initiated in the interpretation to become critical to the understanding which generates further understanding. Knowledge is created through the dialectic tension between experience, which is internal, naive understanding; represented by writing and distance, external, critical explanation, represented by reading. For a discussion about text and the relation between understanding/interpretation and explaining/explanation see (Ricoeur, 1993).

In the text of the thesis and in Paper IV & V quotes are imbedded to show part of the data that the interpretations are based on. When needed the context of the quotes is expressed and the motivations for the interpretation are stated.

The different farmers differ in their way of expressing themselves and thus some of the farmers' quotes are more represented than others within the text. However, all farmers quote has been needed to develop the knowledge I have today and thus all of the quotes are used for the interpretations expressed here.

6.8.5 Interest in nature

I will here only briefly introduce *interest in nature* as a tool and term that I have used to understand the interviews. The term was discovered as important during the interpretation process of the interviews. We define interest in nature as to what extent you have interest in, know and talk about and have feelings for nature (Paper IV). In our definition of *interest in nature* it is both a cognitive and emotional aspect, while Kals *et al.*(1999) use *interest in nature* as the cognitive part and *emotional affinity toward nature* as the emotional part. Interest in nature has also been discussed from three normative view points to highlight the differences in perception of nature and the use of nature (Tybirk *et al.*, 2004). In contrast many studies using interest in nature do not define what interest in nature is, probably because it is seen as an everyday word, see for example (Turpie, 2003).

6.8.6 Classification based on interest in nature

A matrix with quotes for each farmer covering certain topics e.g. species knowledge, nature and species narratives, ecological knowledge, own and governmental nature conservation, interest in nature and pesticides, was put together by me. Based on these quotations, eight researchers (three natural scientists and five social scientists) independently ranked the farmers' interest in nature based on these quotes. The farmers could be ranked according to three classes 1) not very interested 2) interested and 3) very interested in nature. After this classification the average value across all researchers for each farmer was used as the social parameter (interest in nature, ranging from 1 to 3) in the statistical analysis.

7 The red thread in the thesis – results from the papers and deepened discussion

The main aim of this thesis was to study how farmland biodiversity can be enhanced. Agri-environmental schemes are one way of supporting farmers who take action to promote farmland biodiversity. We studied the one important AES in Sweden, organic farming, and its effect on biodiversity through a meta-analysis of results from the literature (Paper I) and found a positive effect on both biodiversity and abundance. The results were highly heterogeneous between studies in the literature. The scale on which the study was done - plot, field or farm – also had a strong effect. Thus if biodiversity should be promoted or studied there is a need to focus and discuss this on both local and regional scale. However, no matter the farming system is used, at the end of the day it is the farmer who decides on management strategies on the farm and thus the effect on biodiversity.

We therefore followed the literature to learn what is already known about what affect farmers' decisions regarding nature conservation (Paper II). In farmland the degrees of freedom of much decision making by farmers are limited by rules and regulations. However, the appearance of farmsteads is more or less a product of the decisions of individual farmers and therefore we conducted a bird study in this habitat. Species richness of birds increased with the area of houses and whether there was manure on the farm (Paper III). Such factors are not easily affected by AES, nor is it to be expected that a farmer would build more houses just to promote birds.

However, the concern about nature and environmental-related issues differs between farmers and leads them to take different decisions and actions. We used the concept of *interest in nature* to analyse our qualitative interview material in order to understand attitudes and willingness to perform measures enhancing biodiversity. The farmers were indeed interested in nature – but their interest differed from a biologist's definition of interest in nature. Successful nature conservation must consider farmers' interest in nature and farmer identity as well as the ecological knowledge of biologists (Paper IV).

The farmers were categorized according to their interest in nature. The farmers' interest in nature was included as an explanatory variable in a statistical analysis together with a landscape and field intensity measure to examine the relation to a biodiversity measure. This biodiversity measure was constructed from the species richness of five organisms groups. We could show that crop density and interest in nature could explain variation in the biodiversity measure as well as species richness in some of the studied organism groups (Paper V).

7.1 Organic farming as an AES (Paper I)

7.1.1 Short summery of Paper I

Organic farming usually held 30% higher species richness and 50% higher abundance than conventional farming but the results varied greatly between studies, organisms groups and study scale. We concluded that the effect of organic farming is likely to be highly dependent on intensity of agriculture within the surrounding landscape but also landscape heterogeneity.

7.1.2 Extended discussion based on Paper I

Organic farming has been suggested as a way to counteract the decline of biodiversity in farmland (Hole *et al.*, 2005; Maeder *et al.*, 2002; Paoletti *et al.*, 1992). In general this positive effect is thought to be because the lower intensity on organic farms meaning that organically managed fields could act as suitable habitats (Rundlöf *et al.*, 2008b) but organic farming may also soften the matrix (Vandermeer & Perfecto, 2007).

Organic farming in the EU is regulated by Council Regulation (EC) No 834/2007. In that regulation organic farming is described as:

> … an overall system of farm management and food production that combines best environmental practices, a high level of biodiversity, the preservation of natural resources, the application of high animal welfare standards and a production method in line with the preference of certain consumers for products produced using natural substances and processes. The organic production method thus plays a dual societal role, where it on the one hand provides for a specific market responding to a consumer demand

> for organic products, and on the other hand delivers public goods contributing to the protection of the environment and animal welfare, as well as to rural development.

Hence, organic farming can simplistically be defined as farming systems where the use of pesticides, herbicides and chemical fertilizers is prohibited. These systems instead rely on crop rotation, natural nitrogen fixation, biologically active soil, green manure, animal manure, and biological and mechanical weed and pest control. Ley and green manure are needed in an organic crop rotation.

Conventional farming is here as in most other comparisons of farming systems, e.g., (Hole *et al.*, 2005), defined as a farming system where pesticides and herbicides and chemical fertilizers are allowed. However, this does not mean that all conventional farmers necessarily use these external inputs. The external inputs have reduced the need for a varied crop rotation. Inclusion of ley in the crop rotation has no incentives in conventional farming without cattle.

Organic farming and conventional farming should not be represented by two points but rather as partly overlapping lines along a continuum. However, they are treated as two separate units in many of the comparative studies because people and politicians want to know which farming type is best from different environmental perspectives (Figure 3a.). The question is not just difficult to answer but in practice more or less impossible to answer. This is due to the fact, as mentioned earlier, that none of the farming systems are fixed in their performance at the farm level and furthermore we seldom see any solution that is best in all possible ways. When organic and conventional farming are discussed in this section it is only with respect to biodiversity. Furthermore, the intention is not a text that should merit the 'best' farming system but to highlight the differences within the systems and the possibilities for both systems to become less negative or to promote biodiversity.

I will now in more detail explore the systems as a partly overlapping along the continuum (Figure 3b.). The two farming systems differ in their rules and regulations but there is also variation within the systems. For example, there are different certification bodies within organic farming system, e.g., KRAV and EU-organic, while conventional farms can also be certified in several ways, e.g. Svenskt Sigill. In all organic farming chemical pesticides and fertilisers are prohibited and as a consequence there are often longer and more varied crop rotations with ley or green manure on organic farms. However, conventional farmers can also choose to reduce or give up the use of fertilisers and pesticides and have ley in the crop rotation and thus the two systems can be related as in figure 3b.

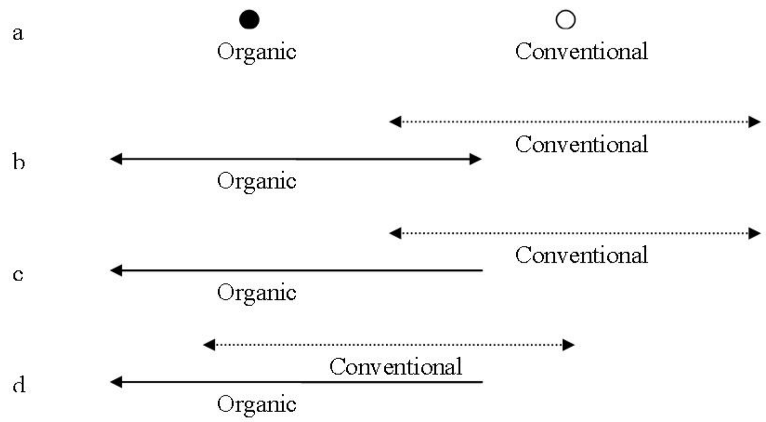

Figure 3. Different ways of showing the relation between organic and conventional farming. For details see the main text.

Organic farmers cannot choose to use these external inputs and this is illustrated in figure 3c, in which the overlap is created only by conventional farmers choosing not to use these external inputs. The less intensively agricultural areas are managed, the smaller are the differences between the farming systems. In, for example, dairy production the two farming systems are similar in both crop rotation and animal husbandry systems (Figure 3d.) (Lubbe & de Snoo, 2007) and thus the overlap is almost total.

The overlaps of the farming systems are created by active choices by farmers, e.g., to use or not use chemical fertilizers. The reasoning behind such decisions, e.g. social norms and household economy, will be explored below. The fact is that no matter what farming system the farm is classified under it is the farmer who takes the final decisions how farm management will affect biodiversity.

There is a need to compare organic and conventional farming since there is a governmental policy in Sweden to increase the certified organic area to 20% until 2010, and other countries within the EU promote organic farming since it is seen as positive for biodiversity and as environmentally sounder farming alternative. But the comparison has to be interpreted acknowledging the problems with the simple division of the complexities of farming systems in just two categories.

The scientific community has tried to evaluate the effects of the different farming systems with different methods and on different scales, i.e. evaluation on plot, field or farm (landscape) scales (Paper I).

The traditional scientific approach is to minimize all other differences between the systems to be compared. However, a comparison between organic and conventional farming using the same crop rotation results in only a comparison between a particular type of farming that uses chemical fertilizers and pesticides and farming that does not. The systemic difference in crop rotation is lost and thus the positive effect of organic farming, e.g. of ley in the crop rotation, is underestimated.

Furthermore, in comparisons made on the plot scale, plot size in the order 10^1-10^2 m^2, and a whole farming system is reduced to small plots in an often randomized spatial pattern. The comparisons on this scale minimize the variation between the systems and takes away large scale effects (e.g., Rundlöf 2008a). The only difference can be the use or non-use of pesticides, i.e., it is not a comparison between organic and conventional farming but a comparison between agriculture with and without pesticides. In addition, if the crop rotations are the same, whether a conventional, an organic or an intermediate rotation, then the positive effect on biodiversity of a varied crop rotation results in the conventional system having a better biodiversity status than expected from a the 'real' situation on whole farms.

Comparisons on the field scale (Paper I) chose fields on farms in an area, e.g., region or country. Often a particular crop or habitat is chosen as the study site. Since the fields are taken from farms with 'real' management the systemic differences between the systems still exist. However, it is now crucial that the fields chosen are either on farms with or on farms without animals. There are large differences between organic farming with and without animals in terms of crop rotations, crops within the rotation, and the use of different forms of manures, e.g., green manure or animal manure. The difference between farms with and without animal husbandry, i.e., dairy and cattle meat production is even greater on conventional farms. Conventional farms with pigs and chickens have similar crop rotations to farms without these animals due to the grain based diet of these animals. If the comparison includes farms with and without animals the fair comparison should be to include all four categories; organic farming with and without animals and conventional with and without animals. The largest difference in biodiversity would be expected between organic and conventional plant production units.

The third form of comparison, here called farm level, consists of comparisons of fields, often field pairs, in matched landscapes (Paper I). In some cases the field pairs are also matched according to crop rotation. The idea to use pairs is good because then landscape factors causing the differences in biodiversity can be accounted for statistically as a separate variable. Still there is a significant problem with this comparison because it may be hard or even impossible to find an organic farm in the most intensely managed cropping areas in Sweden. Thus the most intense conventional farms cannot be included in the comparison. Likewise, a conventional field to compare with the most diverse organic farms will often be found in low intensity farming areas. The conventional farmers in these areas also tend adopt low intense management, in many ways organically, but do not want or cannot certify their production and might not be willing to give up the possibility to spray or use chemical fertilisers if needed.

The differences between organic and conventional farming are landscape dependent with larger differences in homogeneous landscapes with high intensity farming and thus the effect of farming system on biodiversity is also landscape dependent (Rundlöf *et al.*, 2008a).

Despite the considerable work by the scientific community trying to answer the question put by the society on which is the best farming system, the interpretations made are often too general and almost naïve. There sometimes seems to be a lack of knowledge by scientists about how farming is really done on farms. To illustrate this I will now explore a current example showing the problem with doing research within a system in which policies are changing rapidly, and the importance of interpretations based on the real world situation.

Fallows or set-asides have been studied and have been shown to hold high species richness of e.g. birds (Henderson *et al.*, 2001; Henderson *et al.*, 2000; Wilson *et al.*, 1997; Berg & Pärt, 1994), see also the introduction part 3.2.2. These fallows existed because of an EU-regulation stating that a certain area of each farm should be taken out of production because of the overproduction of cereals in Europe.

Rotational fallows were fallows that were rotated amongst fields on the farm year by year. This type of set-aside was usually derived from naturally regenerated weeds over winter stubbles. Non-rotational fallows were land that was taken out of production for several years and was either sown with grass or left to naturally regenerated vegetation. The fallows could also be bare soil fallows, i.e. a weed management strategy; where during spring and summer the fields were harrowed to decrease the populations of perennial weeds, such as the common couch grass (*Elytrigia repens*). The bare soil fallows were forbidden on land with subsidies in 1995 because of the risk of nutrient leakage from frequent cultivations and the negative impact on biodiversity (Personal communication Björn Roland Hushållningssällskapet Skaraborg).

However, from cropping season 2008 it is no longer mandatory to have fallows in Sweden and the fallows that remain are permanent and seeded with ley mixtures, e.g. the fallows are used on fields with low production or to create better shape to obtain rational soil cultivation management. The once common 'truth' that fallows promoted biodiversity now has to be questioned. Fallow do not look as they did when most of the research on fallows was done.

I think it is crucial for scientists to be aware of the context that the farming or agricultural landscape is occurring within to be able to do relevant research (notable exception in the fallow case is (Bracken & Bolger, 2006). However, I do not think research should be limited, in posing questions and hypotheses, by current laws and regulations. Research should be done testing scientifically sound hypotheses - but the interpretations of the results have to be done with knowledge about the real world. Furthermore, using information from earlier studies knowledge about the context of the study and the present context is needed to interpret the results.

In our meta-analysis of the literature until 2002, we found that in general organic farming enhanced species richness (Figure 4.) with 30% and abundances (Figure 5.) of species individuals with 50% (Paper I).

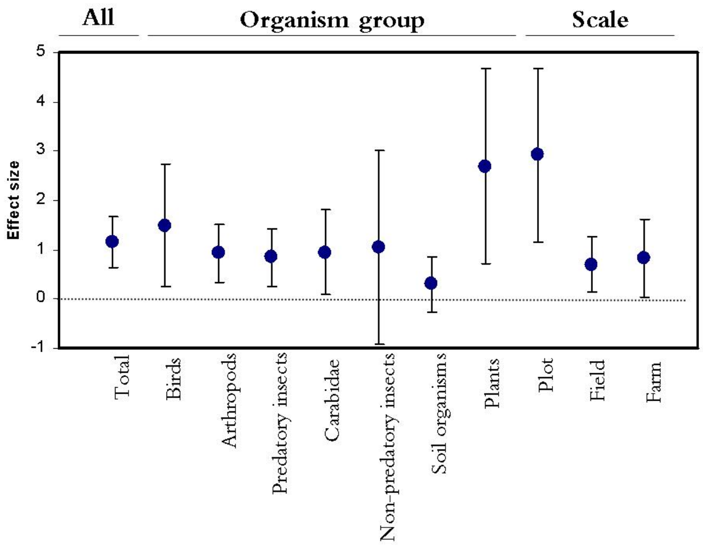

Figure 4. A meta-analysis of the effects of organic agricultural methods on species richness. Positive effect sizes (error bars indicating 95% confidence interval) above zero indicate higher species richness in organic farming systems.

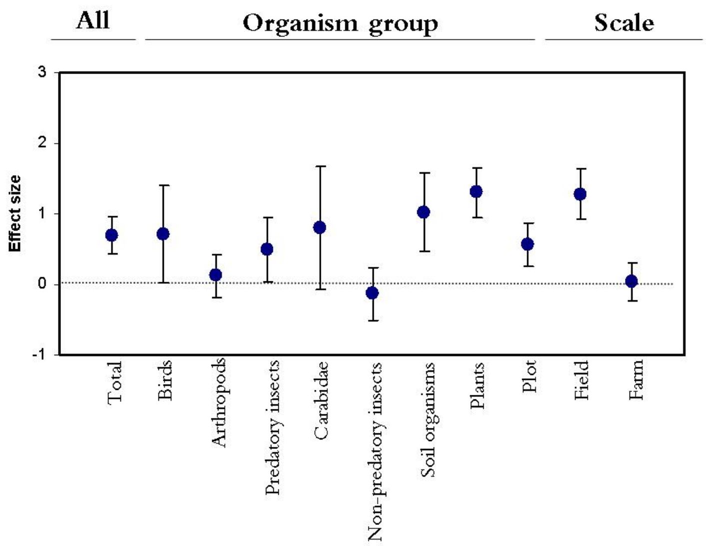

Figure 5. A meta-analysis of the effects of organic agricultural methods on species abundance. Positive effect sizes (error bars indicating 95% confidence interval) above zero indicate higher species abundance in organic farming systems

However, it was obvious that the data within the meta-analysis was highly heterogeneous, i.e., different studies yielded very different results. This was also indicated statistically in the analysis. The variability depended on many factors, for example what organism were studied and on what study scale; plot, field or farm level, the study was performed. We also suggested that it was due to what landscape the study was conducted in, which was subsequently confirmed by (Rundlöf *et al.*, 2008a; Rundlöf & Smith, 2006).

The result in Paper I - that organic farming promotes biodiversity is supported by a number of other review articles, for example (Hole *et al.*, 2005). I will now briefly use the results from paper I and more recent literature published after December 2002, to discuss how different organisms are affected by farming systems, and how landscape heterogeneity and study scales may affect the interpretation of differences between farming systems.

7.1.3 Organisms

Different organisms are likely to react differently to organic farming in general and specific management measures in particular. This is because organisms differ greatly in their requirements, dispersal ability, how large a part of their life cycle that they use farmland, etc. I will discuss the results for an organism group with low and an organism group with high dispersal ability; weeds and birds.

Weeds

No farmer wants weeds whether being organic or conventional. The idea behind plant production is to support one or a few species or varieties, i.e., the opposite to promoting diversity. However, the tolerance to weeds differs between farmers.

Organic farmers try to prevent intolerable weed abundances by a planned crop rotation, i.e. a mix of spring and autumn sown crops and ley, and by direct control measures such as mechanical weeding (Turner et al 2006). In organic farming regulation of weed populations to economically and agronomically accepted levels (Håkansson 2003) is used rather than attempting weed eradication.

Organic farming has more weed species and higher abundances of weeds (Paper I). The organic measures to regulate weeds, e.g., mechanical weeding, are less specific and less efficient than herbicides. The effect of the organic weeding measures is local and short-lived while the effects of herbicides can be more wide spread and long-lived.

Birds

There were more bird species and higher abundances of birds on organic farms (Paper I). This is probably a response to higher food availability. There are more weed seeds and insects and more diverse crop rotations with ley included. However, some organic management practices are fatal for some bird species. For example, the skylark may suffer from the management of green manure crops, because these crops are mowed several times during the growing season to promote plant growth and thus the production of biomass and nitrogen fixation. The first cutting is often performed in late May or early June and coincides with the first skylark clutch. Thus in this specific case, the organic practice is directly lethal for birds although the general picture is that birds are enhanced by organic farming.

Farmers differ in their knowledge and awareness of birds. Some farmers will not see any lapwing nests, some might see nests but do not take any action, and some will see nests and take action to save them. Such actions are not connected to whether the farmers are organic or conventional but rather based on an interest in nature and time available for that kind of management operation (see also Paper III and V).

7.1.4 Landscape

The effect of organic farming on biodiversity varies depending on landscape structure. As suggested in Paper I the positive effect of organic farming has been shown to be greater in homogeneous landscapes and smaller or insignificant in heterogeneous landscapes (Rundlöf *et al.*, 2008a; Rundlöf *et al.*, 2008b; Rundlöf & Smith, 2006; Weibull *et al.*, 2003; Weibull *et al.*, 2000). In the heterogeneous landscape there are refuges and alternative habitats for plants and wildlife while in the homogeneous landscape the organic fields are the refuges for many organisms. Furthermore, a conventional field in a landscape dominated by organic farming will have a greater diversity (plants and butterflies) than a conventional field in a landscape dominated by conventional farming (Rundlöf, 2007). At the other extreme is the homogeneous landscapes dominated by forests, and in such landscapes one could assume that it is more important (for biodiversity) that there is agriculture at all, rather than whether it is organic or conventional. This reasoning is shown in (Figure 6.), suggesting that organic farming as an AES has the largest effect in homogeneous intensively managed agricultural landscapes (Tscharntke *et al.*, 2005), but may have plaid a role in making agriculture possible at all at the other end of the landscape gradient.

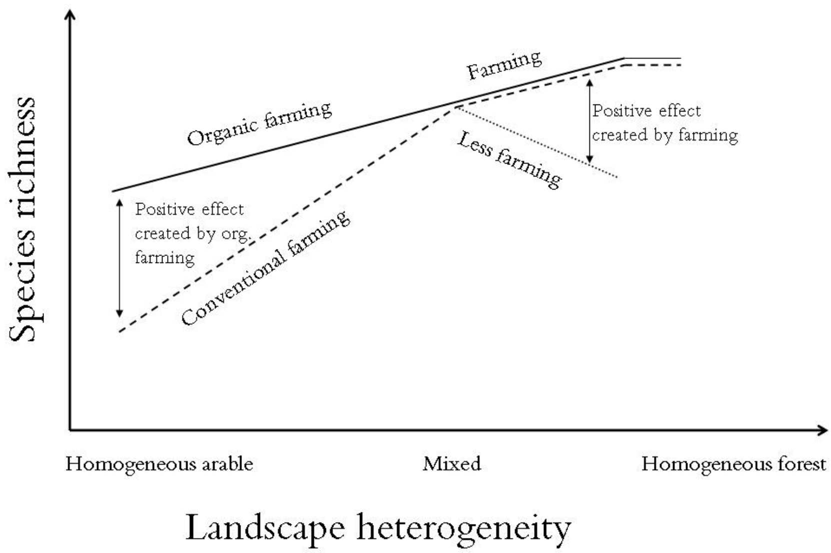

Figure 6. Schematic description of the effect of farming practice on biodiversity under different landscape heterogeneities.

What factors affect biodiversity in the agricultural landscape?

Does the ideal landscape for biodiversity exist and how would it in that case look like? I would argue that there is no such landscape because different organisms have different needs and are differently sensitive to different management practices and disturbances. In Table 2 I have listed some of the landscape characteristics and management practices that affect different organisms.

Table 2. *What landscape characteristics affect components of biodiversity and what organism groups are likely to react on these characteristics?*

Parameter	What will react?	Reference
Varied landscape	Birds, insects	(Weibull *et al.*, 2000)
Uncultivated elements in the field landscape	Butterflies, predatory arthropods, birds	(Öckinger & Smith, 2007)
Natural pastures	Vascular plants, pollinators, birds	(Vessby *et al.*, 2002)
Mixed farms	Earthworms, dung beetles, birds	Paper III
Crop rotation	Vascular plants, soil	(Kromp, 1999)

	organisms, carabids	
Ley	Earthworm, Bumble bees	(Svensson *et al.*, 2000)
Ratio between autumn- and spring-sown crops	Vascular plants, skylark	(Wilson *et al.*, 1997)
Soil disturbance	Earthworms, fungi	(Pfiffner & Luka, 2007)
No pesticides	Vascular plants, arthropods, and birds	(de Snoo, 1999)
Interested and engaged farmers	Nature and landscape	Paper V

The fact that it is the manager of the farm who decides the effects of farm management led me to be interested in the farmer and his relation to nature and nature conservation. Therefore, in Paper II we compiled what was known in the literature about farmers' relationships with nature and nature conservation. We also examined what variables might influence this relationship. We discussed how this knowledge can be used to create more successful nature conservation and positive interactions between farmers and nature conservation agencies.

7.2 Farmers' perception of nature and nature conservation (Paper II)

7.2.1 Short summary of Paper II

Attitudes of farmers, farming context and agri-environmental schemes interact and thus influence how the farming community affects nature and biodiversity. As new agri-environmental schemes are planned, agricultural development specialists need to recognize the complexity of farmer attitudes, the importance of location and individual farmer circumstances, and the multiple factors that influence decisions.

7.2.2 Extended discussion based on Paper II

Paper II includes information from a large number of papers on farmer attitudes and perceptions. The methods used, in the literature, to understand farmers' relations to different issues such as nature conservation, agri-environmental schemes, scientific information, are numerous. The most common are questionnaires, structured interviews and semi-structured interviews: the latter being a qualitative and the others a more quantitative method. Different social science methods have been discussed previously.

Farmers' decision making will be explored using the variables in Figure 7 (from Paper II). The variables are farmer characteristics, subjective norms, the surrounding context (especially AES), and nature.

In the literature simplistic farmer characteristics and context factors are often used as explanatory variables for the behaviour and attitudes of farmers to biodiversity and conservation. These characteristics are, e.g., age, educational level, income, or farm size (Paper II). The literature suggest that older farmers know more about nature but are more reluctant to get involved in nature conservation schemes while younger farmers know less about species but are more willing to join conservation schemes (e.g. Gould *et al.*, 1989). However, it has been questioned if age is a good predictor of behaviours and attitudes (Gravsholt Busck, 2002). Will a young farmer today inevitable end up with the same set of attitudes and behaviour as old farmers? Age might be a predictor but the underlying explanation for its effect ought to be something other than age itself. Age is rather a description of being raised during a certain time period with certain ideas and habits or having a longer experience of agriculture. It is not likely that a farmer brought up in the 30's and a farmer brought up in the 70's, would have the same set of ideas and values when they are both 60 years old. Comparable reasoning can be used for economy and farm size; will a person's perceptions of farming and agriculture fundamentally change if one earns more money and will farmers necessarily change their behaviour and perceptions of biodiversity as their farms grow bigger?

In the conceptual figure attitudes are put outside the farmer to highlight the fact that attitudes are rephrased and changing over time. For more discussion about attitudes see Paper II and the social science theory section of this thesis.

In the context box there are many things that the farmer is affected by. Some of these can be affected by the farmer but several of them are unaffected by the individual farmer, e.g., agricultural policies, technological development, the economic situation, cost of fuel and fertilizers and interest rates. All these factors are 'filtered' through the farmer when transformed from context box, i.e., the society, and on farm actions.

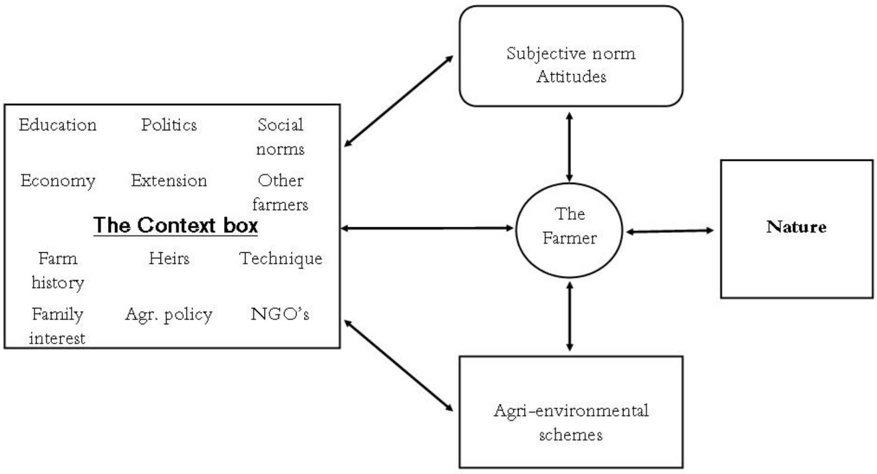

Figure 7. Attitudes and perceptions of farmers as affected by nature, context, and agri-environmental systems. The farmer is in the centre of this model and thus the context box contains factors important for farmers. Deeper explanatory text to the model is included in the text below.

I will now explore some of the topics in the context box (Figure 7.) and use quotations from my interviews to contrast, broaden or strengthen the results that were found in the literature (Paper II). The focus of much of this thesis has been to study farmers and their thoughts, ideas and feelings to nature and nature conservation. I have not studied nature conservationists' thoughts, ideas and feelings to nature and nature conservation, neither have I had any deliberate intention to take part in the discussion regarding who is right and wrong. I have studied farmers and how they perceive nature, nature conservation and nature conservationists and their perceptions are valid and true. Other studies are needed to study other stakeholders' perceptions of the same questions.

7.2.3 Social norms

Social norms are standards of behaviours based on shared beliefs about how individuals should act (Fehr & Fischbacher, 2004) and are constituted when members in a group, in this case farmers, have expectations of how other members in the group think, believe, know and act.

One of the farmers in the study stated that his farm is a hobby even though he managed 50 hectares of arable land.

> The farm is really a loan from the children, so you do not see it just in economic terms. As I see it, the farm is an interest, a way of life and a good

> place to live. I appreciate these things more than the money, because I have enough to get by – I get that from outside the farm…// //…
>
> It's like a hobby, but at the same time you want to do it as well as you can…// //…It's a matter of pride to make sure my cereal rows are straight. I don't want to make mistakes. If there is money in it does not matter, it is the appearance of the farm that is important. As a farmer, I think the greatest pleasure is when the fields have been sown and you can see the crops beginning to come up. (13)

The farmer talks about his farming as a hobby so one could believe that he does not consider himself as a farmer but he does. Since he is a farmer he should manage his land and make sure that it looks good in his eyes and in the eyes of other famers, and the way to do that is to have straight rows of cereals. The norm in the arable farming group is to have straight rows of cereals and that conveys the message that you are a good farmer.

Figure 8 shows two piles of wood that have been harvested. One is done by a local farmer and entrepreneur while the other is done by a contractor coming in and just doing a job. As with the straight cereal rows, these piles convey a message to people passing by or at least to those who understand the language.

Figure 8. Piles of wood just by a road. The left is done by a contracted driver while the right is done by a local farmer. These piles of wood convey different messages about the person who did them; the left one is negligent and the right one is orderly.

When society tries to encourage a farmer to change management behaviour, for example through politics such as agri-environmental schemes, the farmer is implicitly offered a new identity and a new set of social norms. The changes in management can be challenged by the identity and the norms that the farmers already possess. There can be great differences between social norms (actions approved by others); the subjective norm (the beliefs of what actions are approved by others); and the attitudes and actions of the individual farmer (Burton, 2004). In the study of Burgess et al. (2000) farmers saw themselves as food producers. The subjective norm or attitude is being a food producer, and thus their subjective norm is working against the social norm suggested by nature conservation agencies, NGOs and the common opinion of society that the farmer should also be a conservationist. The enrolment process in agri-environmental schemes is thus a violation of the subjective norm. Thus many farmers may be reluctant to join a scheme but that does not necessarily mean that they do not want to provide conservation services, i.e. they balk at the form, not the content.

Being a farmer today is a delicate balance between being a producer of market-based products and a producer of public goods. Parts of the production are market driven while other parts are driven by laws, regulations and public opinion. Farmers are expected by society to produce cheap food in large amounts, i.e., industrial farming, producing high-qualitative food with a local focus, with minimal environmental impacts and maximum benefits for the production of public goods, i.e., small-scale farming. One farmer's wife said that the people in Sweden have an image of farming created by the famous author Astrid Lindgren. In her books she describes farming as it was prior to the industrialization of farming, in other words small-scale farming with different animals and children tending to the animals. The farmer's wife then said

> There is still a touch of romance about farming – or so some people think. "Oh how sweet – what a nice life you must have." I don't find that amusing (7)

The farmer and his wife certainly do not want to be thought of as sweet people patting animals all day. The farmer said that their aim is for their holding to produce as much money as possible, but the wife added that they still have their hearts in the production, i.e., producing milk is the primary target but at the same time the take great care of the animals and the surrounding environment. This farming family wants to be acknowledged for their production as farmers by other farmers and as food producing-farmers by the society.

One of the farmers with a diverse farm production says of small scale production:

> There is an increasing demand for small-scale production. Very tiny…// //…Just as we all built huts once upon a time – that's the kind of thing these people want; small-scale and self-sufficient…// //…They forget that you cannot disregard the normal ways – you have to have communication with the rest of society. (4)

The farmer saying this would be seen as small-scale and diverse by most farmers - but not enough in the views of other peoples. The farmer believes in the idea of small-scale production - but it has to be conducted on a reasonable level. It is possible to be self-sufficient in food if you have land, the farmer believes, but we have other needs - e.g. medicines or glasses: if we are to have a reasonable standard of life, it cannot be fulfilled just by the products from the farm. The farmer (4) questioned the farmer identity by saying *I am a bit critical of our lot* and *Most of the things that do or do not happen are the result of old habits or routines, and so on*…He wanted to highlight that the degree of change is small within his own group and that that is not good. However, he seems to move back and forth - sometimes belonging to the farming community and sometimes being part of an alternative, more small-scale farming community.

7.2.4 Economy

In this section on economy I will deal with both the macro scale, society, and the micro scale, farm. In Paper II we concluded from the literature that economic pressures on the farm may work against the application of conservation actions (McCann *et al.*, 1997). One of the farmers in my study said: *If you are to manage your farm, take care of road verges and so on then you have to have economy on the whole farm.* (15) If the profit of the farm holding is low there is no possibility of carrying out any extra activities like nature conservation measures as all the time and money have to be invested to save the farm holding.

Large scale economic trends and farm economy

The whole farming system, e.g., suppliers, slaughter houses, bakeries and so on, is growing ever larger to be more rational and efficient and this is believed to give a higher profit. One example from my study areas is the fact that silos for cereal drying and storage are being closed down.

> Then [when they closed down the silo] it was hard. Many lost interest since it was too much work and too time-consuming to go to the other silo

[which is now also closed]. It used to take me two minutes to go to the silo – now it's two hours. I started to think about storage and loading facilities at home – but it costs too much. (13)

To be able to deliver the cereals the farmers now have to go a long way by tractor and the closest (20 km) silo will also be closed down. There is now a problem to 'get rid' of the cereals in this area. Many farmers in the area do not have or do not have big enough dryers and storage areas for the cereals. *Without [dryer] you can't get by and even with [dryer] you can't get by, damn it!* (15) Without a dryer you have to sell the cereals directly from the field to a truck and that will result in the lowest possible payment for the cereals. If the cereals are dry enough they can be stored at the farm but then to load the cereals onto a truck is hard work and time-consuming. Furthermore, if the cereals are not loaded fast enough the farmer will get a penalty, i.e., decreased payment for the cereals. The time limit is set by the fact that large-scale cereal growers have large cereal towers and can load the truck fast. Thus again the farming system is promoting large-scale solutions. The farmer then says that even with a dryer you cannot get by either, meaning that the investment is huge compared to net gain from the sold cereals.

The large scale actors in cereal, dairy and meat businesses are farmer owned cooperatives. Thus it is the farmers own cooperatives that have been important actors to rationalise and build up theses large-scale systems. One of the famers said:

Our problem in Sweden is that farmers have created large industries [cooperatives] for meat.... Farmek, Scan. It is really big... From the beginning the idea was to sell and produce at low costs so that farmers could be as well paid as possible. Now they are so big that farmers cannot produce for them. They only give the farmer what they [the cooperatives] want. They are more or less the only market. You cannot sell to any one else. That is the difficulty. You can't grumble at the government or suchlike when it is the farmers themselves who have created this...//...[How could you change it?] It is hard but some farmers say that enough is enough - I do not want to be a part of this. And new small units are created again. Then they grow. A few years ago I wanted to build a slaughter house but they [the cooperatives] stopped me through the state and new rules and laws. The whole system is built for large companies. (15)

All the time these new [new rules, costs for control or registration], different things come in...// //...We have to make sure we make enough

> money to cover taxes and other costs. We must make more money not produce cheaper and cheaper.. But I see now a strong resistance within the farming community to increase profitability on the income side of farming. I get frustrated when I see how farming itself is against this. And we become poorer and poorer – voluntarily, as I see it. Then these costs are a burden. I think that is bad. It is bad that a small farmer should pay more per unit than a larger one and so on… (4)

This farmer thinks the low economic turnover on farm holdings is due to farming itself. Farmers have too easily accepted to trying to lower prices by growing in size and being more efficient, instead of fighting and saying that they do not want to produce for these low prices. He is saying that farming co-operatives have tried to reduce costs but seldom tried to increase prices. He says that farming has voluntarily accepted this situation and that is wrong. Furthermore he is sad about the fact that suddenly there are new costs that he has to pay and especially he thinks it is wrong that small-scale producers have to pay so much more per unit than large producers. He cites the example of a new regulation, that each egg has to be marked with a number. He could either mark each egg by hand or buy a special printer for 25 000 SEK (approx. 2500 €). This investment is huge for him but 'nothing' for a large producer. He really dislikes the fact that the whole food chain is growing larger and larger making life as a small-scale diverse farm holding more difficult.

Farm size is also often coupled to the economy of the farming operation. The larger the farm the larger the economy and thus larger possibilities to invest in modern equipment. Intensification can be measured as farm size and intensification is often considered bad for biodiversity. I will argue that this is not always the case. When the modern equipment e.g. N-sensors used when fertilising and modern air-assisted sprayers are used the risk of wind drift is low and there is a high turnover of each unit applied to the field.

> I have a good sprayer. There are three of us [who own it]. It's a large, air-assisted sprayer. There is a slight risk of wind-drift of the pesticides. Used a lot [many hectares are sprayed per year]. We perform function tests every year to ensure that everything is okay. (6)

This sprayer is used over large areas and thus they cannot afford and do not have time for problems during the spraying periods and this means that the sprayer has frequent services. A leakage of expensive herbicides or pesticides will cost a lot of money when there is a leakage over large areas.

Furthermore, often when machinery is owned together there are service agreements stating that it should be in good and workable condition when it is handed over to another owner.

The fact that this machine is used by three full-time farmers can be seen both as an environmental advantage and an environmental disadvantage. If large areas are to be covered they have to spray when it is allowed, not when it is optimal; but on the other hand the fact that it is used by full-time farmers means that they are on the farm all day and can thus spray during optimal weather.

On farms with lower economy there is no economic incentive or possibility to buy new machinery. Old equipment is not as accurate and the turn-over of each unit of nutrients or pesticides applied is lower meaning that there is a larger risk for leakage of nutrients and pesticides having a negative impact on biodiversity in water systems.

> I have a lousy fertilizer broadcaster. It's old…// //…It spreads damned unevenly. So I have to zigzag, going backwards and forwards and here and there. I drive in a strange manner, but I still get good results [even crops]. (13)

This farmer talks about his old equipment and how he struggles to get a good result with the management operation he is performing. Thus there is an obvious risk of over-use of fertilisers and fertilisers ending up outside the field. There is also a risk that part-time farmers have a very limited time to carry out a management action and thus it is performed not when it is the best time to perform it but when there is available time.

7.2.5 Farm history and heirs

In the literature we found that farmers living on an old family farm were described as having developed greater sympathy with the land and also appeared to be more interested in conservation-oriented farming, compared to relative newcomers to farming (Wilson, 1996). It is stated that ownership of a farm creates emotional links and willingness to honor and maintain the status of the land (Nitsch, 2009; Flygare, 1999). One farmer in my study also expressed how the fact of owning a family farm was also a pressure. In his case six generations had succeeded to manage and pass on the farm and if he could not afford to keep the farm he would be the one losing what six generations before you have fought for. Another farmer stated that knowing about the work of your ancestors was an important motivation for him to continue to develop the farm.

> I am stuck here [said in a very positive manner]. My ancestors lived here and they worked hard to make these fields. They cut down the forest [to make these fields] – it's hard work to do that. I grew up with that. We work this farm for a while – and then we pass it on. (9)

In the literature the future for farms, e.g., if someone will take over the production, is both said to be important (Wilson, 1996; Featherstone & Goodwin, 1993) and not important (Traore, 1998) for the adoption of conservation measures.

In my study, two of the farmers (9 & 15) said that it was their responsibility to make sure that the farm holding was attractive for the children or any other relative to take over, that is, the farm should always be a modern holding both in terms of equipment and business relations.

> I would love to see on the day I quit, or want to quit, a relative of mine – it does not have to be the children – taking over. I don't make any demands of any of them because that would be wrong. But I have to ensure I build a holding that is attractive, in economic terms, to take over. You don't need a large pile of money but you must like the work. You should be rewarded. If you show the interest, you should also have the reward. (15)

Others stated that they did not develop the holding since none wanted, or at least none had expressed any wish, to take over the holding; but some probably wanted to take over the farm since it is good housing.

> …but if any of the kids had been interested I think that we would have built [new stables]…(7)

> …if you really want to go for it, you'll need new machinery – but I don't want to buy any because the kids are not interested in taking over. Now I can play with it as I want – as a hobby…// //…the kids have no interest in agriculture but maybe they'll want to keep the farm. It's a good way of life. (13)

> …it is good housing… (2)

7.2.6 Nature conservation policies and AES

> Common sense is sometimes lacking. I think that they [nature conservation bodies] would care better for the landscape without all these articles [rules]. (13)

The farmer is saying that he thinks that farming and nature conservation in farmland is too heavily regulated. The fulfilment of the rules and regulations is more important than fulfilling the underlying goals of the regulations. He has had at least two encounters with different farming and nature conservation bodies where he thought that his management had promoted biodiversity but the state officers did not agree. They seemed to have looked in the rule book more than at the actual situation. Davis (1985) expressed this as: *Do not fall in your computer, or with your guides or with your standards*. If the aim is to enhance and conserve biodiversity, rules and regulations cannot be too rigid because nature is forever changing (see also paper IV). Aldo Leopold had similar notions when writing: *In our attempt to make conservation easy, we have made it trivial* (Leopold, 1949).

In the literature farmers express their rage that desk work, i.e. filling in subsidy applications, is higher awarded that traditional farm work (Silvasti, 2003). Furthermore, entering a conservation scheme and becoming aware of conservation is not the same thing (Harrison *et al.*, 1998; Morris & Potter, 1995). The attitudes of farmers entering schemes decide the quality of the result (Morris & Potter, 1995). A positive change in attitude will give greater conservation success and more conservation benefits per unit of money invested (Coleman *et al.*, 1992).

7.2.7 Conclusion of Paper II

The results from the literature sometimes contain both contradictions and paradoxes. The literature shows a great diversity of attitudes and since attitudes are not static, but change even within an individual and among individuals attitudes change, generalizations are hard to make. We agree with Burton (2004) that there appears to be an over-confidence in attitudes as a main driver of action, and there is also an unsound belief in the power of attitude studies to reveal the true intentions of stakeholders. However, since farmers impact conservation practices and decisions, incorporating some of the knowledge from attitude studies in the design of new agri-environmental schemes is likely to be better than giving no consideration to the attitudes and perceptions expressed by farmers.

7.3 Birds on farmsteads (Paper III)

7.3.1 Short summary of Paper III

The area of buildings on the farmstead affected bird community composition, total bird density and several abundant species nesting in buildings. Farm production type (livestock or arable production) influenced community composition, species richness and abundance of single species and also total bird abundance. Most of the 42 bird species found in the farmsteads are common in Sweden, but 26 of the species have declined nationally in Sweden since 1975. Farmsteads deserve more attention in conservation of birds in farmland landscapes.

7.3.2 Extended discussion based on Paper III

In this study, we wanted to examine an environment where farmers have strong influence and where their attitudes and following actions are fundamental for biodiversity. We therefore selected the farmstead, i.e., the farmhouse, the garden, the barn and stables and all other houses. We analysed the bird fauna on farmsteads in relation to farm production type, farmstead characteristics and surrounding landscapes. The farmers' views on birds will affect how they affect birds and quotes regarding birds are mostly found in chapter 7.4.

The biodiversity on farmsteads is seldom studied despite the fact that farmsteads might serve as alternative habitat for birds in areas where semi-natural habitats are scarce (Virkkala et al., 2004; Freemark & Kirk, 2001; Lack, 1992). In a Finnish study (Virkkala *et al.*, 2004) farmsteads had higher densities of both birds in general and red-listed birds than other habitats.

Farmsteads offer sheltered nest sites (in houses, nest boxes, trees and shrubs) and food resources, i.e. high abundance of insects, cereals and other seeds, fruit and berries (Mason, 2000). Farmland bird species like the House Sparrow (*Passer domesticus*), Common Swift (*Apus apus*), House Martin (*Delichon urbica*) and White Wagtail (*Motacilla alba*) are connected with farmsteads and other human settlements (Ringsby *et al.*, 2006; Söderlund, 2005; Lack, 1992), all with decreasing populations in Sweden (Lindström & Svensson, 2006).

In general, livestock farming (with pastures and manure facilities) has assumed to be positive for farmland birds (Ambrosini *et al.*, 2002; Møller, 2001; Söderström & Pärt, 2000; Pärt & Söderström, 1999). The decrease of the Barn Swallow (*Hirundo rustica*) population in Denmark has been attributed to the decline in livestock farming (Møller, 2001).

Farmsteads with trees and shrubs may also attract both farmland and forest birds (Lack, 1992). For instance, rural built-up areas occupied only 5% of the land cover in Eastern England, but hosted 35-60% of the observations of different thrush species (Mason, 2000), species which are also associated with forest habitats (Berg, 2002a). Even a small proportion of forest (10-20%) in the open farmland may change the bird species composition from being dominated by farmland species to forest species (Berg, 2002b).

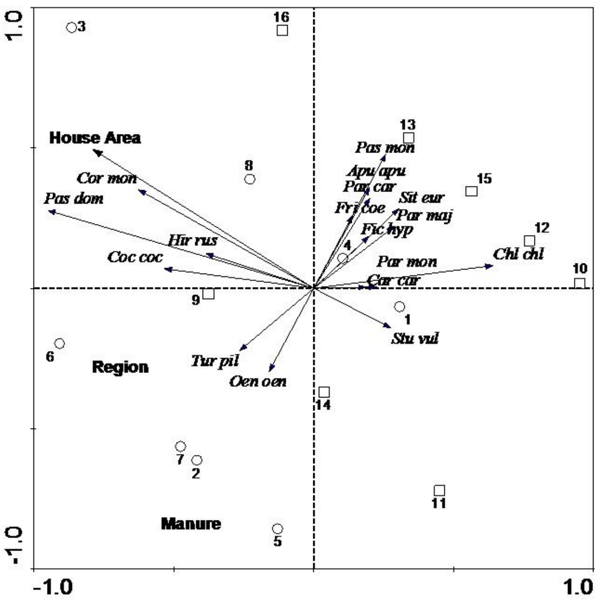

Figure 9. RDA analysis with bird data of maximum abundance and the environmental variables Region, House area, Manure, number of trees and proportion of annual crops. The analysis is performed in Canoco 4.5 and the figure produced in CanoDraw for Windows. To investigate the significant environmental variables a manual forward selection with Monte Carlo test (unrestricted; full model; 999 permutations) was used. Three variables corresponded significantly with the axis; House area (p=0.001), Region (p=0.006) and Manure (p=0.016). The variables and the model they make up explain 34, 58 and 76% of the variance. Manure and Region are not shown with arrows since they are categorical variables. Only species connected at least 20 % with the axis are shown but all species are included in the analysis. Uppsala farms are represented by circles and Heby farms with squares.

In order to see if the effect of farmsteads differed due to landscape composition we analyzed data from two adjacent regions with different landscape composition, Uppsala (30% forest) and Heby (50% forest). Bird community composition (RDA) and abundance of several farmland bird species differed significantly between the two studied regions (Figure 9.). We interpreted this as an effect of the degree of openness of the forest-farmland landscape, since no other habitat variables differed between farmsteads in the two adjacent regions.

The area of buildings on the farmsteads affected bird community composition, total bird density and several abundant species nesting in buildings. Farm production type (livestock or arable production) influenced community composition, species richness and abundance of single species and also total bird abundance. Most of the 42 bird species found in the farmsteads are common species in Sweden, but 26 of the species have declined nationally in Sweden since 1975.

A conclusion from this study is that farms with many houses and animal production are the most valuable bird habitats. There was an interaction effect between region and production type, meaning that animal husbandry was most important for birds in forest regions. However, in reality a recommendation to have many houses in farmsteads and keep livestock is of no use. Farmers will not build more houses to promote birds and they will not have animals just to promote birds. The decision to have livestock is based on the interest of the farmer, distance to slaughter houses, availability of good employees, meat prices, suitable land for grazing etc. and AES can hardly affect any of this. However, financial support for pastures in forest regions, i.e. support for grazing and thus animal husbandry, could be beneficial for birds.

The decreasing number of farms with livestock can in the long run decrease abundances of several bird species, e.g., barn swallow (Møller, 2001). Three of the farmers (1, 5 & 15) are well aware why the swallows and swifts have decreased or disappeared from their farms; no animals on the farm, closed houses and a change from tiles to metal roof, respectively.

> What I miss is the swallows; they disappear when you have a metal roof. I got hold of a book describing how to make nests for swallows and I have been planning to make one because I really want them to return. But there has not been enough time for this kind of pottering. (15)

This farmer sees the cause of the disappearance of the swallows and wants to promote the return of the birds. However, he has not found the time to do the artificial nests. He works part-time with his farm holding and thus it will be difficult to find the time or allocate time to build the nests. This is one example of how expressing a thought or idea is not the same thing as implementing it. However, the first step towards action is of course the realization of the need to perform that action.

The swifts and the swallows are species that the farmers recognize and connect to. According to Lubbe & de Snoo (2007) this applies to all farmers irrespectively whether they are organic or conventional. Below is a quote from a farmer that with great enthusiasm talks about the swifts.

> They [Swifts and Swallows] are flying here. Now they are starting to become really active. Hunt in packs here. They are REALLY fun to watch. (3)

To feed birds during winter time is a natural thing for many Swedes and farmers are no exception. This habit of feeding birds is explained in a very simple way by one of the farmers – who are often more focused on machines rather than on nature.

> If it is 20-25 degrees below zero the birds can die if they do not get food. (12)

On one farm they feed the birds more or less year round and recognize the species that come to the feeder. The sparrowhawk (*Accipiter nisus*) is not well liked since it takes the small birds. I have heard similar comments on many farms. It is interesting that farmers who are often hunters and well aware of the dynamics in nature still consider the raptors as mean birds of less conservation value.

There are of course other bird species that are not looked upon favourably by some farmers. Among these are Jackdaws (*Corvus monedula*) and House sparrows (*Passer domesticus*), because they make a mess in stables and in cereal stores.

> House sparrow and Tree sparrow [*Passer montanus*]… we thought we had Tree sparrow in our barn but it was House sparrow. And since the Jackdaws came I do not suffer from all these damn House sparrows. …/[He used to shoot house sparrows]/… I will not shoot these small birds I will let them live. There is a shortage of them. (7)

Paper III points out that farmsteads are important for birds. Farm holding production type but also individual farmers' decisions shape the appearance of the farmsteads. Several questions emerged from the study: Why do some farmers feed the birds during winter and others not? Why do some farmers have nest boxes? Why are some so rigorous in keeping birds away from foraging in and nesting on the houses? We also wanted to widen our interest in the farmers' effect on biodiversity and expanded our biodiversity inventories to each of the farms largest winter-wheat field. Then the question to explore became: Do farmers differ in their *interest in nature* and does this interest influence biodiversity?

7.4 Interest in nature (Paper IV)

7.4.1 Short summery of Paper IV

Interest in nature emerged as an important term for the interpretation process for the interpretation process of the qualitative interviews. *Interest in nature* is defined as *to what extent you have interest in, know and talk about and have feelings for nature.* Interest in nature is used to understand farmers' identities, and attitudes to nature and nature conservation. The study analyses interest in nature as social relations of farmers with a) the physical and ecological context in which they find themselves, b) the social relations of which they are part and c) the personal emotions, feelings, senses and perceptions of farmers. The paper concludes that the farmers in the study have a distinct interest in nature which differs in important aspects from a scientific-biological interest in nature, and which can explain the lack of success of current agri-environmental schemes. This conclusion is further used to outline implications for the development and innovation of AES and the sociological study of farming practices in relation to nature conservation.

7.4.2 Extended discussion based on Paper IV

Here I will elaborate the discussion in Paper IV by bringing up more aspects of interest in nature. The farmer quotes included in this chapter are, in most cases, not included in Paper IV but shed light on other areas of interest in nature. As stated earlier I have only studied <u>farmers</u> and <u>their</u> relation to nature and nature conservation, not biologists' or anyone else's relations. Thus the tension between farmers and governmental nature conservation is only covered from the farmer's point of view. The relation between farmers and nature conservation bodies is in its very nature skewed. Nature conservation bodies have to work to persuade farmers to adopt nature conservation measure to produce biodiversity. These measures have to be considered valid and reasonable by farmers so that they implement the measures. Trust has to be established between the parties. Farmers need to trust that the measures have a positive effect on biodiversity and an acceptable negative effect on production. Nature conservation bodies have to trust that farmers do what they are expected to do because there is not enough money to protect all nature worthy of protection via expropriation.

The social nature of nature

In paper IV we describe, define and elaborate farmers' interest in nature as a means to grasp famers' attitudes to nature and nature conservation. Farmers' attitudes are considered to be of crucial importance for the promotion of landscape and on-farm biodiversity. Different studies have tried to understand and classify different farmers' attitudes (Schmitzberger *et al.*, 2005; Kristensen *et al.*, 2004; Ryan *et al.*, 2003; Beedell & Rehman, 1999; Willock *et al.*, 1999; Morris & Potter, 1995).

The concept of *interest in nature* was inductively developed during the analysis of the interview material. *Interest in nature* is defined as to what extent you have an interest in, know and talk about, and have feelings for nature. In Swedish 'naturintresse' (interest in nature) is a common word and most people will have an answer on being asked if they are interested in nature. Their answer will often be followed by an example of how their interest in nature is expressed for example walking in the forest, skiing, watching birds, having a picnic outdoors during the summertime, love to watch nature shows on television, etc.

Several sociological studies analysing differences in farm management practices in relation to landscape development, nature management and biodiversity, have suggested that the diverse reasons for farmers to (not) join AES are related to their so-called 'style of farming' (Gerritsen 2002; Gravsholt Busck 2002; Schmitzberger et al. 2005; Swagemakers 2008). These studies argue that farm practices are irreducibly linked with local ecological systems. Thus, different farming styles result in different forms of co-production and consequently have a diverse impact on the rural landscape and farmland biodiversity.

Paper IV discusses "interest in nature" as conceptualisation of the concatenation of the relations of the farmer with a) his or her environmental context, b) the social network of which he/she is part and c) the institutionalised relations between her/his society and nature in general.

The first relation is that interest in nature needs to be understood as a social process between farmers and their environmental context. Interest in nature can be thought of as changing processes of feeling, thinking, wanting, doing, talking and interacting (Pickel 2005) of farmers vis-à-vis their environmental context. Special attention is directed to processes of feelings and we discuss these as the 'sentiments' (Smith 2004 [1759]) that farmers have regarding the nature on their farms. Until now sociological studies have primarily focussed on the functional and instrumental character of the relation between farmers and nature (see Gerritsen 2002; Gravsholt Busck

2002; Schmitzberger et al. 2005; Swagemakers 2008) and paid less attention to its sentimental and emotional dimension.

The second relation is the one between farmer and society discussed in an analysis of how farmers identify themselves. In line with a relational approach, both interest in nature and farmer identity are understood as social processes. This means that farmer identity is a social construction of an ideal type that farmers pursue to realise and of narratives or labels, held within society, indicating what (both real and imagined) farmers are like and what they do (Vanclay et al. 2006). Thus, identity does not exist as an object in or of itself but is constantly redefined through negotiations between farmers and their social context (Wenger 1998). An example of this is how farmers see themselves as food producers (Burton and Wilson 2006) but on the other hand feels that society wants them to change from food producers to biodiversity producers (Burgess et al. 2000).

The third relation is the relation between nature and society. This relation has not been directly studied in this thesis. The findings concerning farmers' interest in nature and farmer identity will be discussed as a means for nature conservation policy, research and extension concerning farmers' perceptions and farming practices.

Are you interested in nature?

When asked 'Are you interested in nature?' most farmers in the research replied 'yes'. The follow-up question 'What group of species are you interested in?' was most often met by incomprehension or a reply indicating a general interest in nature. It was only later that we realized how this miscommunication stemmed from the specific encounter between a researcher-biologist and a farmer. Interest in nature as a common Swedish term, was thought to be unproblematic and unequivocal. However, the question triggered dialogues which show that nature interest for the main author differs substantially from the farmers' understanding of nature interest. The following interview excerpts highlight this discrepancy.

> I … would you rank yourself as interested in nature? You know a lot of species.
> IP But I do not have a life-list of birds (Figure 10.).
> I But it is birds that you are most interested in!?
> IP No! I am generally interested. Geology and those things as well.

The above, short dialogue shows how the main author associates 'being interested in nature' with species knowledge, and how the farmer tries not to be identified as a bird-watcher, but still as someone with an interest in nature. The difference to him between farmers and biologists/bird-watchers is that the latter keep records on the species they see (Figure 10) while farmers do not.

Figure 10. Statistics from a bird watcher (Bo Ahnström). The left shows data for White Wagtail (Motacilla alba). Each month is divided into four parts and each x denotes that the species has been seen in the quarter of a month and to the right a part of a list where the first sighting of a species per year is noted.

The farmers often have an interest in nature. However, their interest in nature differs from mine - or at least they seemed to believe that.

One of the farmers (6) talks about why he is not so knowledgeable about species and why his interest in nature is not so strong.

> My wife knows better [bird species]. She is good at it. I have learnt from her. Then when you are younger and you do not live by the forest but on the plains there are no places to walk. We did not walk as much as she did. She walked a lot in the landscape. An uncle who was very interested in nature has taught her flowers and stuff…//… We have now made walk paths…//… with our neighbors. That is something! Sunday walks. (6)

The farmer has made walk paths, i.e., ley strips alongside the field margins to have somewhere to walk. He also receives subsidies for some of these strips as green border zones and he is also forced to have some green border zones as he is a member of a certification production system Svenskt Sigill.

The open-ended and semi-structured interview method also provide the opportunity to highlight ambiguous and contradictory answers. When asked "Do you know bird species?" Many farmers say "No"! Thus this is the likely answer in a questionnaire. Later in the interview many farmers talk about many different bird species, their population trends and the reasons behind their shifting population trends. These statements contradict their answer that they do not know bird species. This contradiction is an interesting point of departure in a discussion about farmer identity and interest in nature.

I am not very good on birds… (16) said this farmer after having mentioned six species and after the quote he mentioned another four species. Furthermore he talked knowledgeably about several species population trends over the last 30 years. Another farmer said that *We had a bird like that at the bird feeder this winter. Hawfinch (Coccothraustes coccothraustes) Because it had such a [shows a bill]. We did not know what it was so we looked it up. It is a sign of age when you look at birds.* In another interview his wife said *LOOK. Be still. Now this Goldfinch is here. [The husband looked carefully and was interested. Then he looked at me and said] It is an age sign when you sit and look at birds by the bird feeder.* This farmer is really interested but he always seems to feel the need to explain his behaviour. To him being a farmer and at the same time being interested in birds are two conflicting areas of interest. When these areas of interest are expressed he finds it necessary to make an excuse and in this case the excuse to step out of the farmer's identity is age.

Manage nature

The farmers' relation to nature is connected to their management of the fields and the forests, see also (Hansen *et al.*, 2006). When the farmers talk about species or tell different nature narratives they also mention what they did in management terms when experiencing nature.

Management of the farm is often a joy for farmers and when the management of the farm is questioned by nature conservation bodies then the joy is taken from the farmer. Furthermore, management is deeply rooted in the farmer identity. If management is questioned so is also the farmers' identity. One of the farmers said:

> It is much more fun now. Since 1990 we have not used as much… land as we do today. That is much more fun. When the land is used. There is one small field 0.2 hectares that is not used otherwise the whole farm is managed. (15)

This farmer is really happy because his changes in the farm holding were both needed and made it possible to use all his land for production.

Managing and harvesting what is given by nature is to honour and respect nature according to some of the farmers.

> That is also a nature experience, to harvest what is given by nature… (11)

In contrast, governmental nature conservation directives and measures often include the terms conservation, preservation and protection but seldom management. The words the farmers often use when asked to describe nature conservation is to manage, to utilise, to exploit and to help nature. Thus there seems to be fundamental differences in how nature conservation is defined and used between farmers and nature conservationists, see also Carr & Tait (1991).

Nature conservation

The farmers perceive nature as continuously changing and thus nature conservation is seen as odd and strange. The farmers express their doubts about how to conserve/preserve something that is in constant flux, see also Paloniemi & Vilja (2009) and Silvasti (2003). Picket and White (1985) point out the dialectic dilemma with nature conservation that *we seek to preserve what must change*. The day nature conservation succeeds to stop changes to occur within protected areas then nature conservation has failed, i.e., evolution and succession are processes of change and thus preservation that hinders these processes will be a failure. However, the rate of change increased because of human activities and thus only the natural rate and natural causes of change could be accepted within protected areas (Botkin, 1990). One of the farmers talks about how nature changes and that these changes are seen as a bad thing by nature conservation bodies.

> … On the whole, I think that they [the Swedish state] think in a static way. All changes are seen with the feeling of judgment day. I say that it has to be few of some species and plants, otherwise there would not be rare ones. Don't you agree that it would not be fun if all species were common, then we would not have rare birds or rare plants either? It is in its very nature that it is hard for some species… (16).

The farmers seem to notice that nature changes over time but they also seem to perceive nature as quite robust. Nature will recover and develop in a predictable manner after a disturbance (similar to the old ecological thoughts about climax communities developed by Frederic Clements in the early 1900s).

> …Not even this wheat field, such a monoculture, looks the same year to year… Nature changes. It does not matter what we do. It is a constant movement. It does not matter it will never ever look the same again no matter where you are… (16).

One farmer (9) expressed his thoughts about forest reserves by talking about how the nature conservation bodies crept around in the forest and later sent a letter to the land owner saying that there should be a reserve on the land. He says that this is an infringement of the landowner's rights.

> They should look at how the forest has been managed. There is a reason why the forest looks as it looks and the owner has plans for the future. (9)

The farmer is saying that the forest looks as it looks because of the forest management by him and his ancestors. If they would have done anything wrong there would not have been anything there to protect. Another farmer says:

> I have mixed feelings about it, parts of the forest that they [The county administrative board (LST) bought], my dad won a prize for it since it was so well managed. But he [someone at LST] thought that we should destroy it, and that feels silly. (3)

The forest, once awarded for its management, is bought by the state to protect it from the farmers' management. Thus the management and the managers are totally discarded as future managers because they cannot be trusted to keep to desired state of the forest. The farmer admitted that he was well paid but still he was a bit grumpy because of the lack of trust shown by the nature conservation bodies.

The farmers in this study who own forest (all but one) know their forest well since they have lifelong experience of it. They thought that they could point out areas containing higher nature values than the areas pointed out by nature conservationists. The areas could be pointed out based on their own ideas, i.e., their interest in nature that we know differ from biologists' interest in nature, or by mimicking areas that they know biologists have pointed out earlier, i.e., the farmers do not know if there are many species in the area but they can of course base their selection on similar criteria that biologist use, for example high amounts of dead wood, old trees or mixtures of tree species. Thus they might not agree that it is important conserve but they know that biologists want to conserve this kind of habitat.

> [comments to an appointed area important for biodiversity] but I do not think that this is anything extraordinary, there are probably [areas with] higher nature values. (16)

In this case the farmer wonders why this particular area was protected because according to his views there were other parts of his forest that were much more interesting to conserve. I see this statement as a critique of nature conservation. First, that he thinks that nature conservation is inefficient by protecting areas that he would not harvest any way. Secondly, that they [nature conservation bodies] did not bother asking him about areas that he thought were important areas for biodiversity. A discussion between the farmer and nature conservationist could have yielded better understanding of the two different perspectives of the forest, better understanding why an area need/do not need protection and maybe also a better and a more accepted key-habitat could have been found.

The farmers also claim that some of the areas protected by laws and regulations (key-habitats) are already voluntarily protected. They are protected because of their appearance; low growth rate, hard to harvest etc. or that they are kept because the farmers want to keep them.

> …this part that is protected would not have been harvested anyhow… it is a type of forest that you do not harvest so really it does… it does not matter you know… here it is marsh with pine and there you do not go out and harvest. (14)

Some of the farmers in this study express how they will clear their forest that they soon will harvest, of biodiversity habitats because of the risk that they will attract the eyes of conservation people and thus hinder the forest harvest. To be allowed to harvest forest areas larger than 0.5 hectares the forest owners have to seek permission from the state.

> … I am thinking of clearing out a bit, remove, and remove some of the largest [large deciduous trees mostly aspen *Populus tremula*]. (16)

This was said by a farmer who was about to report a harvest in the vicinity of a key-habitat. He was afraid that the governmental agency would enlarge the key-habitat to include the large trees, the aspen, and thus he would lose control over more of the area. It would also mean a loss of income since the harvest would be smaller. It should be noted that the actual risk of this happening is very little but still he was not willing to take this risk. The perverse effect is that he really wanted to keep the trees, i.e., the trees were protected voluntarily but the [probably unnecessary] fear of governmental nature conservation made the farmer consider to take down the trees. The trees had no timber value so they could stay since they did not harm the other trees and they also provided food resources for woodpeckers.

> We do not want that either [take down trees with holes i.e. nesting opportunities for birds]. We are not crazy, we also want birds, it's nice to have them. (7)

With regard to forests, there are several conservation rules and measures but one really important feature is the key-habitats, i.e., habitats that hold or could hold species with high conservation values. But one of the farmers said:

> There are some people being exposed to these habitats…(2)

The farmer talks of being exposed to key-habitats as though it's like being exposed to an illness. When the key concept in nature conservation in the forest is seen by the farmers implementing nature conservation actions as a foul language, then the idea of nature conservation is far from being accepted. This clearly indicates the infected situation between landowners and nature conservation. A discussion on how to solve this situation will follow.

As shown above rules and regulations can create perverse effects, i.e., the rules and regulations may result in the opposite effect to the intended one. Furthermore, rules and regulations have to be followed to have the intended effect.

> Here I shall be mean to nature and fill a ditch [replace the open ditch with a closed]. You know you should ask for permission, but I intend to do it anyway. (12)

The farmer knows that he is about to violate a law and that ditches are protected in national law because of nature conservation interests. He also knows that the risk of being caught and prosecuted is minimal, i.e., the rule lacks meaning to the farmer and there are no sanctions within the regulation framework. He, of course, seemed to think that production was more important than nature conservation and also that the disappearance of this open ditch would have a minor negative effect on biodiversity due to the fact that the landscape had other ditches and streams nearby.

> If you can remove a ditch maybe the field will be five hectares in one area [forest-farmland area]. That is hell of a difference to removing a ditch in the plains [intense agricultural areas]. But they [LST] do not regard that… If it is harder to manage the farm then it will not be managed. You quit faster if it is hard to manage in areas where they [LST] want a heterogeneous landscape] (16).

The farmers want nature conservation needing to be more flexible and focusing not on the fulfillment of each and every rule but the aim of nature conservation in a specific geographic area. In some cases a ditch or field island is the one thing halting the possibility to rationalize, e.g., through buying new equipment or saving time by rational driving in the field. If they are not removed, this can then in turn decrease the possibilities of rationalizing and thus saving money – or even increase the likelihood of the farmer quitting altogheter. This farmer means that for biodiversity it is more important that a farmer can run a farming business then it is to save every open ditch. The species-rich heterogeneous agricultural landscape is dependent on management and continued management is dependent on viable farming businesses.

7.4.3 Conclusion of Paper IV

We have shown that farmers in our study have an interest in nature that varies in magnitude between them. However, this interest in nature differs from biologists such as me, and from nature conservationists interest in nature. The tension between production and nature conservation is well known (Fry, 2001; McHenry, 1997). However, we want to point out that there is also a tension between farmers and nature conservation because of their differences in interest in nature. An important aspect of farmers' interest in nature is management, while for nature conservation the important aspect in interest in nature is species and the conservation of species. The tension and the reasons behind the tension have to be brought to the surface and discussed by different stakeholders. There is a need to create trust and understanding for the different perspectives on nature conservation or nature management. Furthermore, the discussions have to focus not only on the aim of nature conservation but also the means how to achieve the aim. The farmers in this study were not against the conservation of species but the means by how this should be achieved. In some cases they were not even against the means either, but how the means are presented and described, i.e., the farmers react negatively on the words used to describe the means.

Successful nature conservation is not depending on making farmers interested in nature. They are already interested but in another way than nature conservationists. Rather, successful nature conservation needs understanding of farmers' interest in nature. A common understanding of different perspectives of stakeholders on nature and nature conservation both in terms of aims and means will increase the acceptance of nature conservation (Højring & Noe, 2004). Furthermore, this can lead to more protected nature either protected by rules or protected by interest in nature.

7.5 Interest in nature affects biodiversity (Paper V)

7.5.1 Short summary of Paper V

Biodiversity, represented by an index based on species richness of weeds, carabid beetles, solitary bees, bumble bees and birds, was positively related to the farmer's interest in nature and negatively related to crop density. This implies that effective agri-environmental schemes ought to include regional, local and manager considerations and be developed with stakeholder perceptions in mind.

7.5.2 Extended discussion based on Paper V

In Paper V we investigated if farmers' interest in nature relates to the farmland biodiversity on their farm. Furthermore, we wanted to examine which other factors influenced individual organism groups and overall biodiversity. In this study biodiversity was represented by the species richness of five organism groups, weeds, carabid beetles, solitary bees and wasps, bumblebees and birds, from the sixteen farmers' largest winter-wheat fields. A biodiversity index was constructed by using the summed proportion of the regional species pool of each organism group.

To be able to use the qualitative interview material in a traditional statistical analysis we classified the interest in nature of all individual farmers. The classes were: 1) not interested, 2) interested and 3) very interested. Based on quotes from each farmer the farmers were classified by eight researchers. In the statistical analysis the classified average interest in nature was used. The farmer with the lowest interest in nature had 1.0 and the one with highest interest in nature had 2.875. For examples of the classification process see appendix 1 in Paper V.

Three independent variables representing the local field intensity, the landscape and the farmer, i.e., crop density, landscape gradient (first PC-axis correlated with proportion of annual crops and landscape heterogeneity) and farmers' interest in nature were used in the statistical analysis.

Table 3. *Results from stepwise multiple regressions with the biodiversity index and species richness of different organism groups as dependent variables. P-values are presented both for the full models (p-model) and single independent variables (p var). R2 values and F-values are presented for the full models. The direction of the result is indicated by the +/- column.*

Dependent variable	Model R^2	F-model	p-model	Independent-var	+/-	p-var
Biodiversity index	0.549	7.90	0.0057	(1) Crop density	-	0.0100
				(2) Interest in nature	+	0.0293
Carabid richness	0.559	8.23	0.0049	1) Interest in nature	+	0.0111
				(2) Crop density	+	0.0121
Solitary bee richness	0.244	4.52	0.0517	(1) Interest in nature	+	0.0517
Weed richness	0.581	19.44	0.0006	(1) Crop density	-	0.0006
Bumblebee richness						N.S
Bird richness	0.553	17.33	0.0010	Field size	-	0.0010

The biodiversity index was significantly negatively related to crop density but positively by farmers' interest in nature (Table 3. and Figure 11.). Carabid beetles and solitary bees also responded positively as individual groups to farmers' interest in nature (Table 3.). It is interesting to note that these organism groups are more or less unknown by the farmers, meaning that there are no planned management strategies promoting these organisms. Carabid beetles reacted positively and weed species richness negatively to crop density (Table 3.).

Birds did not react significantly to any of the included variables. To further examine bird species richness and bird abundance, but also to test interest in nature as explanatory variable, I used the bird data from the farmstead. There was no correlation between interest in nature and bird species richness but there was a correlation between interest in nature and bird abundance. Farmers with greater interest in nature had more bird individuals on their farmsteads than less interested farmers.

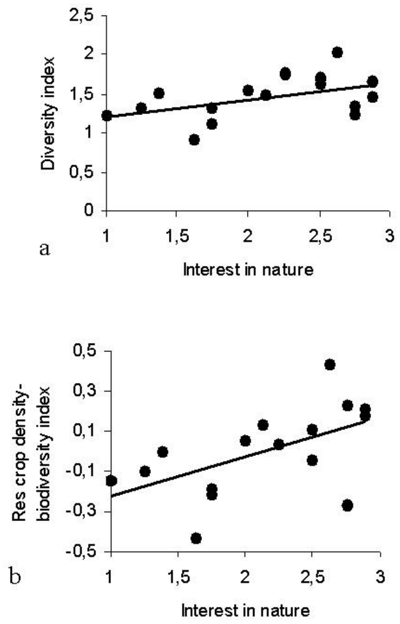

Figure 11. Relationship between the biodiversity index and farmers interest in nature, r2=0.233, p=0.0581 and b) Relationship between the residual of Crop density and biodiversity index and farmers interest in nature, r2=0.315, p=0.0237.

Interest in nature seems to incorporate many actions taken by farmers, but may also include influences of the landscape, farm history and social context. Our results suggest that future studies need to examine the relations between farmer attitudes and their corresponding actions and biodiversity in more detail. Our results indicate that conservation of biodiversity in farmland is dependent on understanding farmers' interest in nature and its relation to agricultural practices. This implies that effective agri-environmental schemes ought to include regional, local and manager considerations and be developed with stakeholder perceptions in mind.

8 Future research and main conclusion

8.1 Questions and ideas for future research

8.1.1 Weedy attitudes

In Paper V the empirical data from the qualitative interviews was reduced to three classes of interest in nature, i.e., qualitative social science is forced into natural science statistics. This is a multidisciplinary approach. Two sciences are used but they are used together to answer a question from one of the disciplines. Thus to make an interdisciplinary or even a transdisciplinary paper I would like to explore weeds and attitudes to weeds. Interview quotes and weed richness and abundance data can be put side by side to explore the relation between what the farmers say and what weeds and weed pressures they have (Figure 12.).

For a farmer to say that *I have problems with weeds* does not necessarily mean that the yield is lowered due to weed competition but it can mean that the farmers themselves have problems with weeds, e.g., thinking their land looks ugly and neglected when one can see the weeds. Weedy fields can convey the message to other farmers that the owner of these fields is a bad farmer.

However, a dislike of weeds does not necessarily lead to actions for getting rid of weeds, since these actions are connected with a cost. If the actions cost more than what will be gained by decreased competition then from an economic perspective the actions should not be taken.

I often use, I have always used a low dose. I have never sprayed violently. …//… When you turn around with the sprayer the bastards should be crooked. I spray cheap and with low doses. I have some weeds in the bottom but that does not disturb the crop. It is so little so I can have it.

	June	August
Shoot per m2/ Ear per m2	907	496
Cover of the crop (%)	64	53
Weed individuals per m2	11	30
Weed cover (%)	0,3	1
Weed species	3	12

Figure 12. Social science data and natural sciences data side by side. The quote and the weed and crop data stem from one farmer and his field.

From this quote (Figure 12.) it is hard to know how he really acts. In the quotes there are contradictions; he wants to kill the bastards and that would indicate that he would need very potent herbicides in high doses, but at the same time he says that he does not spray very much or with strong herbicides. I interpret that the weed data suggests that he is not spraying that much and this talk about killing the bastards was a wish not an implemented action.

8.1.2 Nature conservation and its different meanings

The farmers in my study used terms like to manage, to enhance, to exploit etc. as keywords in their descriptions of nature conservation. What I would like to explore is how different stakeholders use the term nature conservation and with what meaning they attach to the term. I believe that in many cases nature conservation bodies and farmers both want to preserve biodiversity but the ways to get there and the terms to describe the ways differ substantially, thus creating conflict. There are also true goal conflicts between the production of crops and production of public goods that need to be explored. This idea is discussed by Noe et al. (2005) who found that the goals of wildlife conservation differed between organic farmers and biologists. A more thorough discussion of the meanings of interest in nature could be an eye-opener to understanding how differently stakeholders see and use nature. With an understanding of each other's interest in nature there could be room for a discussion to fulfil these different interests within an area. Noe et al. (2005) suggest that this could be achieved by using indicators of biodiversity; indicators that are understood by all the stakeholders.

8.2 Main conclusions

Biodiversity loss on farmland can partly be averted by the AES organic farming. However, the effect of organic farming on biodiversity is organism- and landscape-dependent. No matter what the farming system, organic or conventional, it is the farmer who decides on farm management and the appearance of the farm. Thus, it is necessary to understand motivations for farmers' decisions regarding farm management and nature conservation measures in order to be able to create more landscape- and farm-specific schemes which has been predicted to further promote biodiversity. In this thesis it is concluded that farmers hold an interest in nature. Their interest is not connected with species knowledge but is manifested in the day-to-day management of their fields and forests.

Differences in interest in nature between farmers and nature conservationists are part of the tension between the two groups of stakeholders. This tension has in many cases produced an infected and unconstructive discussion about nature conservation on private land. Another part of the tension is dependent on the lack of trust between farmers and nature conservation, e.g., the farmers believe that nature conservation rather protect the means rather than the aims of conservation. Farmers have to be able to trust nature conservation bodies when it is claimed that measures suggested have positive effect on biodiversity work, and that the measures are indeed needed to conserve biodiversity. Nature conservation bodies need to trust that farmers are only are utilitarian in their management decisions and thus will not deliberately harm nature. Furthermore, conservation bodies have to trust and use the knowledge that farmers have about their land and nature on their land.

This thesis concludes that a key issue for successful future agricultural landscape management is creating arenas where different stakeholders' can consider and discuss the respective perspectives and their understanding of other stakeholders' perception of nature and interest in nature will be appreciated and used for sustainable production and maintaining biodiversity and ecosystem services.

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Appendix 1. *Vascular plant or weed species richness per farm*

	Farms															
Species	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**
Stellaria media (L.) Vill.	X	X		X	X	X	X	X	X	X	X	X	X	X	X	
Fumaria L.	X	X	X	X	X		X	X	X		X	X	X	X	X	
Cirsium arvense (L.) Scop.	X		X	X	X	X	X	X	X		X	X		X	X	X
Lamium purpureum L.	X	X	X	X	X		X	X	X		X		X		X	X
Sonchus arvensis L.	X	X	X	X	X	X	X	X	X			X	X		X	
Myosotis L.	X		X	X	X				X	X	X	X	X	X	X	
Tripleurospermum perforatum (Mérat) Laínz	X			X		X		X	X	X	X	X		X	X	
Polygonum aviculare L.	X							X	X	X	X	X	X	X	X	X
Fallopia convolvulus (L.) A. Löve	X				X	X		X	X		X	X	X	X	X	
Galium aparine L.	X			X	X		X	X			X	X		X	X	
Chenopodium album L.				X	X	X		X	X	X	X	X			X	
Lapsana communis L.			X	X	X				X		X	X	X	X		
Elytrigia repens (L.) Desv. ex Nevski	X					X		X		X		X	X	X	X	
Viola arvensis Murr.	X	X	X		X			X	X			X	X			
Galeopsis speciosa Mill.	X									X	X	X	X	X	X	
Taraxacum F. H. Wigg.		X	X	X		X	X						X	X		
Brassica L.		X	X	X	X	X		X								X
Equisetum arvense L.				X							X		X	X	X	X
Trifolium repens L.			X	X					X					X	X	
Veronica agrestis L.	X				X			X			X					
Sonchus oleraceus L.			X	X					X							
Capsella bursa-pastoris (L.) Medik.				X							X				X	
Thlaspi arvense L.				X					X		X					
Ranunculus repens L.				X						X		X				
Myosurus minimus L.									X	X					X	
Trifolium pratense L.				X					X						X	
Ranunculus acris L.				X						X					X	
Festuca pratensis L.				X						X				X		
Centaurea cyanus L.									X		X					
Matricaria matricarioides Porter ex Britton				X											X	
Phleum pratense L.				X											X	
Galeopsis bifida Boenn.	X								X							

	Farms															
Species	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**
Vicia L.									X						X	
Erysimum cheiranthoides L.											X				X	
Vicia hirsuta (L.) Gray															X	
Lamium hybridum Vill.											X					
Anthriscus sylvestris (L.) Hoffm.			X													
Dactylis glomerata L.										X						
Lotus corniculatus L.				X												
Medicago sativa L.				X												
Lamium amplexicaule L.							X									
Galeopsis tetrahit L.														X		
Consolida regalis S. F. Gray			X													
Tussilago farfara L.															X	
Poa annua L.										X						
Thlaspi perfoliatum L.			X													
Convolvulus arvensis L.					X											
Poa pratensis L.										X						
Species richness	**15**	**7**	**14**	**25**	**14**	**9**	**8**	**14**	**20**	**14**	**19**	**15**	**13**	**16**	**25**	**5**

Appendix 2. Carabid beetle species richness per farm

	Farm															
Species	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**
Pterostichus niger (Schaller)	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Poecilus cupreus (Linnaeus)	X	X	X	X		X	X	X	X	X	X	X	X	X	X	X
Harpalus rufipes (De Geer)	X	X	X	X	X		X	X	X	X	X	X	X	X	X	X
Pterostichus melanarius (Illiger)	X	X	X	X		X		X	X	X	X	X	X	X	X	X
Clivina fossor (Linnaeus)	X	X				X	X	X	X	X	X	X	X	X	X	X
Trechus secalis (Paykull)	X	X	X		X	X	X	X		X	X	X	X	X	X	
Trechus quadristriatus (Schrank)	X	X	X			X	X	X	X		X	X	X	X	X	X
Bembidion lampros (Herbst)	X	X	X	X	X	X	X	X	X	X	X		X			X
Bembidion guttula (Fabricius)	X	X		X		X	X	X		X	X	X	X	X	X	X
Anchomenus dorsalis (Pontoppidan)			X	X	X	X	X	X		X	X	X		X	X	X
Amara aulica (Panzer)	X		X	X			X		X		X	X	X	X	X	X
Loricera pilicornis (Fabricius)		X			X	X			X	X	X	X	X		X	X
Pterostichus crenatus (Duftschmid)	X			X					X	X		X		X	X	
Synuchus vivalis (Illiger)	X		X		X	X	X	X				X				
Agonum muelleri (Herbst)		X		X					X	X			X		X	X
Bembidion quadrimaculatum (Linnaeus)					X			X		X	X			X		X
Carabus granulatus Linnaeus	X											X			X	X
Carabus nemoralis Müller			X							X			X			X
Bembidion deletum Audinet-Serville						X		X			X					
Harpalus affinis (Schrank)				X				X				X				
Stomis pumicatus (Panzer)							X								X	
Calathus erratus (Sahlberg)										X						X
Calathus melanocephalus (Linnaeus)					X									X		
Amara plebeja (Gyllenhal)										X				X		

	Farm															
Species	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**
Amara similata (Gyllenhal)	X														X	
Amara communis (Panzer)															X	X
Amara aenea (De Geer)	X									X						
Amara familiaris (Duftschmid)										X					X	
Leistus terminatus (Panzer)					X											
Leistus syn. rufescens (Fabricius nec Ström)							X									
Cicindela campestris Linnaeus		X														
Blemus discus (Fabricius)														X		
Asaphidion flavipes (Linnaeus)																X
Poecilus versicolor (Sturm)																X
Pterostichus oblongopunctatus (Fabricius)																X
Pterostichus nigrita (Paykull)													X			
Oxyselaphus obscurus (Herbst)															X	
Amara apricaria (Paykull)	X															
Badister bullatus (Schrank)			X													
Ophonus rufibarbis (Fabricius)													X			
Harpalus syn. pubescens (Müller)							X									
Harpalus rubripes (Duftschmid)							X									
Species richness	**16**	**12**	**12**	**11**	**10**	**12**	**15**	**14**	**11**	**18**	**14**	**15**	**15**	**15**	**19**	**20**

Appendix 3. *Solitary bees and wasps species richness per farm*

	Farms															
Species	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**
Chrysis fulgida Linné	X	X	X		X	X	X			X				X	X	X
Hylaeus annulatus (Linné)				X				X	X		X				X	
Hylaeus communis Nylander	X	X					X	X								
Gasteruption assectator (Linné)			X						X					X		X
Coelioxys inermis (Kirby)	X						X								X	
Megachile centuncularis (Linné)	X								X						X	
Megachile ligniseca (Kirby)				X											X	X
Megachile versicolor Smith			X											X	X	
Dipogon variegatus (Linné)	X	X												X		
Crossocerus vagabundus (Panzer)							X		X							
Passaloecus monilicornis Dahlbom									X							X
Pemphredon lugens Dahlbom									X							
Trypoxylon figulus (Linné)			X													
Ancistrocerus trifasciatus (Müller)								X								
Symmorphus allobrogus (Saussure)			X													
Symmorphus angustatus (Zetterstedt)		X														
Symmorphus crassicornis (Panzer)			X													
Symmorphus gracilis (Brullé)			X													
Species richness	**5**	**4**	**7**	**2**	**1**	**1**	**4**	**3**	**6**	**1**	**1**	**0**	**0**	**4**	**6**	**4**

Appendix 4. *Bumblebee species richness per farm*

	Farms															
Species	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**
*Bombus terrestris** (Linné)	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Bombus sylvarum (Linné)	X	X	X	X	X	X			X	X	X		X	X	X	X
Bombus pascuorum (Scopoli)	X			X	X		X	X	X	X	X			X	X	X
Bombus lapidarius (Linné)					X	X	X	X	X		X	X	X	X	X	
Bombus bohemicus Seidl	X			X	X	X	X		X	X		X		X		
Bombus ruderarius (Müller)	X	X	X			X		X	X			X			X	
Bombus subterraneus (Linné)					X			X	X			X	X			
Bombus rupestris (Fabricius)		X		X	X			X							X	
Bombus soroeënsis (Fabricius)				X	X					X		X				
Bombus hypnorum (Linné)		X	X									X				X
Bombus pratorum (Linné)			X	X				X								X
Bombus hortorum (Linné)												X		X		
Bombus norvegicus (Sparre-Schneider)			X							X						
Bombus distinguendus Morawitz								X								
Bombus barbutellus (Kirby)																
Species richness	**5**	**5**	**6**	**7**	**8**	**5**	**4**	**8**	**7**	**6**	**4**	**8**	**4**	**6**	**6**	**5**

* *Bombus terrestris* and *Bombus lucorum*

Appendix 5. *Bird species richness per farm*

	Farms															
Bird species	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**
Alauda arvensis	X	X	X	X	X	X	X	X	X		X	X	X	X	X	X
Fringilla coelebs	X	X	X				X	X	X	X	X			X	X	X
Embriza citrinella	X	X	X	X					X		X	X		X	X	X
Phylloscopus trochilus	X		X				X	X	X	X				X	X	X
Columba palumbus	X		X	X			X		X	X			X	X	X	
Corvus corone		X			X		X	X		X		X	X			X
Parus major		X	X		X				X	X	X	X		X		
Turdus pilaris		X	X	X						X	X	X		X		
Saxicola dacotiae		X		X			X				X	X	X			
Carduelis choris			X	X						X	X			X	X	
Turdus merula	X		X		X							X				X
Phasianus colchicus				X	X					X				X		
Luscinia luscinia		X		X	X										X	
Larus canus											X		X		X	
Clamator glandarius				X								X		X		
Pica pica								X					X		X	
Columba oenas				X										X		X
Turdus philomelos								X	X	X						
Vanellus vanellus				X							X		X			
Locustella naevia					X		X									
Corvus monedula				X									X			
Sturnus vulgaris				X				X								
Parus caeruleus														X		
Sitta europaea															X	
Phoenicurus phoenicurus										X						
Oenanthe oenathe											X					
Numenius arquata				X												
Ficedula hypoleuca															X	
Parus montanus												X				
Sylvia borin												X				
Sylvia communis							X									
Species richness	**6**	**8**	**9**	**14**	**7**	**1**	**8**	**7**	**7**	**10**	**10**	**10**	**8**	**12**	**11**	**7**

Appendix 6. *Measured field and landscape variables*

In field variables	
	Crop density (% cover and number of shoots per m2)
	Crop height
	Yield
	Nitrogen application (kg/ha)
	Farm manure/Green manure/Chemical fertilizer
	Number of herbicide applications
Field variables	
	Area
	Perimeter
	Field islands (numbers and perimeter)
	Number of trees, stones and shrubs in the field border
Landscape variables	
	Habitats 1-2 m from field border (grassy or herby ditch etc.)
	Habitats 2-10 m from field border (cereal field, road, forests etc.)
	Habitats 10-100 m from field border (cereal field, forest etc.)
Area of	
	Forest
	Fields
	Built-up area
	Pasture
	Ley
	Fallow
	Spring sown crops
	Autumn sown crops
	Length of roads
	Number of farms
	Number of houses
	Solitary trees and field islands

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Now it is finally time to write these lines and thank all the people meaning a lot to me and to my thesis.

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