# Pilot study on the Breeding Densities of Yellow Wagtail (*Motacilla flava*) in Relation to Different Habitat Parameters in an Agricultural Landscape

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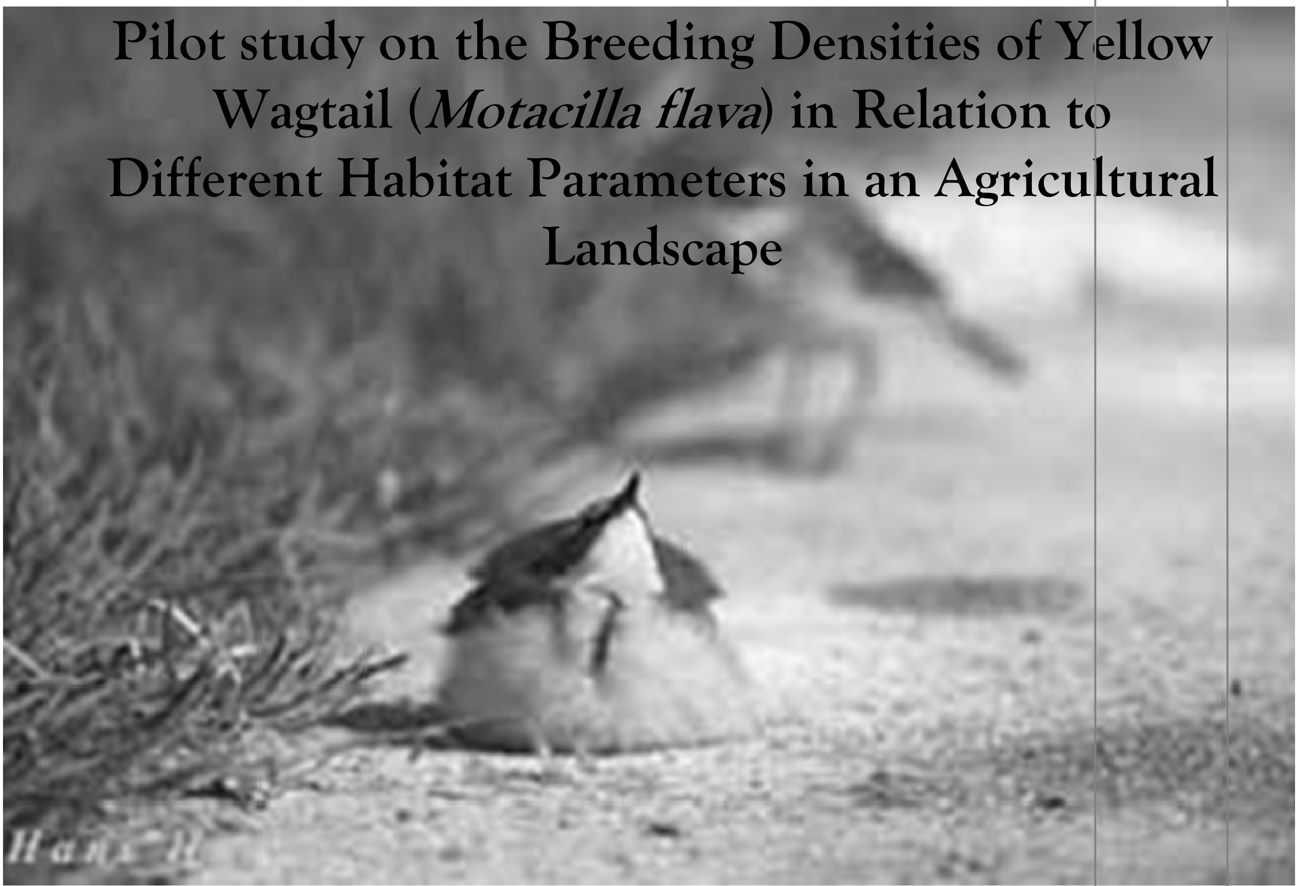


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**Abstract**

Many of the farmland birds in Western European countries are in decline. The declines have mainly been caused by changes in the agricultural practices. The ecology of Yellow Wagtail (*Motacilla flava*), which is on the Red List in different European countries, has been studied little in the arable land. Fauna strips have been introduced as agricultural nature conservation measure on arable land, but how they function for Wagtails is not completely clear. This study aims at showing first results in answering the questions:

a) How do different landscape elements and crop composition contribute to the breeding density of the Yellow Wagtail on landscape scale?

b) How do the different habitats function as foraging habitat for Yellow Wagtails?

c) Does food availability determine Wagtail breeding densities?

We counted farmland birds with the point count method in the North Eastern part of the province of Groningen in the Netherlands and an adjacent area over the German border: Rheiderland, Niedersachsen. During these counts the land use was also surveyed. After the breeding season invertebrates were sampled in several land use types.

Wagtail breeding densities varied considerably through the study area, being highest in the German part. In Groningen densities varied between 0-16 bp/100 ha, in Rheiderland between 0-41 bp/100 ha. The presence of winter wheat, oil seed rape, winter barley and bare soil had a positive influence on Wagtail breeding density, while roads and urban areas had a negative influence. There was no significant relationship between land use diversity and Wagtail breeding densities. With decreasing openness, Wagtail numbers decreased, being completely absent in areas with tree stands.

In literature spiders, *Coleoptera* beetles and *Diptera* are mentioned as Wagtail prey. These invertebrate groups combined were most abundant in fauna strips, sugar beets and set-aside wide. Food availability and Wagtail breeding densities were positively correlated.

Summarizing, Wagtail breeding densities are highest in open, food-rich agricultural areas, whereas roads and urban areas influence their breeding densities negatively. Fauna strips, as agricultural nature conservation measure, function for Wagtails as habitat with highest food abundance.

## 1. Introduction

The last 25 years, many farmland birds have seriously declined in number in the intensive farmland of Western Europe. Several of the farmland bird species were placed on national Red Lists of Endangered Species (table 1.1 for population numbers and Red List status for the Netherlands, Great Britain and Germany).

Table 1.1. Overview of some of the farmland bird population trends in the Netherlands, Germany and Great Britain including Red List Status

| | **The Netherlands** | | **Great Britain** | | **Germany** | |
|---|---|---|---|---|---|---|
| **Species** | ***Population trend*** | ***Reference*** | ***Population trend (1970-2004)*** | ***Reference*** | ***Population trend (1975-1999)*** | ***Reference*** |
| *Skylark* | -90% (1973-2000) *Red List | Beusekom et al, 2005 | -53% *Red List | Eaton et al, 2006 | >-20% *Red List | NABU, 2004 |
| *Yellow Wagtail* | -50% (1990-2005) *Red List | CBS Statline | -64% *Amber List | Eaton et al., 2006 | >-20% *Red List | NABU, 2004 |
| *Grey Partridge* | -60% (1990-2005) *Red List | CBS Statline | -88% *Red List | Eaton et al, 2006 | >-50% *Red List | NABU, 2004 |
| *Corn Bunting* | -90% (1990-2005) *Red List | CBS Statline | -89% *Red List | Eaton et al, 2006 | >-20% *Red List | NABU, 2004 |
| *Meadow Pipit* | -20% (1990-2005) *Red List | CBS Statline | -34% *Amber List | Eaton et al, 2006 | stable | NABU, 2004 |
| *Montagu's Harrier* | Recovery after near extinction *Red List | CBS Statline / Beusekom et al, 2005 | *Amber List | Gregory et al, 2002 | Increase *Red List | NABU, 2004 |

Causes for this decline can be found in changes in many aspects of the agricultural practices. In most cases, the decrease is caused not by a decrease in nesting sites, but by a decrease in food availability during both breeding and winter season (Winspear and Davies, 2005; Newton, 2004; Peach et al, 1999; Kyrkos, 1997). This decrease in food availability is caused by the increase in the use of pesticides and herbicides and by the loss of field margin habitats due to scale enlargement (Winspear and Davies, 2005). These margins can be inhabited by large amounts of spiders and insects because they provide a protected wintering habitat (Winspear and Davies, 2005).

The largest change in agriculture is more intensive land use (e.g. Brickle et al, 2000; Potts, 1986; Newton, 2004). Scale enlargement for efficient practices has transformed the small scale agricultural fields into large monoculture fields (Shrubb, 2003). The possibilities to find both foraging and nesting habitat in close proximity of each other have therefore become limited (Winspear and Davies, 2005). With intensification, more agricultural activities fall within the breeding season of farmland birds. This implies more destruction of eggs and young (e.g. Crick et al, 1994; Court et al, 2001; Henderson et al, 2004), both in arable land as well as in grassland. With scale enlargements, also the field margins and weed flora have decreased (Winspear and Davies, 2005). The loss of weed flora has resulted in a large decrease in biodiversity (Potts, 1997). Field boundaries, like hedgerows, can provide for some species nesting sites (for instance Whitethroats). Uncropped field margins and also field boundaries can supply seeds and insects for foraging birds (Winspear and Davies, 2005). Species differ in preference for certain margin

and boundary types. Some boundary or margin types have hardly any use for birds. In some cases (like dense tree stands), they can even have adverse effects, because some species of the open agricultural landscapes avoid such objects in the landscape (especially the Skylark) (David Kleijn, pers. comm.; Scharenburg et al, 1990). Crop monocultures that are less suitable to species reduce the habitat that is available to less mobile species, like invertebrates. These cannot cross large unsuitable habitat between suitable patches (Winspear and Davies, 2005).
Increased use of pesticides has had its effect on birds too (Newton, 2004). It directly influences insect abundance, while herbicide use has reduced the food supply for insects. Also the decrease of margins has resulted in a decrease in insects (Winspear and Davies, 2005). Insectivorous birds, like Yellow Wagtails, Skylarks and Meadow Pipits during breeding season, therefore have less food supply in the proximity of the nest in the agricultural landscape. Most farmland species feed their young with insects, even if the parent bird is granivorous (Winspear and Davies, 2005). The chemical control of grass weed has been the key to decline of spring sown crops (Shrubb, 2003).
Crops that are sown in autumn instead of spring reduce nesting habitat (Winspear and Davies, 2005), because they already form a tall and dense stand early in the season (Andrews and Rebane, 1994). For the Skylark for instance, this has resulted in a limitation to only one nest per breeding season, while two or three nests are needed to keep the population levels stable (Wilson et al, 1997; Donald and Vickery, 2001; Donald, 2004). Seed eating birds have also been influenced by this change (in combination with herbicide use), which heavily reduces food abundance (Newton, 2004). When the fields are ploughed in autumn, stubbles are removed and with them the food supply.

In all the research carried out on farmland birds a wide variety of solutions have been brought up to halt the population declines. However, the decline in population numbers in the western European farmland birds is in most cases still ongoing (like for instance Skylarks in the Netherlands (Dutch Centre for Ornithology SOVON; Provincie Groningen, 2007) and Great Britain (British Trust for Ornithology BTO). But there have been also unexpected opportunities. In 1988, the European Union set up a large scale, long term set-aside regulation to regulate the cereal surplus (regulation 1094/88). Each year a circling 15% of the arable land of each farm was set-aside and left or was sown with a seed mixture based on grasses. On these set-aside fields, vole numbers increased largely, attracting birds of prey and owls. This measure has been replaced in 1992 by small scale forms of agricultural nature conservation measures on arable land (introduced by EU commissioner MacSharry). These measures can be set-aside strips that are usually mown several times a year or fauna strips which are sown with a mixture of seeds, which are either not mown at all during the breeding season or strips that are partially mown (duo strips (Hoff and Koks, 2007)). All these forms of strips attract many small mammals like voles and hares. Due to their mammal population they play an important role as foraging ground for raptors and owls during the breeding and outside the breeding season (Koks et al., 1992; Zijlstra and Hustings, 1992; Koks and Scharenburg, 1997). In winter those kinds of strips also help wintering seed-eaters. During the breeding season they offer breeding places and feeding grounds for Skylarks (Oosterhuis et al, 2002), Yellow Wagtails, Quails and Grey Partridges. In the province of Groningen fauna strips with a width of more than 6 meters have a positive effect on the breeding success of Skylarks (Oosterhuis et al, 2002; Oosterhuis, 2002). The fauna strips can cover also large amounts of invertebrates (Andrews and Rebane, 1994; Winspear and Davies, 2005; Haveman et al, 2005). In the north-eastern part of Groningen these strips have a minimum width of 3 metres, with an average of 10.5 meters. Just over de Dutch- German border, in Rheiderland (Niedersachsen), the strips are different in terms of width, length and sometimes vegetation mixture. There is such a wide variety of strip types and their functioning for different bird species, that much more research is needed to have a clear picture of the function these strips might have as nature conservation measure. A wide variety of different types of fauna strips and other extensive habitats might create a mosaic structure in the open landscape, supplying more food, shelter and breeding habitat than a limited number of different fauna strips. Age of the strips also influences the functioning of the strips. Up to 6 months they are still developing. After this developing phase they function best for 2-3 years, afterwards their functioning decreases (Koks, pers. comm.).

The decline in the farmland bird populations is widely recognized. Many studies have been carried out to gain insight in the causes of these declines, in for instance Skylarks (e.g. Donald, 2004; Donald et al, 2002; Odderskaer et al, 1997; Teunissen et al, 2007) and Grey Partridges (e.g. Green, 1984; Potts, 1986; Rands, 1986; Aebischer and Ewald, 2004). However the ecology of the Yellow Wagtail this has been little studied (e.g. Mason and Macdonald, 2000; Scharenburg et al, 1990). The Yellow Wagtail was placed on the Dutch Red list while recent knowledge is lacking for this bird on their habitat requirements, especially if the current arable agricultural landscapes still provide this and how to improve them. This makes that research is needed.
Agricultural nature conservation in the Netherlands was traditionally focused on the meadow birds and not on the farmland birds of the arable land (Beusekom et al, 2005), while in the Netherlands the Yellow Wagtail has for its survival become completely dependent on the arable land (Hoff, 2002; Hoff, unpublished). So research on the Dutch situation for the birds of the arable land is urgent.

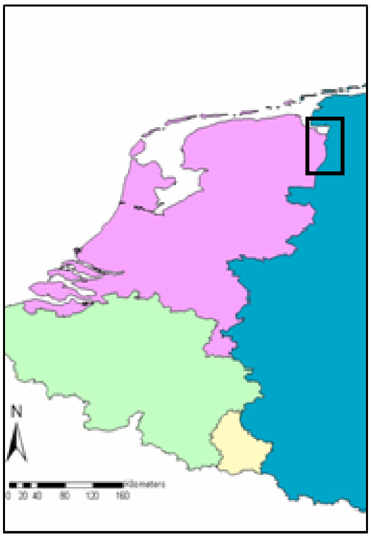
This study focuses on landscape parameters that determine Wagtail breeding density and how nature conservation management may contribute to this. These parameters vary form crop diversity to crop composition. In the large scale open agricultural landscapes fauna strips aim to provide (new) opportunities for farmland birds. These fauna strips can vary a lot in width, length, mowing regime, vegetation height, density and structure. In this study, comparison of the part in the Netherlands and the part in Germany, supplies the opportunity to compare different forms of fauna strips on landscape scale. These strips should function as refuge for both mammals and invertebrates. With wider and/or longer strips more habitat is available for these groups and therefore wider and longer strips should have a positive influence on the food availability for birds. With increasing set-aside field size for instance, biodiversity increases and population numbers and densities increased for most taxa (Buskirk and Willi, 2004). The data are collected in a rather large area and over a longer period of time (three months), allowing for research on differences on landscape scale and a time scale. The complete dataset was also analyzed on different openness categories. In literature available the Wagtail is a bird of the open agricultural landscape (see paragraph 2.2) and is reduced in smaller scale landscapes, sometimes caused by differences in soil type (e.g. Scharenburg et al., 1990). Decrease in food availability is for most species in literature the cause for population declines (see above). So a study on relations to breeding densities therefore requires also study on food abundance. For the insectivorous Wagtails only the invertebrate group is relevant for food availability. Different crops and different set-aside types were compared for their invertebrate food availability. A possible relation between food availability and breeding density was tested.

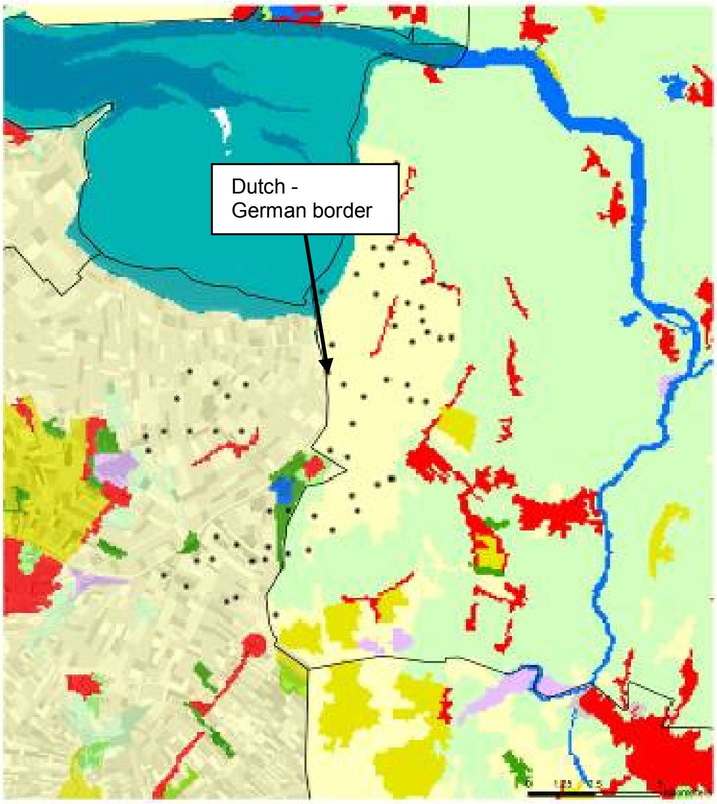
The study aims at showing first results in answering the questions
**a) How do different landscape elements and crop composition contribute to the breeding density of the Yellow Wagtail on landscape scale?**
**b) How do the different habitats function as foraging habitat for Yellow Wagtails?**
**c) Does food availability determine Wagtail breeding densities?**
With these three questions the first steps are taken to value the current nature conservation measures as contribution to the breeding densities of the Yellow Wagtail.

## 2. Material and methods

### *2.1 Study area*

The study area consists of two adjacent agricultural areas divided by the Dutch-German border. The Dutch part is located in the north eastern part of the province of Groningen. In this area, farmers are organised in the agricultural nature society "Agrarische Natuurvereniging Oost-Groningen". The German part is located in Rheiderland, Niedersachsen. Here farmers are organised in the first German agricultural nature society: Landwirtschaftlicher Naturverein "Rheiderländer Marsch". In figures 2.1a and 2.1b an overview of the study area can be found (in appendix I an enlarged version of the map on the right with legend can be found).






Figures 2.1a (left) and 2.1b (right): overview of the study area. Figure 2.1a gives a rough location of the study area, while figure 2.1b gives the study area in more detail with the black dots being the bird point count locations

The Dutch part of the study area consists of large scale agricultural land. The main crop types in the province of Groningen are cereals (table 2.1). Across the area there are fauna strips, set-aside strips and set-aside fields. Fields in general are usually divided by small ditches. A large part of the German side of the study area consists also of large scale open agricultural fields, with winter wheat as main crop type. The percentage oil seed rape is higher than at the Dutch side. Blessed milk thistle (*Silybum marianum*) is a crop unique for this part of the study area and is cropped on fields that otherwise would be set-aside fields. A small part of the German area consists of a small scale landscape with mainly hay meadow. In the German part of the area, there are also fauna strips, but the strips located there are longer and sometimes wider. Set-aside is completely absent in the German part.

Table 2.1. Main crop types for arable land in the province of Groningen for 2006 (CBS-Statline)

| **Crop** | *Cereals* | *Sugar beets* | *Potatoes* | *Lucerne and other animal feeding crops* | *Set-aside* |
|---|---|---|---|---|---|
| **Percentage of arable land** | 40% | 10% | 23% | 18% | 3% |

### *2.2 Species description*

Wagtails breed in lowland areas: moist meadows, moist heath lands, borders of rivers and streams and more and more in large scale pastures (Beintema et al, 1995). On the arable land their presence is correlated to certain crop types, mainly winter wheat and bulbs (Beusekom et al, 2005). They only avoid forests and very small scale agricultural landscapes (Hoff, 2002).

They winter in western and central Africa (Hoff, 2002). The majority arrives in April, the earliest ones already in March. When they arrive, they immediately start defending a territory (Beintema et al, 1995). In May the female builds a highly concealed nest. The eggs hatch after 11-13 days. The nestlings stay in the nest for 10-13 days and fledge after 16 days (Beintema et al, 1995). The first 5 days after hatching the female stays with the young, afterwards they are left alone and the female also starts foraging. The nest and its surrounding area is heavily defended by both parents. Sometimes even neighbouring pairs assist in keeping predators at a distance. Possibly a breeding pair can make a second nest in one season (Beintema et al, 1995).

The most important groups of invertebrate food for farmland birds are grasshoppers (*Caelifera*), spiders (*Araneae*), leaf beetles (*Chrysomelidae*), weevils (*Curculionoidea*), aphids (*Aphidoidea, Homoptera,* order *Hemiptera*) crane flies (*Tipulidae*) and caterpillars of sawflies (*Symphyta*), butterflies and moths (both *Lepidoptera*). In absence of these groups, the birds have to switch to larger insects (Winspear and Davies, 2005). Foraging Wagtails have three different foraging strategies:
- picking, in which Wagtails walk through the landscape picking for prey along the route
- run-picking in which picking is preceded by a short sprint
- fly-catching, in which a prey is caught in mid air after a short sally (Davies, 1977; Roder and Bijlsma, 1984).

The picking strategy is used most often (Roder and Bijlsma, 1984; Bijlsma and Roder, 1985; Davies, 1977). In the small amount of literature that is available on the feeding habits of Yellow Wagtails, Roder and Bijlsma (1984) name flies (*Diptera*), beetles (C*oleoptera*) and spiders (*Araneae*) as main prey source in an agricultural landscape. Davies (1977) names *Chironomidae* and *Drosophilidae* species as main food source when foraging in flocks at the beginning of the season in an open grassland area and he names *Scatophagidae*, *Spaeroceridae* and small beetles as main prey source for single foraging Wagtails, also in an open grassland area.

In the Netherlands, Wagtails can be found in most areas, except the Veluwe. The largest concentration can be found in the province of Groningen and the south-western part of the Netherlands (Hoff, 2002). On clay soils and the corresponding landscape they have higher densities than they have on sandy soils (Hoff, 2002). The Wagtails have disappeared in 14% of the 5x5 km blocks in the Netherlands when comparing the period 1973-1977 and 1998-2000 (Hoff, 2002). They have almost completely disappeared from grassland habitats (Hoff, 2002; Hoff, unpublished; Hagemeijer et al, 1996). The Yellow Wagtail was placed on the Dutch Red List in 2004.

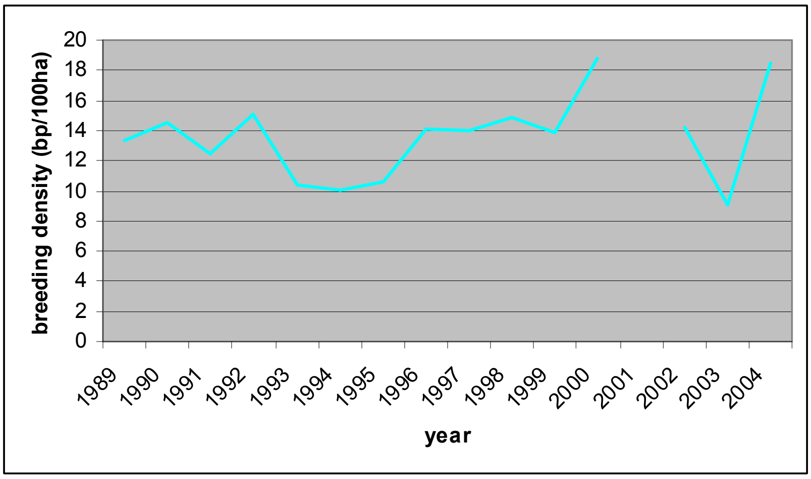
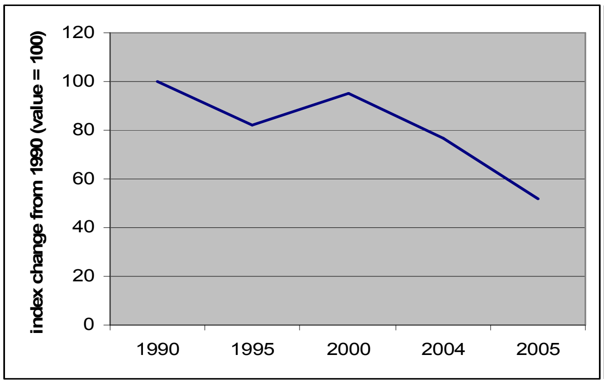



Figure 2.2. Population density trend for the Yellow Wagtail for the province of Groningen for the period 1989-2004

The species decreased with 50-75% since the 1960's. In the province of Groningen, the population numbers based on breeding density (bp/100 ha) have been varying over the period 1989-2004 (figure 2.2) (data Jan van 't Hoff), but are stable. The relative change from 1990 in breeding pair numbers for the whole Netherlands can be found in figure 2.3a (1990-2005) (derived from CBS Statline website) and for Groningen in figure 2.3b (period 1990-2004) (derived from numbers supplied by Jan van 't Hoff). While in the Netherlands in general Wagtails have declined, in Groningen they have been stable.



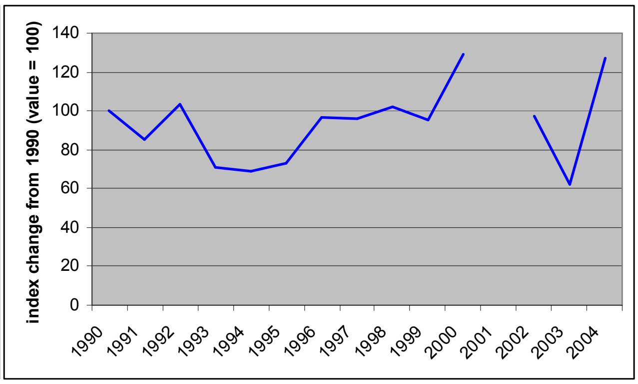




Figure 2.3a (left) and 2.3b (right). Yellow wagtail breeding bird population change from 1990 to 2005 for the whole Netherlands (a) and for the period 1990-2004 for the province of Groningen (b). The number of breeding pairs in 1990 was set to index value 100 (trend derived from CBS Statline website (whole Netherlands) and numbers supplied by Jan van 't Hoff (Groningen)).

### *2.3 Field methods*

To answer research question **a** [**How do different landscape elements and crop composition contribute to the breeding density of the Yellow Wagtail on landscape scale?**] a breeding bird survey on landscape scale combined with survey of the habitat is required. This survey on landscape level is carried out by means of point counts (paragraph 2.3.1). For research question **b** [**How do the different habitats function as foraging habitat for Yellow Wagtails?**] invertebrate samples are needed of different crops and different nature conservation measures (paragraph 2.3.2). For research question **c** [**Does food availability determine Wagtail breeding densities?**] the data from research questions a and b were combined.

*2.3.1 Breeding bird and habitat survey at landscape scale: Point counts*

Point counts take, compared with breeding bird censuses, little time, which makes them ideal to cover large areas. In this method, an area is covered with points. Each point forms the centre of a circle with a diameter of 400 metres (surface area 12.57ha). In this study in total 67 points located in both the German and the Groningen part of the study area were used (appendix I). The method was derived from the point count method described in Bibby et al (2002).

During 5 minutes, each new individual bird that is seen (by eye or with binoculars) or heard is noted on a standardized field form (appendix II). They were divided in breeding pairs, breeding pairs with young (including number of young when known), staging birds (e.g. resting, hunting) and birds passing by. Breeding pairs with young can be determined either direct or indirect (visual of young birds or parent bird with food in its bill). Staging birds were noted as non breeding birds, while passing birds were noted as birds flying over. For every point the land use and the mammals present were also surveyed. If birds or mammals present in the point were scared away to outside the plot during approaching the point, they were included in the count. Harriers were noted separately.

Each point was visited three times during the breeding season (April, May and June). The first two rounds took place in the morning (from dusk till around 10.00h a.m.) and the last one in the evening around dawn (to survey nocturnal birds like Quail and Corn Crake). The points were visited during good weather, to have the largest probability of singing or otherwise active birds and to have comparable results. The points were visited three times, because not all birds arrive at the same moment (e.g. Marsh Warbler arrives later in the season, while Meadow Pipit is very early) and in three rounds all birds should be covered.

*2.3.2 Invertebrate sampling*

For the invertebrate sampling, two different sampling methods were used: buckets to sample ground crawling species, and plots to sample the other groups. The sampling has been carried out within a 5 kilometre radius of another, this to exclude differences due to other factors as much as possible. The sampling was carried out in the period end of July – beginning of August.

The invertebrates were sampled using a line transect of 200 metres length created out of 10 buckets. Every 20 metres a bucket was placed in the ground. They were placed in the evening (between 19.00 and 21.00h) and were dug up 12 hours later. At the first sampling location, it was tested whether there were large differences between night and daytime sampling. No extra species were found during daytime sampling. Because early in the morning flying insects were still present in the vegetation and some species groups are nocturnal (like some carabid beetles), overnight sampling was chosen as most appropriate sampling time.

The buckets at both ends of the transect and 2 randomly chosen other buckets in between each served as a centre of a square of 1 $m^2$ in which all invertebrates were sampled before recollecting the buckets. First the flying invertebrates were counted and afterwards vegetation was checked for invertebrates present.

All invertebrates were categorized on the spot on order name if possible. The numbers of each group were noted. If the invertebrate could not be named, it was taken to the field station to be determined using determination tables (e.g. Veen and Zeegers, 1993).

Transects were made along strips and from the edge of fields inwards. The buckets were accompanied by a roof, to prevent the insects from drowning. Only insects living on top of the soil were sampled. Soil invertebrates are not relevant because Wagtails only feed above soil level (Roder and Bijlsma, 1984; Davies, 1977). Sampling was carried out with dry weather overnight or only an occasional shower, to make them as comparable as possible. The different habitat types were sampled twice, however due to weather and time constraints this was not possible with all types. The habitat types that were sampled, are:

- sugar beets (2x)

- winter wheat (2x)
- fauna strips (2x)
- set-aside (1plot set-aside of more than one year, 2 plots of set-aside that was regularly mown in which one plot was wide and one was small in width)

### *2.4 Analyses*

Research question **a** [**How do different landscape elements and crop composition contribute to the breeding density of the Yellow Wagtail on landscape scale?**] requires a Wagtail breeding density model with the landscape parameters as explanatory variables. The analyses that were carried out with the breeding bird point count data are described in paragraph 2.4.1. The analysis on the invertebrate sampling data for research question **b** [**How do the different habitats function as foraging habitat for Yellow Wagtails?**] is described in paragraph 2.4.2. For research question **c** [**Does food availability determine Wagtail breeding densities?**] the data from research questions a and b were combined. The analysis that was carried out with an explanatory model and an ArcGIS analysis is described in paragraph 2.4.3. In paragraph 2.4.4 an ArcGIS map analysis for fauna strip percentage in the land use is explained.

#### *2.4.1 Breeding bird densities and habitat correlations at different scales*

With the point counts a Yellow Wagtail distribution map was created using ArcGIS. For the distribution map the maximum number of breeding pairs counted in one of the three rounds served as input for the breeding density per point. In GIS, all counted points and their corresponding breeding densities served as input for the map. With the Spatial Analyst toolbox function Interpolate to Raster the counted points were interpolated, within a range of 2 km, creating the distribution map.

In the explanatory model for the number of breeding pairs and landscape parameters, the explanatory variables were the landscape parameters (x-variables) while breeding density was the explained variable (y-variable)[1] (analysis A). A possible relation between breeding densities with the parameter landscape diversity was tested (B)[2]. The analysis for the Wagtail density comparison of the first two counting rounds is described under C[3]. The analysis for possible influence of openness on Wagtail breeding density is described under D[3].

A) With the habitat survey supplied with the point counts (see paragraph 2.3.1), a study on the possible influence of landscape elements and crop composition on the Wagtail breeding densities was carried out. For each point, the number of breeding pairs counted in the round with the highest number of pairs was recalculated as breeding density for that point (breeding pairs/100 ha).

*bp/100ha = (counted number of breeding pairs/12.57)*100*

The habitat elements and crop composition were in the sampling expressed as the percentage of the point area (12.57ha).
The different explanatory land use variables in this analysis were:
- road
- winter wheat
- summer wheat

[1] Regression analyses were carried out in SPSS 12.0.1 for Windows
[2] Regression analysis was carried out in SPSS 12.0.1 for Windows. In the analysis the P-value of .05 was used as critical value for significance
[3] Statistical analyses were carried out in SPSS 12.0.1 for Windows. In the analyses the P-value of .05 was used as critical value for significance

- sugar beet
- oil seed rape
- blessed milk thistle
- winter barley
- summer barley
- forest
- nature
- fauna strip
- ditch
- set-aside
- grassland
- meadow
- urban area
- bare soil
- lucerne
- maize
- potato
- grass seed

All these land use variables were analysed in a multiple linear regression analysis, based on backward elimination (entry F-probability 0.05, removal F-probability 0.10).

B) The explanatory variable land use diversity was calculated with the Shannon-Weaver index (Shannon and Weaver, 1949):

$$H = -\sum_{i=1}^{S} p_i \log p_i$$

With $p_i$ the relative abundance of the *i*-th crop and *S* the total number of crops. A possible relation with Wagtail density was tested with a linear regression analysis in SPSS.

C) The first two counting rounds were used to make a comparison over time. This to analyze if there was a difference between the first two rounds in Wagtail numbers. It was not possible to include the third counting round, because this round took place in the evening, while the other two rounds were carried out around sunrise, which made them not comparable. The breeding pair numbers in both rounds were counts, which implies being not normally distributed, which resulted in an analysis with the Wilcoxon Signed Rank test.

D) The breeding densities were analysed for possible differences between groups of landscape openness.
The points were, with the data on landscape survey, sorted in three groups:
1) open (with only an occasional solitary tree)
2) with tree lane(s)
3) with tree stand(s).

The breeding densities were not normally distributed and therefore a Kruskal-Wallis test was used. Barplots and multiple comparisons with Scheffé were used to gain insight how the categories differed from each other, if applicable. For the two groups with trees (group 2 and 3) a negative influence on Wagtail numbers was expected, because Wagtails in the Netherlands are assumed to avoid tree stands and very small scale agricultural landscapes (Hoff, 2002).

### *2.4.2 Invertebrate sampling*

With the invertebrate sampling, graphs were created showing total number of individuals per species group averaged for the number of samples carried out per habitat and the relative number per species group. To get an idea of the diversity in the habitats, sampling based taxon sampling curves (Gotelli and Colwell, 2001) were created for the habitats for buckets and plots separately.

During sampling, it became clear that with the chosen sampling method, the flying insects could not be captured and therefore not be weighed. Therefore none of the insect groups were weighed and the analysis limited to only abundance.

### *2.4.3 Food availability and breeding density*

This analysis was carried out in ArcGIS 9.2. Two different layers were created and compared:
- breeding densities on landscape level (the Wagtail distribution map)
- food availability index based on the habitat information from the survey at landscape scale and invertebrate numbers for the sampled habitat types.

From the scores the habitats sugar beets, winter wheat, fauna strip and set-aside got for the number of individuals of *Coleoptera*, *Diptera* and *Opiliones* / *Araneae* (spiders), an index was created for Wagtail food availability per point. In GIS, a food availability index layer was made using the Density function in the Spatial Analyst toolbox. The distribution map was compared with the food availability index layer. The food availability index per point could be read in ArcGIS. Food availability index was tested for a relation with number of Wagtail breeding pairs in a GLM, in a log-linear model[4].

### *2.4.4 Fauna strips and breeding density*

This analysis was carried out in ArcGis 9.2. It is a comparable analysis to the one described in paragraph 2.4.1. With the Spatial Analyst toolbox function Interpolate to Raster the densities in the counted points were interpolated, within a range of 2 km. Percentage of fauna strips was also included in the model described in paragraph 2.4.1.

[4] Analysis carried out in GenStat for Windows 7th edition

## 3. Results

### *3.1 Breeding bird densities and habitat correlations at different scales*

*3.1.1 Distribution map*

The Wagtail distribution map, representing the breeding densities for the Yellow Wagtail per square kilometre, is graphically displayed in figure 3.1. An enlarged version is included in appendix III. The densities vary between 0 and 41 breeding pairs/km$^2$. Highest densities were found in a small area in Germany (41 bp/km$^2$) .The densities vary through the whole study area. In the German part the densities vary between 0 and 41 bp/km$^2$. In the Dutch area they vary between 0 and 16 bp/km$^2$. In some points the Wagtails were completely absent, mostly around the border.

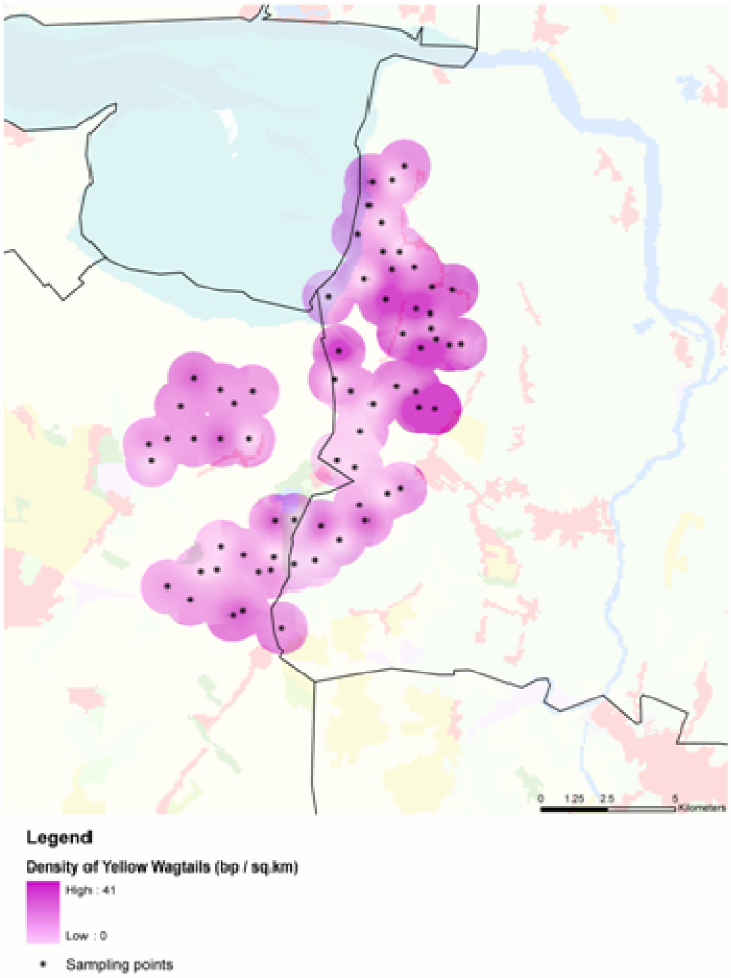



Figure 3.1. Distribution map for the Yellow Wagtail for the study area. The black dots represent the locations of the counting points.

*3.1.2 Explanatory model analyses and statistical analyses with point data*

The best linear regression model for the Wagtail breeding densities could explain 33% of the variance within breeding density ($R^2_{adjusted}$= 0.327). The explanatory variables included in this model were: winter wheat, roads, oil seed rape, urban areas, winter barley and bare soil (estimated coefficients in table 3.1). The variables road and urban area had a negative influence on Wagtail breeding density, the other variables a positive influence.

Table 3.1. Estimated parameters for multiple explanatory Wagtail breeding densities model

| Model parameter | Coefficient estimate | Std error |
|---|---|---|
| *$B_o$ - Constant* | 3.112 | 1.851 |
| *$B_1$ - winter wheat* | 0.124 | 0.029 |
| *$B_2$ - road* | -1.020 | 0.707 |
| *$B_3$ - oil seed rape* | 0.153 | 0.070 |
| *$B_4$ - urban area* | -1.935 | 1.237 |
| *$B_5$ - winter barley* | 0.138 | 0.077 |
| *$B_6$ - bare soil* | 2.647 | 2.126 |

The best model for Wagtail breeding densities and land use diversity was an unimodal model (with a quadratic term).This model could only explain a very small proportion of the variance in breeding densities ($R^2_{adjusted}$ = 0.015). This model did not affect breeding density more than could be expected by chance (F = 1.497, sig. = .231). Model parameters can be found in table 3.2.

Table 3.2. Regression coefficients and significance levels for the explanatory model for Wagtail breeding density and land use diversity

| Model parameter | Coefficient estimate | t-value | Sig. |
|---|---|---|---|
| *$B_o$* | 4.798 | 1.144 | .257 |
| *$B_1$* | 28.139 | 1.458 | .150 |
| *$B_2$* | -35.331 | -1.661 | .102 |

The number of breeding pairs differed between the first two counting rounds (Z-value = -4.205, sig. < .001). The second round had a higher mean (0.89 compared to 0.24) for the number of breeding pairs per point counted in one round.

Wagtail breeding densities differed between the different openness categories defined under 2.4.1 (Chi-square = 7.780, df = 2, sig. = .020). Multiple comparisons with Scheffé did not reveal the differences; the bar plots in figure 3.2 only give and indication about possible differences. The largest difference in breeding density is clearly between the open area points and the points with forest patches in it, where the Wagtails were completely absent. Large variation in the first two categories and a limited number of observations probably resulted in no result with the Scheffé's test.

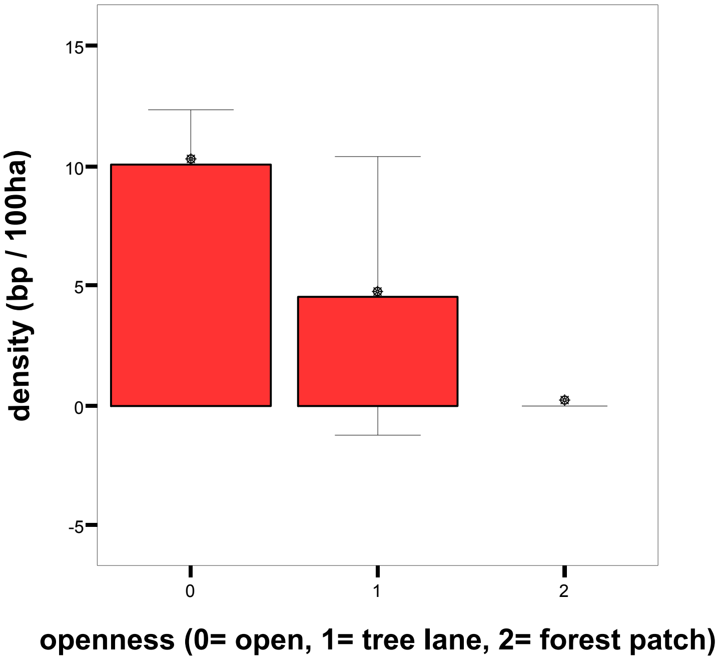



Figure 3.2. Bar plots with the Wagtail breeding pair densities (bp / $km^2$) for the three openness categories open (=0), with tree lane (=1) and with forest patch (=2). The bar values represent the mean, and the errors bars showing the 95% confidence level of the mean

### *3.2 Invertebrate sampling*

For sampling the invertebrates two methods have been used; buckets and plots (see paragraph 2.3.2). With the two sampling methods different species groups have been sampled. To show these differences the two sampling methods are throughout this section separated in the figures and also in the text.

The total number of individuals per group, averaged for the two samplings per habitat (if applicable) can be found in figures 3.3a (buckets) and 3.3b (plots). For the bucket sampling method, the largest numbers are found in the sugar beets (more than 130 individuals on average) while the set-aside habitats >1 year and the small mown plots have the lowest number of individuals in the buckets (less than 50 individuals). The three set-aside types vary a lot in invertebrate numbers found (around 40 for small mown plots and >1 year against 110 for wide mown plots). It might seem remarkable that the two crop habitats have high numbers, while the set-aside and fauna strip habitats have lower numbers. However, an explanation might be found in the field observations that the agricultural land use types also have the largest proportion of bare soil. Ground crawling invertebrates have more suitable habitat in land use types with more bare soil. For instance temperate carabid beetles are mostly active bare soil hunters that need the space to hunt (Turin, 2000). Although the bare soil explanation seems plausible, this is not tested. It might still be possible that other factors determine this difference.

In the plots the highest number of individuals is found in the fauna strips (more than 140 invertebrates on average per transect), while the lowest numbers are found in winter wheat (around 30 individuals). Winter wheat which had the third highest numbers in buckets had the lowest in the plots. The three set-aside types vary considerably again. Highest numbers were found in set aside of more than one year (almost 120), while wide had lowest (around 40).

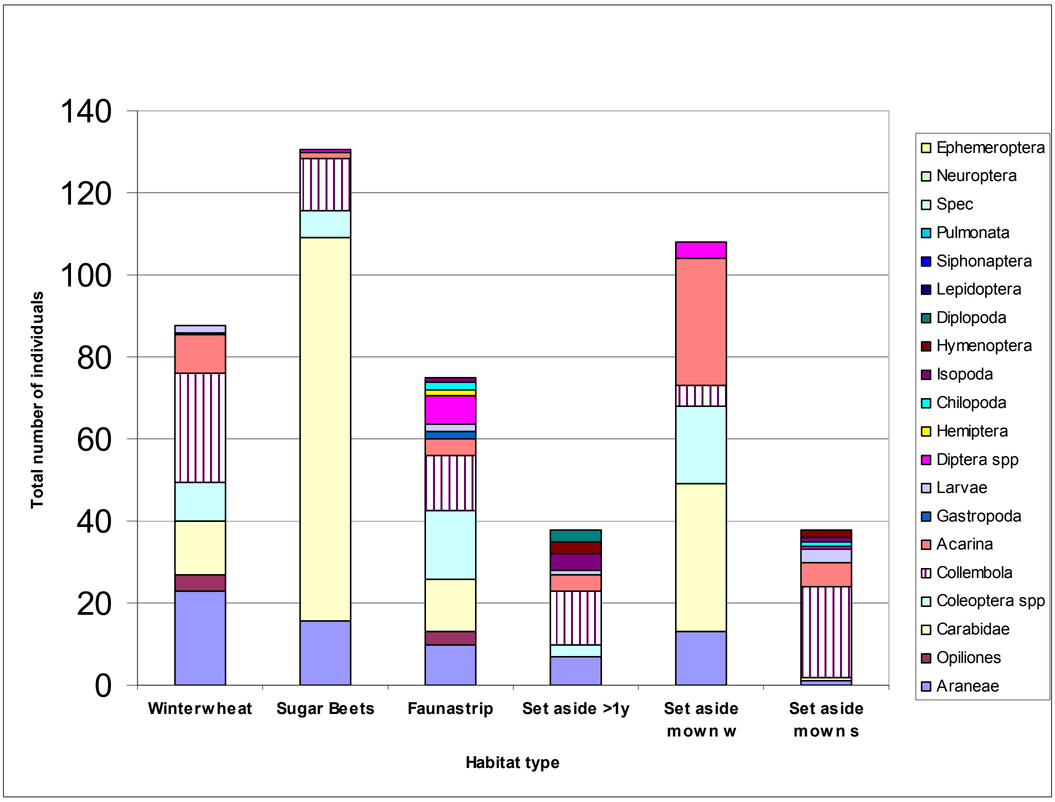



Figure 3.3a. Total number of individuals per invertebrate group for buckets

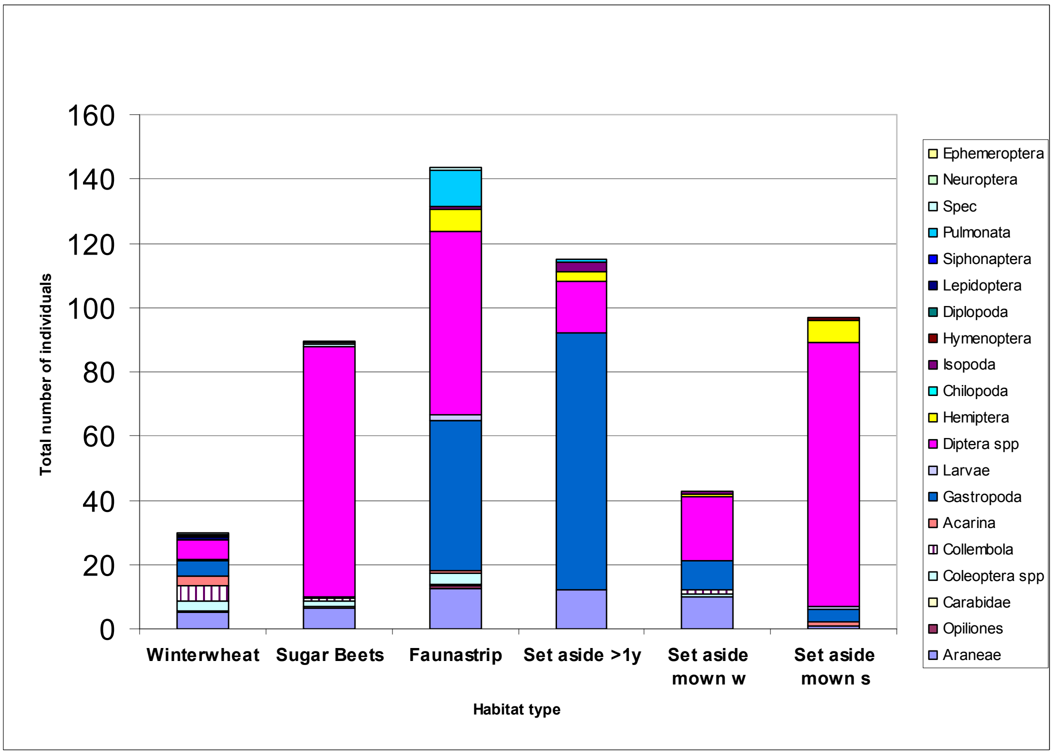



Figure 3.3b. Total number of individuals per invertebrate group for plots

The proportions of groups in average numbers per habitat type can be found in figure 3.4a (buckets) and 3.4b (plots). In the bucket sampling method sugar beets had on average the highest number of invertebrates, and when looking at the composition, they are dominated by carabid beetles (*Carabidae*). Winter wheat was third in line in invertebrate numbers in the bucket sampling method; the invertebrate group that forms the largest proportion of individuals here are *Collembola*. The buckets in the fauna strips show that in the fauna strip no species group is really dominant in this sampling method. However, when combining *Carabidae* and other *Coleoptera* species, around 40% of the individuals originate from one of these two groups. The set-aside >1 year has no dominant group. In the regularly mown wide set-aside type 45% of the individuals originates from either *Coleoptera* or *Carabidae*. Set-aside small does not only have low invertebrate numbers, they are also dominated by *Collembola*. *Collembola* are due to their size (max 6mm) too small to serve as passerine prey, which makes winter wheat and set-aside small less interesting compared to looking at the total numbers alone (which are quite large in buckets for winter wheat).
In plots the fauna strips, with had the highest numbers, are dominated by *Diptera* and *Gastropoda*. Sugar beets, third after fauna strips and set-aside >1 year in total number, are in numbers dominated by *Diptera* (90%). The set-aside types are dominated by *Gastropoda* (more than one year); *Gastropoda, Araneae* and *Diptera* (wide, regularly mown) and *Diptera* (small, regularly mown). Winter wheat has low numbers and has no dominant group. *Diptera* forms 20% of the individuals, while *Collembola* forms 15%, altogether not comparable to fauna strips or sugar beets.

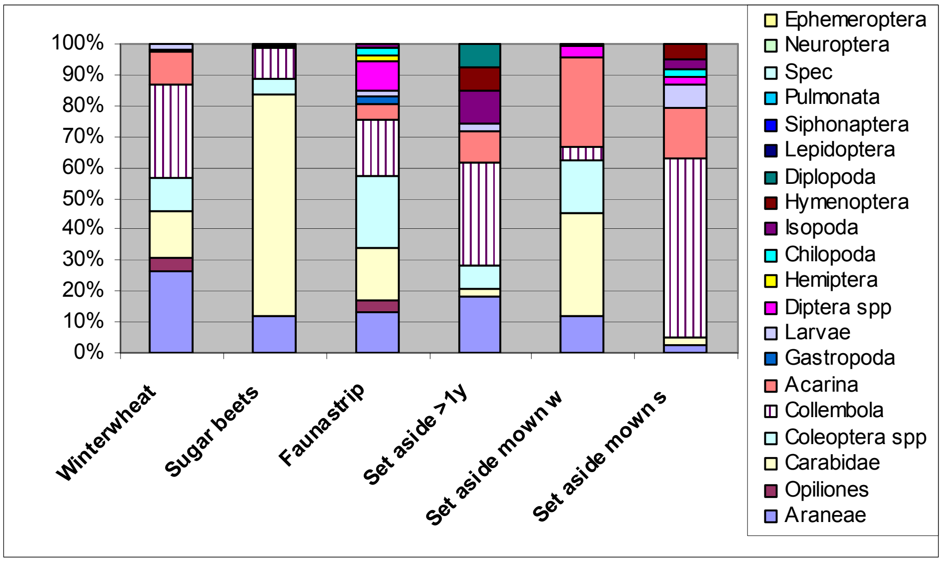



Figure 3.4a. Relative proportion of invertebrate numbers per group for buckets

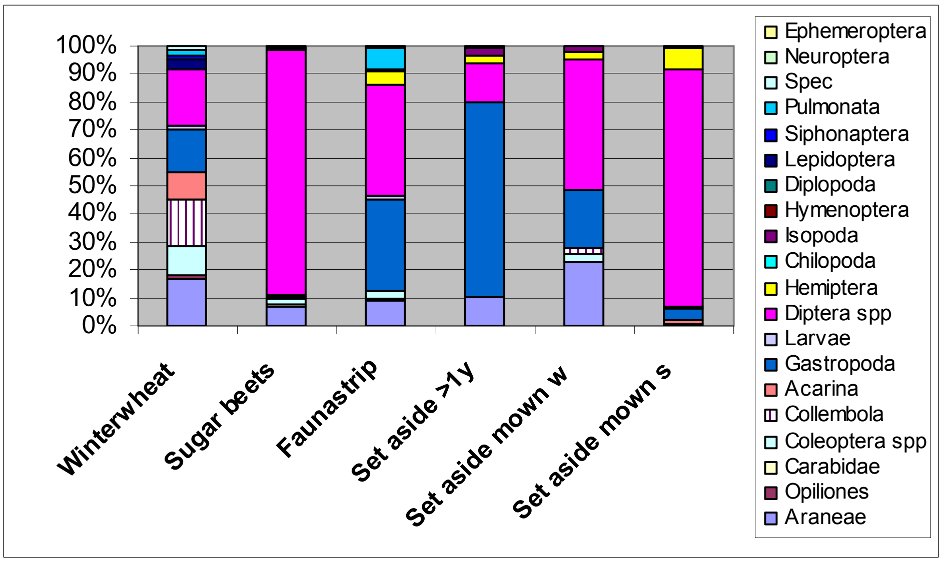



Figure 3.4b. Relative proportion of invertebrate numbers per group for plots

Figures 3.5a and 3.5b display the sample based taxon sampling curves on species group level. In the buckets (figure 3.5a) both fauna strip samples and the set-aside of more than one year have most species groups. In the buckets there appear to be two groups: the upper group consisting of both fauna strips and the set-aside >1 year and the second group with the other habitats.
In the plots (figure 3.5b), there are found less different species groups overall (max. 13 buckets and max. 12 for plots). In the plots the fauna strips have the largest diversity in species groups, while one of the winter wheat samples also has a large number of different species groups. The common agricultural practices and both mown set-asides have lowest number of species groups.

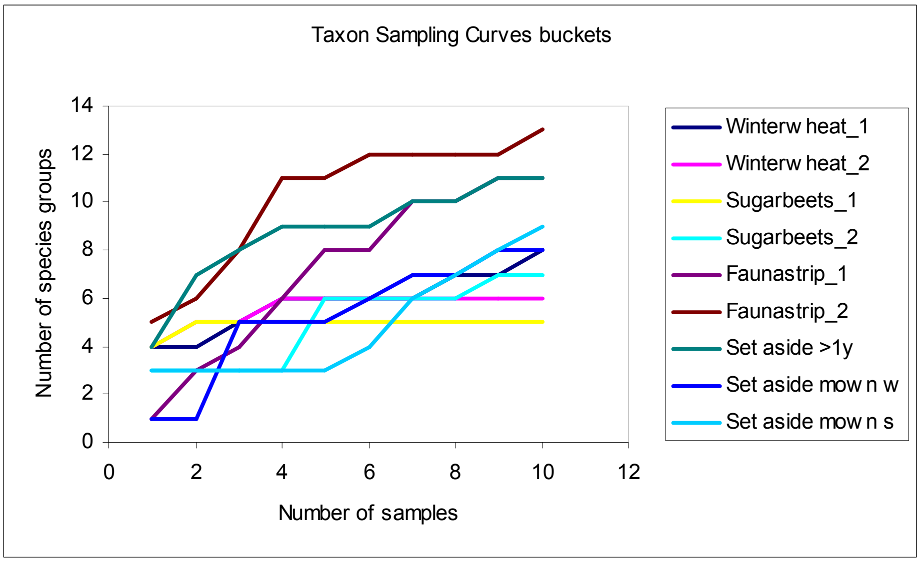



Figure 3.5a. Sampled based taxon sampling curves for buckets

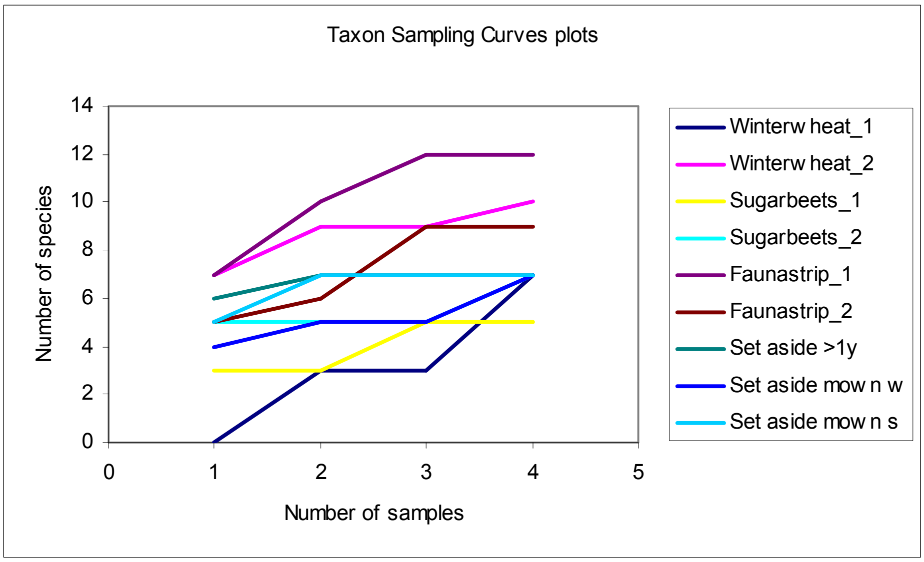



Figure 3.5b. Sampled based taxon sampling curves for plots

### *3.3 Food availability and breeding density*

Food availability index can be compared with the distribution map in figures 3.6a and b. An enlarged version of the food availability index map is included in appendix IV. The highest food abundance was found in the central part of the German side of the study area. When comparing it to the distribution map, both share high scores in the central German part. However the distribution map does not follow the food availability map everywhere. The southern part of the Dutch side for instance seems to have rather low numbers, while the food availability map gives rather high index scores. This map therefore also implies that although food availability might explain the global pattern of wagtail distribution, other factors also have their influence.

Food availability index has a positive influence on Wagtail breeding densities (table 3.3). For a log-linear analysis the predicted relation is:

log Number of breeding pairs= -0.441 + 0.002449*food availability index

Table 3.3. Regression coefficients and significance levels for the explanatory model for breeding density and food availability index

| Model parameter | Coefficient estimate | t-value | Sig. |
|---|---|---|---|
| *$B_o$ - Constant* | -0.441 | -1.77 | .077 |
| *$B_1$ - Food availability index* | 0.002449 | 2.80 | .005 |

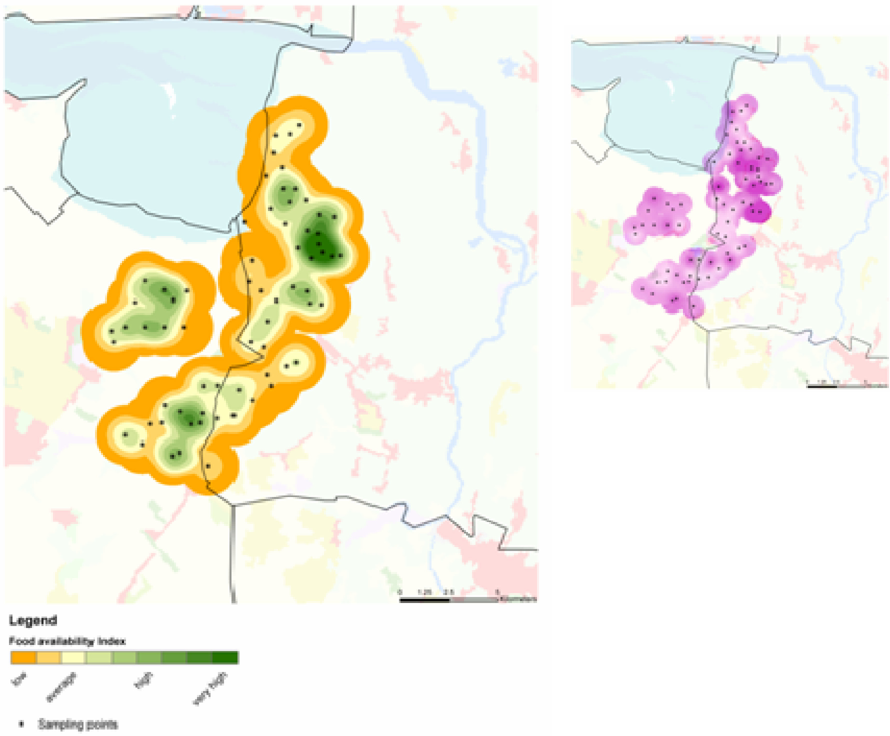



Figure 3.6a (left) and b (right). The GIS output map for food availability index (left), with the smaller Wagtail distribution map (right) for comparison

### *3.4 Fauna strips and breeding density*

The percentage of fauna strips in the land use is displayed in figure 3.7a, with next to it (figure 3.7b), smaller, the Wagtail distribution map. An enlarged version of the fauna strip map is attached in appendix V. There are some core areas with a high percentage of fauna strips in the land use. These areas form the central part of the German side and two areas in both Dutch data clusters. The lowest percentages can be found along the northern part of the Dutch-German border. Comparing the fauna strip map with the distribution map, there are some areas where the fauna strip percentage is high and breeding densities are also high, however especially in the German part a large area has a high fauna strip percentage in the land use, while the Wagtail breeding densities vary considerably. So although in some areas there seems some kind of relation, there is not yet a clear picture for the whole area. A relation between fauna strips and Wagtail densities was already incorporated in the regression model analysis in paragraph 3.1.2., for which no relation was found in the best fitting model. The limited data set or the small percentages for fauna strips in the land use might have had their influence. Therefore a quick statistical analysis with a Mann-Whitney U test was carried out, in which the fauna strip percentages in the land use were transformed to fauna strip present-absent data. The test showed differences between both groups (Z-value =-2.277, sig. =.023). The group with fauna strips had a higher mean rank than group without fauna strips did (29.53 (without) to 40.09 (with)).

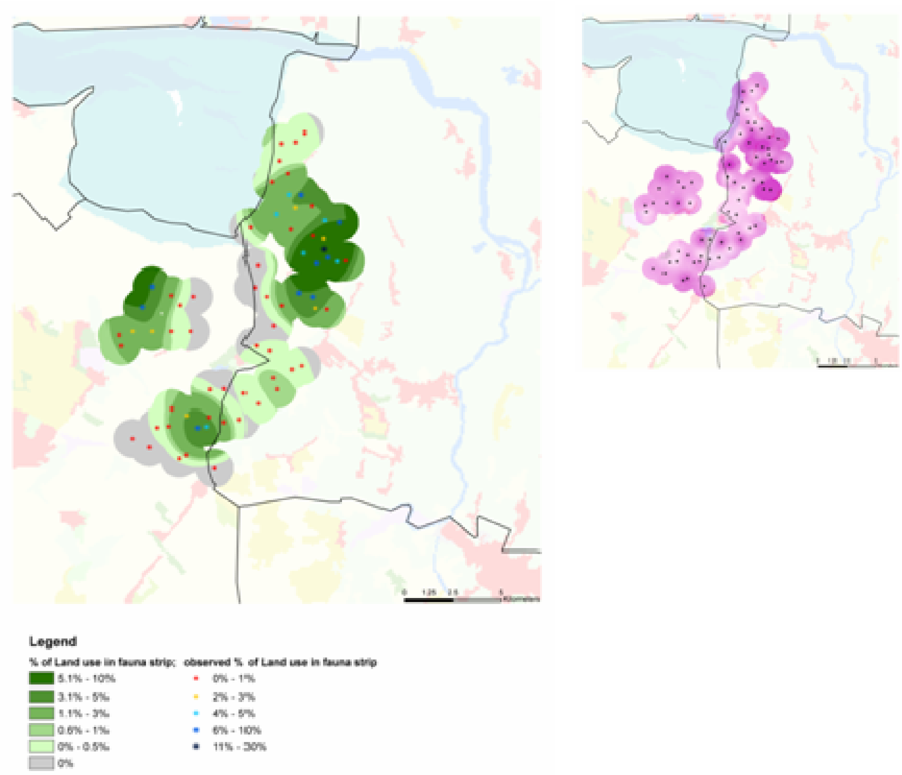



Figure 3.7 a (left) and b (right). ArcGIS output map for the overview of the percentages in land use that are formed by fauna strips (left) and the smaller Wagtail distribution map (right) for comparison

## 4. Conclusions and Discussion

### *4.1 Conclusions and discussion on the results*

The Wagtail distribution map shows variation in density trough the study area. In part of the German data they reach maximum densities (41 bp/100ha), which is considerably higher than average number for the province of Groningen, which is around 14 bp/100ha (figure 2.3). Also in a small part of the Dutch area the density is higher than the long term trend, however in some parts densities are comparable or Wagtails are absent. The average breeding density in the counted points in Groningen is lower (mean=7.29 bp/100ha, ± 1.16 (se), values between 0-16 bp/100 ha) than the long term average for the whole province. Also the average breeding density in Germany is lower (mean=9.9 bp/100ha, ± 1.44 (se), values between 0-41 bp/100 ha). However, this calculation is based on a very limited dataset and therefore no further conclusions should be drawn from this. Unfortunately, it was not possible to have the results of the counted points in the whole province of Groningen at our disposal. That the average density in Germany is also lower than the long term average for the whole province of Groningen might be explained by the counting method. The counting area is rather small, which results in the probability that a bird species is totally absent from a count point is being larger compared to working with breeding bird surveys methods that cover larger counting areas per plot. Zero counts have eventually their influence on the average number. Calculations in ArcGIS show that the location of the counting points should be within 1 km of each other. Above this the variance is increasing, which make predictions and conclusions less reliable.

Some of the variation in the distribution can be explained by the factor openness. This factor can especially explain some of the low Wagtail densities in the southern part of the German side. At this site the agricultural landscape is alternated with tree lanes, having its effect on openness and also Wagtail density. This effect has been previously shown in other research (Scharenburg et al, 1990; Hoff, 2002).

For research question a [**How do different landscape elements and crop composition contribute to the breeding density of the Yellow Wagtail on landscape scale?**] the model that explained most of the variance in the Wagtail breeding density data included six variables: urban areas (-), roads (-), winter wheat (+), oil seed rape (+), winter barley (+) and bare soil (+). Koks (1989) found negative effects for road length and number of urban areas, which can be comparable to the parameters percentage of roads and urban area in the land use. They could be direct or indirect negative effects. Roads and urban areas reduce possible breeding and/or foraging habitat directly. Indirectly, they may have a disturbance effect on Wagtails. Winter wheat, oil seed rape, winter barley and bare soil had a positive influence on Wagtail breeding densities. Winter wheat serves as breeding habitat and a positive relation with Wagtails has also been found in Scharenburg et al (1990). Oil seed rape also functions as breeding habitat and in studies by Rooy (1987), a positive relation was also found. Wagtails were also found breeding in winter barley during the field work, which might be an explanation for this positive relation. If and how winter barley also functions as foraging habitat could not be studied in this research, because the barley was already harvested during the invertebrate sampling. No relation between Wagtails and winter barley was found by Scharenburg et al (1990). Food availability may be an explanation for the positive influence of bare soil. In Scharenburg et al (1990), a positive relation between Wagtail numbers and unpaved roads was found. They related this positive influence to the verges accompanying these road types, which would contain high insect abundance. In a Wagtail study by Roder and Bijlsma (1984), bare fields were frequently used as foraging area. From occasional observations they assumed the Wagtails were hunting for *Diptera* there.

In line with available literature, *Araneae*, *Coleoptera* and *Diptera* would play the most important role in valuing the different habitats as foraging habitats for Wagtails (research question b [**How do the different habitats function as foraging habitat for Yellow Wagtails?**]). For *Araneae* the habitats that had the highest abundance were the fauna strips, for *Coleoptera* (excluding carabids), it were the fauna strips and winter wheat and for *Diptera* fauna strips and sugar beets.

Looking at the food availability per habitat, the best option for foraging Wagtails therefore were fauna strips, followed by sugar beets and set-aside wide. The set-aside small is, when looking at the mentioned species groups, the least favourable option. Fauna strips also have another advantage. It is the most diverse habitat type in species groups, which can help farmland birds in periods when some groups are scarce. Alternative species groups may then compensate for the groups that are scarce or not available. Although the invertebrate sampling has its limitations (paragraph 4.2), several results are supported by other literature. Roder and Bijlsma (1984) mention grassland with life stock, bare fields, potatoes, sugar beets and pea fields as foraging habitats. Although most of these crops were not analysed in this study, sugar beets were, based on the sampled invertebrate numbers, a profitable foraging area. Diversity was higher in the fauna strips than in the other samples habitats, which is supported by research of for instance Gates et al., 1977; Raskin et al., 1992; Snoo, 1999. Several studies show that also vegetation height is important for invertebrate abundance (e.g. Baines et al,1998; Haughton et al.,1999), which was not included in this study but needs to be included in further studies. The set-aside strips that are regularly mown, showed lower numbers than the fauna strips did, which is also supported by other literature that states that mowing during spring and summer reduces invertebrate abundance heavily (Haveman et al, 2005), although it varies per species (Morris and Lakhani, 1979; Morris, 1981; Morris, 1979). In a study carried out in the same region (in Groningen), Haveman et al (2005) mentioned that the invertebrate numbers in the fauna strips exceeded their expectations (Haveman et al, 2005). In their opinion, fauna strips can contribute to the biodiversity in the agricultural landscape. In comparison, also in this study fauna strips had the largest number of species groups and the largest number of individuals in the plots.

The food availability index created from the invertebrate sampling and the land use survey had a positive relation with breeding density. For research question c [**Does food availability determine Wagtail breeding densities?**] a positive relation was found. Although the parameter seems low, the actual index numbers were high, so in this case the coefficient estimate value does not say much on itself. More important is that there is a relation with food availability and that it is a positive relation.

Fauna strips have been designed as an agricultural nature conservation tool. Therefore whether or not they function for Wagtails is an interesting question although it does not form one of the main research questions. As source of invertebrate abundance they have an important function as food source for farmland birds in the open agricultural landscape. Besides that for all the Wagtail invertebrate prey groups overall they are the best option, they also have highest diversity. Looking at the fauna strip GIS output map, they might explain part of the Wagtail distribution pattern, however in the regression model analysis the fauna strips did not contribute to the breeding densities. Although it is possible that Wagtail densities are not related to fauna strip cover, the data representation in the analysis might have had its influence, because the percentages of fauna strips in the land use were rather small (there are some exceptions in Germany). The Mann-Whitney U test that was additionally carried out with transformed fauna strip data showed that in points with fauna strips Wagtail numbers were higher than in points without fauna strips.

Land use diversity did not show a relation with breeding densities in a regression analysis. Wagtails are birds of the open agricultural landscape and therefore the absence of a relation between these variables was not unexpected.

### *4.2 Recommendations*

The land use regression model shows some results that were found in other studies as well, while some relations found in other studies were absent in this study. It is recommendable to carry out a comparable analysis for a larger dataset. Especially the dataset for Groningen was rather small (24 points), which might have had influence on the outcomes of the results.

Although the number of studies on farmland birds is rapidly increasing, the understanding of the farmland bird community pyramid in the Netherlands and the functioning of nature conservation measures for it is far from complete. As stated before, nature conservation for farmland birds tended to focus solely on grassland birds and passing over the birds of the arable land. Only some organisations focused on the farmland birds of the arable land, like for instance in the province of Groningen the Dutch Montagu's Harrier Foundation.

The Dutch Montagu's Harrier Foundation has been working together with different other parties for years, in Groningen for instance with the province of Groningen and agricultural nature societies. Besides the province of Groningen, much research is carried out in Flevoland and the German Rheiderland. In the German Rheiderland, the fauna strip model has been extended and varied. The data from these three areas not only supplies a very large dataset, it also allows for comparing different areas with differences in fauna strip design and fauna strip design phase. Results in one area can be implemented in fauna strip implementation in other areas. In the province of Flevoland for instance fauna strips have just been introduced. They are based on experiences with different design types in other areas. At the same time this offers new research opportunities to test the influence of these fauna strips on the farmland bird community pyramid. In the most positive sense this could lead to a circle leading to most functional nature conservation measure design.

Birds are counted by the Dutch Montagu's Harrier Foundation in cooperation with other parties, in part of the German Rheiderland, Groningen, part of the province of Drenthe and the province of Flevoland. Besides point counts, breeding bird surveys and special farmland bird counts have been carried out. With these bird counts also the habitat has been surveyed, supplying data for analysis on relations with bird densities.
Several different research topics and different research methodologies supply data on several scales, over time as well as on regional and on landscape scale, supplying the widest range of possible analyses. They focus on the whole farmland bird pyramid from top predator to habitat (figure 4.1 for illustration of what is included). Wintering birds have also been counted for years. Vole population variation is studied for years, in relation to raptors and owls. The invertebrate sampling is just starting up, but might be an interesting new instrument. In appendix VI the levels in the pyramid and the work that is carried out on these levels is placed in a scheme, with the underlying background for it.

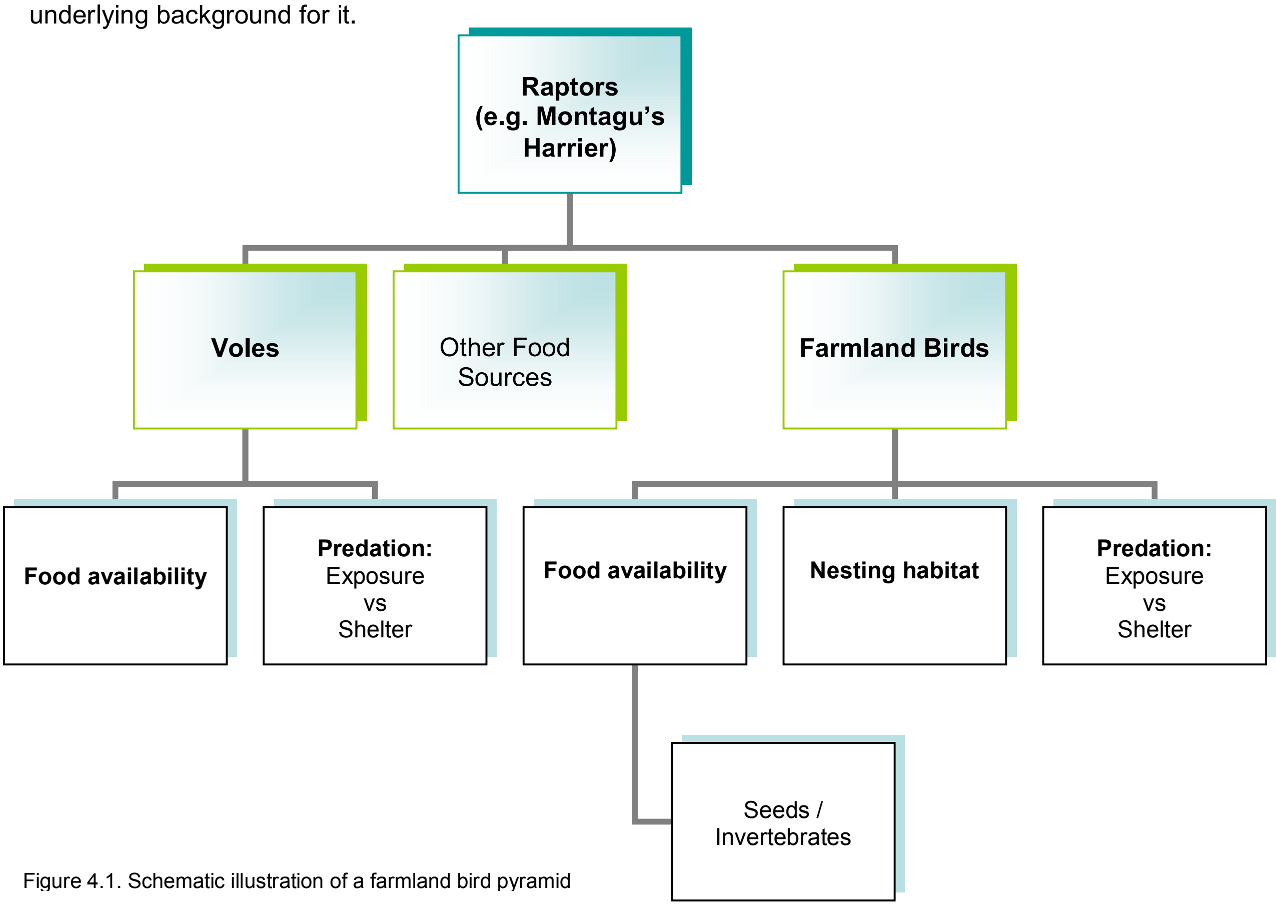



Figure 4.1. Schematic illustration of a farmland bird pyramid

The invertebrate composition needs to be surveyed during the whole breeding season, because the invertebrate survey in this research was carried out during a restricted period of time at the end of the breeding season (end of July – beginning of August). In a study carried out on invertebrates in fauna strips in 2005, the authors concluded that there were large differences in the invertebrate community between May and July; in which July have the largest numbers (Haveman et al, 2005). This would imply that the numbers found in this study would be numbers that correspond to the period in which most invertebrates are found. Sampling should start before the start of the breeding season lasting through the whole breeding. This is important, because parameters and abundances might change during the breeding season. Sampling more habitats is also required, because weather and time constraints made that the sampling in this study has been limited to a small selection. For instance ditch banks, inland dykes with grazing, barley and a wider variety of fauna strips would improve the food abundance picture through the whole landscape. An intensified study on the invertebrate prey items of Wagtails is also desirable, because there is limited literature available. For instance *Gastropoda* are also not mentioned as farmland bird prey items (Roder and Bijlsma, 1984; Davies 1977 and Winspear and Davies, 2005), but they do form the second most important group in plot sampling (after *Diptera*). It is interesting to find out whether they might play a different role in these habitats or that they do serve as prey item for some birds that have not been studied much.

Further research is needed to gain insight in which habitat types Yellow Wagtails and other farmland birds forage during the whole breeding season and if this changes during the breeding season. Also a broader ranged study on the factors that determine nesting locations is recommendable. Such a study should include: invertebrate sampling starting before arrival of the Wagtails (and other farmland birds) from wintering grounds and duration of sampling up to the end of the breeding season, study on vegetation parameters and parameter change during the breeding season, possible predation pressure and nesting habitat preferences. It is also interesting to study whether second or third nests (also for other farmland bird species) are located on different locations and what factors might explain this nest location change.
The functioning of fauna strips needs more and in depth research. The results in this study were not in line with each other. Fauna strip cover did not show a relation with breeding densities, while food availability index does. Food availability index is partially based on fauna strip presence. The analysis with fauna strip presence and absence data showed differences between both groups. No distinction could be made between different types of fauna strips. In other parts of the province of Groningen experiments have been carried out with other types of fauna strips. All these different types function differently for different farmland bird species.

Quantitative and qualitative data analysis is needed to eventually develop optimal functioning nature conservation measures. This then should be combined with sufficient quantities of the developed nature conservation measures. Eventually this should all lead to a halt in the decline in farmland bird species and instead should build a healthy farmland bird pyramid.

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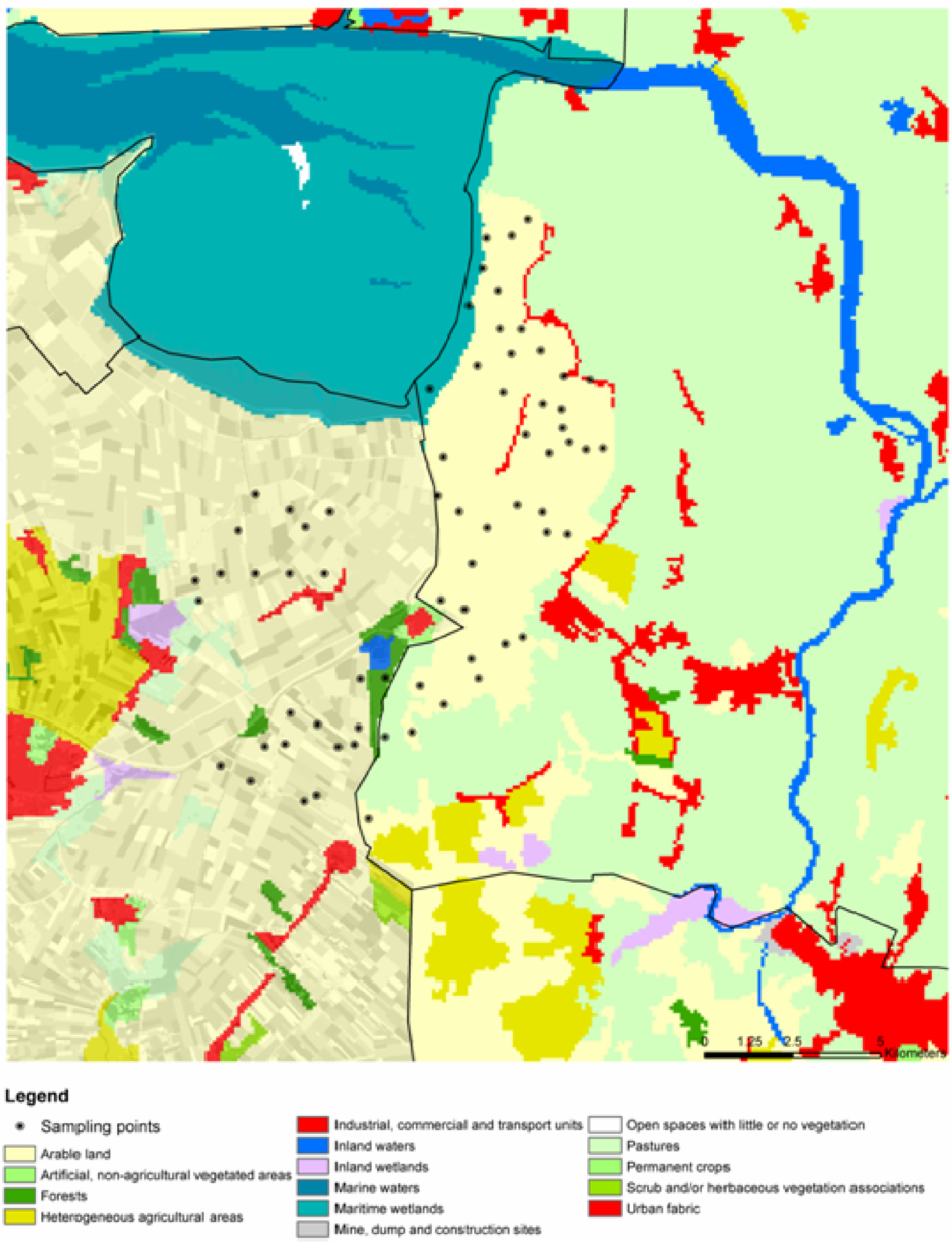
**Appendix I. Overview of and land use in the study area**



**Appendix II. Standardized field form for breeding bird and habitat survey**

**Veldformulier Punttelling Werkgroep Grauwe Kiekendief**

| | |
|---|---|
| Puntnummer | |
| Amersfoort X | |
| Amersfoort Y | |

| | |
|---|---|
| Bezoeknummer | |
| Datum | |
| Tijd | |

| | |
|---|---|
| Waarnemer | |

Opmerkingen (storing, veranderingen etc.)

WEER (omcirkel juiste waarde)

| | |
|---|---|
| Bewolking | 0-25% 26-50% 51-75% 76-100% |
| Windrichting | N NO O ZO Z ZW W NW |
| Windkracht | geen zacht matig hard zeer hard |
| Neerslag | geen miezer regen harde regen hoosbui |
| Zicht | goed matig slecht |

| SOORT | BP | BP+J | JONG | NB | overvliegend |
|---|---|---|---|---|---|
| Gele kwikstaart | | | | | |
| Veldleeuwerik | | | | | |
| Graspieper | | | | | |
| Kievit | | | | | |
| Wilde eend | | | | | |
| Blauwborst | | | | | |
| Geelgors | | | | | |
| Boerenzwaluw | | | | | |
| Fazant | | | | | |
| Zwarte kraai | | | | | |
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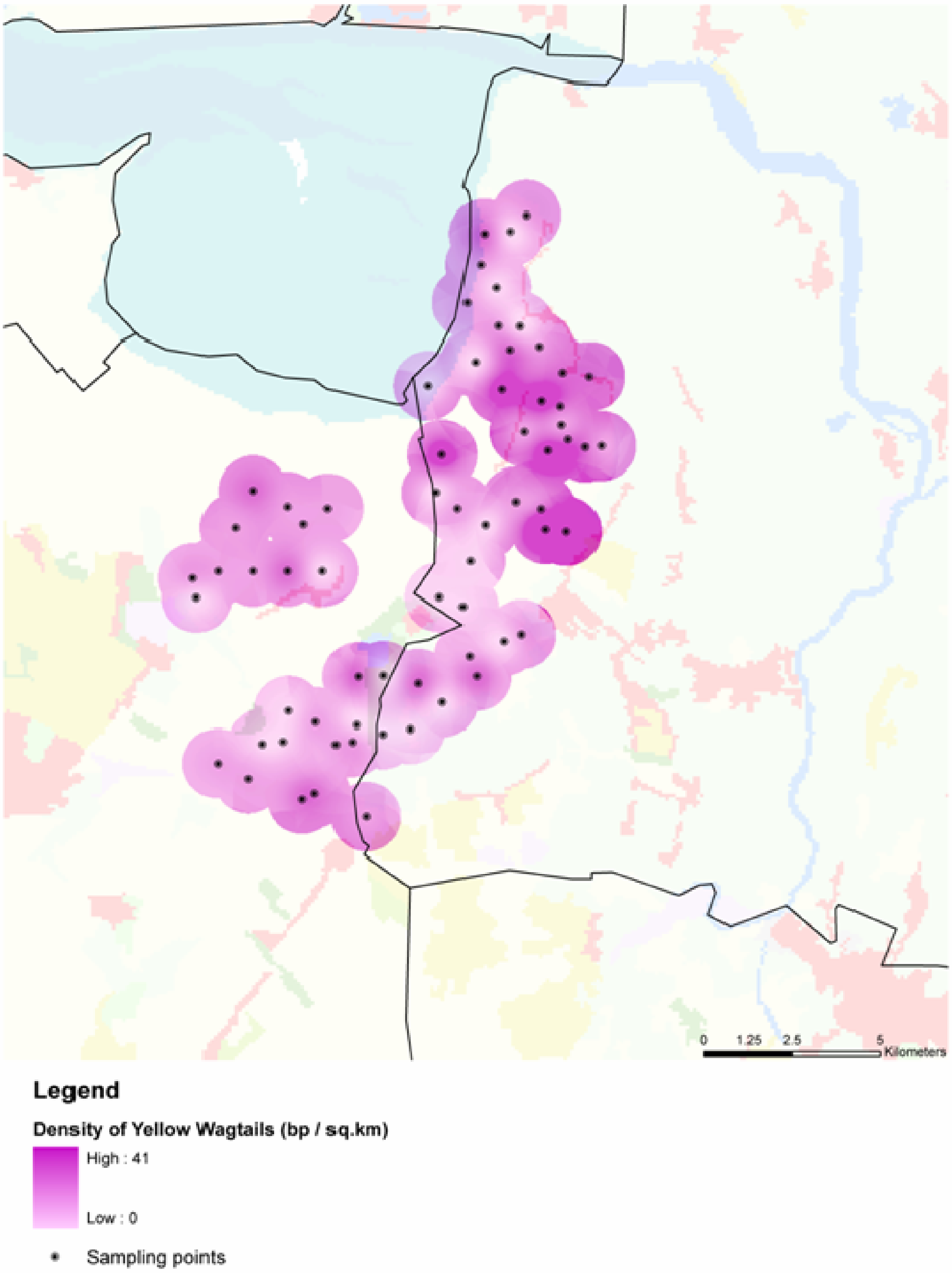
Toelichting:

| | |
|---|---|
| BP: | Broedparen |
| BP+J: | Broedparen met jongen |
| JONG: | Aantal jongen bij BP+J |
| NB: | Niet Broedende individuen |

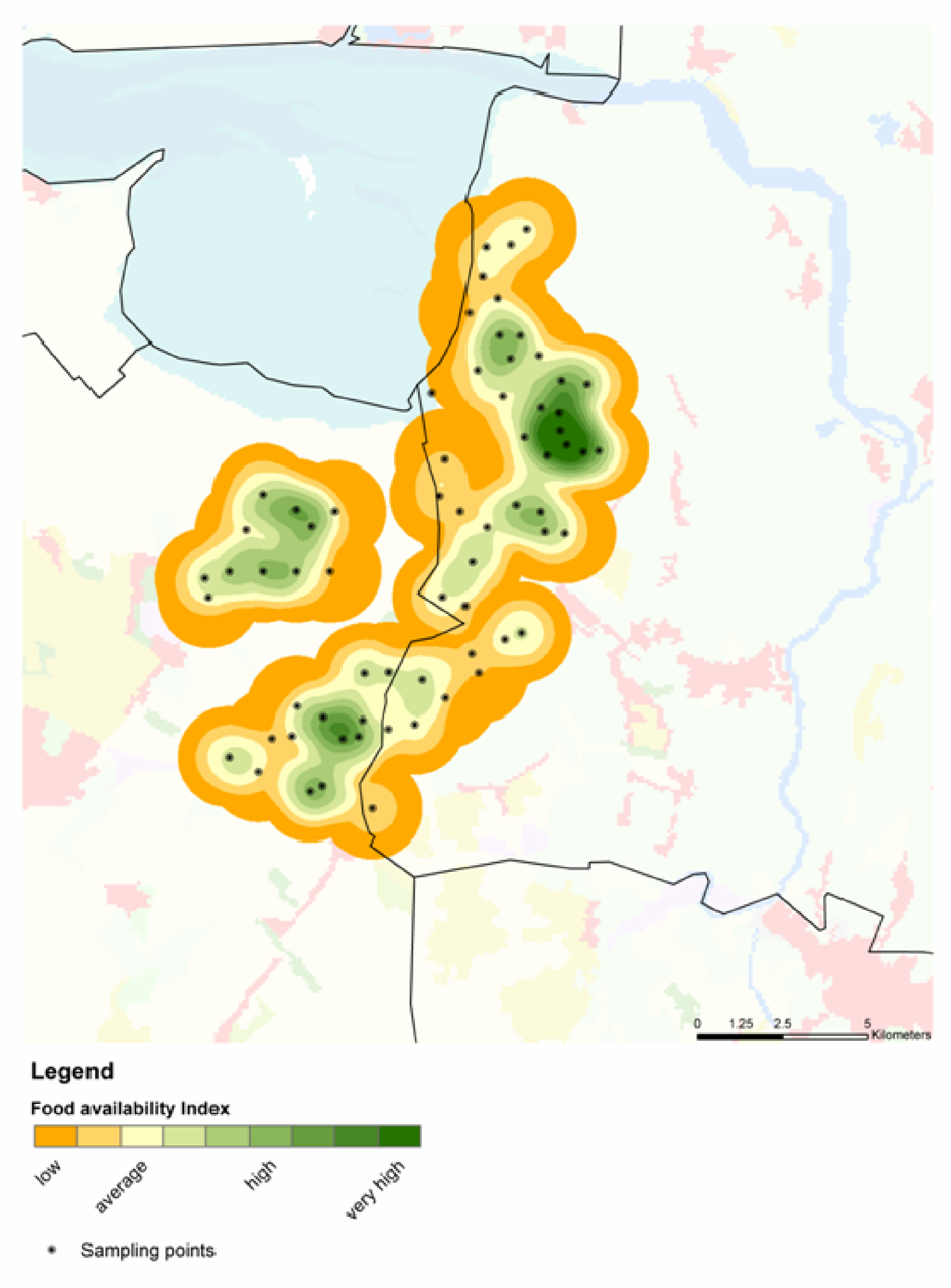
| KIEKENDIEVEN | Binnen waarnemingscirkel | | | Buiten waarnemingscirkel | | |
|---|---|---|---|---|---|---|
| | man | vrouw | juveniel | man | vrouw | juveniel |
| Grauwe kiekendief | | | | | | |
| Bruine kiekendief | | | | | | |
| Blauwe kiekendief | | | | | | |
| | | | | | | |
| | | | | | | |

| Zoogdieren etc. | |
|---|---|
| Haas | |
| Ree | |
| Muis | |
| | |
| | |
| | |

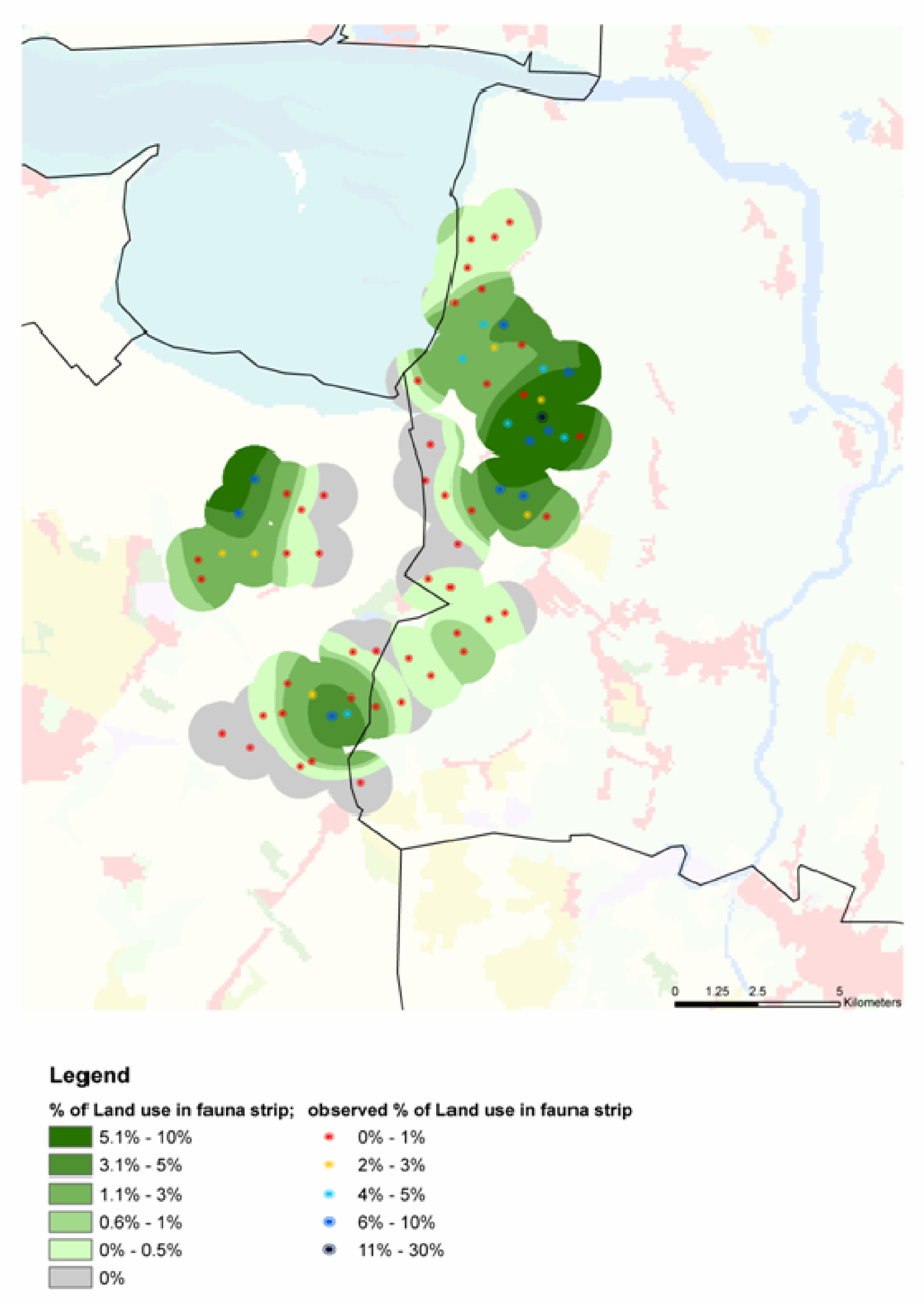
## Appendix III. Distribution map for the Yellow Wagtail



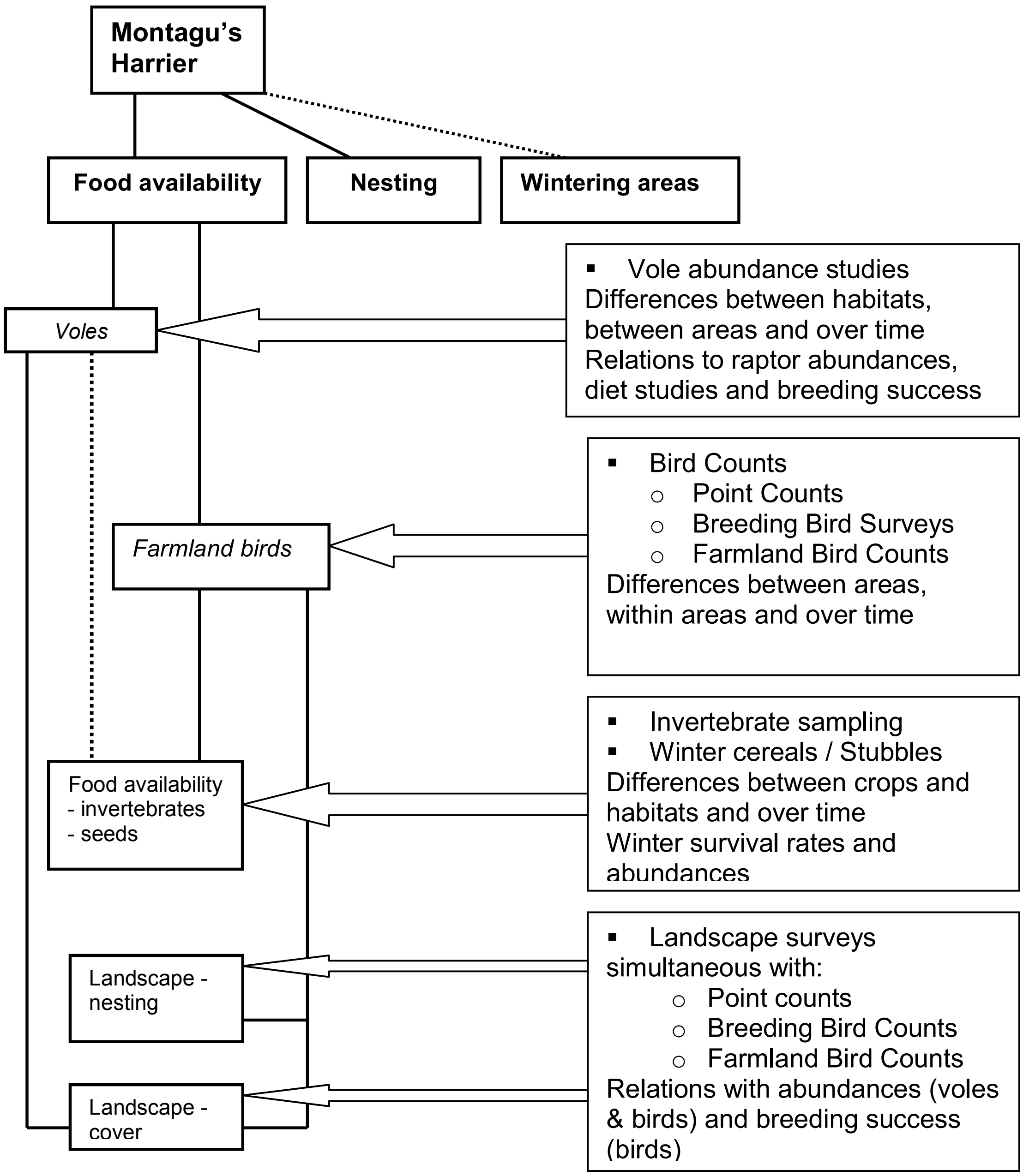
**Appendix IV. Food availability index map**



**Appendix V. Map of fauna strip percentage in the land use**



**Appendix VI. Research work by the Dutch Montagu's Harrier Foundation in relation to Farmland Birds in their working areas**



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To start at the beginning: they always say networking is THE way to get to things. They are right. On a common Thursday evening Joost Brouwer held a speech in Wageningen on the field trip the Dutch Montagu's Harrier Foundation made to Niger. Just being interested I could never have imagined that attending a speech could lead to a very interesting internship and four exciting months in the field. Therefore I have to start with thanking him for informing me on the research project available within the Dutch Montagu's Harrier Foundation and also giving advice during the whole period. Ben Koks apparently saw something in that strange creature from the south of the Netherlands and made it eventually all possible. On a day long before the start of the project we drove around and although the Montagu's Harriers were still in Africa, his stories were so enthusiastic that I could not wait to start. And that did not change….He also supplied me with ideas, tips, literature, comments, inspiration and guidance during the whole period.
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Photo: Aafke van Erk