Habitat selection of the Corncrake (*Crex crex*) in floodplains along the Dutch Rhine River branches

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PREFACE

This report is the product of a six months research project at the Department of Environmental Science of the Radboud University Nijmegen in collaboration with SOVON Dutch Centre for Field Ornithology. This project was embedded in the research programme of the Netherlands Centre for Nature Research (NCN). Subject of the report is habitat selection of the Corncrake (*Crex crex*) in floodplains along the Dutch Rhine River branches in the period 2001-2007. With this report I hope to contribute to extending the knowledge about the mysterious Corncrake.
Before starting this internship I had never heard about the Corncrake. Meanwhile, I know the bird and have even heard one in the Erlecomse waard during a cycle trip. But I have, like many bird watchers, never seen it. This project could be implemented due to availability of basis data collected by volunteer bird watchers and SOVON Dutch Centre for Field Ornithology. The research was a good opportunity to extend my knowledge about Corncrake characteristics, conservation measures, interviewing nature managers, planning and implementing a research project, and working with computer programmes as Geographic Information System (GIS) and Excel.
Several persons have contributed to the realisation of this report. Firstly, I would like to thank Johan Bekhuis from ARK Natuurontwikkeling, Jan Floor from the municipality of Arnhem and Jan Schoppers from SOVON Dutch Centre for Field Ornithology for their useful help and information. Secondly, I thank my supervisors Aafke Schipper and Rob Leuven from the Department of Environmental Science of the Radboud University and Kees Koffijberg from SOVON Dutch Centre for Field Ornithology for the data supply and their support.

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SUMMARY IN DUTCH

Kennis van de ecologie van de Kwartelkoning specifiek voor Nederland is nodig om de beschermingsmaatregelen zo goed mogelijk aan de Kwartelkoning aan te passen. Dit project had als voornaamste doel de habitatselectie van de Kwartelkoning te relateren aan ecotoopkarakteristieken (bv. ecotoopverdeling, ecotoopdiversiteit en patchiness) en overstromingsfrequentie van de uiterwaarden langs de Nederlandse Rijntakken. Daarnaast had het als doel de mogelijke gevolgen van herinrichtingsmaatregelen op de beschikbare hoeveelheid habitat voor de Kwartelkoning te onderzoeken.

Coördinaten van roepplekken van Kwartelkoningmannetjes van de jaarlijkse tellingen in 2001-2007 door SOVON Vogelonderzoek Nederland werden gebruikt om verspreidingskaarten in GIS (ArcGIS 9.2) te maken. Deze verspreidingskaarten werden op de ecotopenkaart van 2005 gelegd om de verspreiding van roepende Kwartelkoningmannetjes over de ecotooptypen te analyseren. Vervolgens werden de verspreidingskaarten in GIS op een uiterwaardenkaart gelegd, zodat de bezettingsfrequentie van alle uiterwaarden langs de drie Rijntakken kon worden bepaald. De uiterwaardenkaart werd ook overlegd met de ecotopenkaarten van 1997 en 2005 om het gemiddelde van de ecotoopkarakteristieken voor de uiterwaarden met een verschillende bezettingsfrequentie te kunnen berekenen, om de gemiddeldes van de ecotoopkarakteristieken tussen de drie Rijntakken te kunnen vergelijken en om de veranderingen in de gemiddeldes van de ecotoopkarakteristieken tussen 1997 en 2005 te kunnen bepalen voor de drie Rijntakken.
Kaarten met de homeranges van 18 gezenderde Kwartelkoningen werden van SOVON Vogelonderzoek Nederland gekregen. Deze kaarten werden in GIS bovenop de ecotopenkaart van 2005 gelegd om de verspreiding van de gepeilde locaties over de ecotooptypen te bepalen en om de ecotoopkarakteristieken van elke homerange afzonderlijk te berekenen. De resultaten werden gebruikt voor het valideren van de output van de ecotoopverspreidingsanalyse.
De habitatselectie van Kwartelkoningen in relatie tot de overstromingsfrequentie werd geanalyseerd met twee verschillende methoden. Allereerst werden de verspreidingskaarten met de roepplekken van Kwartelkoningmannetjes op een inundatiekaart gelegd in GIS. Bij de tweede methode werden de roepplekken verdeeld over hydrodynamisch klassen gebaseerd op de verdeling van de roepplekken over de ecotooptypen. Kaarten van twee 'Ruimte voor de Rivier' plannen en de verspreidingskaarten werden in GIS op elkaar gelegd om de mogelijke gevolgen van herinrichtingsmaatregelen op de beschikbare hoeveelheid habitat voor de Kwartelkoning te onderzoeken.

De belangrijkste conclusies van het onderzoek worden hieronder genoemd:

- Uiterwaardruigte, uiterwaardproductiegrasland, natuurlijk uiterwaardgrasland, uiterwaardgrasland (natuurlijk/productie) en overstromingsvrij productiegrasland bleken geschikt habitat te zijn voor de Kwartelkoning in de uiterwaarden langs de Rijntakken. Daarnaast gaven de Kwartelkoningen de voorkeur aan habitat met een lage overstromingsfrequentie.
- Het zenderonderzoek bevestigde de voorkeur voor uiterwaardproductiegrasland, natuurlijk uiterwaardgrasland en uiterwaardgrasland (natuurlijk/productie), maar niet de voorkeur voor uiterwaardruigte.
- In dit onderzoek werd geen significante seizoensverschuiving in ecotoopvoorkeur gevonden, hoewel het percentage roepplekken in productiegrasland en natuurlijk grasland daalde en in uiterwaardruigte steeg gedurende het seizoen.
- Overdag werden minder gepeilde locaties gevonden in ecotopen die waren gedefinieerd als geschikt habitat dan gedurende de nacht. Dit versterkt de aanname dat de mannetjes overdag hun roepplek verlaten om voedsel te zoeken en hun territorium uit te breiden, terwijl ze in de avond teruggaan naar hun roepplek in het geschikte habitat.
- Kwartelkoningen selecteren uiterwaarden met een grotere oppervlakte (ha), wat kan worden gerelateerd aan de significant grotere hoeveelheid aan geschikt en marginaal habitat (ha) in deze uiterwaarden. Daarnaast geven Kwartelkoningen de voorkeur aan heterogene uiterwaarden met voldoende grote patches die niet veel in grootte verschillen.
- De totale oppervlakte aan geschikt habitat voor de Kwartelkoning blijkt tussen 1997 en 2005 flink te zijn afgenomen in de uiterwaarden langs alle drie Rijntakken. Dit gebeurt waarschijnlijk ook in natuurontwikkelingsgebieden, waar het lijkt bij te dragen aan de verdwijning van de Kwartelkoning na een aantal jaren.
- Gedurende de eerste jaren van de zeven jaar lange monitoringsperiode (2001-2007) werd het hoogste aantal roepende Kwartelkoningmannetjes gehoord in de uiterwaarden langs de Waal, maar de laatste jaren zijn de

uiterwaarden langs de IJssel duidelijk populairder dan die langs de Rijn en Waal. De resultaten van deze studie geven geen verklaring voor deze verschuiving in voorkeur van de Waal- naar de IJsseluiterwaarden.

- Veel van de ‘Ruimte voor de Rivier’ projecten langs de IJssel zullen worden uitgevoerd in uiterwaarden die in de periode 2001-2007 een hoge bezettingsfrequentie van de Kwartelkoning hadden. Daarnaast zullen de projecten worden uitgevoerd in een kort tijdsbestek (2009-2015). Dit kan een bedreiging vormen voor de Kwartelkoning, omdat in één keer een groot deel aan Kwartelkoninghabitat verloren gaat.

SUMMARY

Knowledge of the ecology of the Corncrake specifically for the Netherlands is needed to adapt the conservation measures as well as possible to the Corncrake. This study aimed to assess habitat selection of the Corncrake in relation to ecotope characteristics (e.g. ecotope distribution, ecotope diversity and patchiness) and frequency of inundation of the floodplains along the Dutch Rhine River branches. Furthermore, it aimed to assess possible implications of reconstruction measures for the availability of breeding habitat for the Corncrake.

Coordinates of Corncrake male singing sites of the yearly surveys from 2001-2007 obtained by SOVON Dutch Centre for Field Ornithology were used to make distribution maps in GIS (ArcGIS 9.2). The ecotope map 2005 was overlaid by these distribution maps to asses the distribution of singing Corncrake males over ecotope types. A floodplain map was in GIS overlaid by the distribution maps to determine the occupation frequency of all floodplains along the three Rhine River branches during the seven year monitoring period. Subsequently, the floodplain map was overlaid by the ecotope maps of 1997 and 2005 to calculate the mean of ecotope characteristics, like suitable habitat area (ha) and density of patches (N/ha), for floodplains with different occupation frequencies, to compare the means of ecotope characteristic between the three Rhine branches and to study possible changes in ecotope characteristics for the three Rhine branches between 1997 and 2005.
Maps with home ranges of 18 radio tracked Corncrake males were obtained by SOVON Dutch Centre for Field Ornithology. The ecotope map of 2005 was overlaid by these home ranges in GIS to determine the distribution of the records over the ecotope types and to calculate the ecotope characteristics of each home range, separately. The results were used to validate the output of the ecotope distribution analysis.
The habitat selection of Corncrakes in relation to inundation was analysed by two different methods. Firstly, an inundation map was overlaid by the Corncrake male distribution maps in GIS. Secondly, the singing sites were distributed over hydrodynamic classes based on the distribution of the singing sites over the ecotope types.
Maps of two ‘Room for the River’ plans were overlaid by the distribution maps in GIS to analyse possible implications of reconstruction measures for the availability of breeding habitat for the Corncrake.

The main conclusion derived from the results of this study are mentioned below:

- Herbaceous floodplain, floodplain production meadow, floodplain natural pasture, floodplain grassland (natural/production) and high-water-free production meadow appeared to be suitable habitat for the Corncrake in the floodplains along the Dutch Rhine River branches. Furthermore, the Corncrakes preferred habitat with a low frequency of inundation.
- The tracking study confirmed the preference for floodplain production meadow, floodplain natural pasture and floodplain grassland (natural pasture/production meadow), but not the preference for herbaceous floodplain.
- This study showed no significant seasonal shift in ecotope preference, although the percentage of singing sites in production meadow and natural pasture decreased and in herbaceous floodplain increased during the season.
- During the day a smaller share of records was found in ecotopes defined as suitable habitat than during the night, which confirms the presumption that during the day the males leave their singing site to search for food and extending their territory, while they go back in the evening to their singing site in the suitable habitat.
- Corncrakes obviously selected floodplains with a larger surface area (ha), which could be related to the significantly higher amount of suitable and marginal habitat (ha) in these floodplains. Furthermore, Corncrakes prefer heterogeneous floodplains with sufficiently large patches that do not differ very much in size.
- Between 1997 and 2005 the total surface area of suitable habitat for the Corncrake has been strongly decreased in the floodplains along all three Rhine River branches. This seems also to happen in ecological restoration areas, contributing to the disappearance of the Corncrake out of ecological restoration areas after a number of years.
- During the first years of the seven year monitoring period (2001-2007) the highest number of Corncrake male singing sites was harboured by the floodplains along the Waal, but during the last years the floodplains along the IJssel were obviously more popular than the floodplains along the Rhine and Waal. The results of this study give no explanation for this shift in preference of the Corncrake males from the Waal to the IJssel floodplains.
- Many of the ‘Room for the River’ projects along the IJssel will be executed in floodplains with a high occupation frequency of the Corncrake in the period 2001-2007. Moreover, the projects will be implemented within a short time span (2009-2015). This may be a threat for the Corncrake, because a large part of the Corncrake habitat will be lost at once.

1. INTRODUCTION

1.1 Description of the species

The Corncrake (*Crex crex*) belongs to the family of rails (*Rallidae).* The bird (Figure 1) is closely related to the Eurasian coot (*Fullica atra*), common moorhen (*Gallinula chloropus*) and the water rail (*Rallus aquaticus*). The scientific name is derived from the characteristic singing '*crex crex*' of the male birds.

Figure 1: the Corncrake (From: www.kwartelkoning.nl).

The Corncrake is a migratory bird, breeding in Europe. The breeding habitat is distributed over West-, North- and Central Europe (Schäffer & Koffijberg, 2004). It spends the winter in tall grasslands, hay fields and savannah in East and South-East Africa.

In many areas the numbers of Corncrakes show a strong annual fluctuation, but it is clear that mainly in North- and West-Europe a long-term decline occurs. Because of the decreasing trend, the extension of this trend and local extinction, the species is included in the Red List of many European countries. Globally speaking its status is near threatened (BirdLife International, 2004).

The Corncrake has, contrary to most other birds, a late breeding season. It arrives mid April/early May in Europe to breed. The males arrive first, followed by the females a few days later (Schäffer, 1999). After arrival in the breeding area, a male Corncrake starts singing to attract a female. This singing mainly takes place during the late evening and the early night. When a male has attracted a female, the singing activity decreases (Tyler & Green, 1996). The eggs are laid in a nest of dry leaves on the ground. The mean clutch size is 10 eggs and the female lays one or two eggs per day (Schäffer & Koffijberg, 2004). The eggs hatch after 16-19 days. The male leaves the nest when the female starts with laying eggs and the female after about two weeks of parental care. Both the male and the female are polygamous and two clutches are laid per breeding season. Thus, after leaving the nest they will search for a new partner. In the end of July and the beginning of August, the birds start to moult and can not fly for two to three weeks (Green *et al*., 1997). The Corncrakes leave the breeding habitat migrating to Africa in the end of August and in September.

1.2 General status of the Corncrake

The Corncrake population of West- and North-Europe started to decline in the mid 19th century, and from 1950 this decline accelerated. Mechanisation of the agricultural practice, earlier mowing dates and loss of habitat are the most important causes of this negative trend (Green *et al.,* 1997; Royal Society for the Protection of Birds, 2007c).

Early cutting dates decrease the amount of available habitat at the beginning of the breeding period. In addition, mowing during the breeding period increases the mortality of mainly Corncrake chicks and leads to nest destruction and losses of eggs. Improved drainage and mowing machinery and increased fertilizer applications in combination with dry weather conditions in spring made this early mowing possible. In addition, hay fields changed to silage production allowing earlier cutting dates and two yields per year. In the United Kingdom the hay fields were further reduced by increased sheep stocking (Irish Peatland Conservation Council, 2001). The Corncrake would have been disappeared in the UK and other West-European countries without conservation measures.

Throughout North and Central Europe the trends in number of Corncrakes are highly similar (Koffijberg, not published yet). Since 1995 an increase in Corncrakes has been visible and the yearly fluctuations are also quite similar. Probably, the Corncrake populations in these countries have benefited from an increase in breeding habitat in East-Europe due to the collapse of the collective farming systems (Schäffer & Green, 2001). The UK reached a low point in 1994 (Royal Society for the Protection of Birds, 2007b). Since then, the population increased, probably as a result of conservation measures. The grazing and mowing regime was changed to provide areas of vegetation cover throughout the breeding season, Corncrake Friendly Mowing (CFM) was implemented, and advice and a financial compensation were given to farmers. The number of Corncrakes increased, and in 2007 the number of Corncrakes was the highest of almost three decades. But the distribution area did not increase since the start of the conservation measures. Hence, re-introduction projects have been implemented in South-East England (Royal Society for the Protection of Birds, 2007a).

It is remarkable that France and Ireland show other population trends, regarding development in number of Corncrakes, compared to the rest of Europe (Koffijberg, not published yet). These areas showed no general increase in the mid 1990s.

Nowadays, the Corncrake breeds in 34 European countries. Conservation measures are implemented in several European countries to protect the Corncrake. For some countries, including the Netherlands, even special conservation schemes have been designed (Gerritsen *et al*., 2004). The measures focus on enhancing the survival of nests, chicks and moulting birds. The Corncrake needs a high reproduction rate, because the annual survival rate is only 0.2-0.3 (Schäffer & Green, 2001). The conservation measures consist of delay of mowing activities to the beginning of August or later, reducing the mowing speed, mowing fields from the inner towards the outer parts, leaving strips unmown, and mosaic mowing. Due to these conservation measures, the last ten years a strongly fluctuating, but positive trend has been visible (Royal Society for the Protection of Birds, 2007b; Schoppers & Koffijberg, 2004).

1.3 Status of the Corncrake in the Netherlands

In the Netherlands, the Corncrake core areas mainly consist of the floodplain meadows along the large rivers, valleys of brooks in Drenthe and arable land in Nord-East Groningen and Flevoland (Schoppers & Koffijberg, 2007). The Corncrakes prefer low dynamic structure rich grasslands with a late mowing date as habitat. In addition, a large percentage of the Dutch Corncrake population is present in arable land with crops (Schoppers & Koffijberg, 2001, 2003, 2004, 2005, 2006, 2007, 2008).

Like elsewhere in Europe, the Dutch Corncrake population is also threatened by the mechanization of the agricultural systems, early and synchronous mowing dates and habitat loss. To know where conservation measures have to be implemented, each year from 2001 simultaneous surveys have been organized in the core areas by SOVON Dutch Centre for Field Ornithology. Besides the location of the singing site, also data concerning habitat, management type and owner are stored during the surveys (Schoppers & Koffijberg, 2001, 2003, 2004, 2005, 2006, 2007, 2008). Figure 2 shows the numbers of Corncrake territories (N) in four core areas and in the Netherlands as a whole over the years. Since 1997/1998 a strongly fluctuating recovery has been visible, but 2004-2006 were no good Corncrake years, with a low point of only 85 territories in the Netherlands in 2006. In 2007 a strong recovery was visible. This trend is visible not only in the Netherlands, but also in other European countries (Schoppers & Koffijberg, 2007).

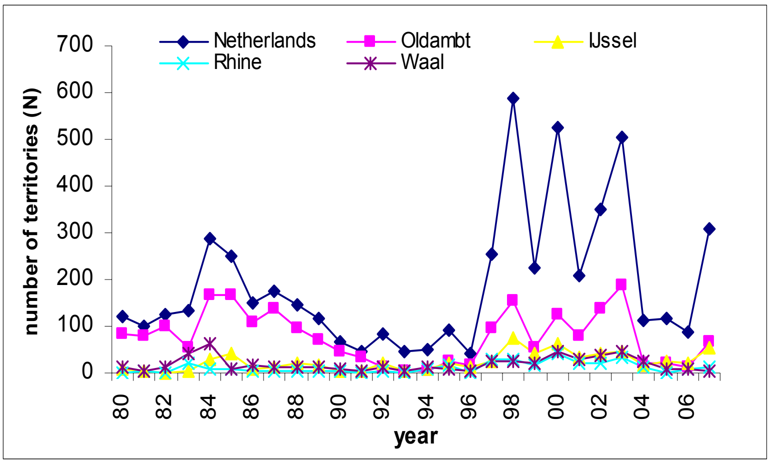

Figure 2: number of territories in the Netherlands, Oldambt and the floodplains along the Rhine, Waal and IJssel over the years.

Due to the surveys of SOVON Dutch Centre for Field Ornithology, mowing activities can be delayed and adaptations in mowing regime are stimulated at singing sites. The organization also gives advice to nature managers and farmers about the desired management in Corncrake areas.

1.3.1 Reconstruction and management measures influencing the availability of Corncrake habitat

Because the rivers in the Netherlands are expected to have higher peak discharges in the future, measures are taken to lower the water level during these high water periods. This should reduce the risk on heavy floods. Most of the projects belong to the 'Room for the River' programme (Ministerie van Verkeer en Waterstaat, 2006). The projects will be implemented in the floodplains along the Dutch Rhine branches, i.e. a core area for the Corncrake.

Reconstruction measures as part of 'Room for the River' and management measures like grazing will possibly have an impact on the habitat available for the Corncrake. So, it is important to account for the Corncrake during the design and implementation of these projects. However, knowledge about the impact of these measures on Corncrake occurrence in the floodplains along the Dutch Rhine tributaries is lacking. Only some general research about reconstruction and management measures has been done that can be related to the Corncrake.

1.4 Scope of research

Knowledge about the behaviour of Corncrakes and observations of females, nests and chicks in the Netherlands is scarce (Gerritsen *et al.*, 2004). The bird is very secretive, spending most of the time hidden in tall vegetation. Surveys have to be done by ear and radio tracking studies are needed to get detailed information about the behaviour of the bird (Green *et al*., 1997). Much research on the ecology of the Corncrake is done outside the Netherlands, mainly in the United Kingdom. In 2007, for the first time, a radio tracking study has taken place in the Netherlands to study habitat use and the reaction of Corncrakes on conservation measures (Koffijberg *et al.*, 2007).
Knowledge of the ecology of the Corncrake specifically for the Netherlands is needed to adapt the conservation measures as well as possible to the Corncrake. Atsma (2006) has made a start with a study to assess habitat selection in relation to ecotope distribution and landscape composition in the Dutch Rhine floodplains. The present study is a continuation and extension of his work. Firstly, it aims to assess habitat selection of the Corncrake in relation to ecotope characteristics (e.g. ecotope distribution, ecotope diversity and patchiness) and frequency of inundation of the floodplains along the Dutch Rhine River branches. Secondly, it aims to assess possible implications of reconstruction measures for the availability of breeding habitat for the Corncrake.

The central research question is:
How is habitat selection of the Corncrake related to ecotope characteristics and frequency of inundation of the floodplains along the Dutch Rhine River branches and what could be the implications of reconstruction measures for the availability of breeding habitat?

The research questions derived from this central question are:

1. What were the geographical distribution and frequency of occurrence of singing Corncrake males in the floodplains along the Dutch Rhine River branches in the period 2001-2007?
2. Are there differences in ecotope distribution, landscape diversity and patchiness between floodplains that were occupied by singing Corncrake males in 0, 1, 2, 3, 4, 5, 6 or 7 of the years 2001-2007?
3. Which ecotopes are preferred by the singing Corncrake males on various temporal scales (seasonal and annual)?
4. Is the distribution pattern of singing Corncrake males related to ecotope turnover?
5. Is the home range of singing Corncrake males related to ecotope characteristics?
6. Is the distribution pattern of the singing Corncrake males related to frequency of inundation of the ecotopes/floodplains?
7. What could be possible implications of reconstruction measures for the availability of breeding habitat for the Corncrake?

1.5 Research approach and outline of the report

Below, the research approach to answer the research questions will be explained with help of the flow chart in Figure 3. The rounded rectangles represent GIS-maps and the rectangles represent results which are processed in Excel. The numbers represent the different actions.

1. From 2001, SOVON Dutch Centre for Field Ornithology has been organizing national simultaneous surveys of Corncrake singing sites in all core breeding areas two times per year. The coordinates of the singing sites were implemented in GIS according to the method of Atsma (2006). Of each year separately and all years together distribution maps were made.
2. The floodplain map was overlaid by the distribution maps to get the number of years the floodplains were occupied and the annual and total number of singing sites per floodplain.
3. The floodplain map was overlaid by the ecotope maps of 1997 and 2005 separately. Subsequently, for both ecotope maps the ecotope characteristics were calculated per floodplain with GIS and Excel.
4. The number of years occupied was plotted against the means of the ecotope characteristics for the ecotope map of 2005. The ecotope characteristics of the 1997 ecotope map were compared with those of the 2005 ecotope map for the Rhine branches.
5. The ecotope map of 2005 was overlaid by the Corncrake male singing sites distribution maps. The number of singing sites per type of ecotope (annual/seasonal) was determined.
6. As each ecotope can be linked to a hydrodynamic class, the singing sites per type of ecotope (step 5) were used to obtain the number of singing sites per hydrodynamic class.
7. The inundation map of 1997 was overlaid by the Corncrake male singing sites distribution maps to determine the number of singing sites per inundation class.

8. Home range maps of 18 radio tagged males were available in GIS. The home range maps were overlaid by the ecotope map of 2005. The distribution of the tracked locations over the ecotopes was determined and the ecotope characteristics per home range were calculated with GIS and Excel.
9. Maps of two ‘Room for the River’ plans were overlaid by the Corncrake male singing sites distribution maps in GIS to get the singing sites situated in the two ‘Room for the River’ project areas.

Results are presented in chapter 3. After statistical analyses the results are discussed (chapter 4). The research questions are answered in the conclusions section (chapter 5.1). Finally, recommendations are made for conservation measures and further research (chapter 5.2).

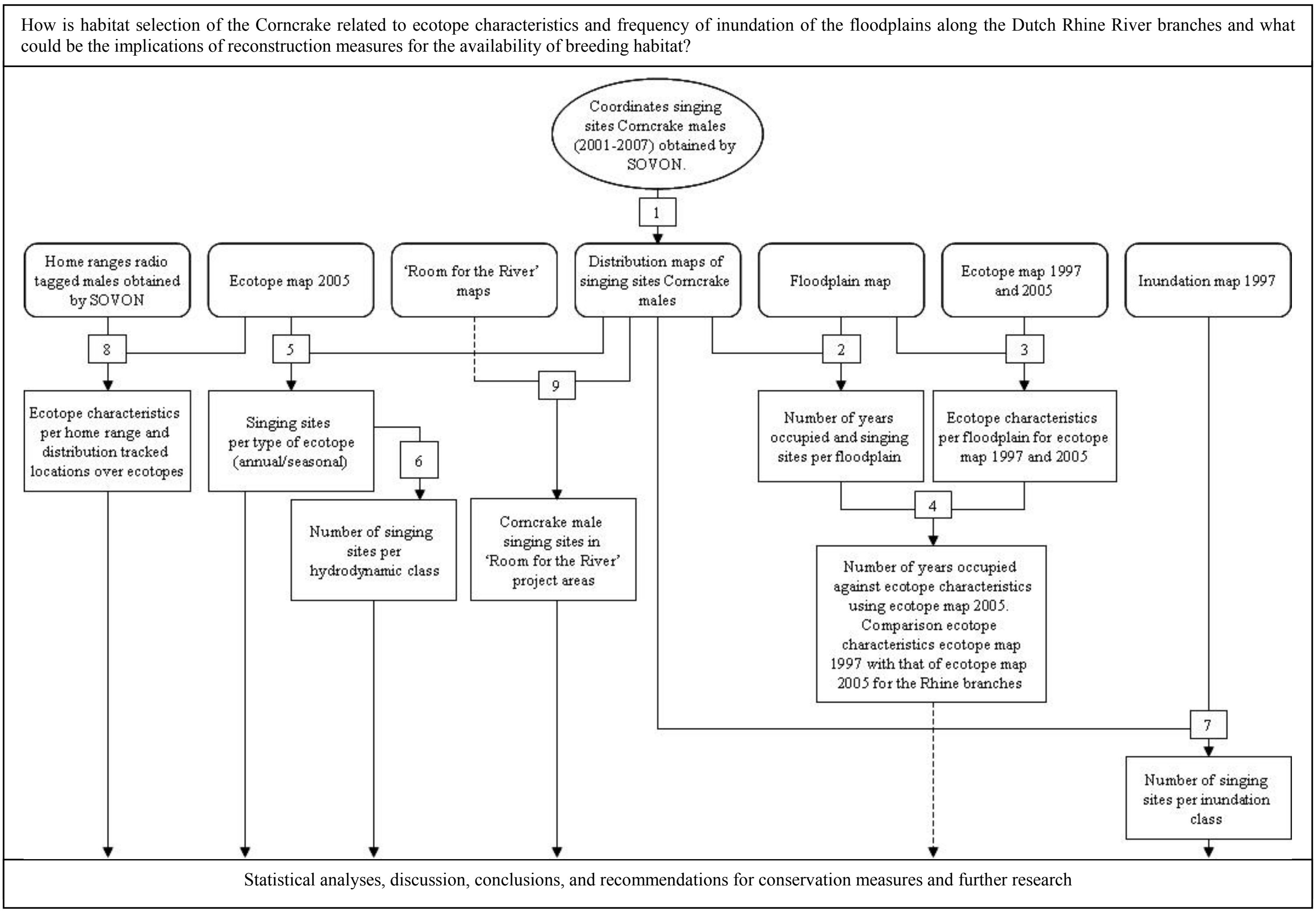

Figure 3: Outline of the study. Rounded rectangles represent GIS-maps and the rectangles represent results which are processed in Excel. The numbers represent the different actions mentioned in *1.5 Research approach and outline of the report*.

2. MATERIALS AND METHODS

2.1 Survey method

The research area comprises the floodplains of the Dutch Rhine River branches: Rhine, Waal and IJssel. From 2001 onwards, every year during the breeding season two simultaneous surveys (around 1 June and around 20 June) have been carried out by 100-150 volunteers from SOVON Dutch Centre for Field Ornithology in these areas (Schoppers & Koffijberg, 2001, 2003, 2004, 2005, 2006, 2007, 2008). The surveys took place at all known core areas and were done in the late evening and early night, during the period of highest singing activity. The Corncrake is a very secretive species, therefore it has to be monitored by ear. The watchers draw the singing site of a bird on a topographic map (1:25000). To prevent double counting, the watcher has also to indicate his/her position on the map and connects this with the singing position of the bird by a dotted line (Schoppers & Koffijberg, 2001). The watchers send their results to SOVON Dutch Centre for Field Ornithology. Observations outside the simultaneous surveys are also collected. All observations are stored in a database. The singing sites get a number and coordinates and are linked to GIS with additional information (e.g. date, owner, date of mowing). In some cases the singing sites are reported as grid cells. These singing sites get the coordinates of the lower left corner of the corresponding grid cell.

To assess population size, the singing sites are clustered in territories according to the guidelines for national breeding bird monitoring (Van Dijk *et al*., 2004). A singing site is considered as a territory only if it is observed between 20 May and 31 July. Two observations of two sites close to each other on different days are only counted as separate territories when there is a distance between them of more than 500 m. A territory is an indication for the population size, but studies about habitat and management are based on singing sites (Schoppers & Koffijberg, 2007). Therefore, also in this study singing sites will be used for the analyses.

2.2 Analyses in Geographic Information System (GIS)

The survey data of the years 2001-2007 were implemented in GIS (ArcGIS 9.2). Singing sites that were assigned the coordinates of the lower left corner of a topographic map grid cell were replaced to the centre (Atsma, 2006). For each year and all years together a distribution map with the singing sites of males was made.

The ecotope map of 2005 was overlaid by the distribution maps. The number (N) and density (N/ha) of singing sites per type of ecotope for each year and in total were determined to see if there is a preference for a type of ecotope. In the attribute tables of the distribution maps new fields were created to indicate in which type of ecotope each singing site was situated. In Excel a table was made with the ecotopes and the numbers and percentages of singing sites within each type of ecotope. Also a table was made indicating the accuracy (1 m, 10 m, 100 m, 1000 m) of the singing sites per ecotope type. Difference in habitat preference within the breeding season was analyzed by comparing the distribution of the singing sites over types of ecotope between the first and second annual simultaneous surveys for the period 2001-2007. Between both censuses, vegetation growth might affect suitability for Corncrakes. Moreover, many agricultural managed fields are mowed around 15 June.

The floodplain map was overlaid with the distribution map of each year to obtain for each floodplain the number of singing sites and the number of years it was occupied. These results were implemented in Excel. The mean yearly Corncrake density (N/ha) for floodplains with different frequencies of occupation was calculated. Furthermore, the floodplain map was overlaid with the ecotope maps of 1997 and 2005 separately. With GIS and Excel the ecotope characteristics per floodplain were calculated for both ecotope maps. For each floodplain the mean of the following ecotope characteristics was determined and calculated: the Shannon Diversity Index (SHDI); area of the floodplain (ha); area of suitable, marginal, unsuitable and crex habitat (ha); share of suitable, marginal, unsuitable and crex habitat (%); number of patches (N); density of patches (N/ha); number of patch types (N); density of patch types (N/ha); number of suitable, marginal and unsuitable patches (N); density of suitable, marginal and unsuitable patches (N/ha); density of suitable patches within suitable habitat (N/ha); density of marginal patches within marginal habitat (N/ha); density of unsuitable patches within unsuitable habitat (N/ha). Crex habitat is the sum of suitable and marginal habitat. Finally, for the 2005 ecotope map the ecotope characteristics per floodplain were combined in Excel with the frequency of occupation. The frequencies of occupation were divided in four groups: 0 year, 1/2 years, 3/4 years and 5/6/7 years. Frequencies were grouped in order to obtain sufficient cases per occupation frequency.

The mean ecotope characteristics were also calculated for the three Rhine branches separately. These were compared for the ecotope maps of 1997 and 2005 in order to determine the ecotope turnover between 1997 and 2005 for the three Rhine branches.

Furthermore, the results of the GIS analyses were used for plotting the mean yearly density of singing sites (N/ha) against the frequency of occupation, against the area of patches of the five most preferred ecotopes which have been occupied at least once during the seven year monitoring period and against the area of suitable habitat (ha) for floodplains with a different occupation frequency. In this case the occupation frequencies were divided in 1, 2, 3, 4, 5 and 6/7. The frequencies 6 and 7 were grouped to obtain sufficient cases per occupation frequency.

2.3 Radio tagging

In the year 2007, for the first time in the Netherlands, Corncrakes were followed by radio telemetry (Koffijberg *et al*., 2007). Members of SOVON Dutch Centre for Field Ornithology captured 14 males in the northern valley of the IJssel and four in the vicinity of the Zwarte Water and tagged them with a radio transmitter. The tagged birds were tracked once per three days during a period varying between 5 and 50 days with an average of 22 days. The locations of capture and radio tracking, plus additional data were collected and implemented in a Geographic Information System (ArcView 3.2). For each bird the home range was determined by the ArcView extension LoCoH (Local Convex Hull Homerange Generator).

The ecotope map of 2005 was overlaid by each home range in GIS (ArcGIS 9.2). First, the distribution of the tracked locations over the ecotope types was determined and implemented in Excel. The results were used to get a better idea of the ecotopes preferred by the Corncrake and to validate the ecotope preferences of the Corncrake as resulting from the distribution of the Corncrake male singing sites over the different ecotope types. Ecotope types containing more than 5% of the tracked locations were marked as suitable habitat and the remaining ecotopes as marginal habitat. Ecotopes located inside the home ranges but not containing a record were indicated as unsuitable habitat. To compare ecotope preferences between day and night a distinction was made between locations that have been radio tracked during the day and locations that have been tracked during the night. It was assumed that the day lasts from 06.00 am to 09.00 pm and the night from 09.00 pm to 06.00 am.

The ecotope characteristics per home range were calculated with GIS and Excel. The following variables were calculated for each home range: the period the Corncrake has been tracked (days), number of patches (N), Shannon Diversity Index (SHDI), number of patch types, area of the home range (ha), area of suitable, marginal, crex and unsuitable habitat (ha) and share of suitable, marginal, crex and unsuitable habitat (%). Crex habitat is the sum of suitable and marginal habitat. Subsequently several of the variables were plotted against each other. The results were put in Excel.

2.4 Inundation

The relation between Corncrake occurrence and inundation was analyzed on two spatial scales: floodplains and ecotopes. First the singing sites were plotted on the inundation map of 1997 in GIS. The frequency of inundation is divided into six classes: *>365 days/year, 180-365 days/year, 50-180 days/year, 20-50 days/year, 2-20 days/year* and *unknown*. In the attribute tables of the Corncrake distribution maps additional fields were created to add the inundation class to each singing site. The number (N) and density (N/ha) of singing sites per inundation class were determined to see if there is a preference (Atsma, 2006).

The second method used to relate the singing sites to inundation is the method of De Nooij *et al*. (2006). Each type of ecotope is classified into a specific hydrodynamic class. Thus, for each singing site the hydrodynamic class it belongs to can be determined based on the distribution of the singing sites over the ecotope map. Once again both the number (N) and the density (N/ha) of singing sites per hydrodynamic class were calculated, to reveal whether there is a preference. Six hydrodynamic classes were distinguished: *high-water-free, periodically to rarely flooded, bank-damp, bank-swampy/damp, bank-swampy, bank-wet/swampy*.

2.5 'Room for the River' maps

Maps of two 'Room for the River' plans in floodplains along the IJssel near Zwolle were implemented in GIS. The first map is of the project that will be implemented in the Vreugderijkerwaard, the second of a project that will be implemented in the Scheller and Oldeneler buitenwaarden. In GIS these maps were overlaid by the distribution maps of the Corncrake male singing sites resulting in maps of the project areas including the singing sites situated in it during the seven year monitoring period. These maps could give an idea of the implications of the plans on the availability of habitat for the Corncrake.

2.6 Statistical analysis

For statistical analyses SPSS 15.0 for windows was used. Mean yearly densities (N/ha) of singing Corncrake males were compared between floodplains with a different occupation frequency and between different suitable ecotope types with the post-hoc Games Howell test for unequal variances. The Games Howell test was also used to compare several ecotope characteristics between floodplains with different frequencies of occupation, and between the three Rhine branches Rhine, Waal and IJssel.

For each of the three Rhine branches, differences in ecotope characteristics between the ecotope maps of 1997 and 2005 were tested with the Paired-samples t-test. Share of singing sites per ecotope type were compared between the first and second simultaneous survey for the ecotopes providing suitable habitat and the groups *natural pasture, production meadow, herbaceous floodplain* and *natural/production grassland* also using a Paired-samples t-test.
The Games Howell test and Paired sample t-test were performed at a significance level of $p<0.05$.
Correlations between the different variables of the home ranges were tested with a Pearson's product moment correlation test. Significant correlations were given at a level of $p<0.05$ or $p<0.01$.

3. RESULTS

3.1 Geographical distribution and frequency of occurrence

The floodplains of the IJssel show the highest number of Corncrake male singing sites from 2005 onwards (Figure 4 and Appendix I). In the years before, except of 2001, the floodplains of the Waal were visited by the highest number of Corncrakes. After 2003 a decreasing trend is ongoing in the Waal River floodplains. In 2007, the floodplains of the IJssel and Rhine contained more singing sites than the floodplains along the Waal.

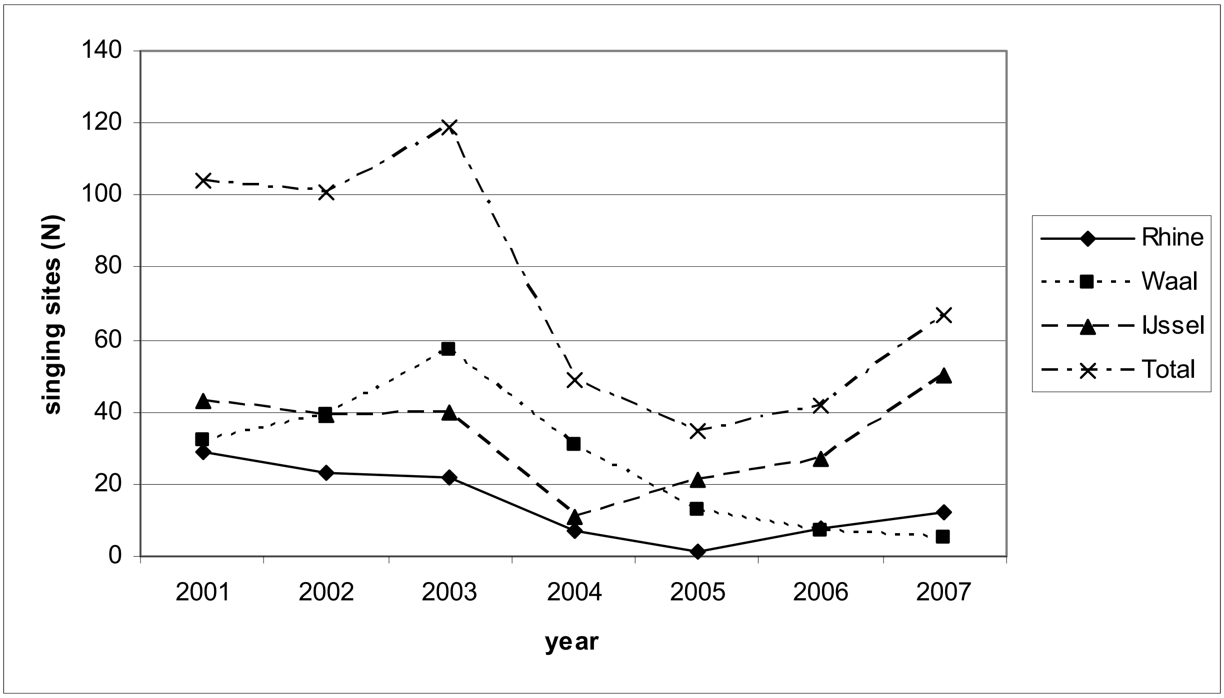

Figure 4: number of singing sites of Corncrake males for the years 2001-2007 per Rhine branch.

In total the Rhine branches include 166 floodplains of which 71 floodplains have been visited by a singing Corncrake male at least once in the period 2001-2007 (Table 1 and Appendix II). Of the floodplains which have been occupied at least once, nearly one third has an occupation frequency of one year. The IJssel comprises the highest number and percentage of floodplains where a Corncrake was heard at least once.
Just in two floodplains, the Hoenwaard and the Ossenwaard, singing Corncrake males were heard each year. The Brakelsche benedenwaarden, the Duursche waarden, the Oenerdijker- and Weelsumerwaarden and the Scherenwelle and Koppelerwaard have an occupation frequency of six years. Five of the six floodplains which have an occupation frequency of six or seven years belong to the IJssel. None of the floodplains along the Rhine has an occupation frequency of more than five years.

Table 1: number of floodplains per Rhine branch which have been visited at least once by a singing Corncrake male in the period 2001-2007.

	# of floodplains	# of occupied floodplains	% of occupied floodplains	One year	Two years	Three years	Four years	Five years	Six years	Seven years
Rhine	57	15	26.3	7	2	1	2	3	0	0
Waal	49	23	46.9	7	2	4	4	5	1	0
IJssel	60	33	55.0	8	9	4	4	3	3	2
Total	*166*	*71*	*42.8*	*22*	*13*	*9*	*10*	*11*	*4*	*2*

There is a tendency for the density of singing sites to increase with occupation frequency (Figure 5). The highest mean yearly density of Corncrake male singing sites (N/ha) is found for floodplains with an occupation frequency of six and seven years. An exception for the tendency is found for the occupation frequency of one year, which corresponds with a higher density than the occupation frequencies of two or three years (0.011 vs. 0.009). However, the differences between the classes are not significant.

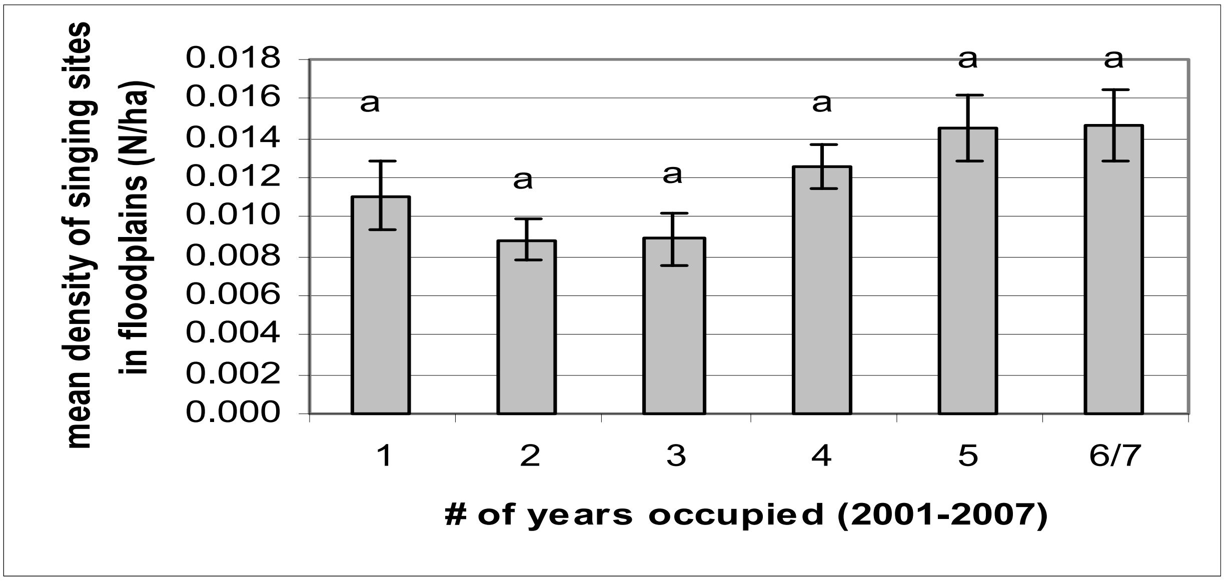

Figure 5: mean yearly density (±SE) of singing males per floodplain (N/ha) in relation to frequency of occupation. 1 year: N=22, 2 years: N=26, 3 years: N=27, 4 years: N=40, 5 years: N=55 and 6/7 years N=38. Differences were tested for significance using a Games Howell test ($p<0.05$). Different letters indicate a significant difference, while identical letters indicate no significant difference.

3.2 Geographical distribution in relation to frequency of inundation

3.2.1 Geographical distribution in relation to inundation class

During the period 2001-2007 the majority of the singing sites was found in the inundation class of *2-20 days/year*, followed by the classes *20-50 days/year* and *<2 days/year*, respectively (Table 2). The inundation class of *20-50 days/year* has the highest density of singing sites (N/ha), followed by the inundation classes of *2-20 days/year* and *50-180 days/year*.

Table 2: distribution of the singing sites over the inundation classes for the period 2001-2007.

Inundation class	Number of singing sites (N)	%	Density of singing sites (N/ha)
<2 days/year	69	13.5	0.0085
2-20 days/year	310	60.7	0.0241
20-50 days/year	110	21.5	0.0329
50-180 days/year	21	4.1	0.0114
180-365 days/year	1	0.2	0.0023
total	***511***	***100***	

3.2.2 Geographical distribution in relation to hydrodynamic class

The hydrodynamic class *periodically to rarely flooded* contains by far the highest number and percentage of singing sites (Table 3). The density is the highest too. The *high-water-free* class contains the second highest number of singing sites, but the hydrodynamic class *bank-damp* contains the second highest density.

Table 3: distribution of the singing sites over the hydrodynamic classes for the period 2001-2007.

Hydrodynamic class	Number of singing sites	%	Density of singing sites (N/ha)
high-water-free	83	16.1	0.0088
periodically to rarely flooded	410	79.3	0.0271
bank-damp	15	2.9	0.0167
bank-swampy/damp	5	1.0	0.0073
bank-swampy	2	0.4	0.0112
bank-wet/swampy	2	0.4	0.0102
total	***517***	***100***	

3.3 Ecotope preference of singing Corncrake males

3.3.1 Ecotope preference

In total, 36 different ecotope types were distinguished which contained a singing Corncrake male at least once (Appendix III, Table III.1 and Table III.2). Five of them are water ecotope types. The singing sites belonging to these ecotopes are considered to be incorrect, which therefore are excluded from further analyses. The accuracies of the singing sites are given in Table III.1 in Appendix III. All ecotope types are listed according to the total number of singing sites for the seven year monitoring period. The ecotope types with the highest number of singing sites are herbaceous floodplain, floodplain production meadow and floodplain natural pasture. For further analyses, to distinguish suitable and marginal ecotope types for Corncrake male singing habitat, all ecotopes containing ≥4% of the singing sites were regarded suitable and ecotopes containing <4 % marginal. Consequently, the ecotope types herbaceous floodplain, floodplain production meadow and floodplain natural pasture together with floodplain grassland (natural pasture/production meadow) and high-water-free production meadow were allocated to suitable habitat for the Corncrake. All suitable and marginal habitat ecotope types together were defined as crex habitat in further analyses. Some ecotope types, such as forest ecotopes, were in advance not expected to be in this list. However, these types merely contain a low number of singing sites.

The mean yearly density of singing males (N/ha) for the herbaceous floodplain patches which have been occupied at least once in 2001-2007 (0.46 singing sites/ha) is significantly higher than the densities for floodplain production meadow, floodplain natural pasture and high-water-free production meadow (Figure 6). High-water-free production meadow has the lowest density (0.12 singing sites/ha) of the five suitable habitat ecotope types. The singing site density for floodplain grassland (natural pasture/production meadow) does not significantly differ from the densities for any of the other suitable ecotope types.

Floodplains with an occupation frequency of five years have the highest density of singing sites within suitable habitat (0.037 singing sites/ha). This significantly differs from the density of floodplains with occupation frequencies of two and three years (Figure 7).

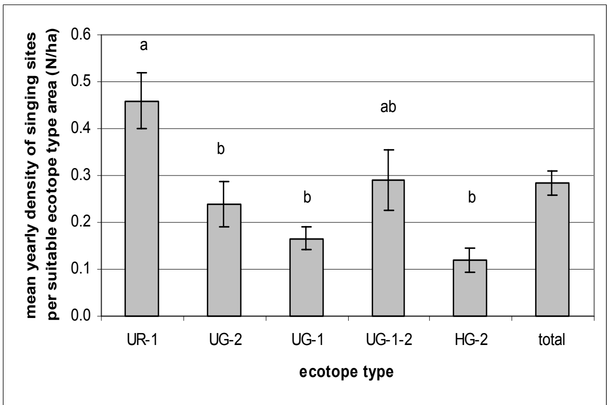

Figure 6: mean yearly density (±SE) of singing sites (N/ha) for the patches which have been occupied at least once in 2001-2007 for each of the suitable ecotopes and the total of the five types. Herbaceous floodplain (UR-1): N=84, floodplain production meadow (UG-2): N=83, floodplain natural pasture (UG-1): N=62, floodplain grassland (natural pasture/production meadow) (UG-1-2): N=26 and high-water-free production meadow (HG-2): N=34. Differences were tested for significance using a Games Howell test (p<0.05). Different letters indicate a significant difference, while identical letters indicate no significant difference.

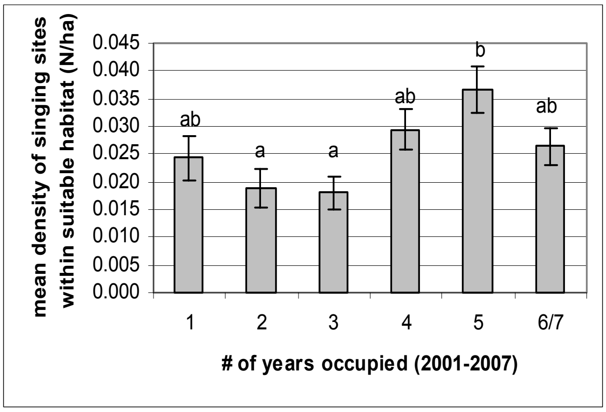

Figure 7: mean yearly density (±SE) of singing sites within suitable habitat (N/ha) for floodplains with a different occupation frequency. 1 year: N=22, 2 years: N=26, 3 years: N=27, 4 years: N=40, 5 years N=55 and 6/7 years: N=38. Differences were tested for significance using a Games Howell test (p<0.05). Different letters indicate a significant difference, while identical letters indicate no significant difference.

3.3.2 Changing preference during the season

To visualize possible changes in ecotope preference during the season, a distinction is made between singing sites which were recorded during the first simultaneous survey (around 1 June) and the singing sites which were recorded during the second simultaneous survey (around 20 June). The differences in singing site distribution between the first and second survey appear to be small (Appendix III, Table III.4). Herbaceous floodplain shows the largest shift in number and percentage of singing sites. None of the ecotope types containing more than 3 % of the singing sites showed a significant difference between the two surveys (Table 4).

The ecotope types containing more than 3 % of the singing sites were aggregated to groups. Herbaceous floodplain and high-water-free herbaceous floodplain were aggregated to *herbaceous floodplain*, floodplain production meadow and high-water-free production meadow to *production meadow*, floodplain natural pasture and high-water-free natural pasture to *natural pasture* and floodplain grassland (natural pasture/production meadow) and high-water-free grassland (natural pasture/production meadow) to *production/natural grassland*. A decrease in singing sites is visible for production meadow, natural pasture and production/natural grassland during the season, while herbaceous floodplain shows an increase (figure 8). However, the differences were not significant.

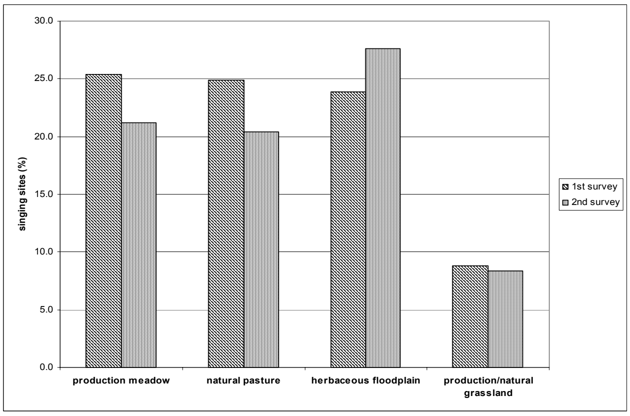

Figure 8: percentages of singing sites for different ecotope groups for the first and second survey. Differences were not significant using a paired samples t-test (p<0.05).

Table 4: significance levels of the differences in singing site distribution between the two surveys for the ecotope types containing more than 3% of the singing sites. Differences were tested for significance using a paired samples t-test (p<0.05).

Group	Ecotope	Significance level	
H	High-water-free herbaceous rough	p=0.543	n.s.
P/N	High-water-free grassland (natural pasture/production meadow)	p=0.400	n.s.
P	High-water-free production meadow	p=0.270	n.s.
P/N	Floodplain grassland (natural pasture/production meadow)	p=0.463	n.s.
N	High-water-free natural pasture	p=0.377	n.s.
N	Floodplain natural pasture	p=0.792	n.s.
P	Floodplain production meadow	p=0.578	n.s.
H	Herbaceous floodplain	p=0.131	n.s.

H=herbaceous floodplain, P=production meadow, N=natural pasture and P/N=production/natural grassland

3.4 Ecotope characteristics

3.4.1 Ecotope characteristics in relation to frequency of occupation

Mean ecotope characteristics per floodplain in relation to frequency of occupation are given in Table 5 and Figure IV.1-IV.21 in appendix IV. The ecotope characteristics floodplain area (ha), number of suitable patches, number of marginal patches (N) and area of crex habitat (ha) increase with the occupation frequency. The floodplains with occupation frequencies of 1/2, 3/4 and 5/6/7 years differ significantly from the floodplains which have never been occupied.

The area of unsuitable habitat (ha) and area of marginal habitat (ha) show also a clear positive tendency, but the occupation frequencies do not significantly differ from each other. However, the floodplains which have been occupied at least once contain a significantly larger area of unsuitable and marginal habitat than floodplains which have never been occupied.

The Shannon Diversity Index (SHDI), area of suitable habitat (ha), share of suitable habitat (%), number of unsuitable patches (N), number of patches (N) and number of patch types (N) show no clear positive tendency, but the floodplains which have been occupied at least once have a significantly higher value for these ecotope characteristics than floodplains with an occupation frequency of 0 years.

The mean density of patches (N/ha) and patch types (N/ha) show a decreasing tendency with increasing occupation frequency. Floodplains occupied at least once have a significantly lower density than floodplains which have never been occupied.

Share of marginal habitat (%), density of marginal patches (N/ha), density of unsuitable patches (N/ha) and density of unsuitable patches within unsuitable habitat (N/ha) show no clear negative tendency, but the floodplains which have been occupied at least once have a significant lower value for these ecotope characteristics than floodplains which have never been occupied.

The ecotope characteristics share of unsuitable habitat (%), share of crex habitat (%), density of suitable patches (N/ha), density of suitable patches within suitable habitat (N/ha) and density of marginal patches within marginal habitat (N/ha) do not show a significant increase or decrease with increasing occupation frequency.

Table 5: differences in mean ecotope characteristics per floodplain in relation to frequency of occupation. Differences were tested for significance with a Games Howell test ($p<0.05$). Identical letters indicate no significant difference. Different letters indicate a significant difference. Differences between floodplains which have never been occupied (N=95) and floodplains which have been occupied at least once (N=71) were tested with an independent-samples t- test ($p<0.05$). A + indicates a higher value and a – a lower value for floodplains which have been occupied at least once compared to floodplains which have never been occupied.

Mean	**Frequency of occupation**				**Significant difference between floodplains never occupied and floodplains occupied at least once?**	
	0 year (N= 95)	**1/2 year (N= 35)**	**3/4 year (N= 19)**	**5/6/7 year (N= 17)**		
Area of floodplain (ha)	a	b	b	b	yes	+
SHDI	a	b	ab	b	yes	+
Area of suitable habitat (ha)	a	b	b	b	yes	+
Share of suitable habitat (%)	a	b	b	ab	yes	+
Area of marginal habitat (ha)	a	a	a	a	yes	+
Share of marginal habitat (%)	a	b	b	ab	yes	-
Area of unsuitable habitat (ha)	a	a	a	a	yes	+
Share of unsuitable habitat (%)	a	a	a	a	no	n.s.
Area of crex habitat (ha)	a	b	b	b	yes	+
Share of crex habitat (%)	a	a	a	a	no	n.s.
Number of patches (N)	a	b	b	b	yes	+
Density of patches (N/ha)	a	ab	b	b	yes	-
Number of patch types (N)	a	b	b	b	yes	+
Density of patch types (N/ha)	a	b	b	b	yes	-
Number of suitable patches (N)	a	b	b	b	yes	+
Density of suitable patches (N/ha)	a	a	a	a	no	n.s.
Density of suitable patches within suitable habitat (N/ha)	a	a	a	a	no	n.s.
Number of marginal patches (N)	a	b	b	b	yes	+
Density of marginal patches (N/ha)	a	ab	b	ab	yes	-
Density of marginal patches within marginal habitat (N/ha)	a	a	a	a	no	n.s.
Number of unsuitable patches	a	ab	b	ab	yes	+
Density of unsuitable patches (N/ha)	a	b	b	b	yes	-
Density of unsuitable patches within unsuitable habitat (N/ha)	a	a	a	a	yes	-

3.4.2 Ecotope characteristics in relation to Rhine branch

Comparison of the ecotope characteristics of the floodplains between the three branches reveals that in many cases the Waal shows either the highest or lowest value. For example, the floodplains along the Waal have the highest mean SHDI, mean area of suitable habitat (ha) and mean area of unsuitable habitat (ha), while they have the lowest mean area of marginal habitat (ha) and mean share of crex habitat (%). Most ecotope characteristics do not significantly differ between the Rhine and IJssel (Appendix V, Figure V.1-V.21).

3.4.3 Ecotope turnover

Between 1997 and 2005, the total amount of suitable habitat (ha) in the floodplains has been decreased for all three Rhine branches (Table 6 and Table 7). In both years, the floodplains of the IJssel comprehend the largest total amount of suitable habitat (ha). Many ecotope characteristics have been changed significantly during the eight year period (Table 8, Table 9 and Table 10). For the floodplains along all three Rhine branches, the mean SHDI and the mean number of (suitable) patches and patch types (N) increased during the eight year period. For the floodplains along the IJssel the mean patch and patch type density (N/ha), the mean density of suitable patches (N/ha) and the mean density of suitable patches within suitable habitat (N/ha) show a significant increase. The mean patch density (N/ha) and the density of suitable patches (N/ha) for the floodplains along the Rhine also have significantly increased. The mean density of suitable patches (N/ha) of the floodplains along the Waal increased too.

Table 6: total area (ha), suitable habitat area (ha) and share of suitable habitat (%) for the three Rhine branches calculated with ecotope map 1997.

Rhine branch	Area (ha)	Area suitable habitat (ha)	Suitable habitat (%)
Rhine	8161.20	4487.68	54.99
Waal	9072.16	4859.08	53.56
IJssel	10328.12	6621.51	64.11

Table 7: total area (ha), suitable habitat area (ha) and share of suitable habitat (%) for the three Rhine branches calculated with ecotope map 2005.

Rhine branch	Area (ha)	Area suitable habitat (ha)	Suitable habitat (%)
Rhine	8280.10	3385.47	40.89
Waal	9239.44	4322.16	46.78
IJssel	10357.14	5374.50	51.89

Table 8: comparison of the means of the ecotope characteristics for floodplains along the Rhine for ecotope map 1997 with ecotope map 2005. A + indicates a positive trend, while a – indicates a negative trend.

Pair	N	Significance level (2-tailed)	
Area floodplain (ha) 1997 & area floodplain (ha) 2005	57	p=0.102	n.s.
Number of patches (N) 1997 & number of patches (N) 2005	57	p=0.000	+
Number of patch types (N) 1997 & number of patch types (N) 2005	57	p=0.001	+
SHDI 1997 & SHDI 2005	57	p=0.000	+
Area of suitable habitat (ha) 1997 & area of suitable habitat (ha) 2005	57	p=0.000	
Share of suitable habitat (%) 1997 & share of suitable habitat (%) 2005	57	p=0.000	-
Patch density (N/ha) 1997 & patch density (N/ha) 2005	57	p=0.000	+
Patch type density (N/ha) 1997 & patch type density (N/ha) 2005	57	p=0.182	n.s.
Number of suitable patches (N) 1997 & number of suitable patches (N) 2005	57	p=0.000	+
Density of suitable patches (N/ha) 1997 & density of suitable patches (N/ha) 2005	57	p=0.305	n.s.
Density of suitable patches within suitable habitat (N/ha) 1997 & density of suitable patches within suitable habitat (N/ha) 2005	53	p=0.012	+

Table 9: comparison of the means of the ecotope characteristics for floodplains along the Waal for ecotope map 1997 with ecotope map 2005. A + indicates a positive trend, while a – indicates a negative trend.

Pair	N	Significance level (2-tailed)	
Area floodplain (ha) 1997 & area floodplain (ha) 2005	49	p=0.000	+
Number of patches (N) 1997 & number of patches (N) 2005	49	p=0.000	+
Number of patch types (N) 1997 & number of patch types (N) 2005	49	p=0.000	+
SHDI 1997 & SHDI 2005	49	p=0.000	+
Area of suitable habitat (ha) 1997 & area of suitable habitat (ha) 2005	49	p=0.000	-
Share of suitable habitat (%) 1997 & share of suitable habitat (%) 2005	49	p=0.000	-
Patch density (N/ha) 1997 & patch density (N/ha) 2005	49	p=0.264	n.s.
Patch type density (N/ha) 1997 & patch type density (N/ha) 2005	49	p=0.327	n.s.
Number of suitable patches (N) 1997 & number of suitable patches (N) 2005	49	p=0.000	+
Density of suitable patches (N/ha) 1997 & density of suitable patches (N/ha) 2005	49	p=0.043	+
Density of suitable patches within suitable habitat (N/ha) 1997 & density of suitable patches within suitable habitat (N/ha) 2005	48	p=0.257	n.s.

Table 10: comparison of the means of the ecotope characteristics for floodplains along the IJssel for ecotope map 1997 with ecotope map 2005. A + indicates a positive trend, while a – indicates a negative trend.

Pair	**N**	**Significance level (2-tailed)**	
Area floodplain (ha) 1997 & area floodplain (ha) 2005	60	p=0.549	n.s.
Number of patches (N) 1997 & number of patches (N) 2005	60	p=0.000	+
Number of patch types (N) 1997 & number of patch types (N) 2005	60	p=0.000	+
SHDI 1997 & SHDI 2005	60	p=0.000	+
Area of suitable habitat (ha) 1997 & area of suitable habitat (ha) 2005	60	p=0.000	-
Share of suitable habitat (%) 1997 & share of suitable habitat (%) 2005	60	p=0.000	-
Patch density (N/ha) 1997 & patch density (N/ha) 2005	60	p=0.000	+
Patch type density (N/ha) 1997 & patch type density (N/ha) 2005	60	p=0.049	+
Number of suitable patches (N) 1997 & number of suitable patches (N) 2005	60	p=0.000	+
Density of suitable patches (N/ha) 1997 & density of suitable patches (N/ha) 2005	60	p=0.000	+
Density of suitable patches within suitable habitat (N/ha) 1997 & density of suitable patches within suitable habitat (N/ha) 2005	58	p=0.000	+

3.4.4 Home ranges of singing Corncrake males in relation to ecotope characteristics

Floodplain production meadow contains 45.1 % of the 162 track records of radio tagged Corncrake males, followed by natural pasture (10.5 %) and floodplain natural pasture (9.3 %) (Table 11). The ecotope types which contain more than 5 % of the tracked locations have been considered suitable habitat. Ecotope types containing less than 5 % of the records but with at least one tracked location have been assigned to marginal habitat. Ecotope types that contained no tracked location, but were situated in the home ranges were considered unsuitable habitat.
The majority of the tracked locations of the radio-tagged Corncrake males is situated in the aggregated group *production meadow* (Figure 9). *Natural pasture* contains 20.4 % of all records and *arable land* 15.4 %. *Herbaceous floodplain* contains only 2.5 % of the tracked locations.

Table 11: distribution of the tracked locations of radio tagged Corncrake males over the ecotope types.

	Ecocode	**Ecotope**	**Number of tracked sites**	**%**
Suitable habitat	UG-2	Floodplain production meadow	73	45.1
	G1	Natural pasture	17	10.5
	UG-1	Floodplain natural pasture	15	9.3
	UA-1	Arable floodplain	13	8.0
	UG-1-2	Floodplain grassland (natural pasture/production meadow)	13	8.0
	G3	Arable land	12	7.4
Marginal habitat	O-UG-1-2	Natural levee or floodplain grassland (natural pasture/production meadow)	6	3.7
	O-UG-2	Natural levee or floodplain production meadow	4	2.5
	O-UR-1	Herbaceous natural levee or floodplain	3	1.9
	G2	Production meadow	2	1.2
	U-REST	Temporarily bare floodplain	2	1.2
	HG-1	High-water-free natural pasture	1	0.6
	UR-1	Herbaceous floodplain	1	0.6
Unsuitable habitat	IV.8-9	Species poor helophyte marsh/species-rich reed	0	0.0
	UM-1	Natural levee or floodplain reed	0	0.0
	VII.1	Marshy natural pasture	0	0.0
	RzD	Deep summer bed	0	0.0
	V.1-2	Herbaceous marsh	0	0.0
	I.1	Dynamic fresh to slightly brackish shallow water	0	0.0
	UB-3	Floodplain production forest	0	0.0
		Total	***162***	***100***

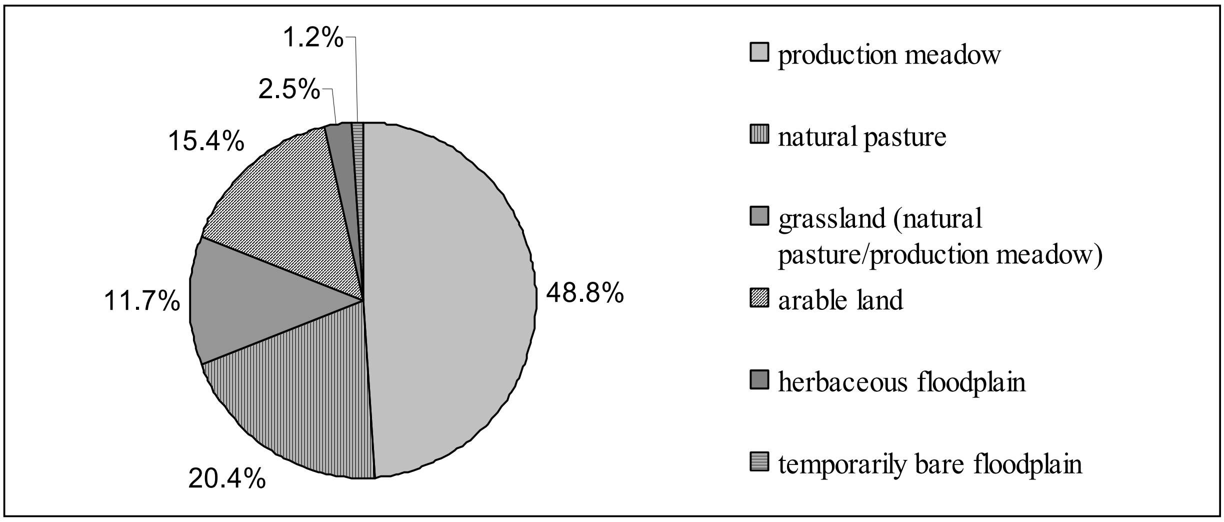

Figure 9: distribution of the tracked locations of radio tagged Corncrake males over ecotope groups. Production meadow = UG-2, O-UG-2 and G2, natural pasture = G1, UG-1 and HG-1, grassland (natural pasture/production meadow) = UG-1-2 and O-UG-1-2, arable land = UA-1 and G3, herbaceous floodplain= O-UR-1 and UR-1, temporarily bare floodplain = U-REST.

Locations in suitable habitat types were recorded both during the day and the night (Table 12). Floodplain production meadow, arable floodplain, floodplain grassland (natural pasture/production meadow) and arable land show a small increase in percentage of records during the night. Natural pasture shows a large decrease, while floodplain natural pasture shows a large increase during the night. The marginal habitat ecotopes, except of production meadow, exclusively comprise locations tracked during the day.

Table 12: Distribution of tracked locations over the ecotope types during the day (06.00 am to 09.00 pm) and night (09.00 pm to 06.00 am).

	Ecocode	Ecotope	Day	%	Night	%
Suitable habitat	UG-2	Floodplain production meadow	51	44.3	22	46.8
	G1	Natural pasture	14	12.2	3	6.4
	UG-1	Floodplain natural pasture	7	6.1	8	17.0
	UA-1	Arable floodplain	9	7.8	4	8.5
	UG-1-2	Floodplain grassland (natural pasture/production meadow)	9	7.8	4	8.5
	G3	Arable land	8	7.0	4	8.5
Marginal habitat	O-UG-1-2	Natural levee or floodplain grassland (natural pasture/production meadow)	6	5.2		
	O-UG-2	Natural levee or floodplain production meadow	4	3.5		
	O-UR-1	Herbaceous natural levee or floodplain	3	2.6		
	G2	Production meadow			2	4.3
	U-REST	Temporarily bare floodplain	2	1.7		
	HG-1	High-water-free natural pasture	1	0.9		
	UR-1	Herbaceous floodplain	1	0.9		
Unsuitable habitat	IV.8-9	Species poor helophyte marsh/species-rich reed				
	UM-1	Natural levee or floodplain reed				
	VII.1	Marshy natural pasture				
	RzD	Deep summer bed				
	V.1-2	Herbaceous marsh				
	I.1	Dynamic fresh to slightly brackish shallow water				
	UB-3	Floodplain production forest				
		Total	***115***	***100***	***47***	***100***
		Suitable	***98***	***85.2***	***45***	***95.7***
		Marginal	***17***	***14.8***	***2***	***4.3***

For each home range a number of ecotope characteristics was determined (Appendix VI, Table VI.1) The period that the Corncrakes were tracked (days) is positively correlated with the area (ha) of the home ranges (Table 13 and Appendix VII). There is no correlation between the period of tracking and the Shannon Diversity Index (SHDI).
The area of the home ranges has a significant positive correlation with the number of patches, the number of patch types, the SHDI, the areas (ha) of suitable, marginal, crex and unsuitable habitat, and the share (%) of unsuitable habitat. It has a negative correlation with the share (%) of crex habitat and is uncorrelated with the shares (%) of suitable and marginal habitat. The number of patches is strongly positively correlated with the number of patch types.
The SHDI is negatively correlated with the shares (%) of suitable and crex habitat and uncorrelated with the area (ha) of suitable habitat. Furthermore, the SHDI is positively correlated with the areas (ha) of marginal, unsuitable and crex habitat, and with the shares (%) of unsuitable and marginal habitat.

Table 13: correlations between the home range variables. The correlations are tested for significance with a Pearson's product moment correlation test.

	N	Correlation	R2	
Area home range (ha)-period of radio tracking (days)	18	+	0.2765*	one-tailed
Number of patches (N)-area home range (ha)	18	+	0.4257**	two-tailed
Number of patch types (N)-area home range (ha)	18	+	0.3721**	two-tailed
Number of patch types (N)-number of patches (N)	18	+	0.9230**	one-tailed
SHDI-period of radio tracking (days)	18	n.s.	n.s.	two-tailed
SHDI-area home range (ha)	18	+	0.4200**	two-tailed
Area suitable habitat (ha)-SHDI	18	n.s.	n.s.	two-tailed
Share of suitable habitat (%)-SHDI	18	-	0.5476**	two-tailed
Area marginal habitat (ha)-SHDI	18	+	0.5322**	two-tailed
Share of marginal habitat (%)-SHDI	18	+	0.2626*	two-tailed
Area unsuitable habitat (ha)-SHDI	18	+	0.3401*	two-tailed
Share of unsuitable habitat (%)-SHDI	18	+	0.4085**	two-tailed
Area crex habitat (ha)-SHDI	18	+	0.2851*	two-tailed
Share of crex habitat (%)-SHDI	18	-	0.4085**	two-tailed
Area suitable habitat (ha)-area home range (ha)	18	+	0.6445**	two-tailed
Share of suitable habitat (%)-area home range (ha)	18	n.s.	n.s.	two-tailed
Area marginal habitat (ha)-area home range (ha)	18	+	0.3989**	two-tailed
Share of marginal habitat (%)-area home range (ha)	18	n.s.	n.s.	two-tailed
Area unsuitable habitat (ha)-area home range (ha)	18	+	0.5427**	two-tailed
Share of unsuitable habitat (%)-area home range (ha)	18	+	0.5112**	two-tailed
Area crex habitat (ha)-area home range (ha)	18	+	0.8446**	two-tailed
Share of crex habitat (%)-area home range (ha)	18	-	0.5112**	two-tailed

* p<0.05
** p<0.01

3.5 Reconstruction measures and the Corncrake

From about 2010 onwards reconstruction measures will be implemented in the Vreugderijkerwaard (Appendix VIII, Figure VIII.1). Side channels will be dug, the floodplain will be lowered and the dike near Westenholte will be displaced (Provincie Overijssel, 2008). The Vreugderijkerwaard has an occupation frequency of 4 years and has been containing singing sites from 2004 onwards (Appendix II, Table II.1). During the period 2001-2003 no singing Corncrake males were heard.
Also in the Scheller and Oldeneler buitenwaarden reconstruction measures will be implemented from 2010 onwards (Appendix VIII, Figure VIII.2). The Scheller and Oldeneler buitenwaarden has an occupation frequency of 5 years (Appendix II, Table II.1). In 2001 and 2005, this floodplain harboured no singing Corncrake males. The southern part of the floodplain, which contained a number of singing sites during the seven year monitoring period, will not be affected, but the northern part will be reconstructed. A new side channel will be dug and a part of the floodplain will be lowered.

The Ossenwaard, Olsterwaard, Duurschewaard, Vorchterwaard and Oenerdijkerwaard are other floodplains along the IJssel where 'Room for the River' projects will start in the coming years. These floodplains have an occupation frequencies of 7, 4, 6, 5 and 6 years, respectively (Appendix II, Table II.1).

4. DISCUSSION

4.1 Habitat selection

4.1.1 Ecotope distribution

For the analysis of ecotope preference a line, based on personal interpretation, was drawn at 4 % of the total number of singing sites. All ecotope types comprehending at least 4 % of the singing sites were assigned to suitable habitat, whereas the remaining ecotope types were assigned to marginal habitat. Consequently, herbaceous floodplain, floodplain production meadow, floodplain natural pasture, floodplain grassland (natural pasture/production meadow) and high-water-free production meadow turned out to be suitable habitat for the Corncrake males. Herbaceous floodplain was preferred mostly, both the number and density of singing sites were higher than in the other suitable ecotope types. Possibly, the number of singing sites per suitable ecotope type has been influenced by the phenomenon clustering. At the beginning of the breeding season the Corncrake males are usually not evenly dispersed over the suitable habitat, due to clustering. The Corncrake males form clumps to strengthen each other's singing and in doing so may enhance their ability to attract a Corncrake female (Green *et al*., 1997). Maybe, this clustering also happens in the floodplains along the Dutch Rhine River branches and influences the habitat selection.
Furthermore, the singing site data base and the ecotope map, where the singing sites were linked to, are characterized by some inaccuracies, through which the preferred ecotopes possibly will be incorrect. The mistakes in mapping singing birds during the nocturnal surveys or errors in the ecotope map could also be an possible explanation for the occurrence of singing sites in forest and water ecotopes, which was no expected in advance of the analysis. Firstly, the singing sites were recorded with different accuracies (1 m, 10 m, 100 m, 1000 m). From that, during the analyses singing sites with a lower accuracy could be easier linked to another ecotope than they in reality occupy. Furthermore the song of the Corncrake males is very loud through which for the bird watchers locating of the singing sites is very difficult and mapping errors could have been made. Secondly, the ecotope map of 2005 will not always show the ecotope type which is there in reality. For the ecotope map, remote sensing and aerial photographs were used to determine the ecotope type located on a certain site. Sometimes the interpretation of the data will be false and the wrong ecotope type is indicated on the map. Ecotope turnover is another aspect. The ecotope map is just a snapshot of the situation somewhere in 2005. In the preceding years maybe a natural pasture indicated on the ecotope map of 2005 was a production meadow or maybe the years after 2005 it has been changed into floodplain shrubs. However, ecotope turnover in the form of succession often takes more than a few years and therefore the map for the greater part will give the right ecotope types. Furthermore, singing sites could fall on ecotopes that were inundated during the period the photographs were made and remote sensing was applied for the ecotope map, but not during the period the Corncrake was there.
Comparison of the results of this study with two independent sources of information, the literature and the tracking study, could give an indication of the consequences of the inaccuracies mentioned above on the correctness of the output of the ecotope distribution analysis.
The natural habitats of the Corncrake probably have been riverine meadows and alpine, coastal and fire-created grasslands with few trees or bushes (Green *et al.*, 1997). Nowadays the original habitats are very scarce. For that reason at the present time the Corncrake prefers low dynamic, rich structured grasslands as breeding habitat (Green *et al.*, 1997; Schäffer, 1999). Two requisites for the selected habitat are a vegetation length > 20 cm to provide enough cover and the vegetation being not too dense to walk through (Green *et al.*, 1997). Therefore, the dead vegetation from the previous year needs to be removed by flooding, burning, ice-rafting, mowing or grazing during late autumn and the winter. These findings correspond for the greater part with the suitable ecotopes found in this study. Herbaceous floodplain, floodplain natural pasture, production meadow and high-water-free production meadow could be defined as rich structured grasslands or riverine meadows with few or no bushes and trees. Accumulation of dead vegetation in the suitable ecotopes of the floodplains along the Dutch Rhine River branches could be prevented by periodically flooding, grazing or mowing. Moreover, the results of preferred ecotope types are supported by the yearly reports about the Corncrake in the Netherlands, showing a preference of singing Corncrake males for hay meadows and ecological restoration areas in the floodplains along the Dutch Rhine River branches (Schoppers & Koffijberg 2001, 2003, 2004, 2005, 2006, 2007. 2008). However, they used a more general classification of ecotope types than this study.
The distribution of the tracked locations of radio tagged Corncrake males over the ecotope types partly confirms the results found for ecotope preference. The preference for floodplain production meadow, floodplain natural pasture and floodplain grassland (natural pasture/production meadow) is supported by the tracking study. However, two remarkable differences have to be noticed for the validation of the ecotope preference analysis. Firstly, the ecotope preference for herbaceous floodplain is not supported by the tracking study, just one location is recorded in

herbaceous floodplain. Secondly, many records are situated in arable land and arable floodplain. Possibly, these differences could be explained by the limit extent of the radio tracking study or by the local circumstances of the Zwarte water and the IJssel floodplains where the tracking study has been executed. The ecotope type herbaceous floodplain can not be found in the Zwarte Water and in the IJssel floodplains the share of arable land (8.8 %) is a bit higher than the share of arable land in the floodplains along all three Rhine River branches (7.7 %).
Altogether, the results of the ecotope preference analysis correspond to a large extent with the information found in the literature and the results of the tracking study. Thus can be concluded that the Corncrake prefers herbaceous floodplain, floodplain production meadow, floodplain natural pasture, floodplain grassland (natural/production) and high-water-free production meadow as habitat in the floodplains along the Dutch Rhine River branches.

4.1.2 Shift in ecotope distribution during the season

Several previous studies have demonstrated a shift in ecotope preference. Atsma (2006) found a significant shift during the season from production to natural/herbaceous ecotopes. Possibly, this was an indication that mowing activities made production meadows in mid-June unsuitable and therefore the Corncrake shifted to natural and herbaceous habitats (Atsma, 2006). Stowe & Hudson (1988, 1991) showed that in spring, when tall grasslands are scarce, radio-tagged Corncrakes used *Iris pseudacorus* (yellow iris), reeds and other tall wetland vegetation as habitat and moved to hay meadows later in the season. Just (2005) presented a shift in habitat choice too. He compared the optimal habitat of the Corncrake in Mid-May with that of Mid-June in the Lower Oder Valley National Park, Germany. In Mid-May annually used meadows with the following characteristics were preferred: a vegetation length > 80 cm; a total cover of 100%; a growth height > 90 cm for the flowering top grasses; a growth height >60 cm and a cover > 80% for the middle layer, which gives protection against predators; a lower layer with a height of 20 cm and a low cover of about 10%, which easily can be walked through. The optimal habitat in Mid-May mainly lays in higher areas, which are the first to dry after inundation in spring. These areas have a higher nutrient conversion and a faster growing and denser vegetation. Therefore, these areas are suitable as habitat only at the beginning of the breeding season. The optimal habitat in Mid-June consisted of annual used production meadows with the following characteristics: a vegetation length between 60-80 cm; a total cover of 100%; a lower layer with growth heights > 25 cm; and an annual harvest preventing the accumulation of dead biomass. These habitats lay mainly in the wetter and lower parts of the park where the vegetation growth starts later. The vegetation of the habitats of Mid-May is too long and too dense during Mid-June, thus explaining the shift.
Contrary to these studies, this study showed no significant shift in ecotope preference, although the percentage of singing sites in production meadow and natural pasture decreased and in herbaceous floodplain increased during the season. Possibly, shifts occur less often as many singing sites are prevented from mowing. On the other hand, the scale of this study is too large to find differences as found by the study of Just (2005). Therefore vegetation and soil characteristics (e.g. nutrient concentrations) studies on local scale are needed. Furthermore, in this study the years 2001-2007 were analysed in total, while analyzing each year separately might show shifts, because of yearly differences in mowing activities, management measures, food availability, inundation frequency and weather conditions.

4.1.3 Shift in ecotope distribution during the day

The analysis of the data of the radio tagged Corncrake males revealed that some ecotopes (natural levee or floodplain grassland, natural levee or floodplain production meadow, herbaceous natural levee or floodplain, temporarily bare floodplain, high-water-free natural pasture and herbaceous floodplain) contained records exclusively obtained during the day. Possibly, these ecotopes are used as foraging habitat. Corncrakes apparently forage only during the day, mostly in cover (Green *et al*., 1997). They feed mainly on invertebrates, small vertebrates (e.g. fish and amphibians), earthworms, molluscs, snails, various insects (e.g. beetles, flies and spiders) and seeds (Tyler, 1996; Schäffer, 1999). As the principal prey is widespread, it is suggested that vegetation structure is a stronger factor in habitat selection than food availability (Green *et al*., 1997). Visiting neighbour territories is another possible explanation why Corncrakes leave their singing site during the day (Sklíba & Fuchs, 2004). Possibly, the reason for these visits is the search for a female.
Floodplain production meadow, natural pasture, floodplain natural pasture, arable floodplain, floodplain grassland (natural pasture/production meadow) and arable land contained locations tracked during the day as well as during the night. During the night, the Corncrake males sing from stable singing sites (Stowe & Hudson, 1988; Schäffer, 1999). During the day 85.2 % of the tracked locations were found in the ecotopes indicated as suitable and during the night 95.7 % of the tracked locations were found in suitable habitat. This confirms the presumption that during the day the males leave their singing site to search for food and extending their territory, while they go back in the evening to their singing site in the suitable habitat (Sklíba & Fuchs, 2004).

4.1.4 Ecotope characteristics in relation to occupation frequency of floodplains

For a few ecotope characteristics clear differences were found between floodplains with an occupation frequency of 0 years and floodplains having an occupation frequency of at least once during the seven year monitoring period (2001-2007). Firstly, Corncrakes obviously selected floodplains with a larger surface area (ha). This could be related to the significantly higher amount of suitable habitat (ha) and crex habitat (ha) in these floodplains. Secondly, the occupation frequency increases with the number of patches and patch types (N), but decreases with the density (N/ha) of patches and patch types. In addition Corncrakes prefer floodplains with a relatively high SHDI. The SHDI increases as the number of different patch types (patch richness) increases or the proportional distribution of area among patch types becomes more equitable, or both (McGarigal & Marks, 1994). This indicates that the Corncrake prefers heterogeneous floodplains with sufficiently large patches that do not differ very much in size. The preference for heterogeneity is supported by a study of Wettstein *et al*. (2001), executed in the Szatmár-Bereg lowland in Hungary, which showed that Corncrake habitats were more heterogeneous than grasslands without Corncrakes.

Clear differences between the floodplains with an occupation frequency of at least one year were not found. Probably, the spatial resolution of this study is too large, therefore it would be better to study the local circumstances (e.g. vegetation structure, food availability, soil characteristics, management history) of singing sites.

The ecotope characteristics of the home ranges revealed also some interesting observations. The positive correlation between period of radio tracking (days) and home range area (ha) indicates that the male Corncrakes extend their territory (Sklíba & Fuchs, 2004). The amount of crex habitat increases with home range area (ha). This could be a reason for the Corncrake to extend the home range. But the share of crex habitat (%) decrease with a larger home range area (ha). Probably the area (ha) of crex habitat is more important than the share of crex habitat (%). The SHDI is not correlated with the period of tracking, but is positively correlated with the home range area (ha). This supports the results on floodplain scale, that the Corncrakes prefer a heterogeneous habitat.

4.1.5 Shift to floodplains along the IJssel

During the first years of the seven year monitoring period (2001-2007) the highest number of Corncrake male singing sites was harboured by the floodplains along the Waal, but during the last years the floodplains along the IJssel were obviously more popular than the floodplains along the Rhine and Waal. Even the Rhine floodplains were preferred over the floodplains along the Waal during the years 2006-2007, in spite of the smaller share (%) of suitable habitat in these floodplains.

Floodplains along the IJssel contain a larger surface area (ha) and share (%) of suitable habitat than the floodplains along the other two Rhine branches. On the contrary, the Waal floodplains contain a larger area (ha) and share (%) of unsuitable habitat and a lower share (%) of crex habitat. Furthermore, the Waal floodplains are patchier, whereas the Corncrake prefers floodplains with a relatively low patch density (section 4.1.4). These differences in landscape characteristics between the three Rhine branches could contribute to the choice of the Corncrake for the IJssel floodplains, but do not explain the shift in preference from the Waal floodplains to the IJssel floodplains during the seven year monitoring period (2001-2007). The patchiness of the Waal floodplains did not increase significantly during this period, while it increased in the IJssel and Rhine floodplains. Moreover, between 1997 and 2005 the total amount (ha) and share (%) of suitable habitat in the floodplains along all three Rhine branches has obviously been declined, but the decline was the smallest for the floodplains along the Waal. Apparently, the results of this study give no explanation for the shift in preference of the Corncrake males from the Waal to the IJssel floodplains.

4.1.6 Habitat selection in relation to frequency of inundation

Two methods were used to analyse the habitat selection of the Corncrake males in relation to frequency of inundation. The first analysis revealed that the highest density of Corncrake male singing sites was found for the inundation class *20-50 days per year*. The total surface area of this inundation class is smaller than the surface area of the inundation class *2-20 days per year*, which could be an explanation for the largest number of singing sites occurring in ecotopes with an inundation frequency of *2-20 days per year*. The analyses of the distribution of singing sites over hydrodynamic classes confirmed that the Corncrake selects low dynamic habitats. The Corncrake males obviously preferred ecotopes within the hydrodynamic class *periodically to rarely flooded*. The higher preference for *periodically to rarely flooded* compared to *high-water-free* areas can be explained by the positive influence inundation can have on the habitat of the Corncrake. A winter flood removes the dead vegetation, preventing the vegetation becoming too dense for the Corncrake to walk through (Green *et al*, 1997). Furthermore, winter floods transport nutrients to the higher areas which after they have dried up have a faster and more dense vegetation growth. These habitats are preferred at the beginning of the breeding season (Just, 2005).

Both analysing methods had their restrictions. For the first method an inundation map of 1997 was used. Probably, the situation has been changed since 1997, therefore it would be better to use an updated inundation map.

Unfortunately, it was not available. Linkage with ecotope type was also not considered during this first analysis. This would be an improvement for future studies. The restriction of the second method was that each ecotope type had a fixed hydrodynamic class. Was a singing site located in a certain ecotope type it automatically was assigned to the hydrodynamic class linked to it, while in reality the inundation frequency could vary for an ecotype type.
Despite of the restrictions, there is no doubt about the validity of the results. Both methods delivered comparable results. Moreover, the differences between the inundation/hydrodynamic classes were large enough to exclude any significant influence of the restrictions on the output of both analyses. Thus, the Corncrake males prefer habitats with a low frequency of inundation.

4.2 Loss of Corncrake habitat in floodplains along the Dutch Rhine River branches

4.2.1 Loss of habitat in ecological restoration

The total amount of suitable habitat has been declined in the floodplains along all three Rhine branches between 1997 and 2005. In ecological restoration areas, loss of suitable habitat probably contributes to the disappearance of singing Corncrake males after a number of years. For example, Klompenwaard, Millingerwaard and Meinerswijk are floodplains with ecological restoration which harboured Corncrakes during the first years of the seven year monitoring period, but the last two or three years Corncrakes were no longer heard. A comparable result was found by Van Turnhout *et al*. (2007), who compared the development of Corncrake numbers between regular floodplains and ecological restoration areas for the period 1989-2003. They found for the regular, usually agrarian managed floodplains, an increasing trend since 1989, but for the ecological restoration areas a clear trend was not visible. The first five years, the numbers were clearly higher than before, but after a period of stabilisation a decrease was visible. Hence, ecological restoration areas seem to become unsuitable for the Corncrake after a number of years, but currently no explicit cause can be mentioned.
In many of the ecological restoration areas large grazers, e.g. Konik horses and Galloways, are present. They feed for a large part on dry grasslands (Cornelissen & Vulink, 2001), which appeared to be suitable habitat for the Corncrake (section 4.1.1). Also small grazers, like the population of geese in Meinerswijk which strongly increased during the last years (Floor, 2008, personal communication), contribute to the grazing pressure. Grazing is one of the important factors influencing the vegetation types and structure of ecological restoration areas (Wolters *et al*., 2001). It mainly gives direction to the succession and for a lower degree it provides rejuvenation of the vegetation (Peters *et al*., 2006). Berg & Gustafson (2007) showed that Corncrakes preferred unmanaged meadows above grazed meadows due to the tall vegetation of the former. However, without disturbing factors, like grazing and inundation, an ecological restoration area would become unsuitable as habitat for the Corncrake after a number of years due to succession and the accumulation of dead vegetation (Rothenbücher *et al*., 2005). Even extensive grazing leads to a too dense vegetation in the long term (Schoppers & Koffijberg, 2001) and will not prevent the development of shrubs and softwood forest (Wolters *et al*., 2001). On the other hand, intensive grazing can lead to a too short vegetation length or even the disappearance of rich structured grasslands (Pelsma *et al*., 2003; Wolters *et al*., 2001).
Thus, grazing seems to be an important aspect influencing the suitability of Corncrake habitat in ecological restoration areas, but the optimal grazing regime (type of grazer, grazing pressure and the period of grazing) is unknown. The more so as in addition to grazing, weather conditions, inundation frequency and soil conditions, but also management measures, like cyclic rejuvenation (Peters *et al*., 2006), affect the quality of habitat. However, it is of importance to get better insight in the influence of these aspects on the suitability of Corncrake habitat, because relatively many singing Corncrake males were heard in ecological restoration areas during the seven year monitoring period (Schoppers & Koffijberg, 2001, 2003, 2004, 2005, 2006, 2007, 2008). With detailed analyses of the vegetation structure, soil characteristics, inundation frequency and management history, knowledge could be obtained which can be used to adapt management measures as well as possible to the needs of the Corncrake. This could possibly prevent habitat loss and the disappearance of the Corncrake out of ecological restoration areas after a number of years.

4.2.2 'Room for the River' projects and the Corncrake

For the IJssel, seven 'Room for the River' projects have been designed. Two of these projects, the displacement of the dike near Westenholte in the Vreugederijkerwaard and the reconstruction of the Scheller and Oldeneler buitenwaarden, will be approved this year by the state secretary of the ministry of Transport, Public works and Water management.
Between 1999 and 2003 a first side channel was constructed in the Vreugderijkerwaard, which may be a cause for the absence of the Corncrake in these years. From 2010 onwards, additional side channels will be dug, the floodplain

will be lowered and the dike near Westenholte will be displaced (Provincie Overijssel, 2008). In the Scheller and Oldeneler buitenwaarden a side channel will also be constructed and a part of the floodplain will be lowered. In both floodplains a large amount of Corncrake habitat will disappear through the construction of the side channels, but also through the wetter conditions which will follow on the reconstruction measures taken. Lowering of the floodplains leads to a decrease of mainly drier grasslands through the increasing frequency, surface area and duration of inundation (Pelsma *et al*., 2003). The Corncrake prefers dry low dynamic tall grasslands as breeding habitat (section 4.1.1 and 4.1.6). Hence, it will decrease in number as consequence of this reconstruction measures (Pelsma *et al*., 2003, Lensink et al, 2004).

In the Vreugderijkerwaard project, the Dutch Centre for Field Ornithology has advised the project team about the implications for the Corncrake and possible compensation measures (Schoppers & Koffijberg, 2008). The project team has decided that the biggest island between the side channels should serve as compensation for the Corncrake habitat loss (Provincie Overijssel, 2008). Therefore the island has to be heightened, so that the frequency of inundation will be lowered and better conditions for the Corncrake are provided. However, the compensation area will be smaller than the area which has been used by the Corncrakes between 2001 and 2007. Furthermore, it will take time before the compensation area has reached the perfect conditions needed for the Corncrake and an island will give difficulties managing it.

The Vreugderijkerwaard and the Scheller and Oldeneler buitenwaarden are not the only floodplains of the IJssel where reconstruction measures will be implemented. In the floodplains Olsterwaard, Ossenwaard, Duurschewaard, Vorchterwaard and Oenerdijkerwaard, which during the period 2001-2007 appeared to be important Corncrake floodplains, 'Room for the River' projects will also be executed within a short time span (2009-2015). This may be a threat for the Corncrake, because a large part of the Corncrake habitat in the most important Corncrake core area of the Netherlands will be lost at once. In addition it takes some time before the compensation habitats have reached suitable conditions for the Corncrake. It would be better to realise compensation habitat in advance of physical reconstruction measures and to spread the implementation of the projects within the time frame to mitigate the effects on the Dutch Corncrake population.

5. CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions

- Herbaceous floodplain, floodplain production meadow, floodplain natural pasture, floodplain grassland (natural/production) and high-water-free production meadow appeared to be suitable habitat for the Corncrake in the floodplains along the Dutch Rhine River branches during the seven year monitoring period (2001-2007). Herbaceous floodplain was preferred mostly, both the number and density of singing sites were higher than in the other suitable ecotope types.
- The tracking study confirmed the preference for floodplain production meadow, floodplain natural pasture and floodplain grassland (natural pasture/production meadow), but not the preference for herbaceous floodplain.
- Two different analysing methods showed that the Corncrakes select habitat with a low frequency of inundation.
- Contrary to other studies, this study showed no significant seasonal shift in ecotope preference, although the percentage of singing sites in production meadow and natural pasture decreased and in herbaceous floodplain increased during the season. Possibly, shifts occur less often as many singing sites are prevented from mowing. Furthermore, the scale of this study is too large to find differences as found in the other studies.
- The tracking study showed that some ecotopes were exclusively visited by Corncrakes males during the day. Moreover, during the day a smaller share of records was found in ecotopes defined as suitable habitat than during the night, which confirms the presumption that during the day the males leave their singing site to search for food and extending their territory, while they go back in the evening to their singing site in the suitable habitat.
- The positive correlation between period of radio tracking (days) and home range area (ha) confirms that the male Corncrakes extend their territory.
- For a few ecotope characteristics clear differences were found between floodplains with an occupation frequency of 0 years and floodplains having an occupation frequency of at least once during the seven year monitoring period (2001-2007). These ecotope characteristics could be an explanation for the preference of the Corncrake for certain floodplains:
    - Corncrakes obviously selected floodplains with a larger surface area (ha), which could be related to the significantly higher amount of suitable habitat (ha) and crex habitat (ha) in these floodplains.
    - Corncrakes prefer heterogeneous floodplains with sufficiently large patches that do not differ very much in size.

  Clear differences between the floodplains with an occupation frequency of at least one year were not found.
- The preference for a heterogeneous habitat is supported by the results of the tracking study.
- Between 1997 and 2005 the total surface area of suitable habitat for the Corncrake has been strongly decreased in the floodplains along all three Rhine River branches. This seems also to happen in ecological restoration areas, contributing to the disappearance of the Corncrake out of ecological restoration areas after a number of years. Loss of habitat could be caused by succession, rejuvenation and ecotope turnover. These processes are influenced by factors like grazing regime, soil conditions, frequency of inundation, weather conditions and management history.
- During the first years of the seven year monitoring period (2001-2007) the highest number of Corncrake male singing sites was harboured by the floodplains along the Waal, but during the last years the floodplains along the IJssel were obviously more popular than the floodplains along the Rhine and Waal. The results of this study give no explanation for this shift in preference of the Corncrake males from the Waal to the IJssel floodplains.
- Many of the ‘Room for the River’ projects along the IJssel will be executed in floodplains with a high occupation frequency of the Corncrake in the period 2001-2007. Moreover, the projects will be implemented within a short time span (2009-2015). This may be a threat for the Corncrake, because a large part of the Corncrake habitat will be lost at once.

5.2 Recommendations

5.2.1 Recommendations for policy and management

- It is important to maintain the conservation measures. Not only to protect the Corncrake against mowing activities, but also to stop the habitat loss, which was obviously visible in the floodplains along all three Rhine branches between 1997 and 2005.
- For the Corncrake it would be better to spread the 'Room for the River' projects within the time frame and to realise compensation measures in advance of physical reconstruction measures, because it takes some time before the compensation habitats have reached suitable conditions for the Corncrake.

5.2.2 Recommendations for research

- The results of the ecotope preference analysis may be influenced by clustering of Corncrake males. The effect of clustering on habitat selection has to be studied.
- The influence of large grazers and also the growing population of geese on the vegetation structure and thus the amount of available suitable habitat for the Corncrake in ecological restoration areas has to be investigated.
- At the locations of the Corncrake male singing sites, more detailed analyses of the local environmental circumstances (e.g. vegetation structure, grazing regime, inundation frequency, food availability, soil characteristics, management history and weather conditions) are needed:
    - to investigate the differences between the floodplains with a different frequency of occupation.
    - to find a possible shift in ecotope preference during the season.
    - to get a better idea of the suitable conditions for the Corncrake in general and to adapt management measures as well as possible to the needs of the Corncrake.
- It is interesting to investigate whether the results of this report can be further confirmed and extended by the data of Corncrakes radio tagged by SOVON Dutch Centre for Field Ornithology in 2008.

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APPENDIX I: DISTRIBUTION MAPS OF CORNCRAKE MALE SINGING SITES (2001-2007)

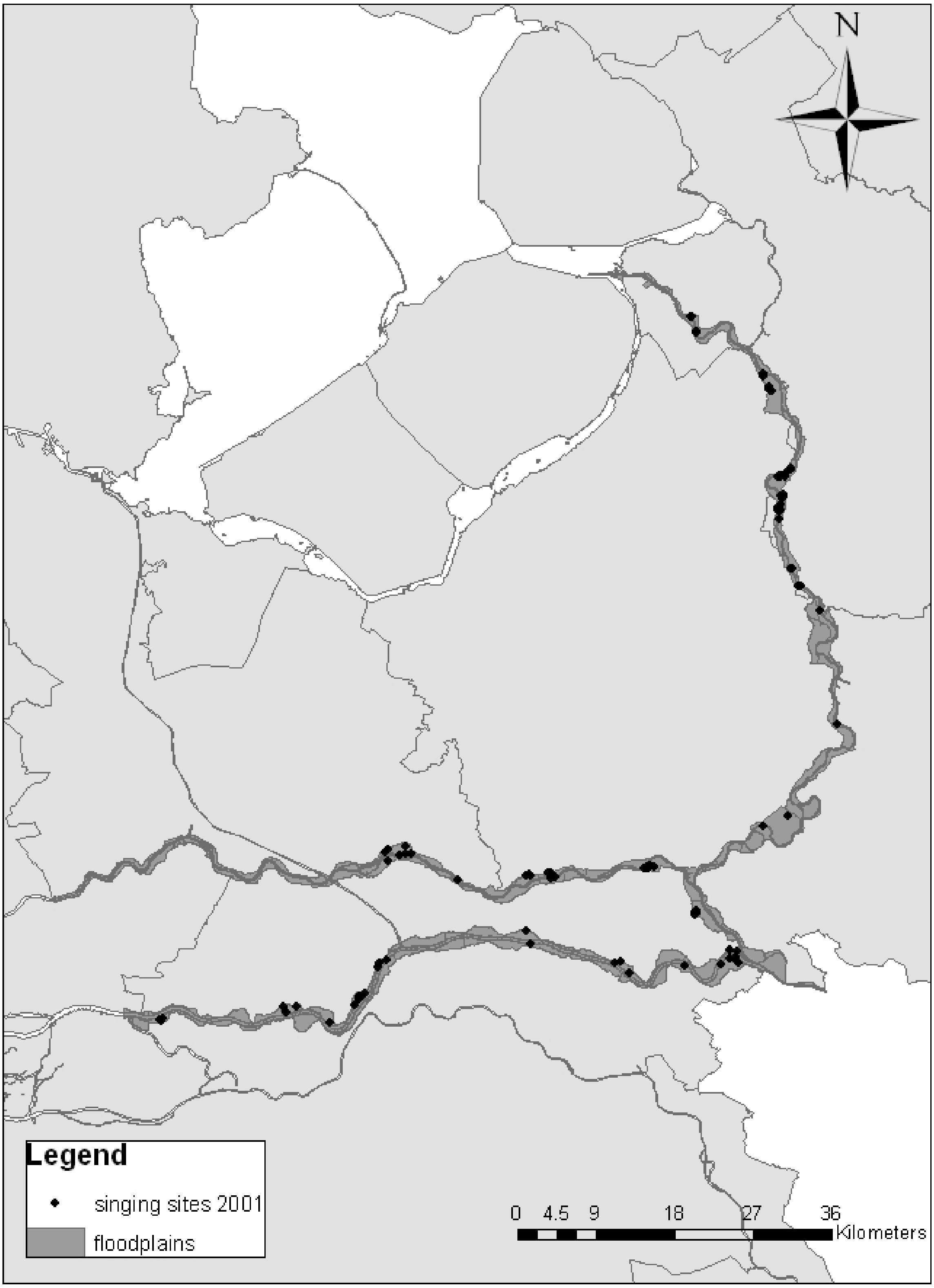

Figure I.1: distribution of Corncrake male singing sites in the floodplains along the Dutch Rhine River branches for the year 2001.

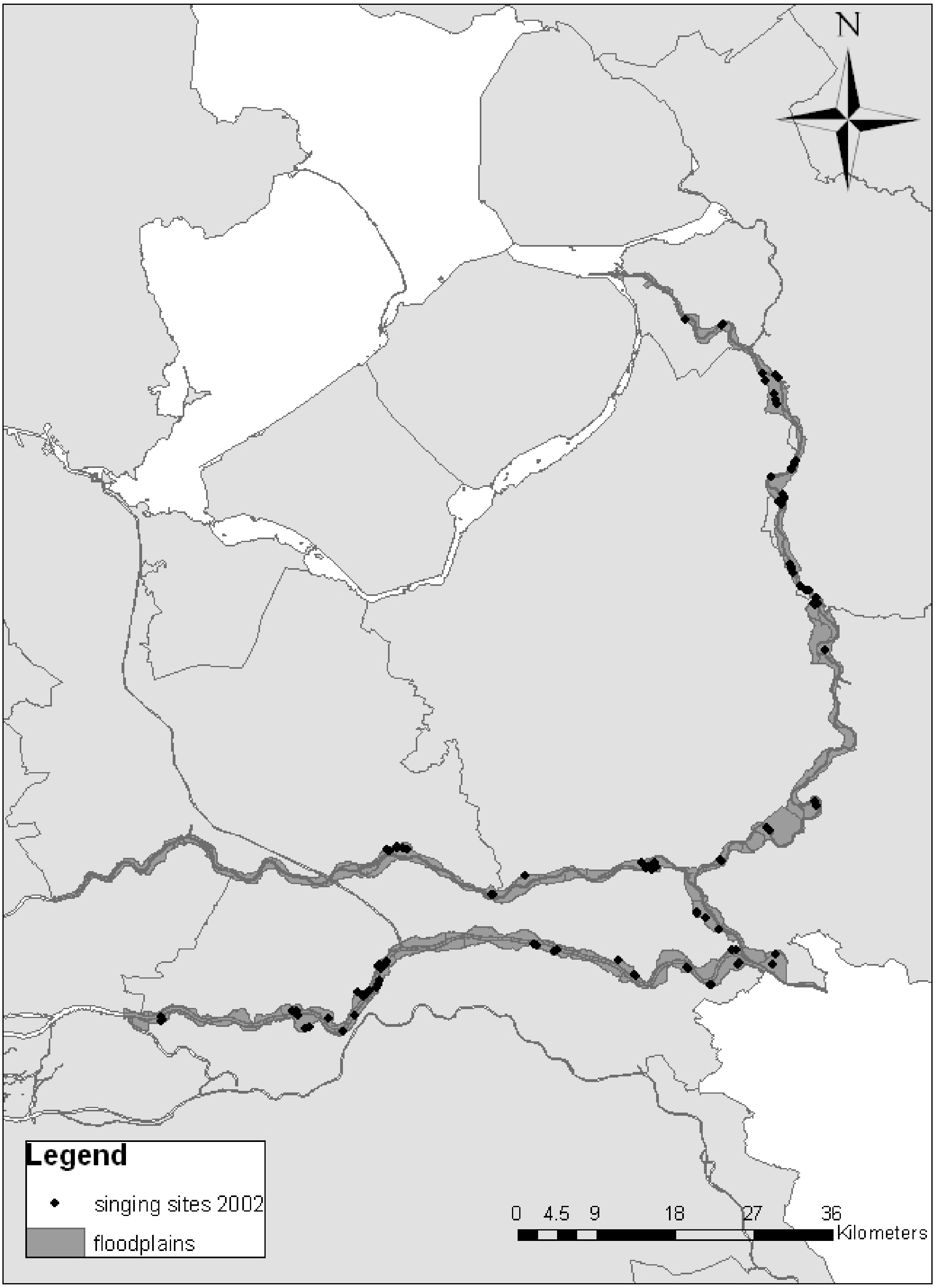

Figure I.2: distribution of Corncrake male singing sites in the floodplains along the Dutch Rhine River branches for the year 2002.

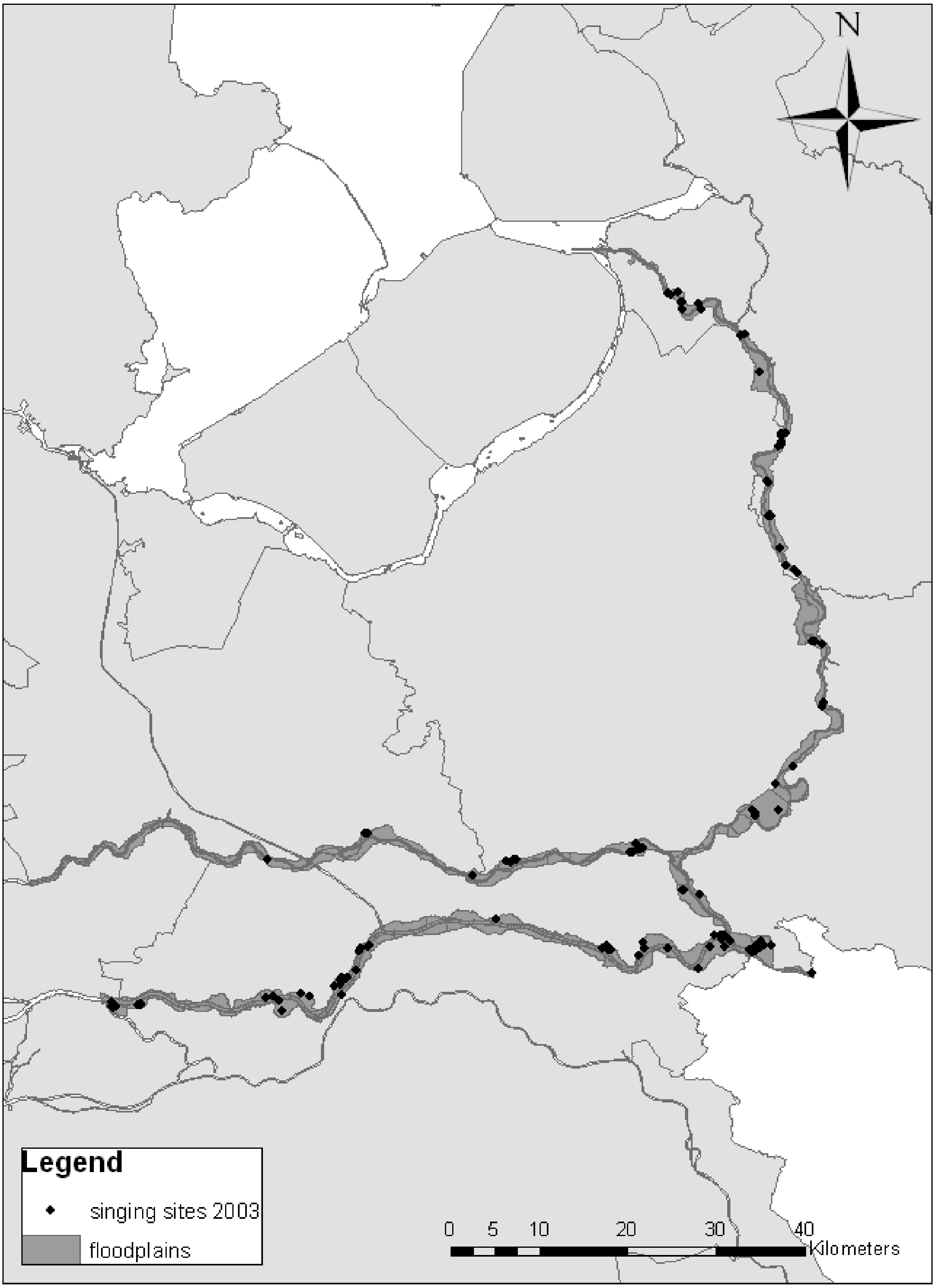

Figure I.3: distribution of Corncrake male singing sites in the floodplains along the Dutch Rhine River branches for the year 2003.

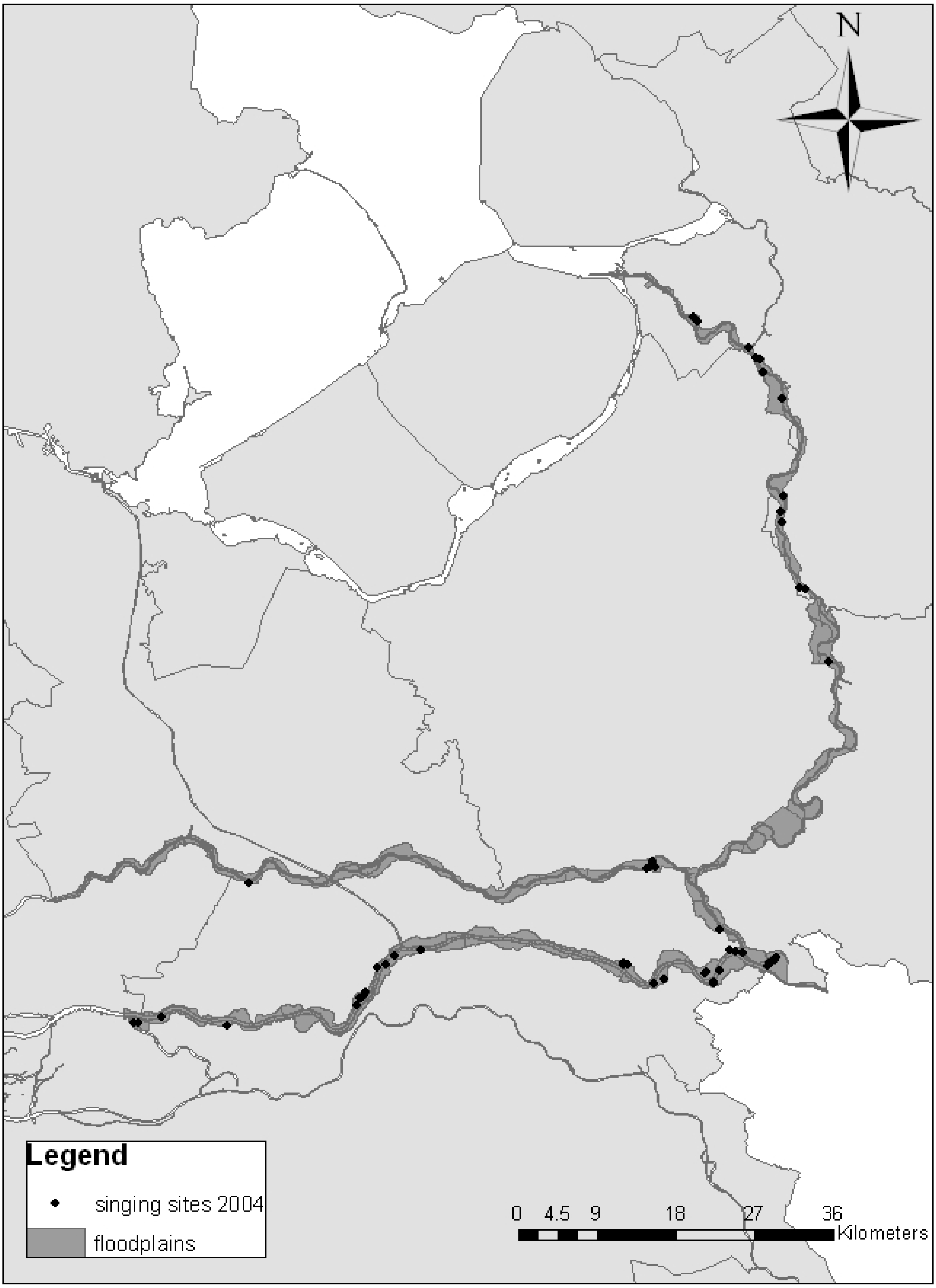

Figure I.4: distribution of Corncrake male singing sites in the floodplains along the Dutch Rhine River branches for the year 2004.

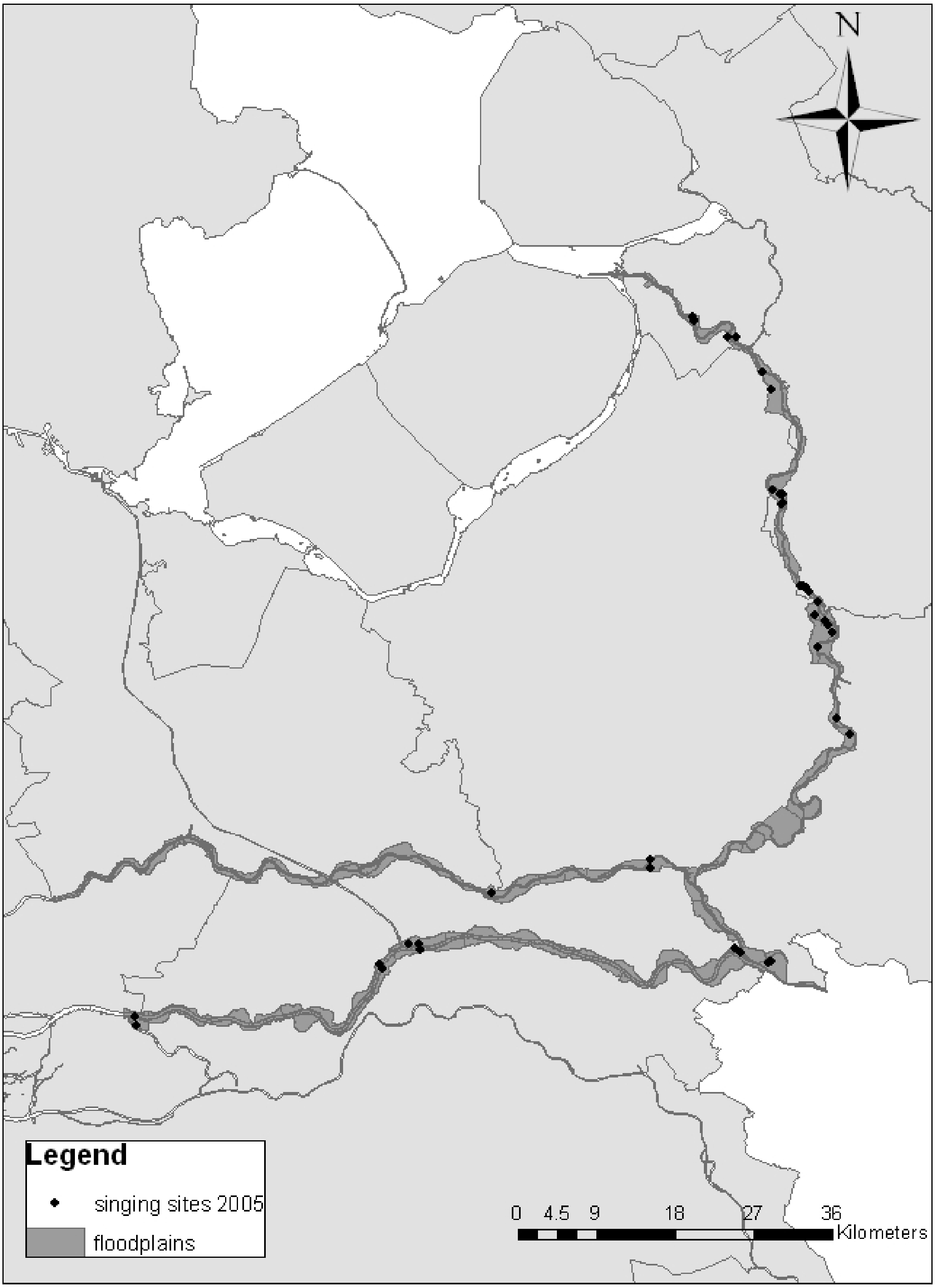

Figure I.5: distribution of Corncrake male singing sites in the floodplains along the Dutch Rhine River branches for the year 2005.

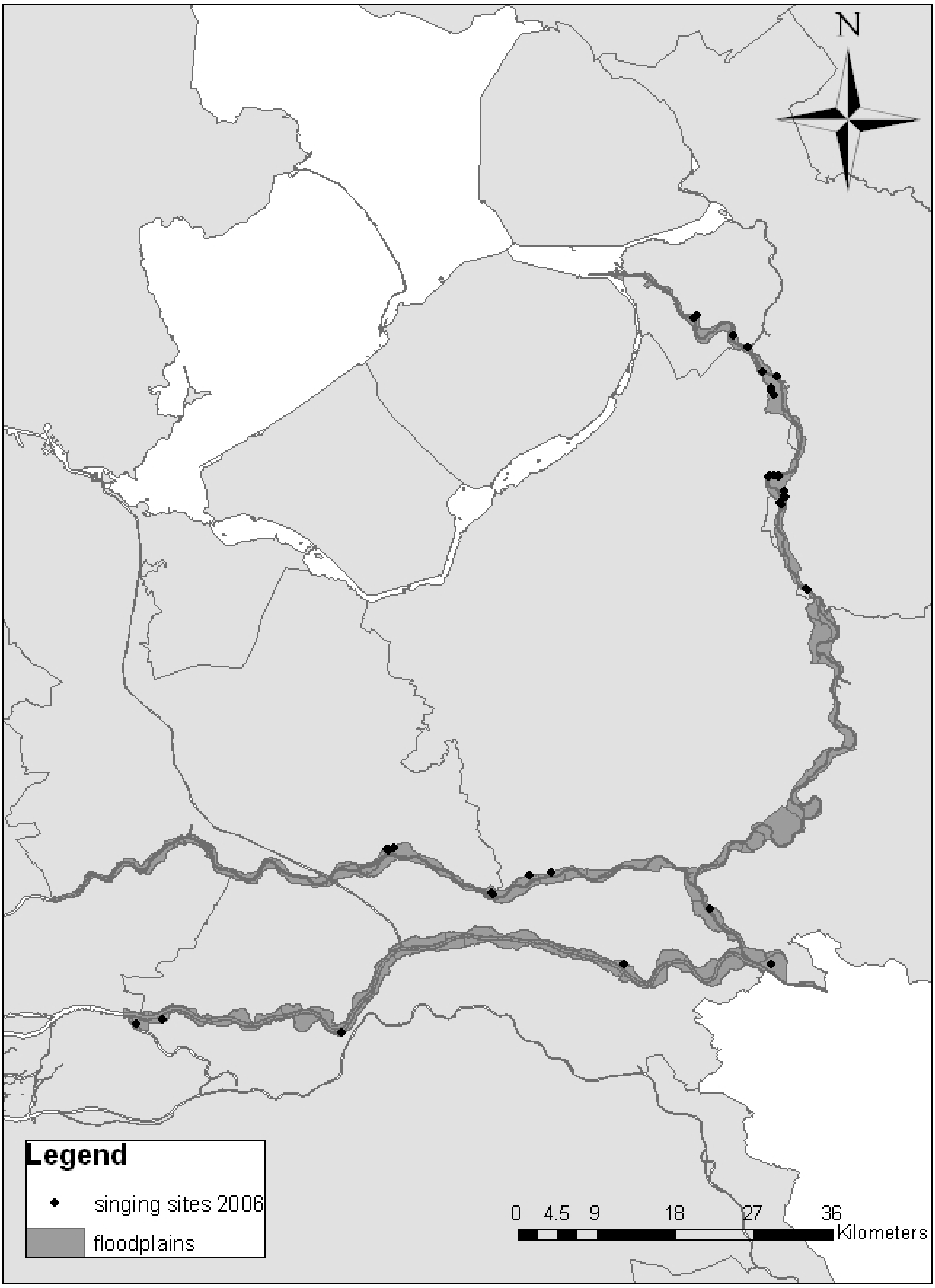

Figure I.6: distribution of Corncrake male singing sites in the floodplains along the Dutch Rhine River branches for the year 2006.

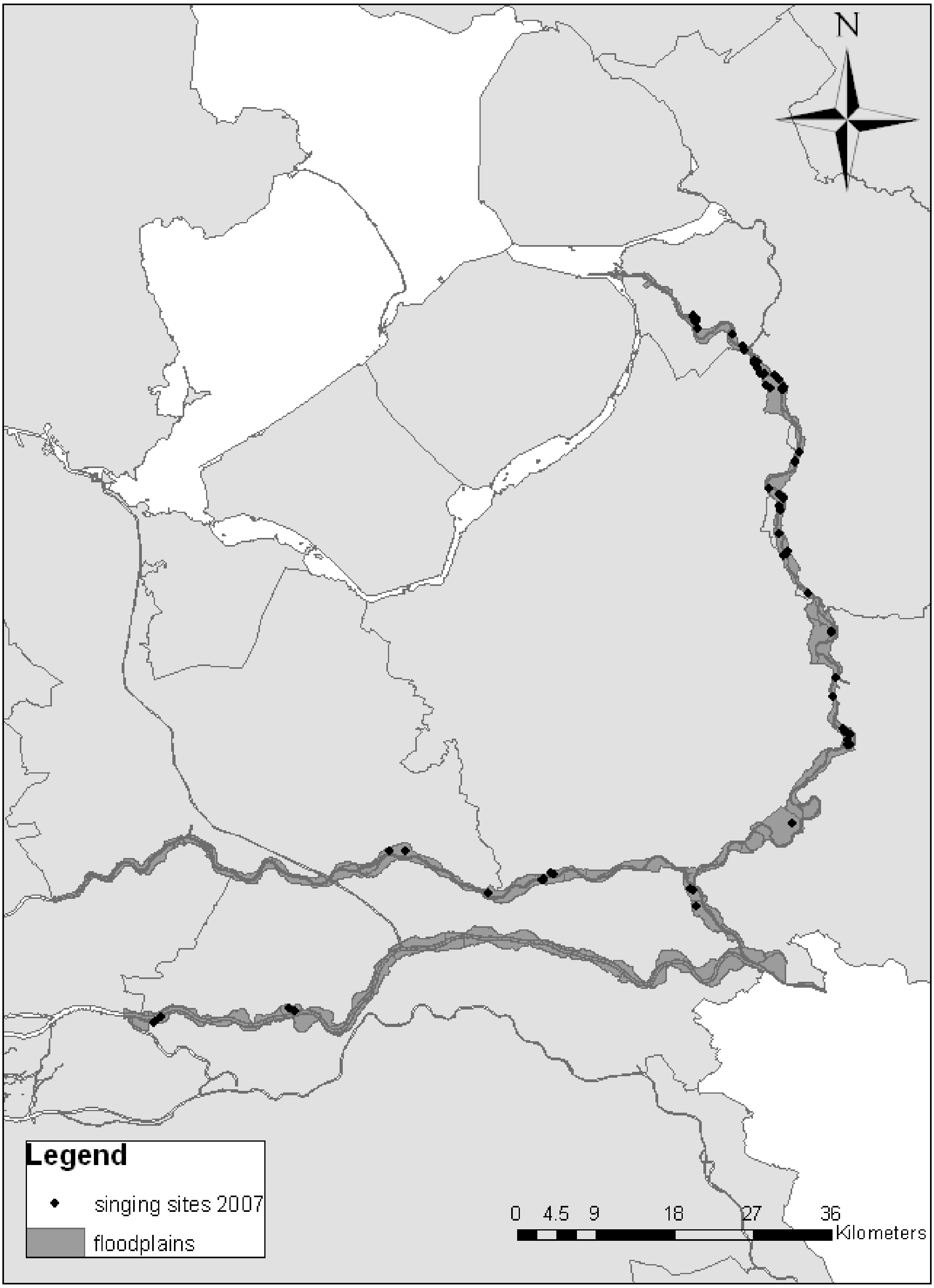

Figure I.7: distribution of Corncrake male singing sites in the floodplains along the Dutch Rhine River branches for the year 2007.

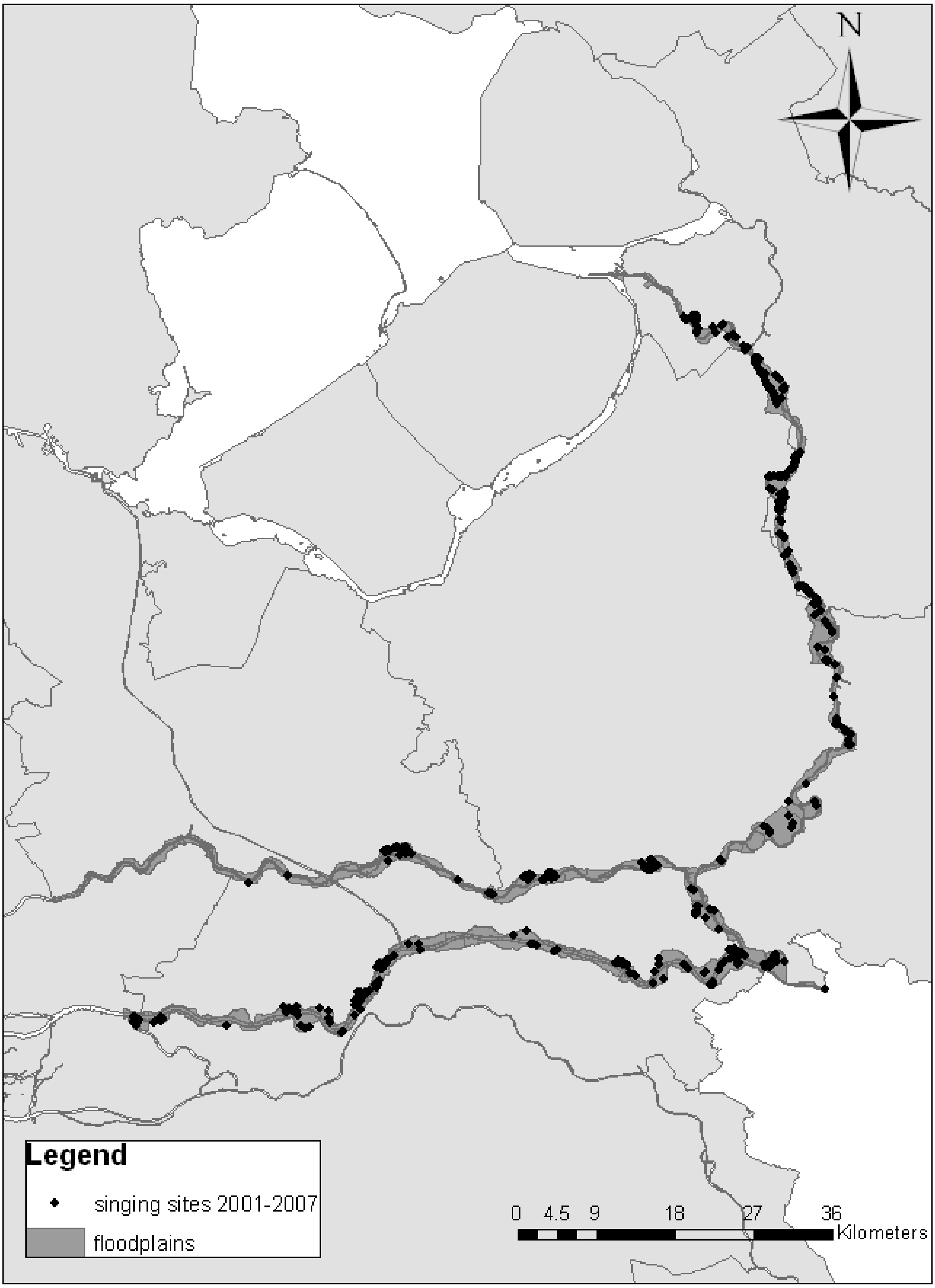

Figure I.8: distribution of Corncrake male singing sites in the floodplains along the Dutch Rhine River branches for the years 2001-2007.

APPENDIX II: FREQUENCY OF OCCURRENCE FLOODPLAINS

Table II.1: number of singing sites each floodplain contains for the years 2001-2007 and number of years each floodplain has been occupied by at least one singing Corncrake male.

Branch	Floodplain	Area (ha)	# singing sites 2001	# singing sites 2002	# singing sites 2003	# singing sites 2004	# singing sites 2005	# singing sites 2006	# singin g sites 2007	Total # singing sites	# of years occu pied
W	Afferdensche en Deestsche waarden	303.1	0	0	0	0	0	0	0	0	0
R	Arnhem	21.4	0	0	0	0	0	0	0	0	0
R	Bosscherwaarden	136.6	0	0	0	0	0	0	0	0	0
R	Bossenwaard	59.1	0	0	0	0	0	0	0	0	0
Y	Bronkhorster waarden	228.2	0	0	0	0	0	0	0	0	0
Y	Brummensche waarden	425.9	0	0	0	0	0	0	0	0	0
W	Dalemsche waard	66.3	0	0	0	0	0	0	0	0	0
Y	De Greente	24.3	0	0	0	0	0	0	0	0	0
Y	De Grind	38.0	0	0	0	0	0	0	0	0	0
Y	de Naters	54.0	0	0	0	0	0	0	0	0	0
Y	De Pijper	109.3	0	0	0	0	0	0	0	0	0
R	De Rauwert	164.2	0	0	0	0	0	0	0	0	0
Y	Deventer	118.1	0	0	0	0	0	0	0	0	0
Y	Doesburg	17.1	0	0	0	0	0	0	0	0	0
R	Domswaard	36.5	0	0	0	0	0	0	0	0	0
R	Doorwerthsche waarden	192.5	0	0	0	0	0	0	0	0	0
R	Drielsche uiterwaarden	119.8	0	0	0	0	0	0	0	0	0
W	Drutensche waarden oost	161.6	0	0	0	0	0	0	0	0	0
W	Drutensche waarden west	275.1	0	0	0	0	0	0	0	0	0
R	Elster buitenwaarden	156.0	0	0	0	0	0	0	0	0	0
Y	Epse- en Bokkenwaard	101.2	0	0	0	0	0	0	0	0	0
W	Ewijcksche waard	85.4	0	0	0	0	0	0	0	0	0
W	Gamerensche waarden	97,9	0	0	0	0	0	0	0	0	0
W	Geitenwaard	94.8	0	0	0	0	0	0	0	0	0
R	Goilberdingerwaard	173.0	0	0	0	0	0	0	0	0	0
W	Gouverneursche polder	329.0	0	0	0	0	0	0	0	0	0
R	Graafsche waard	189.3	0	0	0	0	0	0	0	0	0
W	Grobsche waard	260.0	0	0	0	0	0	0	0	0	0
W	Groesplaat	7.8	0	0	0	0	0	0	0	0	0
Y	Groote of Koningspleij (IJssel)	13.9	0	0	0	0	0	0	0	0	0
R	Groote of Koningspleij (Rijn)	154.5	0	0	0	0	0	0	0	0	0
R	Hagesteinsche uiterwaard	98.8	0	0	0	0	0	0	0	0	0
R	Heerenwaard	50.3	0	0	0	0	0	0	0	0	0
W	Heeseltsche middenplaat	99.4	0	0	0	0	0	0	0	0	0
W	Herwijnensche benedenwaard	91.2	0	0	0	0	0	0	0	0	0
W	Herwijnensche bovenwaard	49.7	0	0	0	0	0	0	0	0	0
Y	Herxer uiterwaarden	79.6	0	0	0	0	0	0	0	0	0
Y	Hondsbroeksche pleij	10.6	0	0	0	0	0	0	0	0	0
R	Honswijkerwaarden	97.6	0	0	0	0	0	0	0	0	0
Y	IJsseldijker waard	77.9	0	0	0	0	0	0	0	0	0
Y	IJsseloordsche polder	62.2	0	0	0	0	0	0	0	0	0
W	IJzendoorn	110.5	0	0	0	0	0	0	0	0	0
R	Ingensche waarden	144.4	0	0	0	0	0	0	0	0	0

Branch	Floodplain	Area (ha)	# singing sites 2001	# singing sites 2002	# singing sites 2003	# singing sites 2004	# singing sites 2005	# singing sites 2006	# singin g sites 2007	Total # singing sites	# of years occu pied
Y	Kampen	71.4	0	0	0	0	0	0	0	0	0
W	Kerkenwaard	190.3	0	0	0	0	0	0	0	0	0
R	Kersbergsche- en Achthovensche uiterwaarden	116.7	0	0	0	0	0	0	0	0	0
R	Koekoeksche waard	59.2	0	0	0	0	0	0	0	0	0
R	Koornwaard	131.2	0	0	0	0	0	0	0	0	0
Y	Koppenwaard	127.8	0	0	0	0	0	0	0	0	0
Y	Kroonestein	39.4	0	0	0	0	0	0	0	0	0
R	Langerak-Nieuwpoort	11.2	0	0	0	0	0	0	0	0	0
Y	Lathumse en Bahrsche waard	99.7	0	0	0	0	0	0	0	0	0
R	Lekwaard	84.1	0	0	0	0	0	0	0	0	0
R	Lobberdensche Waard	313.9	0	0	0	0	0	0	0	0	0
W	Loenensche buitenpolder	164.8	0	0	0	0	0	0	0	0	0
R	Lunenburgerwaard	125.2	0	0	0	0	0	0	0	0	0
Y	Marlerwaarden	154.9	0	0	0	0	0	0	0	0	0
R	Meandertak Gravenbol	101.0	0	0	0	0	0	0	0	0	0
R	Middelwaard	103.6	0	0	0	0	0	0	0	0	0
W	Millingen	17.9	0	0	0	0	0	0	0	0	0
W	Moespotsche waard	223.0	0	0	0	0	0	0	0	0	0
W	Nijmegen	87.0	0	0	0	0	0	0	0	0	0
R	Pannerdensche buitenwaard	118.8	0	0	0	0	0	0	0	0	0
R	Polder de Eendragt	325.2	0	0	0	0	0	0	0	0	0
R	Redichemsche waard	98.3	0	0	0	0	0	0	0	0	0
R	Renkum	88.6	0	0	0	0	0	0	0	0	0
Y	Rheden en de Steeg	69.7	0	0	0	0	0	0	0	0	0
Y	Rijsselsche waard	87.0	0	0	0	0	0	0	0	0	0
R	Rijswijcksche buitenpolder	262.1	0	0	0	0	0	0	0	0	0
R	Rijswijcksche waard	71.6	0	0	0	0	0	0	0	0	0
W	Rossumsche waard	27.1	0	0	0	0	0	0	0	0	0
W	Ruyterwaard	113.0	0	0	0	0	0	0	0	0	0
R	Schalkwijker buitenwaard	163.3	0	0	0	0	0	0	0	0	0
R	Schoutenwaard	69.7	0	0	0	0	0	0	0	0	0
Y	Spaansweerd	104.4	0	0	0	0	0	0	0	0	0
Y	Spoolderwaard	12.4	0	0	0	0	0	0	0	0	0
R	Steenfabriek Ossewaard	24.3	0	0	0	0	0	0	0	0	0
R	Steenwaard	166.5	0	0	0	0	0	0	0	0	0
R	Stuweiland Driel	41.1	0	0	0	0	0	0	0	0	0
R	Stuweiland Hagestein	7.8	0	0	0	0	0	0	0	0	0
R	Stuweiland Maurik	15.5	0	0	0	0	0	0	0	0	0
R	t Waalsche waard	59.4	0	0	0	0	0	0	0	0	0
Y	Tichelbeekse waarden	149.6	0	0	0	0	0	0	0	0	0
W	Tiel	51.4	0	0	0	0	0	0	0	0	0
R	Tollewaard	110.3	0	0	0	0	0	0	0	0	0
R	Vogelzang	70.8	0	0	0	0	0	0	0	0	0
R	Vreeswijk	7.1	0	0	0	0	0	0	0	0	0
W	Vuren	29.6	0	0	0	0	0	0	0	0	0

Branch	Floodplain	Area (ha)	# singing sites 2001	# singing sites 2002	# singing sites 2003	# singing sites 2004	# singing sites 2005	# singing sites 2006	# singin g sites 2007	Total # singing sites	# of years occu pied
Y	Westervoort	32.3	0	0	0	0	0	0	0	0	0
Y	Wilpse klei	674.3	0	0	0	0	0	0	0	0	0
W	Wolferensche waard	55.3	0	0	0	0	0	0	0	0	0
R	Wolswaard	314.0	0	0	0	0	0	0	0	0	0
W	Woudrichem	10.7	0	0	0	0	0	0	0	0	0
W	Zaltbommel	45.0	0	0	0	0	0	0	0	0	0
Y	Zuiderwaard	318.9	0	0	0	0	0	0	0	0	0
W	Bemmelsche waarden	405.8	0	0	3	0	0	0	0	3	1
R	Beusichemse waard	233.7	0	0	1	0	0	0	0	1	1
W	Breemwaard	126.7	0	0	0	1	0	0	0	1	1
W	Buiten Ooy	235.5	0	0	0	2	0	0	0	2	1
Y	Fraterwaard	298.6	0	2	0	0	0	0	0	2	1
Y	Gelderhoofdsche waard	33.3	0	0	0	0	0	0	1	1	1
W	Gendtsche waarden	407.1	0	0	0	2	0	0	0	2	1
Y	Harculosche buitenwaarden	117.9	0	0	0	0	0	0	3	3	1
R	Huissensche waarden noord	261.0	0	0	0	0	0	0	2	2	1
Y	IJsselcentrale	34.1	0	0	0	0	0	0	1	1	1
R	Lazaruswaard	73.4	0	0	0	1	0	0	0	1	1
R	Loowaard	222.3	0	0	1	0	0	0	0	1	1
R	Mauriksche- en Ecksche waarden	302.2	1	0	0	0	0	0	0	1	1
Y	Noordingsbouwing	206.8	0	0	1	0	0	0	0	1	1
Y	Olburgsche waard	150.6	0	0	1	0	0	0	0	1	1
R	Rhenen=Palmerswaard	74.8	1	0	0	0	0	0	0	1	1
R	Rosandepolder	210.9	0	1	0	0	0	0	0	1	1
W	Tolkamer	71.6	0	0	1	0	0	0	0	1	1
Y	Velperwaarden	167.3	0	2	0	0	0	0	0	2	1
W	Willemspolder	472.8	0	0	0	0	2	0	0	2	1
W	Winsensche waarden	228.7	0	4	0	0	0	0	0	4	1
Y	Zutphen	79.4	0	0	0	0	0	0	1	1	1
Y	Bentinkswellen	127.6	0	0	0	0	1	0	1	2	2
Y	Bolwerksweide	235.3	0	2	0	0	1	0	0	3	2
R	Doorneburgsche buitenwaard	91.9	0	0	1	1	0	0	0	2	2
Y	Epseweerdse polder	223.6	0	0	0	0	3	0	2	5	2
W	Hiensche uiterwaarden	280.7	1	0	1	0	0	0	0	2	2
W	Hurwenensche uiterwaarden	413.5	0	2	2	0	0	0	0	4	2
Y	Onderdijksche waard	77.8	0	1	2	0	0	0	0	3	2
Y	Rammelwaard	197.0	0	0	4	1	0	0	0	5	2
R	Randwijcksche uiterwaarden	192.0	2		0	0	0	0	3	5	2
Y	Ravenswaarden	226.0	0	1	0	0	1	0	0	2	2
Y	Welsumvelder buitenwaarden	199.3	0	0	1	0	0	0	1	2	2
Y	Wijher buitenwaarden	118.3	0	0	1	0	0	0	1	2	2
Y	Zalkerbos en de Welle	215.9	0	2	1	0	0	0	0	3	2
W	De Kop	188.7	0	2	1	0	0	1	0	4	3
W	Groenlanden=Bizonbaai	143.0	1	2	1			0	0	4	3
Y	Havikerwaard	962.2	1	0	1	0	0	0	1	3	3

Branch	Floodplain	Area (ha)	# singing sites 2001	# singing sites 2002	# singing sites 2003	# singing sites 2004	# singing sites 2005	# singing sites 2006	# singin g sites 2007	Total # singing sites	# of years occu pied
W	Heesseltsche uiterwaard	285.2	1	1	2	0	0	0	0	4	3
R	Renkumse benedenwaarden	122.2	3	0	0	0	0	1	3	7	3
Y	Reuversweerd	292.0	0	0	1	0	1	0	8	10	3
Y	Stokebrandsweerd	94.1	1	0	1	0	1	0	0	3	3
Y	Vaalwaard	211.4	1	2	3	0	0	0	0	6	3
W	Wamelsche uiterwaard	183.0	1	0	0	2	1	0	0	4	3
Y	Keizers- en Stobbenwaard	296.5	3	1	1	0	0	0	2	7	4
R	Meinerswijk	324.2	8	7	10	4	0	0	0	29	4
W	Millingerwaard	582.9	6	4	3	3	0	0	0	16	4
W	Munnikenland=Loevestein	191.3			3	2	2	1	0	8	4
Y	Olster waarden	165.5	2	0	2	2	0	0	1	7	4
W	Rijswaard	203.7	3	2	2	0	0	0	2	9	4
W	Stiftsche uiterwaarden	251.2	6	5	6	7	0	0	0	24	4
Y	Terwolderdorpenwaarden	132.9	2	1	1	0	0	0	1	5	4
Y	Vreugderijker waard	136.1	0	0	0	1	1	3	2	7	4
R	Wageninger benedenwaarden	185.4	3	1	4	0	0	1	0	9	4
R	Amerongsche bovenpolder	422.3	7	8	2	0	0	4	2	23	5
W	De Bijland	591.9	0	2	13	5	4	3	0	27	5
W	Dreumelsche waard	331.6	1	6	3	1	1	0	0	12	5
Y	Gelderdijksche waard	79.6	0	1	1	0	1	1	4	8	5
R	Huissensche waarden zuid	478.3	4	4	2	1	0	0	1	12	5
W	Klompenwaard	86.2	2	1	5	2	2	0	0	12	5
W	Oosterhoutsche weilanden	245.4	2	3	5	2	0	1	0	13	5
W	Passewaaij	53.9	2	2	2	1	1	0	0	8	5
R	Rhenensche buitenwaarden=Blauwe Kamer	231.1	0	2	1	0	1	2	1	7	5
Y	Scheller en Oldeneler buitenwaarden	161.8	0	2	1	1	0	1	3	8	5
Y	Vorchter waarden	128.3	3	4	5	0	0	1	2	15	5
W	Brakelsche benedenwaarden	212.0	6	3	4	1	0	1	3	18	6
Y	Duursche waarden en Fortmond	403.0	15	3	0	1	1	6	2	28	6
Y	Oenerdijker- en Weelsumerwaarden	217.7	4	5	3	0	3	7	2	24	6
Y	Scherenwelle en Koppelerwaard	257.2	4	0	5	2	3	2	6	22	6
Y	Hoenwaard	704.9	6	5	1	1	1	3	4	21	7
Y	Ossenwaard	102.8	1	5	3	2	3	3	1	18	7
	Total		***104***	***101***	***119***	***49***	***35***	***42***	***67***	***517***	

APPENDIX III: DISTRIBUTION OF CORNCRAKE MALE SINGING SITES OVER ECOTOPE TYPES

Table III.1: number of singing sites of Corncrake males per ecotope type for the years 2001-2007.

Ecotope	Ecocode	Total	2001	2002	2003	2004	2005	2006	2007
Herbaceous floodplain	UR-1	111	20	20	25	15	10	12	9
Floodplain production meadow	UG-2	108	17	25	21	10	7	11	17
Floodplain natural pasture	UG-1	99	27	18	18	10	7	6	13
Floodplain grassland (natural pasture/production meadow)	UG-1-2	39	7	5	9	9	1	0	8
High-water-free production meadow	HG-2	22	6	7	1	1	1	2	4
High-water-free natural pasture	HG-1	19	3	6	5	0	0	2	3
High-water-free herbaceous rough	HR-1	17	5	3	5	1	1	2	0
High-water-free herbaceous grassland (natural pasture/production meadow)	HG-1-2	14	6	2	3	0	1	0	2
Herbaceous marsh	V.1-2	13	3	2	7	0	1	0	0
Natural levee or floodplain natural pasture	O-UG-1	11	1	2	4	0	0	1	3
Deep summer bed*	RzD	10	0	2	2	1	4	1	0
Herbaceous natural levee or floodplain	O-UR-1	9	2	2	1	1	2	0	1
Arable floodplain	UA-1	9	0	2	4	1	1	0	1
(Very) deep floodplain water body*	RvD/RwD	9	1	2	0	1	2	0	3
Moderately deep floodplain water body*	RwM	8	1	3	2	0	1	1	0
Natural levee or floodplain production meadow	O-UG-2	8	1	1	3	0	1	0	2
High-water-free arable land	HA-1	6	0	2	1	0	0	1	2
Marshy natural pasture	VII.1	3	0	0	1	1	0	1	0
Natural levee or floodplain reed	UM-1	3	1	0	1	0	0	0	1
Natural levee or floodplain grassland (natural pasture/production meadow)	O-UG-1-2	3	0	0	3	0	0	0	0
High-water-free built up area	HA-2	3	0	0	0	0	0	3	0
Floodplain natural forest	UB-1	2	1	0	1	0	0	0	0
Species poor helophyte marsh/species-rich reed	IV.8-9	2	0	0	1	0	0	1	0
Temporarily bare floodplain	U-rest	2	1	0	0	0	1	0	0
Floodplain production forest	UB-3	2	0	0	2	0	0	0	0
Floodplain shrubs	UB-2	2	1	0	1	0	0	0	0
Floodplain softwood shrubs or pioneer softwood forest	VI.2-3	2	0	1	1	0	0	0	0
Floodplain softwood forest	VI-4	2	0	1	0	0	0	0	1
Dynamic fresh to slightly brackish shallow water*	I.1	1	0	0	0	1	0	0	0
Marshy natural pasture/production meadow	VII.1-3	1	0	0	1	0	0	0	0
Natural levee or floodplain natural forest	O-UB-1	1	0	0	0	0	1	0	0
Arable natural levee or floodplain	O-UA-1	1	1	0	0	0	0	0	0
High-water-free natural forest	HB-1	1	0	1	0	0	0	0	0
Temporarily bare high-water-free area	H-rest	1	1	0	0	0	0	0	0
Production meadow	VII.3	1	0	1	0	0	0	0	0
Sand bar along freshwater*	II-2	1	1	0	0	0	0	0	0
Total		***546***	***107***	***108***	***123***	***52***	***42***	***44***	***70***

* indicates singing sites located in water ecotopes, which therefore are excluded from the analyses.

Table III.2: percentage of singing sites of Corncrake males per ecotope type for the years 2001-2007.

Ecotope	**Ecocode**	**Total**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**
Herbaceous floodplain	UR-1	20.3	18.7	18.5	20.3	28.8	23.8	27.3	12.9
Floodplain production meadow	UG-2	19.8	15.9	23.1	17.1	19.2	16.7	25.0	24.3
Floodplain natural pasture	UG-1	18.1	25.2	16.7	14.6	19.2	16.7	13.6	18.6
Floodplain grassland (natural pasture/production meadow)	UG-1-2	7.1	6.5	4.6	7.3	17.3	2.4	0.0	11.4
High-water-free production meadow	HG-2	4.0	5.6	6.5	0.8	1.9	2.4	4.5	5.7
High-water-free natural pasture	HG-1	3.5	2.8	5.6	4.1	0.0	0.0	4.5	4.3
High-water-free herbaceous rough	HR-1	3.1	4.7	2.8	4.1	1.9	2.4	4.5	0.0
High-water-free herbaceous grassland (natural pasture/production meadow)	HG-1-2	2.6	5.6	1.9	2.4	0.0	2.4	0.0	2.9
Herbaceous marsh	V.1-2	2.4	2.8	1.9	5.7	0.0	2.4	0.0	0.0
Natural levee or floodplain natural pasture	O-UG-1	2.0	0.9	1.9	3.3	0.0	0.0	2.3	4.3
Deep summer bed*	RzD	1.8	0.0	1.9	1.6	1.9	9.5	2.3	0.0
Herbaceous natural levee or floodplain	O-UR-1	1.6	1.9	1.9	0.8	1.9	4.8	0.0	1.4
Arable floodplain	UA-1	1.6	0.0	1.9	3.3	1.9	2.4	0.0	1.4
(Very) deep floodplain water body*	RvD/RwD	1.6	0.9	1.9	0.0	1.9	4.8	0.0	4.3
Moderately deep floodplain water body*	RwM	1.5	0.9	2.8	1.6	0.0	2.4	2.3	0.0
Natural levee or floodplain production meadow	O-UG-2	1.5	0.9	0.9	2.4	0.0	2.4	0.0	2.9
High-water-free arable land	HA-1	1.1	0.0	1.9	0.8	0.0	0.0	2.3	2.9
Marshy natural pasture	VII.1	0.5	0.0	0.0	0.8	1.9	0.0	2.3	0.0
Natural levee or floodplain reed	UM-1	0.5	0.9	0.0	0.8	0.0	0.0	0.0	1.4
Natural levee or floodplain grassland (natural pasture/production meadow)	O-UG-1-2	0.5	0.0	0.0	2.4	0.0	0.0	0.0	0.0
High-water-free built up area	HA-2	0.5	0.0	0.0	0.0	0.0	0.0	6.8	0.0
Floodplain natural forest	UB-1	0.4	0.9	0.0	0.8	0.0	0.0	0.0	0.0
Species poor helophyte marsh/species-rich reed	IV.8-9	0.4	0.0	0.0	0.8	0.0	0.0	2.3	0.0
Temporarily bare floodplain	U-rest	0.4	0.9	0.0	0.0	0.0	2.4	0.0	0.0
Floodplain production forest	UB-3	0.4	0.0	0.0	1.6	0.0	0.0	0.0	0.0
Floodplain shrubs	UB-2	0.4	0.9	0.0	0.8	0.0	0.0	0.0	0.0
Floodplain softwood shrubs or pioneer softwood forest	VI.2-3	0.4	0.0	0.9	0.8	0.0	0.0	0.0	0.0
Floodplain softwood forest	VI-4	0.4	0.0	0.9	0.0	0.0	0.0	0.0	1.4
Dynamic fresh to slightly brackish shallow water*	I.1	0.2	0.0	0.0	0.0	1.9	0.0	0.0	0.0
Marshy natural pasture/production meadow	VII.1-3	0.2	0.0	0.0	0.8	0.0	0.0	0.0	0.0
Natural levee or floodplain natural forest	O-UB-1	0.2	0.0	0.0	0.0	0.0	2.4	0.0	0.0
Arable natural levee or floodplain	O-UA-1	0.2	0.9	0.0	0.0	0.0	0.0	0.0	0.0
High-water-free natural forest	HB-1	0.2	0.0	0.9	0.0	0.0	0.0	0.0	0.0
Temporarily bare high-water-free area	H-rest	0.2	0.9	0.0	0.0	0.0	0.0	0.0	0.0
Production meadow	VII.3	0.2	0.0	0.9	0.0	0.0	0.0	0.0	0.0
Sand bar along freshwater*	II-2	0.2	0.9	0.0	0.0	0.0	0.0	0.0	0.0
Total		100	100	100	100	100	100	100	100

* indicates singing sites located in water ecotopes, which therefore are excluded from the analyses

Table III.3: accuracies of the singing sites of Corncrake males for each type of ecotope for the years 2001-2007 in total.

Ecotope	Ecocode	Total	1 m	%	10 m	%	100 m	%	1000 m	%
Herbaceous floodplain	UR-1	111	6	12.5	77	22.5	25	18.4	3	15.0
Floodplain production meadow	UG-2	108	12	25.0	72	21.1	23	16.9	1	5.0
Floodplain natural pasture	UG-1	99	11	22.9	62	18.1	24	17.6	2	10.0
Floodplain grassland (natural pasture/production meadow)	UG-1-2	39	6	12.5	24	7.0	9	6.6	0	0.0
High-water-free production meadow	HG-2	22	2	4.2	11	3.2	9	6.6	0	0.0
High-water-free natural pasture	HG-1	19	2	4.2	10	2.9	5	3.7	2	10.0
High-water-free herbaceous rough	HR-1	17	0	0.0	14	4.1	3	2.2	0	0.0
High-water-free herbaceous grassland (natural pasture/production meadow)	HG-1-2	14	2	4.2	9	2.6	2	1.5	1	5.0
Herbaceous marsh	V.1-2	13	0	0.0	8	2.3	5	3.7	0	0.0
Natural levee or floodplain natural pasture	O-UG-1	11	0	0.0	10	2.9	1	0.7	0	0.0
Deep summer bed*	RzD	10	0	0.0	4	1.2	5	3.7	1	5.0
Herbaceous natural levee or floodplain	O-UR-1	9	1	2.1	4	1.2	3	2.2	1	5.0
Arable floodplain	UA-1	9	1	2.1	5	1.5	3	2.2	0	0.0
(Very) deep floodplain water body*	RvD/RwD	9	0	0.0	3	0.9	3	2.2	3	15.0
Moderately deep floodplain water body*	RwM	8	0	0.0	3	0.9	4	2.9	1	5.0
Natural levee or floodplain production meadow	O-UG-2	8	1	2.1	5	1.5	1	0.7	1	5.0
High-water-free arable land	HA-1	6	2	4.2	2	0.6	2	1.5	0	0.0
Marshy natural pasture	VII.1	3	0	0.0	3	0.9	0	0.0	0	0.0
Natural levee or floodplain reed	UM-1	3	1	2.1	2	0.6	0	0.0	0	0.0
Natural levee or floodplain grassland (natural pasture/production meadow)	O-UG-1-2	3	0	0.0	3	0.9	0	0.0	0	0.0
High-water-free built up area	HA-2	3	0	0.0	0	0.0	0	0.0	3	15.0
Floodplain natural forest	UB-1	2	0	0.0	2	0.6	0	0.0	0	0.0
Species poor helophyte marsh/species-rich reed	IV.8-9	2	0	0.0	1	0.3	1	0.7	0	0.0
Temporarily bare floodplain	U-rest	2	0	0.0	1	0.3	1	0.7	0	0.0
Floodplain production forest	UB-3	2	0	0.0	2	0.6	0	0.0	0	0.0
Floodplain shrubs	UB-2	2	0	0.0	2	0.6	0	0.0	0	0.0
Floodplain softwood shrubs or pioneer softwood forest	VI.2-3	2	0	0.0	0	0.0	2	1.5	0	0.0
Floodplain softwood forest	VI-4	2	1	2.1	1	0.3	0	0.0	0	0.0
Dynamic fresh to slightly brackish shallow water*	I.1	1	0	0.0	0	0.0	1	0.7	0	0.0
Marshy natural pasture/production meadow	VII.1-3	1	0	0.0	1	0.3	0	0.0	0	0.0
Natural levee or floodplain natural forest	O-UB-1	1	0	0.0	0	0.0	0	0.0	1	5.0
Arable natural levee or floodplain	O-UA-1	1	0	0.0	1	0.3	0	0.0	0	0.0
High-water-free natural forest	HB-1	1	0	0.0	0	0.0	1	0.7	0	0.0
Temporarily bare high-water-free area	H-rest	1	0	0.0	0	0.0	1	0.7	0	0.0
Production meadow	VII.3	1	0	0.0	0	0.0	1	0.7	0	0.0
Sand bar along freshwater*	II-2	1	0	0.0	0	0.0	1	0.7	0	0.0
Total		***546***	***48***	***100***	***342***	***100***	***136***	***100***	***20***	***100***

* indicates singing sites located in water ecotopes, which therefore are excluded from the analyses.

Table III.4: Number of singing sites per ecotope type during the first simultaneous survey in comparison with number of singing sites per ecotope type for the second simultaneous survey for the years 2001-2007 together.

Ecotope	**1st survey**	**%**	**2nd survey**	**%**
Herbaceous floodplain	40	20.7	64	25.6
Floodplain production meadow	40	20.7	47	18.8
Floodplain natural pasture	35	18.1	45	18.0
High-water-free natural pasture	13	6.7	6	2.4
Floodplain grassland (natural pasture/production meadow)	9	4.7	15	6.0
High-water-free production meadow	9	4.7	6	2.4
High-water-free grassland (natural pasture/production meadow)	8	4.1	6	2.4
High-water-free herbaceous rough	6	3.1	5	2.0
Arable floodplain	4	2.1	4	1.6
Natural levee or floodplain natural pasture	3	1.6	5	2.0
Herbaceous marsh	3	1.6	4	1.6
Natural levee or floodplain production meadow	3	1.6	4	1.6
High-water-free arable land	3	1.6	2	0.8
Deep summer bed*	2	1.0	5	2.0
Very deep floodplain water body*	2	1.0	5	2.0
Species poor helophyte marsh/species-rich reed	2	1.0	3	1.2
Floodplain production forest	2	1.0	0	0.0
Herbaceous natural levee or floodplain	1	0.5	4	1.6
Dynamic fresh to slightly brackish shallow water*	1	0.5	2	0.8
Moderately deep summer bed*	1	0.5	2	0.8
Arable natural levee or floodplain	1	0.5	1	0.4
Floodplain natural forest	1	0.5	1	0.4
Marshy natural pasture	1	0.5	1	0.4
Natural levee or floodplain reed	1	0.5	1	0.4
Floodplain shrubs	1	0.5	0	0.0
Sand bar along freshwater*	1	0.5	0	0.0
High-water-free built up area	0	0.0	3	1.2
Moderately deep floodplain water body*	0	0.0	3	1.2
Temporarily bare floodplain	0	0.0	2	0.8
High-water-free natural forest	0	0.0	1	0.4
Marshy natural pasture/production meadow	0	0.0	1	0.4
Natural levee or floodplain grassland (natural pasture/production meadow)	0	0.0	1	0.4
Production meadow	0	0.0	1	0.4
Built up floodplain	0	0.0	0	0.0
Floodplain reed	0	0.0	0	0.0
Total	***193***	***100***	***250***	***100***

* indicates singing sites located in water ecotopes, which therefore are excluded from the analyses.

APPENDIX IV: ECOTOPE CHARACTERISTICS AND FREQUENCY OF OCCUPATION FLOODPLAINS

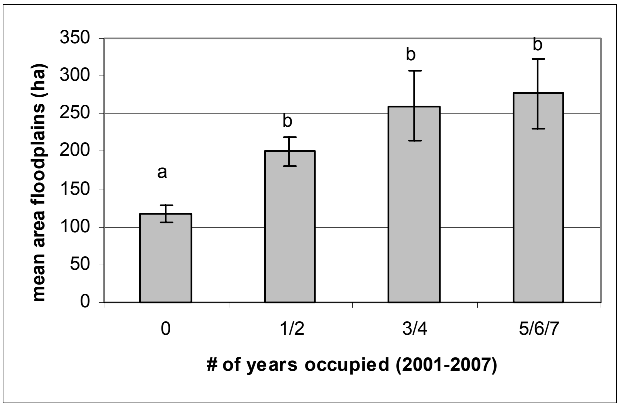

Figure IV.1: mean area (ha) of the floodplains (±SE) in relation to frequency of occupation. Differences were tested for significance using a Games Howell test ($p<0.05$). Different letters indicate a significant difference, while identical letters indicate no significant difference.

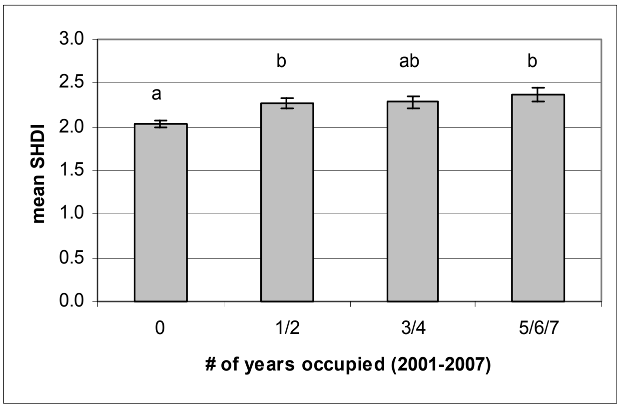

Figure IV.2: mean SHDI of the floodplains (±SE) in relation to frequency of occupation. Differences were tested for significance using a Games Howell test ($p<0.05$). Different letters indicate a significant difference, while identical letters indicate no significant difference.

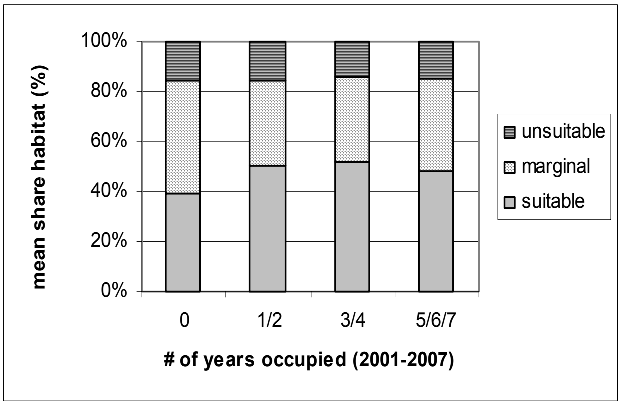

Figure IV.3: shares of mean suitable, marginal and unsuitable habitat (%) per floodplain (±SE) in relation to frequency of occupation. Differences were tested for significance using a Games Howell test ($p<0.05$). Different letters indicate a significant difference, while identical letters indicate no significant difference.

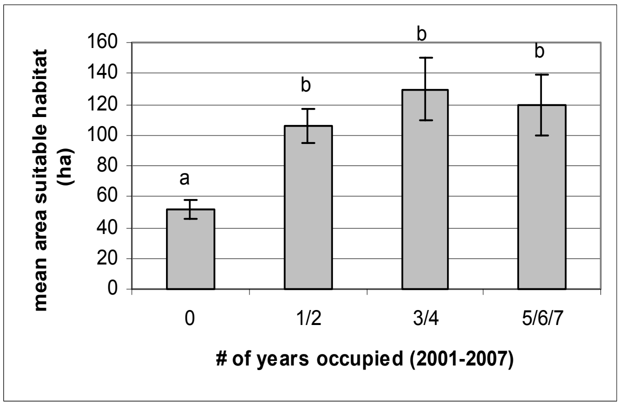

Figure IV.4: Mean area of suitable habitat (ha) per floodplain (±SE) in relation to frequency of occupation. Differences were tested for significance using a Games Howell test ($p<0.05$). Different letters indicate a significant difference, while identical letters indicate no significant difference.

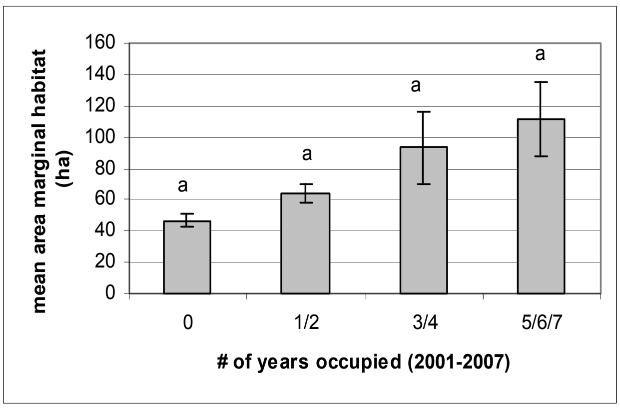

Figure IV.5: mean area of marginal habitat (ha) per floodplain (±SE) in relation to frequency of occupation. Differences were tested for significance using a Games Howell test ($p<0.05$). Different letters indicate a significant difference, while identical letters indicate no significant difference.

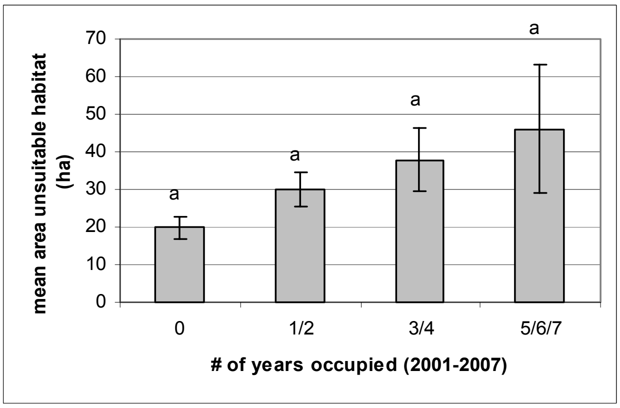

Figure IV.6: mean area of unsuitable habitat (ha) per floodplain (±SE) in relation to frequency of occupation. Differences were tested for significance using a Games Howell test ($p<0.05$). Different letters indicate a significant difference, while identical letters indicate no significant difference.

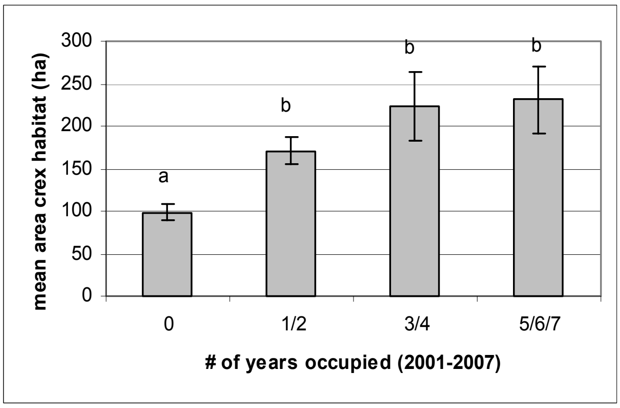

Figure IV.7: mean area of crex habitat (ha) per floodplain (±SE) in relation to frequency of occupation. Differences were tested for significance using a Games Howell test ($p<0.05$). Different letters indicate a significant difference, while identical letters indicate no significant difference.

Figure IV.8: mean share of crex habitat (%) per floodplain (±SE) in relation to frequency of occupation. Differences were tested for significance using a Games Howell test ($p<0.05$). Different letters indicate a significant difference, while identical letters indicate no significant difference.

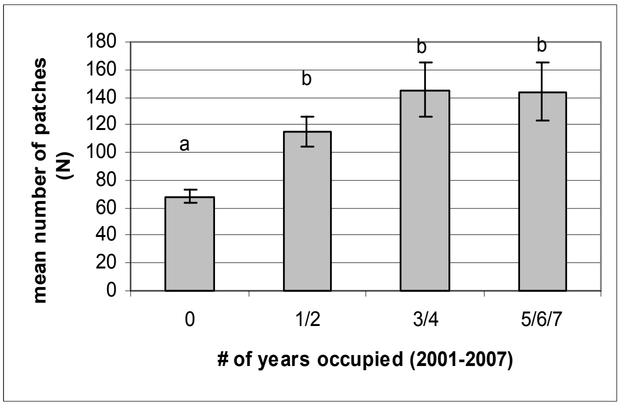

Figure IV.9: mean number of patches (N) per floodplain (±SE) in relation to frequency of occupation. Differences were tested for significance using a Games Howell test ($p<0.05$). Different letters indicate a significant difference, while identical letters indicate no significant difference.

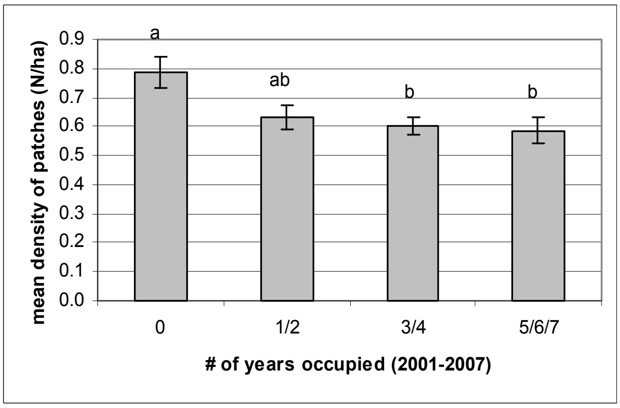

Figure IV.10: mean density of patches (N/ha) per floodplain (±SE) in relation to frequency of occupation. Differences were tested for significance using a Games Howell test ($p<0.05$). Different letters indicate a significant difference, while identical letters indicate no significant difference.

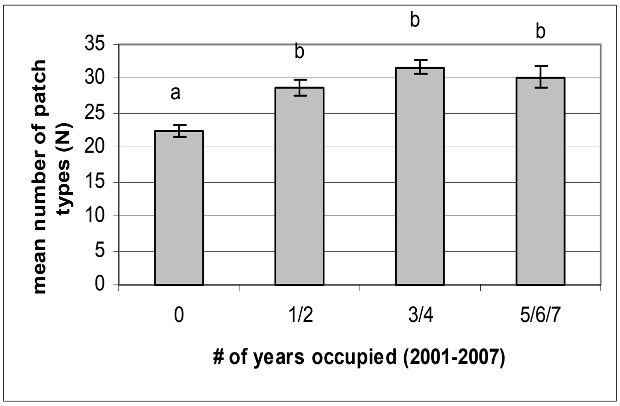

Figure IV.11: mean number of patch types (N) per floodplain (±SE) in relation to frequency of occupation. Differences were tested for significance using a Games Howell test ($p<0.05$). Different letters indicate a significant difference, while identical letters indicate no significant difference.

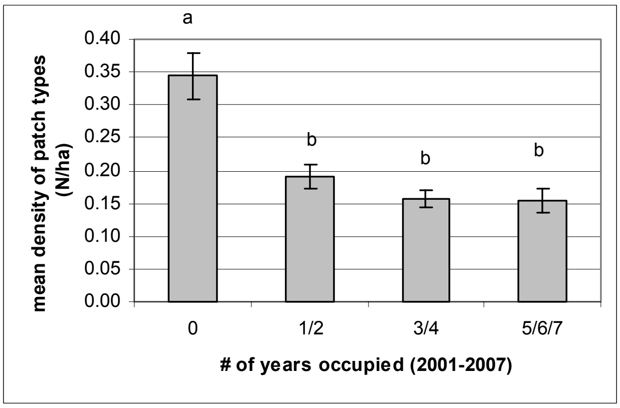

Figure IV.12: mean density of patch types (N/ha) per floodplain (±SE) in relation to frequency of occupation. Differences were tested for significance using a Games Howell test ($p<0.05$). Different letters indicate a significant difference, while identical letters indicate no significant difference.

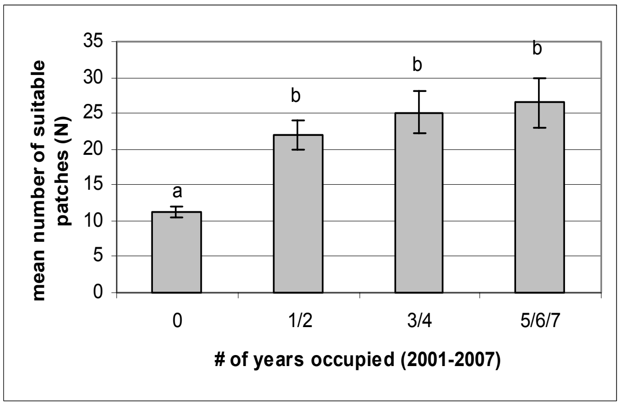

Figure IV.13: mean number of suitable patches (N) per floodplain (±SE) in relation to frequency of occupation. Differences were tested for significance using a Games Howell test ($p<0.05$). Different letters indicate a significant difference, while identical letters indicate no significant difference.

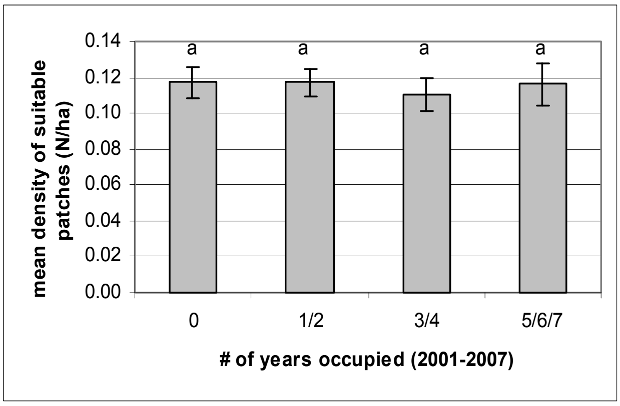

Figure IV.14: mean density of suitable patches (N/ha) per floodplain (±SE) in relation to frequency of occupation. Differences were tested for significance using a Games Howell test ($p<0.05$). Different letters indicate a significant difference, while identical letters indicate no significant difference.

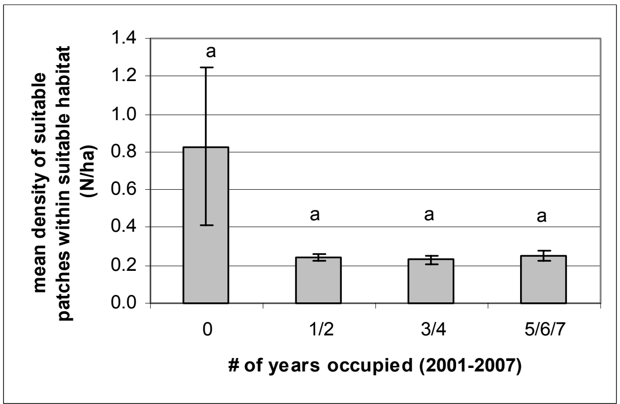

Figure IV.15: mean density of suitable patches within suitable habitat (N/ha) per floodplain (±SE) in relation to frequency of occupation. Differences were tested for significance using a Games Howell test ($p<0.05$). Different letters indicate a significant difference, while identical letters indicate no significant difference.

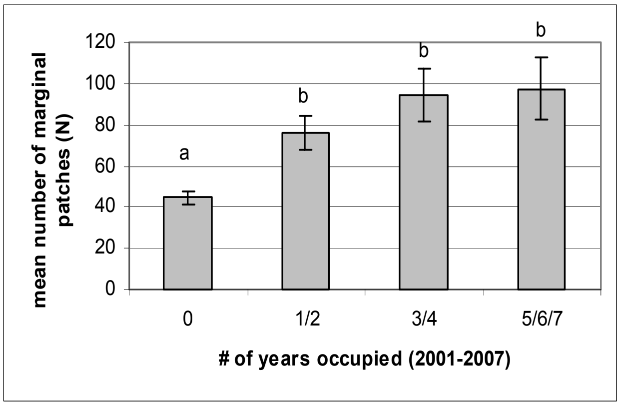

Figure IV.16: mean number of marginal patches (N) per floodplain (±SE) in relation to frequency of occupation. Differences were tested for significance using a Games Howell test ($p<0.05$). Different letters indicate a significant difference, while identical letters indicate no significant difference.

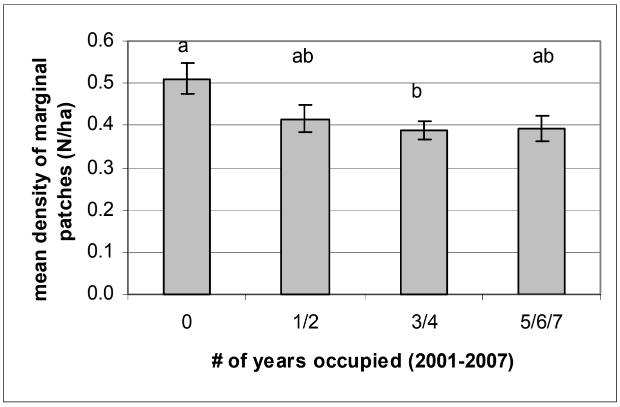

Figure IV.17: mean density of marginal patches (N/ha) per floodplain (±SE) in relation to frequency of occupation. Differences were tested for significance using a Games Howell test ($p<0.05$). Different letters indicate a significant difference, while identical letters indicate no significant difference.

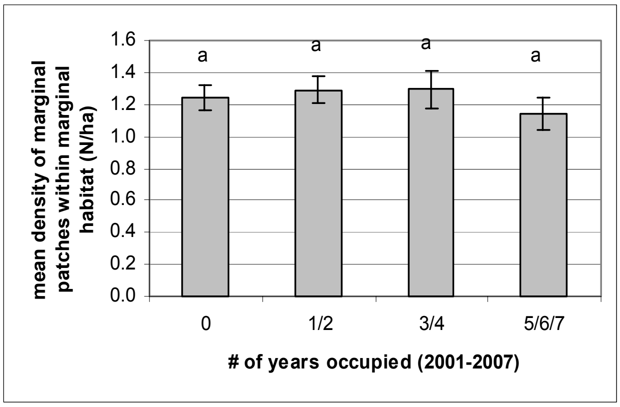

Figure IV.18: mean density of marginal patches within marginal habitat (N/ha) per floodplain (±SE) in relation to frequency of occupation. Differences were tested for significance using a Games Howell test ($p<0.05$). Different letters indicate a significant difference, while identical letters indicate no significant difference.

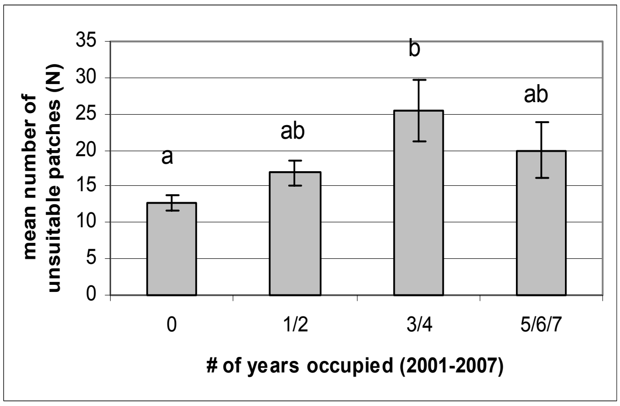

Figure IV.19: mean number of unsuitable patches (N) per floodplain (±SE) in relation to frequency of occupation. Differences were tested for significance using a Games Howell test (p<0.05). Different letters indicate a significant difference, while identical letters indicate no significant difference.

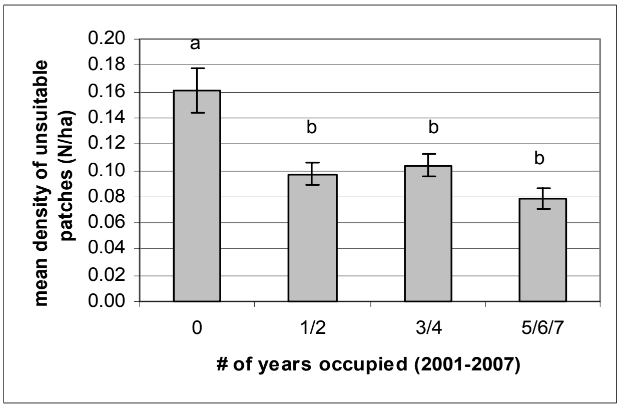

Figure IV.20: mean density of unsuitable patches (N/ha) per floodplain (±SE) in relation to frequency of occupation. Differences were tested for significance using a Games Howell test (p<0.05). Different letters indicate a significant difference, while identical letters indicate no significant difference.

Figure IV.21: mean density of unsuitable patches within unsuitable habitat (N/ha) per floodplain (±SE) in relation to frequency of occupation. Differences were tested for significance using a Games Howell test (p<0.05). Different letters indicate a significant difference, while identical letters indicate no significant difference.

APPENDIX V: ECOTOPE CHARACTERISTICS OF FLOODPLAINS RHINE, WAAL AND IJSSEL

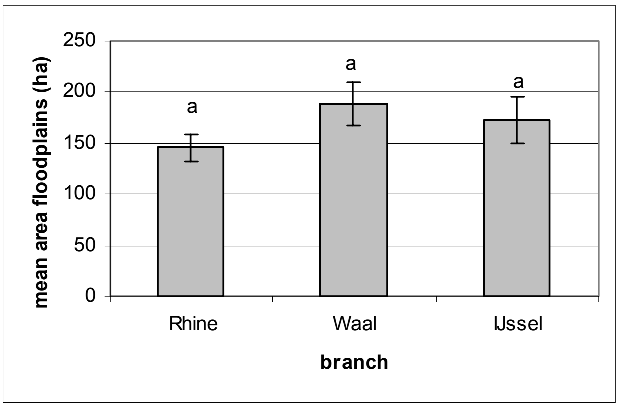

Figure V.1: mean area (ha) of the floodplains (±SE) per Rhine branch. Rhine: N=57, Waal: N=49 and IJssel: N=60. Differences were tested for significance using a Games Howell test ($p<0.05$). Different letters indicate a significant difference, while identical letters indicate no significant difference.

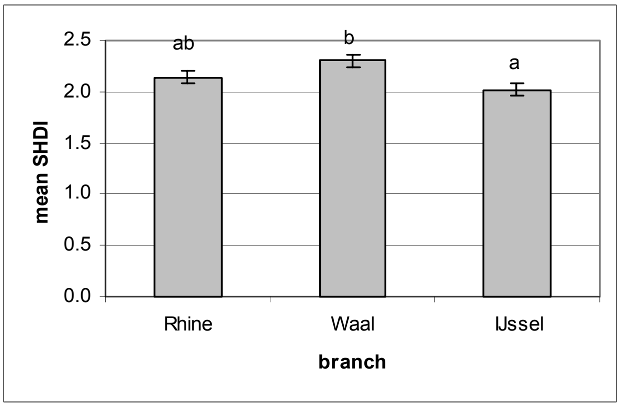

Figure V.2: mean SHDI of the floodplains (±SE) per Rhine branch. Rhine: N=57, Waal: N=49 and IJssel: N=60. Differences were tested for significance using a Games Howell test ($p<0.05$). Different letters indicate a significant difference, while identical letters indicate no significant difference.

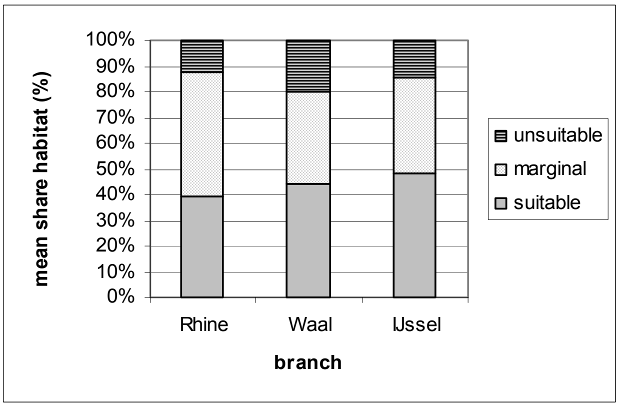

Figure V.3: shares of mean suitable, marginal and unsuitable habitat (%) of the floodplains (±SE) per Rhine branch. Rhine: N=57, Waal: N=49 and IJssel: N=60. Differences were tested for significance using a Games Howell test ($p<0.05$). Different letters indicate a significant difference, while identical letters indicate no significant difference.

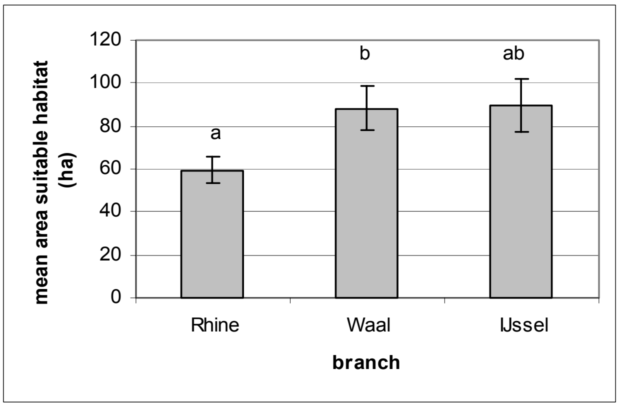

Figure V.4: mean area of suitable habitat (ha) in the floodplains (±SE) per Rhine branch. Rhine: N=57, Waal: N=49 and IJssel: N=60. Differences were tested for significance using a Games Howell test ($p<0.05$). Different letters indicate a significant difference, while identical letters indicate no significant difference.

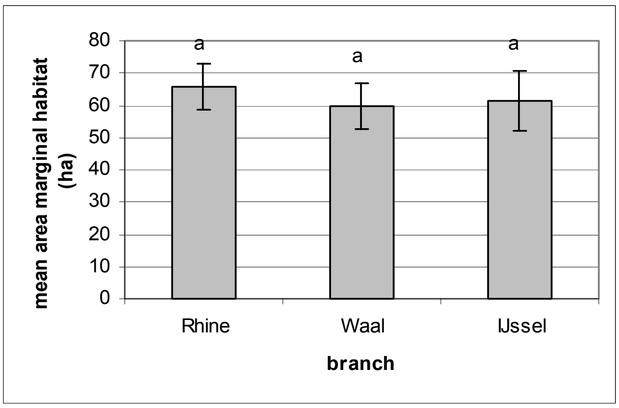

Figure V.5: mean area of marginal habitat (ha) in the floodplains (±SE) per Rhine branch. Rhine: N=57, Waal: N=49 and IJssel: N=60. Differences were tested for significance using a Games Howell test ($p<0.05$). Different letters indicate a significant difference, while identical letters indicate no significant difference.

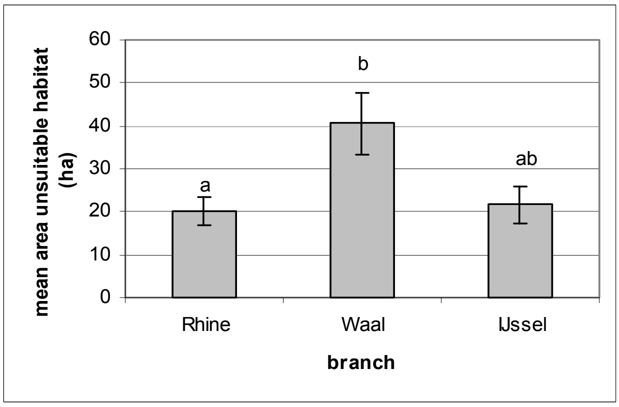

Figure V.6: mean area of unsuitable habitat (ha) in the floodplains (±SE) per Rhine branch. Rhine: N=57, Waal: N=49 and IJssel: N=60. Differences were tested for significance using a Games Howell test ($p<0.05$). Different letters indicate a significant difference, while identical letters indicate no significant difference.

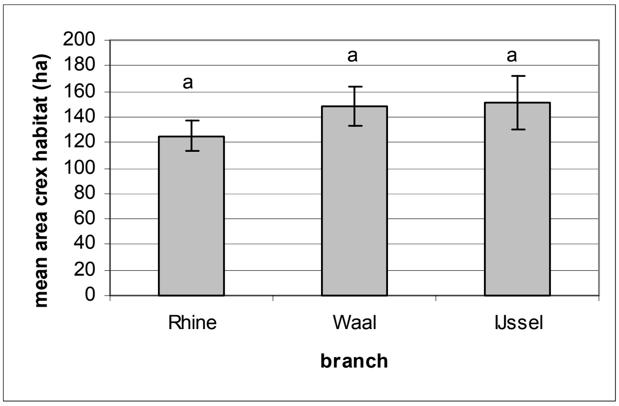

Figure V.7: mean area of crex habitat (ha) in the floodplains (±SE) per Rhine branch. Rhine: N=57, Waal: N=49 and IJssel: N=60. Differences were tested for significance using a Games Howell test ($p<0.05$). Different letters indicate a significant difference, while identical letters indicate no significant difference.

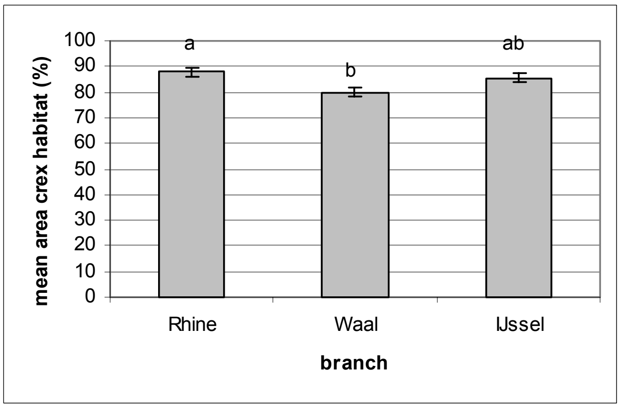

Figure V.8: mean share of crex habitat (%) in the floodplains (±SE) per Rhine branch. Rhine: N=57, Waal: N=49 and IJssel: N=60. Differences were tested for significance using a Games Howell test ($p<0.05$). Different letters indicate a significant difference, while identical letters indicate no significant difference.

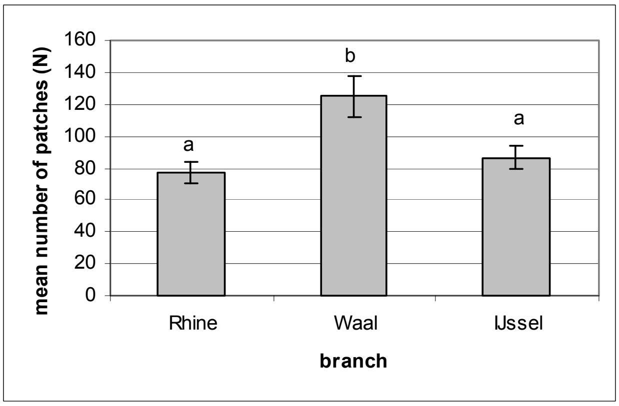

Figure V.9: mean number of patches (N) in the floodplains (±SE) per Rhine branch. Rhine: N=57, Waal: N=49 and IJssel: N=60. Differences were tested for significance using a Games Howell test ($p<0.05$). Different letters indicate a significant difference, while identical letters indicate no significant difference.

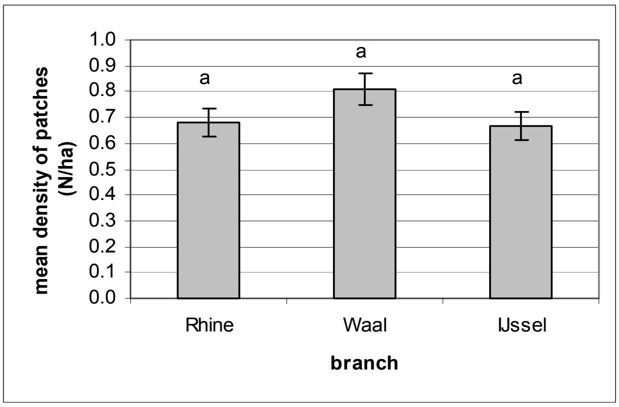

Figure V.10: mean density of patches (N/ha) in the floodplains (±SE) per Rhine branch. Rhine: N=57, Waal: N=49 and IJssel: N=60. Differences were tested for significance using a Games Howell test ($p<0.05$). Different letters indicate a significant difference, while identical letters indicate no significant difference.

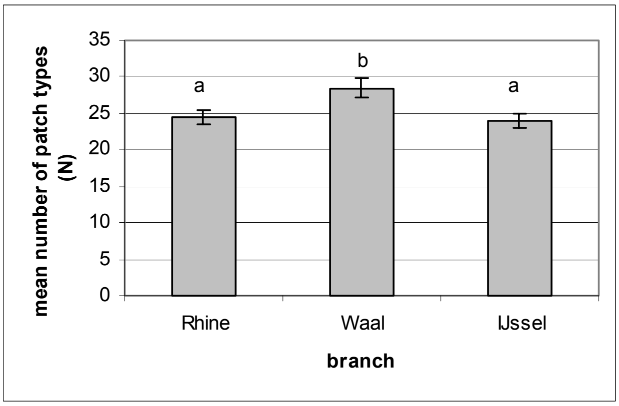

Figure V.11: mean number of patch types (N) in the floodplains (±SE) per Rhine branch. Rhine: N=57, Waal: N=49 and IJssel: N=60. Differences were tested for significance using a Games Howell test ($p<0.05$). Different letters indicate a significant difference, while identical letters indicate no significant difference.

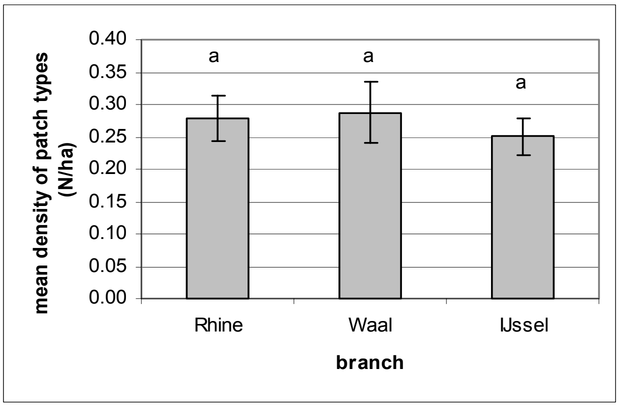

Figure V.12: mean density of patch types (N/ha) in the floodplains (±SE) per Rhine branch. Rhine: N=57, Waal: N=49 and IJssel: N=60. Differences were tested for significance using a Games Howell test ($p<0.05$). Different letters indicate a significant difference, while identical letters indicate no significant difference.

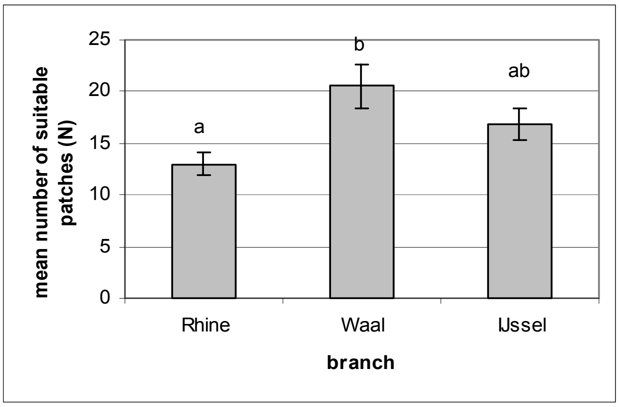

Figure V.13: mean number of suitable patches (N) in the floodplains (±SE) per Rhine branch. Rhine: N=57, Waal: N=49 and IJssel: N=60. Differences were tested for significance using a Games Howell test (p<0.05). Different letters indicate a significant difference, while identical letters indicate no significant difference.

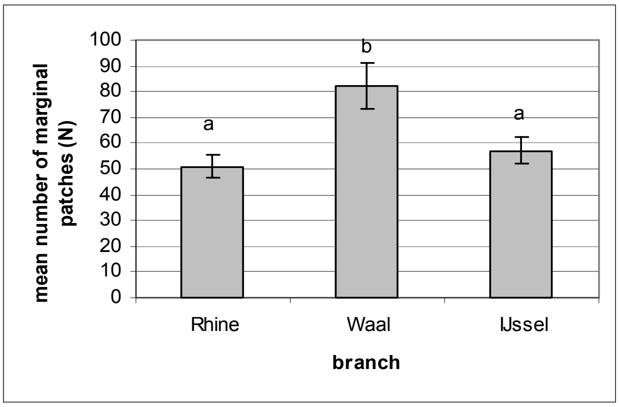

Figure V.14: mean number of marginal patches (N) in the floodplains (±SE) per Rhine branch. Rhine: N=57, Waal: N=49 and IJssel: N=60. Differences were tested for significance using a Games Howell test (p<0.05). Different letters indicate a significant difference, while identical letters indicate no significant difference.

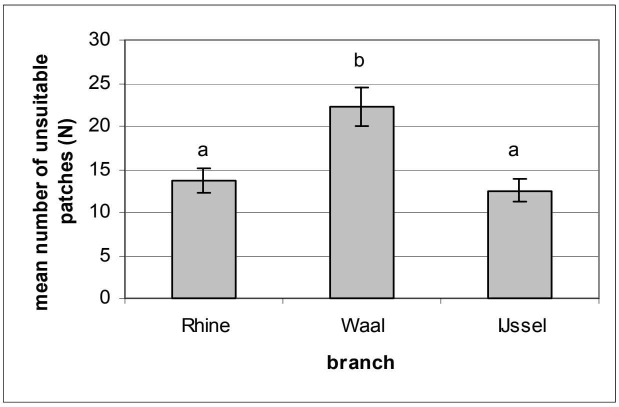

Figure V.15: mean number of unsuitable patches (N) in the floodplains (±SE) per Rhine branch. Rhine: N=57, Waal: N=49 and IJssel: N=60. Differences were tested for significance using a Games Howell test (p<0.05). Different letters indicate a significant difference, while identical letters indicate no significant difference.

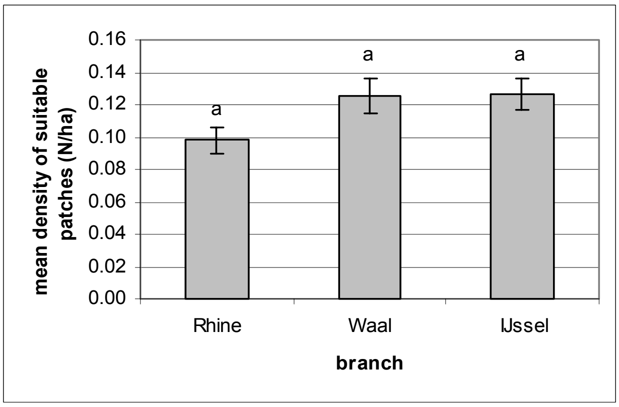

Figure V.16: mean density of suitable patches (N/ha) in the floodplains (±SE) per Rhine branch. Rhine: N=57, Waal: N=49 and IJssel: N=60. Differences were tested for significance using a Games Howell test (p<0.05). Different letters indicate a significant difference, while identical letters indicate no significant difference.

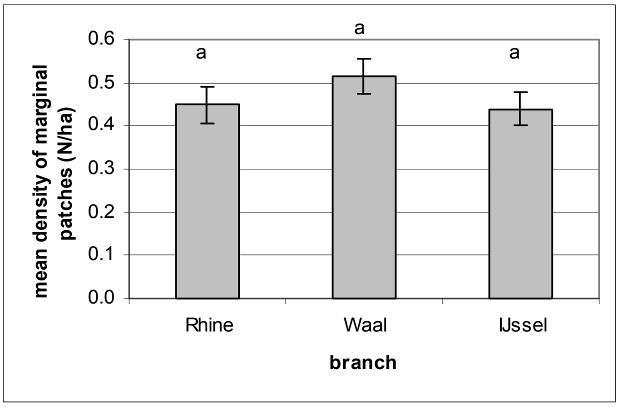

Figure V.17: mean density of marginal patches (N/ha) in the floodplains (±SE) per Rhine branch. Rhine: N=57, Waal: N=49 and IJssel: N=60. Differences were tested for significance using a Games Howell test (p<0.05). Different letters indicate a significant difference, while identical letters indicate no significant difference.

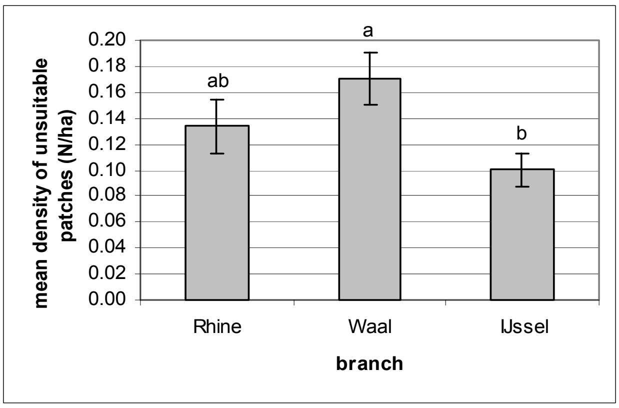

Figure V.18: mean density of unsuitable patches (N/ha) in the floodplains (±SE) per Rhine branch. Rhine: N=57, Waal: N=49 and IJssel: N=60. Differences were tested for significance using a Games Howell test (p<0.05). Different letters indicate a significant difference, while identical letters indicate no significant difference.

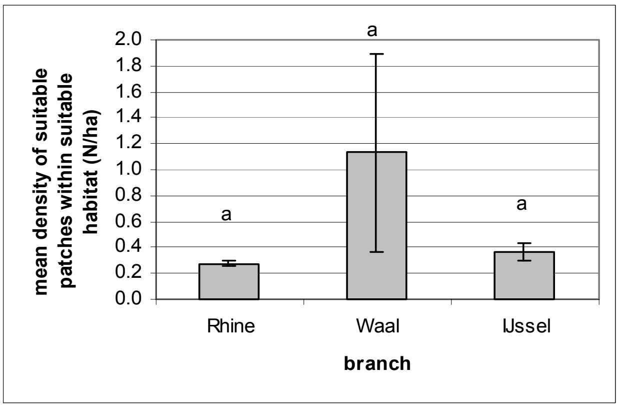

Figure V.19: mean density of suitable patches within suitable habitat (N/ha) of the floodplains (±SE) per Rhine branch. Rhine: N=57, Waal: N=49 and IJssel: N=60. Differences were tested for significance using a Games Howell test ($p<0.05$). Different letters indicate a significant difference, while identical letters indicate no significant difference.

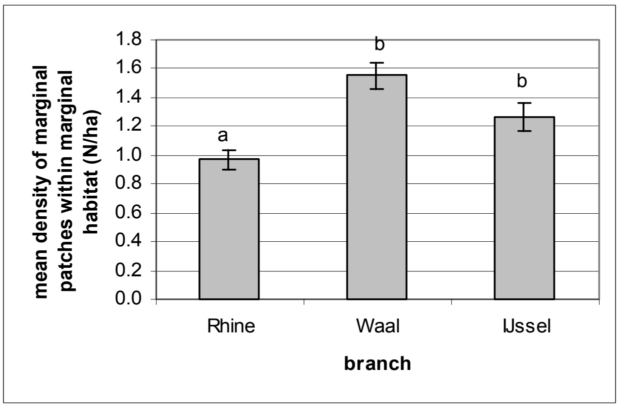

Figure V.20: mean density of marginal patches within marginal habitat (N/ha) of the floodplains (±SE) per Rhine branch. Rhine: N=57, Waal: N=49 and IJssel: N=60. Differences were tested for significance using a Games Howell test ($p<0.05$). Different letters indicate a significant difference, while identical letters indicate no significant difference.

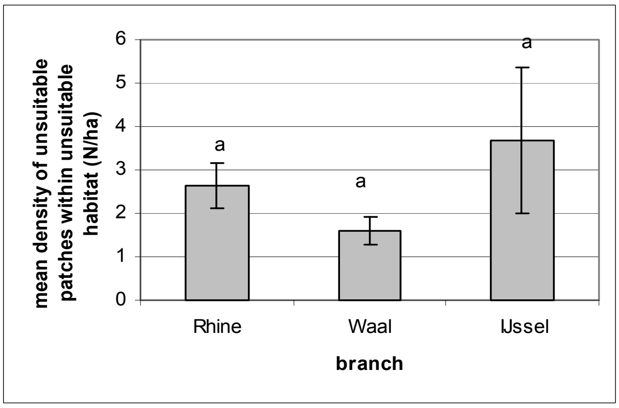

Figure V.21: mean density of unsuitable patches within unsuitable habitat (N/ha) of the floodplains (±SE) per Rhine branch. Rhine: N=57, Waal: N=49 and IJssel: N=60. Differences were tested for significance using a Games Howell test ($p<0.05$). Different letters indicate a significant difference, while identical letters indicate no significant difference.

APPENDIX VI ECOTOPE CHARACTERISTICS OF EACH CORNCRAKE MALE HOME RANGE

Table VI.1: ecotope characteristics of each home range.

Home range	Period of tracking (days)	SHDI	Number of patches	Number of patch types	Area home range (ha)	Area suitable habitat (ha)	%	Area marginal habitat (ha)	%	Area unsuitable habitat (ha)	%	Crex habitat (ha)	%
1	23	0.082	2	2	2.120	2.087	98.4	0.034	1.6	0.000	0.0	2.120	100.0
2	40	1.109	7	6	5.474	4.710	86.0	0.120	2.2	0.644	11.8	4.830	88.2
3	16	0.690	2	2	1.371	1.371	100.0	0.000	0.0	0.000	0.0	1.371	100.0
5.1	15	0.953	3	3	0.308	0.124	40.3	0.184	59.7	0.000	0.0	0.308	100.0
5.2	30	0.593	2	2	1.766	1.766	100.0	0.000	0.0	0.000	0.0	1.766	100.0
6	15	0.666	6	5	0.854	0.780	91.3	0.000	0.0	0.074	8.7	0.780	91.3
9	50	0.661	4	4	2.473	2.351	95.1	0.122	4.9	0.000	0.0	2.473	100.0
10	37	1.414	8	8	4.397	2.194	49.9	0.810	18.4	1.392	31.7	3.005	68.3
11/13	39	0.986	8	8	5.114	4.712	92.1	0.155	3.0	0.247	4.8	4.867	95.2
14	27	0.374	3	3	1.142	1.029	90.1	0.114	9.9	0.000	0.0	1.142	100.0
16	14	1.291	6	4	6.139	1.864	30.4	1.193	19.4	3.082	50.2	3.057	49.8
17	17	0.000	1	1	0.578	0.578	100.0	0.000	0.0	0.000	0.0	0.578	100.0
20	13	0.641	8	6	1.432	1.278	89.3	0.030	2.1	0.123	8.6	1.308	91.4
21	5	0.199	2	2	0.572	0.543	95.0	0.029	5.0	0.000	0.0	0.572	100.0
22	19	0.000	2	1	2.318	2.318	100.0	0.000	0.0	0.000	0.0	2.318	100.0
23	21	1.265	6	6	2.601	1.704	65.5	0.807	31.0	0.090	3.4	2.511	96.6
24	15	0.000	2	1	1.391	1.391	100.0	0.000	0.0	0.000	0.0	1.391	100.0
25	9	0.136	2	2	1.286	1.247	97.0	0.039	3.0	0.000	0.0	1.286	100.0

APPENDIX VII: CORRELATIONS BETWEEN THE HOME RANGE VARIABLES

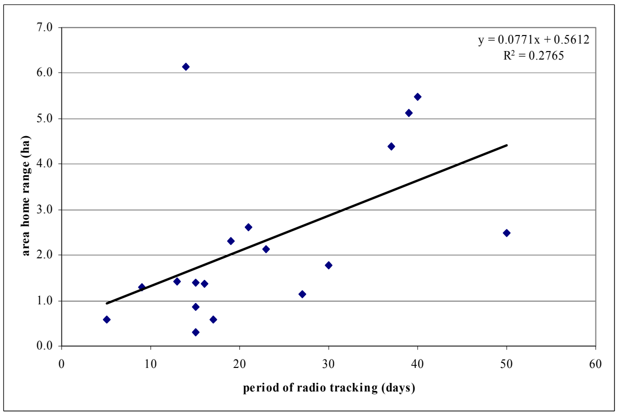

Figure VII.0: area (ha) home ranges of tracked Corncrake males against period of radio tracking (days). Correlation was significant ($p<0.05$) using Pearson's product moment correlation test.

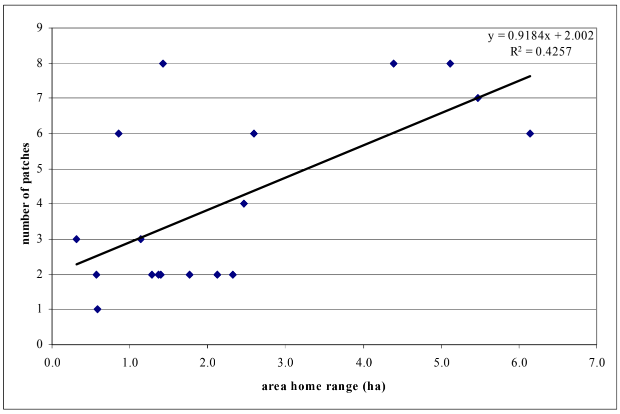

Figure VII.2: number of patches against area (ha) home ranges of tracked Corncrake males. Correlation was significant ($p<0.01$) using Pearson's product moment correlation test.

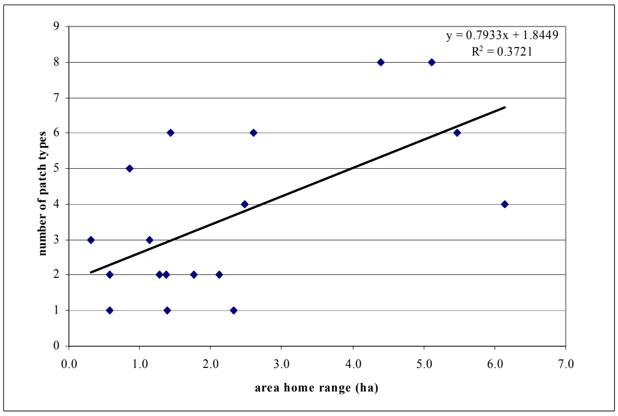

Figure VII.3: number of patch types against area (ha) home ranges of tracked Corncrake males. Correlation was significant ($p<0.01$) using Pearson's product moment correlation test.

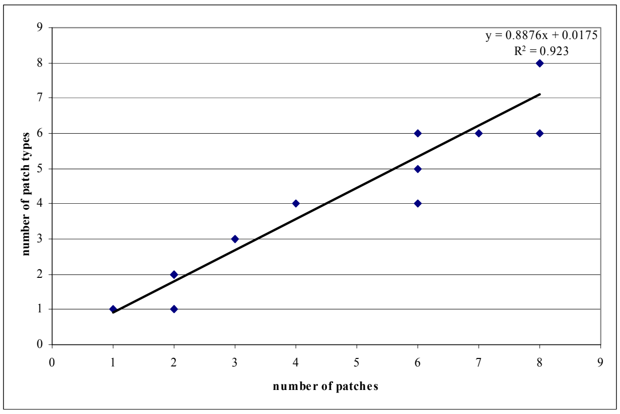

Figure VII.4: number of patch types against number of patches in the home ranges of tracked Corncrake males. Correlation was significant ($p<0.01$) using Pearson's product moment correlation test.

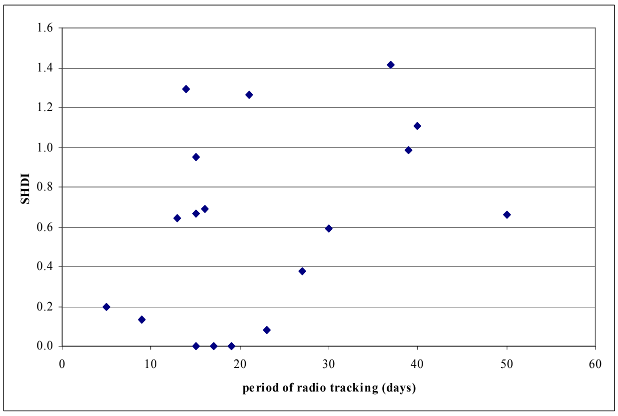

Figure VII.5: the SHDI of the home ranges of tracked Corncrake males against period of radio tracking (days). Correlation was not significant using Pearson's product moment correlation test.

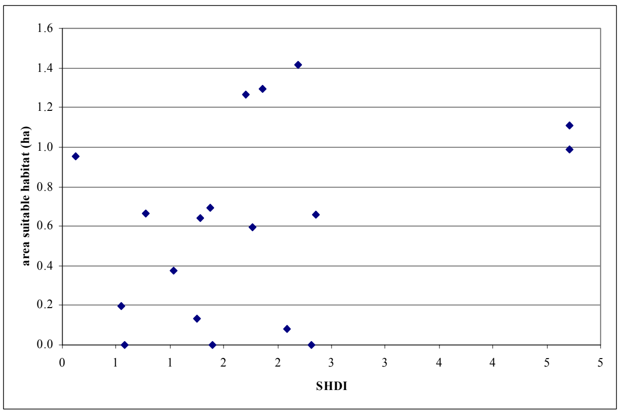

Figure VII.6: area (ha) of suitable habitat against the SHDI of the home ranges of tracked Corncrake males. Correlation was not significant using Pearson's product moment correlation test.

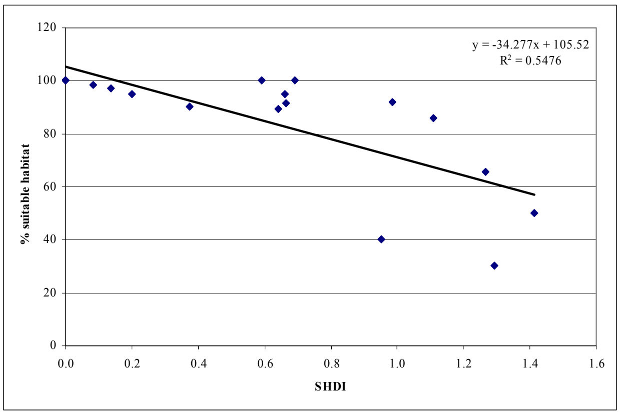

Figure VII.7: share of suitable habitat (%) against the SHDI of the home ranges of tracked Corncrake males Correlation was significant ($p<0.01$) using Pearson's product moment correlation test.

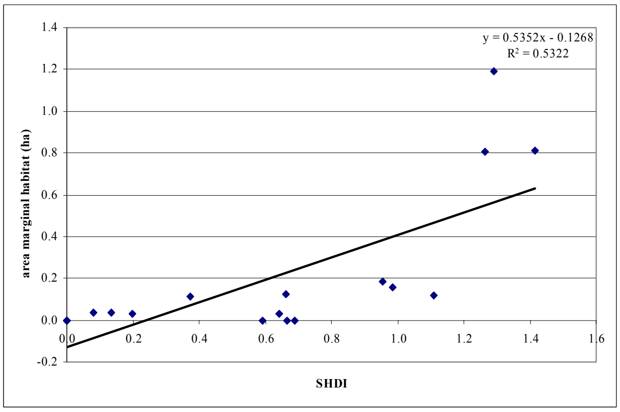

Figure VII.8: area (ha) of marginal habitat against the SHDI of the home ranges of tracked Corncrake males. Correlation was significant ($p<0.01$) using Pearson's product moment correlation test.

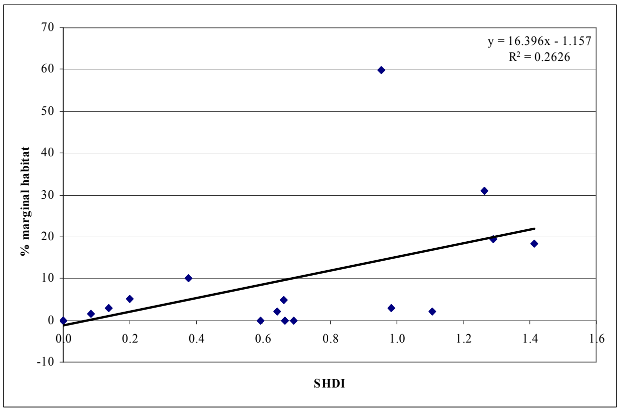

Figure VII.9: share of marginal habitat (%) against the SHDI of the home ranges of tracked Corncrake males. Correlation was significant ($p<0.05$) using Pearson's product moment correlation test.

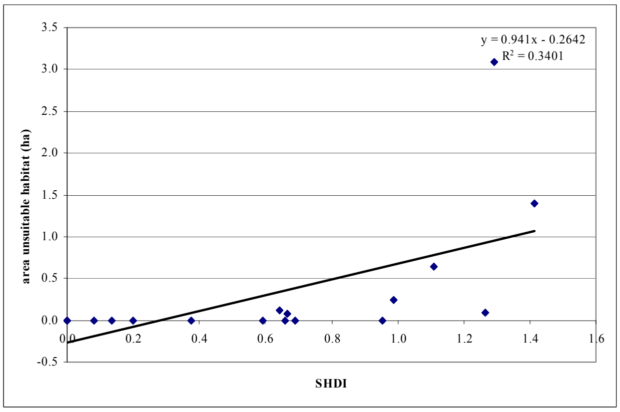

Figure VII.10: area (ha) of unsuitable habitat against the SHDI of the home ranges of tracked Corncrake males. Correlation was significant ($p<0.05$) using Pearson's product moment correlation test.

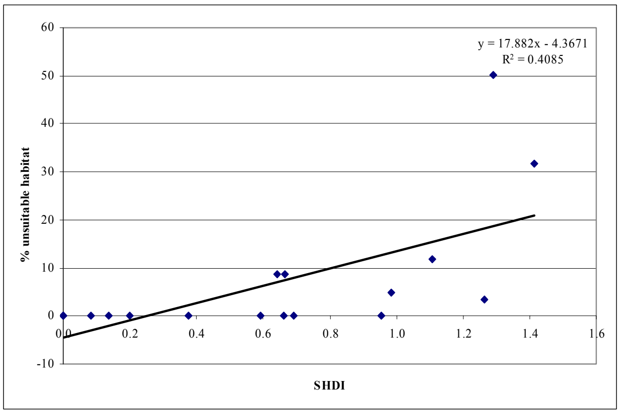

Figure VII.11: share of unsuitable habitat (%) against the SHDI of the home ranges of tracked Corncrake males. Correlation was significant ($p<0.01$) using Pearson's product moment correlation test.

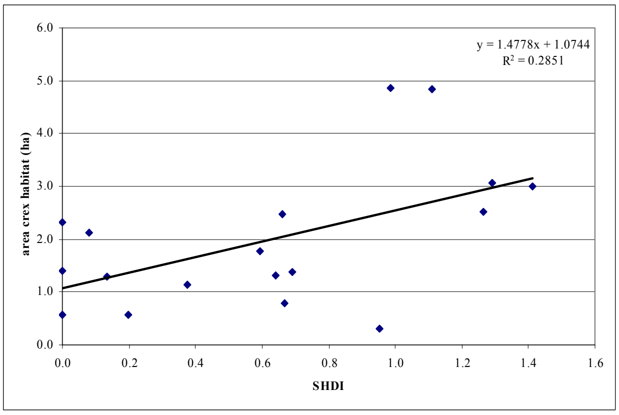

Figure VII.12: area (ha) of crex habitat against the SHDI of the home ranges of tracked Corncrake males. Correlation was significant ($p<0.05$) using Pearson's product moment correlation test.

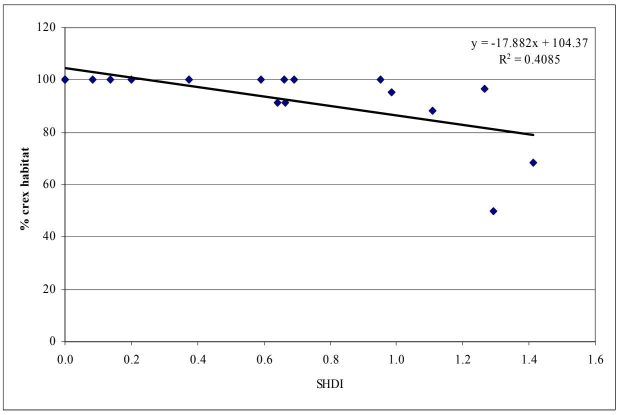

Figure VII.13: share of crex habitat (%) against the SHDI of the home ranges of tracked Corncrake males. Correlation was significant ($p<0.01$) using Pearson's product moment correlation test.

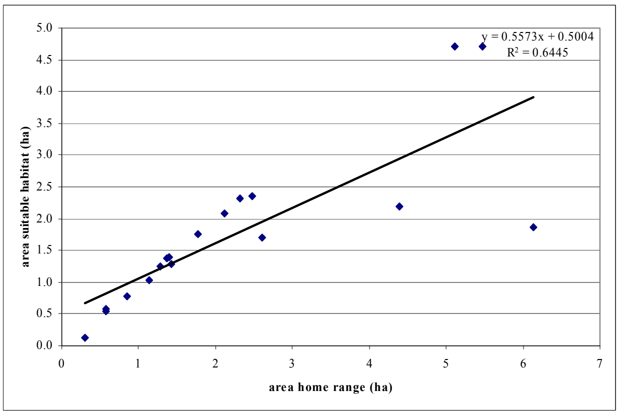

Figure VII.14: area (ha) of suitable habitat against area (ha) home ranges of tracked Corncrake males. Correlation was significant ($p<0.01$) using Pearson's product moment correlation test.

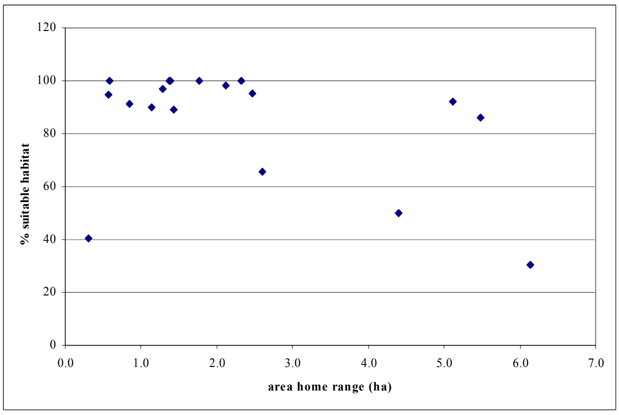

Figure VII.15: share of suitable habitat (%) against area (ha) home ranges of tracked Corncrake males. Correlation was not significant using Pearson's product moment correlation test.

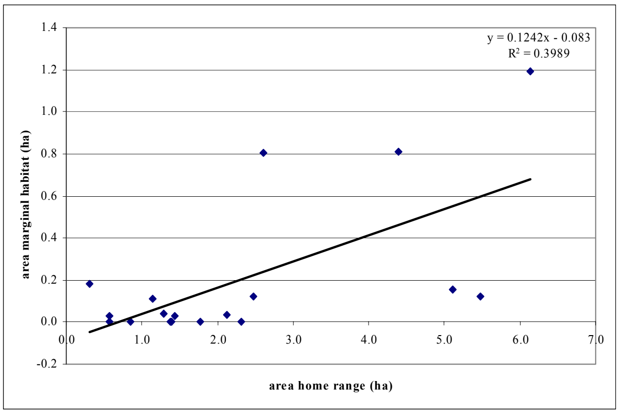

Figure VII.16: area (ha) of marginal habitat against area (ha) home ranges of tracked Corncrake males. Correlation was significant ($p<0.01$) using Pearson's product moment correlation test.

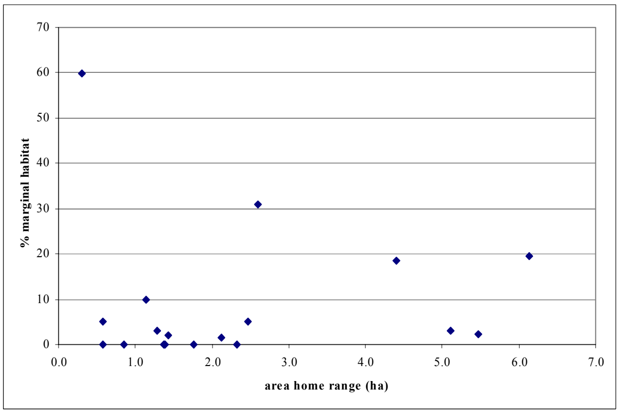

Figure VII.17: share of marginal habitat (%) against area (ha) home ranges of tracked Corncrake males. Correlation was not significant using Pearson's product moment correlation test.

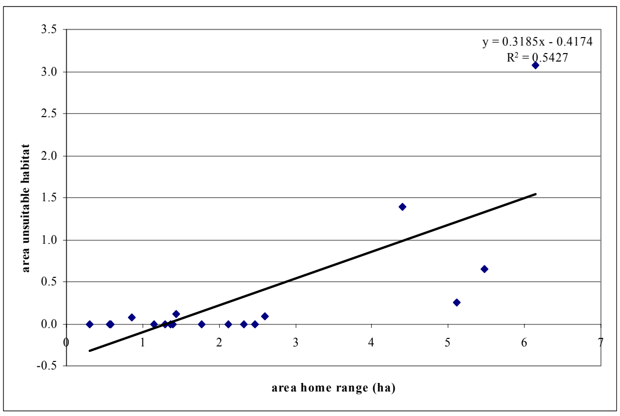

Figure VII.18: area (ha) unsuitable habitat against area (ha) home ranges of tracked Corncrake males. Correlation was significant ($p<0.01$) using Pearson's product moment correlation test.

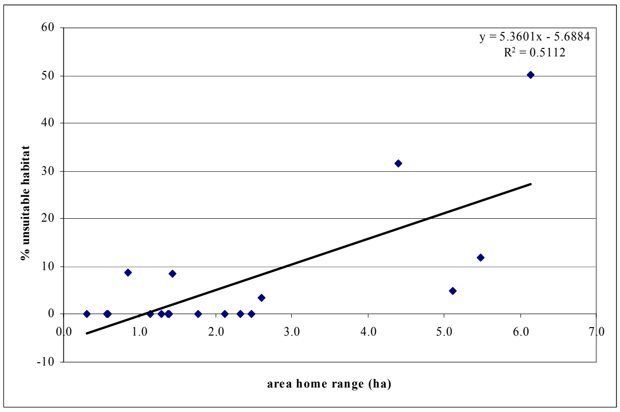

Figure VII.19: share of unsuitable habitat (%) against area (ha) home ranges of tracked Corncrake males. Correlation was significant ($p<0.01$) using Pearson's product moment correlation test.

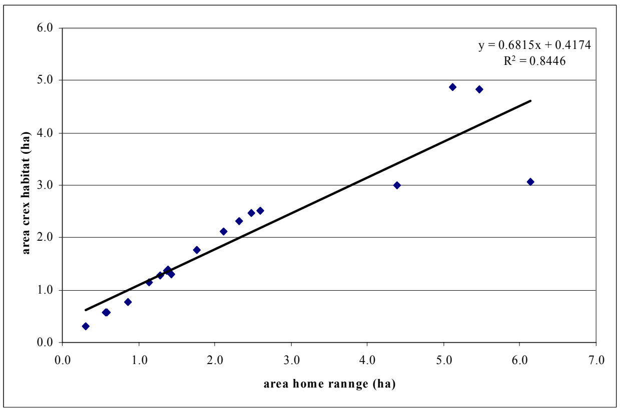

Figure VII.20: area (ha) crex habitat against area (ha) home ranges of tracked Corncrake males. Correlation was significant ($p<0.01$) using Pearson's product moment correlation test.

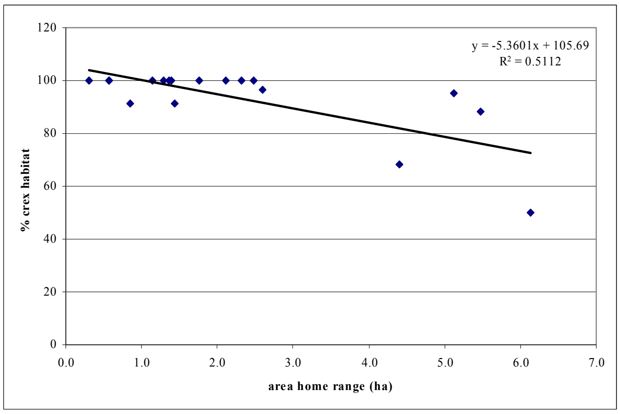

Figure VII.21: share of crex habitat (%) against area (ha) home ranges of tracked Corncrake males. Correlation was significant ($p<0.01$) using Pearson's product moment correlation test.

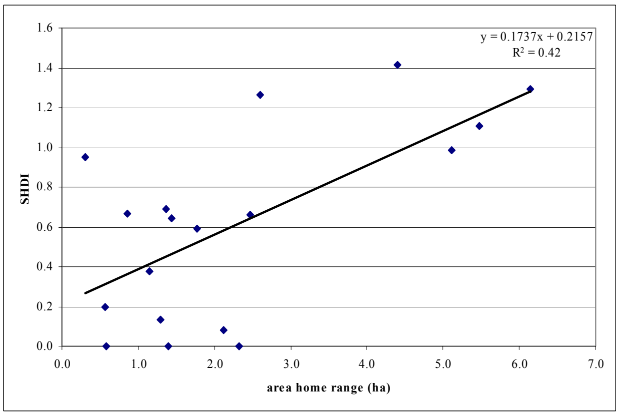

Figure VII.22: the SHDI against area (ha) home ranges of tracked Corncrake males. Correlation was significant ($p<0.01$) using Pearson's product moment correlation test.

APPENDIX VIII: 'ROOM FOR THE RIVER' AND THE CORNCRAKE

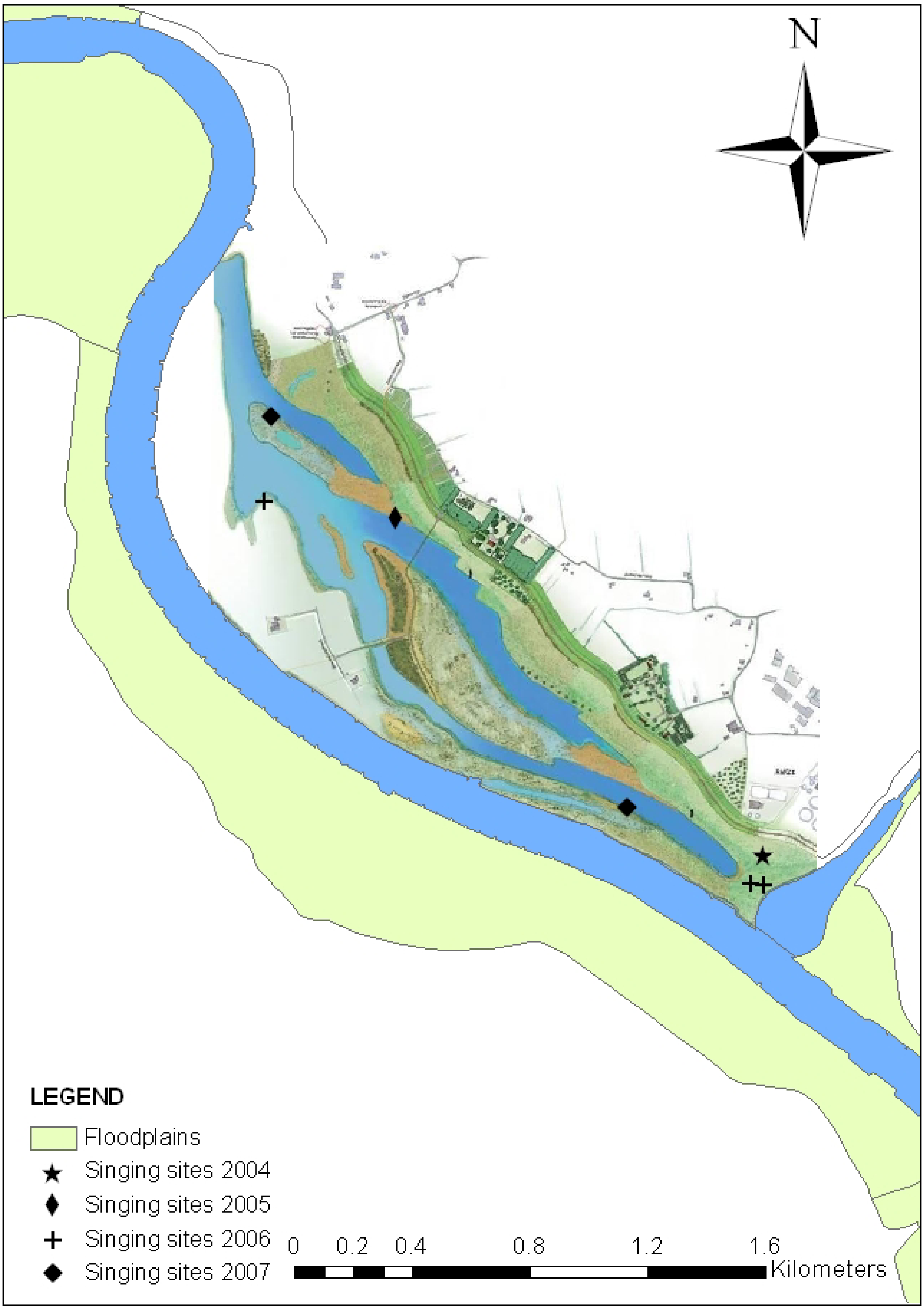

Figure VII.1: Map of how the floodplain Vreugderijkerwaard will look like after implementation of the 'Room for the River' measures combined with the Corncrake male singing sites of 2001-2007.

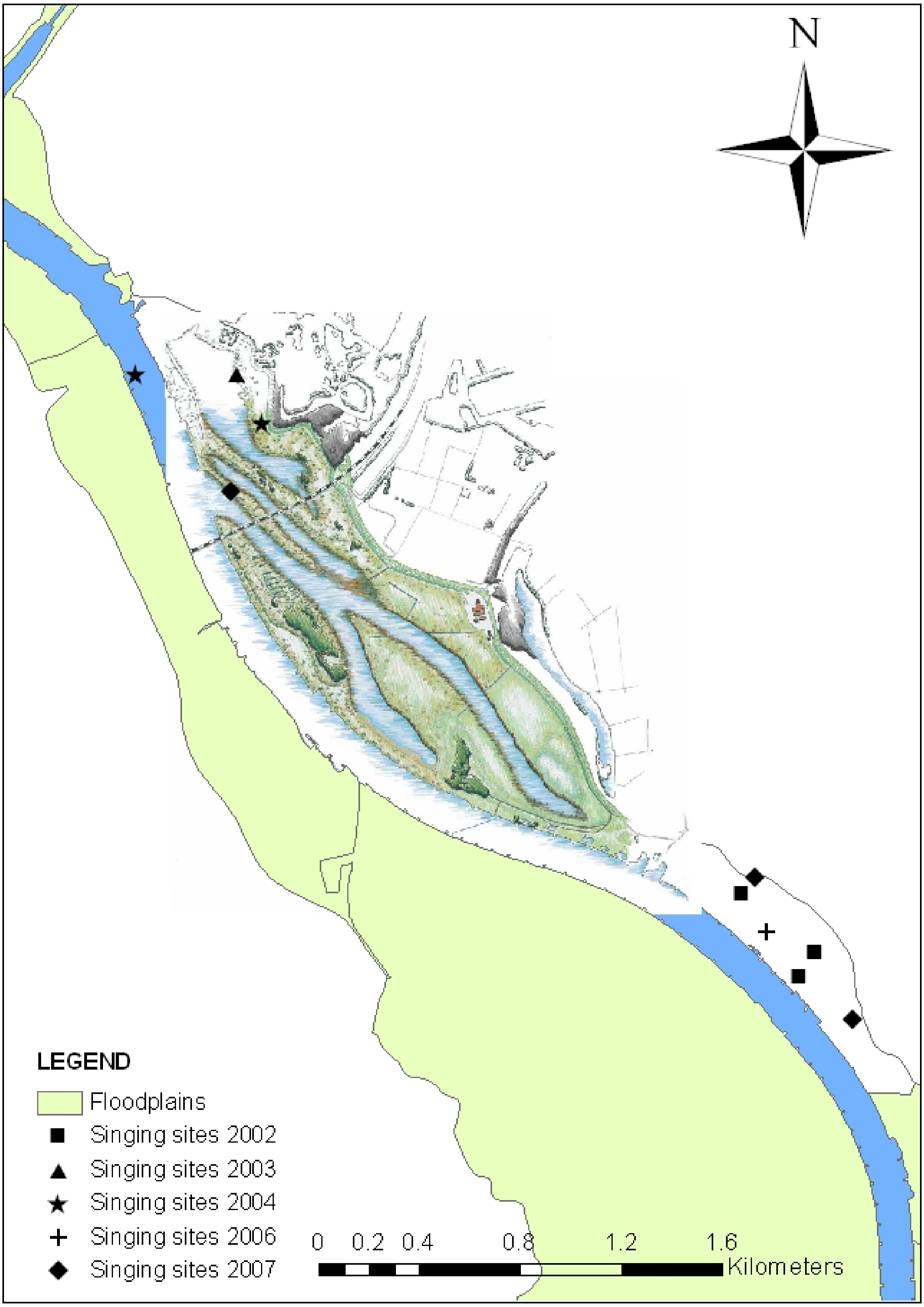

Figure VII.2: Map of how the floodplain Scheller en Oldeneler buitenwaarden will look like after implementation of the 'Room for the River' measures combined with the Corncrake male singing sites of 2001-2007.

APPENDIX IX: TRANSLATION (ENGLISH-DUTCH) OF ECOTOPE TYPES

Ecocode	Ecotope	Ecotoop
UA-1	Arable floodplain	Uiterwaardakker
O-UA-1	Arable natural levee or floodplain	Oeverwal- of uiterwaardakker
UA-2	Built up floodplain	Bebouwde uiterwaard
RzD	Deep summer bed	Diep zomerbed
I.1	Dynamic fresh to slightly brackish shallow water	Dynamisch zoet tot zwak brak ondiep water
UG-1-2	Floodplain grassland (natural pasture/production meadow)	Uiterwaardgrasland (natuurlijk of productie)
UB-1	Floodplain natural forest	Natuurlijk uiterwaardbos
UG-1	Floodplain natural pasture	Natuurlijk uiterwaardgrasland
UB-3	Floodplain production forest	Uiterwaardproductiebos
UG-2	Floodplain production meadow	Uiterwaardproductiegrasland
UM-1	Floodplain reed	Uiterwaardriet
UB-2	Floodplain shrubs	Uiterwaardstruweel
VI-4	Floodplain softwood forest	Zachthoutooibos
VI.2-3	Floodplain softwood shrubs or pioneer softwood forest	Zachthout struweel of pionier zachthoutooibos
UR-1	Herbaceous floodplain	Uiterwaardruigte
V.I-2	Herbaceous marsh	Moerasruigte
O-UR-1	Herbaceous natural levee or floodplain	Oeverwal- of uiterwaardruigte
HA-1	High-water-free arable land	Overstromingsvrije akker
HA-2	High-water-free built up area	Overstromingsvrij bebouwd
HG-1-2	High-water-free herbaceous grassland (natural pasture/production meadow)	Overstromingsvrij grasland (natuurlijk of productie)
HR-1	High-water-free rough herbage	Overstromingsvrije ruigte
HB-1	High-water-free natural forest	Overstromingsvrij natuurlijk bos
HG-1	High-water-free natural pasture	Overstromingsvrij natuurlijk grasland
HG-2	High-water-free production meadow	Overstromingsvrij productiegrasland
VII.1	Marshy natural pasture	Moerassig overstromingsgrasland
VII.1-3	Marshy natural pasture/production meadow	Moerassig overstromings- of (laag gelegen) productiegrasland
RwM	Moderately deep floodplain water body	Matig diep
RzM	Moderately deep summer bed	Matig diep zomerbed
O-UB-1	Natural levee or floodplain natural forest	Natuurlijk oeverwal- of uiterwaardbos
O-UG-1-2	Natural levee or floodplain grassland (natural pasture/production meadow)	Oeverwal- of uiterwaardgrasland (natuurlijk of productie)
O-UR-1	Natural levee or floodplain natural pasture	Natuurlijk oeverwal- of uiterwaardgrasland
O-UG-2	Natural levee or floodplain production meadow	Oeverwal- of uiterwaardproductiegrasland
UM-1	Natural levee or floodplain reed	Oeverwal- of uiterwaard riet
VII.3	Production meadow	Productiegrasland
II-2	Sand bar along freshwater	Zoete zandplaten
IV.8-9	Species poor helophyte marsh/species-rich reed	Soortenarm helofytenmoeras/soortenrijk riet met moerasplanten
U-rest	Temporarily bare floodplain	Uiterwaard tijdelijk kaal
H-rest	Temporarily bare high-water-free area	Overstromingsvrij tijdelijk kaal
RvD/RwD	(Very) deep floodplain water body	(Zeer) diep