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Protection of biodiversity of free living birds and mammals in respect of the effects of pesticides

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Protection of biodiversity of free living birds and mammals in respect of the effects of pesticides

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Abstract

Pesticides can affect wild-living bird and mammal species either directly by poisoning or indirectly by removing food and shelter. In this report we focus on indirect effects and their risk management.

After agriculture in Germany has become more intensive over the past decades, many populations of farmland birds and mammals are in an unfavourable conservation status. For 27 farmland bird species and 22 farmland mammal species we compile trends, habitat (crop) selection, threats and risk management measures. There is scientific-based evidence for indirect effects of pesticides at the population level of four European farmland bird species and several mammal species outside Europe. Data on diet and on habitat selection suggest that indirect effects of pesticides may affect many more species. We develop an index of pesticide sensitivity for farmland birds and mammals in Germany. According to expert opinion pesticides are among the major causes for population declines of farmland birds and we provide supporting evidence for this view.

We analyze risk management measures with respect to efficiency and acceptance by farmers and authorities. At present agri-environmental schemes aiming to compensate for the negative effects of modern agriculture cover only about 0.5 % of the arable land in Germany. We develop a scheme of umbrella species to simplify risk management. We outline different strategies for implementing an effective risk management and we calculate associated costs. A levy on PPPs targeted to the implementation of a region-specific risk management would be practicable at relatively low costs.

Kurzbeschreibung

Pestizide wirken auf Vögel und Säugetiere entweder direkt durch Vergiftung oder indirekt durch Reduktion der Nahrung und der Deckung. In diesem Bericht behandeln wir vor allem die indirekten Effekte und das dafür erforderliche Risikomanagement.

Nach einer jahrzehntelangen Intensivierung der Landwirtschaft in Deutschland befinden sich viele Populationen von Vögeln und Säugetieren der Agrarlandschaft in einem schlechten Erhaltungszustand. Für 27 Vogel- und 22 Säugerarten der Agrarlandschaft stellen wir Daten zu Trend, Habitatwahl (Wahl der Feldfrucht), Bedrohungen und Risiko-Managementmaßnahmen zusammmen. Die indirekte Wirkung von Pestiziden auf Populationsniveau ist für vier europäische Agrarvogelarten und einige Säugerarten außerhalb Europas nachgewiesen. Daten zur Nahrungs- und Habitatwahl lassen jedoch vermuten, dass zahlreiche weitere Arten betroffen sind. Wir stellen einen Index zu Sensivität gegenüber indirekten Effekten von Pestiziden in Deutschland vor. Nach Expertenmeinung gehören Pestizide zu den wichtigsten Gründen für die Bestandsabnahmen bei Vögeln der Agrarlandschaft. Diese Sichtweise wird durch weitere in diesem Bericht zusammengestellte Indizien unterstützt.

Wir untersuchen Risikomanagementmaßnahmen bezüglich ihrer Effizienz und ihrer Akzeptanz bei Landwirten und Behörden. Derzeit umfassen Vertragsnaturschutzmaßnahmen, die negative Auswirkungen der modernen Landwirtschaft kompensieren sollen, nur etwa 0.5% der Ackerfläche Deutschlands, eine offensichtlich unzureichende Fläche. Wir schlagen ein Zielartenkonzept vor um die Umsetzung des Risikomanagements zu erleichtern. Wir skizzieren verschiedene Strategien zur Implementierung eines wirkungsvollen Risikomanagements und

vergleichen die Kosten. Eine Abgabe auf Pflanzenschutzmittel zur Finanzierung eines regionalen Risikomanagements erscheint als die günstigste Lösung.

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List of Abbreviations

AEM	Agri-environmental measure
AEP	Agri-environmental programme
AES	Agri-environmental scheme
AFPC	Agricultural and Food Policy Center
AMI	Agrarmarkt Informations-Gesellschaft
APCA	Assemblée Permanente des Chambres d'agriculture France
BfN	Bundesamt für Naturschutz
BGB	Bundesgesetzblatt
BI	Behandlungsindex (Treatment Index)
BLW	Bundesamt für Landwirtschaft
BMELV	Bundesministerium für Ernährung, Landwirtschaft und Verbraucherschutz
BMU	Bundesministerium für Umwelt, Naturschutz und Reaktorsicherheit
Bti	*Bacillus thuringiensis israelensis*
BVL	Bundesamt für Verbraucherschutz und Lebensmittelsicherheit
CAP	Common Agricultural Policy (of the European Union)
DDA	Dachverband Deutscher Avifaunisten
DEFRA	Department for Environment, Food and Rural Affairs (of the UK Government)
df	Degree of freedom (stat.)
EFA	Ecological Focus Area
EFSA	European Food Safety Authority
EU	European Union
FAZ	Frankfurter Allgemeine Zeitung
FNR	Fachagentur Nachwachsende Rohstoffe e.V.
FPS	Federal Public Service (of Belgium)
HFR	Hochschule für Forstwirtschaft Rottenburg
IFAB	Institut für Agrarökologie und Biodiversität
IPP	Integrated Plant Protection
IUCN	International Union for Conservation of Nature and Natural Resources
JKI	Julius Kühn-Institut
LEAF	Linking Environment and Farming
LfUG	Landesamt für Umweltschutz und Gewerbeaufsicht Rheinland Pfalz
LÖBF NRW	Landesanstalt für Ökologie, Bodenordnung und Forsten Nordrhein Westfalen
LUGV	Landesamt für Umwelt, Gesundheit und Verbraucherschutz Brandenburg

LVZ	Landwirtschaftliche Vergleichszahl
MEKA	Marktentlastungs- und Kulturlandschaftsausgleich
MOIN	Michael-Otto-Institut im NABU
NABU	Naturschutzbund Deutschland e.V.
NAP	National Action Plan
NeFo	Netzwerk-Forum zur Biodiversitätsforschung Deutschland
NEPTUN	Netzwerk zur Ermittlung des Pflanzenschutzmitteleinsatzes in unterschiedlichen, landwirtschaftlich relevanten Naturräumen Deutschlands
NGO	Non-governmental organisation
OECD	Organisation for Economic Co-operation and Development
ÖLN	Ökologischer Leistungsnachweis
PAN	Pesticide Action Network
PflSchG	Pflanzenschutzgesetz
PPP	Plant protection product
RMM	Risk Management Measure
RSPB	Royal Society for the Protection of Birds
SE	Standard error (stat.)
SOU	Statens offentliga utredningar
SPA	Special protection area (Europäisches Vogelschutzgebiet)
SPEC	Species of European Concern
SRU	Sachverständigenrat für Umweltfragen
STMELF	Bayerisches Staatsministerium für Ernährung, Landwirtschaft und Forsten
SYNOPS	Synoptische Bewertung von Pflanzenschutzmitteln
TFI	Treatment Frequency Index
TRIM	Trends and Indices for Monitoring data, software package used to determine species' population trends.
ZALF	Leibnitz-Zentrum für Agrarlandschaftsforschung e.V.

1 Introduction

1.1 Background

Farmland covers roughly half of the surface of Germany (Statistisches Bundesamt 2012). In Germany and in many other European countries farmland is the most extended land-use type. Many bird and mammal species inhabit farmland habitats. In particular in birds, there are very few species which do not at least occasionally visit farmland to feed or to rest. However, population sizes of both avian and mammalian species occurring in German and European agricultural landscapes are predominantly decreasing (Sudfeldt et al. 2009, Meinig et al. 2009, Pan-European Common Bird Monitoring Scheme 2012). With the intensification of agriculture, conditions for farmland species have changed and in many places wildlife populations have been put under severe pressure (Pain & Pienkowski 1997, Donald et al. 2001). The application of synthetic plant protection products (PPPs) is an integral part of agricultural intensification. In this report we investigate the effects of PPP application on farmland birds and mammals and we give suggestions for risk regulation.

1.1.1 Selection of farmland bird and mammal species

Many farmland bird and mammal species do not occur exclusively in just a single habitat type but in several. In this report, we focus on those species that are typical for farmland and for which farmland is an essential habitat in at least a part of their annual cycle (Tables 1.1.1 and 1.1.3). In our definition, farmland includes orchards, vineyards and hops fields. There are many definitions of farmland birds and farmland mammals that result in different selections of species (Pain & Pienkowski 1997, Deutsche Ornithologen-Gesellschaft & Dachverband Deutscher Avifaunisten 2011). Here we employ a relatively strict view. Among the bird species breeding in Germany we selected those whose trends form the farmland bird indicator within the German indicator of sustainability (Achtziger et al. 2004), and we added other species for which farmland is an essential habitat during the breeding season. We did not consider some further species which are listed as farmland species in other sources, e.g. in Pan-European Common Bird Monitoring Scheme (2012). The main reasons for not considering these additional species were their rareness in Germany and their primary occurrence in other habitats than farmland (see Tab. 1.1.2). We also did not specifically select species for orchards, vineyards and hops fields. One of the reasons is that the information we found on birds occurring in these cultures is very scarce. The few available sources suggest that there are no characteristic orchard, vineyard or hops species (Bauer et al. 2005). The Rock Bunting, often associated with vineyards, is a rare species in Germany which, indeed, often breeds close to vineyards on steep slopes. The species, however, actually lives in the rocks and the shrubs in between or adjacent to the vineyards. At least some of the species on our list (Tabs. 1.1.1 and 1.1.3) also occur in orchards, vineyards and hops cultures (e.g. Little Owl, Red-backed Shrike, Linnet, Yellowhammer). Several other species like Wryneck, Collard Flycatcher or Common Redstart are much more common in forests and in human settlements. The tiny parts of their populations breeding in orchards, vineyards and on hops fields do not significantly influence their population trends.

We also selected species which feed in high numbers on farmland in Germany during the non-breeding season. The selection criterion was that more than 10% of the flyway populations regularly occur on German farmland. This holds true for Bewicks' Swans, several geese species, Common Cranes and Golden Plovers. For the analysis of breeding birds, however, we excluded breeding Barnacle Geese, Greylag Geese, Golden Plovers and Common Cranes. Within the breeding season all four species mostly occur in other habitats such as wetlands, peat bogs etc. (Bauer et al. 2005).

The mammal species that are dealt with in this report represent a variety of different habitat requirements. They differ in the amount of time that they actually spend on agricultural land as well as in their feeding habits and other ecological features. We tried to represent the different orders of mammal species occurring in agricultural landscapes with a selection of species in order to cover a preferably wide range of ecological features and assure a comprehensive approach for the protection of farmland mammal diversity. Insectivorous, herbivorous as well as carnivorous small mammal species are taken into account. We included three bat species because they are found to hunt over open farmland landscapes and rely on rich insect ressources. Bats so far are disregarded in current risk regulations concerning the effects of pesticides. With the Fallow Deer and the Wild Boar we examine also two larger mammal species frequently feeding on crops. The European Hamster and the Brown Hare both are very popular but endangered farmland species and belong to the most thoroughly studied species among our compilation of farmland species.

Tab. 1.1.1: List of farmland bird species examined in this report.

Order	Family	Scientific Name	Common English Name	Common German Name
Anseriformes	Anatidae	*Cygnus bewickii*	Bewick's Swan	Zwergschwan
		Branta leucopsis	Barnacle Goose	Weißwangengans
		Anser fabalis	Bean Goose	Saatgans
		Anser albifrons	White-fronted Goose	Blässgans
		Anser anser	Greylag Goose	Graugans
Galliformes	Phasianidae	*Coturnix coturnix*	Common Quail	Wachtel
		Perdix perdix	Grey Partridge	Rebhuhn
Accipitriformes	Accipitridae	*Circus pygargus*	Montagu's Harrier	Wiesenweihe
		Milvus milvus	Red Kite	Rotmilan
Gruiformes	Gruidae	*Grus grus*	Common Crane	Kranich
	Rallidae	*Crex crex*	Corncrake	Wachtelkönig
Charadriiformes	Charadriidae	*Pluvialis apricaria*	Golden Plover	Goldregenpfeifer
		Vanellus vanellus	Lapwing	Kiebitz
	Scolopacidae	*Limosa limosa*	Black-tailed Godwit	Uferschnepfe
Strigiformes	Strigidae	*Athene noctua*	Little Owl	Steinkauz
Passeriformes	Laniidae	*Lanius collurio*	Red-backed Shrike	Neuntöter
	Alaudidae	*Lullula arborea*	Woodlark	Heidelerche
		Alauda arvensis	Skylark	Feldlerche
	Hirundinidae	*Hirundo rustica*	Barn Swallow	Rauchschwalbe
		Delichon urbicum	House Martin	Mehlschwalbe
	Muscicapidae	*Saxicola rubetra*	Whinchat	Braunkehlchen
	Motacillidae	*Anthus pratensis*	Meadow Pipit	Wiesenpieper
		Motacilla flava	Yellow Wagtail	Wiesenschafstelze
	Fringillidae	*Carduelis cannabina*	Linnet	Bluthänfling
	Emberizidae	*Emberiza calandra*	Corn Bunting	Grauammer
		Emberiza citrinella	Yellowhammer	Goldammer
		Emberiza hortulana	Ortolan Bunting	Ortolan

Tab. 1.1.2: List of bird species classified as farmland birds by Pan-European Common Bird Monitoring Scheme (2012) or by others but not considered in this report.

Scientific name	Common English name	Reason for non-consideration
Anthus campestris	Tawny Pipit	Not occurring in farmland in Germany
Ciconia ciconia	White Stork	Strongly associated with wetlands and human settlements
Columba palumbus	Wood Pigeon	Associated with forests and human settlements
Corvus frugilegus	Rook	Associated with human settlements
Erithacus rubecula	European Robin	Associated with forests and human settlements
Falco tinnunculus	Common Kestrel	Associated with human settlements
Galerida cristata	Crested Lark	Associated with human settlements
Passer montanus	European Tree Sparrow	Strongly associated with human settlements
Prunella modularis	Dunnock	Associated with forests and human settlements
Saxicola torquata	Common Stonechat	Until recently restricted to moor and heathland
Serinus serinus	European Serin	Strongly associated with human settlements
Streptopelia turtur	European Turtle-Dove	Strongly associated with woodland
Sturnus vulgaris	Common Starling	Associated with human settlements
Sylvia communis	Common Whitethroat	Strongly associated with bushes
Upupa epops	Eurasian Hoopoe	Very rare in Germany

Tab. 1.1.3: List of farmland mammal species examined in this report.

Order	Family	Species	Scientific name	German name
Rodents	Cricetidae	European Hamster	*Cricetus cricetus*	Feldhamster
		Field Vole	*Microtus agrestis*	Erdmaus
		Common Vole	*Microtus arvalis*	Feldmaus
	Muridae	Striped field Mouse	*Apodemus agrarius*	Brandmaus
		Yellow-necked Mouse	*Apodemus flavicollis*	Gelbhalsmaus
		Wood Mouse	*Apodemus sylvaticus*	Waldmaus
		Harvest Mouse	*Micromys minutus*	Zwergmaus
Insectivores	Soricidae	Bicolored Shrew	*Crocidura leucodon*	Feldspitzmaus
		Greater white-toothes Shrew	*Crocidura russula*	Hausspitzmaus
		Lesser white-toothed Shrew	*Crocidura suaveolens*	Gartenspitzmaus
		Common Shrew	*Sorex araneus*	Waldspitzmaus
		Pygmy Shrew	*Sorex minutus*	Zwergspitzmaus
	Talpidae	European Mole	*Talpa europaea*	Maulwurf
	Erinaceidae	European Hedgehog	*Erinaceus europaeus*	Westeuropäischer Igel
Lagomorphs	Leporidae	Brown Hare	*Lepus europaeus*	Feldhase
Chiropterans	Vesperti-lionidae	Greater mouse-eared Bat	*Myotis myotis*	Großes Mausohr
		Natterer's Bat	*Myotis nattereri*	Fransenfledermaus
		Common Noctule	*Nyctalus noctula*	Großer Abendsegler
Carnivores	Mustelidae	Stoat	*Mustela erminea*	Hermelin
		Least Weasel	*Mustela nivalis*	Mauswiesel
Ungulates	Cervidae	Fallow Deer	*Dama dama*	Damhirsch
	Suidae	Wild Boar	*Sus scrofa*	Wildschwein

1.1.2 Effects of pesticides on birds and mammals

One feature of agricultural intensification is the increasing dependency on the use of plant protection products. PPPs are used to protect crops against negative impact from weeds and from other agricultural pest species. However, the impact of PPPs is not only constrained on those organisms that damage the crop but PPPs may also cause harm to non-target species due to unspecific and adverse effects. In Germany sales of PPPs have increased in recent years (BVL 2012).

PPPs do not only act through direct toxic effects but have also an indirect impact on agricultural ecosystems and the species occurring in them. These indirect effects change key requirements of wildlife populations like food availability or habitat quality. They are inevitably linked to PPP use and can therefore significantly contribute to the risk for non-target species in agricultural landscapes (e.g. Campbell & Cooke 1997, Boatman et al. 2004, Morris et al. 2005). For instance population declines for various farmland birds such as the Grey Partridge or Corn Bunting have been clearly linked to the reduction of food supply during sensitive life stages due to large-area applications of broad-spectrum insecticides (Potts 1986, Boatman et al. 2004). Unfortunately, comprehensive studies on indirect effects are missing for most species occurring in German agricultural landscapes.

Regulation of pesticides

To reduce/avoid the risk of adverse effects of PPPs for non-target species a thorough risk assessment is undertaken. Since the Regulation (EC) No 1107/2009 came into force, biodiversity is defined as an independent subject of protection which has to be integrated into the risk regulation of PPPs. Currently the focus of risk regulation of PPPs at the EU level is exclusively on the risk due to direct toxic effects of PPPs while suitable risk assessment and management schemes to cover indirect effects of PPPs are regarded to be missing (European Food Safety Authority 2009). However, the current state of scientific knowledge indicates that indirect effects can significantly contribute to the risk for non-target species in agricultural landscapes (Geiger et al. 2010). Therefore, a discussion on the protection of biodiversity and farmland bird and mammals species should not only be limited to the assessment of direct effects but also consider indirect effects to enable the development of appropriate risk management strategies which support sustainable use of PPPs in the agricultural practice.

Considering the legal requirements of the new EU pesticide legislation to avoid the occurrence of unacceptable effects on the environment including biodiversity together with the stipulated aim to attain a sustainable use of pesticides it is obvious that indirect effects cannot be ignored in the risk regulation of PPPs. This becomes even more evident considering that the intensification of the agricultural land use during the past decades has generally led to dramatic changes of habitat conditions for many farmland species putting additional pressure on the concerned species (Pain & Pienkowski 1997, Donald et al. 2001).

In order to integrate biodiversity successfully as an independent subject of protection into the risk regulation of PPPs it is important to substantiate the aims of biodiversity and species protection regulation frameworks and to evaluate and enhance current criteria and concepts of risk assessment and management.

Management strategies

If the consideration of indirect effects on birds and mammals is thought to be not feasible within the approval or authorisation procedure for individual substances or products, other options such as integrative risk management strategies have to be developed to minimize indirect effects of PPPs on wildlife to an acceptable level. This includes also compensation measures where the food chain interruption – being the most adverse indirect effect on farmland species – cannot be avoided by other means such as reduction of the use of PPPs. For farmland birds and mammals a variety of different risk management measures exist (see NABU 2004, Setchfield et al. 2012 and many more references in chapter 5 and Annex 1 of this report). These include on-field and off-field measures. The efficiency of some of the more common measures has been studied in detail (e.g. Jenny 1990, Morris et al. 2004). It is often not known, however, to what extent and on which percentage of farmland such measures have to be implemented to halt population decreases. Not all instruments used have been successful (Kleijn et al. 2001). Furthermore, the acceptance of measures amongst farmers and other stakeholders has rarely been studied (Oppermann et al. 2004).

1.2 Project aims & approach

The main focus of the project is to provide insight and knowledge to enable a sound decision making for the protection of free living birds and mammals from adverse PPP effects and to ensure a successful integration of biodiversity into the PPP risk regulation framework.

In order to assess whether current risk regulations of PPPs are suitable to prevent adverse effects of PPP applications on biodiversity we address the following key objectives within the scope of this project:

- Identification of species endangered by (indirect) pesticide effects
- Definition of conservation targets
- Evaluation and adaptation of current risk regulation
- Development of risk assessment and risk management

The sensitivity of free living bird and mammal populations in agricultural landscapes towards the effects of PPPs needs to be evaluated, with special focus on indirect effects. Therefore one aim is to provide a review of current scientific evidence of PPP effects endangering bird and mammal species. This information along with a systematic data collection on the species' ecological traits, population development, etc. is used to identify those species and populations for which an endangerment by PPP applications has already been demonstrated or can be deduced from an ecological traits-based analysis on the sensitivity towards PPP effects.

An evaluation of the efficiency of current risk regulation is required to assess whether it is sufficient to protect non-target species from PPP effects and therewith to prevent inacceptable consequences for the biodiversity in agricultural landscapes. Results of this deficit analysis are used to develop proposals for the improvement of the current risk regulation. For this purpose, in a next step, information on possible risk management measures is gathered to enable conclusions about their efficiency, feasibility and acceptance. Risk minimising and compensating management measures are developed for protected species that are affected by PPP effects.

Finally, we investigate how risk management measures can be developed in praxis without unnecessary efforts. We examine whether all species have to be considered or it is feasible to use a sub-set of selected species which may act as umbrella species covering the requirements of the whole set of other species.

The project is based on comprehensive literature studies which are supplemented by additional assessment methods, expert judgement and extensive data analyzed for these purposes. The literature search was carried out by using web-based search engines including Web of Science and Scopus and the institutes' extensive archives. Additionally, information was gathered from different websites (e.g. DEFRA, RSPB) which were searched for relevant published studies.

Detailed methods applied in the different sections of the project are described in each chapter.

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2 Development of agricultural structures in Germany

The development of land use in Germany can very easily be understood on the basis of agricultural statistics. Continuous statistics have been kept by the Federal Office for Statistics since 1949 for a number of land use parameters, so that the necessary technical information is available in order to analyse the development of land use intensity and structure.

2.1 The status today

The total area presently used for farming in Germany amounts to some 16.5 M ha and thereby accounts for a 46 % share of the total land area in the country. Some 11.8 M ha or 71 % of the farmed area is arable land, some 28 % is permanent grassland, and permanent crops (fruit trees, berries, vineyards) grow on some 1 % of open land. Today, the use of arable land in Germany comprises mainly cereal, maize and rape cultivation (Fig. 2.1.1). Cereals (all types, winter and spring cereals) account for 56 % of arable land and a further 1 % of land used for cereal is whole plant harvest. Maize cultivation takes up 17 % and rape (including other oilseeds - with however only a minor share) 12 %. Together these crops account for an 85 % share of total arable land use. Among cereals, winter wheat cultivation dominates clearly with a bit more than 3 M ha, which corresponds to a share of 49 %. Winter barley is a long way second (1.1 M ha). Cultivation of other cereals (rye, oats and triticale) each amount to about 0.5 M ha. Spring wheat, with 60,000 ha under cultivation, accounts for only 2 % of cereal cropping. Plants grown for green harvesting are dominated by silage maize with somewhat over 2 M ha. Field grass cultivation is carried out on 3 % of arable land, leguminous crops on 2 %. Oilseeds (for seed harvesting) include rape, turnip rape and sunflowers. Here rape dominates with a share of 96 %. Just 5 % of arable land is accounted for by root crops such as potatoes (40%) and sugar beet (60 %).

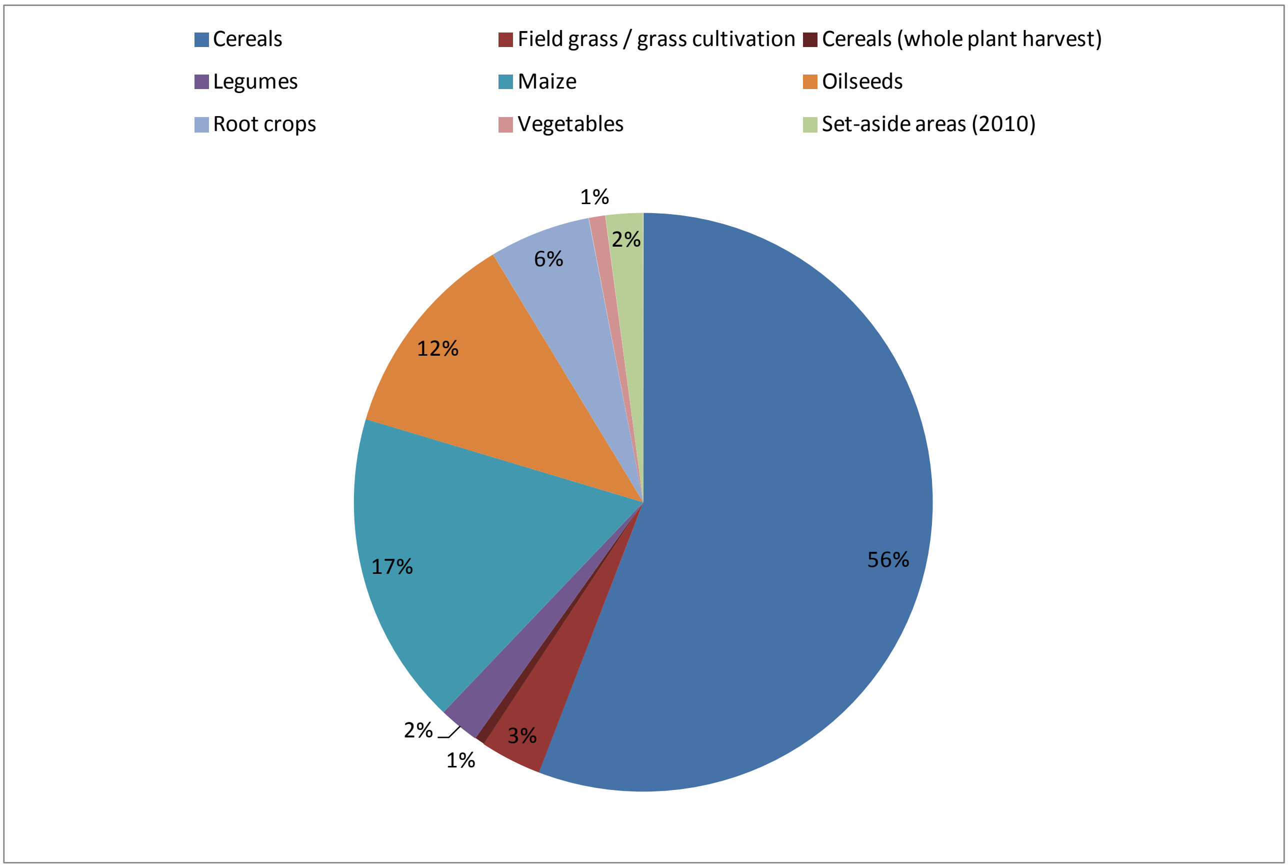

Fig. 2.1.1: Percentage share of main crops of the complete arable area in Germany 2011 (total 11,874,100 ha).

2.2 Development over the past few decades

If the development that has taken place over the past few decades is examined the following main points emerge:

The area under maize cultivation, especially silage maize, has increased significantly (Fig. 2.2.1). In 1960 the area cultivated with maize was just 500,000 ha – in 1977 this had increased to just over 1 M ha. Since then the area of maize cultivation has expanded constantly from year to year. In 2011 some 2.5 M ha of maize was cultivated. According to the Agency for Renewable Resources (FNR) the majority of the crop (1.8 M ha) is used for fodder production. Grain maize has a share of 500,000 ha. The FNR figure for the area cultivated for maize for energy production is 0.7 M ha, equivalent to 28 % of the total maize cultivation area.

Cultivation of rape and turnip rape has also increased greatly, whereby the increase is almost exclusively confined to rape. In 1960 the area cultivated for this crop was 150,000 ha, in 1980 some 260,000 ha and in 1992 the area cultivated with rape amounted to 1 M ha. The share of turnip rape is only 4 % of the total area.

The share of cereals on the total cultivated area has not changed significantly over the years. This area fluctuates in size between 6 M and 7 M hectares. In 2011 somewhat over 6 M ha was cultivated. Cereal cultivation has, however, shifted strongly towards winter cereal crops. Figure 2.2.2 shows that up to the early 1980s more spring than winter barley was grown. Subsequently the area of spring barley cultivation sank relatively quickly, whereas winter barley cultivation expanded and has slightly declined only since the end of the 1980s. Ever since, more winter than spring wheat has been cultivated but, whereas the area cultivated with winter wheat increased 2.5-fold since the 1950s, the area cultivated with spring wheat already began to shrink constantly from the beginning of the 1960s.

Cultivation of clover, clover grass and root crops has sharply decreased. In terms of biodiversity, the decline of clover and clover grass from some 1.2 M ha to only some 200,000 ha is particularly relevant, as the share of the arable area is now only one sixth compared to the beginning of the 1950s.

The farming business structure has changed considerably (Fig. 2.2.3). The number of farms decreased from 1.6 M in 1949 to 0.3 M in 2009. This decrease was accompanied by a change in the average size of the area managed by each farm.

Organic farming has shown a constant albeit slow increase in area over the past few decades. At the end of the 1980s the area used by organic farming was still extremely small. In 2000, with some 0.5 M ha, it covered some 3 % of agricultural land but about 1 M ha in 2011, which amounts to some 6 % of all agricultural land (Fig. 2.2.4). Regarding all arable land, the proportion of organic farming covered only 3.7% in 2011 (AMI 2012).

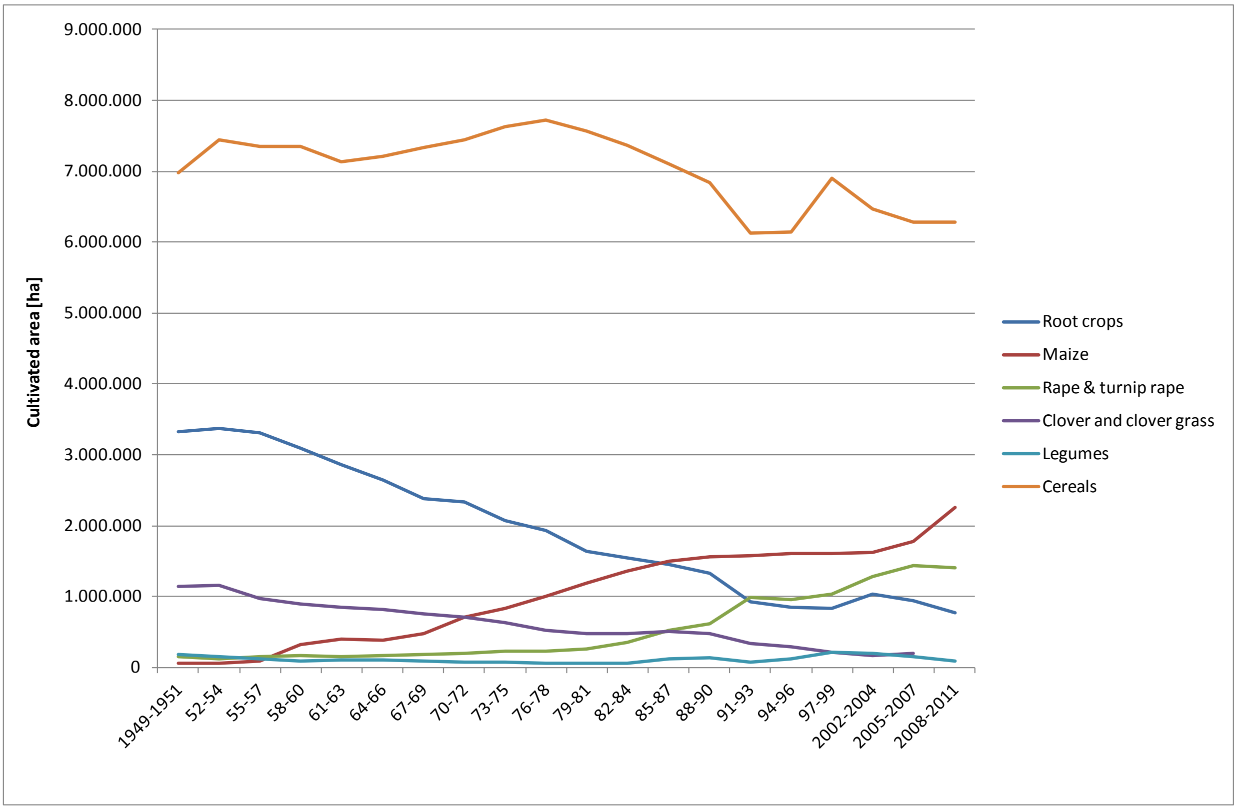

Fig. 2.2.1: Cultivated areas (ha) of cereal, maize, rape & turnip rape, clover and legumes in Germany from 1949 to 2011.

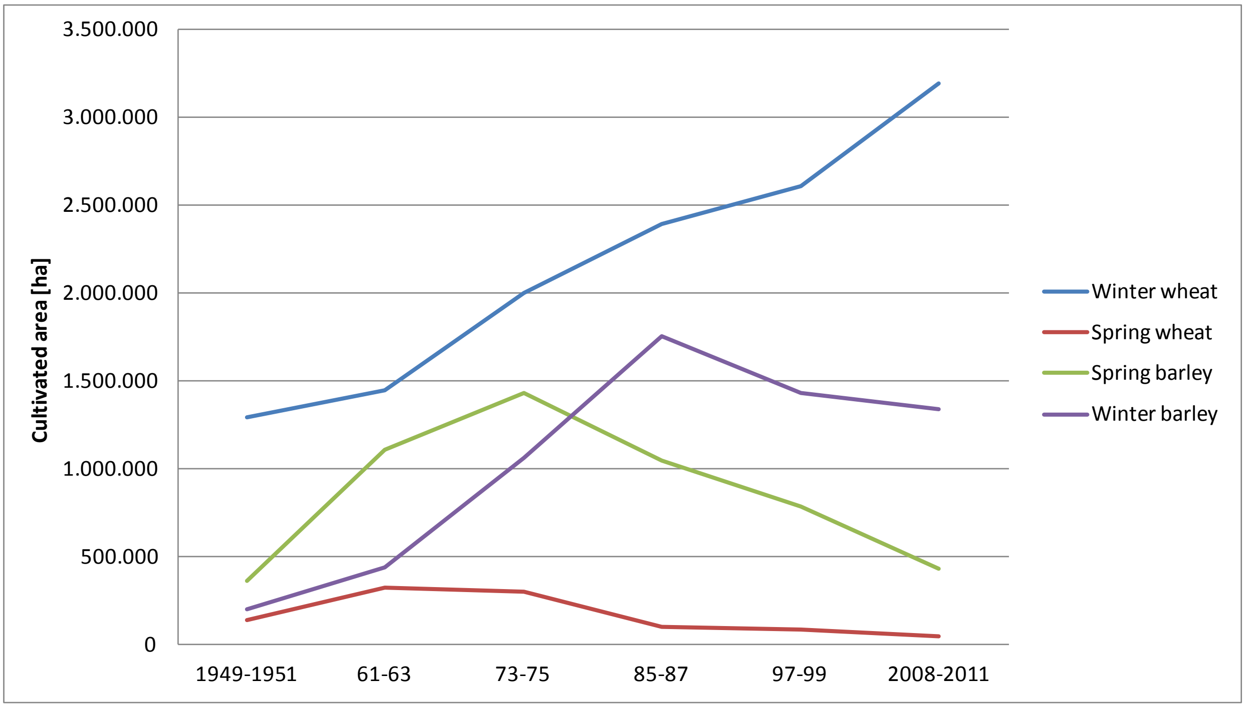

Fig. 2.2.2: Cultivated areas (ha) of wheat and barley in Germany from 1949 to 2011.

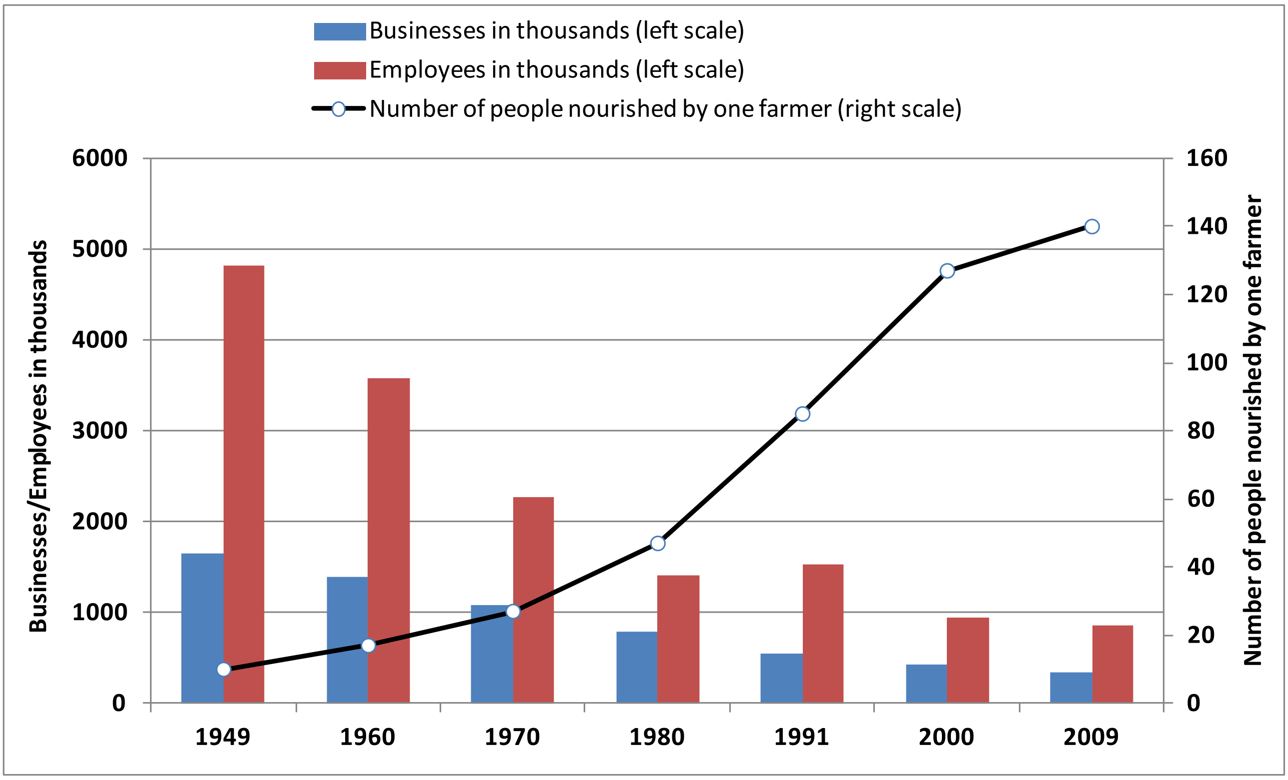

Fig. 2.2.3: Development in the number of farm businesses and their employees in Germany from 1949 to 2009. Modified from FAZ.

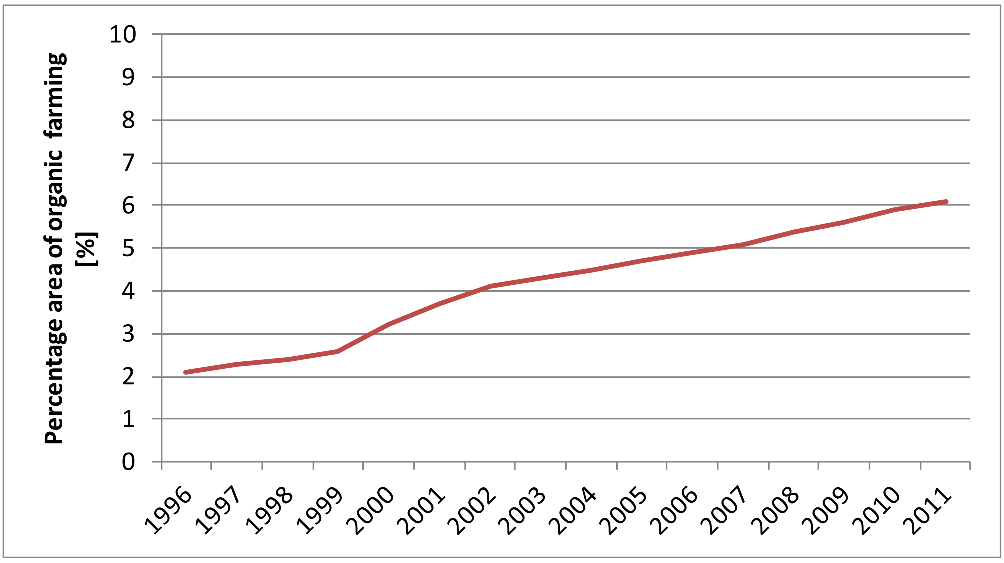

Fig. 2.2.4: Percentage area of organic farmland of the total agricultural area in Germany 1996 -2011. Source: BMELV.

2.2.1 Development of the intensity of land use

The intensity of land use can be described on the basis of the area-related average yields (harvest size/ha). In their entirety yields constitute a number of factors, first, input-related factors (fertilisers, pesticides) and, second, factors related to cultivation and machinery (e.g. crop type selection and cultivation, use of combine harvesters, other management methods such as interim greening etc., which have emerged with the advent of mechanisation and the accompanied increase in efficiency).

Taking yield development of a whole series of crops as an example (cf. Fig. 2.2.5) it is demonstrated that the yield over the past few decades has consistently and markedly increased. The highest increase in yield was in winter wheat and grain maize. Up until the mid-1960s winter wheat yield was some 31 dt/ha. A great advance took place from the mid-1960s when yields of 41 dt/ha were achieved. Thereafter the yield increased constantly. In 2011 an average yield of 70.9 dt/ha was achieved in Germany. A similar trend can be observed in grain maize. Until the early 1960s the yield was some 29 dt/ha. Since then, yields have increased enormously and reached a level of about 100 dt/ha at present.

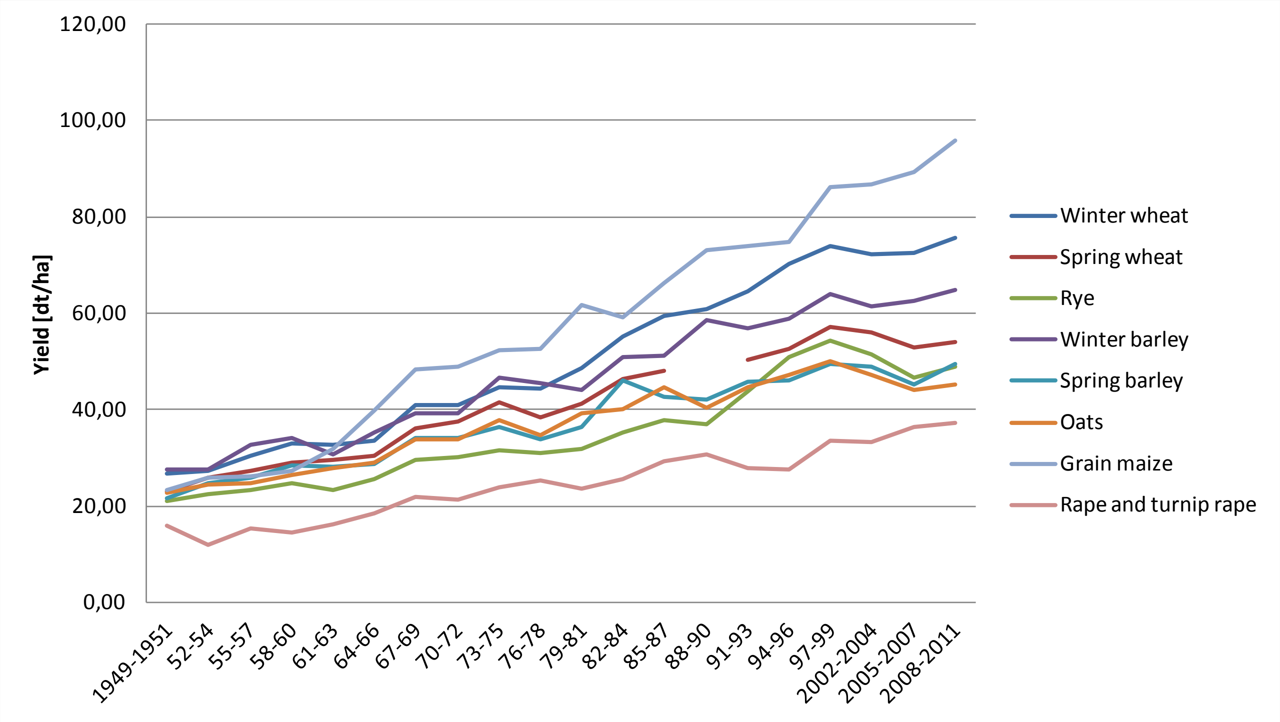

Fig. 2.2.5: Increase of yield for selected crops since 1949 (Mean values. Source: Federal Statistic Office, Land Use and Harvest. Note: No data available for 2000 and 2001 or for spring wheat in the time frame 1988 to 1990.).

2.2.2 Development of ecologically important structures and plots

There are relatively little data available on the development of ecologically important structures and plots as these are traditionally rarely recorded in land use statistics. The decrease of bogland areas in the North German lowland countryside and the alpine foothills has however been identified. Only some 3.7 % of some 18,000 km of bogland areas are still considered semi-natural and moor soils, with an 8 % share, account for a significant part of farmland in use (SRU 2012). The felling of meadow orchards, above all in the second half of the previous century, constituted a great loss of ecologically important agriculturally used areas particularly in the south of Germany. E.g. in Baden-Württemberg, the stand of high-stemmed fruit trees declined from 36.02 M in 1938 to a mere 11.35 M in 1990 and thus by 68.5 % (Rösler 2003). Less well known is the extent of the drainage of arable land to create better crop-growing areas or the felling of hedges. The changes mentioned affect, however, mainly special locations and habitats and not arable land as a whole.

Relevant in this context, especially taking the last two decades into consideration is a) the development of the extent of set-aside plots and b) the transformation of grassland into arable land. There is a series of data available on these latter two developments.

Set-aside was introduced in the EU in 1992/93 (EU 1992) with the aim of limiting overproduction. This so-called compulsory or also called economic set-aside policy affected all farming businesses. Farmers had to set aside a share of 15 % of their arable land at first and were not permitted to use these areas for either crop-growing or as pasture. Later the extent of set-aside was specified annually (economic set-aside) and fluctuated between about 8 % and 10 %. This was of importance because almost throughout the entire farmed countryside plots of varying sizes lay fallow, and many of them went through a self-greening process (some were sown with a simple and cost-effective ryegrass mix for weed repression). The plots had to be mowed once a year in order to keep them in an 'orderly condition'. Exceptionally (which later partly became the rule) it was permitted to grow renewable resources such as rape on the plots, a practice conducted in particular by farmers in the west and south German federal states. The figures 2.2.6 and 2.2.9 depict the development of set-aside areas. In 2007 compulsory set-aside was abolished as there was no more overproduction. The farmers were again permitted to set aside plots for which they received a direct EU subsidy, but few farmers took advantage of this (almost exclusively on marginal yield land mainly in the federal states in Eastern Germany). Since 2008 set-aside areas have declined dramatically and today comprise only 215,000 ha in Germany, just 1.8 % of all arable land (Federal Statistic Office 2013).

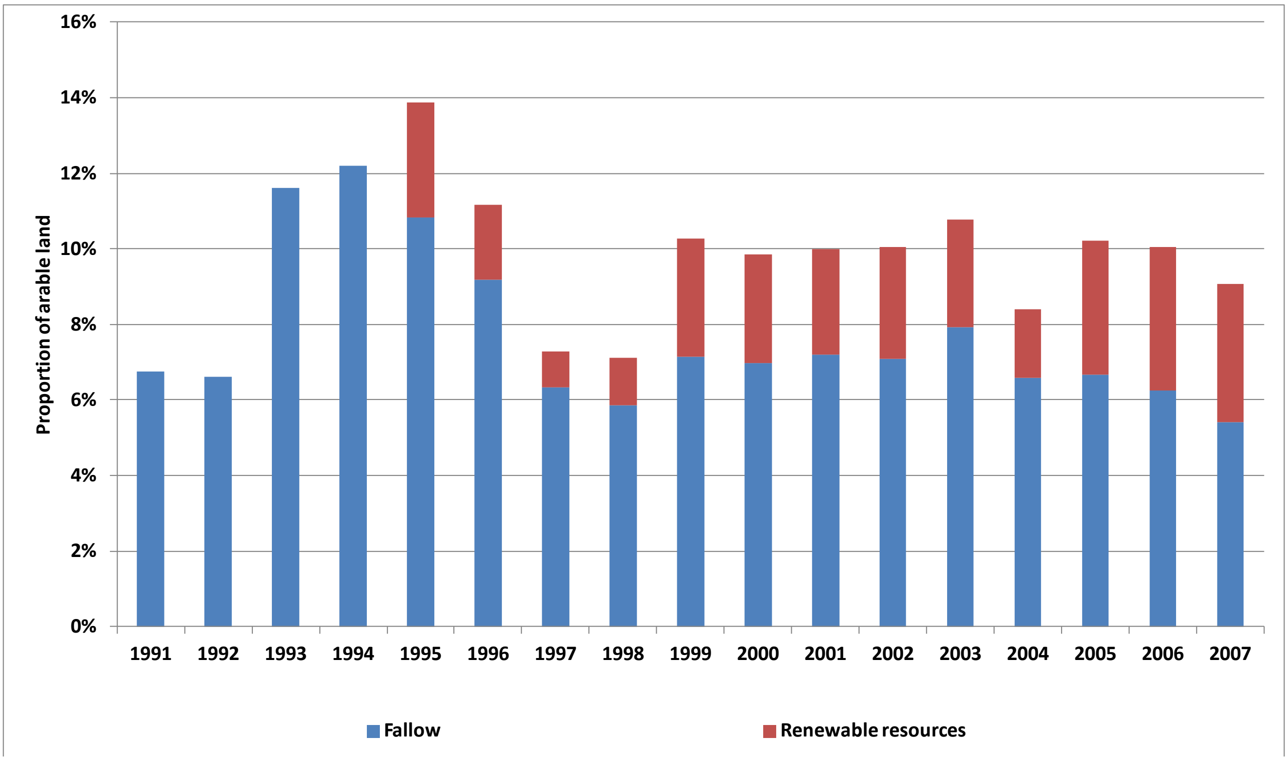

Fig. 2.2.6: Development of set-aside land in Germany. Source: Federal Statistics Office and the Federal Office of Agriculture and Food (Diagram source: NABU 2008).

Set-aside policy was of particular ecological significance because
a) the plots were scattered almost everywhere in the countryside thereby creating a wide-scale network of such areas,

b) the plots were in particular created on low-nutrient soil and mainly went through a self-greening process (i.e. with the natural diversity of the location), and

c) the plots acted indirectly as ecological compensation areas in times when intensification of management and yield rises in conventional agriculture had sharply increased. Thereby set-aside plots created compensatory refuges for farmland wildlife.

Figures. 2.2.7 and 2.2.8 illustrate the relationships between the percentage of set-aside land and Montagu's Harrier and Corn Bunting populations.

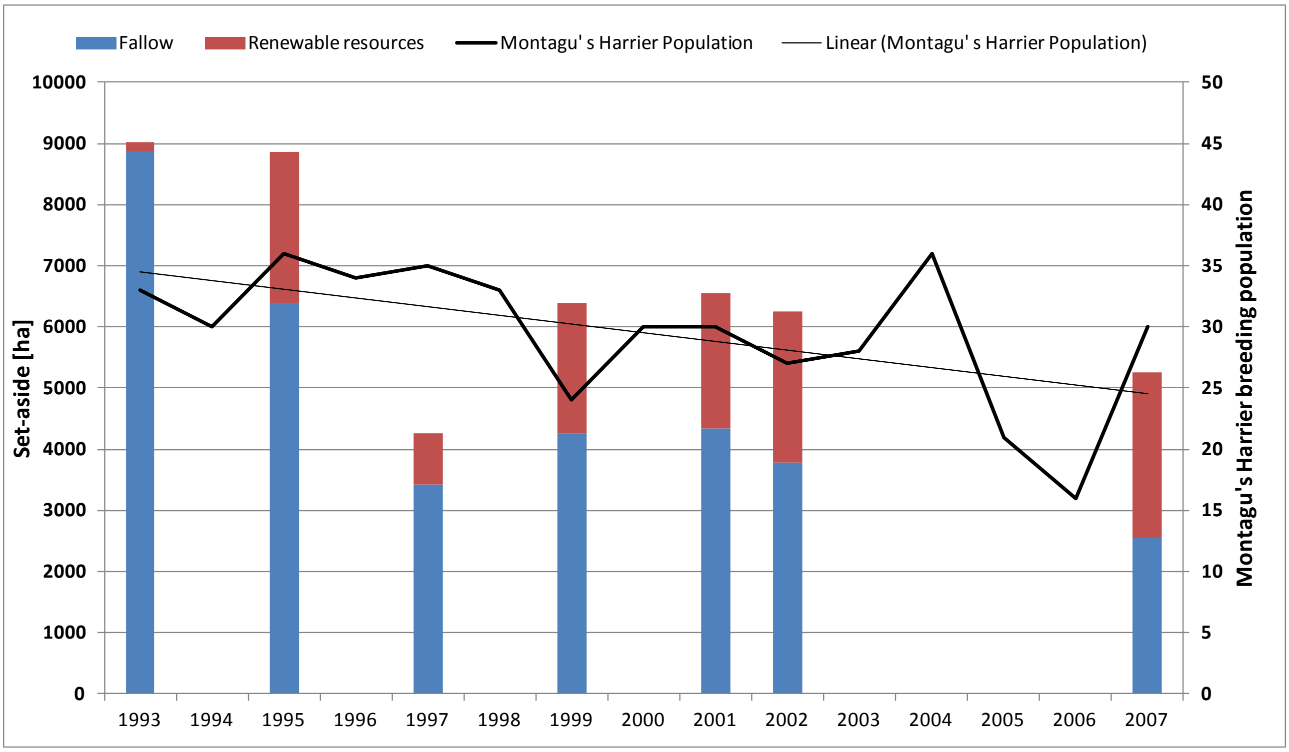

Fig. 2.2.7: Development of set-aside areas and Montagu's Harrier breeding population in the Soest District (adopted from NABU 2008 according to data from ABU 2007 and the North-Rhine Westphalia Agricultural Chamber of Commerce).

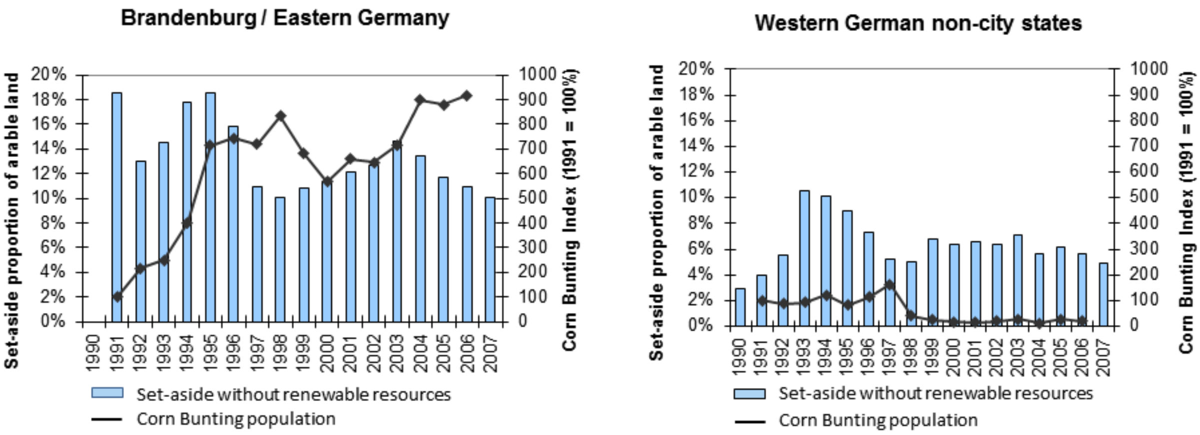

Fig. 2.2.8: Development of set-asides in Germany according to information from the Federal Statistics Office, and development of the Corn Bunting population according to data from Flade 2007 (diagram: NABU 2008).

A further important indicator for ecologically valuable structures is the development of permanent grassland. Superficially this is not related to arable land but a closer examination reveals the following:

Grassland ploughed up to create arable land is, with the exception of organically farmed land, from then on treated with pesticides, whereas permanent grassland as a rule is not, or only to a minor degree.

Ploughed up grassland as a rule belongs to the category of special locations or habitats that had previously been grassland because it was less suitable for crop growing (too damp or too dry, soil too shallow, too steep). This means that locations which were used as grassland because of their less optimal conditions, often associated with high ecological importance, are now used as arable land.

Ploughing up of grassland frequently leads to a homogenisation of the countryside, as it often occurs in locations where individual plots are still used as grassland and 'stand in the way' of wide-scale arable use.

Figure 2.2.9 shows the development of permanent grassland in the past 20 years. The nationwide extent of grassland has declined by 12 % from 5.25 M ha to 4.63 M ha between 1993 and 2012 and the percentage of permanent grassland on total agricultural area by 2.8 % to 27.8 % (BMELV 2012).

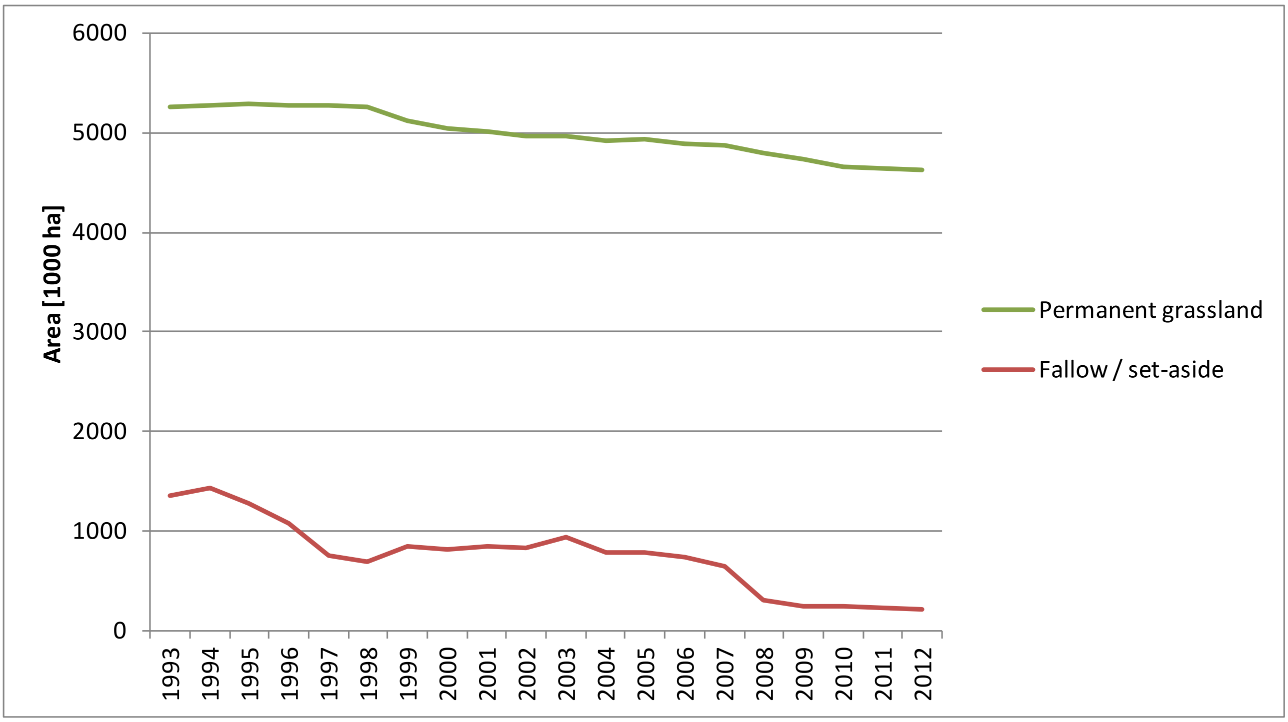

Fig. 2.2.9: Development of permanent grassland and fallow/set-aside in Germany since 1993.

It is evident that valuable ecological structures have been lost over the past years and decades and that there is an increase in intensive management in these areas. This presents birds and mammals of the open countryside with a double threat. On the one hand there are fewer refuge and compensatory plots available and, on the other hand, the areas thus transformed are used intensively which implies further direct and indirect risks.

2.2.3 Relationships between land usage and plant protection

In respect of changes in land use, the following factors can be identified as having occurred as a result of pesticide development over the past few decades:

The sharp decline in spring cereal crops, as well as a decrease in clover and clover grass cultivation, is in part due to the increased capability for repression of weed growth in winter cereal. This means that the cultivation of clover and clover grass, previously used not only as cattle fodder but also for weed repression, is no longer considered essential.

The increase in size of farms, together with the concomitant reduction in the number of employees, has made a less manual work-intensive management possible through the use of chemical pesticides and mechanisation.

Fig. 2.2.10: Ploughing up of grassland in March 2012 in a damp location on the Upper Rhine Plain. Photo: R. Oppermann.

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An increase in area yield can be observed for all crops. This is particularly attributable to pesticide, fertiliser and mechanisation factors.

The temporal reduction in crop rotation became possible through the use of pesticides. The necessity for further crop rotation and interim crops to assist recovery, such as growing of clover grass, no longer exists.

The recultivation of set-aside plots for crop growing and the ploughing up of grassland has caused the loss of extensive farmland refuges and habitat areas for wildlife, and these areas as a rule are subsequently intensively managed including the use of pesticides.

2.3 Use of pesticides in Germany

2.3.1 Overview of the use of pesticides in Germany

The number of authorised pesticides in Germany has declined since 2000, although the number of agents has remained almost exactly the same (Fig. 2.3.1). In 2011 the latter were 258 in number and a total of 43,865 t were deployed.

Herbicides represent the highest domestic use of pesticide agents, followed by fungicides and inert gases. Since 1994 domestic sales of pesticides have risen by some 50 % (Fig. 2.3.2, Tab. 2.3.1). Pesticide types with the greatest increase in use were inert gases (+110 %) and herbicides (+25 %). Inert gases are used to preserve stored products against pests. In 2011 their level of use was the same as fungicides. The use of fungicides and insecticides/acaricides has remained roughly constant since 1994. Table 2.3.1 lists amounts of agents in agent groups used in Germany and exported in 2011. The most sold herbicide agent group are the organophosphorous herbicides (32 %) to which glyphosate belongs. Following the organophosphorous herbicides, amides and anilides (20 %) and triazines and triazinomes (12.6 %) are in the second and third place, respectively. In the case of fungicides not clearly defined organic and inorganic fungicides are most often sold (38,5 %), followed with about 16 % by carbamates and dithiocarbamates as well as imidazoles and triazoles. Nicotinoids, with 33.5 %, have the largest share of insecticide agents. These agents are dangerous above all for pollinators (e.g. honey bees and wild bees including bumblebees, butterflies, hoverflies) (EFSA 2013).

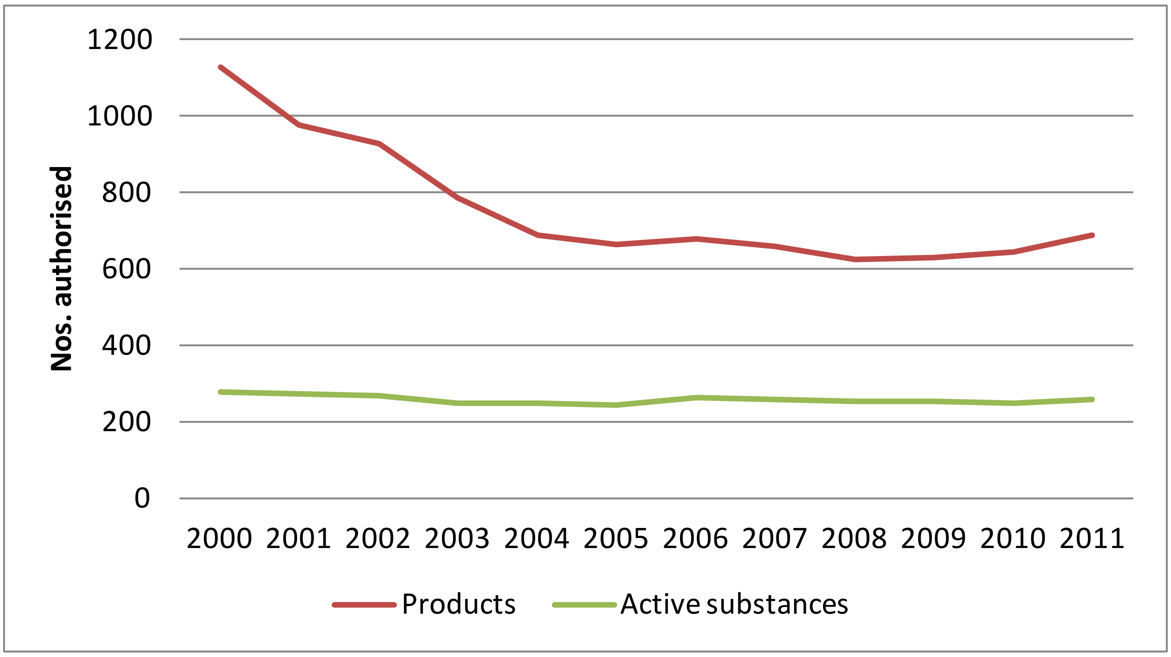

Fig. 2.3.1: Numbers of pesticide products and active substances authorised in Germany since 2000 (Source: BVL 2012).

When nicotinoids are used as seed dressing, dusts with high contents of active ingredient can drift into the neighbouring environment and accumulate on flowers that attract bees. In 2008, in the Upper Rhine Plane and in parts of Bavaria, over 11,500 bee colonies were poisoned, and unquantifiable damage was caused to populations of wild pollinator populations, as a result of the sowing of maize seed that had been treated with the nicotinoid insecticide Clothianidin (Pistorius et al. 2009).

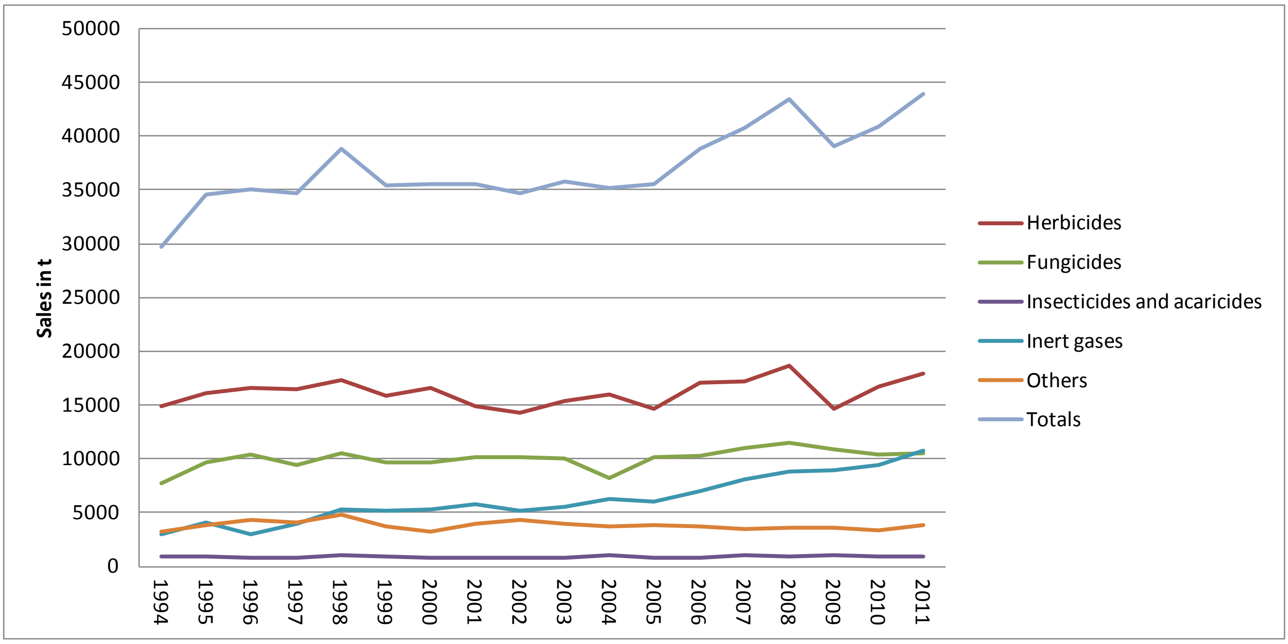

Fig. 2.3.2: Development of German domestic sales of pesticide agents since 1994 (Source: BVL 2012 and BMELV 2009).

Tab. 2.3.1: Amounts of agents in agent groups used in Germany and exported in 2011 (Source: BVL 2012).

Wirkstoffgruppe	Inlandsabgabe			Ausfuhr	
	t	%	*davon PH (t)*	t	%
Herbizide	**17955**	**100**	***2863***	**14466**	**100**
Phenoxy-Phytohormone	915	5,1	*252*	342	2,4
Triazine und Triazinone	2270	12,6	*158*	435	3,0
Amide und Anilide	3586	20,0	*185*	3095	21,4
Carbamate und Biscarbamate	269	1,5	*22*	598	4,1
Dinitroanilinderivate	829	4,6	*48*	641	4,5
Harnstoff-, Uracil- oder Sulfonylharnstoffderivate	1640	9,1	*278*	695	4,8
Organophosphor-Herbizide	5415	30,2	*1603*	2481	17,1
Sonstige organische Herbizide	2906	16,2	*317*	5777	39,9
Anorganische Herbizide	125	0,7	*0*	402	2,8
Fungizide	**10474**	**100**	***634***	**35513**	**100**
Carbamate und Dithiocarbamate	1740	16,6	*148*	10001	28,2
Benzimidazole	136	1,3	*0*	359	1,0
Imidazole und Triazole	1755	16,8	*98*	2036	5,7
Morpholine	668	6,3	*11*	2190	6,2
Fungizide auf pflanzlicher und mikrobieller Basis	1	<0,1	*0*	34	0,1
Sonstige organische Fungizide	4029	38,5	*377*	4194	11,8
Anorganische Fungizide	2145	20,5	*0*	16699	47,0
Insektizide und Akarizide	**883**	**100**	***24***	**2493**	**100**
Pyrethroide	143	16,2	*12*	99	4,0
chlorierte Kohlenwasserstoffe	0	0	*0*	0	0
Carbamate und Oximcarbamate	235	26,6	*7*	290	11,6
Organophosphate	84	9,5	*3*	148	5,9
Insektizide auf pflanzlicher oder mikrobieller Basis	8	0,9	*0*	4	0,2
Nicotinoide	296	33,5	*1*	1765	70,8
Sonstige Insektizide	117	13,3	*1*	187	7,5
Sonstige Wirkstoffe	**14553**	**100**	***296***	**12630**	**100**
Molluskizide	255	1,8	*37*	85	0,7
Wachstumsregler und Keimhemmungsmittel	3123	21,5	*259*	4804	38,1
Mineralöle und Pflanzenöle	230	1,6	*0*	80	0,6
Bodenentseuchungsmittel und Nematizide	32	0,2	*0*	5864	46,4
Rodentizide	66	0,4	*0*	757	6,0
Inerte Gase	10798	74,2	*0*	1014	8,0
alle sonstigen Wirkstoffe	49	0,3	*<1*	26	0,2

2.3.2 Digression - glyphosate as most used herbicide

The use of glyphosate has increased since 2000 (Fig. 2.3.3). In 2007 and 2008 particularly large amounts were used, and in 2011 its use reached the third highest level since 2000. The main area of application of glyphosate in arable farming in Germany is stubble treatment in the first instance, followed by pre-sowing application and desiccation (e.g. for accelerated maturation) according to Dickeduisberg et al. (2012). The use on stubble fields following the harvest does not serve to protect the (already harvested) crops, but to reduce the temporal and financial effort of the preparation of the seedbed for the next crop. Thus, it does not provide plant protection in accordance with the Plant Protection Act (Plant Protection Act dated 6 February 2012 (BGBl. I S. 148, 1281)), which defines plant protection as the protection of plants from pest organisms and non-parasitic influences, as well as protection of plant products from pest organisms (protection of stored products). Neither does the practice of desiccation. The use of broad-band herbicides such as glyphosate for stubble treatment and desiccation is economical to the farmer, but not in compliance with the Plant Protection Act (Haffmanns 2007).

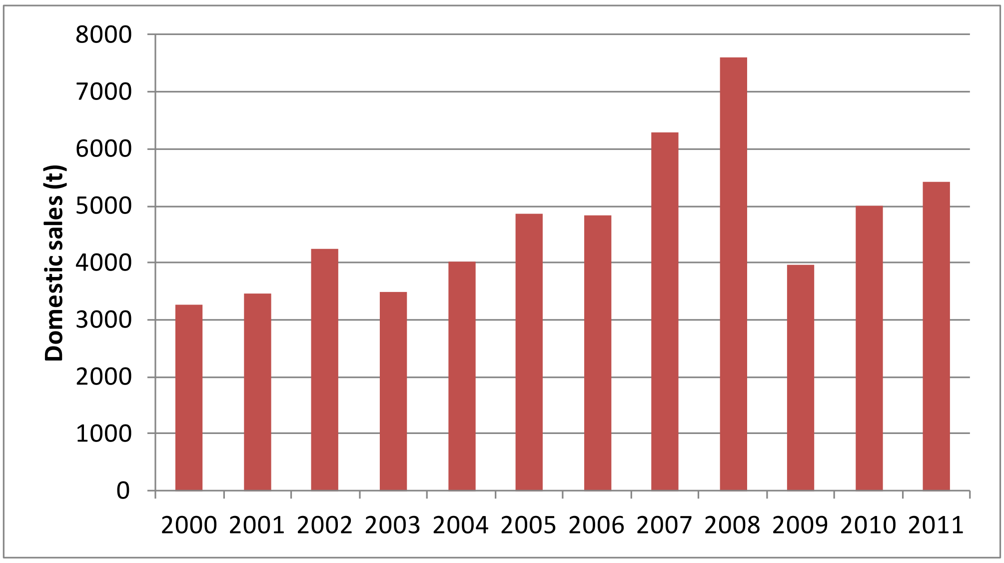

Fig. 2.3.3: Annual domestic use (in t) of Glyphosate in Germany since 2000 (Source: German Parliament brochure 17/7168, 2011).

2.4 Intensity of use on different crops

One indicator for the intensity of pesticide use is the Treatment Index ('Behandlungsindex', BI). The BI is an amended form of the Treatment Frequency Index (TFI), first applied in Denmark in the mid-1990s. The Julius Kühn-Institute applies the BI in the framework of the NEPTUNE programme in order to determine the actual use of chemical pesticides in Germany. Previous estimates of intensity of pesticide use could only be inferred from the industry's sales figures. The BI represents the number of pesticide applications on a farmed area, a crop type or a farm. It is calculated from the permitted use per ha, the amount applied per ha and the percentage of the treated area. The highest permitted amount of a pesticide for a relevant area of application is allocated a value of 1.0. The values of pesticide applications per crop year are then added up. The higher the value the higher is the intensity of chemical pesticide in the respective crop.

Tab. 2.4.1 shows an overview of the BI in different crops. Potato crops show a high BI, above all because of fungicide use against potato blight (*Phytophthora infestans*). Maize has on average a medium BI of 2.0 attributable solely to herbicide. Energy maize receives little treatment as a consequence of the importance of biomass yield rather than of quality. Only values for 2000 are available for spring barley and oats; the BI was with 2.2 for spring barley and 1.7 for oats on a low level. Oats is cultivated as a spring cereal. Spring cereals require generally less pesticide than winter cereals. They are sown in spring and repress weed species by their rapid development. The use of pesticides on winter cereals is analogous to the increase in area of cultivation and the rise in yields of these crops.

A high level of pesticide use is also found in fruit crops. Apple scab (*Venturia inaequalis*) is a significant fungus affecting apple and pear cultivation. Dessert fruit in particular is subject to strict quality requirements and scab marks on an apple represent an exclusion criterion for many consumers, although these fruits can be eaten without any concern. The quality requirements for juice extraction are lower. Permanent crops such as orchards or vineyards have a general higher BI than arable areas with crop rotation. The disease pressure is higher for the former and the failure of an area can mean high economic loss. For this reason many pesticide applications are preventative.

Tab. 2.4.1: Mean values of the treatment indices for different crops in Germany 2007-2010 (data according to JKI (2011), data for spring barley, oats, apples, pears and wine are taken from www.nap-pflanzenschutz.de (26.11.2012)).

Crop	Herbicide	Fungicide	Insecticide	Growth regulator	**Total**
Autumn-sown wheat	1.9	2	1	0.9	**5.8**
Autumn-sown barley	1.6	1.3	0.5	0.8	**4.2**
Autumn-sown rape	1.7	0.8	2.6	1	**6**
Maize	2	0	0	0	**2**
Potatoes	2.3	12.6	0.6	0.1	**15.6**
Sugar beet	2.9	1.2	0,2	0	**4.3**
Spring-sown barley (2000)	1.2	0.7	0.3	0	**2.2**
Oats (2000)	1	0.1	0.3	0.3	**1.7**
Apples (2001)	1.4	21.8	4.8	0	**28**
Pears (2004)	0.4	14.8	3.5	0	**18.7**
Wine (2003)	0.1	12.4	0.6	0	**13.1**

2.5 Implications of the development of agricultural structures in Germany for birds and mammals in the cultivated countryside

Agricultural intensification went along with mechanisation and the intensive use of pesticides, as well as a certain degree of homogenisation of the countryside, a decline in structural landscape elements and, in many areas, a transformation of permanent grassland into intensively managed arable farmland. This development led not only to a massive increase in farming yields, but also to a decline in biodiversity on farmland. The intensive use of pesticides in particular has led to a massive increase in the growing density of crop stands and thus to a greater constriction in food supply for farmland birds and mammals. This has significantly degraded the living conditions for wildlife on arable land. At the same time the area of ecologically valuable landscape structures and areas on farmland have decreased, in particular set-aside and grassland areas, but also special areas like meadow orchards or bogland. As a reaction to the intensification of farming methods, organic cultivation developed as a potentially sustainable form of modern farming, characterised by, among other things, eschewal of synthetic pesticides. Nonetheless, the total area of organic farming in Germany, amounting to only some 435,000 ha and a share of 3.7 % of all arable land, is relatively small (AMI 2012). Numerous studies have proved that organic farming contributes significantly to a higher degree of biodiversity. Higher settlement densities of field-dwelling birds are recorded for instance on organically farmed land as well as a greater diversity of ground beetle and rare plant species (Gabriel et al. 2006, Gabriel & Tscharntke, 2007, NABU 2004, Neumann et al. 2007, Pfiffner & Luka 2003 – all information according to Pfiffner & Balmer 2009).

With only 3.7 % of arable land, the extent of organically farmed land is, however, far too small to compensate for the negative effects of conventional farming using pesticides. In addition, it should also be taken into account that ecological refuges are also needed in organic farming, as the ecological potential for bird and mammal populations in the countryside still remains restricted in the most intensive forms of organic farming (Oppermann et al. 2003).

The development of bird and mammal populations in the farmland countryside, and the effects of chemical pesticides on this development, is discussed in detail in the following two chapters.

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3 Bird and mammal species in agricultural landscapes

3.1 Population trends and conservation status

3.1.1 Population trends and conservation status of birds

In Germany as well as in many other European countries numbers of birds have been monitored for many years. The fieldwork is performed by thousands of well-skilled volunteers employing highly standardized methods. Reports are published regularly, both at European (BirdLife International 2004, Pan-European Common Bird Monitoring Scheme 2012) and national levels (Wahl et al. 2011). In Germany, information about population trends is also available for most of the federal states. For details see bird species portraits in Annex I and Südbeck et al. (2007).

Information about population trends forms a part of the basis for the red lists of breeding bird species which are available at the European level, for Germany (Südbeck et al. 2007) and for Germany's single federal states (Bauer et al. 2011). Red lists examine the conservation status of species not only by regarding trends but also by integrating other factors with possible effects on the extinction risks of global and local populations in a standardized way. The information about species' extinction risks in red lists is more comprehensive than an analysis of mere population trends. Therefore red list classifications of farmland birds are reported together with population trends (see Tab. 3.1.1 for an overview and bird species portraits in Annex I for details).

The terms "Favourable Conservation Status" and "Unfavourable Conservation Status" play an important role in the implementation of the EU nature conservation directives (EU Wild Birds Directive (79/409/EEC) and EU Habitats Directive (92/43/EEC), see below chapter 3.1.3). Both directives do not offer a clear mechanism for the decision whether a population is in favourable or unfavourable conservation status. BirdLife International offers guidelines for the European level (BirdLife International 2004) and for the site level (BirdLife International 2006). On the European level a species breeding in Europe is in unfavourable conservation status when it meets the IUCN Red list criteria at global or at European level (IUCN 2013), or when it meets additional criteria developed by Tucker & Heath (1994): declining, rare, depleted or localized in Europe. At the site level a population of a species is in unfavourable conservation status when it falls below its favourable reference value, judged by population size, habitat or range targets. In its position paper BirdLife International (2006) states: "At its simplest, FRV (favourable reference value) can be equal to the baseline population level of the species in question if that is accepted as being in favourable conservation status, taking into consideration the natural range of fluctuation for the given species or habitat. Baseline population level is the population level at a designated or candidate SPA (=Important Bird Areas as identified by BirdLife International) at the time the Birds Directive came into force in the country in question. The population, habitat or range target can be set at a different level to the one that corresponds to the baseline population level, if there is a good reason to believe that the species in question was not at a favourable conservation status at that time. The following considerations might lead to setting higher population, habitat or range targets:

- Species populations have increased since the baseline date
- Historic data indicates that the species was in decline before the baseline date

- Mechanisms are in place which suppress population density (e.g. hunting or disturbance)
- Research studies indicate that the site's carrying capacity is higher than current population levels
- Higher-level (network, national, EU or European) conservation objectives require setting higher targets at the site level."

From the 20 species of farmland birds breeding in Germany and selected for this study (see chapter 1.1), ten (50%) have been declining in Germany (Tab. 3.1.1). The populations of three species, Grey Partridge, Lapwing and Black-tailed Godwit, have more than halved within the past decades. Seven species showed declines between 20% and 50%: Red Kite, Skylark, Barn Swallow, House Martin, Whinchat, Meadow Pipit and Linnet.

Farmland species have been declining more than other bird species during the last decades and there is a significant difference between the percentage of declining species between farmland and all other habitats (16%, Südbeck et al. 2007).

The observed long-term patterns have not been changing very much during the recent years. In the period 2005 – 2010 stable trends turned into significant declines in Common Quail and Yellowhammer and into a significant increase in Yellow Wagtail (Tab. 3.1.1). In table 3.1.1 some species with a long term decline were listed as "stable" since 2005. This, however, just means that no significant trends were found for 2005 – 2010 (J. Schwarz, DDA, in litt.). As significant trends are relatively hard to detect within short time interval, the absence of statistical significance does not necessarily mean the halt of the long-term trend.

Very recently the German agricultural landscape has been changing considerably (Bundesministerium für Ernährung Landwirtschaft und Verbraucherschutz 2011, see also chapter 2). Since 2007, large areas of set-aside have disappeared, the area covered by grassland has become smaller and maize prevails (Bundesministerium für Ernährung Landwirtschaft und Verbraucherschutz 2011). In order to analyse whether these changes are already reflected by the populations of farmland birds we looked at the trends of the last three years of available data (2008 – 2010) of 15 common farmland bird species (J. Schwarz & M. Flade (DDA), in litt.). Eleven species declined (Common Quail, Grey Partridge, Red Kite, Lapwing, Red-backed Shrike, Skylark, House Martin, Whinchat, Meadow Pipit, Linnet, Corn Bunting) and four species increased (slightly) (Woodlark, Barn Swallow, Yellow Wagtail, Yellowhammer). Notably the declines of Common Quail, Red-backed Shrike and Corn Bunting occurred after longer periods of increase or stability (see Annex 1, Figs. Coco 2, Laco 2, Emca 2). Although three years being not enough to determine a trend, these results indicate that the changes in land-use in Germany since 2007 (end of obligatory set-aside within the EU) have already reached farmland bird populations.

Tab. 3.1.1: (Overleaf) Population sizes, trends and conservation status of selected farmland birds. Explanations: Category in German red list: 1: Critically endangered, 2: Endangered, 3: Vulnerable, V: Near Threatened; SPEC (Species of European Concern): SPEC 1: European species of global conservation concern, SPEC 2: Species whose global populations concentrated in Europe and which have an unfavorable conservation status in Europe, SPEC 3: Species whose global populations are not concentrated in Europe, but which have an unfavorable conservation status in Europe. Sources: BirdLife International (2004), Südbeck et al. (2007), IUCN (2010), Pan-European Common Bird Monitoring Scheme (2012), Detailed Species Portraits (Annex I), J. Schwarz & M. Flade (DDA), in litt.).

Species	Status	Population size in Germany (pairs)	Population size in Europe (pairs)	Trend in Germany	Trend in Germany since 2005	Trend in Europe	Timing of most severe change in Europe	Category German Red List	Category European Red List	Category Global Red List
Bewick's Swan	passage			fluctuating	declining*	declining			SPEC 3 (winter), Vul	-
Barnacle Goose	breeding	192 - 193	41,000 - 54,000	>50%	increasing	>50%		–	–	-
Barnacle Goose	passage			increasing	increasing*	increasing				-
Bean Goose	passage			stable	stable*	stable				-
White-fronted Goose	passage			stable	stable*	stable				-
Greylag Goose	breeding	17,000 - 20,000	120,000 - 190,000	>50%	increasing	>50%		–	–	-
Greylag Goose	passage			increasing	increasing*	increasing				-
Common Quail	breeding	18,000 - 38,000	2,800,000 - 4,700,000	20% - 50%	declining	fluctuating		–	SPEC 3, Depleted	-
Grey Partridge	breeding	86,000 - 93,000	1,600,000 - 3,100,000	<-50%	declining	<-50%	1980s, 1990s	2	SPEC 3, Vulnerable	-
Montagu's Harrier	breeding	410 - 470	25,000 - 65,000	20% - 50%	stable	20% - 50%		2	–	-
Red Kite	breeding	10,000 - 14,000	19,000 - 25,000	-50% - -20%	stable	-50% - -20%	1990s	V	SPEC 2, Declining	Near threatened
Common Crane	breeding	5,200 - 5,400	74,000 - 110,000	>50%	increasing	>50%		–	SPEC 2, Depleted	-
Common Crane	passage			20% - 50%	increasing*	20% - 50%				-
Corncrake	breeding	1,300 - 1,900	1,300,000 - 2,000,000	stable	probably stable	fluctuating	fluctuating	V	SPEC 1, Depleted	Near threatened
Golden Plover	breeding	<8	460,000 - 740,000	<-50%	increasing	unknown		1	–	-
Golden Plover	passage			stable	fluctuating*	20% - 50%				-
Lapwing	breeding	68,000 - 83,000	1,700,000 - 2,800,000	<-50%	declining	-50% - -20%	1980-1995	2	SPEC 2, Vulnerable	-
Black-tailed Godwit	breeding	4700	99,000 - 140,000	<-50%	declining	-50% - -20%	cont. since 1985	1	SPEC 2, Vulnerable	Near threatened
Little Owl	breeding	8200 - 8400	560,000 - 1,300,000	stable	stable	-50% - -20%		2	SPEC 3, Declining	-
Red-backed Shrike	breeding	120,000 - 150,000	6,300,000 - 13,000,000	stable	stable	stable	stable	–	SPEC 3, Depleted	-
Woodlark	breeding	44,000 - 60,000	1,300,000 - 3,300,000	20% - 50%	stable	stable	stable	V	SPEC 2, Depleted	-
Skylark	breeding	2,100,000 - 3,200,000	0,000,000 - 80,000,00	-50% - -20%	declining	-50% - -20%	1980s	3	SPEC 3, Depleted	-
Barn Swallow	breeding	1,000,000 - 1,400,000	6,000,000 - 36,000,00	-50% - -20%	stable	stable	stable	V	–	-
House Martin	breeding	830,000 - 1,200,000	9,900,000 - 24,000,00	-50% - -20%	stable	stable	cont. since 1980	V	SPEC 3, Declining	-
Winchat	breeding	45,000 - 68,000	5,400,000 - 10,000,000	-50% - -20%	stable	-50% - -20%	before 1985	3	–	-
Meadow Pipit	breeding	96000 - 130000	7,000,000 - 16,000,000	-50% - -20%	declining	<-50%	continiously	V	–	-
Yellow Wagtail	breeding	120,000 - 150,000	7,900,000 - 14,000,000	stable	increasing	-50% - -20%	before 2000	–	–	-
Linnet	breeding	440,000 - 580,000	0,000,000 - 28,000,00	-50% - -20%	declining	<-50%	continiously	V	SPEC 2, Declining	-
Corn Bunting	breeding	21,000 - 31,000	7,900,000 - 22,000,000	20% - 50%	stable	<-50%	1980-1985	3	SPEC 2, Declining	-
Yellowhammer	breeding	1,200,000 - 2,000,000	18,000,000 - 31,000,00	stable	declining	-50% - -20%	continiously	–	–	-
Ortolan Bunting	breeding	10,000 - 14,000	5,200,000 - 16,000,000	stable	probably stable	<-50%	1980-1990	3	SPEC 2, Depleted	-

Among the 20 selected species 13 (65%) show Europe-wide declines (BirdLife International 2004). In five species more than 50% of the European population have been lost: Grey Partridge, Meadow Pipit, Linnet, Corn Bunting and Ortolan Bunting. In eight species the declines were between 20% and 50%: Red Kite, Lapwing, Black-tailed Godwit, Little Owl, Skylark, Whinchat, Yellow Wagtail and Yellowhammer.

More evidence for an unfavourable conservation status of farmland birds comes from an overview of trends in common bird species breeding in Europe (Pan-European Common Bird Monitoring Scheme 2012). In this overview, 37 species are classified as farmland species. Fifty-one (35%) of all the 148 species in the overview were declining (reference period in most cases 1980 to 2009). In farmland species, 19 (51%) out of 37 species were declining.

In contrast to the species breeding in Germany, the European/Asian population of only one of the seven species mainly present during the non-breeding season in Germany is decreasing , the Bewick's Swan (Tab. 3.1.1).

Considering both the German and the European level, the following six farmland bird species seem to be declining most severely at present: Grey Partridge, Lapwing, Black-tailed Godwit, Skylark, Meadow Pipit and Linnet.

Among the 20 species of farmland birds breeding in Germany and selected for this study, one (Black-tailed Godwit) is listed as critically endangered in the red list of birds breeding in Germany (Südbeck et al. 2007), four are listed as endangered (Grey Partridge, Montagu's Harrier, Lapwing, Little Owl) and vulnerable (Skylark, Whinchat, Corn Bunting, Ortolan Bunting), respectively, and seven are considered to be near threatened (Red Kite, Corncrake, Woodlark, Barn Swallow, House Martin, Meadow Pipit, Linnet). The percentage of farmland species (selection of this report) in the red list is 45%, or 80% if the category near threatened is included. The percentages for all species breeding in Germany are 28% and 36%, respectively (Südbeck et al. 2007).

Three species in the selection are listed as "near-threatened" according to the global red list (IUCN 2010): Corncrake, Red Kite and Black-tailed Godwit.

In conclusion, taking the red list status into account, most of those species suffering from the strongest declines can be considered to be the most threatened farmland bird species in Germany: Grey Partridge, Lapwing, Black-tailed Godwit and Skylark. A special emphasis has to be put on the Red Kite because of Germany's responsibility for the global population of which more than half is breeding in Germany (BirdLife International 2004).

With respect to the definition mentioned above the following seven species can be regarded to have a favourable conservation status at the European level: Barnacle Goose, Bean Goose, White-fronted Goose, Greylag Goose, Montagu's Harrier, Golden Plover and Barn Swallow. Accordingly the remaining 20 species have an unfavourable conservation status at the European level because they are on the European Red list (SPECs in Tab. 3.1.1) and/or their populations are declining.

When the definition of favourable conservation status at the site level (see above) is applied and Germany is regarded as one single site, all species whose populations are equal to or above the favourable reference value can be considered to have a favourable conservation status. If the year in which the EU Birds Directive came into force in all German federal states (1991) is taken as a reference, the following species meet the criteria for favourable conservation status:

all geese species, Common Quail, Montagu's Harrier, Common Crane, Little Owl, Red-backed Shrike, Woodlark, Yellow Wagtail, Yellowhammer, Corn Bunting and Ortolan Bunting. There are data suggesting that populations of the following species were depleted before the reference year (see Annex I): Common Quail, Common Crane, Little Owl, Red-backed Shrike, Yellowhammer, Corn Bunting, Ortolan Bunting. When these species are not considered only seven species have a favourable conservation status at the national level: the four geese species, Montagu's Harrier, Woodlark and Yellow Wagtail. Only five species meet the criteria for a favourable conservation status both at the European and at the national level: Barnacle Goose, Bean Goose, White-fronted Goose, Greylag Goose and Montagu's Harrier.

3.1.2 Population trend and conservation status of mammals

Tab. 3.1.2 compiles the information published in the red rist Germany (Meinig et al. 2009) with additional information on the species` European and global status (IUCN data). The short term population trend refers to the last 10-15 years, the long term population trend to the last 150 years (Meinig et al. 2009). Especially the estimation of the long term trend is difficult for many species since early data are often not available at least not on a comprehensive scale, e.g. for the bat species. In general, information on population trends is missing for many small mammal species that are not huntable or classified as pest species (Meinig et al. 2009). Even for pest species, like the Common Vole, data availability on current population densities are poor since the development of high densities has become rare due to modern agricultural management techniques and intensive monitoring of these events therefore decreased (Meinig et al. 2009).

Population trends of hunted species (here Brown Hare, Stoat, Least Weasel, Fallow Deer and Wild Boar) can be analyzed by considering hunting bags. For details on hunting statistics for the single species as well as on information of the red list categories of the all species in the single federal states see the species portraits in Annex I.

Tab. 3.1.2: Population trends and conservation status of selected farmland mammals. Explanations: Category in the German red list: 1: Critically Endangered, 2: Endangered, 3: Vulnerable, V: Near Threatened, G: Endangered to an unknown extent, D: Data deficient. Sources: Meinig et al. (2009), Temple & Terry (2007), IUCN (2012).

Species	Long term trend in Germany	Short term trend in Germany	Current status	Category German Red List	Category European Red List	Category Global Red List
European Hamster	very strong decline	very strong decline	very rare	1	–	–
Field Vole	moderate decline	stable	common	–	–	–
Common Vole	strong decline	moderate decline, unknown extent	very common	–	–	–
Striped field Mouse	insufficient data	stable	common	–	–	–
Yellow-necked Mouse	decline, unknown extent	stable	common	–	–	–
Wood Mouse	stable	stable	very common	–	–	–
Harvest Mouse	decline, unknown extent	stable	moderately common	G	–	–
Bicoloured Shrew	moderate decline	insufficient data	moderately common	V	–	–
Greater white-toothed Shrew	moderate decline	insufficient data	common	–	–	–
Lesser white-toothed Shrew	insufficient data	insufficient data	rare	D	–	–
Common Shrew	insufficient data	stable	very common	–	–	–
Pygmy Shrew	insufficient data	stable	common	–	–	–
European Hedgehog	clear increase	stable	common	–	–	–
European Mole	moderate decline	moderate decline, unknown extent	common	–	–	–
Brown Hare	strong decline	insufficient data	moderately common	3	–	–
Greater mouse-eared Bat	strong decline	clear increase	moderately common	V	–	–
Natterer's Bat	moderate decline	clear increase	moderately common	–	–	–
Common Noctule	moderate decline	stable	moderately common	V	–	–
Stoat	decline, unknown extent	insufficient data	unknown	D	–	–
Least Weasel	decline, unknown extent	stable	unknown	D	–	–
Fallow Deer	clear increase	stable	moderately common	–	–	–
Wild Boar	clear increase	clear increase	very common	–	–	–

Most farmland mammal species are currently described as being common in Germany except the European Hamster (very rare) and the Lesser white-toothed Shrew (rare). Especially rodent species, other than the Hamster, still seem to be abundant.

The European Hamster is the only species listed as critically endangered and the Brown Hare the only species categorized as vulnerable. Three species are listed as near threatened (Bicoloured Shrew, Greater mouse-eared Bat and Common Noctule), one species is considered to be endangered to an unknown extent (Harvest Mouse). For three species a categorization was not possible because of insufficient data (Lesser white-toothed Shrew, Stoat and Least Weasel). Thirteen of the 22 species are listed under least concern. At the European and global level none of the species is listed as being endangered of any degree.

Only three species show declining short term population trends (European Hamster, Common Vole and European Mole) but data are missing for many species, especially shrews. Most species seem to have stable population numbers over the last 10 – 15 years. However, considering long term data 14 of the 22 species show a declining population trend and populations are increasing in only three species (European Hedgehog, Fallow Deer and Wild Boar). Among rodents and shrews the Wood Mouse is the only species with a stable population, while again information regarding the population development is missing for some shrew species.

Germany has a special responsibility for the populations of the Greater Mouse-eared Bat, the isolated west-Rhine population of the European Hamster and possibly for the Common Noctule and its populations in Schleswig-Holstein but here the data are insufficient (Meinig et al. 2009).

3.1.3 Conservation targets

Summary of conservation status of farmland birds and mammals in Germany

From the evidence presented in chapter 3.1.1 it is obvious that most populations of farmland birds breeding in Germany are depleted due to past population declines and/or are presently declining. Only seven out of the 27 bird species selected for this report show a favorable conservation status at the European level when the definition of BirdLife International (2004) is applied. When the definition of BirdLife International (2004) for sites is applied for Germany (Germany regarded as one single site), again only seven species can be regarded to have a favourable conservation status. Only five species meet the criteria at both European and site/national level (see chapter 3.1.1).

Unfavourable conservation status often means declining population sizes. Low population sizes are undesirable for several reasons:

- Increased risk of extinction due to stochastic processes and catastrophes.
- Increased risk of genomic impoverishment resulting in higher long term extinction risk.
- Possible occurrence of an Allee-effect (Allee et al. 1949): Individuals are too dispersed to form an intact population.
- Ecosystem services are not fulfilled anymore.

For some of these reasons, a population may fall below the threshold for a minimum viable population size or minimum viable population density when becoming very small. This means an exposure to a high risk of extinction locally and globally. Minimum viable population size is the smallest possible size at which a biological population can exist without facing extinction from natural disasters or demographic, environmental, or genetic stochasticity (Holsinger 2011). There are very little data on minimal densities of viable populations of farmland birds and mammals. Jenny et al. (2005) state that Grey Partridge populations in Switzerland require a minimum local population size of 50 pairs on a local scale scattered on up to five sub-population each not being more than 2 to 3 km apart. For other species we were not able to find similar data. For other bird species except very rare ones like the Great Bustard (Otis tarda) it is unlikely that such minimum densities are already reached. For vertebrates minimum viable population sizes usually comprise a few thousands of individuals (Traill et al. 2007). The generally high mobility of birds and high dispersal rates probably prevent the occurrence of Allee-effects in many cases. Some species, notably Lapwings and Black-tailed Godwits form semi-colonies where several individuals often successfully engage in communal defense against nest predators (Green et al. 1990, Salek & ` milauer 2002). The establishment of semi-colonies requires obviously minimum densities. Among the species treated in this report, apart from the Grey Partridge, the Little Owl is another candidate for detecting minimum densities for viable populations because Little Owls are relatively sedentary and have low dispersal rates (Abadi et al. 2010).

Mammals in general have lower dispersal abilities than birds and often do not migrate. Therefore the existence of minimum densities is much more obvious. However, the absence of data on especially small mammal population numbers and densities makes a thorough determination of minimum densities impossible. No information was found on this topic for any of the species that are relevant here. In the following we therefore concentrate on bird species only.

Legal requirements

The European nature conservation directives set a framework for the protection of bird and mammal species. The relevant passages of the directives are:

Directive 2009/147/EC of the European Parliament and of the Council of 30 November 2009 on the conservation of wild birds (formerly Council Directive 79/409/EEC of 2 April 1979 on the conservation of wild birds):

Article 2

Member States shall take the requisite measures to maintain the population of the species referred to in Article 1 (all species of wild birds occurring naturally in the European territory of the Member states) *at a level which corresponds in particular to ecological, scientific and cultural requirements, while taking account of economic and recreational requirements, or to adapt the population of these species to that level.*

Article 4

1. The species mentioned in Annex I shall be the subject of special conservation measures concerning their habitat in order to ensure their survival and reproduction in their area of distribution.

In this connection, account shall be taken of:

(a) species in danger of extinction;

(b) species vulnerable to specific changes in their habitat;

(c) species considered rare because of small populations or restricted local distribution;

(d) other species requiring particular attention for reasons of the specific nature of their habitat.

Trends and variations in population levels shall be taken into account as a background for evaluations.

Member States shall classify in particular the most suitable territories in number and size as special protection areas for the conservation of these species in the geographical sea and land area where this Directive applies.

Council Directive 92/43/EEC of 21 May 1992 on the conservation of natural habitats and of wild fauna and flora:

Article 1

(i) conservation status of a species means the sum of the influences acting on the species concerned that may affect the long-term distribution and abundance of its populations within the territory referred to in Article 2; The conservation status will be taken as 'favourable' when:

- *population dynamics data on the species concerned indicate that it is maintaining itself on a long-term basis as a viable component of its natural habitats, and*
- *the natural range of the species is neither being reduced nor is likely to be reduced for the foreseeable future, and*

— *there is, and will probably continue to be, a sufficiently large habitat to maintain its populations on a long-term basis.*

Setting the targets

The most obvious conservation target is to turn all species into a favourable conservation status at both European and site/national level. Turning populations into a favourable conservation status means to reverse the declines and to bring the population above a certain threshold (see chapter 3.1.1 and BirdLife International 2004 and 2006). For farmland birds breeding in Germany no numerical thresholds exist that define when a favourable conservation status is reached. Obviously, thresholds have to be above minimum sizes of viable populations or, translated to a site scale, above minimum viable population densities.

In absence of evident thresholds and of relevant data at the national scale we suggest to follow the settings of conservation targets which were developed for the German index of sustainability. The index is composed by population indices of 50 bird species breeding in Germany, among them ten farmland bird species as well as Barn Swallow and House Martin, the latter species representing urban birds. The index compares the actual population as derived from monitoring data and a population target. The target was guided by a reconstruction of the populations in the early 1970s and by an extrapolation of possible population levels in 2015, under the conditions that all legal instruments for bird protection and all guidelines for sustainable development are completely implemented. The actual values were derived by expert judgment with help of a so-called Delphi-procedure (Stickroth et al. 2003).

The outcome of the Delphi-procedure is shown in table 3.1.3. On average the population target was set 63% above the population at the time of assessment (2001). The values derived by the above-mentioned procedure are widely accepted by conservation authorities and politicians. Therefore, we do not see a reason for developing own conservation targets. For those species not covered by the Delphi-procedure we suggest to use the same basal year as for the other species and to add the average of 63% to these values (see 3.1.3).

In contrast to many farmland birds breeding in Germany, Geese, Common Cranes and Golden Plovers seem to have a favorable conservation status. The Bewick's Swan is an exception. In the Bewick's Swan species action plan (Nagy et al. 2012) a conservation target of ca. 23,000 individuals (population around 2000) is set for the European-West Asian flyway population of this species. Other single species action plans for farmland birds lack such settings.

Tab. 3.1.3: Population targets of farmland birds. Targets developed for the German index of sustainability are shaded red (Stickroth et al. 2003). Population sizes are taken from Südbeck et al. (2007). The target population sizes for 2015 were estimated by applying the targeted population increase on the mean population size in Südbeck et al. (2007).

	Population size in Germany (pairs)	Target for 2015 (% of population in 2001)	Target for 2015 (rough estimate of population sizes)
Red Kite	10,000 - 14,000	130	16,000
Lapwing	68,000 - 83,000	230	180,000
Black-tailed Godwit	4700	130	6,100
Little Owl	8200 - 8400	117	9,700
Red-backed Shrike	120,000 - 150,000	170	230,000
Woodlark	44,000 - 60,000	200	100,000
Skylark	2,100,000 - 3,200,000	180	480,000
Barn Swallow	1,000,000 - 1,400,000	180	2200,000
House Martin	830,000 - 1,200,000	150	1500,000
Winchat	45,000 - 68,000	200	110,000
Corn Bunting	21,000 - 31,000	150	39,000
Yellowhammer	1,200,000 - 2,000,000	120	190,000
Bewick's Swan	European - West Asian flyway population		23,000
Barnacle Goose	192 - 193		not set
Barnacle Goose			not set
Bean Goose			not set
White-fronted Goose			not set
Greylag Goose	17,000 - 20,000		not set
Greylag Goose			not set
Common Quail	18,000 - 38,000	163	46,000
Grey Partridge	86,000 - 93,000	163	160,000
Montagu's Harrier	410 - 470	163	717,200
Common Crane	5,200 - 5,400	163	86,000
Corncrake	1,300 – 1,900	163	26,000
Golden Plover	<8	163	not set
Meadow Pipit	96000 - 130000	163	180,000
Yellow Wagtail	120,000 - 150,000	163	220,000
Linnet	440,000 - 580,000	163	830,000
Ortolan Bunting	10,000 - 14,000	163	20,000

Population sizes and trends at the national scale are influenced by population dynamics at a local scale. Population targets at a local scale can be developed by employing the BirdLife International (2006) approach (see chapter 3.1.1). This approach requires knowledge about local population size or density from the year the EU Birds Directive has been implemented.

Article 1(i) of the EU Habitats Directive (see above) offers another option of defining favourable conservation status at a local scale. Article 1(i) requires that the natural range of the species is neither being reduced nor is likely to be reduced for the foreseeable future. This can be translated into a requirement to safeguard not only the national population but also local populations.

A prerequisite to ensure the survival of a local population can be to ascertain a minimum density for long-term survival. As mentioned above there is very little data on minimal densities of viable populations of farmland birds and mammals at the local scale except the estimate by Jenny et al. (2005) for Grey Partridges in Switzerland.

Estimates should be based on analyses of minimal viable population size. Given the generally poor knowledge of relevant population parameters these estimates should be backed up by empirical data. Such empirical data could be gathered by following locally isolated populations for long time periods and by trying to extract the effects of population density on the fates of local populations. As all farmland birds and mammals are capable to disperse, re-colonization of patches by immigration has to be taken into account. A temporary loss of a small population could be acceptable as long as the probability of re-colonization is high enough. A realistic estimate of a minimum density, therefore, has to include a meta-population analysis (Hanski & Simberloff 1996).

3.2 Habitat selection and crop-specific occurrence of farmland species

3.2.1 Habitat selection and crop-specific occurrence of farmland bird species

Many farmland bird species are known to be able to breed and to forage in several different crops. Despite much research into habitat selection of farmland birds (e.g. Wilson et al. 1996, Bradbury et al. 2000) there is not yet any published and freely available comprehensive overview of crop selection of farmland birds or mammals according to our knowledge. Here we aim to compile literature data and expert judgement in order to present the significance of different crops for farmland species in Germany.

Methods

We examined approximately 1,400 sources and extracted data out of approximately 350 literature sources, reports and unpublished own material (Annex I). The methods as well as the quantity and quality of data differed between studies and, hence, between species. Differences in methods included differences in the size of study sites, in counting methods, in lengths of study periods and in the definition of crop categories. In order to make sure, that each study was represented not more than once in the data set, we checked for double publications of the same data, and we took arithmetic means of parameters when studies lasted for more than one year. We either omitted studies or we aggregated crop categories when the presentation of the results in single studies did not follow our scheme of crop categories.

The data which we selected were either densities of pairs or individuals, or measurements of time spend on different crops, or preference indexes for different crops. If possible we also investigated changes of these parameters within or between seasons. As our aim was the presentation of a rough but comprehensive overview of crop use in different species, we did not try to correct for the size of the study site in general. However, for seven species (Common Quail, Lapwing, Skylark, Meadow Pipit, Yellow Wagtail, Whinchat, Corn Bunting) we could gather sufficient data to use statistical models. We used mixed-effect models with “crop” and “size of study plot” as fixed variables and “name of study” site as a random variable. In any of the models “size of study plot” had a significant effect (see Annex I for details of the statistical treatments). We also did not consider possible variation of results due to different counting methods, but we evaluated only studies which followed certain research standards. These are:

- At least three counting visits per season.
- Minimum size of study site 5 ha.

In order to get an overview of the preferences of single species for crops we tried to calculate crop specific densities. These were the arithmetic means of densities reported in different studies. The results of these exercises are presented in detail in the species portraits (Annex I). For many crop-species combinations data were not available or too sparse to be representative. This was particularly often the case in rare crops like vegetables, sunflowers or hops. In such cases we took data from culture alike or, expert opinion or, if the best available option, our personal expert judgement. In general we distinguished densities of foraging individuals and densities of nests, because nest sites and foraging habitats may be different (e.g. House Martin). In some species (e.g. Common Quail), however, data did not allow a differentiation between nest and foraging densities. We also distinguished between the breeding and the non-breeding season. Some species are present in Germany only in either the breeding or the non-breeding season. Therefore the set of species differs between tables.

Although being preferred by a species, a crop may be insignificant for this species on a national scale if the crop is rare. In order to estimate the significance of a crop for farmland bird species at the national German level, we multiplied the mean crop-specific densities (see above) with the area covered by this crop in Germany (Tab. 3.2.1). For species breeding in semi-natural or natural habitats we took these into account as well. We then calculated the percentage of the population nesting or foraging in these crops or habitats. The detailed results are again given in the species portraits (Annex I). The tables 3.2.2 to 3.2.4 summarize the results. Some of the results, especially for the rare cultures, are based on few data or on expert judgement alone. The significance of crops, therefore, is given in categories rather than in concrete estimates.

Tab. 3.2.1: Coverage of open habitats in Germany in 2010 (Statistisches Bundesamt 2012).

Crop	x100ha	% of total open habitats	% of total cropland	% of total arable	% of total surface of Germany
Winter cereals	56181	33,3	33,6	49,0	15,7
Summer cereals	5753	3,4	3,4	5,0	1,6
Maize	22955	13,6	13,7	20,0	6,4
Oilseed rape	14773	8,8	8,8	12,9	4,1
Beets	3699	2,2	2,2	3,2	1,0
Legumes (Alfalfa)	3467	2,1	2,1	3,0	1,0
Potatoes	2544	1,5	1,5	2,2	0,7
Vegetables	1309	0,8	0,8	1,1	0,4
Sunflower	250	0,1	0,1	0,2	0,1
Other Crops	1141	0,7	0,7	1,0	0,3
Set aside	2524	1,5	1,5	2,2	0,7
Total arable	114596	67,9	68,6	100,0	32,1
Grassland	50416	29,9	30,2		14,1
Vineyards	970	0,6	0,6		0,3
Fruit crops, gardens	692	0,4	0,4		0,2
Tree nurseries	364	0,2	0,2		0,1
Total cropland	167038	99,0	100,0		46,8
Moorland	929	0,6			0,3
Heathland	649	0,4			0,2
Saltmarsh	184	0,1			0,1
Total open habitats	168800	100,0			47,3

In Germany, 99% of open habitats are farmed (Tab. 3.2.1). Natural or semi-natural habitats cover just one percent of the open landscape in Germany. Except for some specialists like the Golden Plover which nests in peat bogs or coastal birds like Oystercatcher (*Haematopus ostralegus*) and Redshank (*Tringa totanus*) which nest on salt marshes the majority of open habitat species nests and forages on farmland.

Within the farmed area four crop types dominate. Autumn-sown cereals, grassland, maize and oilseed rape together cover more than 86% of the farmland in Germany. Although there are obvious regional differences in the occurrence of crops (e.g. vineyards and hops being typical for southern Germany), the general pattern of preponderance on arable land of autumn-sown cereals and rape and the spring-sown maize is visible in all parts of the country.

Results

In six out of seven tested species (Common Quail, Lapwing, Skylark, Meadow Pipit, Whinchat) the mixed-effect models revealed significant differences in densities between different crops. In Corn Buntings the effect of “crop” was marginal (p=0.05) and in Yellow Wagtails we could not detect significant differences between crops (see Annex I for details of statistical analyses). Taking these results and the tendencies for those species into account, that could not be statistically tested due to lack of data, the following picture emerges: During the breeding season, there are three crops which were clearly preferred by more farmland bird species than others: grassland, set-aside and, to a smaller extent, legumes (Tab. 3.2.2). The preference for grassland can partly be accounted for the presence of some grassland specialists among the selected species such as Corncrake, Black-tailed Godwit and Meadow Pipit. Many other species which are generally more associated with arable land such as the Linnet prefer to forage in grassland. Like grassland, set-aside is a habitat many species prefer to forage in. Eleven out of 20 species preferred both habitats for foraging. Possibly set-aside and grassland are quite similar with respect to vegetation structure and other features. One of them is that both habitats are the only ones which are not sprayed and often offer more food than farmed arable fields (Brickle et al. 2000). All other cultures on conventional farms regularly receive pesticides.

Besides grassland and set-aside, legumes are the preferred foraging habitats of some species. In most cases this is due to alfalfa cultures which are attractive because they are perennial and because they are regularly mown. Mowing offers excellent foraging opportunities for Red Kites and Montagu’s Harriers. In being perennial and being regularly mown alfalfa resembles grasslands.

Among all other cultures oilseed rape is preferred by Grey Partridges and some other species. The preferences for beets, potatoes and spring-sown cereals are based on few data only.

The significance of different crop types for farmland bird species is not only influenced by the preference for the crop but also by the extent of area covered by the crop. In general the most common crops are also the most important for farmland birds. Although not being the first preference for any of the selected species, autumn-sown cereals are the most important crop for seven out of 20 of the selected species (Tab. 3.2.2). The single most important crop type is grassland which holds the biggest population share of 12 species. Grassland is the preferred habitat of many species and it still covers a relatively large part of the German farmland (30.2%). Oilseed rape has some significance for some species, in particular Linnets, which feed on rape seeds. Maize, in spite of its relatively high share within farmland (13.7%), is relatively unimportant for most species which means that the extension of maize areas has led to a loss of favorable habitats for most farmland bird species. Although representing only a tiny part of farmland in Germany (1.5%) set-aside land is the third most important habitat for four species and the second most important habitat for three species.

Regarding nest sites (Tab. 3.2.3) the patterns resemble those of foraging farmland birds during the breeding season: grassland and set-aside are the most preferred habitats for nest sites and, partly due to the large extent of the crops, most nests are build in grasslands and in fields of autumn-sown cereals. A notable difference to the habitat choice at foraging is the high number of species whose most important nesting habitat is set-aside and uncultivated stripes. The reason behind this pattern is the fact that many farmland bird species do not nest on the fields themselves but at uncultivated field margins, next to ditches or farmland tracks.

During the non-breeding season, grassland and set-aside remain habitats that are preferred by many farmland bird species. In addition, stubble fields and maize fields (in stubbles for most of autumn, winter and early spring) are selected for by many species (Tab. 3.2.4). Even autumn-sown cereals are very attractive for some species in autumn and winter. These species are Bewick's Swans, geese, Common Cranes, Golden Plovers and Lapwings. They either feed on the young leaves of the cereals or on soil-dwelling invertebrates which they can catch relatively easily in the still sparse vegetation. In contrast to the breeding season, the significance of different crop types for farmland birds during the non-breeding season reflects more the availability of crops than the species' preferences for certain crop types.

The patterns emerging from Tab. 3.2.2-7 and the data in the species portraits (Annex I) clearly show that, with the exception of grassland birds, there are no crop specialists in a strict sense. Most species breed and forage on a variety of different crops. The biggest part of the population usually occurs on the most common crops. Grassland birds like Black-tailed Godwits do hardly occur on any other habitat than grasslands and Lapwings, Little Owls, Whinchats and Meadow Pipits are strongly associated with grassland. Among the birds on passage this holds true for the Bewick's Swan.

More than half (11 of 20) of the species selected for this study changed their preferences for certain crops during spring and summer (Tab. 3.2.5). The swallows shifted between wetlands and crops in the beginning and in the end of the season. In the remaining nine species the shift occurred between crops like autumn-sown cereals, oilseed rape and maize, which were still short in the first half of the breeding season but grew tall later, and crops which were still short in the second half of the breeding season like beets, potatoes and set-aside. Obviously, farmland birds can change foraging or nesting habitats only if the preferred habitats are available within the home ranges (Red Kite, Montagu's Harrier) or within the territories (all other species) of the species under consideration. This implies a requirement of high crop diversity.

Some species do not only require relative short vegetation. Bare patches or very short swards are known to be essential for Red Kites, Lapwings, Golden Plovers, Little Owls, Skylarks, Meadow Pipits, Yellow Wagtails, Corn Buntings, Yellowhammers and Ortolan Buntings (see Annex I).

Some of the preferences mentioned in table 3.2.5 do not appear in table 3.2.2 because table 3.2.2 gives a rough overview of crop selection and does not refer to changes within the season.

3.2.2 Habitat selection and crop-specific occurrence of farmland mammal species

Tab. 3.2.6 gives an overview on the use of different crops by farmland mammals. Due to a lack of data a differentiation between the breeding and non-breeding season and foraging and nesting sites is not feasible for the mammal species. Furthermore, we only give estimates for the habitat selection based on either a species' preference or the frequency of its occurrence in a certain crop type. Complete and comparable information on habitat selection, like records on crop related densities, is not available for most of the species. For detailed information on the habitat selection see the species portraits in Annex I.

Tab. 3.2.2: Usage of crops for foraging by farmland birds in Germany during the breeding season. For details and sources see text and Annex I.

Feeding, breeding season	Percentage feeding on sprayed cultures	Autumn-sown cereals	Spring sown cereals	Maize	Oilseed rape	Legumes (Alfalfa)	Beets	Potatoes	Vege-tables	Sun-flowers	Set-aside, uncultiv. Stripes	Grass-land	Orchards	Vinyards	Hops	Most important other habitats
Common Quail	78	XX				X					XXX					
Grey Partridge	80				X	XX					XXX					Hedgerows, bushes
Montagu's Harrier	35		X			XX					XXX					Salt marshes
Red Kite	70					XXX					X	XX				Temporal food sources, rubbish dumps etc.
Corncrake	10	XX									X	XXX				Sedge moors
Lapwing	50			XXX							XX	X				
Black-tailed Godwit	5											XXX				Wetlands, salt marshes
Little Owl	20											XXX	XX			
Red-backed Shrike	50										XX	XXX				Peat bogs, heathland, forest clearings
Woodlark	30										XXX	XX				Forest edges, heathland
Skylark	59					XX					XXX	X				Dunes, salt marshes, moor- and heathland
Barn Swallow	8				XX	X						XXX				Wetlands, woodland edges, farm buildings
House Martin	8					X	XXX					XX				Wetlands, woodland edges
Winchat	31				X						XXX	XX				Moor- and heathland, forest clearings
Meadow Pipit	29						X				XX	XXX				Moor- and heathland, salt marshes
Yellow Wagtail	73	X	XXX		XX											Moorland, salt marshes
Linnet	60				X						XXX	XX				Hedgerows, bushes
Corn Bunting	75		XX?								XXX	X				
Yellowhammer	65					XXX					X	XX				Heath- and moorland, forest clearings
Ortolan Bunting	90					X	XXX	XX								Forest edges

Legend			
(red)	Habitat holding most individuals	XXX	Habitat most preferred
(orange)	Habitat holding second most individuals	XX	Habitat second most preferred
(yellow)	Habitat holding third most individuals	X	Habitat third most preferred
(grey)	also occurring		

Tab. 3.2.3: Usage of crops for nesting by farmland birds in Germany. Only ground-nesting species were taken into account. For details and sources see text and Annex I.

Nesting	Percentage nesting on sprayed crops	Autumn sown cereals	Spring sown cereals	Maize	Oilseed rape	Legumes (Alfalfa)	Beets	Potatoes	Vege-tables	Sun-flowers	Set-aside, uncultiv. Stripes	Grass-land	Orchards	Vinyards	Hops	Most important other habitats
Common Quail	78	XX				X					XXX					
Grey Partridge	80				XX	X					XXX					Hedgerows, bushes
Montagu's Harrier	90	XXX									XX	X				
Corncrake	10	XX									X	XXX				Sedge moors
Lapwing	50			XXX							XX	X				
Black-tailed Godwit	<1											XXX				Wetlands, salt marshes
Woodlark	30										XXX	XX				Forest edges, heathland
Skylark	80		X								XXX	XX				Dunes, salt marshes, moor- and heathland
Winchat	31				X						XXX	XX				Moor- and heathland, forest clearings
Meadow Pipit	<5		X								XX	XXX				Moor- and heathland, salt marshes
Yellow Wagtail	73	X									XXX	XX				Moorland, salt marshes
Corn Bunting	39										XXX	XX				
Yellowhammer	5										XXX					Hedgerows, bushes, moor- and heathland, forest clearings
Ortolan Bunting	95	XX	XXX			X										Forest edges

Legend:

- Habitat holding most nests (red)
- Habitat holding second most nests (orange)
- Habitat holding third most nests (yellow)
- nests also occurring (grey)

XXX	Habitat most preferred
XX	Habitat second most preferred
X	Habitat third most preferred

Tab. 3.2.4: Usage of crops for foraging by farmland birds in Germany during the non-breeding season. For details and sources see text and Annex I. Species spending most of the non-breeding season outside Germany are not listed.

Feeding, non-breeding season	Percentage feeding on sprayed crops	Autumn sown cereals	Spring sown cereals	Maize	Oilseed rape	Legumes (Alfalfa)	Beets	Potatoes	Stubbles	Set-aside, uncultiv. stripes	Grass-land	Orchards	Vinyards	Hops	Most important other habitats
Bewick's Swan	14	X			XX						XXX				Wetlands
Barnacle Goose	10	XX			X						XXX				Salt marshes, wetlands
Bean Goose	60	X		XXX							XX				Wetlands
White-fronted Goose	40			XX	X						XXX				Wetlands
Greylag Goose	59			XX	X						XXX				Wetlands
Grey Partridge	90			X					XXX	XX					Hedgerows, bushes
Red Kite	70					XXX				X	XX				Temporal food sources, rubbish dumps etc.
Common Crane	95	XX		XXX	X										Wetlands
Golden Plover	53	XXX		X							XX				Coastal habitats
Lapwing	70	XX		XXX							XX				Coastal habitats, wetlands
Little Owl	20										XXX	XX			
Skylark	90				X				XXX	XX					Salt marshes
Meadow Pipit	29				X					XX	XXX				Moor- and heathland, salt marshes
Linnet	60				X				XXX	XX					Hedgerows, bushes
Corn Bunting	75								XXX	XX	X				
Yellowhammer	90								XXX	XX	X				Heath- and moorland, forest clearings

Legend (cell colours):
- Red: Habitat holding most individuals
- Orange: Habitat holding second most individuals
- Yellow: Habitat holding third most individuals
- Grey: also occurring

- XXX: Habitat most preferred
- XX: Habitat second most preferred
- X: Habitat third most preferred

Grassland as well as set-aside and uncultivated stripes are the most selected habitat types for many small mammal species in agricultural landscapes. These habitats provide sufficient cover as well as food. Cereal crops also seem to be important as habitat and especially rodent species are often found here. In general most small mammal species prefer structural landscape elements like hedgerows, grassy field margins or woodland edges. Here the highest densities are recorded and many species use these structures as their main habitat from which they start foraging trips into the adjacent crops. Wood Mice for example used their habitats in proportion to the habitats' availability and spent most of their time in crops. However hedgerows were still highest ranked in preference but comprised only little of the landscape (Todd et al. 2000). The permanent provision of cover by those structural habitats is essential for small mammals while the use of crops is restricted to certain periods determined by the growing stages of the crop plants and management actions.

Tapper & Barnes (1986) found that during most of the summer Brown Hares avoided winter cereals. Winter as well as spring cereals were preferred only during their main tilling periods when the crops were short in length. Cover by cereal fields was only provided between mid-April and mid-July to mid-August when the plants were tall enough (Tapper & Barnes 1986).

During nights in May and June Hares were mainly located in sugar beet fields and field edges while beet crops were avoided during daytime, presumably due to the lack of cover (Rühe & Hohmann 2004). Instead hares stayed in tall and dense stands of cereal crops during the day. The situation changed in July and August when Hares also used beet fields during the day since then the crop provided both food and shelter (Rühe & Hohmann 2004).

Todd et al. (2000) studied the habitat selection of Wood Mice and found that seasonal patterns in habitat use seemed to be largely a response to seasonal disturbance by agricultural operations (harvesting, ploughing and sowing) and the availability of food and cover in the fields (Todd et al. 2000). Tattersall et al. (2001) radio-tracked Wood Mice in order to compare their use of set-aside, crops and hedgerows before and after harvest. Before harvest Wood Mice had larger home ranges and were more mobile. They used habitats within their ranges at random and the ranges contained a high proportion of cropped areas. After the harvest home range sizes and the proportion of crops within their ranges decreased. Wood Mice preferred hedgerows and uncut set-aside and avoided cut set-aside during this period probably due to increased predation risk and low food availability (Tattersall et al. 2001). Voles move into wheat and barley fields when the crops are ripening and are harvested and stay there until the time of ploughing (Heroldova et al. 2007).

Vegetation cover is highly important for Hamsters to avoid the risk of predation. Best cover in May (spring), and hence a reduced predation risk, is found in winter wheat, triticale and alfalfa, whereas in late summer maize and sugar beet offer better protection (Kayser et al. 2003b). Crops with year-round cover like clover and alfalfa are preferred habitats by the Hamster as well as hedges and field margins, but also cereals and beet root crops are inhabited during the harvest (Niethammer 1982). Gall (2008) states that preferred crops and habitats of the Hamster are winter cereals (and rape and marginal structures) in spring, cereal crops during summer with refuge habitats in marginal structures and forage crops, and cereals, beet root and to a minor extent maize in late summer.

During winter most species move more into marginal structures, mainly hedgerows, woodland or also in set-aside that provide sufficient cover and food supply. Winter cereals are another option.

For example does the Striped field Mouse not permanently depend on forest habitats and is mainly found inside crops during the growing period of crops from spring to autumn (Kozakiewicz et al. 1999). After the harvest in autumn the species moves into the forests for overwintering.

Tab. 3.2.5: Shifts of habitat preferences within the breeding season of 20 selected farmland species. Habitats preferred only in the first half of the breeding season are marked in red, habitats preferred only in the second half of the breeding season are marked in green. Sources: Detailed species portraits and references therein.

	Habitat preference in the first half of the breeding season	Habitat preference in the second half of the breeding season	Percentage of population shifting habitats	Remarks
Common Quail	Set-aside, legumes, oilseed rape	Set-aside, legumes, oilseed rape	<10%	
Grey Partridge	Oilseed rape, legumes, set-aside	Oilseed rape, legumes, set-aside	<10%	
Montagu's Harrier	Set-aside, legumes, spring-sown cereals	Set-aside, legumes, spring-sown cereals	<10%	
Red Kite	Alfalfa, grassland, spring-sown cereals, maize	Alfalfa, grassland, borderlines, harvested fields	>50%	
Corncrake	Grassland, autumn-sown cereals	Grassland, autumn-sown cereals, set-aside, alfalfa	10% - 50%	
Lapwing	Non-intensive grassland, intensive grassland, autumn-sown cereals, oilseed	Non-intensive grassland, set-aside, maize	10% - 50%	Chicks move from arable to grassland
Black-tailed Godwit	Grassland	Grassland	<10%	
Little Owl	Grassland, orchards	Grassland, orchards	<10%	
Red-backed Shrike	Grassland, set-aside	Grassland, set-aside	<10%	
Woodlark	Set aside, grassland, maize	Set aside, grassland	10% - 50%	
Skylark	Set-aside, legumes, grassland, autumn-sown cereals, oilseed rape	Set-aside, legumes, grassland, spring-sown cereals, oilseed rape, beets, sunflowers	>50%	
Barn Swallow	Wetlands preferred before breeding	Wetlands preferred late in the season	>50%	
House Martin	Wetlands preferred before breeding	Wetlands preferred late in the season	>50%	
Winchat	Set-aside, grassland, oilseed rape	Set-aside, grassland, oilseed rape	<10%	
Meadow Pipit	Grassland, set-aside, beets	Grassland, set-aside, beets	<10%	
Yellow Wagtail	Autumn-sown cereals, oilseed rape	beets, potatoes	10% - 50%	
Linnet	Set-aside, grassland, oilseed rape	Set-aside, grassland, oilseed rape	<10%	
Corn Bunting	Set-aside, grassland, cereals	Set-aside, grassland, potatoes	10% - 50%	
Yellowhammer	autumn-sown cereals, maize	spring-sown cereals, beets, grassland	10% - 50%	
Ortolan Bunting	Hedgerows, forest edges	beets	10% - 50%	

Ouin et al. (2000) studied phenological abundance and habitat preference of Wood Mice (*Apodemus sylvaticus*) applying life-trapping in an arable landscape in France. The Abundance of Wood Mice peaked in crops in May while the rate of captures in hedges decreased. Activity appeared to be more centered on hedgerows in autumn (Shore et al. 1997, Ouin et al. 2000). During winter home ranges of Wood Mice contained significantly more hedgerows than barley and wheat as well as significantly more rape than wheat (Todd et al. 2000). Hedgerows were the main over-wintering habitat but were also used in summer since they are a good source of invertebrate prey and provide shelter. During spring, when crops provided sufficient

Tab. 3.2.6: Use of crops by farmland mammals. For details and sources see text and Annex I. The category "vegetables" was omitted due to lack of data.

Species	Percentage feeding on sprayed crops	Autumn sown cereals	Spring sown cereals	Maize	Oilseed rape	Legumes	Beets	Potatoes	Alfalfa	All arable fields	Set-aside, uncultiv. Stripes	Grass-land	Orchards	Vinyards	Hops	Most important other habitats
European Hamster	90															hedges, field margins
Field Vole	50															wet meadows, river banks, field margins
Common Vole	50															field margins, ditches
Striped field Mouse	50												?			hedges, woodland, marshes
Yellow-necked Mouse	30							?					?			forests, hedges
Wood Mouse	60															woodland, hedges, road/ditch margins
Harvest Mouse	30															reed beds, hedges, ditch edges, woodland
Bicoloured Shrew	40															woodland, drywalls, hedges, poor grassland
Greater white-toothed Shrew	40															hedges, gardens,
Lesser white-toothed Shrew	40															hedges, gardens, woodland
Common Shrew	40															wetlands, forests, hedges, grassy margins
Pygmy Shrew	30	?	?													reed, swamps, dunes, mature woodland
European Hedgehog	20															open forests, field margins, headlands
European Mole	20															gardens, woodland, field margins, hedges
Brown Hare	60															woodland, hedges
Greater mouse-eared Bat	40															open forests, forest edges
Natterer's Bat	40															open forests, parkland, water bodies
Common Noctule	40															open forests, parkland, water bodies
Stoat	40															hedges, woodland
Least Weasel	40															hedges, woodland
Fallow Deer	30															mature forests, woodland
Wild Boar	40															forests, woodland

Habitat most preferred/selected
Habitat second most preferred
Habitat third most preferred
also occurring

cover, more Wood Mice were caught in arable crops than in woodlands. After the harvest Wood Mice moved into woodlands (Fitzgibbon 1997).

As for the bird species for mammals no clear specialization for a particular crop type is detectable. The provision of food and sufficient cover are the main components determining habitat selection. Further, the availability of a habitat plays a crucial role. Detailed studies are needed that give insight in the phenological, crop-specific occurrence of small mammals in German agricultural landscapes.

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4 Effects of pesticides on farmland species

4.1 Review: Direct and indirect effects of pesticides on farmland bird and mammal species and the impact on their populations

4.1.1 Introduction

Several studies assumed that the use of pesticides has a high impact on biodiversity in agricultural landscapes (Günther et al. 2005, Geiger et al. 2010). In order to assess the impact of pesticide applications on bird and mammal species inhabiting arable land in more detail we reviewed the available literature to gain insight into the underlying mechanisms and to provide an overview on the current knowledge on this issue.

In their analysis of risks for wildlife species in German landscapes Günther et al. (2005) define the application of pesticides to have a high-ranking negative impact on animals that live in open landscapes. While in earlier times, during the 1960s, 70s and 80s, the focus of investigations was on severe damage caused by direct effects of pesticides on wildlife species, this focus shifted in the more recent time to indirect effects striking populations (Bright et al. 2008, DEFRA 2005). Today there is little evidence of significant population effects arising from direct effects of pesticides on farmland birds (Boatman et al. 2004). However, several studies confirm the adverse impact of indirect effects on bird species on the population level (e.g. Brickle et al. 2000; Boatman et al. 2004; Morris et al. 2005), drawing the attention into a new direction. In our review, we consider both direct and indirect effects to provide a detailed picture on the current situation of farmland bird and mammal species in relation to the impact of pesticide applications.

A number of different mechanisms have to be considered when assessing the impact of pesticides on farmland species. Direct effects describe toxic forces of pesticides that have either lethal or sub-lethal effects on animals, the latter affecting the behaviour or physiology of an individual (Burn 2000). Indirect effects, on the other hand, act through changes in key requirements of a wildlife population induced by pesticide applications, such as food availability and habitat quality (Burn 2000). They may affect demographic rates of a species by adversely altering productivity or survival. The conceptual model illustrates the mechanisms of such direct and indirect effects of pesticide applications and how they may affect farmland bird and mammal species (Fig. 4.1.1).

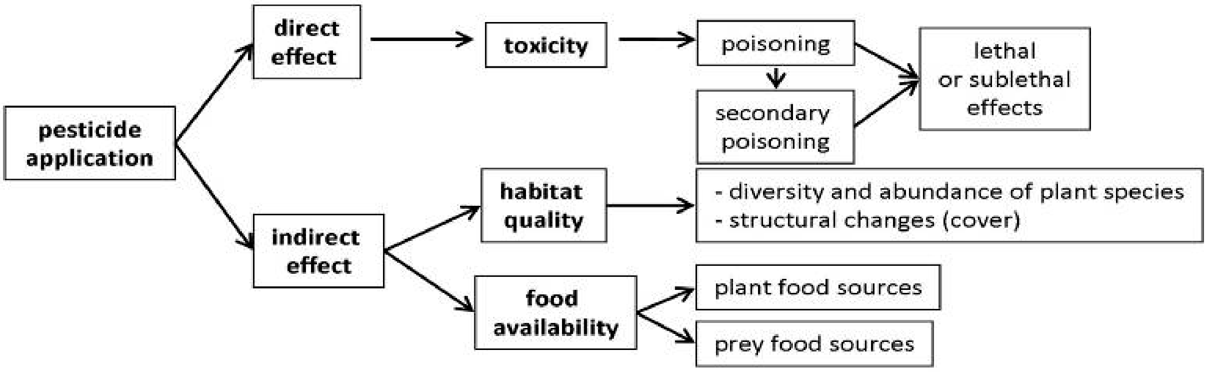

Fig. 4.1.1: Overview over general mechanisms of direct and indirect effects of pesticides on the requirements of bird and mammal species in agricultural landscapes.

We viewed a wide range of literature already available in the database of the Michael-Otto-Institute. In addition we searched scientific databases such as Web of Knowledge and Scopus for keywords such as 'pesticide', 'indirect effects', 'small mammal' or 'farmland bird'.

For bird species we were able to review an extensive number of publications, mainly on lowland bird species in the UK but also from other European countries. Here, comprehensive work in form of reviews is available from Campbell et al. (1997), Boatman et al. (2004) and Bright et al. (2008).

Tab. 4.1.1: Overview on the number of literature sources on direct and indirect effects of the different pesticide agents on bird and mammal species examined in this review.

		direct effects		indirect effects	
	pesticide	poisoning	secondary poisoning	food supply	habitat quality
birds	herbicide			1,2,3,4,5,6,38,39,40, 41,42,45,46,47	36,41
	insecticide	7,8,10,11,50	50,51	1,3,4,5,12,13,14,15, 42,43,44	
	rodenticide	8,55	50,54,55		
	fungicide			1,3,4,5	
	molluscicide				
mammals	herbicide	10,16		17,18,19,20,21,35, 45,46,48	18
	insecticide	9,10,22,23,24,25,2 6,37,49	27,49	28,29	
	rodenticide	8,10,30,31,52	32,53	30,32	
	fungicide	56,57			
	molluscicide	11,33,34			

Sources: (1) Boatman et al. 2004, (2) Bradbury et al. 2008, (3) Brickle et al. 2000, (4) Ewald & Aebischer 1999, (5) Rands 1985, (6) Rands 1986, (7) BBA 1998, (8) BVL 2009a, (9) BVL 2009b, (10) de Snoo et al. 1999, (11) Joermann & Gemmeke 1994, (12) Hart et al. 2006, (13) Morris et al. 2001, (14) Morris et al. 2005, (15) Poulin et al. 2011, (16) Edwards et al. 2000, (17) Fagerstone et al. 1977, (18) Johnson & Hansen 1969, (19) Spencer & Barrett 1980, (20) Tew et al. 1992, (21) Tietjen et al. 1967, (22) Clark et al. 1978, (23) Dell'Omo & Shore 1996, (24) Geluso et al. 1976, (25) Geluso et al. 1981, (26) Jones et al. 2009, (27) Dell'Omo et al. 1999, (28) Bellocq et al. 1991, (29) Wickramasinghe et al. 2004, (30) Brakes & Smith 2005, (31) Dowding et al. 2010, (32) McDonald et al. 1998, (33) Johnson et al. 1991, (34) Shore et al. 1997, (35) Hull 1971, (36) Dziewiaty & Bernardy 2007, (37) Kayser et al. 2001, (38) Potts

1997, (39) Potts 1971, (40) Marshall et al. 2001, (41) Campbell et al. 1997, (42) Bright et al. 2008, (43) Ewald et al. 2002, (44) Morris 2002, (45) Freemark & Boutin 1995, (46) de Snoo 1999, (47) Moreby & Southway 1999, (48) Hole et al. 2005, (49) Stahlschmidt & Brühl 2012, (50) Burn 2000, (51) Dietrich et al. 1995, (52) Gall 2008, (53) Townsend et al. 1984, (54) Knott et al. 2009, (55) Berny & Gaillet 2008, (56) Barber et al. 2003, (57) Brühl et al. 2011.

The majority of available studies on mammals focused on populations in the UK too. Generally, information on indirect effects of pesticides on mammal populations in agricultural landscapes is scarce. In order to gain a broader picture of effects on small mammal species we had to include studies from North America as well. Here, Freemark & Boutin (1995) reviewed the impact of herbicides on mammals but also on other wildlife in terrestrial habitat. Table 4.1.1 gives an overview on the available literature sources for bird and mammal species.

For both, mammal and bird species, studies on pesticide effects that focus on agricultural landscapes in Germany are very rare. In general, it is difficult to analyse especially indirect effects of pesticide applications on wildlife in arable landscapes because they are often studied and discussed within the wide scope of agricultural intensification which has a broad variety of negative impacts on the performance of farmland species. These effects may interact or add up to conditions adversely affecting wildlife species, making an evaluation of the single causes of a species' poor performance very difficult.

Nevertheless, in this review we try to point out specific direct and indirect impacts of pesticide usage as detailed as possible by reviewing the available literature for effects of the application of herbicides, insecticides, rodenticides, fungicides and molluscicides. In a second step we focus on those studies that found an impact on species on the population level.

4.1.2 Direct and indirect effects on farmland bird and mammal species

In the following we give an overview on direct and indirect effects of pesticide applications on birds and mammals in agricultural landscapes. We address the different pesticide agents and give examples for their possible and proven effects. For an overview on the different indirect effects on bird and mammal species see also the tables at the end of this chapter.

Herbicides

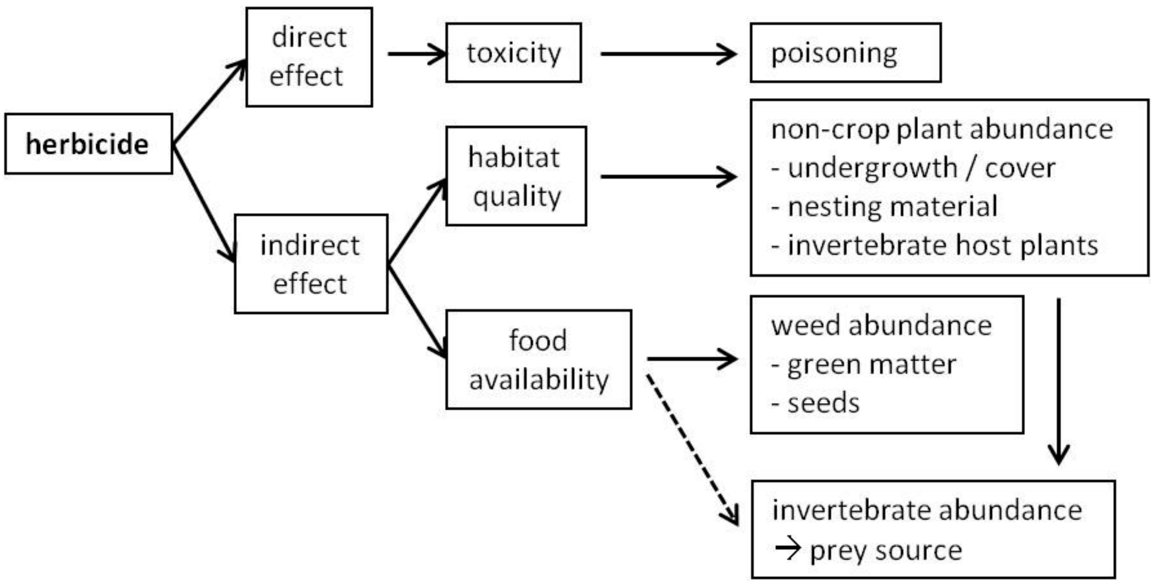

Fig. 4.1.2: Direct and indirect effects of herbicide applications.

For bird species, direct effects of herbicides are not considered to be important nowadays (Marshall et al. 2001). Herbicides may have adverse direct effects on herbivorous mammal species due to the consumption of toxic plant material. However, no confirming studies could be found. Therefore it is likely that for mammals a similar situation applies as for bird species.

Edwards et al. (2000) review reasons for the decline of Brown Hare populations in Europe. An analysis of wildlife incident data confirmed the exposure of Hares to herbicides in stubbles, grassland (in January), potatoes (in August) and dormant alfalfa crops. Though residues of the herbicide Paraquat were detected in tissues and stomach contents of Hares, it remained unsure whether this exposure was actually the cause of death of these animals. In the UK 2% and in France only 0.06% of Hare incidents were confirmed Paraquat incidents over a period of 23 and eleven years respectively (Edwards et al. 2000). A supplemental experimental study showed that Hares were likely to be deterred from consuming Paraquat sprayed vegetation and reduced foraging on affected stubbles (Edwards et al. 2000). The authors conclude that the non-selective herbicide Paraquat was not responsible for the decline of Hare populations in the UK and France.

A review on records on vertebrate wildlife incidents with pesticides in Europe registered few poisonings by approved herbicide application in the time from 1990-1994 in the UK (de Snoo et al. 1999). A Hedgehog was poisoned after spraying Paraquat in grassland and one Hare died after spraying in crop.

The majority of incidents with different pesticide types were recorded in France, the UK and The Netherlands and most of these incidents (53-66%) occurred due to deliberate abuse (de Snoo et al., 1999). The authors limit the significance of their results since the efficiency of monitoring is uncertain and very inconsistent between the different countries in Europe. The use of Paraquat is forbidden in the EU since 2007.

The arable intensification in general and the usage of herbicides in particular changes the flora of arable land (Stoate et al. 2001). Herbicide applications reduce the herbaceous layer of crops and adjacent areas and therewith the availability of food and shelter for many wildlife species living in arable crops. Induced changes in plant biomass (affecting cover from predation), food quantity (availability of food) and food quality (protein within the diet) have to be considered when analysing indirect effects of herbicide applications (Spencer & Barrett 1980). A further mechanism is the reduction of the abundance of weeds, functioning as host plants for invertebrates, which reduces the quantity of food sources for insectivorous vertebrate species (Campbell et al. 1997).

Densities of male Grey Partridges were negatively related to the number of herbicide applications per field and positively related to mean number of dicotyledonous weed species (Ewald & Aebischer 1999). Those broods of Grey Partridges which had access to unsprayed headlands of cereal crops used smaller home ranges than Partridge families in fields with fully sprayed headlands (Rands, 1986).

Densities of singing Corn Buntings were significantly lower in fields with high numbers of herbicide (and fungicide) applications per field (Ewald & Aebischer 1999). The occurrence of four of the seven weed taxa most important to Partridges, Skylarks and Corn Buntings was negatively related to spring and summer herbicide spraying and dicotyledon-specific herbicides (Ewald & Aebischer 1999).

Bradbury et al. (2008) showed that Cirl Buntings as well as Yellowhammers and Reed Buntings fed significantly more on special protected stubbles under a low-input herbicide regime where seed densities were higher than on conventional stubbles. The Linnet, an exclusively granivorous bird species, is likely to be affected by indirect effects of herbicide applications reducing weed seed abundances (Bright et al. 2008). However, detailed investigations on this relationship are missing.

Freemark & Boutin (1995) focused on herbicide effects on wildlife species in North America. In their review they documented regional population declines of bird species in temperate landscapes caused by changes in plant species abundance and composition. The change of habitat structures and species composition negatively influences not only herbivorous species that lose important food resources like weeds and herbs (Freemark & Boutin 1995). It also reduces the number or availability of invertebrate food sources by removing their host plants and therewith affects insectivorous species as well (Marshall et al. 2001). In several studies it has been shown that herbicides can reduce the availability of invertebrate food for birds (e.g. de Snoo 1999). Many arthropod groups, considered to be important in the diet of farmland birds, as well as floral cover and diversity were significantly reduced in winter wheat crops after autumn herbicide applications (Moreby & Southway 1999). Food availability in autumn, winter and spring may be important for survival and for building up body reserves to fuel migratory journeys.

Herbicide applications may also affect nesting behaviour of birds by destroying vegetation and preventing them from making nesting attempts or by changing the vegetation in a way that nests are more exposed and therewith become vulnerable to effects of weather and predation (Campbell et al., 1997). However, only a few bird species actually nest within crops like the Skylark and Corn Bunting. Some of these may actually profit by short and open crops after herbicide applications that make the habitat more attractive to them for nesting. Campbell et al. (1997) therefore doubt that the impact of herbicides on nesting habitat is of great importance for farmland bird species. On the other hand, Dziewiaty & Bernardy (2007) state that herbicide applications on maize fields destroy the cover for nest sites of ground breeding bird species and therewith increase the risk of predation.

Freemark & Boutin (1995) describe adverse impacts by herbicides on populations of small mammals in North American grasslands such as shifts in diet with subsequent decreased survival, lower reproductive success or increasing foraging dispersal.

Herbicides are likely to negatively affect small mammal species such as the Common Shrew, Wood Mouse and Badger by removing plant food resources and changing the microclimate (Hole et al., 2005). De Snoo (1999) found that leaving field edges unsprayed can have positive effects on the presence and diversity of plant species and therewith on small mammal abundance.

Brown Hares inhabiting agricultural landscapes need species rich field margins with herbal undergrowth since the diet offered by large crops is too one-sided due to the rapid decline of herbs on arable land that derives from the application of herbicides and fertilizer (Grzimek 1984).

A study on habitat selection of small mammals in relation to herbicide application investigated winter wheat fields under different agrochemical treatments in the UK (Tew et al. 1992). The authors tested the response of radio-tracked Wood Mice to reduced applications of herbicides on experimental plots with resulting increased floral and invertebrate abundances. Other pesticides (insecticides, fungicides), growth regulators and fertilisers were applied following the normal farm practice. The animals significantly preferred unsprayed and selectively sprayed areas (conservation headlands sprayed to control grasses but not broadleaved species) from those fully sprayed with herbicides (Tew et al. 1992). The authors conclude that Wood Mice selected these areas because of higher food availability.

An indirect effect of 2,4-D applications on the diet of Prairie Dogs (Cynomys ludovicianus) was found by Fagerstone et al. (1977). Due to a significant reduction of foliar cover by forbs and shrubs the diet of Prairie Dogs changed from 73% forbs and 5% grass before spraying to 9% forbs and 82% grass after the applications. Despite this drastic change in diet composition there was little evidence for negative effects on the animals which remained in good condition and showed no significant difference in activity compared to those animals studied in an area not treated with herbicides (Fagerstone et al. 1977).

Insecticides

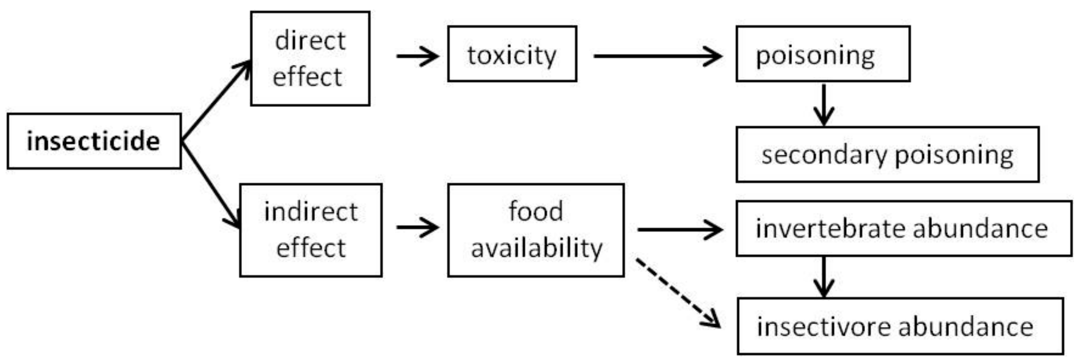

Fig. 4.1.3: Direct and indirect effects of insecticide applications.

Granivorous birds may be at risk from direct effects of insecticide seed treatments while secondary poisoning may occur in species than consume contaminated earthworms after granular insecticide application (Burn 2000). De Snoo et al. (1999) report a number of incidents of poisoned birds caused by spraying and seed treatments with insecticides in France, the UK and The Netherlands in the 1990s. In Germany, 60-70 birds have been killed due to the consumption of insecticide treated seeds in a winter rape field (BVL 2009a). In the 1990s several incidents were recorded related to misuse or deliberate abuse of insecticides where more than 100 birds died (BBA 1998). In one case about 140 birds were poisoned by the approved use of the insecticide Methomyl (Joermann & Gemmeke 1994).

In Switzerland, Dietrich et al. (1995) investigated the mortality of Buzzards on fodder and sugar beet crops treated with granular Carbofuran. They found that Buzzards have been secondarily poisoned with the insecticide-nematicide by eating contaminated earthworms. The same threat exists for Red and Black Kites (Dietrich et al. 1995).

Wood Mice exposed to the insecticide Dimethoate were observed by radio-tracking in a wheat field (Dell'Omo & Shore 1996). The exposed rodents reacted to the exposure by significantly decreased locomotor activity. This reaction lasted only about six hours and had no effect on medium-term survival, since after 24 hours the animals appeared to have recovered. However, the authors conclude that a longer period of application, which is likely to happen in the field under more realistic conditions, would negatively affect Wood Mice survival by altering their ability to find food and avoid predation (Dell'Omo & Shore 1996).

Another experimental study on the effects of Dimethoate applied on soil demonstrated a direct negative impact on earthworms and through secondary poisoning on Common Shrews feeding on these worms (Dell'Omo et al. 1999). The shrews' blood cholinesterase activity decreased significantly but it remained unsure whether this exposure was likely to occur in the field. If so, the secondary poisoning could negatively affect the insectivore's locomotor and behavioural activities (Dell'Omo et al. 1999).

Due to their preference for intensively used deep loess soils, European Hamsters come into direct contact with a wide range of applied pesticides (Kayser et al. 2001). However, Kayser et al. (2001) found residues of organochlorine insecticides only on a very low level and conclude that they can be classified as not dangerous for the Hamster.

Stahlschmidt & Brühl (2012) investigated the exposure of bats foraging in an apple orchard treated with insecticides. They recorded bat activity as well as pesticide residues on bat-specific food items after insecticide applications. Bat species showed high activity levels over orchards and foliage-dwelling arthropods had the highest initial residue values. The authors found no acute dietary risk for all recorded bat species. However, they conclude that due to certain life-history traits of bats, like their long life span and low reproductive rate, bats may be more sensitive to long-term effects of pesticides than other mammals (Stahlschmidt & Brühl 2012). Furthermore bats may experience higher risk of being exposed to pesticides by skin contact or inhalation since they are active during dusk when pesticides are commonly applied.

Several other studies confirm the toxic effects of insecticide application through secondary poisoning of bats consuming contaminated insects in the US and UK (see Jones et al. 2009). The bat species Tadarida brasiliensis was affected by heavy mortality after pesticide applications in New Mexico (Geluso et al. 1976) and young bats died by absorbing pesticides transferred to them by the milk (Geluso et al. 1981). Individuals of the bat species Myotis lucifugus were killed by DDT in a nursery colony in New Hampshire, USA. The authors suggest that adults of this species are twice as sensitive to the insecticide as are laboratory rats and mice (Clark et al. 1978).

A threat of insecticide application specific to bats is the usage of such agents in their roosts. Several lethal incidents of bats contaminated with Permethrin (UK) and Endosulfan (the Netherlands) were recorded from 1990-1994 (de Snoo et al. 1999). A Hedgehog was listed as poisoned by the insecticide Parathion in Germany in 2003 (BLV 2009b). Permethrin, Endosulfan as well as Parathion are banned in Germany today.

Ewald & Aebischer (1999) showed that numbers of invertebrate species, important as chick food for species such as Skylarks and Corn Buntings, have declined since the 1970s and that these declines correlate with increasing pesticide uses. Applications of insecticides in spring and summer appeared to have the most damaging impact on invertebrate groups in cereal fields.

Insecticide applications during the breeding season in cereal fields reduced the abundance and biomass of invertebrate food for Yellowhammer chicks (Morris 2002). Invertebrate numbers were significantly lower in these crops than in fields with no or winter-only applications of insecticides. Yellowhammers foraged in higher densities in crops without summer applications than in those where insecticides were sprayed. However, when grain was available later in the breeding season no significant effect of insecticide application on foraging patterns was detected (Morris et al. 2001).

Poulin et al. (2010) studied the effects of *Bacillus thuringiensis israelensis* (Bti) on the breeding success of House Martins in France. The intake of invertebrate species affected by the spraying of Bti decreased significantly and House Martins foraging on treated sites took more small prey while large prey was significantly more taken on control sites with no applications (Poulin et al. 2010). The authors showed that clutch size and fledgling survival were significantly lower at treated areas with breeding success being positively correlated with intake of those invertebrates which numbers were declined by Bti. In addition, they observed a higher proportion of second clutches at treated sites, but these did not compensate for the lower reproductive success. Poulin et al. (2010) suggest that, since female House Martins with two clutches per breeding season survive less, the application of Bti could even affect adult survival.

Insects are a very important food resource for many small mammal species and intensively consumed by shrews. The application of insecticides reduces the amount of insects and therewith highly influences the occurrence and performance of insectivorous species which in turn may affect predators, e.g. the Least Weasel or Stoat, relying on these small mammals as an important food source.

Bats, like the Common Noctule, are very likely to be negatively affected by the lack of large insects due to insecticide application on farmland (LUNG 2004). However, evidence of indirect effects on bat populations through the reduction of insect food supply by insecticide applications is lacking (Jones et al. 2009).

A study on the North American shrew species *Sorex cinereus* (Masked Shrew) demonstrated indirect effects of the insecticide agent *Bacillus thuringiensis* on the population structure, diet and prey selection of this insectivorous species due to the reduction of food supply (Bellocq et al. 1992). The abundance of Masked Shrews did not differ significantly after spraying in comparison to an untreated area. However, fewer males and more juveniles were detected in the treated plots. Furthermore, the animals showed a shift of their diet from the most common prey items Lepidopteran larvae to alternative food sources. The authors conclude that generalist insectivores are less likely to be negatively affected by selective insecticides (Bellocq et al. 1992).

Rodenticides

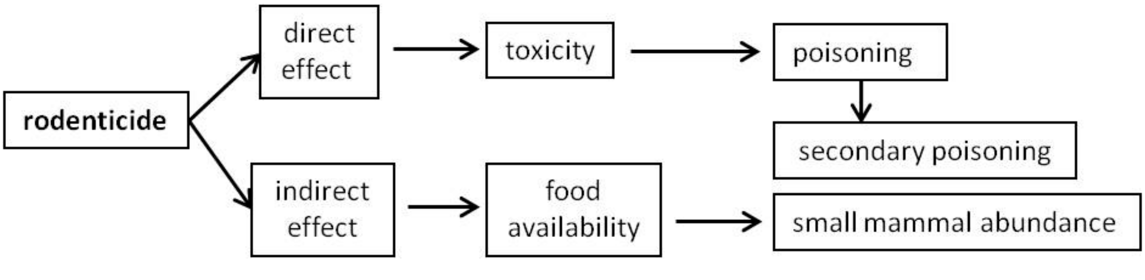

Fig. 4.1.4: Direct and indirect effects of rodenticide applications.

While nowadays direct effects of other pesticides (besides herbicides and insecticides) on bird species are considered to be only marginally important to bird populations (e.g. Marshall et al. 2001), lethal and sublethal effects of rodenticides should still be paid attention (Burn 2000).

Secondary poisoning is a potential threat for birds of prey consuming contaminated rodents and other small mammals. In the UK lethal incidents caused by second-generation rodenticides ingested by barn owls are not regarded as being a risk for this species' population but the extent of this hazard is hard to predict since it is unknown what proportion of the contaminated population dies unobserved (Burn 2000). Records of lethal incidents related to rodenticides in the UK involve bird species such as Little Owls, House Sparrows, Barn Owls, Kestrels and Goshawks (Burn 2000). Red Kites are considered to be at risk from secondary poisoning due to the consumption of carrion and the approximation to human settlements (Burn 2000).

In Germany about 40 Common Cranes were poisoned from rodenticides (poisoned wheat) in 2004 (BVL, 2009a). Furthermore, several incidents of dead geese (Greylag and Bean Goose) were reported poisoned with rodenticides.

Red Kites are known to be threatened by secondary poisoning from rodenticides. The main reason for declining populations is an increased mortality due to poisoning (Knott et al. 2009). In France, the death of more than 80% of 62 investigated Red Kites suspected of poisoning was actually caused by toxicants (cholinesterase inhibitors and anticoagulant compounds) (Berny & Gaillet 2008). A major threat was secondary poisoning after the application of anticoagulants applied to control vole outbreaks but also malicious poisoning with carbamates in meat baits.

A number of studies is available that deal with direct effects of rodenticides on small mammals through poisoning and secondary poisoning. Especially non-target rodent species are affected by intoxication through rodenticide baits.

The application of rodenticides can have negative effects on European Hamster populations, but its extent is unknown (Gall 2008). The damage may occur on a small scale only. Hence it is unlikely to have remarkable impact on whole populations. Risks are probably higher when rodenticides are applied over extended areas. Direct damage in form of residues accumulation in tissues is likely to be small or non-existent due to the short life span of this species (Gall 2008).

Dowding et al. (2010) found that contamination of European Hedgehogs with anticoagulant rodenticides is very common in agricultural landscapes in the UK. However, it could neither be proven that this exposure commonly resulted in lethal poisoning nor were negative effects of rodenticide accumulations detected. The authors conclude that the exposure of insectivores to rodenticides, here the Hedgehog, and specialized predators appears similar, which indicates that rodenticides find their way into ecosystems via transfer routes other than through consumption of contaminated rodents, which Hedgehogs rarely do, for example through direct access to baits (Dowding et al., 2010). This may demonstrate the risk of poisoning for other species that do not include small mammals in their diet either.

The poisoning of non-targeted small mammals through rodenticides opens up a route of exposure for predatory species like Weasels or Stoats as well as for birds of prey (Brakes & Smith 2005). Results from laboratory experiments by Townsend et al. (1984) suggest that Weasels could be at risk from secondary poisoning from rodenticides under field conditions, although in this study these direct effects were assessed under experimental conditions and the animals were exposed to contaminated prey exclusively.

However, residues of rodenticides were detected in 23% of investigated Stoats and in 30% of the Weasels in another study which investigated concentrations of anticoagulant rodenticides in livers of animals trapped or shot by gamekeepers in the UK (McDonald et al. 1998). Stoats and Weasels are exclusively carnivorous and grain-based rodenticide baits are unlikely to be directly consumed by these predators. Therefore, it is concluded that they are exposed to rodenticides by eating contaminated small rodents. Exposure of rodenticides was more prevalent in female Stoats than in males. Females may be at higher risk from secondary poisoning by rodenticides than males because their diet depends more on small rodents. The importance of small rodents in the diet of Stoats and Weasels is inversely correlated with increasing body size. The authors conclude that these predatory species are secondarily exposed to rodenticides mainly by eating contaminated non-target species and that further research is needed in order to identify possible lethal or sub-lethal effects due to secondary poisoning (McDonald et al. 1998).

Several lethal poisoning incidents are recorded for Brown Hares and Wild Boars in Germany (BVL 2009a). In France, incidents for Wild Boars, Brown Hares and Hedgehogs poisoned with rodenticide baits were recorded (de Snoo et al. 1999).

In addition to negative direct effects of rodenticides like secondary poisoning, an obvious indirect effect of rodenticide application in hedgerows and crops is the resulting lack of prey for predatory species like Stoats, Least Weasels and several birds of prey depending on rodent populations (Brakes & Smith 2005). McDonald et al. (1998) conclude that the reduction of prey abundance is likely to harm predator populations of Stoats and Weasels by reducing their reproductive success and juvenile survival.

Fungicides

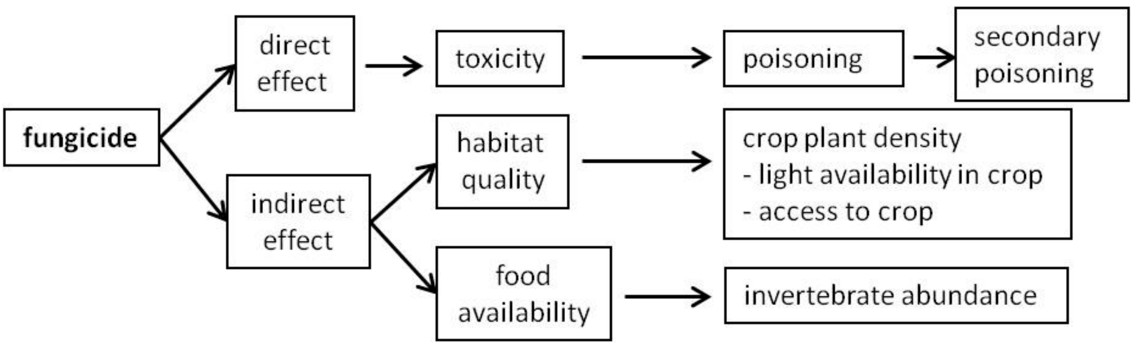

Fig. 4.1.5: Direct and indirect effects of fungicide applications.

The exposure of Wood Mice to seeds treated with fungicides was studied by snap-trapping them inside arable fields and hedges (Barber et al. 2003). They found, that 80% of the animals trapped in hedges consumed no seeds, while 90% of animals trapped in crops had consumed seed, though 90% of these animals had less than 20% seed in their stomach. Residues of fungicides in stomach tissues were lower than expected and the researchers concluded a connection to the behavior of dehusking seeds before consumption (Barber et al. 2003). Brühl et al. (2011) showed in their study that the dehusking behavior of Wood Mice reduced exposure to fungicides by 60% for cereals and by 90% for sunflower seeds and recommend to include these factors in the risk assessment scheme for granivorous mice. Thus, direct effects of fungicide treatments could not be proven and adverse effects were rather put into perspective by proving the decreased risk of poisoning for granivorous rodents due to the dehusking behavior.

Among a number of factors associated with agricultural intensification, fungicide – and insecticide – applications most negatively affected diversity of plant species, carabids and ground-nesting farmland birds (Geiger et al. 2010). Ewald & Aebischer (1999) detected a negative relationship of invertebrate abundance with fungicide applications. Four out of five invertebrate groups important in bird diet were negatively related with fungicide treatments (Ewald & Aebischer 1999), though a correlation with insecticide effects is possible and therefore more research on the effects of fungicides on invertebrate food source availability is needed (Bright et al. 2008).

Fungicide applications increase plant biomass by allowing crop plants to grow in higher densities. As a result, less light is getting through the vegetation and reaches the ground resulting in a loss of herb and weed diversity and making it impossible for many farmland species to access and use these crops as habitat. Chicks of bird species occurring inside crops, such as the grey partridge, may suffer from a lack of warmth from sunlight that is not able to reach the ground anymore due to the small distances of crop row.

Molluscicides

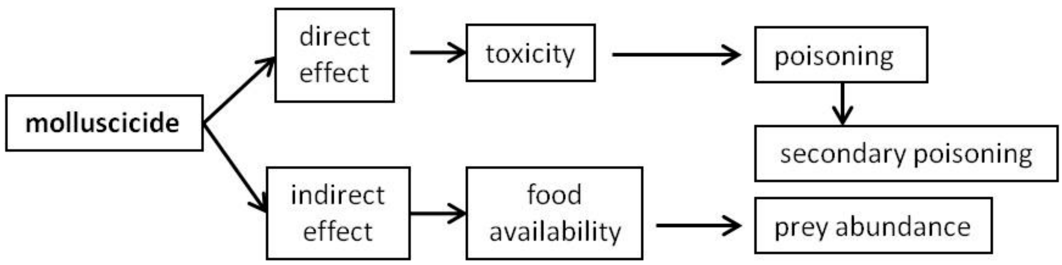

Fig. 4.1.6: Direct and indirect effects of molluscicide applications.

In two places in Germany Hoopoes have been found dead possibly due to ingestions of molluscicides (Methiocarp) (NABU-Kreisverband Spreewald 2010, Münch 2011).

The Hedgehog may face a high risk of exposure to molluscicides by consuming contaminated earthworms and mollusks. Lethal incidents of Hedgehogs killed by baits of the molluscicide Metaldehyde were recorded in Germany in the year 1988 (Joermann & Gemmeke 1994).

Two studies on rodents found adverse effects on the survival of Wood Mice in arable fields treated with the molluscicide Methiocarb (Johnson et al. 1991; Shore et al. 1997). These results are further discussed in the next section about effects of pesticides on birds and mammals on the population level.

The direct effects of molluscicides by reducing small mammal populations through poisoning (Johnson et al. 1991) may have indirect negative consequences for predatory species like Weasels due to a reduction in prey availability (Shore et al. 1997). Additionally, the invertebrate food supply for small insectivorous mammals may be reduced by molluscicide applications and thus have negative impact on their performance.

For an overview on the different indirect effects of pesticides on bird and mammal species described above see also tables in Annex II.

4.1.3 Pesticide impact on farmland bird and mammal species on the population level

In the former section we described the mechanisms of direct and indirect effects of the usage of different pesticide agents and their impact on farmland bird and mammal species. These effects may be of short- or long-term duration and their impact on wildlife populations is often unclear. We therefore reviewed studies that specifically focused on population level effects and were able to prove the relationship of direct and particularly indirect effects of pesticide applications and the decline or change in a wildlife species population. The results of these studies are presented in the following section.

Pesticide impact on farmland bird species

In order to assess the impact of indirect effects on a species' population, evidence is needed for the relationship between pesticides and for example food availability, next between food availability and breeding performance and ultimately between breeding performance and population size (Boatman et al. 2004; see also Fig. 4.1.7). In the following we will give a more detailed insight in studies that aspire to prove indirect pesticide effects on bird species with consequences on the population level.

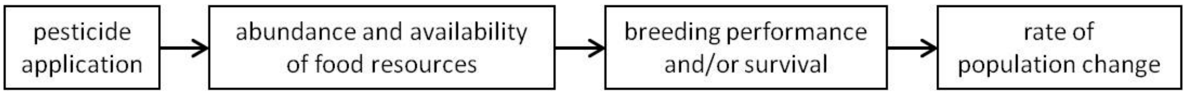

Fig. 4.1.7: Causal relationship between pesticide application and population changes of birds and mammals in relation to indirect effects, here on food resources (after Boatman et al. 2004).

Grey Partridge – herbicides (fungicides, insecticides)

The only farmland bird species for which a relationship between pesticides, food availability, breeding performance and population size has been fully demonstrated is the Grey Partridge in the UK (Marshall et al. 2001). The species' population has declined in Europe by at least 83% since the 1930s (Potts 1997) and underlying negative effects of pesticide applications on Grey Partridges have been demonstrated in an extensive long-term study in Sussex, UK (The Game Conservancy Trust's study).

Chick survival is the key factor determining population development and Grey Partridge chicks are highly dependent on invertebrate prey abundance in arable crops, mainly cereals, where they feed on insects and other arthropods along the edges (Potts 1971, Rands 1985). In an experimental study, Rands (1985) found that the abundance of insects and the mean brood size of Partridges were significantly higher in cereal fields where areas were left unsprayed with pesticides (broad-spectrum grass and broad-leaved weed herbicides, fungicides and insecticides). Declines in insect abundances due to herbicide applications went parallel to the negative trend of Grey Partridge populations (Potts 1971). By reducing chick food supply pesticide applications decreased chick survival and therewith brood sizes of the Grey Partridge (Rands 1985). Declined chick survival rates are seen as the major factor responsible for the decrease of Grey Partridge numbers (Rands 1985; Potts & Aebischer 1991). Brood sizes of an average of 3.14 chicks are needed to sustain Partridge populations (Potts 1980). Rands (1985) recorded mean brood sizes of less than 3.0 chicks in sprayed cereal fields, while brood sizes in unsprayed headlands were larger than 5.0. Hence, brood sizes in sprayed habitats were insufficient to maintain Grey Partridge populations. These and further findings are discussed extensively in the review by Campbell et al. (1997) as well as in Marshall et al. (2001) and Bright et al. (2008).

Corn Bunting – insecticides (herbicides, fungicides)

In a study by Brickle et al. (2000) evidence was found for a negative correlation of Corn Bunting chick weight and nestling survival with invertebrate food availability. Furthermore, chick food abundance was negatively correlated with the number of insecticide applications to cereal fields (which contained about 70% of the nests) and with herbicide, fungicide and insecticide applications on all foraging areas. Foraging crops of Corn Buntings received fewer applications of pesticides than fields that were not used as foraging habitats by this species (Brickle et al. 2000). Subsequent results of Boatman et al. (2004) suggest that invertebrate food abundance in the area around the nest had a significant effect on survival of Corn Bunting chicks. Ewald et al. (2002) found a positive correlation of Corn Bunting densities and chick food abundance and negative, yet not significant, relationships with pesticide applications. Lower chick food abundances in the vicinity of the nests forced parents to forage in greater distances, prolonging foraging trips which was negatively correlated with chick weight (Brickle et al. 2000). Moreover, it reduced the likelihood of nest survival, probably due to increased risk of predation. The authors conclude that the decrease of chick food availability, correlating with reduced breeding success of Corn Buntings, may have contributed to the species' decline and continues to threaten its populations (Brickle et al. 2000).

Without population modelling it cannot be concluded whether the negative effects of pesticide applications on chick food abundance and following negative impacts on chick weight and survival result in severe consequences on the population level (Bright et al. 2008). Nevertheless, Corn Bunting populations are seen to be at risk from indirect effects from pesticides (Boatman et al. 2004).

Yellowhammer – insecticides

The Yellowhammer is the third farmland bird species for which indirect effects on population development (here breeding performance) are considered to have been proven (Boatman et al., 2004). In an experimental approach Boatman et al. (2004) found a relationship between the probability of brood reduction and the proportion of the proportion of foraging area around the nest that was sprayed with insecticides. Furthermore, they detected that the levels of chick starvation were negatively related to the abundance of important chick food invertebrate taxa. These findings were supported by Hart et al. (2006) where field studies showed a positive correlation of nestling condition and mass with the abundance of arthropods, resulting in fewer incidences of brood reduction. Arthropods abundance was depressed within 20 days of an insecticide application to levels likely to depress Yellowhammer breeding performance (Hart et al. 2006).

Further evidence for indirect effects of pesticides on behaviour and nestling condition were provided in a field study by Morris et al. (2005). Insecticide applications in cereal fields significantly reduced the abundance of invertebrate food during the breeding season which was negatively correlated with Yellowhammer foraging intensity. Adults avoided these areas especially early in the season when their broods predominantly feed on insectivorous food.

Later in the season they took also semi-ripe cereal grain and therefore visited those fields treated with insecticides as well (Morris et al. 2005). Insecticide spraying during the breeding season may have more detrimental effects than multiple sprays at other times and the probability of brood reduction is affected by the proportion of spayed foraging area. Although no significant relationship between insecticide use and brood reduction was found, there was still a negative effect on nestling body condition. The authors therefore conclude that an impact on the species' population level might still be possible since individuals with poor body conditions as nestlings might not survive until they reach the reproductive age (Morris et al. 2005).

Skylark – insecticides

Oddeskær et al. (1997) found a higher breeding success on organic fields and suggested food shortage as a reason for the low success on conventional fields. Boatman et al. (2004) detected no significant effects of pesticide applications on Skylark chick condition or growth rate, but found a relationship between chick condition and chick food abundance. Further, mean brood weight was lowest in nests located in fields exposed to breeding season insecticide applications. Hence, some evidence for a relationship of pesticides and nestling condition seemed to exist, though on the other hand, chick growth rates were not significantly correlated with pesticide applications (Boatman et al. 2004). However, since sample sizes were very small, the authors conclude that indirect effects cannot be ruled out for this species and more research is needed.

Pesticide impact on farmland mammal species

For small mammals we found no study that assessed negative effects of pesticides and came up with evidence for an adverse long term impact on a species' population inhabiting agricultural landscapes. However, some studies prove adverse effects on the population level of farmland mammal species, at least on the short term, and these are described in the following.

Rodents – rodenticides

A study in the UK found a large proportion of individuals (48.6%) in local populations of three non-target rodent species feeding on rodenticide bait (Brakes & Smith 2005). Wood Mice, which were most exposed with 57.4% of their populations feeding on these baits, Bank Voles (30.6%) and Field Voles (19.5%) were affected. The local populations declined significantly but recovered partially after three month. The recovery depended on the time of the year relative to the breeding cycle of the species. However, negative effects on population sizes were only partly offset by summer breeding. The authors found shrews to be affected as well, whether this was through direct poisoning by consuming rodenticide baits or by secondary poisoning remained unclear (Brakes & Smith 2005).

Rodents – molluscicides

Johnson et al. (1991) studied the effects of applications of the molluscicide Methiocarb on Wood Mouse populations under field conditions in Britain ("The Boxworth Project"). Methiocarb is usually applied in pellet form with a cereal base and therefore is also attractive to non-target species such as rodents and other small mammal species (Shore et al. 1997). Broadcasting Methiocarb pellets in winter wheat fields had severe impact on Wood Mouse survival (Johnson et al. 1991). However, it seemed that there was no long-term effect on populations from applications in autumn when population numbers peak and many juveniles are dispersing. Thus a depletion of the population during this time of the year is likely to be short-lived (Johnson et al. 1991). Application in summer, however, may have greater impact on Wood Mouse populations. Furthermore, the results suggest that the impact of molluscicide applications is reduced when pellets are drilled instead of being applied to the field surface. It remained unclear whether rodents were poisoned by direct intake of the molluscicide pellets or due to indirect effects by consuming contaminated invertebrates (Johnson et al. 1991).

Shore et al. (1997) also found decreasing numbers of Wood Mice on arable fields after the application of the molluscicide Methiocarb. The decline was greater in autumn (73%) than in spring (33%). They concluded that by poisoning of small mammals their predators could be at risk from secondary poisoning as well (Shore et al. 1997).

Rodents (North America) – herbicides

Decreased abundance of Meadow Voles (Microtus pennsylvanicus) and a change in the sex ratio were found in an experimental study in the US investigating the response of small mammals to vegetation changes after the application of the herbicide 2,4-D (Spencer & Barrett 1980). Herbicides significantly altered the plant community structure and reduced plant species diversity and therewith changed the treated area into a "monoculture-type" Giant Foxtail (Setaria faberii) habitat (Spencer & Barrett 1980). Vole numbers in these treated plots reached a peak density of 68 individuals / 0.4 ha while the population in the untreated area gained a density of 116 animals / 0.4 ha (Spencer & Barrett 1980). The significant differences in plant biomass and species diversity affected the vole population by reducing changes in population densities and female survival rates. Voles in the treated plots were exposed to food quality differences which affected their population dynamics and hence the authors could prove that a non-target species was adversely influenced by herbicide applications resulting in lower reproductive success from diet shift (Spencer & Barrett 1980).

Johnson & Hansen (1969) documented changes in rodent populations after the application of 2,4-D, which reduced the coverage of forbs and sages in North American rangeland. Densities of Pocket Gophers (Thomomys talpoides) and Least Chipmunks (Eutamias minimus) decreased. The changes in densities were induced by altered food availability due to herbicide treatments. The elimination of forbs, which is the primary food source for Pocket Gophers, declined this species' numbers.

Chipmunks were negatively affected by both changes in the availability of food and cover, whereas the widely distributed and polyphagous Deer Mouse (Peromyscus maniculatus) was not significantly affected in its density and litter sizes. The numbers of Montane Voles (Microtus montanus) even increased, benefiting from increased grass cover usually following the herbicide treatment of perennial forb and shrub ranges (Johnson & Hansen 1969). Population numbers of Pocket Gophers and voles reestablished after a recover of the forb species.

Another study on herbicide effects on Pocket Gophers found reduced population sizes of up to 90% after 2,4-D applications (Tietjen et al. 1967). The population decline resulted from low survival due to the elimination of their food source, namely a reduction of forb abundance in rangeland habitat. Pocket Gophers directly depend on the production of annual and perennial forbs. The application of herbicides significantly reduced their density by reducing the habitat's carrying capacity (Tietjen et al. 1967). This is a direct evidence for negative consequences on the population level for a small mammal species due to herbicide usage.

Similar results were found in an opening in Idaho, USA, where over a period of 10 years indications (summer mounds and winter casts) for the presence and abundance of Pocket Gophers decreased by 93% and 94% respectively due to herbicide (2,4-D) applications (Hull 1971).

Bats – insecticides

In the UK, Jefferies (1972 in Jones et al. 2009) found that organochlorine residues may have been responsible for declining bat populations, since experiments showed that bats were highly sensitive to DDT contaminations, with toxic levels becoming a serious threat after hibernation. DDT is banned in the EU. Wickramasinghe et al. (2004) study the abundance and species richness of nocturnal insects on farmland. They conclude that pesticide applications are responsible for reduced insect numbers of both target and non-targeted species which again affect the occurrence of insectivorous species leading for example to declines in bat populations (Wickramasinghe et al. 2004).

4.1.4 Conclusion

Several reviews and comprehensive studies on indirect effects with enduring impact on populations of farmland bird species are available. These studies mainly focus on arable landscapes in the UK (see Campbell et al. 1997; Boatman et al. 2004; Bright et al. 2008). Campbell et al. (1997) demonstrate the clear relationship of adverse pesticide effects with the decline of Grey Partridge populations and assume possible negative effects on eleven further species, such as Turtle Doves, Reed Bunting or Blackbirds. Boatman et al. (2004) expand these results by proving the negative indirect effects of pesticide applications for another three species, the Yellowhammer, Skylark and Corn Bunting.

For mammals thorough studies on enduring effects of pesticide usage in agriculture that affect species on the population level are lacking. Individuals are negatively affected by direct effects such as poisoning but certainly also by indirect effects on habitat quality and food availability. Due to the general lack of knowledge on many small mammals species, about their population numbers and trends but also ecological features like habitat occurrence and diet choice, the actual role taken by pesticides in the presumably decline of small mammal populations is hard to estimate.

The impact of insecticides seems to be most studied and study results show the adverse effects on bird species like the Yellowhammer or Corn Bunting feeding on insects during the breeding season and therefore being most vulnerable in this phase of reproduction. Feeding on wild plant parts and simultaneously needing a high proportion of ground cover to avoid predation makes small mammals vulnerable towards indirect herbicide effects. Although few studies addressed this issue several authors mention such a possible negative impact e.g. for the Brown Hare or the Common Shrew. Furthermore, a number of studies from North America have proven adverse indirect herbicide effects on rodents even on the population level. These effects concerned both habitat quality and food availability. However, in total it seems that food availability is the more important ecological prerequisite that, when altered by pesticide applications, induces negative consequences for both farmland bird and mammal species.

For an overview for evidence for direct and indirect effects on bird and mammal species described in this review see figure 4.1.8.

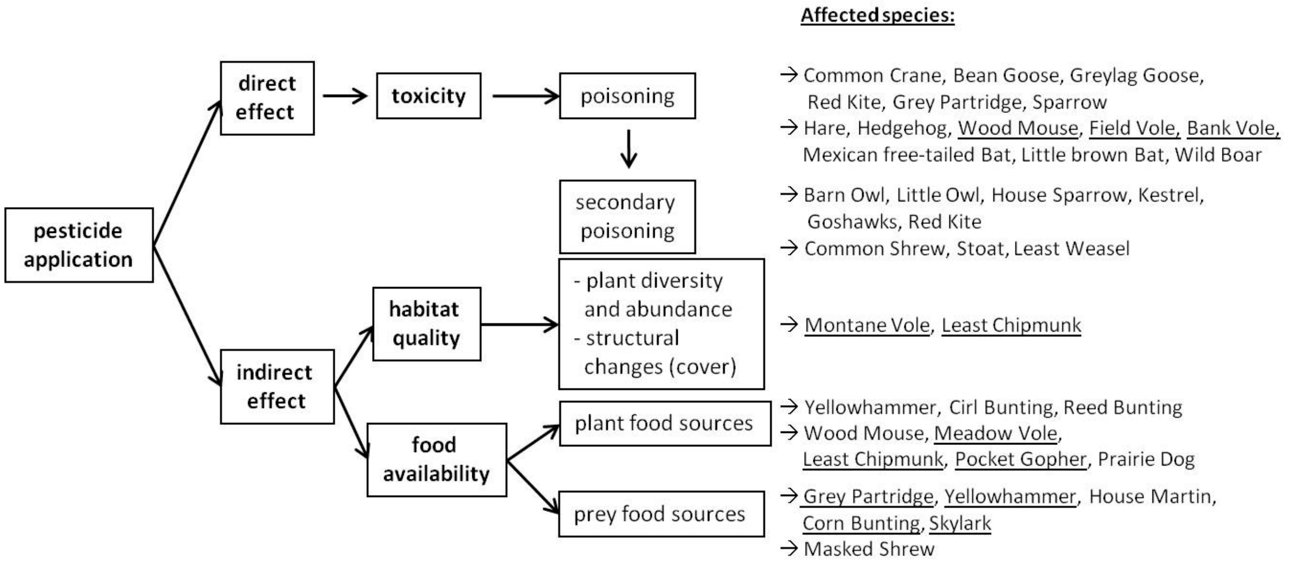

Fig. 4.1.8: Overview on effects of pesticides on farmland species described in this review (species verifiably affected on population level are underlined).

The lack of comprehensive studies on indirect effects of pesticides and therewith insight in the relationship with the performance of species in agricultural land demonstrates the necessity of different approaches. To get a better insight in the situation of farmland bird and mammal populations being affected by pesticides their vulnerability needs to be assessed by accounting for important ecological features directing towards their sensitivity to pesticide applications (chapter 4.2). Furthermore a pesticide related endangerment of potentially affected species is analyzed in the context of seasonal and crop specific relations of species and pesticide applications (chapter 4.3).

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4.2 Pesticide sensitivity index for farmland bird and mammal species

4.2.1 Introduction

Pesticide applications affect organisms directly, through poisoning, and indirectly by changing the availability of resources essential to the survival and performance of wildlife species. The most important indirect effects are the loss of food and loss of ground cover and therewith loss of protection from predators. They are inevitably linked to pesticide use and can significantly contribute to the risk of non-target species in agricultural landscapes. Boatman et al. (2004) presented evidence for indirect pesticide effects on four species of farmland birds but unfortunately, comprehensive studies on these indirect effects are missing for the majority of species occurring in German agricultural landscapes (see review in section 4.1). However, the outcome of those studies available (e.g. Campbell et al. 1997, Boatman et al. 2004, Morris et al. 2005) suggests that many more species, also endangered ones, might be affected.

When specific investigations on the effects of pesticides on farmland birds and mammals are missing another approach has to be selected to assess the pesticide related endangerment of the species. Assuming that the relevance of indirect effects of PPPs for farmland species is mainly determined by the species´ habitat and feeding requirements we used species-specific information gathered on these parameters together with model assumptions on corresponding impacts of pesticide applications to derive an estimate of the species´ sensitivity towards indirect pesticide effects. This ecological traits-based approach again allows for an extrapolation from species A with a demonstrated impact of indirect effects on the potential relevance of indirect effects for other species with similar habitat and feeding preferences, and therefore a similar index of sensitivity. Advantages and limitations of the proposed approach are discussed in detail further below.

In order to generate an efficient risk management for species endangered by indirect effects of pesticides one of the essential prerequisites is the identification of those species concerned. Therefore our objective was to develop a sensitivity index to assess the risk of indirect effects of pesticides applied in German agricultural landscapes affecting populations of farmland bird and mammal species.

4.2.2 Methods

The index reveals the degree of sensitivity a species' population is facing towards the application of pesticides. After applying the index-model we obtain a specific score for each species and therewith a ranking of all farmland species of interest according to their sensitivity to indirect effects of pesticide applications. The index enables us to estimate and compare the impact of pesticides on the various species.

Qualitative and quantitative data from a comprehensive literature review is used to assess the potential risk a species is facing from indirect effects of pesticides by classifying certain factors that represent ecological features in an index-based system. The key factors that have to be analyzed are the likelihood of a species´ exposure to such indirect effects and the possible impact of the pesticide application on key parameters of the species´ population dynamics. As main impacts of indirect pesticide effects we identified the reduction of food supply and elimination of ground cover functioning as protection from predators.

We therefore gathered data on the proportion of food taken from cultures with pesticide applications as well as the proportion of nests and time spend on such crops and the proportion of a species' diet and obligatory ground cover affected by pesticides (Fig. 4.2.1).

Thus, the four categories that run into the index-calculation are:

- Proportion of diet taken from sprayed crops (exposure)
- Proportion of diet potentially affected by pesticides (impact)
- Proportion of nests on sprayed crops / time spend on sprayed crops (exposure)
- Proportion of obligatory ground cover potentially affected by pesticides (impact)

Sprayed cultures are defined as crops excluding set-aside, grassland and adjacent structures like hedgerows, road margins etc. This results in a rather conservative estimate of the impact of pesticide applications. The proportion of diet taken by a species from these crops with pesticide applications is derived from studies that investigated the occurrence of a species on agricultural land in relation to its occurrence in other habitats. The same applies for the proportion of nests and time spend on sprayed crops. The proportion of time a species spends on sprayed cultures was taken as an indirect measure of the proportion of diet it takes from these crops. The same approach was also taken in the GD risk assessment for birds and mammals by EFSA (2009).

The amount of diet affected by pesticides reveals the composition of a species' food intake and evaluates the proportion that is potentially eliminated by pesticides. If a species diet exclusively depends on invertebrates, farmland weeds or rodents, we assume that 100% of its diet is potentially affected. The more a species consumes items unaffected by pesticides like for example crop plants or forest fruits the less of its diet is affected. The value concerning the ground cover affected by pesticides describes the importance of cover for a species.

Lack of cover is assumed to increase predation rates on nests and unfledged chicks of birds and of young and adult mammals. As there are virtually hardly any published studies investigating the influence of cover on breeding success of farmland birds, we scored 0.5 for those species nesting on the ground and having concealed nests: Common Quail, Grey Partridge, Corncrake, Woodlark, Skylark, Whinchat, Yellow Wagtail, Meadow Pipit, Corn Bunting, Yellowhammer and Ortolan Bunting. We assumed no influence of pesticides on cover in all other species.

In case scientific studies on one of the topics were not available we had to estimate the values based on our personal judgment or derive them from species with similar requirements. All background information and explanations for the derivation of the different values included in the index calculation can be found in the detailed species portraits provided in the annex.

The index aims to describe the threat of farmland birds and mammals due to pesticide applications in Germany. Pesticide applications outside Germany e.g. in winter quarters are not taken into account. In different countries indices for the same species might be different due to different habitat choices of birds or different percentages of crops cultivated on farmland.

Furthermore, the risk a species' population is facing depends on whether this species is active and/or present in German agricultural landscapes all year round. Hence, we evaluate the factors for three time periods to account for the different circumstances an organism is facing throughout the year. We distinguish between 'reproduction', representing the risk a species' offspring is facing, 'adults breeding season', evaluating adult survival during the reproduction period, and 'adults non-breeding season', considering survival and performance of individuals during the time when they do not reproduce. For each of these phases we calculate a seasonal sub-index and these sub-indices are integrated in the sensitivity index (Fig. 4.2.2). In order to keep its population stable a species needs to obtain a sufficiently high score for each of these three periods.

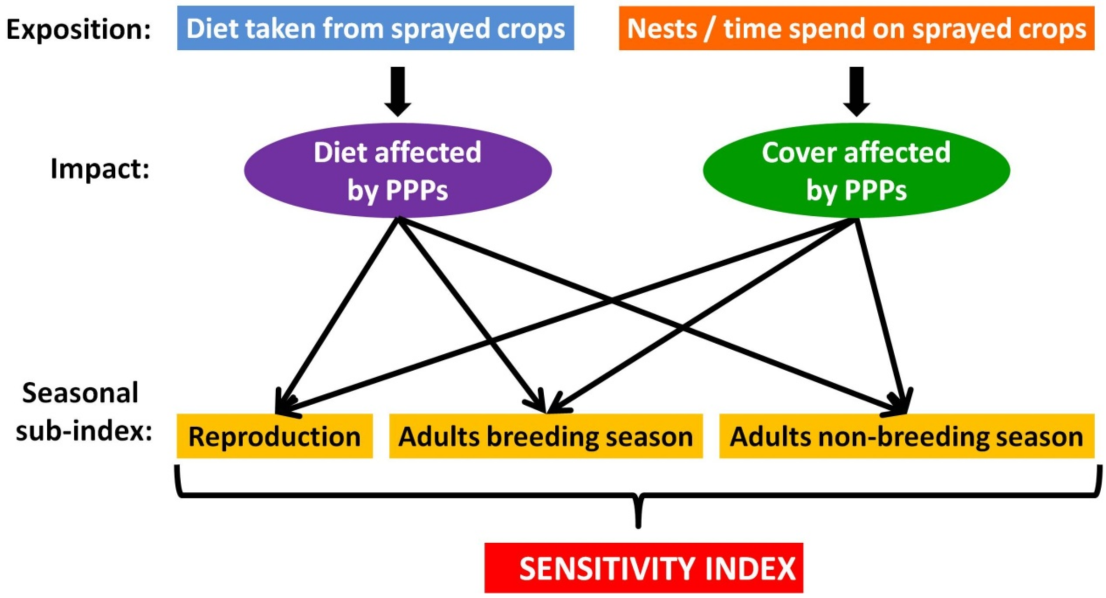

Fig. 4.2.1: Variables included in the index calculation for birds and mammals (breeding season=reproductive season).

When species are migratory or hibernating and therefore "absent" in one of the periods sub-indices were set as 1. Furthermore, some differences between bird and mammal species had to be factored into the calculation of the index. The reproduction phase of mammals usually lasts over a long period compared to the birds' breeding season. Variations in diet composition are rather influenced by seasonal differences than by reproduction and the raising of offspring. Moreover, young mammals are lactated and share after the lactation period the adults' diet. Therefore the diet related values in the calculation of the sub-indices for 'reproduction' and 'adults breeding season' are the same. In contrast, in many bird species the diet of chicks differs from the diet of adults.

In general, for birds a more differentiated analysis of the potential sensitivity of a species towards indirect effects was possible than for mammals due to a lack of data for example on crop-specific occurrence or habitat related choice of diet.

The sensitivity index is calculated as follows:

Index = 1-(sub-index$_{\text{reproduction}}$ x sub-index$_{\text{breeding season}}$ x sub-index$_{\text{non-breeding season}}$)

An index score of 1 reveals a high negative impact of pesticides on the reproduction and survival of a species while and index score of 0 represents a low negative or no impact of pesticides on the reproduction and survival.

See figure 4.2.2 for an example of the calculation of the sub-index for the reproduction phase.

We chose to calculate the sensitivity index based only on a few, very simplified parameters in order to keep the calculation and scoring traceable. We are aware that many more species specific characteristics and requirements influence a species' sensitivity towards indirect effects of pesticides. Due to the lack of detailed data on a wide range of ecological and behavioral traits of wild farmland species we decided to focus on the two main factors influenced by indirect pesticide effects, food availability and ground cover.

Furthermore, attention has to be paid to the fact that the occurrence of species in sprayed crops might be very difficult to assess because the available data is already influenced by the fact that species, “naturally” being present on certain crops, already have disappeared due to pesticide applications. This possibly already acting effect is not reflected by the index.

Example – calculation of sub-index$_{reproduction}$

Proportion of diet taken from sprayed crops (0.6)

Proportion of diet potentially affected by pesticides (0.8)

Proportion of nests on sprayed crops (0.05)

Proportion of obligatory ground cover potentially affected by pesticides (importance of cover for breeding success) (0.5)

$$\text{sub-index}_{rep.} = ((1 - 0.6) + (0.6 - 0.6 \times 0.8)) \times ((1 - 0.05) + (0.05 - 0.05 \times 0.5)) = 0.51$$

Fig. 4.2.2: Example for the calculation of the sub-index reproduction.

However, since other autecological parameters such as the population dynamics within and between local populations determine whether indirect effects might lead to population-relevant effects the sensitivity index can only give an indication on the likelihood of population-relevant indirect effects but species specific field monitoring and population modeling would be necessary to verify the indicated risk.

4.2.3 Results & Discussion

Tables 4.2.1 and 4.2.2 show the different values for the different parameters that are included in the calculation of the index for 27 bird and 22 mammal species of German agricultural landscapes. They give the results for the three sub-indices for the periods of ‘reproduction’ (Repr), ‘adults breeding season’ (ad b) and ‘adults non-breeding season’ (ad nb) and the final index score.

Tables 4.2.3 and 4.2.4 reveal a ranking of the bird and mammal species according to their sensitivity index score. Ortolan Bunting, Grey Partridge, Yellow Wagtail, Common Quail, Lapwing and Corn Bunting are the bird species that reach a high index score above 0.9. For mammals Brown Hare, European Hamster and Wood Mouse are the potentially most affected species with a high score above 0.9, though the mammal species do not reach such high scores as the bird species do. The least affected bird species are goose and swan species while the large mammal species Wild Boar and Fallow Deer get the lowest scores among the mammals.

The sensitivity ranking corresponds to the results of the literature review on farmland species affected by direct and indirect pesticide effects (see chapter 4.1). Those species for which population level effects by pesticides have been clearly demonstrated in the scientific literature (Grey Partridge, Corn Bunting, Yellowhammer and Skylark, see chapter 4.1), all received relatively high index scores. Although most index scores could not be based on direct field evidence the good correspondence of the results for these species indicates that the sensitivity index might appropriately fulfill its function.

Considering the number of index scores higher than 0.5 of more than half of all species analyzed, many more species than those evidently suffering from indirect effects of PPPs as proven in literature seem to be at risk from indirect pesticide effects (see conclusions (chapter 4.2.4) for further discussion).

Birds

Bird species that are insectivorous at least during the breeding season rank highest in the index score whilst herbivorous swans and geese that often feed on crops or on grass outside the breeding season do not seem to be affected at all (Tab. 4.2.3, see also Fig. 4.2.4 for a specification according to the different orders). There seems to be little influence of the systematic order on sensibility against PPPs. However, both Galliform species and all three Buntings (Corn Bunting, Yellowhammer, Ortolan Bunting) score very high (Tab. 4.2.3).

Tab. 4.2.1: Pesticide sensitivity index for farmland birds: parameter values (100%: 1) and index scores.

Species	Reproduction				Adults breeding season			Adults non-breeding season			Sub-index			Index
	Diet taken from sprayed cultures	Diet affected by pesticides	Nests on sprayed cultures	Cover affected by pesticides	Diet taken from sprayed cultures	Diet affected by pesticides	Cover affected by pesticides	Diet taken from sprayed cultures	Diet affected by pesticides	Cover affected by pesticides	Repr.	ad b	ad nb	Index
Barn Swallow	0.4	1	0	0	0.3	1	0				0.60	0.70	1.00	0.58
Barnacle Goose								0.1	0	0	1.00	1.00	1.00	0.00
Bean Goose								0.6	0	0	1.00	1.00	1.00	0.00
Bewick's Swan								0.14	0	0	1.00	1.00	1.00	0.00
Black-tailed Godwit	0.02	1	0.05	0	0.05	1	0				0.98	0.95	1.00	0.07
Common Crane	0.05	0.4	0	0	0.05	0.4	0	0.95	0	0	0.98	0.98	1.00	0.04
Common Quail	0.70	1	0.70	0.5	0.70	0.95	0.2				0.17	0.29	1.00	0.95
Corn Bunting	0.75	0.82	0.39	0.5	0.75	0.95	0.1	0.75	0.05	0	0.31	0.27	0.96	0.92
Corncrake	0.1	1	0.1	0.5	0.1	1	0.1				0.86	0.89	1.00	0.24
Golden Plover								0.53	1	0	1.00	1.00	0.47	0.53
Grey Partridge	0.8	0.95	0.6	0.5	0.8	0.65	0.2	0.9	0.5	0.2	0.17	0.40	0.45	0.97
Greylag Goose	0.05	0	0	0	0.05	0	0	0.59	0	0	1.00	1.00	1.00	0.00
House Martin	0.3	1	0	0	0.2	1	0				0.70	0.80	1.00	0.44
Lapwing	0.5	1	0.5	0	0.5	1	0	0.7	1	0	0.50	0.50	0.30	0.93
Linnet	0.6	0.5	0	0	0.6	0.5	0	0.6	0.5	0	0.70	0.70	0.70	0.66
Little Owl	0.2	0.7	0	0	0.2	0.7	0	0.2	0.7	0	0.86	0.86	0.86	0.36
Meadow Pipit	0.15	1	0.05	0.5	0.15	1	0	0.15	1	0	0.83	0.86	0.86	0.39
Montagu's Harrier	0.35	0.3	0.9	0	0.35	0.3	0				0.90	0.90	1.00	0.20
Ortolan Bunting	0.9	1	0.05	0.5	0.9	0.8	0	0.9	0.2	0	0.01	0.28	0.82	0.98
Red Kite	0.7	0.29	0	0	0.7	0.29	0	0.7	0.29	0	0.80	0.80	0.80	0.49
Red-backed Shrike	0.5	1	0	0	0.5	0.9	0				0.50	0.55	1.00	0.73
Skylark	0.59	0.95	0.59	0.5	0.59	0.7	0	0.9	0.2	0	0.31	0.59	0.82	0.85
Whinchat	0.31	1	0.1	0.5	0.31	1	0				0.66	0.69	1.00	0.55
White-fronted Goose								0.4	0	0	1.00	1.00	1.00	0.00
Woodlark	0.3	0.9	0.9	0.5	0.3	0.8	0				0.40	0.76	1.00	0.69
Yellow Wagtail	0.73	1	0.73	0.5	0.73	1	0				0.17	0.27	1.00	0.95
Yellowhammer	0.65	0.95	0.05	0	0.65	0.8	0	0.9	0.3	0	0.38	0.48	0.73	0.87

Tab. 4.2.2: Pesticide sensitivity index for farmland mammals: parameter values (100%: 1) and index scores.

Species	Reproduction				Adults breeding season			Adults non-breeding season			Sub-index			Index
	Diet taken from sprayed cultures	Diet affected by pesticides	Nests on sprayed cultures	Cover affected by pesticides	Diet taken from sprayed cultures	Diet affected by pesticides	Cover affected by pesticides	Diet taken from sprayed cultures	Diet affected by pesticides	Cover affected by pesticides	Repr	ad b	ad nb	
European Hamster	0.9	0.2	0.9	0.7	0.9	0.2	0.7				0.30	0.30	1.00	0.91
Field Vole	0.5	0.3	0.4	0.8	0.5	0.3	0.8	0.3	0.2	0.8	0.58	0.51	0.71	0.79
Common Vole	0.5	0.3	0.4	0.7	0.5	0.3	0.7	0.3	0.2	0.7	0.61	0.55	0.74	0.75
Striped field Mouse	0.5	0.5	0.5	0.7	0.5	0.5	0.7	0.3	0.5	0.7	0.49	0.49	0.67	0.84
Yellow-necked Mouse	0.3	0.5	0	0	0.3	0.5	0.7	0.3	0.5	0.7	0.85	0.67	0.67	0.62
Wood Mouse	0.6	0.5	0.6	0.7	0.6	0.5	0.7	0.4	0.5	0.7	0.41	0.41	0.58	0.91
Harvest Mouse	0.3	0.7	0.1	0.7	0.3	0.8	0.7	0.1	0.7	0.7	0.73	0.60	0.86	0.62
Bicoloured Shrew	0.4	0.9	0.2	0.4	0.4	0.9	0.4	0.2	0.9	0.4	0.59	0.54	0.75	0.76
Greater white-toothed Shrew	0.4	0.9	0.2	0.5	0.4	0.9	0.5	0.2	0.9	0.5	0.58	0.51	0.74	0.78
Lesser white-toothed Shrew	0.4	0.9	0.2	0.5	0.4	0.9	0.5	0.2	0.9	0.5	0.58	0.51	0.74	0.78
Common Shrew	0.4	0.9	0.2	0.7	0.4	0.9	0.7	0.3	0.8	0.7	0.55	0.46	0.60	0.85
Pygmy Shrew	0.3	1	0.2	0.8	0.3	1	0.8	0.3	1	0.8	0.59	0.53	0.53	0.83
European Hedgehog	0.2	0.7	0	0	0.2	0.7	0.5				0.86	0.77	1.00	0.33
European Mole	0.2	1	0.2	0	0.2	1	0	0.2	1	0	0.80	0.80	0.80	0.49
Brown Hare	0.6	0.5	0.6	0.7	0.6	0.5	0.7	0.6	0.4	0.7	0.41	0.41	0.44	0.93
Greater mouse-eared Bat	0.4	1	0	0	0.4	1	0				0.60	0.60	1.00	0.64
Natterer's Bat	0.4	1	0	0	0.4	1	0				0.60	0.60	1.00	0.64
Common Noctule	0.4	1	0	0	0.4	1	0				0.60	0.60	1.00	0.64
Stoat	0.4	0.2	0	0	0.4	0.2	0.7	0.4	0.3	0.7	0.92	0.66	0.63	0.61
Least Weasel	0.4	0.7	0	0	0.4	0.7	0.7	0.4	0.8	0.7	0.72	0.52	0.49	0.82
Fallow Deer	0.3	0.2	0	0	0.3	0.2	0	0.3	0.2	0	0.94	0.94	0.94	0.17
Wild Boar	0.4	0.1	0	0	0.4	0.1	0	0.4	0.1	0	0.96	0.96	0.96	0.12

Tab. 4.2.3: Index scores and trends of bird species. Species evidently affected by indirect effects of pesticides (see chapter 4.1) are marked by orange cells. Species known to profit from organic farming are marked by green cells (1: non-significant differences between organic and conventional farming, 2: significant differences). The population trends for Germany and Europe (Tab. 3.1.1) are also given.

Species	Index	Org. Farm.	Trend in Germany	Trend in Europe
Ortolan Bunting	0,978	1	stable	<-50%
Grey Partridge	0,969	1	<-50%	<-50%
Yellow Wagtail	0,954	1	stable	-50% - -20%
Common Quail	0,951	1	20% - 50%	fluctuating
Lapwing	0,925		<-50%	-50% - -20%
Corn Bunting	0,921	1	20% - 50%	<-50%
Yellowhammer	0,866	2	stable	-50% - -20%
Skylark	0,851	2	-50% - -20%	-50% - -20%
Red-backed Shrike	0,725	1	stable	stable
Woodlark	0,690		20% - 50%	stable
Linnet	0,657	2	-50% - -20%	<-50%
Barn Swallow	0,580	1	-50% - -20%	stable
Whinchat	0,548	2	-50% - -20%	stable
Golden Plover	0,530		stable	20% - 50%
Red Kite	0,494		-50% - -20%	-50% - -20%
House Martin	0,440		-50% - -20%	stable
Meadow Pipit	0,391	2	-50% - -20%	<-50%
Little Owl	0,364		stable	-50% - -20%
Corncrake	0,238		stable	fluctuating
Montagu's Harrier	0,199		20% - 50%	20% - 50%
Black-tailed Godwit	0,069		<-50%	-50% - -20%
Common Crane	0,040		20% - 50%	20% - 50%
Barnacle Goose	0,000		>50%	>50%
Bean Goose	0,000		stable	stable
Bewick's Swan	0,000		fluctuating	declining
Greylag Goose	0,000		>50%	>50%
White-fronted Goose	0,000		stable	-50% - -20%

Bird species known to profit from organic farming generally rank high in the index (Tab. 4.2.3). This clearly supports the significance of the index. The index is also clearly associated with the population trend of the species in Europe. High scoring species are more likely among the species declining or severely declining than species with low index scores (Fig. 4.2.3). It should be kept in mind that other factors such as fertilization might be responsible for the attractiveness of organic farms. The population trends of some of the species are clearly caused by other factors than pesticides, such as loss of grassland (Black-tailed Godwit, Meadow Pipit, see also chapter 4.4).

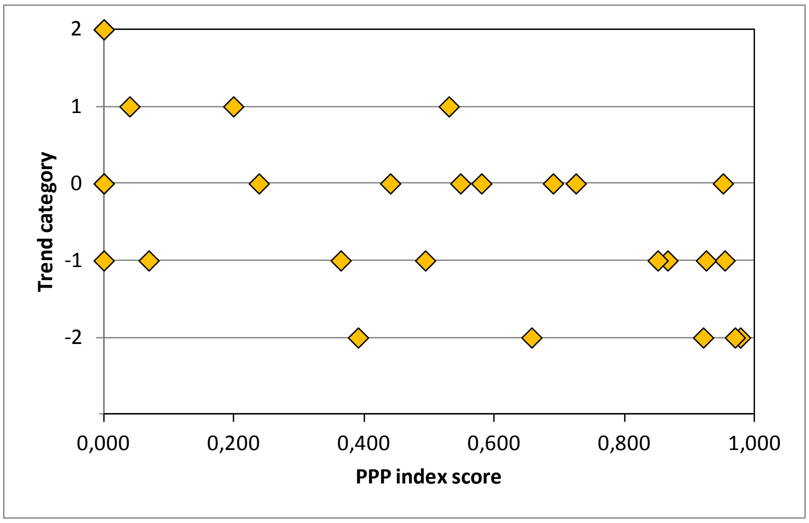

Fig. 4.2.3: PPP index scores for birds and population trends in Europe. -2: strongly decreasing, -1: decreasing, 0: stable or fluctuating, 1: increasing, 2: strongly increasing.

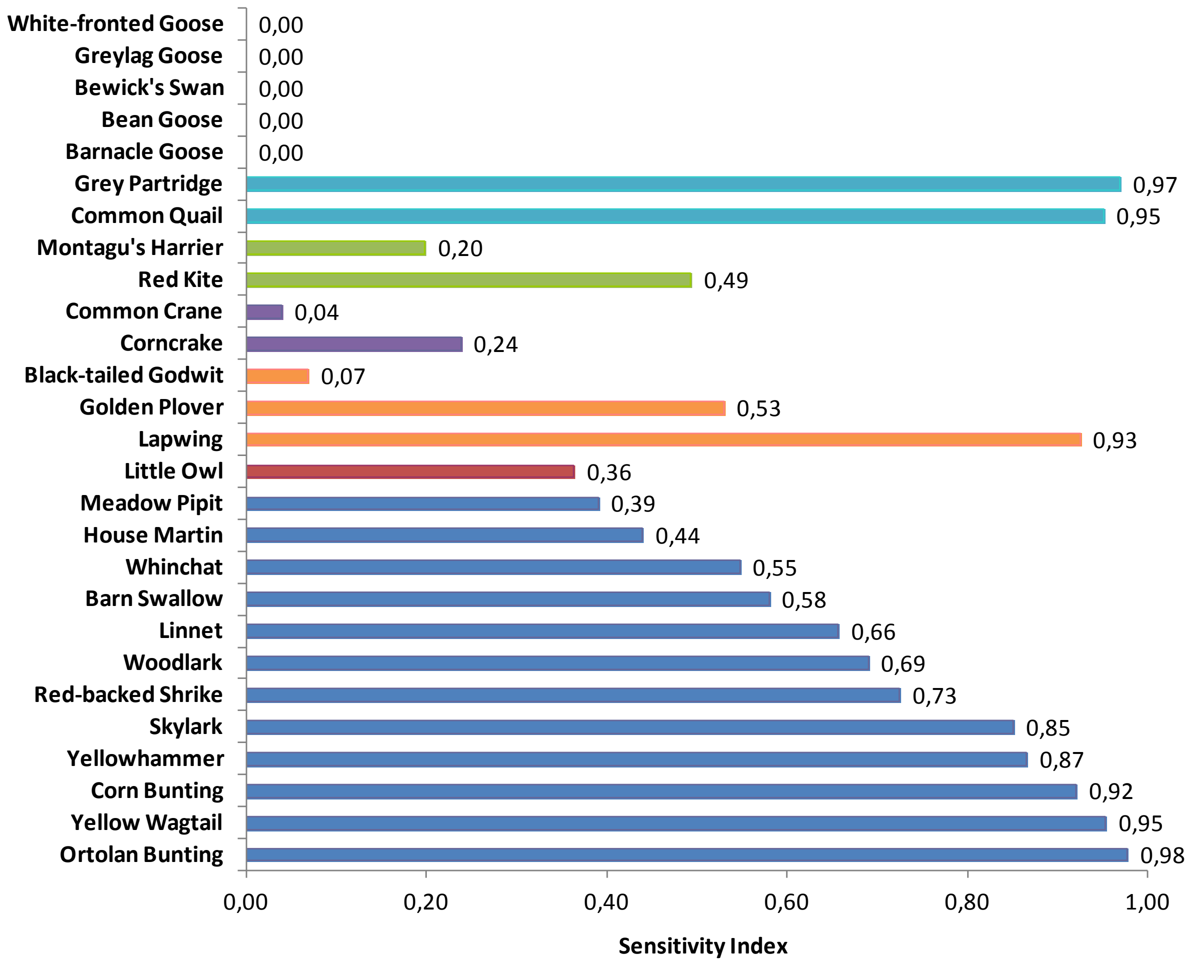

Fig. 4.2.4: Bird species scores grouped according to the species' order (light blue: Galliformes, green: Accipitriformes, purple: Gruiformes, orange: Charadriformes, red: Strigiformes, blue: Passeriformes).

Mammals

Addressing the mammals, species with increasing population trends receive also very low index scores while two species with strong and very strong declining populations rank highest (Tab. 4.2.4), indicating the indicative power of the sensitivity index ranking.

Tab. 4.2.4: Index scores and long term population trends for farmland mammal species in Germany (source: Meinig et al. 2009).

Species	Index	Long term trend in Germany
Brown Hare	0.93	strong decline
European Hamster	0.91	very strong decline
Wood Mouse	0.91	stable
Common Shrew	0.85	insufficient data
Striped field Mouse	0.84	insufficient data
Pygmy Shrew	0.83	insufficient data
Least Weasel	0.82	decline, unknown extent
Field Vole	0.79	moderate decline
Greater white-toothed Shrew	0.78	moderate decline
Lesser white-toothed Shrew	0.78	insufficient data
Bicoloured Shrew	0.76	moderate decline
Common Vole	0.75	strong decline
Greater mouse-eared Bat	0.64	strong decline
Natterer's Bat	0.64	moderate decline
Common Noctule	0.64	moderate decline
Harvest Mouse	0.62	decline, unknown extent
Yellow-necked Mouse	0.62	decline, unknown extent
Stoat	0.61	decline, unknown extent
European Mole	0.49	moderate decline
European Hedgehog	0.33	clear increase
Fallow Deer	0.17	clear increase
Wild Boar	0.12	clear increase

Mammals species that highly depend on crops as habitat in combination with a diet based on wild plants or insects (like the Brown Hare) or for which cover is a very important to escape from predation (e.g. Wood Mouse, European Hamster) seem to be at the highest risk to be affected by indirect effects. On the other hand, species like the Wild Boar, Fallow Deer, European Mole or Hedgehog that feed on crop plants, do not depend on ground cover or have a major part of their home range outside sprayed cultures are not affected by pesticide application.

In total, the order of rodents seems to be most sensitive to pesticides, followed by Insectivores (Fig. 4.2.5). The high importance of cover for vole species combined with their relatively strong presence on sprayed crops results in relatively high index scores although these species are very common on crops and well adapted to the living conditions provided by an intensive agriculture. The European Hamster appears to be very sensitive towards indirect pesticides effects (index score of 0.91), nevertheless, though it is the most threatened farmland mammal species, the reasons for its current endangerment status are rather related to other adverse impacts of agricultural intensification. Again, this species' index score suggests a high sensitivity due to the Hamster's high presence on sprayed crops and its need for cover. For the Wood Mouse however, the indicated sensitivity towards indirect effects (index score 0.91) may be indeed a threatening factor. It is one of the best studied small mammal species and studies show that indirect effects of pesticides (herbicides) adversely affect the availability of wild plant food for the species (Tew et al. 1992; see also chapter 3.1). Additionally, ground cover is important for Wood Mice to successfully avoid predation and they frequently occur on agricultural crops.

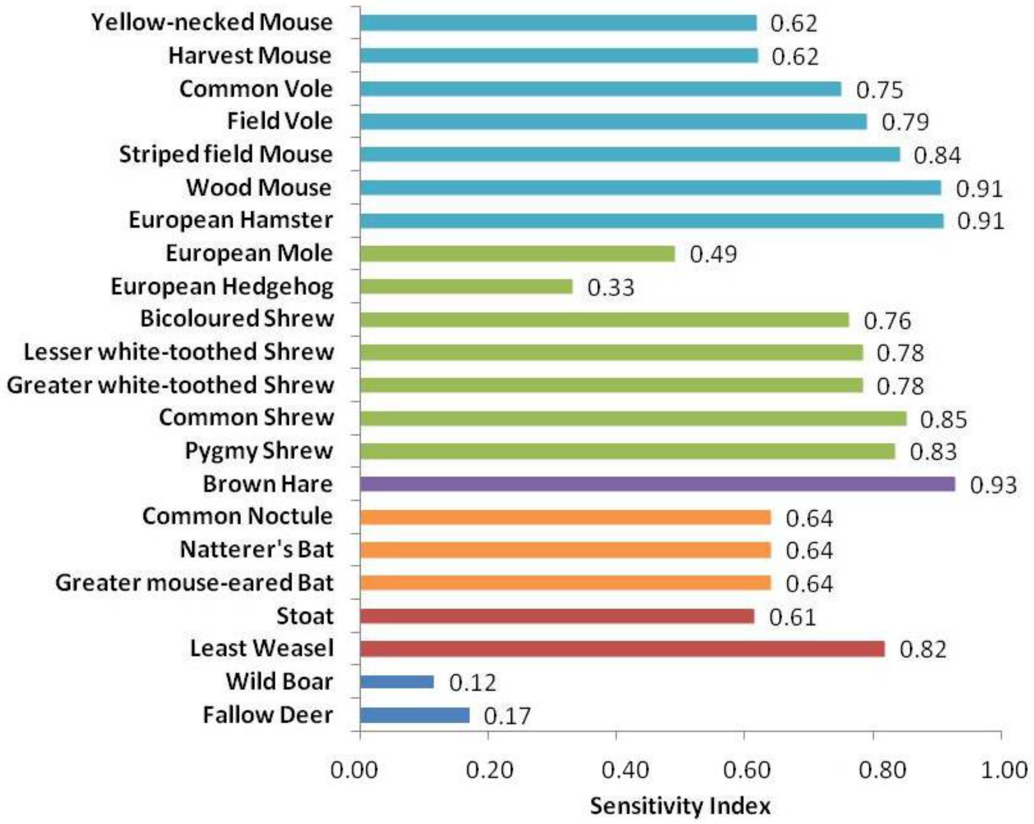

Fig. 4.2.5: Mammal species scores grouped according to the species' order (light blue = Rodents, green = Insectivores, purple = Lagomorphs, orange = Chiropterans, red = Carnivores, blue = Ungulates).

4.2.4 Conclusions

The sensitivity index evaluation scheme allows for assessing each species' potential sensitivity to indirect effects of pesticides based on species-specific features making the possible hazards of pesticides visible. The results from this evaluation support the definition of focal species in German agricultural landscapes with a specific focus on indirect effects. Furthermore, they highlight the necessity of comprehensive risk assessment strategies for a wider range of species than indicated by published scientific studies.

Clearly more experimental studies on the indirect effects of pesticides on farmland birds and mammals are needed. For now, species with high index-scores, i.e. species that are indicated to be highly sensitive to indirect pesticide effects, should be in the focus of attention for further field studies and risk management strategies.

The index is designed to detect possible risks for farmland bird and mammal species due to indirect effects of application of pesticides. Besides pesticides, many other factors like the loss of the preferred habitat or reductions in the area of the preferred crop can have an effect on the population dynamics of birds and mammals. This is elaborated on in chapter 4.4. The pesticide sensitivity index clearly does not mirror all the risks a population might face and, therefore, it cannot be used to assess the overall risk of a population. The pesticide sensitivity index even is not capable to mirror losses in population size which occurred do to indirect pesticides in the past. If a species has evacuated cropped land due to pesticide applications and persists in the few remaining bits of unsprayed land its index score will be low. The index just gives an indication of future risks due to pesticides viewed from the present time. The good accordance of index scores with proven indirect effects of pesticides (chapter 4.1) and with expectation fed by reactions of species towards organic farming indicates the usefulness of the pesticide sensitivity index.

4.2.5 References

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4.3 Impact of pesticide classes and application times

4.3.1 Pesticide classes

Based on the review of direct and indirect pesticide effects (chapter 4.1) as well as expert judgment we conducted an evaluation of the impact and relevance of the pesticide classes herbicides, insecticides, fungicides, rodenticides and molluscicides on the 27 bird and 22 mammal species considered in this report (Tab. 4.3.1). By ranking the impact of each pesticide class between high, medium and no impact for each species we try to get an overview on the endangerment of species by the different pesticide agents. We do not consider insecticide seed dressings (e.g. systemic insecticides) which are commonly applied and which might have secondary toxic or indirect effects during early growth stages of crops. The relevance of seed dressing is largely unknown (but see Tennekes 2010).

Among all pesticide classes insecticides and herbicides have the most adverse impact on bird and mammal species. Insecticides have a high negative impact on more than half of the considered species of both birds and mammals. Direct as well as indirect effects play an important role and several studies have investigated these impacts (e.g. Ewald & Aebischer 1999, Morris et al. 2001, Stahlschmidt & Brühl 2012). Among the bird species many rely on rich insect resources and so do insectivorous mammals and to a lesser extent rodent species that consume insects as well. These species groups are directly affected due to the reduction of insect food resources by insecticides. Strictly herbivorous species like geese, the Linnet or the Brown Hare are the only ones not affected by insecticide applications.

Herbicides have a great impact on bird and mammal species as well. One third of our bird species seem to be highly affected by herbicide applications. The reduction of important weed species that function as host plants for insect populations decreases the food availability for many bird species such as the Grey Partridge, Corn Buntings or Yellowhammer (Rands 1986, Ewald & Aebischer 1999, Bradbury et al. 2008). For mammals and for some bird species not only the reduction of plant material and therewith food resources is essential (e.g. Tew et al. 1992) but also the resulting lack of cover (Johnson & Hansen 1969).

Tab. 4.3.1: Classification of negative impacts of different pesticide classes on 27 bird and 22 mammal species based on expert judgment (red= ✥50% of species occur in this category, orange= ✥25% of species occur in this category).

	Birds			Mammals		
	high	medium	no	high	medium	no
Herbicide	9	9	9	10	11	1
Insecticide	14	5	8	13	6	2
Fungicide	0	0	27	0	17	5
Rodenticide	3	0	24	10	8	4
Molluscicide	1	2	24	7	9	6

Poisoning by fungicides represents a risk for several species like Wood Mice that feed on seeds treated with this pesticide agent (Barber et al. 2003). Invertebrate populations may be also affected by fungicide applications which influence the food availability for many bird and mammal species negatively (Ewald & Aebischer 1999). Another negative impact of fungicide applications is their influence on the vegetation structure. The prevention of fungal attacks enables very dense and highly fertilized crops of increasing dimensions. These characteristics of intensive agriculture are, however, key factors in the decrease of farmland wildlife populations. Unfortunately, the extent of the indirect effects of fungicides on farmland bird and mammal species is poorly studied which is reflected by the low impact classification in our evaluation.

Obviously, rodenticides have the most negative impact on rodent species that are directly persecuted and harmed by the application. However, also other mammal species like the Hedgehog, Brown Hares and Wild Boars have been contaminated with this pesticide by consuming the baits (de Snoo et al. 1999, BVL 2009, Dowding et al. 2010). In birds, incidents with poisoned geese and cranes are officially documented (BVL 2009). Other species groups for which rodenticides have a negative impact on are those that prey on species demolished by this pesticide. Birds of prey like the Red Kite and carnivorous small mammals like the Stoat and Least Weasel are highly affected by the reduction of their food resource (Brakes & Smith 2005).

Very little is known about the effects of molluscicides, except for poisoning incidents with for example Hedgehogs, Wood Mice or Hoopoes (Joermann & Gemmeke 1994, Münch 2011, NABU Kreisverband Spreewald 2010, Shore et al. 1997). Insectivorous species that feed on slugs may be at risk due to the reduction of food resources as well as secondary poisoning. Here, especially mammal species like Shrews seem to be at risk.

4.3.2 Application times

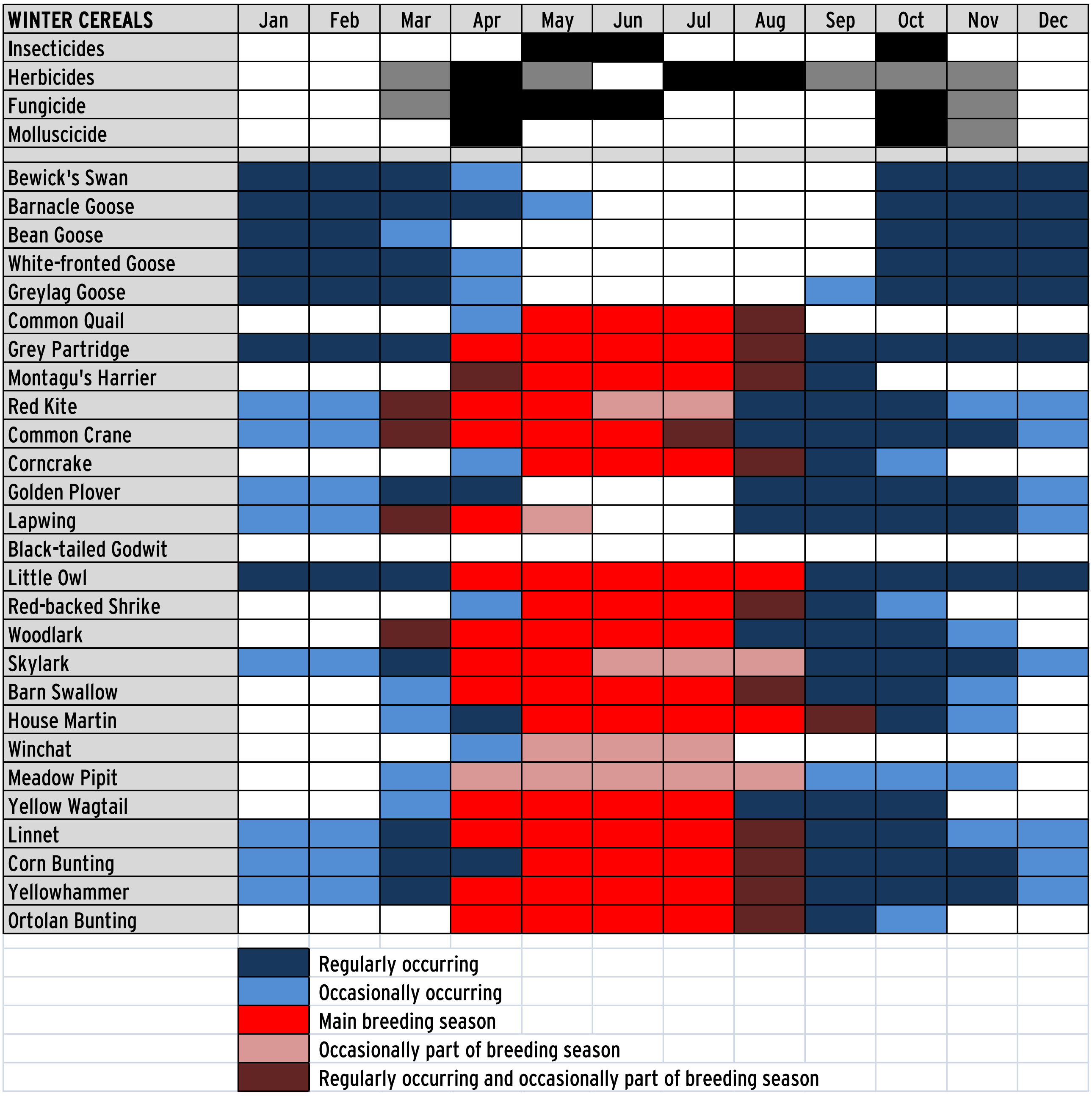
Pesticide application schemes differ between crop types and depend on the growth stage of the crop plants. Bird and mammal species also show differences in their seasonal behavior and occurrence in crops. We therefore looked at the seasonal and crop specific relations of species occurrence and pesticide applications. Unfortunately detailed records on application times on different crops in Germany are not available. Thus, we estimated monthly main and secondary application periods for different crops based on expert judgment (Tab. 4.3.2).

Tab. 4.3.2: Monthly pesticide applications in autumn-sown cereals, rape, maize and sugar beet (black indicates main application period, grey indicates secondary application period, data by D. Holland, in litt.).

Crop	Pesticide	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Winter cereals	Insecticide					■	■				■		
	Herbicide			▒	■	▒		■	■	▒	▒	▒	
	Fungicide			▒	■	■	■				■	▒	
	Molluscicide				■						■	▒	
Rape	Insecticide			■	■	■							
	Herbicide								■	■			
	Fungicide			■	■	■				▒	▒		
	Molluscicide								■	■	▒	▒	
Maize	Insecticide							▒					
	Herbicide				▒	■	■						
	Fungicide												
	Molluscicide												
Sugar beet	Insecticide				■	■	■	▒	▒				
	Herbicide				■	■							
	Fungicide					▒	▒	■	▒				
	Molluscicide				▒	▒	▒						

The seasonal occurrence of bird species in specific crops is mainly driven by behavioural responses to food availability and reproduction activities. Tables 4.3.3 to 4.3.6 show the monthly occurrences of farmland birds in winter cereals, rape, maize and sugar beets together with pesticide application times shown for each month of the year. We did not investigate other crops due to lack of bird data.

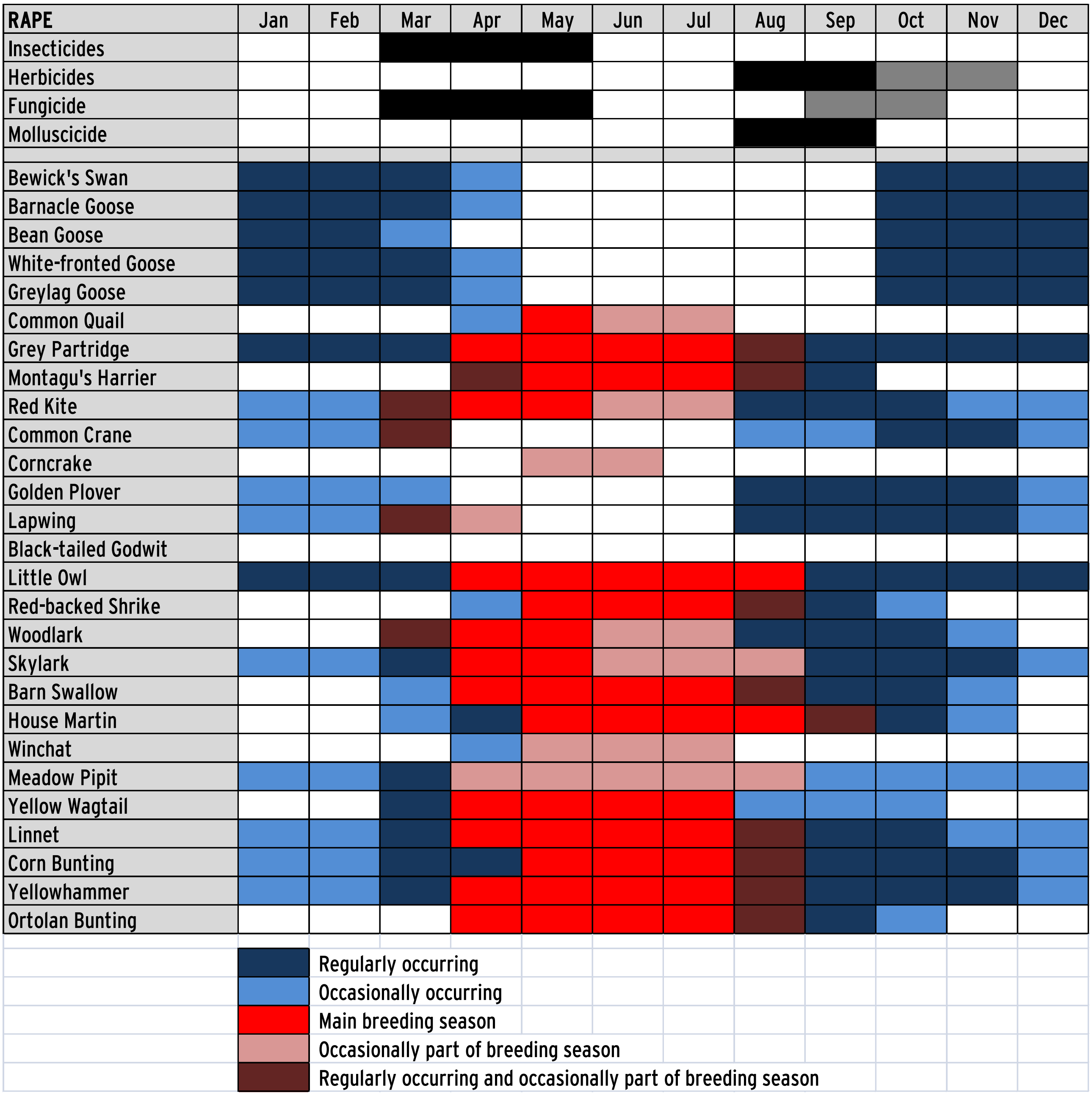
Tab. 4.3.3: Seasonal occurrence of farmland bird species on autumn-sown cereals (sources in Detailed Species Portraits, Annex I) and pesticide application times (data based on D. Holland, in litt.).



Obviously, the main application times of especially insecticides and herbicides fall into the period when many bird species are in their main breeding season from April to June. This holds for three out of the four crops considered here, winter cereals, maize and sugar beets and partly also for rape crops. In winter cereals many bird species may be affected by food shortages due to insecticide applications late in the season when the crop is sown again after the harvest.

Investigations have shown that in summer the effects of insecticide applications on invertebrate numbers are larger than those of autumn applications (Boatman et al. 2004). Summer applications of pesticides (from the beginning of April) are regarded to have greater effects than autumn applications not only on invertebrate populations but also on bird species and other insectivorous vertebrates due to the decreased food availability (DEFRA 2004).

Tab. 4.3.4: Seasonal occurrence of farmland bird species on oilseed rape (sources in Detailed Species Portraits, Annex I) and pesticide application times (data based on D. Holland, in litt.).



Fields sprayed with insecticides during summer had significantly lower invertebrate numbers and biomass than field with no or winter-only applications (Morris et al. 2002, 2004 in Boatman et al. 2004). Furthermore, the foraging density of early nesting Yellowhammers was almost four times higher in fields without insecticide spraying in summer than on crops with summer applications (Morris et al. 2001). This effect on the foraging pattern disappeared later in the year when grain was available.

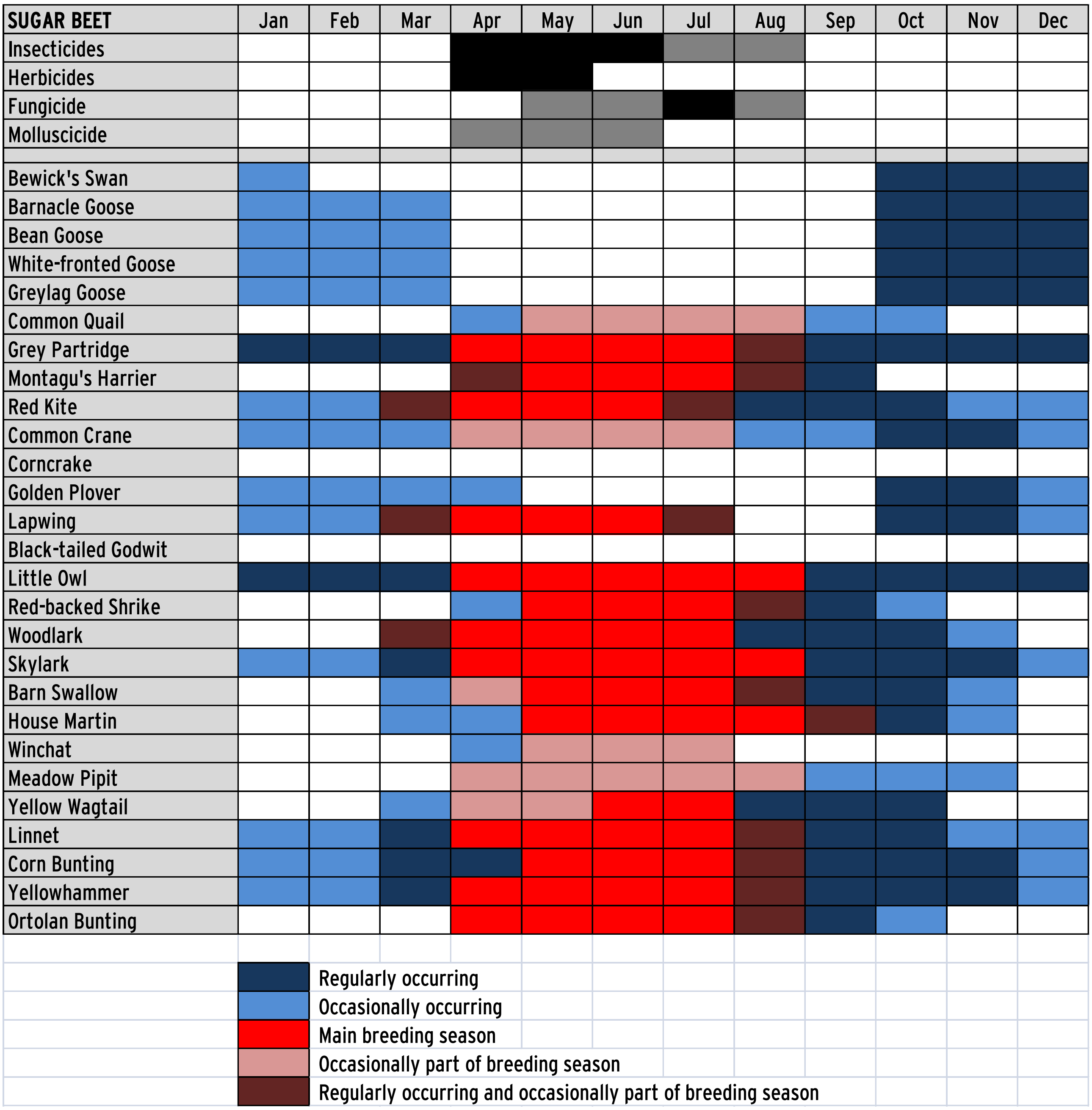
Ewald & Aebischer (1999) state that while summer applications of herbicides were agronomical highly effective they were probably also most damaging from an ecological point of view. During this time when invertebrate food is essential for birds to feed their chicks the destruction of herbs prevented the seed set and eliminated host plants of insects. The same holds for spring and summer insecticide applications (Ewald & Aebischer 1999).

Tab. 4.3.5: Seasonal occurrence of farmland bird species on maize (sources in Detailed Species Portraits, Annex I) and pesticide application times (data based on D. Holland, in litt.).

MAIZE	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Insecticides							(X)					
Herbicides				(X)	X	X						
Fungicide												
Molluscicide												
Bewick's Swan	R	O	O	O						R	R	R
Barnacle Goose	O	O	O							R	R	R
Bean Goose	R	R	O							R	R	R
White-fronted Goose	R	R	R	O						R	R	R
Greylag Goose	R	R	O							R	R	R
Common Quail				O	(B)							
Grey Partridge	R	R	R	B	B	B	B	R/(B)	R	R	R	R
Montagu's Harrier				R/(B)	B	B	(B)	(B)	O			
Red Kite	O	O	R/(B)	B	B	B	(B)	O	O	R	O	O
Common Crane	O	O	(B)	(B)	(B)	(B)				R	R	O
Corncrake												
Golden Plover	O	O	O	O						R	R	O
Lapwing	O	O	R/(B)	B	B	(B)				R	R	O
Black-tailed Godwit												
Little Owl	R	R	R	B	B	B	(B)	(B)	O	R	R	R
Red-backed Shrike				O	B	B	(B)	(B)	O	O		
Woodlark			R/(B)	B	B	B	(B)	O	O	R	O	
Skylark	O	O	R	B	B	B	(B)	(B)	O	R	R	O
Barn Swallow			O	B	B	B	B	R/(B)	R	R	O	
House Martin			O	R	B	B	B	B	R/(B)	R	O	
Winchat				O	(B)	(B)						
Meadow Pipit			O	(B)	(B)	(B)				O	O	
Yellow Wagtail			O	(B)	(B)	(B)						
Linnet	O	O	R	B	B	B				R	O	O
Corn Bunting	O	O	R	R	B	B	(B)	(B)	O	R	R	O
Yellowhammer	O	O	R	B	B	B	(B)	(B)	O	R	R	O
Ortolan Bunting				B	B	B	(B)	(B)	O	O		

R = Regularly occurring
O = Occasionally occurring
B = Main breeding season
(B) = Occasionally part of breeding season
R/(B) = Regularly occurring and occasionally part of breeding season

Tab. 4.3.6: Seasonal occurrence of farmland bird species on sugar beets (sources in Detailed Species Portraits, Annex I) and pesticide application times (data based on D. Holland, in litt.).



Wang & Grimm (2010) found in their modelling study that the population decline of Common Shrews caused by pesticide applications in July was stronger than after applications in April. While during spring the reproduction of Shrews had just started, populations consisted mainly of offspring and juveniles during the summer applications. They conclude that the timing of pesticides but also the landscape structure greatly influences the population recovery.

A pesticide class not considered in the tables above but nonetheless of great importance, especially for many small mammal species, are rodenticides. Rodenticides are used all-year-round but mainly applied in autumn and winter when rodents move from the crops into buildings (Dawson et al. 2000). The timing as well the main location of application in and around buildings may take some pressure from raptors like the Red Kite that are mainly present during the summer months when they hunt on small mammals on crops but mammalian carnivores like the Stoat or the Least Weasel are still affected, especially when they follow their prey closer to farm buildings. Furthermore, in their study on rodenticide use on arable farms in Great Britain Dawson et al. (2000) found that while 49% of rodenticide baits are applied around buildings and 38% inside buildings another 13% are placed away from buildings in field boundaries, woodlands and hedgerows. These locations are intensively used by small mammals particularly during winter when they no longer find enough food on the harvested crops.

4.3.3 References

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4.4 Impacts of indirect PPP effects in the context of an agricultural intensification

In order to evaluate the relevance of indirect effects of pesticides compared to other negative developments in agriculture, we estimated the importance of different threats for all species (Tabs. 4.4.1 and 4.4.2). The sources for this analysis are the detailed species portraits (Annex I) and the references cited therein.

4.4.1 Birds

Due to the lack of detailed studies for many species (chapter 4.1), the relevance of indirect pesticide effects could not be assessed completely for most of the species. Indirect effects were assumed when the composition of diet and the percentage of food taken from sprayed cultures suggested a potentially high impact of pesticides (see chapter 4.2). We regarded invertebrates as well as seeds and green parts of farm weeds as food sources potentially negatively affected be pesticides.

The knowledge of the relevance of different threats differs greatly between species (see detailed species portraits in Annex I). In only very few cases comprehensive analyses were made to detect the most relevant factor driving the population. Often even single factors assumed to be relevant were not experimentally tested, but correlative evidence and a great amount of expert knowledge is available frequently. In some cases the main reasons for population declines are very obvious like habitat loss in the Black-tailed Godwit (Jensen et al. 2008) whilst in other cases it is likely that a multitude of factors which is responsible for a trend.

In order to classify the importance of different factors we distinguished between factors that probably have an effect on the population (source: expert judgement), factors that, at least locally, evidently have a significantly effect on population development and factors which are known to be critical factors for the population development.

We selected categories of threat factors in order to ensure that the factors reported in literature could easily fit into our system. In addition we also tried to make factor categories as independent from each other as possible. Factors “Loss of set-aside, margins etc.” and “Loss of (non-intensive) grassland” were problematic in this respect, because they could not always be clearly distinguished from the literature sources. We had the impression that in a considerable number of cases different authors named grass dominated margins of fields, ditches, farmland tracks and roads differently. Therefore, we tried to avoid over-interpretations of differences between loss of set-aside and loss of grassland. Factors not related to agriculture were just listed.

In most cases it is unknown which population parameter, reproduction or survival, is most relevant for the current trend. Hence, it is not clear whether potential problems occur in the breeding sites and during the breeding season or outside the breeding season and possibly in other countries. In four out of five species for which evidence is available (Grey Partridge, Corncrake, Black-tailed Godwit, Lapwing) effects acting on reproduction are more relevant than effects acting on survival. Red Kite populations are clearly mainly influenced by winter survival (Knott et al. 2009).

Among those species which are considered here mainly because Germany holds large populations on passage or in winter (Bewick’s Swan, geese, Common Crane, Golden Plover) it was hardly possible to detect any important threats. With the exception of Bewick's Swan, all of these species are not declining.

All other species were threatened by several factors each. The factors associated with most species' population trends (21) were the loss of grassland and the indirect effect on pesticides on food. For only four species, however, there is evidence for the relevance of indirect pesticide effects (see chapter 4.1). The third-most often occurring threat was the loss of uncultivated margins and set-aside. When considering only evident threats, loss of grasslands affects most species, loss of uncultivated margins and set-aside becomes second-most important and the fact that most crops become too tall and too dense and therefore unattractive late in the breeding season occupies position three. The factors associated with a medium number of species are most often related to grassland (loss of animal husbandry, mowing). Loss of crop diversity and lack of landscape elements such as hedgerows and bushes are also important for some further species. The factor "increased loss due to predation" has not yet been systematically studied. An increase in predation might be affected by other agricultural factors because many predatory species themselves react on some of the factors evaluated here (Langgemach & Bellebaum 2005).

Tab. 4.4.1 shows that many species are threatened by the loss of habitats that belong to farmland such as grassland, set-aside, bushes and hedgerows, but which are not related directly to the management of arable fields. If these factors are taken away pesticide effects are probably at least as important as decreased crop diversity and too tall growth at the end of the breeding season. The indirect effects of pesticides, however, have not yet been sufficiently studied.

There are no obvious differences in threats associated with species declining and species being stable or increasing. For all severely declining populations it is known that the most critical threats act during the breeding season.

4.4.2 Mammals

The loss of set-aside and uncultivated field margins was the factor threatening most of the mammal species (18; Tab. 4.4.2). It was followed by the loss of hedges, bushes and trees which was associated with 16 of the 22 species. This factor affected most species when considering only evident threats. Field margins as well as hedgerows form very important habitats that provide sufficient food and cover. The loss of these structural elements in intensified agricultural landscapes leads to an elimination of suitable habitat for almost all small farmland mammal species.

The third factor affecting many species (14) was the lack of cover due to pesticides. This reveals the importance of sufficient ground cover for many small mammals to be able to escape from predation during day and night. Unlike for bird species the food shortage due to pesticide applications was affecting fewer species but still almost half of all the 22 considered. However, due to the lack of studies investigating these indirect effects the real potential of these factors is hard to assess.

Agricultural operations like harvesting of crops, mowing of grassland and also ploughing are a direct threat to some small mammals species like the European Hamster (Kayser et al. 2003) or Brown Hare leverets (Edwards et al. 2000). The intensification of grassland utilization (earlier and more frequent mowing) has a negative impact on Hare populations by increasing leveret mortality. Further reason might be higher livestock densities and digestive problems from cultivated grasses (McLaren et al. 1997 in Edwards et al. 2000).

The resulting loss of cover and food shortage after harvest are major threats for species like the Common Vole. After harvesting or mowing range sizes of Common Voles decreased probably as a reaction to less cover and therewith a higher risk of predation (Jacob & Hempel 2003). Many rodent species move out of crops after the harvest. Hamsters as well are especially threatened in periods of low cover in early spring and after the harvest.

Tab. 4.4.1: Threats on the population level to farmland birds in Germany. +: expert judgement, + and light violet shaded cell: at least local evidence, dark violet cell: critical cells. Sources see Detailed Species Portraits (Annex I).

Threats	Trend	Critical threat within breeding season?	Food shortage due to pesticides	Lack of cover due to pesticides	Crops too dense in part of the season	Decreased crop diversity	Fields too large	Loss of set-aside, margins etc.	Loss of (non-intensive) grassland	Loss of animal husbandry	Mowing of grassland and crops	Loss of hedges, bushes, trees	Lack of nest sites	Increase of nest predation	Other important factors
Grey Partridge	<-50%	yes	+	+		+		+	+			+		+	Increase of nest predation
Lapwing	<-50%	yes	+		+	+		+	Critical	+	+			+	Increase of nest predation
Black-tailed Godwit	<-50%	yes							Critical	+	+			+	Increase of nest predation
Red Kite	-50% - -20%	no	+		+	+		+	+	+					Illegal poisoning, mortality due to traffic, electrocution and windfarms
Skylark	-50% - -20%		+	+	Critical	+	+	+	+		+			+	Increase of nest predation
Barn Swallow	-50% - -20%		+			+			+	Critical		+	+		
House Martin	-50% - -20%		+						Critical	+		+	+		
Winchat	-50% - -20%		+			+		+	Critical	+	+				
Meadow Pipit	-50% - -20%		+	+	+			+	Critical	+	+				
Linnet	-50% - -20%	probably	+				+	+	+			+	+		Loss of farm weeds
Corncrake	stable	yes	+					+	+	+	Critical				
Little Owl	stable		+		+	+	+		Critical	+		+	+		
Red-backed Shrike	stable		+					+	+	+		+	+		
Yellow Wagtail	stable		+	+	+	+		+	+	+	+				
Yellowhammer	stable	not solely	+		+	+	+	+	+			+			
Ortolan Bunting	stable		+	+	+	Critical	+					+			
Common Quail	20% - 50%		+	+	+	+		+							
Montagu's Harrier	20% - 50%		+		+			+	+		+				
Wood Lark	20% - 50%		+	+	+			+	+						
Corn Bunting	20% - 50%		+	+	+	+		Critical	+		+	+			

Tab. 4.4.2: Threats on the population level to farmland mammals in Germany. -: expert judgement, + and light violet shaded cell: at least local evidence, dark violet cell: critical cells. Sources see Detailed Species Portraits (Annex I).

Species	Food shortage due to pesticides	Lack of cover due to pesticides	Crops too dense in part of the season	Decreased crop diversity	Fields too large	Loss of set-aside, margins etc.	Loss of (non-intensive) grassland	Loss of animal husbandry	Mowing of grassland and crops	Loss of hedges, bushes, trees	Lack of nest sites	Increase of nest predation	Predation	Other important factors
European Hamster		+		+	+	+			+				+	Intensive agricultural operations, direct take (illegal killing, traffic kills)
Field Vole		+				+	+		+					
Common Vole		+				+	+		+					Intensive agricultural operations (harvesting, ploughing, harrowing)
Striped field Mouse		+				+				+				
Yellow-necked Mouse		+				+				+				Forest management, habitat fragmentation
Wood Mouse	+	+				+			+	+				
Harvest Mouse	+					+			+	+	+			Habitat destruction
Bicoloured Shrew	+				+	+				+				
Greater white-toothed Shrew	+	+			+	+				+				
Lesser white-toothed Shrew	+	+			+	+				+				Habitat destruction
Common Shrew	+	+			+	+				+				
Pygmy Shrew	+	+			+	+				+				
European Hedgehog		+			+	+				+				Traffic kills
European Mole						+	+							Direct take (illegal killing)
Brown Hare	+	+	+	+	+	+	+		+	+			+	Intensive agricultural operations, climate change, legal killing
Greater mouse-eared Bat							+	+		+	+			Forest management, habitat fragmentation
Natterer's Bat							+	+		+	+			Forest management, habitat fragmentation
Common Noctule						+	+	+		+	+			Forest management, habitat fragmentation, kills by wind turbines
Stoat		+				+				+				Legal killing
Least Weasel	+	+				+				+				Legal killing
Fallow Deer														
Wild Boar														

The increase of autumn sown crops results in a food shortage for Brown Hares during summer when reproduction is at its peak and therefore most threatens Hare populations (Wincentz 2009, Reichlin et al. 2006, Tapper & Barnes 1986). Further, mature cereal crops are too dense for Hares to move through.

4.4.3 References

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4.5 How do pesticides shape modern agriculture?

4.5.1 Introduction

Pesticides may have direct (poisoning) and indirect effects (removing food and shelter) on birds and mammals (de Snoo et al. 1999, Boatman et al. 2004, Bright et al. 2008). Pesticides may also have secondary effects on birds and mammals in a way that they allow farming practices which are harmful to birds and mammals independently of and in addition to the direct and indirect effects of pesticides. An example of these effects is the current practice of cultivating autumn-sown wheat. From May/June onwards wheat fields are very dense stands of relatively small stems. Wheat fields in May/June are too dense to offer suitable breeding sites for most farmland birds (see chapter 4.4). The microclimate within the stands is damp and favours the growth of harmful fungi. Without the excessive application of fungicides (see Fig. 4.3.3 in chapter 4.3) the cultivation of autumn-sown wheat as it is performed presently would not be possible. In this case pesticides play a crucial role in the farming practice which itself is harmful to farmland birds. Pesticides thus have a double indirect effect on farmland birds because they facilitate a harmful farming practice even if there are no toxic effects or indirect effects on food or cover.

In order to detect such kinds of double indirect effects we compare the present conventional farming to a hypothetical farming practice in which neither synthetic nor organic pesticides exist but in which all other production factors like machinery, synthetic fertilisers and other farming practices are present. Such a farming practice, furtheron called pesticide-free conventional farming, is purely imaginary. The comparison of pesticide-free conventional farming and conventional farming, therefore, can not be based on data. Instead it is a simulation of a scenario in order to highlight some effects of PPPs. The view on the imaginary pesticide-free conventional farming is aided by present features of organic farming, although there are considerable differences between present day organic farming and the hypothetical pesticide-free conventional farming. Amonge these differences are the application of organic pesticides in organic farming and many of the specific regulations with organic farming. We develop a scenario how modern farming without applications of pesticides would look like and use the data of chapters 3 and 4.4 as well as expert opinion to estimate the effects of PPP-free farming on population trends in farmland birds.

We did not try to include farmland mammals because, due to lack of data, there is not enough evidence for the relationships between agricultural features and population trends.

4.5.2 Risk-management in pesticide-free conventional agriculture

In pesticide-free conventional farming more care has to be taken to minimize losses due to agricultural pests. Risks of pest damage have to be integrated into decisions on which crop to grow and how to organize farming. Precautionary activities for pest control will replace chemical treatments of single crops. Here we describe some possible measures against crop pests in a pesticide-free agriculture.

Mechanical pest control

Mechanical weed control by harrowing and currycombing is the most important measure against pest weeds. It also may harm populations of pest rodents (and Brown Hares).

Mechanical weed control does not completely eradicate farmland weeds so that some food is left for birds and mammals. Mechanical pest control potentially threatens farmland mammals, amphibians and ground nests of farmland birds. The density of tractor tracks rises because the working width of mechanical pest control is much less (12 m) than of pest control by spraying (52 m). In practice, periods of mechanical treatments and breeding periods do not overlap very much (Stein-Bachinger et al. 2010).

Biological pest control

Biological pest control is usually based on artificially introducing useful species. These useful species usually are natural enemies of pest species. Examples are ladybirds introduced in vineyards in order to control aphids (Lillig 2008). Other examples are setting up nest boxes for insectivore birds and the cultivation of ichneumonids to control insect pests (Zimmermann 2004). In Germany there are lists of useful species and their possible application (Fortmann 2000). Great care has to be taken when selecting useful species. Non-native species must not be introduced. Useful species should be highly specialized in order to avoid damage on non-target organisms. Biological pest control usually is quite difficult because populations of useful species (e.g. ladybirds) grow slower than those of pest species (e.g. aphids).

Biotechnical pest control

Pest control can also be achieved by biomechanical measures. Examples are traps or sticky strips for insects. Again, these methods often do not work very well on crops grown on a large scale. The economic effect often is very small.

Selection of resistant and robust breeds/crops

Crops and breeds of crops differ in resistance against fungi and other pests. In pesticide-free conventional farming, more resistant breeds will be selected. The yield of these breeds could be smaller than the yield of presently grown brands but the risk of severe losses due to pests would also be reduced. The share of tall-growing strains will increase because their stands are kept dry by the wind and thus suffer less from fungal infection. Moreover, tall-growing crops suppress pest herbs better than small growing crops. Tall growing crops, however, are more susceptible to twisting. The twisting risk may be reduced by reducing fertilization. Potentially, genetically modified plants bearing resistances would be established. There is also evidence that genotypic diversity within crops reduces pest abundance and damage (Tooker & Frank 2012).

Other on field risk management

Besides using different breeds, on field risk management like sowing wide rows in order to prevent losses caused by harmful fungi may become more important when pesticides are not applicable. It is not sure, however, whether growing crops in wide rows will be economically competitive.

Undersown crops

Undersown crops can suppress pest weeds, can improve the soil fertility, can reduce erosion and may be used as fodder after the harvest of the principal crop (Haas 2004). Undersown crops have to be selected specifically in order not to compete with the principal crop in regard to light, water and nutrients. Undersown crops are expensive and may raise additional problems if not properly integrated into crop sequencing.

Growing of clover, alfalfa or grass

Perennial cultivation of a clover-grass mixture or legumes like alfalfa could suppress pest herbs. In addition these crops have a phytosanitary effect by controlling soil-bound plant diseases.

Mixed crops

Mixed crops can reduce the speed of pathogen dispersal because they suppress the probability for a pest agent to find a new host plant at close distance. The risk of complete failure is reduced because it is less likely that all components of a mixed crop fail at the same time. As the stands may be dense, pest weeds are suppressed.

Crop diversity

Crop diversity, both in space (many different crops per farm) and time (comprehensive crop rotation, avoidance of monocultures) is an essential element in the control of harmful fungi, weeds and other pests. When crops change annually pest which are often specialized on one crop are less likely to get established. Moreover, the spread of pests is likely to be slowed down when non-host crops form a barrier between an infected and a non-infected field.

Structural elements

Creating structural elements such as hedgerows, uncultivated strips and flower strips helps separating crops and restrict activities of pest agents. Naturally occurring biological control agents can find refuges in structural elements. Structural elements improve the stability of farmland ecosystems and reduce the risk of pest outbreaks (Letourneau et al. 2012).

In Germany fungicides, herbicides and insecticides are the most commonly applied pesticides. Further on, growth regulators, molluscicides and rodenticides are also used frequently (see chapter 2). As shown above, alternative measures for pest control are known in principle. They have not been applied in conventional agriculture for many years because pesticides applications are relatively cheap, also in terms of manpower, and they deliver higher yields with less risk of losses due to pests. Therefore, pesticide free agriculture (except applications of organic pesticides) is only practiced in organic farming. Organic farming differs from conventional farming in many aspects such as fertilising methods or choice of plant breeds. Therefore, the efficiency and the extent of the alternative pest control methods can hardly be estimated. There are no studies of the effects of pesticide-free agriculture (except organic farming) at a landscape wide scale. Table 4.5.1 gives a rough estimate on which methods could be applied in order to substitute different pesticides classes.

Tab. 4.5.1: Substitutes for pesticides controlling different pest classes (own estimates).

Pests	Fungi	Farmland weeds	Insects	Rodents	Molluscs	
Substitutes for PPP	Fungicides	Herbicides	Insecticides	Rodenticides	Molluscicides	Growth-regulators
Mechanical pest control		x		x	x	
Biological pest control	x		x		x	
Biotechnical pest control			x	x	x	
Selection of resistant and robust breeds/crops	x	x	x			x
Other measures of on field management (wide row)	x	x	x	x		
Cultivation of undersown crops		x				
Cultivation of clover, grass and legumes		x	x			
Cultivation of mixed crops	x	x	x		x	
Crop diversity in space and time	x	x	x		x	
Structural elements	x		x		x	

It would be very speculative to predict which sort of pest control would be applied to what extent. Under the scenario of pesticide-free conventional farming it can be assumed that these and possible other methods of pest control would be more elaborated and would work much better than they do now because much more research would have been devoted to them.

In general the measures of pest control resemble those applied in organic farming. Compared to conventional farms organic farms have

- more frequent mechanical pest control,
- different crop breeds,
- more frequently alternative forms of on-field management like wide-spaced rows,
- a higher share of undersown crops,
- more grass-clover or legume crops,
- more mixed crops
- higher crop diversity (both in space and time)
- on average smaller fields resp. divided fields with two or more cultures in strip form (not in all regions).

Several studies give evidence for a higher biodiversity on organic farmland compared to conventional farmland. Densities of birds breeding on farmland such as Skylark, Grey Partridge and Whinchat on average are higher on organic than on conventional fields (Pfiffner & Balmer 2009, Neumann et al. 2007, NABU 2004). Also rare farmland weeds and ground beetles have higher diversities on organic fields compared to conventional fields (Gabriel et al. 2006, Gabriel & Tscharntke 2007, Pfiffner & Luka 2003). However, as well as in conventional farming, in organic farming there is a trend to intensify management including applications of organic pesticides. Not all organic fields are more species-rich than conventional fields (Oppermann et al. 2003).

One of the main differences between existing organic farming and the hypothetical pesticide-free conventional farming would be the application of synthetic fertilisers and, perhaps, the possible growing of genetically modified crops in PPP-free conventional farming. It remains an open (and academic) question how far an PPP-free agriculture would adopt methods and management from organic farming, e.g. choice of more robust breeds, machinery for cultivation and weed control, use of legumes and wide rows etc..

In order to conclude, the compilations above show that alternatives for pest control without pesticides exist. They are associated with a substantial increase in farming effort. The yield per ha for most if not all products would drop to a certain degree. This in turn would probably mean an increase in producer prices, but not necessarily a loss of farmers' incomes. As pests would have a greater influence on productivity and productivity generally would drop prices for agricultural products will be higher.

4.5.3 Exploration of the effects of PPP-free farming on birds

In a pesticide-free conventional agriculture there would probably be more crop diversity, both in space (more different crops per farm) and time (comprehensive crop rotation). Consequently fields theoretically should become smaller. The effectiveness of farming, however, is very closely related to field size. Big machinery, a prerequisite for cost-effective farming large areas, can only be used efficiently on large fields. It would therefore be quite uncertain whether the effect of refraining from applying pesticides is reduced field sizes.

Mixed cultures, undersown crops and grass-clover or legume fields will become more abundant in a non-PPP scenario. Some crops will grow higher due to changed choice of breeds, others will become less dense. Mechanical weed control will be widespread. Perhaps also structural elements like tree rows or hedgerows will become more abundant. Generally, it can be assumed that arable fields would be richer in wild herbs and insects.

In pesticide-free conventional farming it is very likely that the high market pressure on land will remain, due to less productivity. Set-aside, therefore, will continue to vanish. Moreover, set-aside will be seen as a seed source of problematic weeds like thistles. At present set-aside covers only a small percentage of farmland in Germany. Under the scenario of pesticide-free conventional farming the increase in area covered by grass, clover and other legumes is expected to be much higher than the loss of set-aside.

We tried to obtain an idea how the replacement of pesticides by alternative methods of pest control would affect crucial parameters for farmland birds (Tab. 4.5.2). Based on table 4.5.2 we estimated how population trends of farmland birds would change if the current agricultural system was transferred into a pesticide-free conventional farming system. We investigated single factors and decided by referring to literature cited in Annex I or expert opinion whether the change of these factors under a PPP-free scenario would have a positive or a negative effect on the population trend (Tab. 4.5.3). Finally we weighted the effects of the factors and estimated an overall effect of pesticide-free conventional farming on trends. In the following paragraphs we explain our judgements for all species.

Tab. 4.5.2: Effects of the use of pesticide substitutes for key criteria for the occurrence of farmland birds. The results given in this table derive from own estimation based on long-term experiences in monitoring of farmland birds.

Effects / Substitutes	Higher availa-bility of inverte-brates	Higher availa-bility of rodents	More herbs on fields	Increase of crop diversity	Multiple crop fields	Less dense vegeta-tion on fields	Clover and clover-grass	Less set-aside
Mechanical pest control	x	x	x			x		
Biological pest control	x	x	x					
Biotechnical pest control	x	x	x			x		
Selection of resistant and robust breeds/ crops				x				
Other measures of on field management (wide row)			x	x		x		
Cultivation of undersown crops				x			x	
Cultivation of clover, grass and legumes				x			x	x
Cultivation of mixed crops				x	x			x
Crop diversity in space and time				x	x		x	
Structural elements	x	x						

Bewick's Swan, geese species, Common Crane, Golden Plover

Bewick's Swans, all geese species mentioned in this report, Common Cranes and Golden Plovers mainly use farmland in Germany outside the breeding season. They seem to be only marginally affected by changes due to absence of PPP in agriculture. However, there is circumstantial evidence that geese and swans prefer to feed on rather conventional farmland than on organic farmland or on non-intensively managed farmland (M. Flade and H. Jeromin, personal communication). We assume that their population trends would not be changed under a PPP-free scenario.

Common Quail

In the scenario of pesticide-free conventional farming Common Quails would greatly profit from a better availability of food and from higher crop diversity. It is very likely that these factors would more than offset possible negative effects of further losses of set aside. Mechanical herb control which is common practice in organic farming does not seem to be very problematic for Common Quails. Common Quails clearly prefer organic over conventional fields. In conclusion pesticide-free conventional farming is expected to positively affect Common Quail trends.

Grey Partridge

For the same reasons as for Common Quails the effects of pesticide-free conventional farming on Grey Partridges are estimated to be positive.

Montagu's Harrier, Red Kite

Both species can profit from an increased density of rodents, from higher crop diversity and from more grass and legumes. The latter will more than offset possible losses of set-aside.

Corncrake

Under the scenario of pesticide-free conventional farming arable fields might become more attractive to corncrakes. Grassland will increase in size. We therefore estimate a slight positive effect of pesticide-free conventional farming on the population trend of Corncrakes.

Lapwing

The positive effects of increased food availability on arable land and (perhaps) increased area of grassland will offset the negative effects of loss of set-aside and increased mechanical weed control.

Black-tailed Godwit

Black-tailed Godwits very rarely breed on arable land. The grassland which would appear under a pesticide-free conventional farming scenario is probably unsuited as breeding habitat. In conclusion, no effect is expected.

Little Owl

Little Owls would profit from increased food availability (insects and rodents), from increased crop diversity and from an increase in grassland.

Red-backed Shrike

Red-backed Shrikes would profit from increased food availability (insects), from increased crop diversity and from an increase in grassland and legumes/leys. These advantages for the population would be stronger than the predicted loss of set-aside. In total pesticide-free conventional farming is expected to have a positive effect on the population trend of Red-backed Shrikes.

Woodlark

Woodlarks would profit from increased food availability (insects), from increased crop diversity, less densely growing crops and from an increase in grassland. These advantages for the population would be stronger than the predicted loss of set-aside and the nest losses due to increased mechanical weed control. In total pesticide-free conventional farming is expected to have a positive effect on the population trend of Woodlarks.

Skylarks

As Woodlarks, Skylarks would profit from increased food availability (insects), from increased crop diversity, less densely growing crops and from an increase in grassland. These advantages for the population would be stronger than the predicted loss of set-aside and the nest losses due to increased mechanical weed control. Mechanical herb control which is common practice in organic farming does not seem to be very problematic for Skylarks. When a field becomes attractive to Skylarks, the vegetation often is already too high for harrowing (Stein-Bachinger et al. 2010). Skylarks clearly prefer organic over conventional fields. McKenzie et al. (2011) found a negative effect on feeding sites selection in wintering Skylarks of pesticides but not of fertilizers. In total pesticide-free conventional farming is expected to have a positive effect on the population trend of Skylarks.

Barn Swallow, House Swallow

Both swallow species would profit from increased food availability (insects), from increased crop diversity, less densely growing crops and from an increase in grassland and legumes. The total effect of pesticide-free conventional farming thus would be positive.

Whinchat

On arable land, at present, Whinchats are strongly associated with set-aside due to the unfavourable conditions on farmed arable land. It is expected that positive effects of increasing food availability and of new of habitats on clover, clover-grassland and legume fields in a pesticide-free conventional farming scenario will overrule the further loss of set-aside.

Meadow Pipit

Increases in food availability, cover on fields and grassland will probably more than outweigh the losses of set-aside.

Yellow Wagtail

Increases in food availability (insects), crop diversity, grassland and legumes are expected to have a stronger effect on population trend than possible nest losses due to mechanical herb control.

Corn Bunting, Yellowhammer

Both species will strongly profit from increased food availability, better cover on arable field, higher crop diversity and more grassland and legumes. It is expected that these benefits will weigh more than the predicted losses of set-aside. As Corn Buntings are very strongly associated with set-aside, the prediction is somewhat unsure.

Ortolan Bunting

Nearly all features associated with the hypothetical pesticide-free conventional farming have a positive effect on the population trend of Ortolan Buntings. Only few if any nests will be affected by mechanical weed control which usually takes place before Ortolan Buntings start to nest.

General literature data

Donald et al. (2001) showed that population trends of farmland birds across Europe were correlated with the development of yield in different countries. Yield was used as a proxy of agricultural intensification. Geiger et al. (2010) tried to disentangle the effects of different components of farming intensification. For the number of breeding bird species the only significant variable factor they found was the frequency of fungicide application. Birds do not feed on fungi and it is unlikely that the fungi have a very strong effect on the food chain. The correlation mainly reflects the fact that fungicides are used to allow the cultivation of dense crops which in turn hinder farmland birds from breeding.

4.5.4 Conclusions

Table 4.5.3 shows that most of the selected farmland bird species breeding in Germany profit from agriculture without pesticides. Great effects on the species occurring in Germany outside the breeding season are not expected.

The expected positive effects on breeding farmland birds are partly due to increased food availability (insects, rodents, farmland weeds). Suppressed food availability is a typical indirect effect of PPP application (see chapter 4.1). The expected increases of grassland and legumes, of multiple crop fields, of less dense stands of cereals and of crop diversity under a PPP-free scenario also play an important role for the expected positive effects. These all refer to double indirect effects of pesticide applications. Pesticide applications lead to reduced crop diversity and remove the reasons for having multiple crop fields, less dense stands of cereals and more grassland and legumes. As these are important factors for many populations of farmland birds, the effect of PPP-applications is not only visible in direct and indirect effect but also in these double indirect effects. Table 4.5.3 suggests that the double indirect effects (through crop diversity, multiple crops, density of crops, grass and legumes) are widespread among farmland birds breeding in Germany. For at least two species, Skylark and Ortolan Bunting, double indirect effects are seen to be the most critical factors governing the population trends (density of stands, crop diversity, see Tab. 4.4.1).

Pesticides are an integral part of modern farming. Without pesticides farming would look very different and would be much more beneficial to farmland birds breeding in Germany. Without being able to quantify the effect of pesticides exactly, we conclude that pesticides have had and still have a huge effect on population trends of farmland birds. Geiger et al. (2010) come to the same conclusion in respect to farmland birds and other biota. Indirect and double indirect effects should be considered in risk management strategies.

Certainly there are important benefits of pesticide applications for crop production. However, the use of pesticides in agriculture has led to tremendous changes in the farming practices causing negative impacts on many farmland species. The sustainability of the current practice of PPP application, therefore, has to be risen to question. It is doubtful whether the headline target of the EU biodiversity strategy (COM (2011) 244 final) "*halt the loss of biodiversity and the degradation of ecosystem services in the EU by 2020*" can be reached by the current farming and the intensive pesticide use. In support of target 3 of the EU biodiversity strategy ("Increase the contribution of agriculture and forestry to biodiversity") it seems inevitable that both indirect and double indirect effects of PPP applications have to be considered in risk management strategies for pesticides.

Tab. 4.5.3: Expected effects on population trends on farmland birds of a hypothetical conventional agriculture without pesticides (see text for more explanations). The central part shows the expected effects on population trends of single factors which differ between conventional and PPP-free conventional agriculture. The last column gives a judgment of the overall effect of all factors.

Species	Status	Current trend	Expected development of ecological key factors											Expected trend
		Trend in Germany	Higher availability of inverte-brates	Higher availability of rodents	More herbs on fields	Decreased yield	Increased crop diversity	Multiple crop fields	Less dense vegetation on fields	More grassland, clover/grass and legumes	Less set-aside	Biological pest control	More mechanical herb control	
Bewick's Swan	passage	declining				-	-			+				-
Barnacle Goose	passage	increasing				-	-			+				-
Bean Goose	passage	stable				-	-			+				-
White-fronted Goose	passage	stable				-	-			+				-
Greylag Goose	passage/breeding	increasing				-	-			+				-
Common Quail	breeding	increasing	+		+		+	+	+		-		-	+
Grey Partridge	breeding	declining	+		+		+	+			-			+
Montagu's Harrier	breeding	increasing		+			+	+	+	+	-			+
Red Kite	breeding	declining		+			+	+	+	+	-			+
Common Crane	passage/breeding	increasing	+			-	-			-	+			-
Corncrake	breeding	stable	+		+				+	+	-		-	+
Golden Plover	passage	increasing	+				-	-			+			-
Lapwing	breeding	declining	+							+	-		-	+
Black-tailed Godwit	breeding	declining	+							+				0
Little Owl	breeding	stable	+	+			+	+		+				+
Red-backed Shrike	breeding	stable	+	+	+					+	-			+
Woodlark	breeding	increasing	+		+		+		+	+	-		-	+
Skylark	breeding	declining	+		+		+	+	+	+	-		-	+
Barn Swallow	breeding	declining	+		+		+	+		+				+
House Martin	breeding	declining	+		+		+	+		+	-			+
Whinchat	breeding	declining	+		+				+		-			+
Meadow Pipit	breeding	declining	+		+					+	-			+
Yellow Wagtail	breeding	stable	+				+		+	+			-	+
Linnet	breeding	declining			+	-	+	+		+	-			0
Corn Bunting	breeding	increasing	+		+	-	+		+	+	-		-	+
Yellowhammer	breeding	stable	+		+	-	+	+		+	-			+
Ortolan Bunting	breeding	stable	+		+	-	+		+		+		-	+

4.5.5 References

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4.6 Conclusion: Evaluation of whether the current practice of PPP usage supports conservation goals for affected species

4.6.1 Conclusions

The data compiled in the preceding chapters show that the evidence for indirect effects of pesticide application on the population trends of farmland birds and mammals is limited to a few well studied species (chapter 4.1). Obviously it is very difficult and very time-consuming to distinguish between the effects of pesticides and all other effects acting on farmland bird and mammal populations at the same time (Boatman et al. 2004).

The population relevance of reported indirect effects also depends on the conservation status of the local population of the affected species. Whereas for species in a favourable conservation status of the local population indirect effects might not necessarily result in a population-relevant impact this might more likely be the case for species in an unfavourable conservation status.

Moreover, relevant studies are not available from all countries where PPPs are applied. Quite the contrary, in most countries indirect effects of PPPs have not been addressed at all. Research efforts on farmland birds have been particularly strong in the UK. Indirect effects of pesticides on species not or scarcely occurring in the UK such as Red-backed Shrike and Ortolan Bunting, therefore, had a relatively low chance of being detected.

Most pesticide application times coincide with the reproductive period of farmland birds and most farmland mammals which is the most stressful period in the annual cycle. This holds true in particular for altricial birds and lactating mammals.

The pesticide sensitivity index for farmland bird and mammal species (chapter 4.2) indicates that very probably many more species than those that have been studied are indirectly affected by PPPs. It should be kept in mind that the pesticide sensitivity index is largely based on the exposure of birds and mammals to sprayed cultures. The exposure is measured by the percentage of time spent foraging on sprayed cultures. If birds or mammals avoid cultures because they are sprayed the index will be suppressed.

The generally good performance of farmland birds on organic farms where synthetic pesticides are not applied gives another hint for a relatively large influence of spraying on farmland bird populations.

The data presented in chapter 3.2 give evidence for a clear preference of farmland birds and mammals for non-sprayed habitats such as grassland, grassy field margins, set-aside etc. There are admittedly more differences than just the spraying regime between grassland, set-aside, unmanaged stripes and agricultural crops. The fact that margins, grasslands and fields set aside receive fewer if any pesticide applications, however, contributes to these differences.

The analysis of threats of farmland birds and mammals again reveals the indirect effects of pesticides and the loss of unsprayed habitats as the most important factors acting on the populations. As mentioned before there is little empirical evidence for the factor first mentioned, but it is a very often heard expert judgement. Obviously, in order to persist, populations of wild farmland birds and mammals need certain amounts of natural or semi-natural (unsprayed) habitats scattered within arable landscapes (Potts 1986, Hoffmann et al.

2012). It is highly probable that a completely sprayed arable landscape could not hold any breeding birds and very few mammals.

Some of the other factors that have led to severe declines of populations of farmland birds and mammals are also related to PPP applications. Without applying pesticides, for example, the dense stands of winter cereals would frequently fall victim to harmful fungi or other pests. Hence, pesticide application allows the growth of dense winter cereal crops which are unsuitable for almost all farmland birds in the second half of the breeding season. The switch from summer to winter cereals is one of the reasons for the declines of several farmland bird species (chapter 4.4). Chapter 4.5 indicates how much PPPs enable a way of farmland management that itself is harmful to birds and mammals.

Despite little direct evidence, the collection of information in chapters 3 and 4 indicates very clearly, that pesticides have strongly contributed to the decline of many populations of farmland birds and mammals. Obviously, the current practice of PPP usage does not support given conservation goals for affected species. The most recent declines of farmland birds can be linked to the disappearance of the last unsprayed habitats in their home ranges.

In order to turn the populations into a favourable conservation status, the risk management for pesticide applications has to be improved. Indirect effects of pesticide applications have to be taken into account. In chapter 5 we investigate which risk management measures are available and feasible and how these could be implemented.

4.6.2 References

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5 Risk management

The analysis of the risk situation of birds and mammals of the agricultural landscape reveals that many species are indirectly affected by the use of pesticides. In order to prevent negative population-relevant effects that result from the use of pesticides or their combination with other stressors, or reverse those already affecting population development it is essential to take suitable counter-measures.

At the start of chapter 5.1 possible measures to minimise and compensate for the effects of pesticides on birds and mammals in the agricultural landscape (risk management measures – RMM) are listed, briefly described and achievable synergy effects are discussed (chapter 5.1.1). This is followed by a presentation of their technical suitability for the protection of the birds and mammals under study (chapter 5.1.2). In addition to technical suitability it is, however, crucial to determine whether and to what extent the measures are viable in practice; that is to what extent practicability, acceptance and controllability are given. In addition, the customary agri-environmental programmes (AEPs) currently implemented are analysed. The extent and level of participation of these measures give an indication of the prospects for implementation of RMMs in practice (chapter 5.1.3). The consolidation of the corresponding tables on technical suitability and implementation practicability highlight those measures particularly relevant for a broad-based realisation of risk management (chapter 5.1.4).

In a further step, a target species concept is developed in chapter 5.2.

Building on both of these sub-chapters, a strategy for implementation of RMM in the agricultural and funding policy practice is discussed in chapter 5.3. This includes a review of existing risk management strategies and, on this basis, an elaboration of methods for realisation and funding of a broad-based risk management.

Finally, a cost-benefit analysis of the risk management follows in chapter 5.4.

5.1 Risk management measures (RMMs)

The RMM discussed in this paper include all conceivable measures that appear in principle to be potentially suitable to reduce or compensate for the direct and indirect effects of the use of pesticides. This compilation comprises both measures practised currently (e.g. in the framework of agri-environmental programmes or contractual nature conservation measures) as also measures that were only of a theoretical nature until now but that should in principle be possible to implement (e.g. the development of herbicides with very specific effects that only affect individual problem weed species). With respect to currently practised measures, all German federal state agri-environmental programmes that offer measures for preservation and improvement of biodiversity on farmland were studied. Regarding agent-related measures, the relevant literature was scrutinised in order to establish what reduction measures exist. Other conceivable measures were supplemented. In a second step, the measures are evaluated in terms of their actual suitability and acceptance. Some of the measures described here are scarcely feasible or will find little acceptance – nonetheless none of the measures considered are excluded at the outset, but rather a comprehensive overview of all thinkable measures is presented in this chapter. The subsequent analysis then presents the package of those measures that appear most suitable to be implemented in practice (see chapter 5.1.4).

5.1.1 Description of possible RMMs

Generally, there is a variety of different conceivable RMMs which, depending on their approach, can be sub-divided into direct (pesticide agent-related and application-related) and indirect (landscape-related in-crop and off-crop) measures (Fig. 5.1.1). Below, the generally possible RMMs are presented, their implementation and theoretical background described, and possible synergy effects in terms of the benefits for other taxa and ecosystem functions are mentioned.

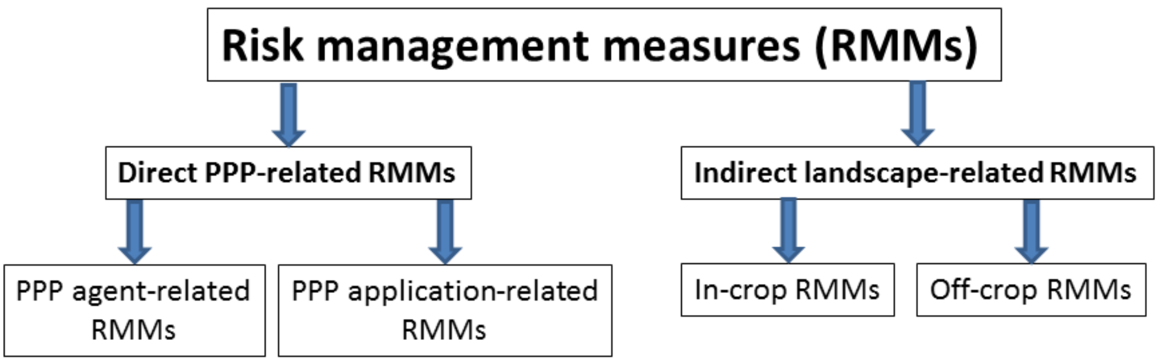

Fig. 5.1.1: Groups of risk management measures (RMMs).

No application of non-selective, broad-spectrum herbicides

Implementation and description

Broad-spectrum herbicides eliminate a large part of the plant species spectrum at the basis of the food chain and thereby have particularly wide-scale effects on the diversity of agricultural biocenoses. Direct toxic effects of broad-spectrum herbicides on non-target organisms are provable and are probably underestimated. For example glyphosate has toxic effects on amphibians and causes serious population declines (Relyea 2005) and can lead to cell damage and cancer growth in humans (Marc et al. 2002; Eriksson et al. 2008; Benachour & Séralini 2009; Gasnier et al. 2009).

The application of broad-spectrum herbicides should be limited because of their toxic effects for amphibians and above all their indirect effects on birds and mammals (see chapter 4.1.2). The most effective measure is to give up using broad-spectrum herbicides altogether and replace them with plant cultivation measures (e.g. crop rotation, crop type selection and undersowing), through mechanical weed control and /or herbicides with selective effects.

Synergy effects for other taxa

Because a restriction of the use of broad-spectrum herbicides enhances the abundance and diversity of wild plants as primary producers, it is beneficial for species on all trophic levels. Amphibians could profit in particular, as it has been proved that these are also affected by direct toxic effects of glyphosate, the most widely used broad-spectrum herbicide (see above).

Fig. 5.1.2: Use of broad-spectrum herbicide in viticulture. Picture: R. Oppermann.

No application of pre-sowing, pre- and post-emergence herbicides

Implementation and description

Herbicides account for 54 % of the pesticides applied in Germany. The most widely used herbicides in Germany are the selective isoproturone (for winter wheat, winter barley, rye, spring barley and spring wheat) followed by the non-selective glyphosate (Eurostat 2007). Broad spectrum herbicides such as glyphosate are frequently applied as pre-emergence herbicides, but also for pre-sowing and post-harvest weed repression, and for desiccation (acceleration of maturation) in the pre-harvest period for instance in cereals and rape (see digression on glyphosate in chapter 2.3).

Herbicides in general have a very strong effect on ecosystems as they severely restrict plant diversity and plant abundance/plant cover, thereby removing the basic food resource for many species (affecting the complete food chain). Herbicide use can in principle be given up altogether and replaced by cultivation measures (e.g. crop rotation, crop type selection and undersowing) and mechanical weed control.

Synergy effects for other taxa

Because a restriction of the use of herbicides enhances the abundance and diversity of wild plants as primary producers, it is beneficial for species on all trophic levels.

Amphibians could profit in particular, as it has been proved that these are also affected by direct toxic effects of herbicides (Brühl et al. 2013)

Application of highly targeted herbicides against key weed species

Implementation and description

Selective herbicides purposefully combat certain groups of plants, mostly either monocotyledonous or dicotyledonous plants, i.e. in general terms they affect grasses or broad-leaved plants. Because herbicides with very selective effects are only or mainly effective against individual species or groups of species, part of the arable wild flora continues to flourish and the base of the food chain on the affected area is not completely eliminated. Nevertheless, there are hardly any effective selective herbicides available to combat the relevant problem weeds. On the contrary, it is often the case that an increasing number of weeds develop resistances to one or more agent groups. E.g. more than 60 weed species have developed resistences against triazines and ALS inhibitors (Hemmerde 2009).

The application of herbicides should be confined to weed clusters if possible. See below for more information on this aspect.

Synergy effects for other taxa

If herbicide use is restricted to selective agents, species at all trophic levels will profit as food availability on the primary producer level will be increased with the implementation of this measure.

Restricted application of insecticides

Implementation and description

In Germany, insecticides are most commonly used on arable land, viticulture and for fruit cultivation and are effective against insects that damage the cultivated plants.

The use of insecticides affects not only the pests, but also other insects, including beneficial organisms. Secondary pest outbreaks can occur as a result, i.e. pest organisms that played no previous role because of competitive pressure or natural pest control. These invade areas after the insecticide application and proliferate in an area free from competition and natural enemies. Therefore, they become economically significant and have to be controlled in turn (Vandermeer 2009). The deliberately targeted pests can also profit from the use of insecticide because of damage to beneficial species. Krauss et al. (2011) conclude that insecticide use in cereal crops had only a short-term effect on cereal aphid density. Later, the aphid density exceeded the density of the species in untreated fields because of the low density of natural enemies.

Other organisms providing ecosystem services such as soil arthropods and pollinators are as well negatively influenced by insecticides (for an overview of the effects of insecticides on ecosystems see Devine and Furlong (2007)). Sharp population declines particularly in bee species has been observed, which can be attributed partially to the use of insecticides. Insecticides used for seed dressing can, as a result of drift in the environment, damage particularly the pollinator populations. Consequently, insectivorous vertebrates including many bird species, several European bat species and a few other mammal species can be deprived of their food supply (see chapter 4.1).

A restriction or dispensation of the use of insecticide could achieve a significant improvement in resource availability and therefore improve the size and stability of populations of many insectivorous species. The implementation of plant cultivation measures (crop rotation and type selection) can serve as an alternative to insecticide use in many cases.

Synergy effects for other taxa

A restriction or dispensation of the use of insecticide is particularly sensible in combination with other measures that promote populations of beneficial species. Besides measures that promote biodiversity and structural diversity in general, providing alternative food sources, nesting and wintering structures, other specific measures include the creation of fallow strips on crop fields - in particular beetle and bee banks - and the use of biological and biotechnical plant protection methods. In addition to insectivorous birds and mammals, other insectivorous taxa such as amphibians also profit from a restriction or dispensation of the use of insecticides. The latter can also be damaged by the direct toxic effects of insecticides (Brühl et al. 2013) and can therefore profit twofold from the restriction of insecticide use.

Restricted application of fungicides

Implementation and description

The important application areas of fungicides are cereal, potato, fruit and wine cultivation. Whereas winter wheat receives on average two full fungicide treatments every year (BI = 2, see chapter 2.4), the related figures are 13 for potatoes, 15 for viticulture and 25 full treatments per year for dessert apples, respectively (JKI 2011a).

Fungicide treatment of cereal crops has an indirect effect on bird and mammal species because its use permits a very high growth density of the crop (with an increased use of fertiliser this leads to high yields). This reduces wild herb undergrowth and the abundance of invertebrates, and at the same time causes a deterioration of the living conditions of ground-nesting birds (e.g. Skylarks) and mammals (e.g. Brown Hare), respectively (see chapter 4.1.2). A further consequence is the wide-scale cultivation of monocultures that would be restricted without the use of fungicides, because wide-scale monocultures facilitate the propagation of fungal spurs and outbreaks of fungal diseases. Halting the use of fungicides can, lead to a change in crop type selection, a reduced use of fertiliser, a more diverse crop rotation and smaller fields in order to avoid or at least reduce fungal propagation at least in cereal crop cultivation.

Synergy effects for other taxa

Fungicides can have severe effects on non-target organisms. Negative effects of copper-based fungicides on earthworms are well documented (reviewed by Bünemann et al. 2006). Other soil organisms, especially non-target fungi, can be damaged by fungicides, which can lead to an impairment in the decomposition of organic materials. A limitation in the use of fungicides can trigger a side effect leading to an improvement in soil conditions. In a recently published study, alarmingly high amphibian mortality rates were recorded after exposure to the recommended application amounts of several fungicides (Brühl et al. 2013). Amphibians would therefore directly profit from a restriction in the use of fungicides.

A less dense crop structure in cereal fields would permit more light to penetrate to the lower vegetation layer, with corresponding benefit for wild field herbs and invertebrates. Other insectivorous groups such as amphibians would in turn profit from a higher invertebrate density.

Restricted application of rodenticides and molluscicides

Implementation and description

Molluscicides are used to combat snails. Molluscicides target mainly the commonly occurring Grey Field Slug (*Deroceras reticulatum*) and Land Slug (*Deroceras agreste*) that can cause large harvest losses. Damage to crops by snails has increased because their living conditions in fields have improved with the introduction of no-tillage systems (Börner 2009). They are very difficult to target with PPPs under mulch layers, and greened stubble fields and crop rotations with a high proportion of wintering crops provides them with an abundant food supply. The use of three molluscicide agents is at present permitted in Germany - methiocarb, metaldehyde and iron(III) phosphate (Börner 2009). Methiocarb is not only effective against snails; it is also used as an insecticide. All three agents are used as contact or stomach poisons and are set out in the form of slug pellets.

As these agents act as contact or stomach poisons other wildlife is also affected. Granivorous and insectivorous birds and mammals can ingest the poison either directly or indirectly via poisoned invertebrates. Negative effects from methiocarb pellets have been recorded for the Wood Mouse (*Apodemus sylvaticus*), and there are indications of poisoning of Hoopoes (*Upupa epops*) by contaminated Mole Crickets (Gryllotalpidae) (see Chaps. 4.1.3 and 4.1.2). Despite cases of poisoning observed in birds, there is no evidence in the literature of negative effects of molluscicides or of positive effects as a result of dispensation with molluscicides for the majority of species. This could mainly be due to the lack of specific studies dealing with this aspect, which is correspondingly reflected in table 5.1.2.

Rodenticides are used against rodents such as the Field Vole (*Microtus agrestis*), Bank Vole (*Myodes glareolus*), and the European Water Vole (*Arvicola terrestris*). Mass invasions by these species can cause enormous damage to field crops or stored products. The rodenticides used in Germany belong to the chemical classes coumarines, indandiones, phosphides and carbides (Börner 2009). Rodenticides are also applied as stomach poisons. They can be differentiated in single-dose and multiple-dose rodenticides. The most commonly used rodenticide is Warfarin, a coumarine (trade name Coumadin). This agent has an anti-coagulant effect and is used as a multiple-dose rodenticide (Goel & Aggarwal 2007).

Depending on the form of bait used, and the associated specific target species, many other vertebrate species can be affected. A wide-scale scattering of poisoned wheat for example is necessarily linked with very high risks for other species. Many cases of poisoning of different bird species by rodenticides are known of (see chapter 4.1.2). Among mammals, non-target rodent species in particular are affected by poisoning through rodenticide baits. A threat through secondary poisoning and prey shortage also exists for carnivorous mammals such as the Least Weasel (*Mustela nivalis*) (see chapter 4.1.2). In addition to the lethal side effects for non-target organisms, there is also the problem that rodents develop resistances against these agents.

A reduction of the use of molluscicides and rodenticides would be possible in many cases if preventive measures are taken instead, such as the removal of food sources that attract rodents. On organic farms, traps are set against rodents. In fruit orchards, wire cages and migration barriers are used to combat voles. In the case of molluscicides, the relatively non-toxic iron (III) phosphate can preferably be used in addition to preventive measures in contrast to the more toxic agents methiocarb and metaldehyde. Moreover, natural enemies of rodents can be promoted, for instance by the provision of perches and nest boxes for birds of prey, or stone heaps and wood piles, rootstocks and similar refuges or nesting aids for weasels.

Synergy effects for other taxa

Because of its side effect as an insecticide, insects will also benefit from restrictions in the application of the molluscicide methiocarb.

Restricted application of other pesticides (growth regulators, etc.)

Implementation and description

Growth regulators are often applied to cereal crops to shorten stalk length and to increase stability. Thicker and shorter stalks tolerate more nitrogen fertiliser and consequently lead to a higher yield. Growth regulators are phytohormones that restrict growth in cultivated plants. There are no problematic direct negative effects of growth regulators. However, the combination of growth regulators, fertiliser and use of fungicides results in an extremely dense vegetation structure with implications for the availability of food and nesting habitats for species such as the Skylark or the Brown Hare (see measure ‘Restricted application of fungicides' in this chapter and chapter 4.1.2). As the use of growth regulators is mostly confined to cereal crops, this measure is primarily related to grain cultivation.

Synergy effects for other taxa

A less dense crop structure in cereal fields would permit more light to penetrate to the lower vegetation layer, with corresponding benefits to wild field herbs and invertebrates. Other insectivorous groups such as amphibians would in turn profit from a higher invertebrate density.

Restricted usage of plant protection agents (fungicides, insecticides) for seeds treatment

Seed treatment is performed to protect seeds from being eaten by birds and other small animals like rodents or insects and to protect seedlings from early pathogenic infections and pests. For the latter purpose, seeds are usually coated with systemic fungicides and insecticides which disperse in the tissue of the emerging seedling. On the one hand, this practice strengthens the growing plants and prevents the need to apply pesticides later in the season. On the other hand, it may also have the same effects as usual applications of fungicides and insecticides. Regarding fungicides, it allows for dense stands of the crops which deteriorate conditions for many species on arable land (see above). Regarding insecticides, it breaks the food chain by decreasing resources for insectivores (see above). Moreover, especially neonicotinoid seed dressings pose a high risk for pollinators like honeybees and wild bees as well as for other non-target arthropods when dust from abrasion drifts to neigbouring untreated habitats (see chapter 2.3). A more restricted use of PPPs for seed treatment could help to protect farmland biodiversity. Technical alternatives to chemical seed dressing are available and used in organic farming. They include the production of high quality healthy seeds, seed dressings with natural substances and beneficial microorganisms, the classical hot water treatment, and electron treatment of seeds (Drangmeister 2003).

Synergy effects for other taxa

See synergy effects in the main sections about fungicide and insecticide restriction. A specific synergy effect applies for the restriction or prohibition of neonicotinoid seed treatments. This would benefit particularly honeybees and other pollinators and thereby the ecosystem service of pollination.

No application of pesticides in ecological hot spots (nesting sites, burrows)

Implementation and description

This measure involves restrictions of the application of pesticides in the breeding and nest-building seasons of birds as well as in the gestation and lactation periods of mammals, especially in ecological 'hotspots'. These are for instance the areas immediately surrounding the breeding sites of birds such as Montagu's Harrier (*Circus pygargus*) or the burrows of the European Hamster (*Cricetus cricetus*). Ususally farmers react positively on requests for these measures and agree on an area to be spared. The usual protective area is some 50 x 50 m and this is excluded from farming activities (including a delayed harvest). Some protective measures against predators can also be taken (e.g. Fonger 2007). In the regions where birds nest and breed, or where small mammals have their burrows, pesticides can be especially harmful if the species forage on the treated fields. With birds for example, pesticides can have a negative effect on reproduction through toxic effects on the adult birds, toxic effects on the embryo and/or reduction of the robustness of the eggshell (Mineau 2005). Avoiding the use of pesticides in the vicinity of nests or burrows can help to minimise such threats.

Synergy effects for other taxa

Synergy effects for other taxa than birds and mammals are not to be expected to any great extent because of the rather localised measures.

Selective control of weed clusters and target weed species only

Implementation and description

An alternative to the wide-scale use of herbicides is the targeting of individual weed clusters or individual problem weed species on the fields. This ensures that not all areas of the field are burdened with pesticides and a selective targeting of plant pests is carried out. The selective targeting of smaller areas and/or individual plants with pesticides is relatively widespread on grassland, for instance to combat the occurrence of Broad-leaved Dock (Rumex obtusifolius), in order to avoid extensive ploughing up and reseeding.

In arable areas, the development of a pinpoint or carefully targeted application of herbicide in the framework of 'precision farming' is gaining in importance in this context. Precision farming is the carefully targeted and location-differentiated management of arable land. With respect to plant protection there are two possible procedures – offline and online procedures. In the offline procedure, the plot to be treated must be mapped in advance, which is very time-consuming. Data collation, data management and management measures are carried out in separate work stages. In the online procedure the work stages are conducted in parallel as the sensors identify the weeds directly in the field. Identification is done by optoelectronic sensors that are mounted on the bars of the pesticide sprayer and which record the light reflected from the plants in the red and infrared spectrum. The differentiated application of herbicide is steered by an algorithm in real time. To date, the simplest online procedures differentiate only between ground and green plants, and is therefore non-selective, and can only be used in the pre-emergent phase (Rösch & Dusseldorp 2007). Because of the high technical (online procedure) and time-consuming (offline procedure) effort, however, precision farming is not economically viable to date for use in plant protection. More research is required in this promising field, as the use of pesticides could be considerably reduced by a selective control of weed clusters and target weed species.

Synergy effects for other taxa

Because restrictions in the use of herbicides enhance the abundance and diversity of wild plants as primary producers, they are beneficial for species on all trophic levels.

Application of biological and biotechnical methods of plant protection in agriculture, hop growing, fruit crops and viticulture

Implementation and description

In contrast to natural pest control, which is based on the control by naturally occurring antagonists and which can be supported by the creation of landscape structures that promote these antagonists, biological pest control implies the active use of an organism to control the population density of another organism (Bale et al. 2008).

Beneficial organisms are most frequently introduced in large numbers in order to control pest populations during a critical phase of their development or mass propagation. Organism groups used as natural antagonists include entomopathogens (bacteria, fungi, viruses, nematodes and protozoa), predators, parasites, and parasitoids. The latter three are in the first instance insects (Dent 2000).

In the open land in Germany for example Trichogramma parasitic wasps (e.g. Trichogramma evanescens) have been used for over 30 years against the European Corn Borer (*Ostrinia nubilalis*). In greenhouse cultivation, particularly in tomatoes and cucumbers, an almost 100 % plant protection can be achieved using beneficials (Zimmermann 2004).

Biotechnical measures can include, for example, the fencing off of an area so that it is protected from predators, or the use of animal traps such as glue rings or yellow sticky traps. In orchards and vineyards the Pheromone Confusion Technique can be effective against Tortrix moths (Tortricidae) (i.e. female pheromones of the species are applied to confuse males and disrupt mating). In apple orchards this technique has proved more effective than the conventional use of insecticides and can also be used in cases of high infestation pressure. As a result, the acceptance of the Pheromone Confusion Technique has markedly increased for instance in the Lake Constance area (Lange 2002). In general, insectivorous birds and mammals benefit from biological and biotechnical plant protection measures as their natural food resources are not destroyed in contrast to the use of insecticides

Synergy effects for other taxa

The mass application of natural antagonists has only temporally limited effects as no natural balance is established (Dent 2000). Synergy effects of these measures can therefore be achieved in combination with other measures, in particular the creation of structures that enable the long term settlement of beneficials. In addition to measures that generally promote biodiversity and structural diversity, measures such as the creation of fallow strips in crop fields can be implemented. These provide alternative food sources and structures for nesting and wintering, in particular bee and beetle banks (see below). As adult Trichogramma wasps are not parasitic but feed on nectar, synergy effects can also be achieved by the creation of flower strips or plots.

Wide-scale application of biological and biotechnical plant protection methods also works against the development of resistances to insecticides.

Besides insectivorous birds and mammals, other insectivorous groups, for instance amphibians, benefit from the replacement of insecticides by biological and biotechnological control methods.

Spatial restriction (unsprayed field edges and headlands)

Many field edges are ecologically depauperate, consisting of only a few grass species, because they receive considerable drifts of herbicide treatment when the field is sprayed (Brühl in prep.). Consequently, they are also characterized by low arthropod numbers and therefore do not constitute a valuable foraging habitat for birds and mammals. By leaving headlands unsprayed, field edges receive less or no pesticide drift and both areas become more semi-natural and can develop a richer plant community, favoring also a more diverse arthropod community. Therefore, these areas are beneficial for bird and mammal species because they offer more diverse foraging opportunities (e.g. Hötker et al. 2004b; Mayer et al. 2009).

Synergy effects for other taxa

Because spatial restrictions of insecticide use enhance the abundance and diversity of wild plants as primary producers, they are beneficial for species on all trophic levels.

Indirect, landscape-related RMMs

Indirect landscape-related RMMs are presented here because in some cases it can be more favourable to implement certain compensatory measures than to avoid or minimise the indirect effects in the crops through complicated regulation and measures. For instance favourable conditions for farmland birds and mammals, also in terms of long term viable populations, can be achieved by creating broad fallow strips in a field, while at the same time conducting relatively intensive management methods close by. This type of practice corresponds roughly to the usual land re-parcelling process where, as a rule, many small fields are merged in a single large plot. As compensation for the loss of numerous ecotones and small-scale landscape structures such as grassed tracks, special compensatory plots are created. Such indirect landscape-related measures can differ in type. In-crop measures are measures taken in the field, i.e. the field remains as it is, but is managed differently, for instance with flower strips. Off-crop measures refer to the creation of special biotopes such as hedgerows or field borders which are no longer managed. Individual off-crop measures could be possibly more favourable and effective than in-crop measures. See the following descriptions and evaluations of these measures for more details.

Cultivation of at least four different crop types (diversified crop rotation) in spatial proximity

Implementation and description

The diversity of the cultivated landscape and the associated diversity of the resident wildlife, is promoted by the cultivation of different crop types in close spatial proximity allowing birds and mammals access to different resources and habitats within a small area.

With a diversified small-scale crop rotation positive effects in abiotic and biotic resource conservation can be achieved (e.g. Osterburg 2002, Stinner & House 1990, Fuchs & Saacke 2006; Schindler & Schumacher 2007). For example field birds including the Skylark benefit from the latter measure (Chamberlain et al. 2000; Jenny 1990, Weibel et al. 2001). It is, however, difficult to regulate or control crop rotation, as a number of factors has to be considered (soil type, suitability for cultivation of different crops, landscape type, sales situation, business cycles etc.). Some farmers still rely on a broad-based crop rotation comprising five, six or seven crops. The prevailing trend is, however, towards a limitation of crop rotation of two to three crops.

Synergy effects for other taxa

Crop rotation reduces the availability of large-scale homogenous structures rendering the respective sites less attractive for specialised pest species. In particular monocultures are centres for spreading pathogens. The latter can be avoided with heterogeneous cultivation with several different crops. Maintaining crop rotation is for example essential in order to restrain insect pests, e.g. the Western Corn Rootworm (*Diabrotica virgifera virgifera*), a beetle that has spread from North America to Europe and is becoming more and more widespread in Germany. The beetle's eggs are laid in maize fields and remain in the soil over winter. If a different crop is sown in the following year (preferably dicotyledonous plants), the larvae starve of food deprivation.

The Julius Kühn Institute recommends the cultivation of maize at the most twice in three years. This is possible without the use of insecticides (JKI 2011b).

A diversified crop rotation increases the structural diversity of cultivated land, particularly effectively in combination with the measure 'small-scale crops'.

Catch cropping after the main fruit harvest for winter greening

Implementation and description

Following the harvest of the main crop, a further crop is sown that remains on the field over winter as a catch crop. Candidates for catch crops are hardy plants that can be harvested as forage in spring or ploughed into the soil or plants that freeze in winter and form a mulch layer.

In the same way as fallow field strips, fields with winter greening provide protection, food supply and wintering areas for wildlife. In particular carnivorous and insectivorous bird species can benefit from catch cropping (Hötker et al. 2004a). Flowering plants as catch crops also provide resources for flower-visiting insects late in the year (Schindler & Schumacher 2007). It must, however, be mentioned that a potential limitation of sowing catch crops is that the stubble fields in late summer are lost (food resources and habitat for insects, birds and mammals) and the catch crop often consists of only a single crop type - this hardly creates diverse living conditions. In comparison to stubble greening, the catch crop offers fewer survival possibilities for many species.

Synergy effects for other taxa

In addition to the provision of resources and habitats for wildlife, the main advantage of the cultivation of catch crops as winter greening is preservation and accumulation of soil nutrients, improvement of the soil structure, promotion of soil life and protection against erosion.

Fig. 5.1.3: Winter greening can provide resources and wintering structures for many species. Picture: R. Oppermann.

The bonding of nutrients in the organic substance of the plants prevents them from being washed out into water bodies or into deeper soil layers or ground water. A Swiss study (Spiess et al. 2011) calculates the reduction of losses through eluviation from nitrogen in different soils and with different catch crops as between 100 – 200 kg N ha-1 a-1. On average, the seepage water showed a reduced nitrate pollution by some 27 %. Lower nitrate values in seepage water mean lower costs for drinking water treatment in addition to lower nutrient pollution of water bodies.

After the catch crop is ploughed in in spring, the bonded nutrients become progressively available to the plants through decomposition. With cultivation of legumes additional atmospheric nitrogen is bonded, which achieves a fertilising effect. In addition, catch crops improve soil quality by improving the biological, chemical and physical soil characteristics, including the organic carbon content, cation exchange capacity, aggregation stability and water filtration rate.

The coverage with living, or dead and frozen organic substance in the period from autumn to spring protects the upper soil layers from erosion, and cover crops can for instance prevent the spread of weeds or infestation by nematodes (reviewed by Snapp et al. 2005).

Keeping stubble fields until next seeding in the following spring

Implementation and description

Stubble fields are harvested arable crop fields on which the stubble is left standing after the harvest and is ploughed in during seed bed preparation just before the next sowing in spring. Alternatively to ploughing in, a direct or mulch sowing can be employed in row crops. Here, stubble fallow is defined as the stubble left after cereal and rape harvest; there is also stubble following the maize harvest, but the area hardly becomes greened. Granivorous birds and mammals still find sufficient spilt grain on stubble fields providing an attractive food source in winter (Moorcroft et al. 2002; Gillings et al. 2005). Carnivorous species benefit as well from stubble fallow as the latter attracts their granivorous prey (Hötker et al. 2004a). Additionally, stubble fields left standing offer a certain degree of shelter over winter.

If possible, stubble should be left standing until the end of February with a minimum height of 20 cm in order to protect young animals during the harvest. When post-harvest ploughing is not intended to be abandoned altogether, stubble can be left on parts of the respective area (Stiftung Westfälische Kulturlandschaft 2012).

Stubble fields are very important in particular for the highly endangered European Hamster as this species feeds on ear and grain remnants and depends on them for the accumulation of food caches for the winter (Weinhold & Kayser 2006).

Synergy effects for other taxa

The enormous ecological significance of stubble fields for wild herbs is often underestimated. Stubble also offers wide-scale habitat for numerous wild insects. Earthworm channels can remain undisturbed by ploughing and soil life is not affected. Small-flowered plants can continue to grow on the fields and these offer resources for flower-visiting insects. Especially for many highly endangered field weeds (e.g. various Cancerworts, *Kickxia* spp.), whose seeds ripen after the grain harvest, it is important that fields are not ploughed up immediately after the harvest.

Fig. 5.1.4: On stubble fields, wild herbs can establish and grain leftovers can be used by granivorous species. Picture: R. Oppermann.

Creation of sparsely sown field crops (defined areas or strips) with reduced fertilization (in wide rows)

Sparsely sown areas or strips are created during the sowing of cereal crops by closing individual coulters of the seed drill (Fig. 5.1.5), for example closing every second coulter will create double spacing between rows. Alternatively, two closed coulters can alternate with four sown rows (Fig. 5.1.6). Arable herb species like Corn Poppy (Papaver rhoeas) or Cornflower (*Centaurea cyanus*) can establish in the rows between the crop plants (Fig. 5.1.7). Sparsely sown areas within fields can be created with a minimum effort. They provide foraging and breeding habitats for farmland species such as the European Hare (*Lepus europaeus*) or ground-nesting birds while the whole field can still be used for crop production. Wider spaces between rows of crop plants respectively despite the field is still used for agriculture. Except for a few unwanted weed species, most wild herbs in cereal cropping do not cause considerable yield losses. The species richness on fields with sparsely sown strips can be enhanced by sowing autochthonous wild herbs or species like Borage (*Borago officinalis*), Buckwheat (*Fagopyrum esculentum*) or Marigold (*Calendula officinalis*) with low sowing density. In the areas of sparsely sown field crops with 'left out rows', no herbicides should be applied and fertilization should be reduced. In experimental studies these measures led to an enhancement biodiversity on the respective study plots (Huber et al. 2008; NABU 2010)

Synergy effects for other taxa

Sparsely sown fields are characterized by an increased abundance and diversity of wild plant species. Therefore species of all trophic levels benefit from this measure.

Fig. 5.1.5: Sparsely sown areas or strips are created during the sowing of cereal crops by closing individual coulters of the seed drill. Picture: R. Oppermann.

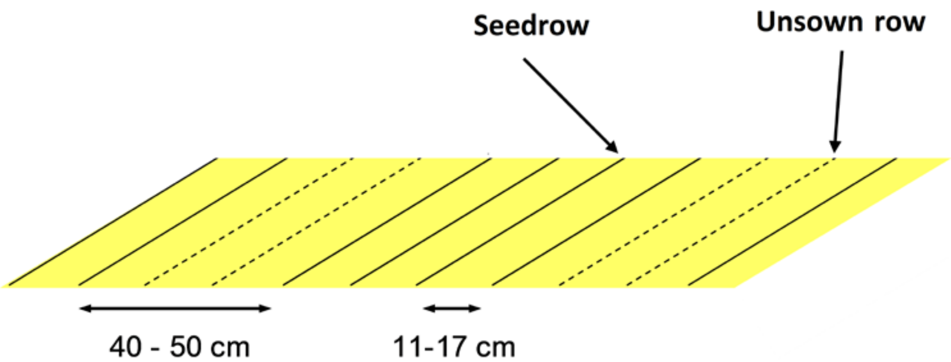

Fig. 5.1.6: Pattern of a sparsely sown area with two unsown rows and four sown rows alternating.

Fig. 5.1.7: In the unsown rows of sparsely sown areas, wild herbs can establish and a valuable habitat for ground-nesting birds, European Hares and other agricultural wildlife is provided while the field can still be used for crop production. Picture: R. Oppermann.

Extensive arable farming (minimal use of fertilizers, no use of pesticides)

Extensive farming without using pesticides, herbicides and fungicides and with minimal use of fertilizers is a measure to enhance the abundance of wild flowers and overall biodiversity on arable fields. This is mediated through the less dense stands of the crop and the poorer soils creating favourable conditions for wild flowers which provide resources for consumers such as arthropods which in turn attract granivorous as well as insectivorous and carnivorous birds and mammals.

Synergy effects for other taxa

Because extensive farming enhances the abundance and diversity of wild plants as primary producers, species on all trophic levels benefit from this measure.

Creation of flower plots or flower strips

Implementation and description

Flower plots or strips are created by the sowing of flowering mixtures available on sale. Flower plots provide food for birds, insects, in particular bees, and smaller mammals. If they are not mown too early, flower strips and plots also offer ample resources for granivorous birds and mammals. Wild field herbs can also be re-established by sowing a suitable seed mixture. In the Göttingen district flower strips not only contributed towards stabilising Grey Partridge (Perdix perdix) populations, but also affected the spread of the population positively (Beeke & Gottschalk 2010).

The flower mixes on offer can be basically divided into annual and perennial mixtures. Perennial mixtures are mostly species-richer and contain a greater share of non-cultivated plants, compared to annual mixtures which are dominated by non-hardy cultivated plants that are especially suitable for bee forage such as Sunflower, Oilseed, Yellow Mustard, Phacelia or Buckwheat.

Annual seed mixes are usually sown from the end of April to the beginning of June. Perennial mixes can also be sown in autumn – it is, however, recommended to sow them in spring.

Flower plots or strips are particularly valuable when they are not mowed and remain standing over winter. For instance, the average density of small mammals was eight times higher in permanent flower and fallow strips than in regularly mowed extensive meadows and artificial grassland (Aschwanden et al. 2007). The promotion of flower plots should therefore take account of the differences between annual and permanent flower strips and plots.

Synergy effects for other taxa

Many important natural enemies of agricultural pests, such as parasitic wasps, hoverflies, ladybirds and lacewings, feed as adults on pollen and/or nectar and therefore benefit from flower strips and plots. Several studies found an increased activity of natural antagonists in fields adjacent to flower strips (e.g. Tylianakis et al. 2004; Lavandero et al. 2005). In addition to the provision of resources and habitat, flower strips and plots can also serve as a boundary between pesticide-polluted farmland and adjacent ecologically valuable structures such as hedgerows or water bodies.

A combination of flower strips or plots with already existing or newly-created hedgerows and similar structures also provides many wildlife species with foraging areas in close spatial association to breeding and refuge structures.

Fig. 5.1.8: Flowering areas/strips provide resources for pollinators, but also for many bird and mammal species. Picture: R. Oppermann.

Creation of fallow strips on crop edges

Implementation and description

Fallow field margins are created by sparing edges of crop fields during cultivation. The implementation has little effect on farming and creates no extra work.

Fallow field margins serve as foraging areas or habitat for many wildlife species such as insects, smaller mammals, and birds (e.g. Lille 1996, Oppermann et al. 2010, Berger & Pfeffer 2012). For example, fallow areas are frequently the preferred habitat for birds, providing sufficient food resources for breeding. Berger & Pfeffer (2012) have developed a sophisticated system of different types of fallow strips and areas (e.g. bare fallow, fallow with seeding of mixtures for game animals, wild herb mixtures, etc.), differentially designed to meet ecological and arable farming requirements in all kinds of landscapes and farming environments.

Similar to flower strips and plots, fallow field margins are also particularly valuable if they are not or only seldom mowed, and therefore offer adequate protection to for wildlife throughout the winter.

Synergy effects for other taxa

In addition to the provision of resources and habitat, fallow strips can also serve as a boundary between pesticide-polluted farmland and adjacent ecologically valuable structures such as hedges or water bodies.

Furthermore, fallow field margins also provide alternative resources and habitat, especially for the wintering of beneficials. The survival rate of beneficials on arable fields is low because arable land offers little vegetation cover. The majority of predators winter therefore in field margins and only spread out into the cultivated crops in spring (Landis et al. 2000).

Autochthonous wild field herbs can establish in fallow field margins and a combination of fallow field margins with already existing or newly-created hedgerows and similar structures also provides many wildlife species with foraging areas in close spatial association to breeding and refuge structures.

Fig. 5.1.9: A fallow strip in grassland in the haymaking season. Picture: R. Oppermann.

Creation of fallow strips inside crops (beetle banks / bee banks)

Implementation and description

The creation of fallow strips in crop fields is easy to implement by sparing out a strip from seeding and the application of pesticides or fertiliser.

As semi-natural areas in the midst of the arable habitats, fallow strips provide useful habitats and foraging areas for wildlife including invertebrates, field birds and small mammals. As beneficials can find suitable habitat there as well, the creation of fallow strips in the middle of crop fields can be considered a form of biological pest control.

Beetle banks, a special form of fallow strips inside crops, are some two metres wide raised grass areas created parallel to the crop rows through large fields. The distance between the end of the bank and the field edge can be up to 20 metres so that the field can still be managed as a single unit. Special grass-dominated seed mixtures are recommended for beetle banks because in the resulting habitats, beneficials can find good living conditions and settle in numbers. Predators such as carabids, rove beetles and spiders have greater chances of survival if they winter in dense tufty grass. In winter, beetle banks can be home to more than 1,000 individual invertebrate predators per square metre (Thomas et al. 1992). Cock's-foot grass (*Dactylis* spp.)

and Yorkshire Fog grass (*Holcus lanatus*) are recommended for beetle banks (Thomas et al. 1991; Sotherton 1995).

Up to three mowings can be carried out on beetle banks in the first year. However, mowing should be avoided during the main nesting and breeding period of birds from April to August. Once the beetle bank is established it should usually not be necessary to mow it more often than once in every three years. Pesticides should only be applied at some distance from the beetle bank (RSPB 2012).

In contrast to fallow field margins, beetle banks help to establish beneficials on entire fields, especially when the latter are relatively large. Therefore the use of insecticides can be reduced or given up altogether (Sotherton 1995). Various studies confirm the usefulness of beetle banks for the conservation of biodiversity and natural pest repression (e.g. Collins et al. 2002; MacLeod et al. 2004).

To create bee banks, as for beetle banks, soil is heaped up with the plough but in order to provide soil-nesting insects such as wild bees and others with bare ground, the banks are not sown. On the bee banks vegetation growth fluctuates in the course of the year according to the natural weed growth. Published studies on bee banks are sparse, but trials in Southern Germany have shown that they are broadly accepted by soil-nesting bees, wasps and kleptoparasitic bees (Schanowski, personal communication 2012)

For birds and mammals, bee and beetle banks serve as foraging structures and are used occasionally for nesting.

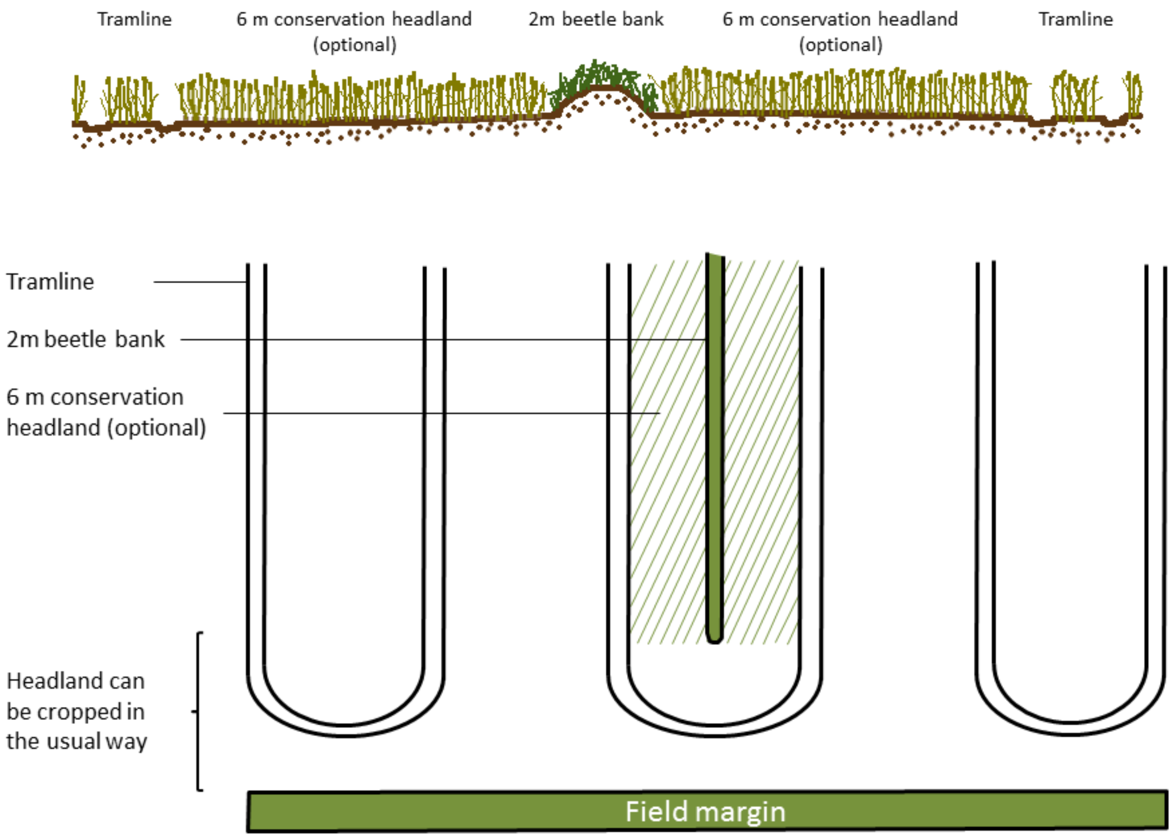

Fig. 5.1.10: Diagram and plan view of a beetle bank. Source: RSPB.

Synergy effects for other taxa

Bee banks serve not only as nest sites for soil-nesting wild bees, but also for other soil-nesting insects such as many wasp species. They can also serve as habitat for thermophile insects such as the Small Blue (*Cupido minimus*) or the Dingy Skipper (*Erynnis tages*). Because of their vegetation in early successional stages, including flowering plants, fallow strips and bee and beetle banks also offer food-rich structures for flower-visiting insects.

Fig. 5.1.11: Beetle bank. Picture: LEAF.

Fig. 5.1.12: Bee bank. Picture: IFAB.

Conversion of arable land into fallow land / set-aside for one or more years

Implementation and description

Entire fields left fallow for one year or optimally for several years benefit many bird and mammal species. There are a number of studies on the ecological effects of fallow land (e.g. Lille 1996, NABU 2008, Oppermann et al. 2010, Berger & Pfeffer 2011). Particularly ground-nesting species such as Skylark, Grey Partridge or Common Quail can settle in this new habitat. Brown Hare and Red Deer also find food resources on fields lying fallow. In some regions of Germany, beaver populations also benefit from fallow fields. Beavers are very adaptable and can settle ditches in the farmland countryside. Bavaria has offered subsidies for letting fields lie fallow for beaver habitat. The aim in Bavaria is to preserve the beaver as part of the cultivated landscape and to keep the damage caused to farmers by the beaver at a low level. Beaver damage in Bavaria can for instance include the collapse of agricultural machinery into beaver tunnels, partial flooding of fields with associated devaluing of the area or feeding damage. Fallow areas can also serve as part of a biotope network enhancing wildlife migration. Initially, mainly nutrient-loving plants settle on fallow areas, depending on the crop grown previously and to what extent it has been fertilised. Later, the plant community shifts towards species that prefer sites with meagre soil such as plants that have become uncommon because of the use of fertilisers on arable land.

Fig. 5.1.13: Species-rich fallow on nutrient-poor soil in Brandenburg. Picture: R. Oppermann.

The related costs for farmers are relatively high as converting arable into fallow land involves high yield losses. From an economic point of view, grassland sites or areas with marginal soils are particularly suited for conversion into self-greening fallow land. Regular mowing or mulching of multi-annual fallow areas is required in order to prevent them becoming overgrown with bushes.

Synergy effects for other taxa

Because on fallow land, the abundance and diversity of wild plants as primary producers is enhanced, it is beneficial for species on all trophic levels.

Creation of Skylark plots

Implementation and description

Skylark plots are some 20 m large artificially created cleared spaces in winter cereal, rape or maize crop fields. They are created by lifting the drills of the sowing machine for a distance of several metres (depending on the width of the machine) so that no seed is sown. Alternatively, wildflower mixes can be sown in the plot. As ground-nesters, Skylarks are particularly affected by intensive farming methods and profit above all from such plots providing valuable sites for foraging (Morris et al. 2004). However, Skylark plots provide also plots for landing and entering the centres of fields, which is otherwise often impaired by the dense crop cover. The creation of Skylark plots is recommended on arable crop areas from 5 ha in size, with two plots per ha (NABU 2012). Because of the increased predator threat, minimum distances to tracks, field edges and trees or copses should be observed (Fig. 5.1.14). Areas recommended for Skylark plots are large fields with few landscape structures and areas with low and/or sharply declining field bird populations (Sacher & Bauschmann 2011).

Experience in Germany and Switzerland shows that this measure could gain wide acceptance by farmers. In Germany, the project '1,000 fields for the Skylark' proved to be very popular with the participation of over 400 farmers on a voluntary and non-compensatory basis. In Switzerland, 25 % of the cereal farmers of IP-Suisse (The Swiss association of integrated producing farmers) created Skylark plots on a voluntary basis and without compensation (Birrer et al. 2010).

Fig. 5.1.14: Skylark plots in a cereal field. Picture: R. Oppermann.

Synergy effects for other taxa

Although there are hardly any scientific studies, it is likely that other insectivorous bird species such as the Corn Bunting or Common Quail will benefit from Skylark plots (Sacher & Bauschmann 2011). Additionally, the relatively easy to create field bird plots could possibly also prove to be the start of motivation for farmers to implement other effective measures to support field bird populations (e.g. fallow and flower strips) that are locally more effective than Skylark plots (Sacher & Bauschmann 2011).

Temporary interruption of crop management in spring

Implementation and description

Interruption of crop management is particularly valuable in arable areas used by amphibians (e.g. Common Toad and Common Spadefoot) as migration corridors. During the spawning migration, no management such as fertilising, application of pesticides and growth regulators or mechanical weed repression is permitted to take place. An interruption in crop management also has positive effects for ground-nesting birds such as the Skylark and Northern Lapwing because clutches are prevented from being damaged. However, as far as ground-nesting birds are concerned, the interruption of crop management must be extended at least to the end of June.

Synergy effects for other taxa

In addition to amphibians and birds, a wide number of other taxa, in particular field flora and invertebrates, benefit from an interruption of crop management in spring. However, this measure contradicts the intentions of the farmer, who is urged to conduct weed repression at this time of the year.

Creation of biotope networks in order to enhance biodiversity (e.g. sowing of wild herbs from autochthonous seeds)

Implementation and description

The creation of biotope networks provides the linkage amongst biotopes and promotes the colonisation of isolated habitats by wildlife and plant species (especially those that disperse their seeds via animals). Biotope networking is of greatest importance for the survival of metapopulations, i.e. populations in fragmented habitats consisting of a number of sub-populations. These sub-populations exist on habitat islands surrounded by areas that are unsuitable as habitat for the respective species. Examples are hedgerows and copses etc. surrounded by agriculturally used areas. The more permeable the surrounding matrix of agricultural land - i.e. the better the habitat islands are networked - the better is the genetic exchange between the sub-populations, and local extinction can be better compensated for by migration from other sub-populations (Perfecto et al. 2009).

Different structures can serve as network biotopes such as fallow flower and wild herb strips, hedgerows etc. Ideally, a network-concept as wide-scaled as possible, including several or many farms, needs to be created. Subsidies for network biotopes can be paid in addition to the regular subsidy for the respective measure.

Synergy effects for other taxa

Synergy effects occur for a broad spectrum of other taxa that also profit from the linkage of biotopes such as reptiles, amphibians and arthropods. Synergy effects also occur with respect to crop protection when beneficials profit from the measure.

Planting of individual trees, field trees (woodland), hedges and scrubs

Implementation and description

Planting of solitary trees, field coppices, hedgerows and bushes provide the chance to re-introduce landscape structures in a cleared and intensively managed agricultural countryside. As a result, foraging and reproduction habitats and migration corridors are created for many bird and mammal species. Such plantings can form the core element of the networking of different habitats. Planting is a one-off measure and maintenance once a year is usually adequate. Autochthonous species should be planted as they offer the greatest ecological value for indigenous wildlife and plant species because of their evolutionary adaptation to the prevailing conditions. Practical guidance and background information concerning this measure can be found in Oppermann et al. (2006) and Huber et al. (2008).

It must, however, be borne in mind that some of the most endangered bird species of the open countryside are displaced by woodland structures. The creation of such structures must therefore be carefully considered in the first instance and should only be implemented in those parts of the countryside where their presence is typical.

Synergy effects for other taxa

Foraging and reproduction habitats and migration corridors for arthropods and other invertebrates are also created through this measure.

A combination for example of hedgerow planting adjacent to flower strips or fallow plots is sensible and provides many bird and mammal species with foraging areas in close spatial association to breeding and refuge structures.

Creation of meadow orchards, as well as nest sites and hollow trees

Implementation and description

Meadow orchards are among the most diverse habitats on cultivated land in Central Europe as they offer multi-storeyed habitats. In contrast to intensively managed orchards, meadow orchards with their mainly extensive management, little or no fertilisation, and only two or three annual mowings or grazing offer a suitable habitat for many farmland birds and mammals (Bünger & Kölbach 1995). Conventional orchards are often regularly mulched, the foot of the trees is kept free of vegetation and the trees remain low in height and do not reach a great age. In meadow orchards in contrast the trees become hollow from a certain age onwards and offer nesting sites for hole-nesters such as Little Owl, Wryneck, Edible Dormouse or bat species.

Additionally the extensive management and restricted use of pesticides encourage the settlement of many plant and wildlife species that otherwise, would have little or no chance of survival with more intensive management of the habitat. Wild field herbs for instance, displaced in the intensively managed countryside because of frequent mowing can re-establish themselves in meadow orchards. New meadow orchards should be created only on suitable sites and be planted with old, tall-growing, regionally-typical fruit types. The maintenance of young trees is initially time-consuming. Annual pruning should be carried out and, depending on the location, animal browsing protection fitted to trees and the grassland regularly mowed.

Traditionally very little or no pesticides are applied in meadow orchards. As a result meadow orchards represent a possible landscape element to compensate for the absence of diversity and the heavy use of pesticides in conventional fruit orchards (Rösler 2004).

Synergy effects for other taxa

Many insect species and other invertebrates benefit from the extensive management, the structural richness and the restricted use of pesticides in meadow orchards.

In addition to the direct advantages of meadow orchards as habitat for very different organisms, there are also other positive effects. The natural scenery is enhanced, soil erosion, especially on slopes is counteracted, beneficials find suitable habitats and, with the use of old fruit types, the diversity of the gene reservoir of the respective fruits is preserved (LfUG Rheinland-Pfalz 2002).

Fig. 5.1.15: Recently created meadow-orchard strip. Picture: R. Oppermann.

Creation of dry stone walls and stone heaps

Implementation and description

Dry stone walls or stone heaps are made of loosely layered stones in some cases fixed with mortar. In Germany, they are found most commonly in steep slope wine growing areas where they are used to create and support terraces. Dry stone walls can also serve as boundaries of grazing land, but this practice is uncommon in Germany. The creation of dry stone walls or stone heaps represents a structural enhancement of the countryside and creates a habitat for a special species community. Birds such as the Dunnock, Wren or Robin forage for food in dry walls or stone heaps and small mammals such as the Weasel find refuge here.

Dry stone walls can also act as an extension of landscape structures as for instance flower strips or support habitat networking.

Synergy effects for other taxa

Above all, thermophilic reptile species, including endangered lizard species, profit from these structures. Bumblebees can also nest in the hollows. Specific microclimatic conditions are also created in dry stone walls and heaps where lichens and mosses thrive. Vascular plants which require the special dry stone wall habitat for their development can also settle here. Typical species are for example Viper's Bugloss (*Echium vulgare*), Ivy-leaved Toadflax (*Cymbalaria muralis*) or Cypress Spurge (*Euphorbia cyparissias*) (Baur et al. 1997). Thus, an enhanced diversity of plant species is the result of the creation of stone walls and stone heaps.

Fig. 5.1.16: Dry stone walls create new structures in the landscape and harbour special species communities. Picture: R. Oppermann.

Creation of road, water and bank verges with extensive grassland

Implementation and description

Field margins offer foraging areas and habitat for many wildlife species and are therefore important parts of the agricultural countryside. Bank verges, which act as demarcation between water bodies and agriculturally managed land, also serve an important buffer function, reducing the input of fertilisers and pesticides into the water. In modern intensively managed farming it can, however, be increasingly observed that crop fields with no, or with only a very narrow margin border on roads, hedgerows and even water bodies. Existing verges are often strongly affected by pesticide drift and frequent mowing and provide habitats of only very low quality.

The creation of verges with extensive grassland, broad enough to not be fully affected by pesticide drift and fertilisers and providing a buffer effect for water bodies and other ecologically valuable structures, is an effective measure to counteract this development.

In order to qualify as a non-target area under the distance rule laid down in plant protection regulations, verge structures must be at least 3 m wide. If, however, it can be proved that they are used for the creation of verge biotopes they are not subject to these distance regulations. Corresponding rules must therefore be devised for inclusion in the description of this measure. Apart from an annual or bi-annual mowing, no farming activity such as use of fertiliser or melioration measures is to take place (LÖBF NRW 2003).

Synergy effects for other taxa

Arthropods, including many pest antagonists such as ground beetles, rove beetles or spiders, settle in verge habitats. Sufficiently broad and greened verges are important for these species, especially for wintering (Freier & Kühne 2001). Sufficiently broad field margins are in addition ideal biotope network structures.

Ground water is also protected by the creation of broad road and bank verges. Studies conducted over several years have concluded that pesticide agent deposits on farm roads and tracks represent with a proportion of up to 90 % the most significant cause of ground water pollution. Greened verges with a minimum width of 1.5 m can reduce pollution of the roads and tracks by up to 95 % (Altmayer et al. 2003).

Fig. 5.1.17: Bank verges serve at the same time as habitat and as buffer structures against run-off of PPPs and fertilizers. Picture: R. Oppermann.

Creation of water body and bank verges with reeds / tall forbs / shrubs / trees

Implementation and description

Water body/bank verges with reeds, tall forbs, shrubs and trees serve as habitats for many wildlife species. Birds and small mammals, for example mice, find food and settle in these structures.

Planting of reeds, tall forbs, shrubs and trees is a one-off measure and few subsequent maintenance measures are necessary.

Synergy effects for other taxa

A large number of invertebrates find food and settle in these structures. In addition amphibians, which often stay in the proximity of water bodies, find refuge and food between the reeds and tall forbs.

Bank verges, which act as demarcation between agriculturally managed areas and water bodies, also represent an important buffer structure that reduces the input of fertiliser and pesticides into water bodies.

Creation of moist sink areas with utilisation (crop and grassland)

Implementation and description

In the course of the transformation of the agricultural landscape over the past decades many biotope structures such as moist sinks in the midst of arable areas were removed.

Through the re-creation of moist sinks on arable and grassland areas, foraging area for birds such as many snipe species and allies can be provided. Moist sinks can best be created by the blocking of drainage ditches and channels.

Synergy effects for other taxa

Synergy effects can be expected above all for amphibians that use sinks as (stepping-stone) habitats.

Creation of still water bodies (pond biotopes) and wetlands without utilisation

Implementation and description

Wetlands have a high ecological significance and offer a habitat for many species including endangered bird species. In contrast to moist sinks with farming utilisation, which have mainly a stepping-stone function and provide foraging habitat, wetlands without utilisation can be used as a permanent habitat including for reproduction.

Synergy effects for other taxa

Here too, synergy effects can be expected above all for amphibians, for which pools and wet biotopes serve as habitat for doraging and reproduction. Aquatic and semi-aquatic arthropods also benefit to a high degree from this measure.

Restoration of drained grassland areas

Implementation and description

In the course of agricultural intensification in Germany wide-scale wetlands were drained through the construction of drainage ditches and channels in order to develop the land for crops and intensive grassland use. The drainage and subsequent intensive management of wetlands endangered the populations of many meadow bird species.

Wetlands can be restored by the closure of drainage ditches and channels. Endangered species such as Common Snipe, Black-tailed Godwit, Northern Lapwing, Corncrake and many more will profit from this measure. The rewetting of grassland plays only a subsidiary role for mammal conservation. Wet grassland can and must be extensively managed, for instance as pasture with low cattle density.

Synergy effects for other taxa

Apart from birds, which find a large food supply on such sites, wet areas also provide habitat for amphibians. A few invertebrates also settle and profit from such restored areas.

Extensive grassland - restriction of management periods, mowing and grazing frequency and use of artificial fertiliser

Implementation and description

Meadow bird species are disturbed during the breeding season by fertiliser application and mowing, which can lead to the nests being abandoned or to their destruction. Late-breeding species such as Whinchat, Yellow Wagtail or Corncrake are especially affected.

In order to avoid destruction of nests, mowing and fertiliser application should be delayed, and grazing cattle density restricted, until after the end of the breeding season for meadow birds.

Synergy effects for other taxa

In addition to breeding birds, other species on the affected areas can benefit from a reduction in the intensity of disturbance by restriction of the management time frame.

Small-scale crops

Implementation and description

Farming of small-scale arable crop fields is of particular importance for less mobile wildlife species. With the implementation of this measure they can forage on another neighbouring plot following the harvesting of a field. This option scarcely exists in the case of larger fields, as the distances that less mobile species need to cover are often too far increasing e.g. the danger of predation.

An example of a species profiting from this measure is the European Hamster. The German populations of the European Hamster are endangered and the species feeds to a great extent on grain ears and corn remnants on the fields. They live mostly underground in their burrows and come to the surface to forage. Above ground, the European Hamster is faced with a high predation risk. Should only one large field be harvested the animals must move to another field to forage for food and collect their winter caches. The underground burrows are, however, not long enough to reach into the next field and therefore they must cover a long stretch above ground each time they leave their burrow for foraging. With small-scale crop farming the predation risk is reduced as the neighbouring fields are in very close proximity (Mammen & Mammen 2003; Weinhold & Kayser 2006).

Synergy effects for other taxa

In compartmentalised agricultural landscapes, more edge structures, even if narrow, exist as opposed to landscapes characterised by large-scale cultivation. These structures may serve as food sources and for habitat networking.

Small-scale fields, particularly in combination with diverse crop rotation, assure a heterogeneous natural landscape. They also help to prevent the spread of disease.

5.1.2 Evaluation of the suitability of RMMs

In the previous chapter, the measures fundamentally suitable for the minimisation of or compensation for unavoidable indirect (or as appropriate direct) pesticide effects were presented. This chapter will now examine the level of suitability that different measures possess with respect to the bird and mammal species studied. To achieve this, an evaluation was made to determine what effect different RMMs have on the affected species, based on an analysis of the relevant literature, knowledge of the respective habitat requirements of the species, their behaviour, and reasons for their threat.

Detailed information on the individual species and the corresponding references can be found in the Detailed Species Portraits in Annex I. Particularly in terms of the restricted use of pesticides, the evaluation could only rarely be based on data from experimental field studies that permit a comparative judgement of the effects on birds and mammals. This evaluation is therefore rather based on plausible values that depend on knowledge of the species and the causes of their threat and, in addition, on a series of experiences with agri-environmental programmes and contractual nature conservation measures being currently conducted. Scientifically proven effects of RMMs are available for only a few well-researched bird (e.g. Grey Partridge and Skylark) and mammal species (e.g. Brown Hare and European Hamster). The detailed results are presented in table 5.1 (see Annex III). In the following, the collective results for the farmland bird species are interpreted and presented in two separate tables (Tab. 5.1.1 and Tab. 5.1.2).

With respect to farmland bird and mammal species, the following is evident:

Pesticide-related measures

Complete dispensation with or very strict limitation of the use of herbicides or insecticides is relevant to a great degree. We estimate that this measure has positive effects for more than half the bird species and almost all mammal species. In this respect it should be noted in particular that some herbicides are exclusively applied in order to facilitate working processes, without any direct effect on crop quality or yield. These applications include for instance desiccation in potato, cereal, and rape crops or wide-scale stubble treatment on cereal fields.

The spatial restriction of pesticides (field margins) and selective control of weed clusters can also result in a positive to very positive effect for a number of species.

Limiting the application of herbicides to hotspots, and restricting their use in critical periods, has been proven to be associated with positive effects especially for bird species. For example the broods of Montagu's Harriers are less often destroyed when such measurements are taken compared to broods in conventionally managed fields. For mammals on the other hand, this measure has hardly been considered (difficulty of spatial restriction) and therefore cannot be evaluated to the same degree.

Restricting the use of molluscicides and rodenticides has limited effects as a relatively low number of species benefits from these measures. However, for some mammal species these measures are of great significance, reducing their mortality through poisoning. Additionally, negative effects for bird species, such as methiocarb poisoning of Hoopoes (see chapters 4.1.3 and 4.1.2), could be avoided by the implementation of these measures.

The use of biological and biotechnical measures, which have been applied mainly for the control of individual insect pest species, is considered to be very effective. Examples are the use of pheromones to control the European Grape Berry Moth (*Lobesia botrana*) in viticulture or use of Trichogramma parasitoids in maize.

It is noticeable that dispensation with or restriction of the use of fungicides and other pesticides such as growth regulators do not appear to be particularly effective in the evaluation, even though they are often applied on a wide scale. This is because their effects are not of direct nature and their indirect effects are often not considered. I.e. they enable a very dense crop growth (in cereal crops in combination with the use of fertilisers) that has a negative effect on bird and mammal species.

Cultivation and landscape-related compensatory measures

At first glance, the large number of very positive effects is evident, especially for landscape-related in-crop measures, but also for some off-crop measures.

The effects of fallow land, flower areas and strips and fields kept in stubble are particularly positive for the majority of all species studied. This is hardly surprising as these measures include only occasional management measures and wildlife and plant species can complete their development cycle without interruption (and flower areas in addition are conceptualised with regard to their ecological effects). Moreover, these measures were the subject of scientific studies providing evidence for their effectiveness in some cases.

The creation of sparsely sown field crop areas (sowing of cereals in wide rows and lower seed density, no fertilisers or use of pesticides) is judged to be less positive. This is primarily because this measure has only been implemented locally to date and no comprehensive reports are available yet. However, a comparative and very similar measure, 'Agricultural extensification measures', is judged to be very positive for both bird and mammal species.

Crop rotation and catch crop/autumn and winter greening are also judged to have positive effects. Nevertheless, the measures must be interpreted in relation to the alternative scenario – in comparison with a bare, ploughed field they have the positive effects listed (this is taken as the basis of assessment here); compared with a self-greening stubble fallow, however, they have mainly disadvantageous effects (the numbers of wild field herbs are reduced, and the soil is ploughed during the critical autumn period and there is no considerable growth for about one month).

The skylark plots and the temporary interruption of crop management in spring are measures that only affect relatively few bird species; the majority of bird species and almost all mammal species do not profit from this measure.

It is noticeable that several off-crop measures have a positive effect for some species but a negative effect for others. This pertains to the creation of high growing structures (individual trees, hedgerows and also meadow orchards) that ground-nesting species avoid or keep their distance from. This does not mean that the measures are to be considered negative, but that they can or should only be implemented on a landscape-specific basis, giving consideration to the composition of landscape-specific zoocoenoses.

Among the landscape-related off-crop measures some have very positive effects for a majority of species. These include the networking of valuable agricultural habitats, the creation of verges (along roads and tracks, water bodies, hedgerows etc.), and the creation of small-scale special sites in arable areas (e.g. moist sinks) and the creation/promotion of small-scale parcelling of arable land.

Comparing measures as a whole, more measures for improvement or enhancement of food availability and breeding habitat (crop and landscape-related measures) are associated with overall positive effects for a large number of species compared to the effects of pesticide-related measures. The different types of measures must or should, however, complement one another. In the next step in the following chapter an analysis is presented explaining which controllable measures can be implemented in practice and gain acceptance from farmers.

Tab. 5.1.1: Estimate of the ecological effectiveness of RMMs for the 27 bird species studied.

RMMs with a very broad effectiveness are highlighted yellow = positively or very positively effective with more than half of the bird species (at least 14 of the 27). In some cases, two similar measures were treated together as one in 5.1.1 but were evaluated separately here.

Risk-management Measures (RMMs)	**Effects of the RMMs on birds**						
Number of species, for which very positive, positive, neutral, negative or very negative effects of the RMMs are known or assumed.	**very positive**	**positive**	**neutral**	**negative**	**very negative**	**Number of species**	**Sum very positive and positive effects**
Objective: Reduction of threats associated with pesticide applications							
Pesticides – agent-related measures:							
No application of non-selective, broad-spectrum herbicides	11	5	11	0	0	27	16
No application of pre-sowing, pre- and post- emergence herbicides	9	6	12	0	0	27	15
Application of highly targeted herbicides against key weed species	6	9	12	0	0	27	15
Restricted application of insecticides	14	3	10	0	0	27	17
Restricted application of fungicides	0	2	25	0	0	27	2
Restricted application of rodenticides	3	0	24	0	0	27	3
Restricted application of molluscicides	1	3	23	0	0	27	4
Restricted application of other pesticides (growth regulators, etc.)	0	0	27	0	0	27	0
Restricted usage of plant protection agents (fungicides, insecticides) for seeds treatment	3	9	15	0	0	27	12
Pesticides – application-related measures							
No application of pesticides during breeding, nesting and fledging periods (birds) as well as gestation and	14	5	8	0	0	27	19

lactation periods (mammals)							
No application of pesticides in ecological hot spots (nesting sites, burrows)	16	1	10	0	0	27	17
Selective control of target weed species	4	11	12	0	0	27	15
Selective control of weed clusters	4	11	12	0	0	27	15
Application of biological and biotechnical methods of plant protection in agriculture, hop growing, fruit crops and viticulture	10	4	11	0	0	25	14
Spatial restriction (unsprayed field edges and headlands)	13	2	12	0	0	27	15
Objective: Improvement of food availability and habitat quality							
Crop-related measures (in-crop):							
Cultivation of at least four different crop types (diversified crop rotation) in spatial proximity	8	9	9	1	0	27	17
Catch cropping after main fruit harvest for winter greening	5	8	13	1	0	27	13
Keeping stubble fields until next seeding in the following spring	13	3	11	0	0	27	16
Creation of sparsely sown field crops (defined areas or strips) with reduced fertilization (in wide rows)	2	9	16	0	0	27	11
Extensive arable farming (minimal use of fertilizers, no use of pesticides)	11	6	10	0	0	27	17
Creation of flowering areas or strips	10	5	12	0	0	27	15
Creation of fallow strips on crop edges	16	1	10	0	0	27	17
Creation of fallow strips inside crops (beetle banks / bee banks)	14	3	9	1	0	27	17
Conversion of arable land into fallow land / set-aside for one year	17	1	8	0	1	27	18
Conversion of arable land into fallow land / set-aside for a couple of years	14	3	8	1	1	27	17
Creation of skylark plots	0	3	24	0	0	27	3
Temporary interruption of crop management in spring	5	5	17	0	0	27	10
Landscape-related measures (off-crop):							
Creation of biotope networks in order to enhance biodiversity (e.g. sowing of wild herbs from autochthonous seeds)	2	10	15	0	0	27	12
Planting of individual trees, field trees (woodland), hedges and scrubs	7	3	1	1	15	27	10
Creation of meadow orchards, as well as nest and	2	3	4	1	17	27	5

hollow trees							
Creation of dry stone walls and stone heaps	1	3	19	4	0	27	4
Creation of road-, water- and bank-verges with extensive grassland	20	3	4	0	0	27	23
Creation of water- and bank-verges with reeds / tall forbs	7	1	7	6	6	27	8
Creation of water- and bank-verges with trees/shrubs	2	4	2	2	17	27	6
Creation of moist sink areas with utilisation (crop and grassland)	15	6	6	0	0	27	21
Creation of still water bodies (pond biotopes) and wetlands without utilization	8	7	12	0	0	27	15
Restoration of drained grassland areas	14	4	9	0	0	27	18
Extensive grassland: restriction of management periods, mowing- and grazing-frequencies and usage of artificial fertilization	7	7	13	0	0	27	14
Small-scale crops	10	6	7	2	2	27	16

Tab. 5.1.2: Estimate of the ecological effectiveness of RMMs for the 22 mammal species studied. RMMs with a very broad effectiveness are highlighted yellow = positively or very positively effective with half or more of the mammal species (at least 12 of the 22). In some cases, two similar measures were treated together as one in 5.1.1 but were evaluated separately here.

Risk-management Measures (RMMs)	**Effects of the RMMs on mammals**						
Number of species, for which very positive, positive, neutral, negative or very negative effects of the RMM is known or assumed.	**very positive**	**positive**	**neutral**	**negative**	**very negative**	**Number of species**	**Sum very positive and positive effects**
Objective: Reduction of threats associated with pesticide applications							
Pesticides – agent-related measures:							
No application of non-selective, broad-spectrum herbicides	10	10	2	0	0	22	20
No application of pre-sowing, pre- and post- emergence herbicides	10	9	3	0	0	22	19
Application of highly targeted herbicides against key weed species	10	9	3	0	0	22	19
Restricted application of insecticides	17	3	2	0	0	22	20
Restricted application of fungicides	0	9	13	0	0	22	9

Restricted application of rodenticides	11	7	4	0	0	22	18
Restricted application of molluscicides	7	9	6	0	0	22	16
Restricted application of other pesticides (growth regulators, etc.)	0	1	21	0	0	22	1
Restricted usage of plant protection agents (fungicides, insecticides) for seeds treatment	7	7	8	0	0	22	14
Pesticides – application-related measures							
No application of pesticides during breeding, nesting and fledging periods (birds) as well as gestation and lactation periods (mammals)	0	5	3	0	0	8	5
No application of pesticides in ecological hot spots (nesting sites, burrows)	1	1	20	0	0	22	2
Selective control of target weed species	10	10	2	0	0	22	20
Selective control of weed clusters	10	10	2	0	0	22	20
Application of biological and biotechnical methods of plant protection in agriculture, hop growing, fruit crops and viticulture	16	4	2	0	0	22	20
Spatial restriction (unsprayed field edges and headlands)	19	3	0	0	0	22	22
Objective: Improvement of food availability and habitat quality							
Crop-related measures (in-crop):							
Cultivation of at least four different crop types (diversified crop rotation) in spatial proximity	8	2	12	0	0	22	10
Catch cropping after main fruit harvest for winter greening	12	5	5	0	0	22	17
Keeping stubble fields until next seeding in the following spring	12	5	5	0	0	22	17
Creation of sparsely sown field crops (defined areas or strips) with reduced fertilization (in wide rows)	4	10	8	0	0	22	14
Extensive arable farming (minimal use of fertilizers, no use of pesticides)	17	3	2	0	0	22	20
Creation of flowering areas or strips	19	3	0	0	0	22	22
Creation of fallow strips on crop edges	20	2	0	0	0	22	22
Creation of fallow strips inside crops (beetle banks / bee banks)	11	10	1	0	0	22	21
Conversion of arable land into fallow land / set-aside for one year	15	7	0	0	0	22	22
Conversion of arable land into fallow land / set-aside for a couple of years	17	5	0	0	0	22	22

Creation of skylark plots	0	2	20	0	0	22	2
Temporary interruption of crop management in spring	1	1	20	0	0	22	2
Landscape-related measures (off-crop):							
Creation of biotope networks in order to enhance biodiversity (e.g. sowing of wild herbs from autochthonous seeds)	13	8	1	0	0	22	21
Planting of individual trees, field trees (woodland), hedges and scrubs	20	2	0	0	0	22	22
Creation of meadow orchards, as well as nest and hollow trees	3	12	7	0	0	22	15
Creation of dry stone walls and stone heaps	5	0	17	0	0	22	5
Creation of road-, water- and bank-verges with extensive grassland	15	3	4	0	0	22	18
Creation of water- and bank-verges with reeds / tall forbs	9	4	9	0	0	22	13
Creation of water- and bank-verges with trees/shrubs	12	7	3	0	0	22	19
Creation of moist sink areas with utilisation (crop and grassland)	9	2	6	4	1	22	11
Creation of still water bodies (pond biotopes) and wetlands without utilization	10	1	6	4	1	22	11
Restoration of drained grassland areas	7	4	7	4	0	22	11
Extensive grassland: restriction of management periods, mowing- and grazing-frequencies and usage of artificial fertilization	8	4	8	0	0	20	12
Small-scale crops	10	9	3	0	0	22	19

Extent of necessary measures

The extent of necessary RMMs is essentially dependent on the species and aims under consideration. In the framework of a project for further development of European agricultural policy, detailed studies and literature analyses were carried out in order to determine how and to what extent Ecological Focus Areas (EFAs) are necessary, if conventional (intensive) farming methods are maintained, in order to compensate for the negative effects of the latter and to secure the long term survival of animal and plant populations (IFAB, ZALF, HFR 2012). The following results emerged:

A percentage of 10 – 15 % of well managed EFAs in good condition[1] is necessary to ensure sustainable positive effects (Jenny et al. 2011, Flade et al. 2012, Kohli et al. 2004, Holzgang et al. 2005, Birrer et al. 2007, Holzschuh et al. 2012, Krewenka 2011).

[1] Ecological Focus Areas (EFAs) require in part regular upkeep or management if they are to realise their full ecological potential (e.g. occasional mowing of fallow plots) or, with particular types of EFAs, deliberate cultivation measures (e.g. on specially thinned out cereal fields for species protection).

Of particular importance are unused structures and areas that offer refuge and habitat for flora and fauna during autumn and winter (Berger et al. 2006, Bürki & Pfiffner 2000). Structures left unused or with stubble cover also support protection from soil erosion and nitrate leaching (Brunotte 2007).

Extensively used arable crops and unmanaged structures as ecological compensation areas can also achieve positive effects for biodiversity. Studies of farmland birds show that increasing intensification of land use results in decreasing importance for biodiversity (Joest & Illner 2011, Luick et al. 2011, Bernardy & Dziewiaty 2012).

Studies of crops dependent on insect pollination show that the extent of pollination increases with a corresponding percentage of semi-natural habitats. A 10 – 20 % share of semi-natural structures is the minimum proportion required in order to guarantee good pollination (Krewenka 2011). Further, studies of strawberry crops showed that fruit weight and quality rise with an increase in visits by pollinating insects and that the economic yield is dependent to more than 30 % on pollination (Holzschuh et al. 2011).

A closer look at studies of landscapes with predominant arable land use shows the following:

Farmland bird species

With the introduction of the set-aside programme in 1993 (discontinued in 2007) a large number of positive effects for wildlife and plant life could be observed. A summary of the effects was presented by NABU (2008).

Interesting in this context is the population development of the Corn Bunting as a function of the extent of set-aside (see Fig. 2.2.8). With the introduction of the set-aside programme, the Corn Bunting population increased sharply, especially in the eastern German federal states, while the previously declining population in the western German federal states stabilised and even slightly increased. The increase followed the extent of set-aside areas with a delay of 2 – 3 years and reacted most notably to a value of 10 % or more set-aside areas. Because of poor yield conditions in Brandenburg, considerably more than 10 % of arable land was set-aside enabling the population to stabilise and develop further (Flade et al. 2006, 2007). In the western German federal states there was a temporary population increase (from 1993 to 1996). Following the permission to grow renewable resources on set-asides, the share of 'real' (fallow) set-asides fell to a level of 5 - 7 % (and locally / regionally even lower) with the consequence that the Corn Bunting population again collapsed and then levelled off at a very low level.

As the Corn Bunting population development, together with the underlying set-aside policy, reflects the wide-scale development in birds (data from monitoring of breeding birds and the nationwide set-aside statistics), the data are very convincing. They imply a requirement of a proportion of at least 10 % of suitable habitat areas for preservation of the Corn Bunting and other farmland species (with a habitat quality at least as good as that of fallow areas - no mowing and no interference with these areas until at least mid-July; de facto many set-asides were mulched for the first time in autumn or winter, not already at the end of July or in August).

Hoffmann et al. (2012) studied the significance of arable land and biotopes in relation to the occurrence of bird species in the north-eastern part of Brandenburg. The study area covered 29 conventionally managed arable plots. The results show that on intensively managed arable land the majority of farmland bird species are dependent on self-greening fallow plots and semi-natural biotopes, on cultivated plots with sparse vegetation structures, as well as on parts of crop stands. However, crops in arable areas with high soil fertility have a high crop density and are therefore unfavourable habitats for farmland birds. In these areas, therefore, a fundamentally higher percentage of compensation areas is necessary.

For the indicator species Skylark, Corn Bunting, Yellowhammer, Yellow Wagtail, Red-backed Shrike and Whinchat, Hoffmann et al. (2012) calculated the total requirement of semi-natural biotopes in arable areas. In the territories of the individual bird species, the requirement for semi-natural biotopes varies between 7 % for the Yellow Wagtail to 49 % for the Whinchat. The preferred biotope also varied between bird species and their biology, whereby the self-greening fallow plots and coppices played a major role for the indicator species studied.

In addition, the results show that very small-scale vegetation structures, as for instance the creation of skylark plots, lead to only marginal or hardly measurable improvements in the population of farmland birds such as the Skylark. Ecological enhancement through widely spaced vegetation structures should therefore be implemented on larger areas of arable fields.

The German scientific network of biodiversity research (NeFo, 2012), on the basis of studies on the Corn Bunting (Fischer 2006), Quail (Herrmann & Dassow 2006) and Grey Partridge (Herrmann & Fuchs 2006), calculated a minimum required set-aside share of 10 - 12 % on arable land for the majority of farmland birds.

Mammals – Brown Hare

In a long term study (since 1992) in Switzerland, the effects of ecological compensation areas2 on the Brown Hare population were examined (Holzgang et al. 2005). In the Klettgau study area, a comparison was made between neighbouring municipal areas with a high and a low percentage of ecological compensation areas. Whereas in one municipal area, the extent of ecological compensation areas (flower strips, flower plots, planting of extensive cereals, creation of extensive grassland and verges) demonstrated a steadily increasing trend to ultimately 15 % until 2011, the extent of ecological compensation areas in the other community remained at a level of 3 - 5 % (Holzgang et al. 2005, Jenny 2011). With an extent of over 8 - 12 % ecological compensation areas, the Brown Hare population increased to a level of 12 individuals/100 ha (a population density of more than 10 individuals/100 ha is regarded a stable population). In the comparative area with 4 % of ecological compensation areas the low level of 4 individuals/100 ha is close to the limit of local extinction. In their evaluation of the long term data, the authors wrote that a level of at least 10 -15 % of ecologically high value compensation areas should be achieved in order to ensure the survival of the population in the long term (Holzgang et al. 2005, Jenny 2011). Decisive for the positive effects were, in addition to the extent of the ecological compensation areas, the optimal design and on-site care of the areas as well as intensive consultations and agreements with farmers (Holzgang et al. 2005).

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[2] In Swiss specialist agricultural terminology EFAs are designated ecological compensation areas (‘ökologische Ausgleichsflächen (öAF))

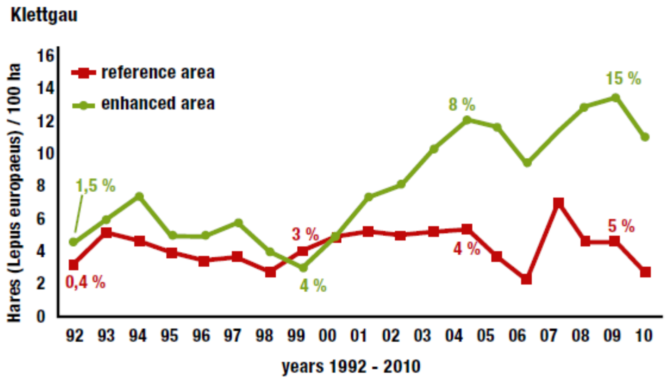

Fig. 8: A wide scale, long term study of the population development of the European Hare in two communities shows how the hare population in one community reached a stable level of over 10 animals per 100 ha only after a percentage of 8 - 15 % of EFAs had been established. The hare population in the other community with only 4 - 5 % EFAs failed to achieve a stable level in the long term (Jenny et al. 2011 amended).

Fig. 5.1.18: Results of a long-term study according to IFAB, ZALF and HFR (2012).

Other species and synergy effects (bees and other pollinators, arable wild herb flora)

Studies by Westphal and Tscharntke (2011) show, that the percentage of semi-natural habitats has a positive effect on the number of solitary wild bee species. A share of 40 % semi-natural habitat increases the number of species threefold compared with a share of 10 %. In contrast, the flower visitation rates decrease with a higher percentage of arable area in the countryside. From these results and those of their other studies Westphal & Tscharntke (2011) conclude that complex landscapes with more than 20 % of semi-natural areas provide a high degree of functional biodiversity.

For pollinating insects not only is the percentage of semi-natural land important but also the distance between such areas. Many pollinators are affected by too great distances between semi-natural plots and the latter must therefore be available and distributed across large areas of the countryside. According to Winfree et al. (2008) 7 % of ecological compensation areas appear adequate for parts of the countryside which are characterised by small fields and many field margins. The ecotone effect of a large number of field margins must however be added to the effect of the 7 % of semi-natural areas, which is not quantified in the study. In areas with larger fields, a higher percentage of associated habitats is therefore necessary.

In addition to farmland wildlife, wild arable herb flora also needs suitable areas for the various species to settle and reproduce. Although no special studies are available, NeFo (2012) states that in addition to 10 % of ecological compensation areas (for farmland animal species) a further 5 % of managed arable areas should be specifically available for wild arable herb flora conservation.

Summary and conclusions

The different data from various studies show unanimously that a minimum of some 10 % of ecological compensation areas is necessary to sustainably secure the populations of many farmland species. Some authors put this figure at 15 % whereby some species require a markedly higher share of up to over 30 % of extensively managed areas. Several authors point out that the percentage area given must consist of well managed areas of good habitat quality and well distributed across the landscape. The ecological effects of such areas in actual practice are much lower, as they are for the most part not on ecologically optimal sites or of adequate quality (NABU 2008). In order to guarantee a high quality and good distribution of ecological compensation areas in the countryside, planning and management of these areas should be conducted in cooperation with the farms.

5.1.3 Feasibility and acceptance

The feasibility and acceptance of risk management is equally important as ecological effectiveness. In this respect, experience has been gained over the past few decades with agri-environment programmes and contractual nature conservation, with which measures at local and/or regional level have been implemented to compensate for negative impairment through intensive land use, or measures to support certain forms of land management and /or promote plant and wildlife species. This experience can be evaluated in terms of the feasibility of implementing the RMMs described.

The available mid-term reports from ten federal states are analysed explicitly here to establish which of the RMMs have been implemented to date in the framework of AEPs to what extent (level of participation by farmers). The quantitative evaluations are supplemented with experiences from contractual nature conservation programmes, for which often no detailed figures are available (these are based on statements by numerous nature conservation specialists from public authorities and associations with whom the authors have been in contact for many years).

To begin with, an overview of AEPs in Germany is given. This is followed by an analysis of the AEMs in relation to the classification of the RMMs in this paper, and finally the conclusions on the feasibility, practicability and acceptance of the RMMs are presented.

Implementation of AEMs in Germany in respect of measures for risk management of PPPs

Agri-environmental programmes that promote particularly environmentally-friendly management practices exist in Germany and in all EU member states. In Germany, these programmes are conducted at federal state level, i.e. there are 14 different programmes (the federal states of Lower Saxony and Brandenburg have joint programmes with Bremen and Berlin, respectively). These programmes have been in operation since 1992/1993, which means that some 20 years of practical experience of agri-environmental programmes is available (in some states, contractual nature conservation programmes have been running for considerably longer periods of time). The programmes are based on a regulation in the European Common Agricultural Policy, according to which development measures for rural areas are subsidised. The budget for these programmes is very limited, on the one hand at the European level and on the other at national or regional level, at which they are co-financed (in Germany at the federal states-level). Depending on the respective co-financing capability, the programmes differ in extent. The German programmes are relatively large and comprehensive in the southern states (especially Baden-Württemberg and Bavaria) but markedly smaller in the northern states (e.g. Schleswig-Holstein). There are also considerable differences in the content of the programmes and the priorities or foci of the individual states. Whereas the programmes in Northern Germany consist of only a few subsidy positions, which are however relatively sophisticated and are only implemented by a relatively small numbers of farmers, the programmes in Southern Germany include a large number of very easy to implement measures, and are adopted by a larger number of farmers. Altogether in Germany, some 7.6 % of the total agricultural funding is allocated to AEM (Fig. 5.1.19).

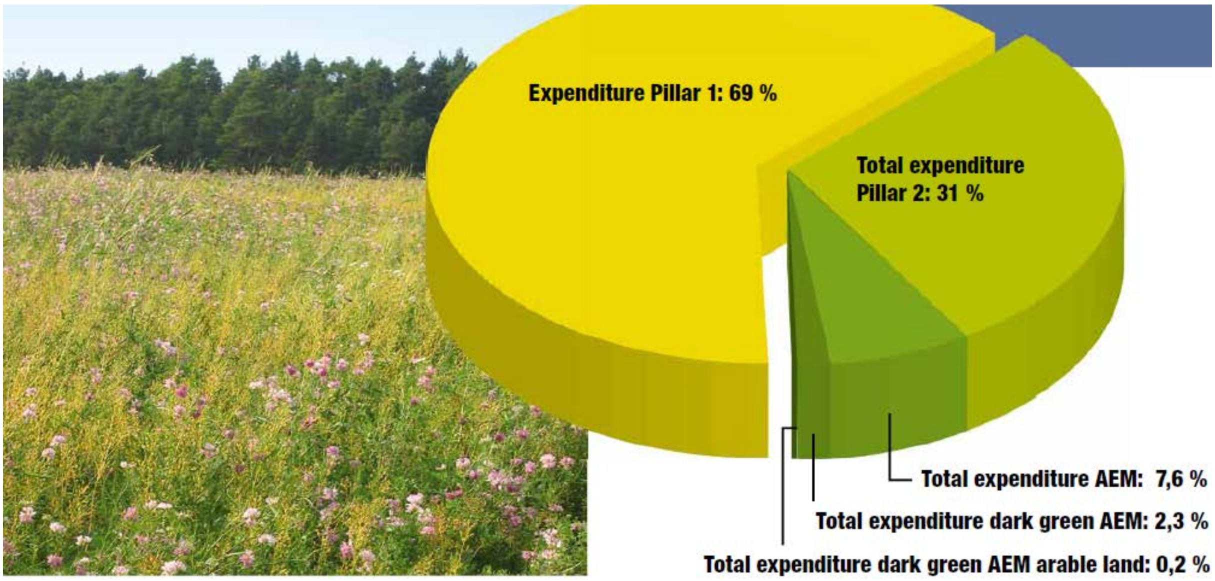

Fig. 5.1.19: Percentage distribution of agricultural subsidies in Germany (total 8.3 billion € a year); Diagram: IFAB, ZALF, HFR (2012).

In the following paragraphs, those RMMs listed in chapter 5.1.1 that are already a component of AEM in Germany are presented and, where data is available, to what extent these measures are implemented. Unless otherwise indicated, the information on the implementation of the agri-environmental programmes is taken from the federal state mid-term evaluation reports as at 31.12.2009 (mid-term evaluation is related to the current funding period for the development plans for rural areas that covers the time-frame 2007 to 2013). Eight evaluation reports from ten federal states for which sufficiently accurate data is available are evaluated. These states cover some 70 % of Germany's total agricultural area and encompass all regions (North, South and East). The evaluation is based on work in the framework of a project conducted by IFAB, ZALF, HFR (2012) that has been continued and edited for this study. In the tables 5.1.3 to 5.1.10, the results for the relevant RMM groups are presented.

Pesticide agent-related measures

All German federal state agri-environmental programmes subsidise organic farming, which does not use synthetic pesticides. The voluntary restriction of application of certain pesticides entirely or on individual field plots in the framework of AEMs is found in only a few agri-environmental programmes. In Baden-Württemberg, there is a funding position 'complete dispensation with pesticides' aimed at the complete farm business and which is in effect a preliminary stage towards organic farming. This measure is, however, mainly implemented by grassland farmers or adopted by farmers who for a number of reasons are unable to decide to convert to organic farming (e.g. because of the livestock keeping standards then required) but do not use pesticides on any of the grassland on their farm.

A further AEM is the subsidy of 'dispensation with the use of herbicides', that is available in Baden-Württemberg. Here, subsidies are available for dispensation with the use of herbicides on arable land and permanent crops, implying other laid down management measures. The measure is relatively easy to monitor, a decisive criterion for the programming of such measures at federal state level. All subsidised measures must be controllable in order to qualify for financing from public funds. Besides herbicides, there are hardly any other groups of PPPs excluded or restricted by individual AEMs, as these are in general difficult to control. In addition to financial payments for dispensing with the use of herbicides, corresponding regulations in plant protection legislation would also be a possibility, prohibiting or setting regulations for individual application areas. A few exceptions exist, e.g. conservation measures for the European Hamster in which the use of rodenticides is excluded (e.g. as a criterion within the measures cereal and alfalfa cultivation, and sparing out of crop rows until after the harvest), whereas in these measures other PPP groups are not excluded.. The measure ‘extensive arable use in a laid down subsidy framework’ in Saxony includes dispensation with the use of both insecticides and rodenticides. Thuringia also bans the use of rodenticide in the measure ‘Hamster-friendly conservation farmland use’. The mid-term evaluation reports contain no figures relating to the extent of this specific measure - it comprises however only small-scale measures in the last remaining areas where the European Hamster still occurs.

In Baden-Württemberg there is a subsidy position ‘dispensation with the use of growth regulators’. It applies to wheat, spelt and rye. This measure is intended to create less dense crop stands with less fertilisation. Growth regulators restrict the height of cereal crops so that as a result they can tolerate more fertiliser and have a higher yield, without being subject to crop lodging (flattening and damaging of crops as a consequence of rain or wind storms). A ban on growth regulators is also included in the Rhineland-Palatinate measure ‘environmentally-friendly management methods in businesses - arable farming’ and in a measure in Saxony that provides for a temporary interruption to crop management in spring.

Dispensation with the use of insecticides has not until now been funded as a special measure but it is included in some AEMs. Examples of this are the measures ‘application of biological/biotechnical measures in plant protection’ or ‘dispensation with chemical synthetic inputs’ in Baden-Württemberg. Rhineland-Palatinate also promotes alternative plant protection and lays down specific conditions for instance for control of the Corn Borer or Codling Moth (*Cydia pomonella*). If the infestation is, however, too strong, or was at very high level in spring, insecticide may be applied to stop the pest spreading and prevent loss of yield.

The restricted application of fungicides has not yet been accepted as an independent measure. There are measures in only a few federal states that include it. In Baden-Württemberg for example only the use of fungicides that do not affect predatory mites (*Gamasina*) is permitted as part of the measure to preserve discrete vineyards on steep slopes.

Tab. 5.1.3: Measures to limit the use of pesticides. Exemplary evaluation of agri-environmental programmes in ten German federal states on the basis of the states' mid-term evaluation reports of 2009. The mostly minor contractual conservation measures on small plots are not included (in the case of this type of measure only in one of the ten states – Baden Württemberg – are there corresponding AEMs).

Federal state	Arable area (ha)			Expenses	Area implemented [ha]		Area implemented [%]
		Code	Measure	Premium [€/ha]	Arable land	Other	Arable land
Baden-Württemberg	837700	B1	Dispensation with PPPs + synth. fertilisers	80.00 €	55260		6.60%
Baden-Württemberg	837700	B2	Dispensation with growth regulators	50.00 €	94500		11.28%
Baden-Württemberg	837700	C3	Dispensation with herbicides - arable farming	70.00 €	3088		0.37%
Baden-Württemberg	837700	C4	Dispensation with herbicides - permanent crops	40.00 €		25177	

Pesticide application-related measures

Application-related measures exist above all in contractual nature conservation on specific sites that are home to rare wildlife species. This affects for example the protection of Montagu's Harrier in North-Rhine Westphalia and the European Hamster in several federal states. As a result of individual contracts, regulations for farmers come into force banning the use of pesticides and delaying the harvest in the vicinity of the nest site or burrow. This is mostly related to the breeding season or, in the case of the European Hamster, the vegetation period. There are no figures available for the extent of this measure. The conclusion of these contracts requires, however, much effort as an individual procedure in terms of the respective local conditions need to be worked out.

No AEMs are known of for the measure of selective control of individual weed species or weed clusters. There are however measures for the spatial restriction on the use of pesticides in the form of untreated field margins (so-called field margin programmes), which however are only offered in individual federal states in the framework of contractual nature conservation. The extent of the field margin programmes has declined over the past few years because on the one hand there is less and less acceptance on the part of farmers (weed pressure builds up on these verges that can cause considerable problems in subsequent years), and on the other hand because these programmes are less offered or are poorly compensated. Exact figures on the extent of the field margin programmes are not available.

In contrast, AEMs for the implementation of biological and biotechnical methods of plant protection are relatively widespread. These measures are principally available in the case of viticulture and fruit growing, and individually also in the fields of arable and permanent crop cultivation. In viticulture in particular these measures have been widely implemented (use of pheromone traps to control the Grapevine Moth (Lobesia botrana)). As of 2009, among the ten evaluated states Baden-Württemberg promotes the use of biotechnical methods of plant protection in arable farming, horticulture, orchards, and viticulture, Bavaria in viticulture, Brandenburg/Berlin in horticulture and Saxony in orchards and viticulture (Tab. 5.1.4).

Tab. 5.1.4: Measures to improve biological and biotechnical procedures in plant protection. Exemplary evaluation of agri-environmental programmes in ten German federal states on the basis of the states' mid-term evaluation reports. The mostly minor contractual conservation measures on small plots are not included.

Federal state	Arable area (ha)			Expenses	Area implemented [ha]		Area imple-mented [%]
		Code	Measure	Premium [€/ha]	Arable land	Other	Arable land
Baden-Württemberg	837700	D1	Biological control - arable farming	60.00 €	17207		2.05%
Baden-Württemberg	837700	D2	Biological control - horticulture	2500.00 €		92	
Baden-Württemberg	837700	E1	Biological control - orchards	100.00 €		1912	
Baden-Württemberg	837700	E2.1	Biological control - viticulture	100.00 €		16966	
Bavaria	2093200	*K34*	Environmentaly compatible viticulture	1305.00 €		163	
Bavaria	2093200	*K57*	*Environmentaly compatible viticulture (outstanding commitments)*	1530.00 €		311	
Brandenburg/Berlin	1037500	A2	Controlled-integrated horticulture	194.49 €	6282		0.61%
Saxony	721200	A4	Biotechnological measures in fruit-growing and viticulture			821	

Tab. 5.1.5 provides an overview of the practicability and acceptance of PPP-related RMMs. The evaluation and assessments are derived from experience with AEMs and knowledge of agricultural practice. In the framework of the IFAB, ZALF, HFR (2012) study for example, a detailed analysis of mid-term evaluation report from ten federal states was undertaken and the

implementation of the agri-environmental programme MEKA in Baden-Württemberg has been closely monitored since 1995 and critically analysed. In 2006 strategic environmental assessments were conducted for two rural development programmes. Additionally, close cooperation was undertaken with farmers in a large number of projects and a personal exchange of views on agri-environmental themes took place.

Tab. 5.1.5: Overview of pesticide-related RMM in terms of the realisation complex (practicability / acceptance / controllability). Realisation is highlighted/evaluated orange, if the measure is evaluated in all fields as positive or at least neutral; yellow, if the measure is evaluated as positive or limited positive at least in terms of practicability and controllability. Legend: + practicability or acceptance given, (+) limited practicability or acceptance or AEM given, 0 indifferent rating, - practicability or acceptance not given, * related AES exist but only as total abandonment of pesticide use.

Risk management measures (RMM)				
	Realisability of RMMs with agricultural practice			
Aim: Minimisation of the threat through reduction of pesticide application.	Practicability	Acceptance by farmers	Controls possible	AES exists
Pesticides – agent-related measures:				
No application of non-selective, broad-spectrum herbicides	+	-	(+)	*
No application of pre-sowing, pre- and post- emergence herbicides	+	-	(+)	+
Application of highly targeted herbicides against key weed species	(-)	(+)	-	-
Restricted application of insecticides	+	-	-	*
Restricted application of fungicides	+	-	-	*
Restricted application of rodenticides	+	-	-	*
Restricted application of molluscicides	+	-	-	*
Restricted application of other pesticides (growth regulators, etc.)	+	-	-	*
Restricted usage of plant protection agents (fungicides, insecticides) for seeds treatment	+	-	-	*
Pesticides – application-related measures				
No application of pesticides during breeding, nesting and fledging periods (birds) as well as gestation and lactation periods (mammals)	+	-	-	(+)
No application of pesticides in ecological hot spots (nesting sites, burrows)	0	+	(+)	(+)
Selective control of target weed species	0	(+)	-	*
Selective control of weed clusters	0	-	(+)	*
Application of biological and biotechnical methods of plant protection in agriculture, hop growing, fruit crops and viticulture	+	+	+	+
Spatial restriction (unsprayed field edges and headlands)	+	-	+	(+)

Landscape-related in-crop measures

Landscape-related in-crop measures are offered in the agri-environmental programmes of almost all federal states. The AEMs for planting of catch crops for autumn and/or winter greening, crop rotation management, and measures for the creation of flower areas or strips are particularly comprehensive. In tables 5.1.6 to 5.1.10, an overview of the extent of the measures implemented in the different federal states is presented.

In contrast to those measures widely on offer and in demand, other measures are only to a minor extent part of the agri-environmental programmes. These include measures for keeping fields in stubble and the creation of sparsely sown strips/areas in cereal crops and fallow strips in the middle of fields. Sparsely sown strips/areas have to date only been trialled but are increasingly propagated from different sides. Fallow strips, for instance bee and beetle banks, exist only in individual projects but as far as we know not in agri-environmental programmes. In Germany, Saxony alone provides for the financial subsidy of the creation of fallow plots and strips in the middle of arable fields. The subsidy amounts to 232 €/ha. When beetle banks are created these are frequently in cereal fields for repression of cereal aphids (Collins et al. 2002).

Leaving fields in stubble is subsidised by Saxony, Lower Saxony and Rhineland-Palatinate. Saxony also subsidises stubble fields on cereals, maize, sunflowers or leguminous crops with 47 €/ha under further conditions such as a ban on the use of fertiliser and pesticide and leaving stubble standing until 15 February of the following year. Rhineland-Palatinate links leaving fields in stubble with the subsidising of mulching on arable land. North-Rhine Westphalia also has this linkage in the AEM 'environmentally-friendly management practices in arable farming'. Saxony-Anhalt and Thuringia have a measure pertaining to leaving fields in stubble for conservation of the European Hamster population. In Saxony-Anhalt this measure includes a ban on loosening of the soil to a depth of more than 25 cm and ploughing up of stubble within four weeks of harvesting. The subsidy amounts to 30 €/ha.

Thuringia has extended this measure to include restrictions in crop rotation, which permits the cultivation of winter and spring cereals and leguminous crops only. Further conditions include a ban on irrigation and application of liquid manure, dispensation with the use of rodenticides, and a longer period in stubble. The subsidy of 350 €/ha is correspondingly higher than in Saxony-Anhalt.

Letting field margins go fallow is not as such subsidised in Germany, but variations of the measure are funded. There are for instance AEMs for field margin strips and unmanaged strips. Especially in the proximity of water bodies, field margins are often promoted by financial grants.

In Bavaria there is a subsidy for creation of a fallow area with self-greening on an arable field. Subject to further conditions, this measure is subsidised with a sum of 245-895 €/ha. Leaving meadows to go fallow in Beaver habitat is also subsidised with 250-400 €/ha.

Hamburg subsidises green fallow with associated maintenance conditions with 422.15 €/ha. North-Rhine Westphalia subsidises bare fallow, i.e. the creation of field strips or plots with self-greening with 625 €/ha. In Saxony, the subsidy for the creation of fallow plots and strips on grassland with maintenance conditions amounts to 545 €/ha.

The measure 'creation of skylark plots' is propagated through a joint project by the German Farmers' Association and the NABU Bundesverband (BirdLife Germany), as well as in the framework of regional initiatives, and there is a surprisingly high level of participation by farmers (particularly in North-Rhine Westphalia, where the measure is subsidised, participation is widespread). The measure 'crop management interruption in spring' on the other hand can only be found in individual projects and occasionally in contractual nature conservation measures for the protection of spring breeders (e.g. meadow breeders to protect the clutches).

The creation of flowering areas or strips is subsidised in seven of the ten evaluated federal states, as of 2009. These are Baden-Württemberg, Bavaria, Hesse, Lower-Saxony/Bremen, Thuringia, and Saxony. The subsidy amount varies from state to state depending also on the maintenance conditions attached to the measure.

Although the measures, especially the creation of field margins, flower plots and strips as well as greening measures (cultivation of catch crops and undersowing) are on offer on a wide scale, the actual share of land affected in relation to total arable land area is very small. Table 5.1.3.4 shows the complete AEM area (in %) of measures for the creation of extensively used conservation headlands and flower strips in relation to the total arable area of the states. At first glance the 7,654 ha in the measure 'flower strips (annual)' (Lower Saxony/Bremen) may appear high, but in relation to the total arable land area of Lower Saxony/Bremen amounts to only 0.406 % which is the highest figure of all states in this category. On the total arable land area of the federal states listed in table 5.1.3.4 there is only 0.21 % of AEM areas taken up by the measure for creation of flower strips and extensively used conservation headlands.

Tab. 5.1.6: Measures for the creation of extensively used conservation headlands and flower strips. Exemplary evaluation of agri-environmental programmes in ten German federal states on the basis of the states' mid-term reports of 2009. The mostly minor contractual conservation measures on small plots are not included.

Federal state	Arable area (ha)			Expenses	Area implemented [ha]		Area implemented [%]
		Code	Measure	Premium [€/ha]	Arable land	Other	Arable land
Baden-Württemberg	837700	C1	Fallow greening	130.00 €	80		0.010%
Bavaria	2093200	A29	Agroecological arable use and flowering areas	200.00 €	4663		0.223%
Hesse	482800	214 C	Flowering strips and protection strips without PPPs and fertilisers	372.55 €	18		0.004%
Hesse	482800	f2-LP4	Protection areas/strips without PPPs and fertilisers	409.03 €	5		0.001%
Lower Saxony/Bremen	1884200	A5	Flowering strips (annual)	540.00 €	7646		0.406%
Lower Saxony/Bremen	1884200	A6	Flowering strips (perennial)	330.00 €	49		0.003%
Lower Saxony/Bremen	1884200	FM431	*Field margins*	600.00 €	*78*		0.004%
Lower Saxony/Bremen	1884200	FM412	extensive arable fields - wild herbs	480.00 €	184		0.010%
Schleswig-Holstein	668000		Protection strips without PPPs and fertilisers	219.00 €	100		0.015%
Thuringia	614500	L31	Flowering strips on arable land	435.16 €	178		0.029%
Thuringia	614500	L32	Field margins	445.21 €	28		0.005%
Saxony	721200	B3.1	Environmentally compatible management of arable areas	257.86 €	2269		0.315%
Sum/mean	7301600				15298		0.21%

In some federal states, measures to protect specific bird and mammal species are offered. These measures are implemented on 0.26 % (8,079 ha) of the total arable land area in Lower Saxony/Bremen, Schleswig-Holstein and Thuringia (see Tab. 5.1.7). The largest share is taken up by the measure 'visiting Nordic bird species on arable fields' with a total area of 4,990 ha in Lower-Saxony/Bremen. In contrast, the measure 'Red Kite conservation' in Thuringia covers only 16 ha of Thuringia's total arable land area of 614,500 ha.

With only 0.05 % (1,395 ha), the measures on set-aside or conversion of arable areas (Tab. 5.1.8) have the lowest share of AEMs in arable farming. Only 18 ha of the measure 'bank verges' in Thuringia are, measured against the total arable area in the state, negligible.

While measures that are conceived primarily to increase biodiversity or for the direct protection of the bordering areas of water bodies, for instance flower strips and field margins, faunistic-oriented measures, and the set-aside and conversion measures, take up together markedly less than 1 % of all arable land, measures for catch crops and winter greening play a considerably greater role. These latter measures are designed primarily to prevent nutrient loss after the harvest and as protection against soil erosion. Table 5.1.9 contains greening measures that are on offer in similar forms in different federal states. The measure 'planting of catch crops' (Saxony) has, with 2.09 % (15,071 ha) the highest share in relation to the total area of arable land in the state. Although 1,000 €/ha is paid as subsidy in Bavaria for the measure 'green verges for water body and soil protection', in 2009 only 845 ha were covered by this measure, a share of only 0.04 %. Altogether, greening measures comprise 3.09 % of the total arable land area of Bavaria, Baden-Württemberg, Lower Saxony/Bremen, Saxony, Schleswig-Holstein und Thuringia.

Tab. 5.1.7: Measures to protect special bird and mammal species. Exemplary evaluation of agri-environmental programmes in ten German federal states on the basis of the states' mid-term reports of 2009. The mostly minor contractual conservation measures on small plots are not included.

Federal state	Arable area (ha)			Expenses	Area implemented [ha]		Area implemented [%]
		Code	Measure	Premium [€/ha]	Arable land	Other	Arable land
Lower Saxony/Bremen	1884200	FM411	Nordic visiting birds on arable land	265.00 €	4990		0.26%
Lower Saxony/Bremen	1884200	FM421	extensive arable areas - birds/animal species	600.00 €	53		0.00%
Lower Saxony/Bremen	1884200	FM422	*Nordic visiting birds*	420.00 €	*2499*		0.13%
Schleswig-Holstein	668000		Resting place for migrating bird species - arable land	205.00 €	229		0.03%
Thuringia	614500	N12	Protection of European Hamster	?	292		0.05%
Thuringia	614500	N14	Protection of Red Kite	281.06 €	16		0.00%
Summe/Durchschnitt	3166700				8079		0.26%

Tab. 5.1.8: Set-aside measures and/or measures to convert arable land into grassland. Exemplary evaluation of agri-environmental programmes in ten German federal states on the basis of the states' mid-term reports of 2009. The mostly minor contractual conservation measures on small plots are not included.

Federal state	Arable area (ha)			Expenses	Area implemented [ha]		Area implemented [%]
		Code	Measure	Premium [€/ha]	Arable land	Other	Arable land
Bavaria	2093200	A25/26	*Conversion of arable land to grassland (outstanding commitments)*	500.00 €	*133*		0.01%
Bavaria	2093200		Conversion of arable land to grassland	400.00 €	1051		0.05%
Thuringia	614500	L33	Bank verges	383.78 €	18		0.00%
Thuringia	614500	N15	Setting aside arable areas for nature conservation	246.79 €	34		0.01%
Thuringia	614500	N5	Conversion of arable land to grassland	491.34 €	159		0.03%
Summe/Durchschnitt	2707700				1395		0.05%

While measures that are conceived primarily to increase biodiversity or for the direct protection of the bordering areas of water bodies, for instance flower strips and field margins, faunistic-oriented measures, and the set-aside and conversion measures, take up together markedly less than 1 % of all arable land, measures for catch crops and winter greening play a considerably greater role. These latter measures are designed primarily to prevent nutrient loss after the harvest and as protection against soil erosion. Table 5.1.9 contains greening measures that are on offer in similar forms in different federal states. The measure 'planting of catch crops' (Saxony) has, with 2.09 % (15,071 ha) the highest share in relation to the total area of arable land in the state. Although 1,000 €/ha is paid as subsidy in Bavaria for the measure

'green verges for water body and soil protection', in 2009 only 845 ha were covered by this measure, a share of only 0.04 %. Altogether, greening measures comprise 3.09 % of the total arable land area of Bavaria, Baden-Württemberg, Lower Saxony/Bremen, Saxony, Schleswig-Holstein und Thuringia.

Finally, measures towards preservation of multiple crop rotation (Tab. 4.1.3.8) are clearly at the top of the list with 779,219 ha or some 22 % of the total arable land area of the states where they are implemented (Bavaria, Baden-Württemberg and Thuringia). North-Rhine Westphalia also offers a similar AEM. State-specific conditions are in force that lay down the type and extent of crops that can be planted, or if a four or five part crop rotation has to be adhered to. In Baden-Württemberg maize can be cultivated on a maximum of 40 % of arable land according to the conditions of the measure. On the areas subsidised for crop rotation, other AEMs can be implemented additionally.

Tab. 5.1.9: Greening measures, e.g. catch crops, undersowing. Exemplary evaluation of agri-environmental programmes in ten German federal states on the basis of the states' mid-term reports of 2009. The mostly minor contractual conservation measures on small plots are not included.

Federal state	Arable area (ha)			Expenses	Area implemented [ha]		Area imple-mented [%]
		Code	Measure	Premium [€/ha]	Arable land	Other	Arable land
Baden-Württemberg	837700	B3	Autumn greening - arable farming/horticulture	90.00 €	123271		14.7154%
Baden-Württemberg	837700	B4	Greening in permanent crops	90.00 €		26082	
Bavaria	2093200	A23	Winter greening	80.00 €	8937		0.4270%
Bavaria	2093200	A27	*Winter greening (outstanding commitments)*	80.00 €	*43650*		2.0853%
Bavaria	2093200	A28	Grass verge for water and soil protection	1000.00 €	845		0.0404%
Hesse	482800	214 B	Winter greening	70.43 €	65		0.0135%
Schleswig-Holstein	668000		Winter greening by nurse crops/cover crops (new)	65.29 €	700		0.1048%
Lower Saxony/Bremen	1884200	A7	Cultivation of cover crops	70.00 €	31970		1.6967%
Saxony	721200	A1	Seeding of cover crops		15071		2.0897%
Saxony	721200	A2	Nurse crops		178		0.0247%
Saxony	721200	B3.2	Wintering stubble		166		0.0230%
Thuringia	614500	W21	Cultivation of cover crops/nurse crops	67.77 €	484		0.0788%
Summe/Durchschnitt	7301600				225337		3.0861%

Tab. 5.1.10: Measures for the implementation of multiple crop rotation. Exemplary evaluation of agri-environmental programmes in ten German federal states on the basis of the states' mid-term reports. The mostly minor contractual conservation measures on small plots are not included.

Federal state	Arable area (ha)			Expenses	Area implemented [ha]		Area imple-mented [%]
		Code	Measure	Premium [€/ha]	Arable land	Other	Arable land
Baden-Württemberg	837700	A2	Quadrinomial crop rotation	20.00 €	358653		42.81%
Bavaria	2093200	A11	Extensive crop rotation	115.00 €	102575		4.90%
Bavaria	2093200	A21	Diverse crop rotation	100.00 €	124308		5.94%
Bavaria	2093200	A22	*Multiple crop rotation (outstanding commitments)*	70.00 €	*73122*		3.49%
Thuringia	614500	L2	Species rich crop rotation	34.78 €	120561		19.62%
Summe/Durchschnitt	3545400				779219		21.98%

Landscape-related off-crop measures

Landscape-related measures are mostly not AEMs in a strict sense, but measures of contractual nature conservation that are offered in specific local projects and are implemented in cooperation with the farmers involved. There is no nationwide comparative material to show the extent of these measures. In those locations where measures are on offer, they are however as a rule successful and effectively targeted. Landscape-related measures generally require a high level of maintenance.

An exemplary description of various measures implemented in German federal states is given below. These are intended to give an overview of and insight into the variety of the measures – a comprehensive presentation can be found in the publication by Frieder et al. (2009). As mentioned above, no nationwide comparative figures are available. Nevertheless, on the basis of the individual figures available, it can be estimated that the extent of these measures lies in the parts-per-thousand range only, in relation to the total arable land area in Germany.

Regarding the creation of habitat networks, Schleswig-Holstein subsidises a project for conservation, enhancement and restoration of the natural heritage and the development of areas with a high natural value, which include also the linear or plot-wise networking of indigenous wildlife and plant species habitats.

Baden-Württemberg and Mecklenburg-Western Pomerania offer a subsidy for networking of Natura2000 areas.

In Saxony-Anhalt the networking and creation of habitats for indigenous wildlife and plant species is subsidised.

The planting of individual trees, field coppices, bushes and above all hedgerows is subsidised by some federal states. North-Rhine Westphalia subsidises such measures under the umbrella term ‘conservation and enhancement of rural heritage in the area of nature protection’. Some federal states such as Bavaria no longer subsidise the planting but instead the maintenance of existing hedgerows.

The maintenance, protection and conservation of meadow orchards is subsidised by eight German federal states. In Saxony, there is a subsidy for the re-creation of meadow orchards. North-Rhine Westphalia has cancelled the subsidy for new meadow orchards and, as with the other federal states, subsidises solely their maintenance and conservation. The amount of subsidy can vary dependent on other maintenance conditions attached.

Some communities (e.g. Wiesbaden) subsidise the creation of new meadow orchards. Many communities or local nature conservation groups organise annual ’Hochstammaktionen’, in which frequently not only high stemmed fruit trees of regional and old cultivars are on offer at reasonable prices, but also other autochthonous trees and bushes.

The conservation of meadow orchards is best guaranteed through use of the fruit. Fruit trees earlier served self-subsistence; nowadays the utilisation is moving strongly towards cultivation of cider apples in order to preserve the meadow orchards.

The creation of dry stone walls and stone heaps are in some federal states taken into account as part of other, more comprehensive, AEMs.

In the measure ‘conversion of arable land into species-rich grassland‘ Rhineland-Palatinate also honours the additional module ‘creation of a stone heap’ with a one-off payment of 25 €. Apart from Rhineland-Palatinate, only Mecklenburg-Western Pomerania offers such one-off payments for dry stone walls. Saxony-Anhalt subsidises the preservation of steep slope viticulture and the repair of vineyard stone walls.

The creation of water body and bank verges with reeds, tall forbs, trees and bushes are included in several different AEMs in Germany, for instance as creation of marginal strips on water bodies or planting of trees and bushes (Frieder 2009).

A special subsidy for moist sinks with agricultural use is not yet offered as an AEM in Germany. The maintenance and conservation of damp grassland and wetland habitats is however financially supported by almost all federal states.

The creation of pools and wetland biotopes is promoted only on a single project basis.

Rhineland-Palatinate subsidises the creation of moist sink areas with 100 €/ha in connection with the conversion of arable land into species-rich grassland. Hamburg and Mecklenburg-Western Pomerania offer one-off payments for wetland restoration as part of the AEM 'preservation and development of valuable natural biotopes on farms'. North-Rhine Westphalia and other federal states also subsidise wetland restoration.

According to our information, small-scale crop fields are not to date subsidised in Germany through AEMs.

There is a large number of programmes for subsidy of extensive grassland in all German federal states. In Bavaria, there is subsidy of 150-350 €/ha for extensive grassland management for meadow breeders and wild herbs, with specific laid down maintenance measures such as restricted mowing periods. In Baden-Württemberg, extensive grassland management is subsidised in the framework of the MEKA agri-environmental programme. This includes extensive grassland management with at most 2.0 livestock units (LU)/ha or 1.4 LU/ha. At least 5 % of the area may not be mowed until after 15 June (MLR 2010).

Tab. 5.1.11 presents an overview of the practicability and acceptance of the crop and landscape-related RMMs. The assessments are derived from experience with AEMs and knowledge of agricultural practice. As far as implementation in practice is concerned, it should be noted that many of the off-crop and some of the in-crop RMMs are offered exclusively, or for the most part, in contractual nature conservation arrangements in the form of individual contracts (that are different in every federal state), and therefore do not have a broad impact. They are often tied to specific regional scenarios.

Tab. 5.1.11: Overview of landscape-related in-crop and off-crop measures with the aim of improving food availability and the breeding habitat in terms of practicability and acceptance by farmers as well as the possibility of conducting controls and whether corresponding AEMs exist. Realisation is highlighted: Orange, if the measure is evaluated on the whole as positive or at least neutral; Yellow, if the measure is evaluated as positive or limited positive at least in terms of practicability and controllability. Legend: + practicability or acceptance given, (+) limited practicability or acceptance or AEM given, 0 indifferent rating, - practicability or acceptance not given, * related AEM exist but only as total abandonment of pesticide use.

Aim: Augmentation of food availability and improvement of the breeding habitat				
	Realisability of RMMs with agricultural practice			
Landscape-related in-crop measures	Practicability	Acceptance by	Controls possible	AEM exists
Cultivation of at least four different crop types (diversified crop rotation) in spatial proximity	+	(+)	(+)	(+)
Catch cropping after main fruit harvest for winter greening	+	+	+	+
Keeping stubble fields until next seeding in the following spring	+	(+)	+	(+)
Creation of sparsely sown field crops (defined areas or strips) with reduced fertilization (in wide rows)	(+)	0	+	(+)
Extensive arable farming (minimal use of fertilizers, no use of pesticides)	+	0	+	(+)
Creation of flowering areas or strips	+	(+)	+	+
Creation of fallow strips on crop edges	+	-	+	(+)
Creation of fallow strips inside crops (beetle banks / bee banks)	+	-	+	-
Conversion of arable land into fallow land / set-aside for one year	+	-	+	(+)
Conversion of arable land into fallow land / set-aside for a couple of years	+	-	+	(+)
Creation of skylark plots	+	+	+	(+)
Temporary interruption of crop management in spring	+	-	(+)	(+)
Landscape-related off-crop measures				
Creation of biotope networks in order to enhance biodiversity (e.g. sowing of wild herbs from autochthonous seeds)	+	(+)	+	(+)
Planting of individual trees, field trees (woodland), hedges and scrubs	+	(+)	+	(+)

Creation of meadow orchards, as well as nest and hollow trees	+	(+)	+	(+)
Creation of dry stone walls and stone heaps	+	(+)	+	(+)
Creation of road-, water- and bank-verges with extensive grassland	+	(+)	+	(+)
Creation of water- and bank-verges with reeds / tall forbs	+	(+)	+	(+)
Creation of water- and bank-verges with trees/shrubs	+	(+)	+	(+)
Creation of moist sink areas with utilisation (crop and grassland)	+	(+)	+	(+)
Creation of still water bodies (pond biotopes) and wetlands without utilization	+	(+)	+	(+)
Restoration of drained grassland areas	+	-	+	(+)
Extensive grassland: restriction of management periods, mowing- and grazing-frequencies and usage of artificial fertilization	+	(+)	+	+
Small-scale crops	(+)	-	+	-

Conclusions

The analysis of the implementation of agri-environmental and contractual nature protection measures in the agri-environment programmes of the German federal states shows that many measures are implemented that correspond to the RMMs presented. They are however far too inadequate in scale and scope to achieve a noteworthy positive effect on more than local level for the farmland bird and mammal populations. In general, it appears that farmers select principally those measures that they can integrate with little effort in their day-to-day management processes (e.g. regulation of crop rotation and autumn and winter greening). In contrast, the extent of measures that have a direct positive effect on biodiversity on arable land amount to only 0.32 % of the total arable land area in Germany (IFAB, ZALF, HFR 2012), whereas according to various scientific studies a coverage of some 10 % of such areas is necessary to sustainably secure the populations of farmland wildlife species (see chapter 5.1.2). The analysis of the agri-environmental programmes further shows that farmers are willing to implement the measures and participate in the corresponding programmes if the corresponding subsidies are high enough. In this regard, the following example is interesting. Participation by farmers in Baden-Württemberg's AEM 'flowering areas (greening of fallow land with flower mix)' three years after its introduction - with a support premium of only 130 €/ha - amounted to only 80 ha. Two years later, with a support premium of 500 €/ha, the coverage of this measure had risen to 3,800 ha, notwithstanding that farmers were restricted to participation up to a maximum of only 5 ha per farm. This demonstrates that the level of support premium is decisive for acceptance of AEM by the farming community.

It is further evident that the measures must be simply structured and easy to control so that they are acceptable to farmers and can be properly monitored by the respective authority in charge. Special measures, which are restricted to only parts of fields or limited to parts of the vegetation periods, require very individual on-site care and control and should not be conducted over large areas. In addition, it is shown that mainly landscape-related in- and off-crop measures are offered and implemented, whereas the pesticide agent-related and application-related measures are not implemented to any great extent (with the exception of total dispensation with pesticide, which is however limited mainly to grassland - and biological and biotechnical measures applied mainly in fruit cultivation and viticulture).

Tab. 5.1.12: Overview of the currently implemented AEMs with high effectiveness for biodiversity conservation on arable land (especially for bird and mammal species) with the corresponding support premiums in €/ha (from IFAB, ZALF, HFR 2012).

Dark green agri-environmental measures on arable land	Support premiums in €/ha
Field border strips, extensive management of wild herbs and plant communities on arable land, arable land conversion management agreements	450 € - 1,160 €
European Hamster conservation , conservation of foraging areas and nest sites, Red Kite conservation, support foraging winter arctic visitors (geese and swans) on arable fields	280 € - 450 €
Setting-aside arable fields for conservation purposes	140 €
Agri-ecological use of arable land and creation of flowering areas, flowering and buffer strips, border and ribbon structures	200 € - 600 €
Buffer strips of water and soil protection, strips along ditches and streams	370 € - 1,000 €
Transformation of arable land to grassland	320 € - 745 €
Preservation of typical regional cultivated plant species and types	150 € - 400 €

5.1.4 Overview of the ecological suitability of the measures and their practical implementation

For the implementation of a good and broadly effective risk management, it is equally important that the measures are broadly effective, i.e. as many species as possible are served, and that the measures are easily realised, i.e. are practicable and controllable and, are accepted by the farming community as well as possible. In order to check these factors and analyse the suitability of the measures as a whole, the values from the previously presented tables have been summarised in table 5.1.13 The criteria evaluated and the threshold value applied is shown in the legend beneath the table. It is however essential to emphasise that this evaluation only serves to identify the most important RMMs; in principle, all RMMs are suitable in certain circumstances, for individual species, for individual crops or parts of the countryside, or in certain agricultural constellations, and this should not be forgotten in practice. For a superordinate risk management, however, the total overview is important in the first place.

At first glance, it becomes evident that in the field of PPP-related measures, only very few meet both criteria complexes (effectiveness for protection of bird and mammal species, practicability):

- No application of total herbicides and analogous no application of herbicides
- Retaining untreated margins or plots
- Use of biological and biotechnical methods

These measures relate to partly limitations of pesticides either certain groups or for part-areas. There are no measures that can achieve good effects with limitation of pesticide use as a whole and are also practicable and controllable.

In contrast, it is evident that in the case of crop and landscape-related RMMs there are a whole series of measures that are both effective and easy to implement - with only a few exceptions the majority of the RMMs are very suitable. This is because on the one hand, pesticide use is not excluded on these areas and, on the other hand, these measures deliberately integrate ideally suitable habitats in the agricultural countryside. Hence, risk management with a focus on compensation for negative effects of PPPs by indirect landscape-related measures can be seen as more effective than a focus on direct PPP-related measures.

According to the evaluation below, the most effective RMMs are as follows (dark-green highlighted value field = the RMM has proved in local or regional projects or as AEM. It can find acceptance and can be controlled, at the same time it features a high effectiveness in respect of the farmland bird and mammal target groups):

Creation of extensive field crops without application of pesticide and with reduced sowing density and fertilisation (very similar: creation of sparsely sown cereal crops (defined areas or strips) – to date little known and tested[3)]

- Creation of flowering areas or strips
- Keeping stubble fields with self-greening and as appropriate with maintenance measures
- Creation of road, water and bank verges with extensive grassland
- Creation of biotope networks (e.g. sowing of wild herbs from autochthonous seeds)

These five measures can be implemented generally in almost all arable countryside in Central Europe. They could become the key measures of a risk management programme (certainly only combined with an adequate level of financial compensation). The other RMMs listed can be sensibly implemented on a partial or local basis and they can, with corresponding on-site project management, complement the above-named measures. It is altogether important that on-site management of the measures in the environmental regions is guaranteed. In this way not only can the broad-based measures be adequately accompanied by counselling and quality control, but special projects with targeted support for individual species can also be implemented in augmentation.

[3] The difference is that sparsely sown areas or strips are deliberately planted in 'wide row' system, which means that individual drill coulters are closed. This represents a special form of extensive arable land management that could eventually achieve wider acceptance if it proves itself in practice).

Tab. 5.1.13: Overview of the RMMs with a comparison of the effects on the bird and mammal species studied (n=49) on the one hand, and the realisation complex (practicability / acceptance / controllability) on the other. In respect of suitability as a whole, those fields or measures are marked where both a good effect on many species as well as a good chance of realisation exist. Marking is as follows: **Effect of the measures:** Orange, if the measures have a positive effect on at least 30 species; Yellow, if the measures have a positive effect on at least 25 species; **Realisation:** Orange, if the measures are overall positive or at least neutral; Yellow, If the measure is at least positive or positive to an extent in terms of practicability or controllability; **Suitability as a whole:** Dark green: very good suitability as a whole, if the measure is highlighted as 'orange' (see above) both in terms of effect and realisation; light green: good overall suitability, if the measure is highlighted as 'yellow' (see above) in terms of both effect and realisation. Legend: + practicability or acceptance given, (+) limited practicability or acceptance or AEM given, 0 indifferent rating, - practicability or acceptance not given, * related AEM exist but only as total abandonment of pesticide use. Remarks, evaluation, suitability as a whole: A 1 Devaluation because competition to RMM for stubble fallow is given; A 2 only partly good, but partly markedly negative; A 3 Only possible on small plots.

Risk management measures (RMM)												
	Effects of RMM: Nos. of bird and mammal species that react positively (2, 1), neutral (0) or negatively (-1, -2) to the RMM							Realisability of RMMs with agricultural practice				Suitability as a whole
Aim: Minimisation of the threat through reduction of pesticide use	very positive	positive	neutral	negative	very negative	No of species	No of species that react very positive or positive to the RMM	Practicability	Acceptance by farmers	Controls possible	AEM exists	Suitability as a whole
Pesticide agent-related in-crop measures:												
No application of non-selective, broad-spectrum herbicides	21	15	13	0	0	49	36	+	-	(+)	*	
No application of pre-sowing, pre- and post- emergence herbicides	19	15	15	0	0	49	34	+	-	(+)	+	
Application of highly targeted herbicides against key weed species	16	18	15	0	0	49	34	(-)	(+)	-	-	
Restricted application of insecticides	31	6	12	0	0	49	37	+	-	-	*	
Restricted application of fungicides	0	11	38	0	0	49	11	+	-	-	*	
Restricted application of rodenticides	14	7	28	0	0	49	21	+	-	-	*	
Restricted application of molluscicides	8	12	29	0	0	49	20	+	-	-	*	
Restricted application of other pesticides (growth regulators, etc.)	0	1	48	0	0	49	1	+	-	-	*	
Restricted usage of plant protection agents (fungicides, insecticides) for seeds treatment	10	16	23	0	0	49	26	+	-	-	*	
Pesticide application-related in-crop measures:												
No application of pesticides during breeding, nesting and fledging periods (birds) as well as gestation and lactation periods (mammals)	14	10	11	0	0	35	24	+	-	-	(+)	

No application of pesticides in ecological hot spots (nesting sites, burrows)	17	2	30	0	0	49	19	0	+	(+)	(+)	
Selective control of target weed species	14	21	14	0	0	49	35	0	(+)	-	*	
Selective control of weed clusters	14	21	14	0	0	49	35	0	-	(+)	*	
Application of biological and biotechnical methods of plant protection in agriculture, hop growing, fruit crops and viticulture	26	8	13	0	0	47	34	+	+	+	+	
Spatial restriction (unsprayed field edges and headlands)	32	5	12	0	0	49	37	+	-	+	(+)	
Aim: Augmentation of food availability and improvement to the breeding habitat												
	Effects of RMM: Nos. of bird and mammal species that react positively (2, 1), neutral (0) or negatively (-1, -2) to the RMM							Realisability of RMMs with agricultural practice				Suitability as a whole
Crop-related in-crop measures:	Nos. when value = 2	Nos. when value = 1	Nos. when value = 0	Nos. when value = -1	Nos. when value = -2	Check: total Nos.	Totals of positive values 2 and 1	Practicability	Acceptance by farmers	Controls possible	AEM exists	Suitability as a whole
Cultivation of at least four different crop types (diversified crop rotation) in spatial proximity	16	11	21	1	0	49	27	+	(+)	(+)	(+)	
Catch cropping after main fruit harvest for winter greening	17	13	18	1	0	49	30	+	+	+	+	A1
Keeping stubble fields until next seeding in the following spring	25	8	16	0	0	49	33	+	(+)	+	(+)	
Creation of sparsely sown field crops (defined areas or strips) with reduced fertilization (in wide rows)	6	19	24	0	0	49	25	(+)	0	+	(+)	
Extensive arable farming (minimal use of fertilizers, no use of pesticides)	28	9	12	0	0	49	37	+	0	+	(+)	
Creation of flowering areas or strips	29	8	12	0	0	49	37	+	(+)	+	+	
Creation of fallow strips on crop edges	36	3	10	0	0	49	39	+	-	+	(+)	
Creation of fallow strips inside crops (beetle banks / bee banks)	25	13	10	1	0	49	38	+	-	+	-	
Conversion of arable land into fallow land / set-aside for one year	32	8	8	0	1	49	40	+	-	+	(+)	
Conversion of arable land into fallow land / set-aside for a couple of years	31	8	8	1	1	49	39	+	-	+	(+)	
Creation of skylark plots	0	5	44	0	0	49	5	+	+	+	(+)	
Temporary interruption of crop management in spring	6	6	37	0	0	49	12	+	-	(+)	(+)	
Landscape-related off-crop measures:												
Creation of biotope networks in order to enhance biodiversity (e.g. sowing of wild herbs from autochthonous seeds)	15	18	16	0	0	49	33	+	(+)	+	(+)	
Planting of individual trees, field trees (woodland), hedges and scrubs	27	5	1	1	15	49	32	+	(+)	+	(+)	A2
Creation of meadow orchards, as well as nest and hollow trees	5	15	11	1	17	49	20	+	(+)	+	(+)	
Creation of dry stone walls and stone heaps	6	3	36	4	0	49	9	+	(+)	+	(+)	
Creation of road-, water- and bank-verges with extensive grassland	35	6	8	0	0	49	41	+	(+)	+	(+)	
Creation of water- and bank-verges with reeds / tall forbs	16	5	16	6	6	49	21	+	(+)	+	(+)	

Creation of water- and bank-verges with trees/shrubs	14	11	5	2	17	49	25		+	(+)	+	(+)		
Creation of moist sink areas with utilisation (crop and grassland)	24	8	12	4	1	49	32		+	(+)	+	(+)		A3
Creation of still water bodies (pond biotopes) and wetlands without utilization	18	8	18	4	1	49	26		+	(+)	+	(+)		
Restoration of drained grassland areas	21	8	16	4	0	49	29		+	-	+	(+)		
Extensive grassland: restriction of management periods, mowing- and grazing-frequencies and usage of artificial fertilization	15	11	21	0	0	47	26		+	(+)	+	+		
Small-scale crops	20	15	10	2	2	49	35		(+)	-	+	-		

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5.2 Umbrella species

5.2.1 Introduction

An umbrella species acts as a representative for a range of other species and enables target-oriented conservation actions from which not only individuals of that species but many other organisms benefit. Certain standards have to be fulfilled by a species in order to function as an umbrella species whose protection positively reflects on other species.

In the context of adverse pesticide effects, especially indirect ones, we here define a number of criteria a species had to meet to be selected as umbrella species.

A species taken as umbrella species should be reasonably common and wide-spread in German agricultural landscapes. Scarce species would not allow the application of the umbrella species concept where they do not occur. It should be a characteristic species of agricultural landscapes, i.e. a main part of its habitat is strongly associated with arable land. Moreover, there has to be sufficient evidence for and adverse effect of the application of pesticides on the species and its population has to be endangered. In addition, ecological requirements of a species have to resemble the ones of a wide range of other farmland species which therefore benefit from management strategies applied for the umbrella species. Finally, a positive image and a high awareness by the public is another important criterion since the species has to communicate the needs of many other species less known and conservation efforts should be accepted in public.

In order to find suitable umbrella species we selected the species along following criteria:

- reasonably common
- widespread (likely to occur at most sites)
- strong association to arable land
- high PPP sensitivity index (or evidence for pesticide effects)
- unfavourable conservation status (declining)

We conducted an evaluation of all 27 bird and 22 mammal species according to those five criteria (Tabs. 5.2.1 and 5.2.2). For birds three species meet all five criteria: Grey Partridge, Skylark and Linnet. In mammals, Field and Common Vole as well as Brown Hare fulfil all criteria. However, Vole species, though their long term population trends might be decreasing, are not seen as endangered species and are even considered as pest species in agricultural landscapes. Hence, they would not meet the acceptance in public as a farmland species in need of protection. The Brown Hare seems to be much more appropriate as an umbrella species.

In the following we present a brief reasoning for the four species that could function as umbrella species for the list of other farmland species examined in this report.

Grey Partridge

Grey Partridges are endangered in Germany and their populations have been severely declining. The Grey Partridge generally occurs all over Germany. It lives on open farmland. As the species mainly feeds on seeds and green parts of plants but also consumes animal food, mostly arthropods and their chicks depend entirely on small invertebrates during their first weeks the Grey Partridge embodies both herbivorous and insectivorous species and therewith is suitable to represent a wide range of other farmland species.

In our sensitivity index ranking, the Grey Partridge scores third highest. The Grey Partridge is one of the species for which the adverse impact of indirect pesticides has been proven (see Campbell et al. 1997). Hence, especially related to indirect pesticide effects the Grey Partridge is a very prominent species and therefore for our purposes most suitable as an umbrella species.

Skylark

Skylarks occur all over Germany. They are classified as vulnerable in the Red List Germany and their populations are declining in Germany as well as in total Europe. Skylarks nest on all crop types.

During the breeding season Skylarks mainly feed on insects and other vertebrates but they take some seeds and green parts of plants as well. During the rest of the year their diet is based more on plants.

Pesticide applications are threatening Skylark due to the food reduction during the breeding season which negatively reflects on nestling condition (Boatman, Brickle et al. 2004). Moreover, their nests are placed on the ground and sufficient cover, potentially negatively affected by herbicides, is an important factor for the breeding success. These negative indirect effects are also revealed by high sensitivity index score.

Linnet

The Linnet is classified as near threatened on the Red List Germany. It occurs all year round in open landscapes all over Germany and feeds both on grassland and arable land. Linnets feed nearly exclusively on seeds and hence represent granivorous species like for example some small mammal species that include a great proportion of seeds in their diet.

Though there is no direct evidence of indirect effects of pesticides on Linnets, its dependences on wild plant seeds suggests a potential danger from herbicide applications, further supported by a relatively high score in our sensitivity index analysis.

In contrast to Grey Partridges and Skylarks, Linnets breed in hedgerows or bushes and, therefore, represent birds associated with these habitat elements.

Brown Hare

The Brown Hare is listed as vulnerable (category 3) on the Red List for Germany. On the federal state level, its populations are classified as being vulnerable in several states (Red List category 2) or even endangered (Red List category 2). In general, the Brown Hare is widely distributed in German agricultural habitats, though its numbers are decreasing. Crops form an important habitat for Brown Hares and arable areas, where pesticide applications are most dominant, maintain higher Hare densities than grassland areas. The species represents mainly herbivorous species that live in open landscapes.

Although no comprehensive studies have investigated the indirect effects of pesticides on Brown Hare populations the influence of especially herbicides is potentially very important due to the reduction of wild plant species that form an important part of its diet. The Brown Hare suffers from a lack of alternative food sources like wild herbs, especially when crops grow too high and dense for the Hare to access (Tapper and Barnes 1986). The adverse impact of indirect effects of pesticides is also supported by the high scoring in our sensitivity index analysis (chapter 4.2) where the Brown Hare is top-ranking.

Finally, the Brown Hare is a species that meets the public's interests and sympathy making the species' needs easily communicated.

Tab. 5.2.1: Criteria-evaluation for the selection of bird umbrella species for risk management (1 = meets the criterion, 0 = does not meet the criterion). Yellow marked species are those that meet all criteria.

Species	Common	Wide-spread	Association to farmland	High PPP index	Negative long-term trend	Ecology
Bewick's Swan	0	0	0	0	1	non-breeding
Barnacle Goose	1	0	0	0	0	non-breeding
Bean Goose	1	0	1	0	0	non-breeding
White-fronted Goose	1	0	0	0	0	non-breeding
Greylag Goose	1	0	0	0	0	non-breeding
Common Quail	0	1	1	1	0	ground nest, farmland
Grey Partridge	1	1	1	1	1	ground nest, farmland
Montagu's Harrier	0	0	1	0	0	ground nest, farmland
Red Kite	0	0	1	0	0	tree nest, farmland
Common Crane	0	0	0	0	0	non-breeding
Corncrake	0	0	0	0	0	grassland
Golden Plover	0	1	1	0	0	non-breeding
Lapwing	1	1	0	0	1	grassland
Black-tailed Godwit	0	0	0	0	1	grassland
Little Owl	0	0	0	0	0	village, grassland
Red-backed Shrike	1	1	0	1	0	bush, farmland
Woodlark	1	0	0	1	0	ground nest, farmland
Skylark	1	1	1	1	1	ground nest, farmland
Barn Swallow	1	1	0	1	1	farm building
House Martin	1	1	0	1	1	farm building
Winchat	1	0	0	1	0	grassland
Meadow Pipit	1	0	0	0	1	grassland
Yellow Wagtail	1	1	1	1	0	ground nest, farmland
Linnet	1	1	1	1	1	bush farmland
Corn Bunting	0	0	1	1	0	ground nest, farmland
Yellowhammer	1	1	1	1	0	bush, farmland
Ortolan Bunting	0	0	1	1	0	ground nest, farmland

5.2.2 Applicability of the umbrella species concept for risk management

In our analysis of the suitability of risk management measures a number of pesticide-, crop- and landscape-related measures were identified as being relevant for a majority of the species examined in this report (see also chapter 5.1.2).

Regarding risk management strategies, several groups of bird species can be identified (Tab. 5.2.1). These are non- breeding swans, geese, Common Cranes and Golden Plovers, grassland birds (Lapwing, Black-tailed Godwit, Yellow Wagtail, Meadow Pipit, Whinchat), species that nest on trees, in hedgerows or bushes and ground-nesting arable species. Within these groups many bird species are alike in their reaction to different measures.

The non-breeding species and the grassland birds are probably less affected by PPPs (chapter 4.2). Risk-management strategies should therefore concentrate on species breeding in German farmland and on species mainly occurring on arable land.

In figure 5.2.1 we give an overview on the suitability of the different risk management measures evaluated in chapter 5.1.2 for bird and mammal species and how the umbrella species respond to these measures. In general, it becomes clear, that the four species cover a wide range of management measures, including those measures that are most favourable to the majority of farmland species like the annual and perennial set-aside, the creation of edge structures with extensive grassland or the restricted application of insecticides and broad-spectrum herbicides.

Tab. 5.2.2: Criteria-evaluation for the selection of mammal umbrella species for risk management (1 = meets the criterion, 0 = does not meet the criterion, ? = population trend unknown). Yellow marked species are those that meet all criteria.

Species	Common	Wide-spread	Association to arable land	High PPP sensitivity index	Negative trend
European Hamster	0	0	1	1	1
Field Vole	1	1	1	1	1
Common Vole	1	1	1	1	1
Striped field Mouse	1	0	0	1	?
Yellow-necked Mouse	1	1	0	1	1
Wood Mouse	1	1	1	1	0
Harvest Mouse	0	1	0	1	1
Bicoloured Shrew	0	0	1	1	1
Greater white-toothed Shrew	1	0	1	1	1
Lesser white-toothed Shrew	0	0	1	1	?
Common Shrew	1	1	0	1	?
Pygmy Shrew	1	1	0	1	?
European Hedgehog	1	1	0	0	0
European Mole	1	1	0	0	1
Brown Hare	1	1	1	1	1
Greater mouse-eared bat	0	1	0	1	1
Natterer's Bat	0	1	0	1	1
Common Noctule	0	1	0	1	1
Stoat	1	1	0	1	1
Least Weasel	1	1	0	1	1
Fallow Deer	1	1	0	0	0
Wild Boar	1	1	0	0	0

Bird species – Grey Partridge, Skylark, Linnet

Among pesticide related risk management measures, all three bird species positively respond to restrictions in herbicide applications since this is not only influencing wild plant species diversity but also invertebrate occurrence. Measures such as application of highly targeted herbicides, avoidance of broad-spectrum herbicides and spatial restriction of applications (also insecticides) are positively associated to a great majority of farmland species. For the Grey Partridge and the Skylark the restricted application of insecticides in another important measure that would ensure the availability of invertebrate food sources. Here, the two species represent a number of insectivorous bird and also mammal species like shrews and bats.

All three bird species respond very positive to the crop-related measures of creation of set-aside and fallow land as well as flower strips and leaving stubble fields over winter. Many other farmland bird and mammal species benefit from these measures as well.

Concerning the landscape-related measures Skylarks represent very characteristic needs distinctive from those of the Grey Partridge and the Linnet and many other farmland species. While the latter species favor structural elements like hedgerows, woodland or tree lines, Skylarks avoid such habitats. With this characteristic they represent a number of other species like Yellow Wagtails, Meadow Pipits and Whinchats, while the majority of farmland species, especially small mammals, highly depends on the availability of such elements in the agricultural landscape. These species are represented by the habitat preference of Grey Partridges and Linnets. Possible conflicts between measures for different species have to be resolved at the local level.

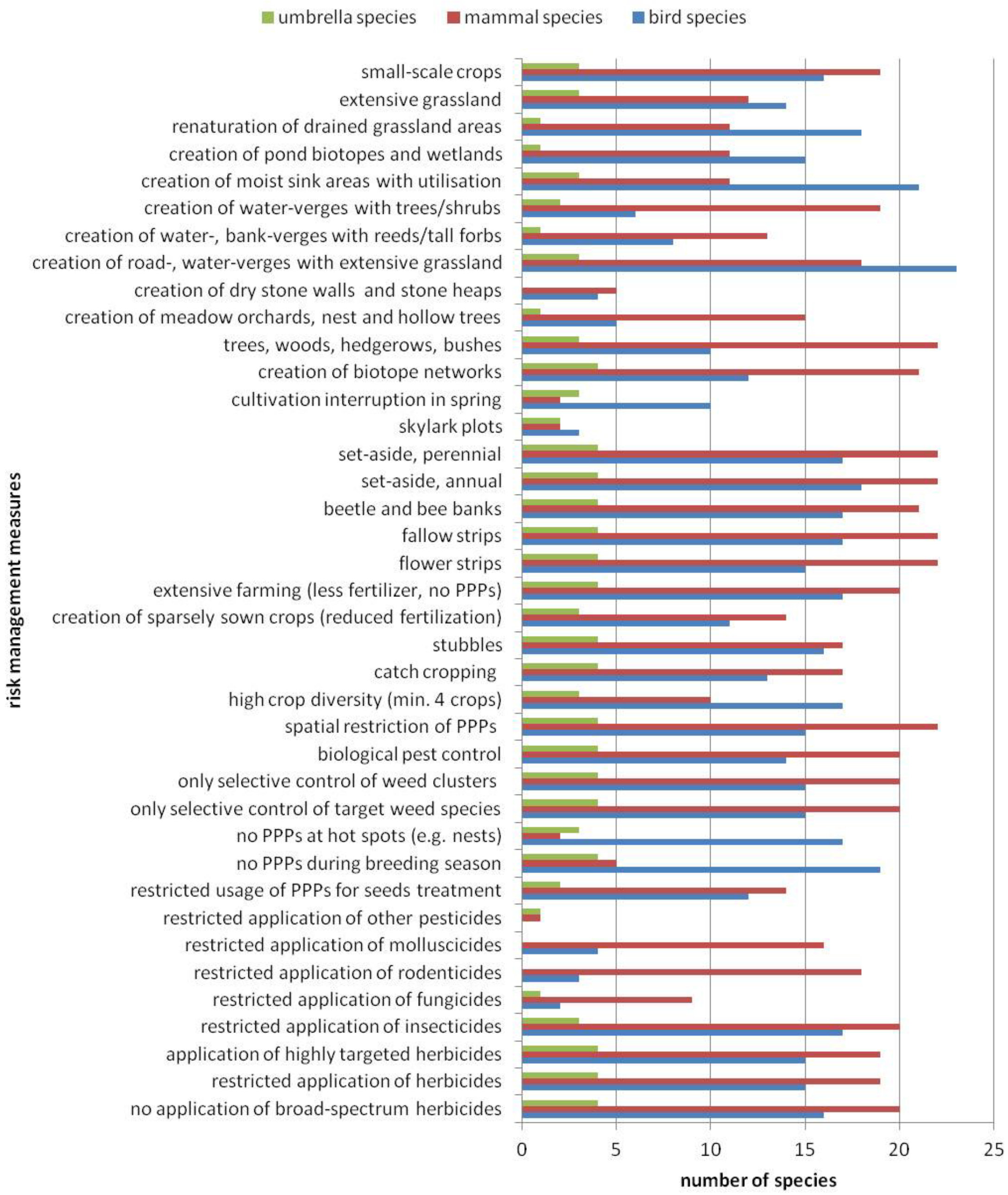

Fig. 5.2.1: Overview on the suitability of the different risk management measures for bird, mammal and the selected umbrella species. The horizontal axis shows the number of species that positively respond to the corresponding risk management measure.

The three birds species selected here as umbrella species have great potential to successfully represent the diverse requirements of other farmland bird and also mammal species. Through their expected synergy-effects management strategies developed for Grey Partridges, Skylarks and Linnets positively influence the diversity of farmland species in German agricultural landscapes.

Mammal species – Brown Hare

Concerning pesticide-related risk management, Brown Hares are mainly threatened by the applications of herbicides. Therefore, obviously restrictions in the application of non-selective, broad-spectrum herbicides are a good pesticide-related management measure that is relevant for a great number of other farmland species as well. An important measure is also the spatial restriction of herbicide applications which leaves field edges and headlands unsprayed. A number species benefit from this measure, especially small mammals that prefer to stay in the boundary areas of crops.

In crop-related management the creation of fallow land and wildflower strips were among the most popular measures for the majority of species and these are also measures Brown Hare populations benefit from, since they increase the availability of wild plant food sources (see for example (Holzgang, Kéry et al. 2005)). The creation of sparsely sown field crops and keeping stubble fields until the next seeding in the following spring are two important measures for Hares and many other species, especially small mammal species like rodents, response positively to these measures as well.

The creation of hedgerows and woodland as part of landscape-related management is a measure that is not only beneficial for the Brown Hare but for many more small mammal species that all rely on food, shelter and living habitat providing structures in arable landscapes. Small scale crops and the creation of biotope networks are also very important to keep the agricultural habitat accessible for small mammal species that are, different from bird species, very restricted in their movement distances and dispersal abilities.

In total, the protection of Brown Hare populations with a range of pesticide-, crop- and landscape-related risk management measures is suitable to provide protection for a wide range of other farmland species.

On this basis and for other reasons mentioned above the Brown Hare seems like an appropriate umbrella species deployed for the achievement of the goal to protect biodiversity in agricultural landscapes from negative effects of pesticide applications.

5.2.3 References

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5.3 Risk management strategies – implementation of risk management measures into agricultural practice

In order to assure an effective protection of birds and mammals in agricultural landscapes from negative effects of PPPs, risk management measures (RMM) need to be embedded in a comprehensive risk management strategy that creates an appropriate framework and regulates their funding and implementation into agricultural practice.

The feasibility and effectiveness of such a strategy will have to meet the following demands:

- As part of an appropriate framework it should minimize risks for agricultural wildlife, and created incentives for farmers to use less PPPs.
- A market based approach is needed that improves the economic situation of low-risk PPPs as opposed to high-risk products.
- The 'polluter-pays-principle' needs to be implemented internalizing costs being up to now paid by nature and society.
- A direct link between on-farm PPP usage and conduction of RMM should create awareness about risks of PPPs.
- Management should be adapted to regional conditions.
- Acceptance among farmers needs to be assured especially regarding the fairness of the additional costs.
- Flexibility concerning reactions to yearly changes and broader trends needs to be given.
- Implementation of measures needs to be precisely targeted and conducted on a large scale.
- The strategy should be of low administrative effort.

5.3.1 Existing tools of risk reduction

Before discussing the design of a comprehensive risk management strategy, existing tools to reduce risks from PPPs that are already in place in Germany and/or in other European states need to be identified. These are:

- Legally established regulations for authorization and use of PPPs
- National action plans including promotion of integrated plant protection
- Agri-environmental programmes including promotion of organic agriculture
- Taxes or levies on PPPs

To give an overview on their suitability concerning this objective, these tools are briefly characterized below with regard to the aim of protecting wildlife in agricultural landscapes from negative effects of PPPs,

Legally established regulations for approval and use of Plant Protection Products

In Germany, the registration, approval and use of plant protection products has a broad legal basis and is regulated to provide a certain degree of protection for humans, animals, groundwater and the natural environment. Basic guidelines have been published on good plant protection practice (Bundesanzeiger 2005) which includes consideration of the principles of integrated plant protection as defined in Section 2a of the German Plant Protection Act (PflSchG 1998).

Important use restrictions include maximum yearly application quantities for the different active ingredients, the utilization of equipment to reduce driftage, and minimum distances to bodies of water and certain other neighbouring areas. Besides this, use regulations focus on the selection of adequate measures and an appropriate use and storage of products and equipment.

Within the authorization of PPPs, considered aspects regarding implications for ecosystems are mostly confined to ecochemical (behaviour and persistence in the environment) and ecotoxicological aspects (direct toxicity for organisms).

As pointed out (see chapters 4.1 and 4.6), the most far reaching impacts of PPPs on the ecosystem are those of indirect nature. Therefore, while being indispensable to reduce toxicity in the environment, the use and approval regulations do not address the main causes for the decline of biodiversity in agriculture.

National action plans including the promotion of integrated plant protection

According to EU Directive 2009/128/EC article 4, Member states have to adopt National Action Plans to set up their quantitative objectives, targets, measures and timetables to reduce risks and impacts of pesticide use on human health and the environment and to encourage the development and introduction of integrated pest management and of alternative approaches and techniques in order to reduce dependency on the use of pesticides.

The German NAP was formerly an Action Plan of the Federal Ministry of Food, Agriculture and Consumer Protection and was adopted by the federal and states' conference of agriculture ministers in 2008 as NAP. Central elements of the plan are the promotion of innovations in plant protection and the advancement of integrated plant protection (IPP).

The German Plant Protection Act defines integrated plant protection as a combination of procedures that limit the use of chemical plant protection products to the necessary minimum, taking account of measures of plant breeding, biological and biotechnical measures, as well as cultural and cultivation measures. The necessary minimum describes the intensity of the use of plant protection products that is necessary to secure the cultivation of crops, in particular regarding economic efficiency (BMELV 2008).

The NAP provides for the development of crop-specific and sector-specific IPP guidelines. However, while only the fairly vague general principles of IPP are mandatory according to the Plant Protection Act, implementation of the specific guidelines will be on a voluntary basis.

Despite stating the goal of reducing PPP usage and promoting non-chemical plant protection measures, no measures to promote or advance organic farming are included in the NAP. Moreover, although the NAP has formally been made an integral component of Germany's National Biodiversity Strategy (BMU 2007), it does so far not foresee any measures that directly aim at conserving biodiversity.

The NAP may be seen as a valuable tool to promote technical innovations to reduce over-use of PPPs and the principles of IPP – if implemented effectively – may also contribute to reduce the usage of PPPs to a certain degree. However, as both do neither seriously support non-chemical plant protection nor address biodiversity related topics, they do not constitute a significant contribution to the minimization of risks for agricultural wildlife.

Agri-environmental programmes including promotion of organic agriculture

Agri-environmental programmes (AEPs) are covered to a broader extent in chapter 5.1.3. The programmes contain measures including many of the measures proposed in chapter 5.1.1 which contribute to an effective protection of agricultural wildlife. However, agri-environmental measures (AEM) with strong positive effects on biodiversity (maintenance and promotion), are implemented only on a very marginal fraction of farmland (in Germany currently only on 0.5 % of the farmland, see IFAB et al. 2012). Experience from the last decades shows that this fraction was by far not sufficient to halt the loss of biodiversity in agricultural habitats.

By implementing agri-environmental measures, AEPs constitute a tool which truly addresses the compensation of indirect effects of PPPs (and agricultural intensification in general) on agro-ecosystems. Yet, to be effective, they need to be focused much more on 'dark-green measures' and need much better funding to implement the latter on a large scale.

The National Strategy for Sustainability promotes an increase of the share of organic agricultural area to 20 %. Subsidies for organic agriculture are paid in all German Federal States but were lowered almost anywhere after 2007 – despite the ambitious goals. Moreover, funds for the Federal Programme for Organic Agriculture which includes funding of research and development were cut back from 35 Million € in its first years 2002 and 2003 to 16 Million € yearly from 2007 on when it was also opened to 'other forms of sustainable agriculture'. In contrast, the National Research Strategy BioEconomy 2030 which focuses on biotechnology is granted a total 2,4 Billion € from 2010 to 2016.

Because of its renouncement of chemosynthetic PPPs, the promotion of organic agriculture constitutes a valuable tool to reduce impacts of PPPs on agricultural ecosystems.

Taxes or levies on PPPs

Charging a tax or levy on PPPs is a tool to reduce pesticide use through economic mechanisms. Meanwhile, it may also serve as a tool for funding risk management measures and thus might be a promising tool not being used in Germany so far. Therefore, its implementation in other European states including Denmark, Sweden, Norway, Belgium, and France deserves to be covered in more detail here (Tab. 5.3.1).

Denmark

The first governmental PPP Action Plan to reduce PPP use in Denmark was set up in 1986. In the course of this programme, an ad valorem tax was introduced which used to be 34 % of the retail price for herbicides and fungicides and 54 % for insecticides for many years (Schou 1999; Nielsen 2005). The tax amounted to approximately 2 % of the value of crop production (Ecotec 2001). Presently, the tax is 25 % for herbicides and fungicides and 35 % for insecticides (Danish Ministry of the Environment). It is paid by producers and importers. The major part of the revenue is channelled back to the agricultural sector via different agriculture-related funds and subsidies, including the promotion scheme for organic farming. Furthermore, tax revenue is used to fund approval authorities, the PPP reduction plan and research (Schou 1999; Nielsen 2005).

Currently, plans are being elaborated to restructure the tax into a differentiated model levying PPPs according to their harmfulness towards health and environment. As a supplement of the new tax system, plans include a guidance system by which farmers can quickly and easily determine which product has fewest side effects and should therefore be used in preference. Within the new plans, it will be considered to counteract outsourcing of the cultivation of specific high-value crops to other countries (Danish Ministry of the Environment).

Sweden

In Sweden, the tax is raised as a fixed amount on kg of active ingredient. Additionally, there is a registration fee which is paid yearly during the admission period. The tax rate before 2004 was 20 SK (ca. 2.3 €) per kg of active ingredient, which accounted for about 5 - 8 % of the product price (Sjöberg 2005). In 2004 the rate was increased to 30 SK (ca. 3.5 €). An originally raised price regulation charge based on the standard dose per hectare and complementing the former per kg charge was abolished in 1992 due to the deregulation of Swedish agricultural markets abolishing guaranteed prices for cereals. The tax is paid by producers and importers who have to submit a monthly return to the Swedish National Tax Board. In addition, Sweden raises a yearly registration charge for PPP of 1.8 % of the sales value during the approval period (minimum 2 000 SK (ca. 230 €), maximum 200 000 SK (ca. 23 000 €)). The charge is used to cover the costs of the National Chemical Inspection (Ecotec 2001).

It is assumed that the Swedish PPP tax is too low to evoke noticeable changes in the consumer behaviour (SOU 2003). Therefore, the effectiveness of the tax rests on the uses of its revenues (Pearce & Koundouri 2003). Before it was substantially increased in 1995 and declared an official tax, the payments had been a levy which had financed a PPP action programme. Within this programme, research and development projects as well as advisory services in the context of PPP reduction were funded. After its increase and declaration as a tax, the revenues went directly into the national budget and did no longer exclusively fund the PPP programme which was from then on financed by the public budget.

Norway

The Norwegian tax is raised depending on properties relating to health and environmental risks of PPPs. This system replaced the old ad valorem tax of 15.5 % raised from 1988 till 1999 (Schou 1999).

In the Norwegian system, PPPs are classified into three tax classes by use of risk indicators, assessed via a series of scores for intrinsic hazard and exposure. To calculate the tax of a PPP for commercial use, the respective tax class factor (1, 4, or 8) assigned to the tax class of the product, is multiplied with a basic tax of 20 Norwegian Krones (NOK) per hectare (ca. 2.7 €). Hence, a product with low health and environmental risks is taxed 20 NOK per hectare (1 (tax class factor)   20 (basic tax)) and a PPP with high health and environmental risks is charged 160 NOK (ca. 22 ¬) per hectare (8 (tax class factor)   20 (basic tax)). Then, to calculate the tax per volume, per hectare taxes are offset against standard area doses (averaged of the recommended rates in various crops). E.g. a product with an average standard area dose of 2 kg per hectare will be taxed 10, 40, or 80 NOK per kg (1.4, 5.5, or 10.9 €) respective of its tax class (1, 4, or 8   20   2-1). Other products subject to the tax are adjuvants (tax class factor 0), biocides and fungicides for seed treatment (0.5), PPPs for non-commercial purposes (i.e. amateur use) (50), and ready-to-use PPPs for non-commercial purposes (150).

Additionally, Norway raises a standard levy of 16 NOK per hectare (ca. 2.2 €), irrespective of the tax class, which is used to finance testing, control, and registration of the products. Tax and levy are paid by importers and producers (Schou 1999; PAN Europe 2005).

About one third of tax revenues are used to fund the PPP reduction programme (PAN Europe 2005).

Belgium

The planned extension of the Belgian Ecotax onto PPPs for agricultural use failed because of the strong influence of agricultural sector lobbying (Ecotec 2001). However, in 1998, a charge on PPPs was implemented. With approximately 0.25 € per kg of active ingredient, the charge was substantially lower than the planned tax and thus found acceptance in the agricultural sector. The rate has since been increased to 0.395 € per kg but is still too low to have significant effects on sales figures (OECD 2007).

The charge is paid by marketing authorization holders on the basis of the inherent risk of the product and its sales figures in Belgium. The inherent risk is determined on the basis of a score that is assigned to the various risk sentences on the product labels. Revenues of the charge accrue to the fund for raw materials and products which among other things finances the Programme for the Reduction of PPPs and Biocides (FPS Health).

France

In 2000, in the context of the new Law to Finance the Social Security, the General Tax on Polluting Activities was extended, among other things, onto PPPs. Producers and importers were charged based on the net weight of substances serving to produce PPPs. Substances were classified into seven tax classes according to their toxicology and ecotoxicology. The tax rate ranged from 0 € per kg for substances in class 1 to 1.68 € per kg for substances in class 7 (Parsche et al. 2004).

In 2008, the tax on PPPs was converted into a levy paid to the water authorities. The levy is paid by distributors of PPPs, who since then are obligated to keep an account of their sales. The levy rate is specified by the regional water authorities according to the pollution rate of their waters within a frame of a maximum of 3 € per kg for toxic, very toxic cancerogenous, mutagenic, and teratogenic substances, 1.2 € per kg for substances dangerous to the environment, and 0.5 € per kg for mineral substances (APCA 2007).

The objective of the tax reform was to bring the perception level of the levy closer to the farmers (also, the levy has to be shown separately on the bills) and to implement regionally adapted tax rates according to the pollution of watersheds from PPPs (Sido 2005).

Effects of taxes and levies on PPPs in other European countries

PPP sales in Sweden and Denmark as well as the average crop-specific treatment frequency in Denmark have decreased since taxes were established. However, many authors state that it is extremely difficult to separate impact of taxation on PPP use patterns from other factors influencing farmers' purchase and use decisions, either those forming part of a PPP reduction programme or those linked to broader agricultural or market trends (e.g. Ecotec 2001; PAN

Europe 2005; Sjöberg 2005). Furthermore, a reduction in PPP-usage does not necessarily imply a reduction of PPP-related risks, because products with lower standard doses but higher risks may have replaced others. Also, the Danish drop in crop-specific treatment frequency, for example, was offset by a shift towards crops requiring more intense PPP usage (Ecotec 2001).

The Danish government and NGOs estimate that taxation lead to a reduction in PPP usage of 5 %, whereas in Sweden and Norway, taxation is believed to have minimal or zero effect on PPP sales (PAN Europe 2005). The ineffectiveness of PPP taxes in terms of reducing the demand for PPPs can be explained by the very low price elasticity of the demand for PPPs estimated by several studies. A recent study by Jacquet et al. (2011) on the possibility of reducing PPP use in France gives an estimate of -0.3 for price elasticity (i.e. a levy of 100 % of the price would be necessary to reduce PPP consumption by 30 %). However, in the scenario of a weighted taxation, cross price elasticities between PPP groups (grouped according to their immanent risk) are expected to be greater than the 'own' price elasticities of the products, suggesting that demand could at least be effectively driven towards low-risk PPPs (Pearce & Koundouri 2003). Insights from the Norwegian toxicity-dependent taxation system confirm this estimation (PAN Europe 2005).

Tab. 5.3.1: Taxes/levies on PPPs in other European countries. Explanations: [1]: on herbicides and fungicides / on insecticides; [2]: in part, indirectly via the national budget; [3]: about ⅓ of revenues; [4]: in part, indirectly via fund for raw materials and products.

Tax/levy…	Denmark	Sweden	Norway	Belgium	France
…rate:	25 % / 35 %[1]	3.5 €; 1.8 %	4.9 € - 24.2 €	0.395 €	0 – 3 €
…charged on…	retail price	kg active ingredient; sales value	hectare (average standard area dose)	kg active ingredient	kg active ingredient
…paid by…	producers, importers	producers, importers	producers, importers	marketing authorization holders	distributors
…used for…	agric. Funds & subsidies, approval authorities, PPP action plan, research	PPP action programme[2], National Chemical Inspection	PPP reduction programme[3], approval authorities	PPP reduction programme[4]	water authorities
…adapted to harmfulness?	two categories: 1. insecticides 2. herbicides & fungicides	no	according to health and environmental risks	according to risk sentences on product labels	according to toxicology and ecotoxicology
…regionally adapted?	no	no	no	no	according to watershed pollution from PPPs

With limited direct market-driving impacts of PPP-taxation, effectiveness of PPP taxation for risk minimization rests to a large extent on the use of the revenues.

Conclusions

None of the currently existing approaches is suitable or far-reaching enough to effectively protect farmland birds and mammals from negative influences of PPPs. Legally established regulations for the approval and application of PPPs may be suitable to implement a few application restrictions, however, the control of the application in practice stays difficult and not at all sufficient to achieve the targets of the risk management. For a broad implementation of area-based measures an encompassing strategy is indispensable which is based on financial funding and which is able to flexibly manage implementation. The NAP's strategy fails to tackle fundamental problems of the protection of agrobiodiversity from impacts of PPP usage which is primarily the indirect effects of losing habitat and food resources. Alone AEPs really take up the problem and address compensations. However, the extent of AEMs related to the needs of sustainable arable production is by far insufficient to halt the loss of biodiversity in agricultural landscapes, particularly because funding for AEPs is scarce. Charging a tax or levy on PPPs might be a valuable approach to assure sufficient funding for RMMs while also creating economic incentives and internalizing environmental costs of PPPs. Still, other approaches of assuring a broad implementation of RMMs are possible. These are discussed in the next section, which approach can be considered to be the best for designing a comprehensive risk management strategy.

5.3.2 Designing a comprehensive risk management strategy

A regionally adapted implementation of risk management measures that address indirect effects of PPPs has to be the central element of a strategy to protect the biodiversity of free living birds and mammals from the effects of PPPs. Moreover, the strategy has to assure implementation of the measures on a large scale with sufficient funding, while the criteria for its feasibility and effectiveness as stated at the beginning of chapter 5.3 need to be met to the greatest possible extent.

Thereby, two fundamental parts can be distinguished:

- Implementation of risk management measures
- Funding

Implementation of risk management measures

For the implementation of risk management measures addressing indirect effects of PPPs, in turn, two possible approaches can be defined:

- Regulations obligating PPP users to implement risk management measures
- Implementation of risk management measures on a voluntary basis

(a) Regulations obligating PPP users to implement risk management measures

Any professional user of PPPs in agriculture could be obligated to conduct measures to compensate for their risks. Therefore, to purchase PPPs for professional use, it could be made mandatory to possess a proof of risk management which farmers could apply for at regional agencies.

A possible way to arrange such a proof could be a score system in which each risk management measure is assigned a number of points. In order to meet the requirements of the score system and obtain the proof, farmers would need to reach a certain number of points by choosing and conducting measures from a catalogue of RMMs.

Tab. 5.3.2 shows an outline of an RMM-score-system which is kept simple to assure controllability. Measures which are difficult to control like most of the PPP-agent-related measures were left out in this outline. For a more differentiated score system, confer the system which has been worked out for biodiversity-promoting measures by IP-Suisse (Jenny et al. 2009).

In our outline, the score which has to be reached is 100. Each measure is characterised by a combination of a score value and a percentage of land value. E.g. measures of creating ecologically valuable areas like fallows, water verges or extensive grassland/cultivation reach a score of 10 for each one per cent of farmland on which they are realised. By this means, farmers creating ecologically valuable areas on 10 % of their land reach the acquired score of 100 to obtain the proof of risk management. By implementing other, non-area-demanding measures like keeping stubble fields over winter or refraining from the use of herbicides, the proportion of land which has to be withdrawn from production can be reduced.

We propose a general implementation of such a regulation within the German Plant Protection Act. An adaptation of mandatory risk management to different PPPs and their specific utilization, and implementation within authorization of the products appears to be inconvertible because its realisation would be too bureaucratic and its control too difficult. Also, on one farm, usually various PPPs are used and PPP amounts and types may vary from year to year. It is highly impracticable to adjust RMMs on a yearly base according to the actual PPP usage. Besides being impractical from the farmers' point of view, regarding area-based measures, yearly shifts of presence and absence of habitats are not desirable for a long-term establishment of animal populations.

Tab. 5.3.2: Outline of an exemplary score system to implement regulations obligating PPP users to conduct risk management measures. The score to be reached is 100.

Pesticides – agent-related measures	**Score**	**per % of land**
no application of herbicides	50	100
Crop-related measures (in-crop)		
cultivation of at least four different crop types (diversified crop rotation) in spatial proximity	5	100
catch cropping after main fruit harvest for winter greening	1	10
keeping stubble fields until next seeding in the following spring	1	10
creation of sparsely sown field crops (defined areas or strips) with reduced fertilization (in wide rows)	10	1
creation of flower areas or flower strips	10	1
creation of fallow areas	10	1
creation of fallow strips inside crops (beetle banks / bee banks) - 1 strip per 10 ha	5	1
creation of so-called „skylark windows" - 2 plots per ha	5	1
Landscape-related measures (off-crop)		
creation of biotope networks in order to enhance biodiversity (e.g. sowing of wild herbs from autochthonous seeds)	10	1
planting of individual trees, field trees (woodland), hedges and scrubs	25	1
creation of meadow orchards, as well as nest and hollow trees	10	1
creation of dry stone walls and stone heaps	5	per unit
creation of road-, water- and bank-verges with extensive grassland	10	1
creation of water- and bank-verges with reeds / tall forbs	10	1
creation of water- and bank-verges with trees/shrubs	10	1
creation of moist sink areas with utilisation (crop and grassland)	10	1
creation of still water bodies (pond biotopes) and wetlands without utilization	10	1
renaturation of drained grassland areas	10	1
extensive grassland: restriction of management periods, mowing- and grazing-frequencies and usage of artificial fertilization	10	1
small-scale crops	10	100

Whether this obligatory approach implements the 'polluter-pays-principle' depends on the extent to which risk management measures are funded by public budgets. The principle only applies if part of the economic losses caused to the farmer by conducting risk management measures are not covered by public budget-funding. If economic losses are completely covered by public budget-funding, the proposed strategy would not imply the 'polluter-pays-principle'.

An advantage of this strategy is that the usage of PPPs and compensation for their effects on biodiversity are directly linked to each other because the proof of risk management has to be obtained to be able to purchase PPPs. This direct causal relationship could help to create consciousness among farmers about the effects of PPPs and the necessity of compensation to protect farmland species. Another advantage is that it guarantees the implementation of RMMs on a large scale. However, an adaptation of risk management to region-specific conservation needs does not fit well with the approach and also, if in general every farm has to conduct measures of the same extent (relative to the farm size), regions with large-scale intensive agriculture are not subject to more compensation measures than regions with a less intensively used, more heterogeneous agricultural landscape. Moreover, although the outline is kept simple and designed for best possible controllability, still the administrative effort will be high because every professional user of PPP will have to participate. Already, enforcement agencies are not capable of accomplishing adequate controls of the Plant Protection Act. Bach et al. (1999) calculate that in order to control only 1 % of the activities to be monitored, every enforcement officer would have to deal with 594 cases in a year. Yet, a sample size of 1 % is far too little to ensure an implementation in accordance with the regulations. The Swiss 'Proof of Ecological Performance', in contrast, has to be controlled on at least 30 % of farms each year (Nitsch & Osterburg 2005).

Finally, the strategy's most severe drawback is probably that it implies a strong intervention into farm management, and therefore its acceptance among farmers can be expected to be accordingly low.

(b) Implementation of risk management measures on a voluntary basis

Alternatively, the implementation of RMMs by farmers could be on a voluntary basis which is the approach of the existing AEPs. As an expansion of the existing AEPs, a new programme could be integrated with the special aim to compensate for negative effects of PPPs on farmland birds and mammals. This approach implies that a certain budget is set up (the funding of which is covered below) and a catalogue of measures is offered to farmers who can voluntarily participate in the programme and carry out measures on their land up to a certain percentage of area. The catalogue of measures includes specific payment rates for each measure according to the costs for implementation. Because of its voluntary nature, this approach does not link risk management with PPP-usage on a farm level. However, such a link could be made on a regional level by the creation of new structures allowing a region-based allocation of funds according to the amounts of PPPs used in each region and also allowing regionally adapted management plans.

Compared to the above strategy, besides not linking the implementation of RMMs directly on a farm level with the usage of PPPs, this strategy does not create incentives to use less PPPs or less harmful ones and does not imply the 'polluter-pays-principle'. Furthermore, it does not necessarily guarantee that RMMs are conducted on a large scale which can be seen as a central criterion for the success of a strategy. In this regard, an adequate funding becomes very essential. Experience from the AEPs shows that measures can be broadly accepted by farmers if they are adequately funded. E.g. in 2007 in Baden-Württemberg a new AEM „seeding of flower mixtures“ was implemented with a payment of 130 €/ha. However, due to the low payment, rising market prices for agricultural products and the abolishment of the set-aside obligation in the EU 27 until 2009 only some 80 ha have been implemented (compared to a total of 800 000 ha arable land in Baden-Württemberg). The government recalculated the measure and from 2010 the payment rose to 500 €/ha. Following this recalculation, until the end of 2011 an extent of nearly 4 000 ha of this AEM got implemented.

Funds for RMMs may not exceed returns that can be gained by agricultural production because this would constitute an irregular subsidization. Yet, if funds are about at the same level as returns gained by production, their great advantage is that they do not underlie uncertainties of climatic and various other factors influencing yield rates. Adapting funded RMMs, e.g. by a five-year contract as usual within AEPs, a farmer will have secure returns for five years. Thus, given an adequate funding, implementation of RMMs on a voluntary basis may be accomplished on a large scale. The great advantages of this strategy as opposed to regulations are its acceptance among farmers because no forced interventions into farm management are made and farmers may profit by having secure returns that compensate for their economic losses caused by lower yields. Furthermore, the strategy does not have the flexibility problems of the regulations strategy because RMM extents do not have to be adapted to varying PPP usage on a farm level. Contracts with farmers can be made flexibly according to regional conditions. The administrative effort would also be lower because of a lower number of involved farmers, and because data on PPP usage does not have to be gathered and controlled.

The strategy’s major drawbacks, i.e. the fail to create incentives to use less PPPs and less harmful ones as well as to implement the ‘polluter-pays-principle’, are very fundamental factors for reducing the impact of PPPs on ecosystems. They constitute one of the two sides of risk reduction which is the direct reduction of impact through quantity and quality of PPP application, the other side being the indirect reduction through compensation measures.

This direct side of risk reduction can be covered by the way funds are gathered as will be discussed in the following section.

Funding

For the funding of RMMs, again two possible methods can be defined:

- Funding through public budgets
- Funding through a levy on PPPs

(a) Funding through public budgets

Currently, AEMs are funded by public budgets. This is the method with least administrative effort because the extra effort linked to raising a tax or levy is relatively low. However, public budgets are always tight and a programme funded by public budgets does neither create incentives for farmers to use less PPPs nor generate market driving forces in favour of low-impact PPPs nor implement the ‘polluter-pays-principle’ which drastically constrains its overall effectiveness.

Hence, coupling this funding method with voluntary implementation of measures which has the same disadvantages can be regarded as the least effective way of promoting risk management. This is current use in AEPs. A better coupling would be with the above proposed approach of regulations obligating PPP users to implement risk management measures because the latter already creates incentives favouring less use of PPPs and less harmful products. Still, the extent to which the 'polluter-pays-principle' applies depends on the extent to which economic losses are covered by funding of the measures. Also, the disadvantages of the regulations-approach being low acceptance, low flexibility and high administrative effort would still apply.

(b) Funding through a levy on PPPs

According to the rule of non-assignment of revenue and expenditure, tax revenues may usually not be tied to specific purposes. To make this possible, the payments would need to be a levy.

Charging a levy on PPPs which is then used to fund RMMs constitutes a strategy which fully and precisely implies the polluter-pays-principle without the need to gather data on PPP consumption of the users. The latter would automatically contribute to risk management according to the extent of their PPP usage. Moreover, because the costs of PPPs increase this approach also creates economic incentives to use less of them. In order to drive consumers towards preferring less harmful PPPs, the amount charged on each product or product group could be conditioned on its harmfulness. As buyers will prefer cheaper products, the demand for less detrimental PPPs with a lower charge will rise and the demand for more detrimental products with a higher charge will fall, also pushing the development sector of producers towards a new focus.

This approach can be regarded as socially fair, because part of the external environmental costs of the use of PPPs, i.e. the loss of biodiversity and ecosystem services become internalized.

An optimal combination would be with the approach of a voluntary implementation of RMMs because the drawbacks of the latter are offset by this funding method.

Therefore, we consider this to be the best strategy to implement Risk Management Measures into agricultural practice. A more detailed proposal for the realization of this approach will be given in the following section.

Tab. 5.3.3: Comparison of both implementation approaches in combination with each of the two funding approaches regarding several criteria, determining their feasibility and effectiveness. Symbols represent properties of the approaches regarding the respective criterion: ++ very good, + good, 0 medium, - bad, -- very bad, 0[1] Depending on the extent to which economic losses are covered by funding.

	Implementation			
	Regulations		Voluntarily	
	Funding			
Appraisal criteria	Public budgets	Levy	Public budgets	Levy
Incentives to use less PPPs	-	++	--	++
Market driving forces towards lower harmfulness of PPPs	--	++	--	++
Polluter-pays-principle	0[1]	++	--	++
Direct link between on-farm PPP usage and conduction of RMM	+	+	--	--
Regionality	--	--	+	+
Acceptance among farmers	-	--	++	0
Flexibility	--	--	++	++
Precisely targeted implementation on a large scale	++	++	-	-
Low administrative effort	-	--	+	0

5.3.3 Elaboration of a strategy to implement RMMs into agricultural practice on a voluntary basis funded by a levy charged on PPP sales

Characteristics of the levy

A levy on PPPs needs to be low enough to not endanger the financial viability of farmers but sufficient to create incentives to use as little PPPs as possible, sufficient to create market-driving forces towards less harmful agents, and sufficient to fund to an adequate degree measures to compensate for negative effects of PPPs. As outlined above, experience from other European countries shows that PPP usage responds rather inelastic to price elevations. Thus, to evoke a substantial reduction in application amounts, a levy needs to be correspondingly high and it needs to be risk-adjusted to create demands for low-risk products. Furthermore, to complement potentially insufficient direct effects on PPP-demand, it is imperative to channel the revenues into compensation programs.

Concerning farmers' income and price stability of agricultural products, a French study estimates that reducing PPP use by 30 % could be possible without reducing farmers' incomes (Jacquet et al. 2011). Another study states that it should be possible to reduce PPP use by 50 % in the US without reducing crop yields or 'cosmetic standards' (Pimentel et al. 1993). The same study estimates an increase in food prices of only 0.6 % while pointing out the tremendous environmental and public benefits of a 50 % reduction of PPP use.

However, aiming at a certain quantitative reduction has the drawback that various factors underlie quantitative changes in PPP sales which therefore cannot be clearly linked to a levy. Furthermore, because of different properties concerning application doses and immanent risks of different PPPs, overall quantitative reductions do not proportionally reflect risk reductions.

In order to meet the clear objective of reducing negative impacts of PPPs on biodiversity in agricultural landscapes, we propose therefore not to aim at a certain quantitative reduction, but on an adequate extent of compensation for these negative impacts. Hereby, an adequate extent of compensation is to be defined as an extent of measures that ensures the continued existence of viable populations of species that suffer from PPP usage.

Regarding measures that focus on the creation of ecological compensation areas, we assume - as pointed out in chapter 5.1 - that compensation areas of the size of 10 % of the conventional farming area, could provide sufficient habitat and resources for endangered agricultural species.

Based hereon, the resources required for funding the measures can be calculated as the product of the total area corresponding to 10 % of Germany's conventionally managed farmland (excluding grassland and permanent crops) and the mean cost of the measures per hectare, plus administration costs:

$$\text{Required resources } [€] = \text{Conv. farming area } [ha] \times 10^{-1} \times \text{Mean cost of measures } \left[\frac{€}{ha}\right] + \text{ Administration costs } [€]$$

Charging the levy as a percentage of the prices of PPPs has the drawback that technological progress in PPP manufacturing may give rise to price falls and consequently absolute tax reductions, encouraging more PPP use (Pearce & Koundouri 2003). Therefore, following the advice of the cited study, we propose to design a levy as an absolute sum per kg of risk-weighted ingredient.

The mean charge per kg – not yet taking into account different risk levels – can be calculated as the quotient of required resources and the status quo amount of PPP sales:

$$\text{Mean charge } [€/kg] = \text{Required resources } [€] \times \text{ PPP sales } [\text{kg}]^{-1}$$

The area of arable land under conventional farming (excluding organic farming, grassland and permanent crops) was 11.389 Million ha in Germany in 2010 (Statistisches Bundesamt 2011), while in the same year, domestic sales of PPP amounted to 40 844 t of active ingredients (BMELV 2012). As a rough estimate from empirical values, we expect 500 € as mean costs of the measures (some figures are given in chapter 5.1.3) and 20 % of the total costs as administrative expenses. Doing so, the required resources amount to 683.34 Million € and the average levy per kg of active ingredient comes to 16.73 €. This is equivalent to 49.95 % of the average price per kg[4] and thus lower than Denmark's initial tax on insecticides.

What will be the levy's financial effect on farmers?

In recent years, average per area application rates of PPPs in Germany have levelled off at about 1.7 kg/ha (Koppelmeyer & Wöbbecke 2012). Taking this as a basis, the surplus cost for farmers would be 28.44 € per hectare and annum. This means that a small farm with an area of 5 ha and an average PPP consumption would have to expect additional costs of 142 € a year, while a medium sized farm of 50 ha would envisage a 1,422 € rise in yearly expenses, and a sum of about 5,688 € would come up to a large farm of 200 ha.

PPPs make up only 3,6 % of total farm expenditures (excluding depreciation and interest expense) on German commercial agricultural holdings (calculation based on statistics taken from BMELV 2012). Including the levy, this proportion would increase only slightly to 5.4 %. It should be noted, however, that for pure crop producers, expenditures on PPPs will make up a considerably higher share. Expenditures depend also on the type of crop and its plant protection requirements under conventional management.

Winter wheat and maize – two examples

Winter wheat and maize are two of the most widespread crops in Germany and have different requirements regarding plant protection in conventional agriculture. Therefore we consider both crops for an exemplary breakeven analysis based on the breakeven analysis tool on the website of the Bavarian State Research Centre for Agriculture[5].

Variable expenditures relating directly to winter wheat production[6] in one year total 897.1 €/ha, of which costs of PPPs make up 16 % (142.9 €/ha). A levy of 49.95 % on PPPs would

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[4] Estimation based on domestic sales figures and parallel import estimations (source: Industrieverband Agrar 2011). Not included: profit margin of wholesale traders.

[5] Accessible at https://www.stmelf.bayern.de/idb/ (access date 23/Nov/2012)

[6] Quality class: A-Wheat, period under consideration: 2009-2011, field size: 5 ha, man-hours/ha: 6, Plant protection intensity: medium. Variable costs include seeds, fertilizers, PPPs, variable machine expenditures (equipment is assumed to be owned by the farmer except for harvester) drying, and hail insurance, fixed operating costs like maintenance , lease, general insurances etc. are not included

add 7.96 % (71.38 €/ha) to the total variable expenditures of which costs of PPPs would then make up 22 % (214.3 €/ha), reducing the gross margin by 18 %. The producer price which underlies this calculation is 18.85 €/dt (mean price level in Bavaria 2009-2011) and the yield is 68.6 dt/ha (mean yield level in Bavaria 2009-2011). A rise in the producer price of 1 €/dt would already offset the economic loss caused by the levy. Producer prices for the harvest year 2012 were at about 26 €/dt and thus about 7 € above the level of 2009-2011.

Regarding grain maize, variable expenditures[7] amount to 1406 €/ha, of which PPPs make up 5.35 % (75.3 €/ha). Here, the levy would add only 2.68 % (37.61 €/ha) to the total variable expenditures of which costs of PPPs would then make up 7.82 % (112.9 €/ha), reducing the gross margin by 9 %. The producer price which underlies this calculation is 18.1 €/dt (mean price level in Bavaria 2009-2011) and the yield is 101 dt/ha (mean yield level in Bavaria 2009-2011). Here, a rise in the producer price of 0.37 €/dt would offset the economic loss caused by the levy. Producer prices for the harvest year 2012 were at about 25.5 €/dt and thus a levy introduced in 2011 would already have been offset about 20-fold by risen prices.

Although maize is one of the least PPP-treated crops, our exemplary breakeven analysis results in surplus costs of 37.61 € provoked by the levy. This does not fit well with our calculations above which result in average surplus costs of only 28.44 €. An explanation for this is the fact that we did not consider unknown profit margins of the trade sector. The levy rate of 49.95 % refers to payments of producers. As traders add their profit margins to the price, the levy's proportion of the end price is effectively lower than 49.95 %. Hence, the results of our breakeven analysis concerning surplus expenditures caused by the levy can be considered to be overestimated. Another explanation could be an underestimation of Koppelmeyer and Wöbbecke (2012) when the authors give 1.7 kg/ha as average application rates of PPPs per ha and year, leading us to underestimate average surplus costs caused by the levy.

Implications of a levy on PPPs

Because of their relatively low costs and the tendency of many farmers to avoid any risks related to pests and diseases, PPPs can be expected to be over-used by farmers. (Pearce & Koundouri 2003). From the point of view of the experts of the official plant protection services of the Federal States, about 11 % of PPP applications in winter wheat in the frame of a study by JKI (2011) were classified as exceeding the necessary measure.

A levy that is high enough to provoke farmers to use less PPPs (or less harmful products because they are levied less) will effect a decrease in their over-use. Less over-use of PPPs, in turn, decreases farmers' expenditures without decreasing their profit from crop yield. In consequence, their additional expenditures caused by the levy can be expected to be lower than in the calculations above. Further effects that buffer additional expenditures are a

[7] Marketing form: dry, period under consideration: 2009-2011, field size: 5 ha, man-hours/ha: 5.9, Plant protection intensity: medium. Variable costs include seeds, fertilizers, PPPs, variable machine expenditures (equipment is assumed to be owned by the farmer except for harvester) drying, and hail insurance, fixed operating costs like maintenance, lease, general insurances etc. are not included

decrease in the need for PPPs because natural pest control profits from certain RMMs and a possible drop in prices for biological pest control methods because a stronger demand favours mass-production e.g. of purchasable biological pest control organisms or pheromone traps and the like.

Regarding the macroeconomic balance, the hard to quantify economic value of preserved ecosystem services like those related to soil organisms (e.g. carbon sequestration, nutrient cycling), pollination, natural pest control, and not least the recreational value of the landscape deserve consideration and costs of drinking water purification can be expected to drop.

Because PPP sales may be expected to fall, given a sufficiently high levy, the latter needs to be calculated on the base of a status quo of PPP sales. If the levy is to be calculated from PPP sales on a yearly base, decreased total consumptions in one year would lead to higher charges in the next year to accumulate the relatively constant amount of required resources. While, in this case, an incentive to use less PPPs would still be given, the mechanism could substantially decrease acceptance among farmers. If calculated on a status quo base, in the case of decreasing PPP sales, funds generated through the levy will not be sufficient to finance measures for compensation areas of 10 % of the conventional farming area. However, the best way to achieve the goal of reducing negative effects of PPPs on birds, mammals and other organisms obviously is the reduction of PPP usage itself. Therefore, to the extent that PPP usage is reduced, a waiver of measures to compensate for their damage is acceptable.

Moreover, regarding farmers' acceptance of a levy on PPPs, transparency concerning the use of revenues as well as involvement of famers associations is crucial, as experience from Scandinavia shows (PAN Europe 2005).

How can the levy be conditioned on the harmfulness of PPPs?

For an adequate implementation of the polluter-pays-principle, payments need to be conditioned on the immanent risk of a product. By doing so, incentives will also be created for farmers to favour less harmful PPPs over more damaging ones. So far, developing low-impact products is of no great interest for producers because their use is not linked to any direct benefits for farmers and thus there is little demand for them. If PPPs are categorized according to their risks for wild species and ecosystems and if the levy is conditioned on the categories, demand for less harmful products (which then will be cheaper than more damaging ones) will rise, creating an incentive for the industry to develop effective low-impact PPPs and to establish them on the market.

As pointed out in chapter 4.1, negative effects of PPPs on birds and mammals are predominantly of indirect nature. However, PPP risk indicators, as used in other European countries to categorize PPPs, address only toxicological and ecotoxicological aspects. In the process of product approval, extensive data on toxicology and ecotoxicology are gathered but none on effects upon the composition of the agricultural biocoenosis. The latter effects constitute the main factor affecting the food chain and thus impacting species, particularly those on a higher trophic level like birds and mammals on a population scale. With current data, it is impossible to classify PPPs according to their indirect effects on wildlife. The European Food Safety Authority (EFSA) has recognized this shortcoming but did not consider its remedy in the revised Guidance Document on Risk Assessment for Birds and Mammals (EFSA 2009):

"Risk managers should be aware that two main issues have not been considered [...]: indirect effects and overspraying of eggs of ground nesting birds. Further work is required in this area to develop suitable schemes as well as risk mitigation measures."

Given the shortage of data on indirect effects of PPPs, we propose a pragmatic approach which is a classification of PPPs using the SYNOPS risk index which is calculated by the Federal Research Institute for cultivated plants (Julius Kühn Institut, JKI) on a yearly base.

The SYNOPS model evaluates the ecotoxicological risk potential of active ingredients of PPPs for terrestrial organisms in the soil and in field margin biotopes and for aquatic organisms. It considers different usage patterns and inherent properties of the agents including also persistence in the environment. The indicator uses model organisms (earthworms for soil, honeybees for field margin biotopes, and algae, daphnia, and fish for aquatic habitats) for which acute and chronic risk indices are calculated.

We propose that each PPP should be classified according to its risk index weighted by the relative importance of different areas of usage (which is already being done in the SYNOPS model) and according to risk indices of other PPPs in the same category (categories are herbicides, fungicides, insecticides, ...). This classification could be at a scale from 1 to 5 where the product with the lowest SYNOPS index of each category is assigned a value of 1 and the one with the highest index a value of 5. All other products are then assigned to a value according to their index relative to the two reference products. The end point of the scale of course is freely adjustable according to how pronounced the differences in price are desired to be.

In order for market driving forces to give effect, it is important to treat each category of PPP for its own because for any purpose, farmers will chose only among products made for this specific purpose. Thus, the effect of price differentiation will be diluted if products of overly different categories are ranked altogether on a single scale.

In order to prevent any effects of different mass of active ingredients we propose to charge the levy on an area base. This can be done by charging it on kg of active ingredient while incorporating maximum application rates per hectare and year (calculated from application rates and maximum numbers of applications per year) into the levy calculations.

Furthermore, to calculate the levy rate of a product (L(product)), a base levy (L(base)) will be needed which is multiplied with the product's risk coefficient (RC) - in this example between 1 and 5 - and divided by the application rate (AR):

$$L_{(product)}\,[€/kg] = L_{(base)}\,[€/ha] \times RC_{(product)} \times AR_{(product)}\,[kg/ha]^{-1}$$

Derivation of the base levy

The total levy revenue (R(total)) is composed by the revenues generated by the single revenues from each admitted product (R(product)) and needs to cover the required resources (RR) for risk management:

$$R_{(total)}\,[€] = \sum_{i=1}^{n} R_{(product\ i)}\,[€] = RR\,[€]$$

Where n = number of admitted PPPs

The revenues from a single product in the reference year are its levy rate per kg ai (L(product)) multiplied with the sales of the product in that year (S(product)).

$$R_{(product)}[€] = L_{(product)}[€/kg] \times S_{(product)}\ [kg]$$

Thus, the required resources need to equal the sum of the levy rates of each product multiplied with its sales in the reference year:

$$RR\ [€] = \sum_{i=1}^{n}(L_{(product\ i)}[€/kg] \times S_{(product\ i)}\ [kg]$$

Where n = number of admitted PPPs

Because the levy rate of a product is the base levy (L(base)) multiplied with its risk coefficient (RC) and divided by its application rate (AR) (see above) the same equation can be expressed as follows:

$$RR\ [€] = \sum_{i=1}^{n}(L_{(base)}\ [€/ha] \times RC_{(product\ i)} \times AR_{(product\ i)}\ [kg/ha]^{-1} \times S_{(product\ i)}\ [kg])$$

From this equation, the base levy can be derived as the required resources divided by the product of risk coefficient, application rate and sales of each product in the reference year summed up across all products on the market.

$$L_{(base)}[€/ha] = RR\ [€] \times \sum_{i=1}^{n}(RC_{(product\ i)} \times AR_{(product\ i)}\ [kg/ha]^{-1} \times S_{(product\ i)}\ [kg])^{-1}$$

How can the levy be charged?

Already, producers and importers are obligated to report sales figures of their PPPs and containing active ingredients to the Federal Office of Consumer Protection and Food Safety (Bundesamt für Verbraucherschutz und Lebensmittelsicherheit, BVL) on a yearly base, according to § 19 of the Plant Protection Act. Without great efforts for data collection, the levy could be charged based on these yearly figures directly upon producers and importers.

As producers will pass on the costs of the levy to the prices of their products, farmers would indirectly contribute to the funding of compensations corresponding to the amount and to the class of PPPs they buy. Through the compensation programs, money would flow back to the farmers and if a farmer conducts compensation measures financially equivalent to the levy he or she paid for PPPs, there will be no direct financial loss. However, the implementation of the RMM to an extent of e.g. 10 % of the arable land will on the first view lead to a reduction of yield on the farm and income losses can be predicted. On the other hand due to a shortage of yields in implementing this strategy the market prices will rise and thus it is expected that the financial revenues will be about the same as without introduction of levies. However, much attention has to be directed to this sensible field of market influence. Most probably an approach with increasing levies during the first years could lead to a slow and cautious implementation.

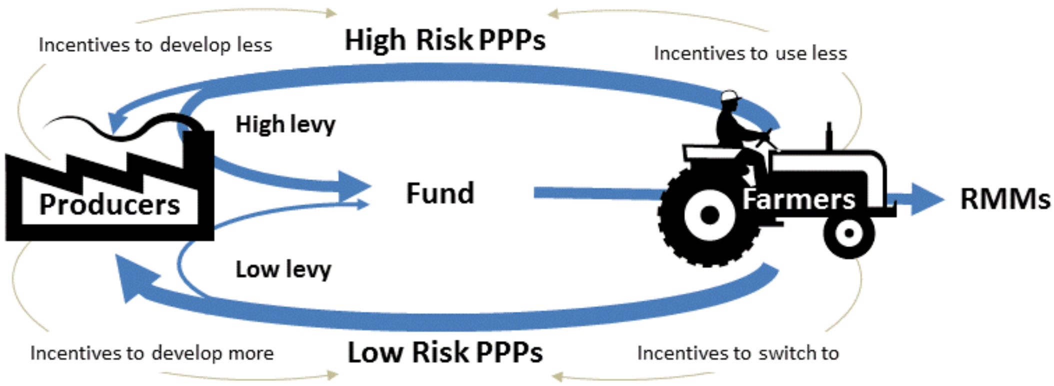

Fig. 5.3.1: Money flow and incentives created by a levy on PPPs.

How can regionality be implemented?

Regions differ substantially in the quantity of PPP usage and in their physiographic composition. To assure a close spatial relationship between PPP usage and compensation measures, distribution and employment of the funds created by the levy need to be region-based, i.e. regions with higher PPP usage need to receive proportionally more funds for compensation measures than regions with lower PPP usage. Funds for compensation programs could be allocated to regions according to estimates of their utilization of PPPs. These could be calculated from land use statistics (which crops are cultivated on what proportion of the area) and recommended standard area doses for the respective crops or simply from the area of cropland of a region. Furthermore, comparative figures of agricultural potential, e.g. the "Landwirtschaftliche Vergleichszahl" (LVZ; this figure describes the yield potential of agricultural holdings and includes factors such as soil quality, climate, and farm size) have to enter the calculation of fund distribution because payments for RMM should be higher in regions where potential yields and thus yield losses caused by the measures are greater. Fund distribution could additionally be based in part on regional conservation needs assessed by monitoring of certain ecological indicator species.

We propose the creation of regional management units that set up regional development plans on the basis of local physiographic composition and populations of focus species. These management units could be situated in the administrative districts (Landkreise). However, as some administrative districts encompass different types of agricultural landscapes (e.g. at the border between Black Forest and the Upper Rhine Valley many districts cover parts of both natural regions with very different natural conditions), local management structures could also be created in units with similar agricultural landscape independent from administrative districts. Planning and implementation of RMMs would be the duty of the local management units which receive funds according to the estimates of PPP usage in their region. Small-scale management structures of the size of administration districts ensure a close relation between management and farmers. Moreover, confining management entities to landscape units with uniform agricultural use properties makes it possible not only to distribute funds precisely according to regional PPP usage, but also to create uniform management plans based on local conservation needs and possibilities.

To make it a market-based approach, local management units could be economically independent entities with complete decision rights concerning the usage of their funds. They could freely conclude contracts with farmers and would have to analyse their own management success by monitoring occurrence and development of populations of indicator species. A bonus system could reward successful managers, thereby creating incentives to optimize management and creating competition among management units.

Whether the system of regional management structures can go in hand with existing AEP structures on the federal state level or whether a restructuring of the sector of agri-environmental subsidies would be necessary needs to be examined in more detail.

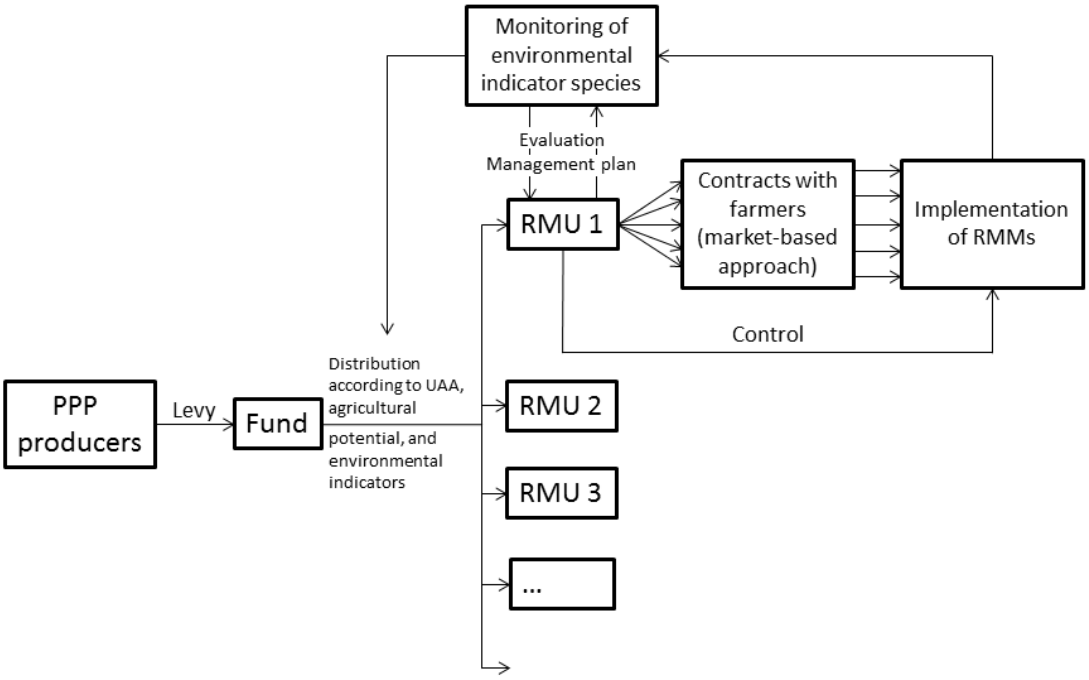

Fig. 5.3.2: Design of a risk management strategy. RMU = Regional Management Unit.

5.3.4 Conclusions

For the major drawbacks of low acceptance among farmers, low flexibility and high administrative efforts regarding an adequate control, we propose not to use the approach of regulations obligating professional users of PPPs in agriculture to implement RMMs but to manage their implementation using a market-based approach. We propose to adopt from other European states the chargement of a tax or a levy and to use the revenues for funding of RMMs. This approach combines important factors for the effectiveness of the whole strategy which are on the one hand economic incentives to reduce PPP usage and internalization of external environmental costs and hence application of the 'polluter-pays-principle' and on the other hand flexibility and a certain level of acceptance among farmers because RMMs can be implemented on a voluntary base and no interventions are made into farm management. Moreover, the RMMs will be paid according to the necessary land management prices. The creation of regional management units would assure a close contact to farmers and make regionally adapted management plans possible. Additional expenses of conventional farmers flowing into the levy will be in part offset among other things by a reduction of over-use of PPPs. The remaining additional expenses take account of the responsibility of agriculture to produce sustainably. A probably slight increase of prices of conventional agricultural products would only express the inclusion of part of the environmental costs of PPPs. Hence prices would become more realistic while agricultural production would become more sustainable, preserving a certain ecological equilibrium and thereby also ecosystem services, not least the recreational value of the landscape.

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5.4 Cost-Benefit-Analysis

To reach its goals, any risk management strategy needs to be sufficiently funded. In the last section, we calculated that under current conditions (e.g. market prices and price levels for agri-environmental measures) a funding of roughly 680 Million € will be needed to reach the goal of establishing RMMs on 10 % of the conventionally managed agricultural area - independent of the pursued strategy (voluntary or obligatory implementation, source of funding). In this section, we tested the financial favourability of a strategy focusing on compensation measures to protect the diversity of free living birds and mammals from the effects of PPPs against a strategy that would address the ultimate cause, hence a ban of PPPs. This was done by comparing two theoretical scenarios on an on-farm-level for model farms of the size of 100 ha under the assumption that any costs that arise to the farmer compared to the gross margin of present production are fully compensated.

1. RMM-scenario: economic losses that arise from the loss of harvest of 10 % of the arable area plus the costs for conducting RMMs on the same area need to be compensated.
2. PPP-ban-scenario: economic losses that arise to farmers from the refrain from PPPs on all their arable land need to be compensated.

For differences in gross margin resulting from a refrain from PPPs, we drew on data from Orum et al. (2002) who conducted an analysis of economic consequences of a reduction of PPPs in Danish agriculture for different farm types on clayey as well as on sandy soils. We used the same farm types and calculated the costs of conducting RMMs for flowering areas as model-RMM for clayey soils and for fallow areas as model-RMM for sandy soils. Fallow areas have the potential to develop a species-rich sward community on sandy soils, whereas on well-fertilized clayey soils they often develop a close weed vegetation. On these sites, flowering areas constitute a good alternative suppressing weeds and providing shelter and ample nectar and seed resources benefiting many animal groups. The following cost-assumptions for both model-RMMs were taken in part from the breakeven analysis tool on the website of the Bavarian State Research Centre for Agriculture[8].

Costs for the conduction of model-RMMs (not including compensation for shortfall in production):

Flowering areas: 239 €/ha

- Seeds: 100 €/ha (for flowering areas, different seed mixtures are available, ranging in price roughly between 70 and 150 €/ha)
- Drilling: 72 €/ha (rotary harrow and sowing machine, conducted by agricultural wage enterprise)
- Mulching: 67 €/ha (conducted by agricultural wage enterprise)

Fallow areas: 67 €/ha

8 Accessible at https://www.stmelf.bayern.de/idb/ (access date 30/Jan/2013)

- Mulching: 67 €/ha (conducted by agricultural wage enterprise)

Tab. 5.4.1: Comparison of economic consequences of a ban of PPPs as opposed to the implementation of RMMs on 10 % of agricultural area, calculated for model farms of 100 ha of different farm types on clayey and on sandy soil. Gross margins (first two data columns) were taken from Orum et al. (2002). PPP-ban scenario costs were calculated as (gross margin [€/ha] (present production) - gross margin [€/ha] (without PPPs)) x 100 ha. RMM-scenario costs were calculated as (gross margin [€/ha] (present production) + costs for conduction of RMM [€/ha]) x 10 ha + 20 % administration costs.

	Gross margin (present production) [€/ha]	Gross margin (without PPPs) [€/ha]	PPP-ban-scenario costs [€/farm]	RMM-scenario costs [€/farm]	Difference between scenarios [€/farm]
Clayey soil					
Arable farms	444	307	13700	8196	5504
Pig farms	389	273	11600	7536	4064
Arable farms with beets	556	350	20600	9540	11060
Arable farms with seeds	515	357	15800	9048	6752
Dairy farms	291	227	6400	6360	40
Sandy soil					
Arable farms	298	227	7100	4380	2720
Pig farms	295	223	7200	4344	2856
Arable farms with potatoes	499	252	24700	6792	17908
Dairy farms ext. prod.	252	228	2400	3828	-1428
Dairy farms int. prod.	271	257	1400	4056	-2656

For all farm types except for dairy farms on sandy soils, the costs of implementing RMMs on 10 % of the agricultural area resulted to be lower than the costs that would arise from production deficits due to a prohibition of PPPs (Tab. 5.4.1). E.g. gross margins of arable farms on clayey soils can be expected to drop by 137 €/ha without the use of PPPs after Orum et al. (2002). For an arable farm of 100 ha, this would result in economic deficits of 13,700 €. In comparison, economic deficits resulting from a withdrawal of 10 % of its land from production and from implementing RMMs on this fraction (flowering areas in this example) would only amount to 8 196 €, including also administration costs for the risk management programme. Thus, costs for compensation of economic deficits in the RMM-scenario would be about 5,500 € less for this common farm type than in the PPP-ban-scenario. The farm type showing the biggest difference between both scenarios is arable farms with potatoes on sandy soil. This is probably due to the fact that quality requirements are very high for potatoes in all marketing areas and potatoes deliver a high gross margin to the farmers. However, a considerable crop shortfall can be expected, when potatoes are grown without PPPs.

To refine insights into on-farm economic effects of a compensation-based strategy and also to analyse economic effects of its funding via a levy as proposed in 5.3, we performed a model calculation for an exemplary arable farm of 100 ha with a rotation of 50 % winter wheat, 25 % maize and 25 % spring barley (Tab. 5.4.2). The calculation was made based on the breakeven analysis tool on the website of the Bavarian State Research Centre for Agriculture (see above). It was made for the years 2009-2011 (based on average values of e.g. yields and producer prices) and 2012 separately to compare effects with regard to yearly changes in producer prices and variable expenditures. Furthermore, we supposed that surplus expenditures of the levy could lead farmers to decrease their intensity of plant protection. Therefore, besides the base calculation with medium intensity of plant protection, we recalculated all values for low intensity of plant protection (the breakeven analysis tool allows to choose between the predefined levels low, medium or high intensity of plant protection).

Rewards for RMMs were set at a level where their gross margin per hectare equals the average gross margin of the cultivated crops in 2009-2011 as this would be optimal to assure profitability of RMMs while not overpaying them. The latter needs to be avoided because it could be classified as an illegal subsidisation. Variable expenses for RMMs were considered to be as above with half of the realised measures being flowering areas and half being fallow areas. The levy rate was supposed to be 49.95 % (see chapter 5.3).

Under medium intensity of plant protection, our model farm would have had to pay 5 075 € of PPP-levy (indirectly, given that producers allocate the levy entirely onto product prices) on average 2009-2011. This would have made up 5.49 % of variable expenses and lowered the gross margin by 16.02 %. A mean rise in producer prices of the three crops of only 0.77 €/dt suffices theoretically to completely compensate the expenditures caused by the levy. In the scenario of turning to low-intensity plant protection, the levy would have only been 3 277 € or 3.7 % of variable expenses and would have lowered the gross margin by 9.29 %. It could have been offset by a mean rise in producer prices of 0.49 €/dt. Still, the farmer would receive 4 389 € for his 10 ha of RMM and thus get more money back than what was originally paid in the levy.

In contrast to the low values of producer price augmentation necessary to compensate economic effects of the levy, the mean producer price of the three crops rose by 6.89 €/dt in 2012 compared to the mean of prices 2009-2011. This, together with slight increases in yield but also in variable expenses, leads to an increase in the model farm's gross margin of 134 %. Because PPP-usage also increased in 2012, the levy rises to 6 575 € making up 6.23 % of variable expenses but falls to only 9.04 % of the gross margin. With low-intensity plant protection, levy expenditures of 2012 amount to 4 720 € or 4.65 % of variable expenses and 6.12 % of the gross margin. Lower expenditures for work and machinery related to low-intensity plant protection were not considered.

This exemplary calculation shows also that rewards for RMMs need to be adjusted regularly to producer prices. In this case, the reward was calculated to result – less variable expenses for RMM-conduction – in the mean per hectare gross margin of the farm 2009-2011. By this means, conducting RMMs is as profitable for the farmer as growing crops on average. With 2012 producer prices however, conducting RMMs becomes unprofitable. To keep it profitable (given a voluntary implementation programme also to keep it competitive with cropping), rewards for RMMs have to be adjusted to producer prices of crops regularly. An obstacle to adjust them on a yearly base could be that this will imply a considerable administrative effort, taking into account that the levy rate would have to be adjusted as well in order to decouple the magnitude of risk management realised in total in the whole country from price fluctuations. Therefore, it might be more practical to adjust rewards and levy rate in a wider cycle of e.g. every five years. In the case of voluntary implementation of risk management, contracts will then have to be made for the same period to avoid that farmers retreat from conducting RMMs because of rising producer prices. This of course is of disadvantage for farmers, however only if prices rise. With falling prices, farmers would profit from RMMs more than from their crops.

Thus, a stability of rewards over some years can make RMMs also interesting as a certain buffer against price falls.

Tab. 5.4.2: Exemplary calculation of on-farm economic effects of an RMM-based strategy with funding via a levy on PPPs. The model farm is an arable farm of 100 ha with a rotation of 50 % winter wheat, 25 % maize and 25 % spring barley. Rewards for RMMs were set at a level where their gross margin per hectare equals the average gross margin of the cultivated crops in 2009-2011. Half of the realised measures were supposed to be flowering areas and half to be fallow areas. Data based on the breakeven analysis tool on the website of the Bavarian State Research Centre for Agriculture (see above).

Crop / land use	Winter wheat	Maize	Spring barley	RMM	Total/mean
Area	**45 ha**	**22.5 ha**	**22.5 ha**	**10 ha**	**100 ha**
2009-2011					
Producer price	18.85 €/dt	18.1 €/dt	17.87 €/dt	-	18.27 €/dt
Yield	68.6 dt/ha	101 dt/ha	49.1 dt/ha	-	72.9 dt/ha
Revenue	58190 €	41132€	19742 €	4389 €	123453 €
Variable expenses (excl. levy)	40370 €	31642 €	15372 €	1530 €	88913 €
Gross margin	14608 €	8644 €	3348 €	2859 €	29459 €
Medium intensity PP					
Levy	3212 €	846 €	1017 €		5075 €
Levy - proportion of variable expenses	7.37 %	2.6 %	6.21 %		5.49 %
Levy - proportion of gross margin	18.02 %	8.92 %	23.3 %		16.02 %
Rise in producer price equivalent to levy	1.04 €/dt	0.37 €/dt	0.92 €/dt		0.77 €/dt
Low intensity PP					
Levy	2030 €	651 €	597 €		3277 €
Levy - proportion of variable expenses	5.07 %	2.04 %	3.95 %		3.7 %
Levy - proportion of gross margin	10.05 %	6.58 %	11.48 %		9.29 %
Rise in producer price equivalent to levy	0.66 €/dt	0.29 €/dt	0.54 €/dt		0.49 €/dt
2012					
Producer price	26.02 €/dt	25.51 €/dt	23.78 €/dt	-	25.10 €/dt
Yield	70.1 dt/ha	107 dt/ha	52.8 dt/ha	-	76.63 dt/ha
Revenue	82080 €	61415 €	28251 €	4389 €	176135 €
Variable expenses (excl. levy)	45347 €	35960 €	17687 €	1530 €	100523 €
Gross margin	32912 €	23995 €	9271 €	2859 €	69038 €
Medium intensity PP					
Levy	3821 €	1461 €	1292 €		6575 €
Levy - proportion of variable expenses	7.77 %	3.9 %	6.81 %		6.23 %
Levy - proportion of gross margin	10.4 %	5.74 %	12.23 %		9.04 %
Rise in producer price equivalent to levy	1.21 €/dt	0.61 €/dt	1.09 €/dt		0.97 €/dt
Low intensity PP					
Levy	2697 €	1011 €	1011 €		4720 €
Levy - proportion of variable expenses	5.89 %	2.8 %	5.58 %		4.65 %
Levy - proportion of gross margin	6.82 %	3.83 %	9.03 %		6.12 %
Rise in producer price equivalent to levy	0.86 €/dt	0.42 €/dt	0.85 €/dt		0.71 €/dt

In conclusion, the RMM-strategy can be seen as financially more favourable than a prohibition of PPPs already when considering only on-farm economics. Negative macroeconomic consequences of prohibiting PPPs have not been considered but can be expected to be severe (cf e.g. Knutson 1999) rendering the RMM-strategy even more favourable.

On-farm economic effects of a levy designed to fund RMMs on 10 % of arable land can be regarded as negligible compared to fluctuations of prices for agricultural goods and become even weaker when the levy leads to a reduction of over-use of PPPs. Still, any strategy focusing exclusively on indirect landscape-related RMMs for the compensation of negative effects of PPPs remains curative and does not address the ultimate cause of the problem. Therefore, direct PPP-related measures (active-ingredients-related and practice-related measures, including reduction of or refrain from use of certain PPP-groups, see chapter 5.1.1) also need to be an integral part of an RMM-strategy. Furthermore, besides the promotion of compensation measures in conventional agriculture, organic agriculture as an economically viable cultivation method refraining from synthetic PPPs needs stronger promotion including also more funds channelled into research to develop even more synergy effects between organic agriculture and biodiversity.

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6 Proposals and Recommendations for the PPP risk management in respect of particularly endangered species

6.1 Current concepts of risk regulation

The current concepts of risk regulation take into account only the direct effects of PPPs. The concepts try to exclude mortality due to PPP applications among identified key species. The current concepts have proved to be successful when three preconditions were fulfilled:

1. All relevant species have been considered during the tests
2. There is no misapplication of PPPs
3. There are still enough resources (habitat, food and shelter) for the species in the agricultural landscape.

Regarding 1. and 2., some examples demonstrated that the risks have not been excluded in a sufficient extent. For instance, rodenticides or molluscicides (e.g. Methiocarb, Metaldehyd, see also chapter 4) are still applied in sites where European Hamsters (*Cricetus cricetus*) occur. Another example is the poisoning of Hoopoes (*Upupa epops*) after the application of the molluscicid Methiocarb (see also chapter 4). The implementation of restrictions on the local level after the occurrence of the poisoning could not "repair" the severe damage to the particularly endangered species. Moreover, the current concepts are static because they do not consider changes in habitat choice of species. A species might invade a habitat and come into contact with PPPs which not had been tested. Habitat changes are frequent but not often detected because some of the species are rare and not well monitored.

Regarding 3., the agricultural development was very fast over the past few decades. When PPP came up and PPP risk regulation was put in place there were still parts of the agricultural landscape which were not managed intensively. Thus many farmland species had still enough (unsprayed) habitats to recover. The Common Agricultural Policy contributed suitable habitats by the obligation of a mandatory set-aside which was in place from the early 1990ies until 2007 (see chapter 2). Although there was no focus on wildlife-friendly management, mandatory set-aside fields assured the survival of farmland species' populations to a certain extent. With the abolishment of obligatory set-aside and a further increase in intensity of agricultural management at the same time (including PPP applications) the populations of typical farmland species and especially of threatened species started to decline very quickly (chapters 3 and 4.4). In many parts of Germany some species are locally or regionally extinct (e.g. European Hamster, Corn Bunting, Grey Partridge).

The current practice of risk regulation obviously is not capable to prevent the decline of threatened species and the loss of whole populations. Therefore, it is urgently necessary to develop and to implement a modern risk regulation which takes into account the current practice of agriculture which takes place on almost 100 % of the arable land and which does not leave sufficient space for threatened farmland species. A modern risk regulation concept has to ensure that populations of endangered species can live in viable and stable populations in all suitable landscapes within their distribution area.

In the following subchapter we describe the risk management for examples of particularly endangered species. Once put in place on a landscape wide level this risk management would also be beneficial to many other species in the farmland.

6.2 Risk management for particularly endangered species

In chapter 3.1 we showed that farmland birds and mammals are more endangered than most other groups of bird or mammal species in Europe. Within farmland birds and mammals, some species suffered from population declines more than others. Here we review possible risk management measure for some species which deserve special attention regarding risk management measures due to their vulnerability to PPP applications (evidently or indicated by the PPP sensitivity index, see chapter 4.2) and their negative population trend or due to the high responsibility Germany has for the global population of the species. We selected following species:

Grey Partridge	Very strong population decline, German Red List category 2
Red Kite	High German responsibility for the global population, global Red List category Near Threatened
Skylark	Population decline, German Red List category 2
Linnet	Very strong population decline, German Red List category V (Near Threatened)
Corn Bunting	German Red List category 3
Ortolan Bunting	German Red List category 3
Hamster	Very strong population decline, German Red List category 1
Brown Hare	Strong population decline, German Red List category 3

Species for which pesticides are unlikely to be main causes for population developments are not regarded here, even if they are considered to be highly threatened like Lapwing and Black-tailed Godwit.

6.2.1 Grey Partridge

There is evidence that pesticides have an effect on population growth in Grey Partridges (Boatman et al. 2004). Pesticides reduce food availability of Grey Partridge chicks (Borg & Toft 2000, Smart et al. 2000) and, hence, reduce chick survival (Potts 1971, Potts 1973). As chick survival has a significant effect on population growth, pesticides influence the population dynamics of the species. Pesticides thus very probably have contributed to the decline of the species in Europe (Potts 1986, Morris 2002, Boatman et al. 2004, see also chapter 4.1).

Other changes in agricultural practices also had negative effects on Grey Partridge populations, among them the loss of mixed farming and hence crop diversity (Potts 1971), the loss of undersown cultures (Potts 1973) and the loss of structures offering cover (Döring & Helfrich 1986, Panek 1997). The key factor for the population dynamics seems to be the survival of the chicks which is mainly influenced by food availability (Potts 1986).

It is evident, therefore, that refraining from applying insecticides and herbicides in potential Grey Partridge habitats would improve food availability and, hence, the survival of chicks and the growth of the population. In accordance with these findings there is some evidence that Grey Partridges profit from organic farming (Christensen et al. 1996, Chamberlain et al. 1999a). Joest (2011) could show that Grey Partridge densities where higher on plots that were not sprayed or fertilized and had wide spaces between rows of cereals. Growth rates of chicks were higher on organic fields than on conventional fields (Fuchs 1997). Chicks kept on unsprayed flower strips grew in body mass whilst chicks forced to feed on cereal fields lost weight (Gottschalk & Beeke 2010). Organic farming can be seen as a useful approach for the conservation of Grey Partridges.

In areas where Grey Partridges occur, spraying insecticides should be restricted in time and space. Potts (1986) estimated that at least 4% of the farmland should consist of non sprayed conservation headlands to reach population stability. Beeke et al. (2013) could show in a long term Grey Patridge project that unsprayed and optimally managed flower strips with an extent of 6 -7 % of the agricultural area led to an increase of the Grey Partridge population. The non-sprayed areas should be next to areas offering cover for nests and chicks and they should be more than 10 m wide. The most critical time of the year is the reproduction period which widely overlaps with the time of most frequent insecticide applications.

Besides restricting pesticide applications, other on-field and off-field risk management measure have been proven to be effective. Given the strong preference for set-aside and the need for cover, increasing the area set-aside and establishing unmanaged field margins can be assumed to be highly beneficial for the species (Kaiser & Storch 1996). The same holds true for the establishment of flower strips (Gottschalk & Beeke 2010) of hedgerows and bushes (Kaiser & Storch 1996). According to Panek (1997) cover in optimal habitats exceeds a coverage of 8%. The establishment of undersown cultures may also be beneficial for Grey Partridges (Potts 1971).

The high preference for field margins and mixed farming (see above) indicates that high crop diversity and relatively small field sizes could be beneficial to Grey Partridges.

In winter, stubble fields, set aside and again structures that provide cover are important features in Grey Partridge territories. Their maintenance and establishment can be beneficial to Grey Partridge populations.

Control of predators has been assumed to increase population size (Potts 1971). There is evidence that predator control can increase breeding success (Tapper et al. 1996).

Conclusions

Risk management for Grey Partridges can be achieved by refraining from spraying insecticides on at least 6-7% of field area (preferably on field margins) during the breeding season in combination with establishing habitat providing food and cover (set-aside, flower strips). These areas should be established in a way that at least 8% of each territory consists of these habitats.

6.2.2 Red Kite

According to Knott et al. (2009, EU species action plan) the global Red Kite population is critically threatened by illegal poisoning from feeding on illegally poisoned carcasses laid in order to control predators such as foxes and wolves. Such practices are rare in Germany but still widespread in the winter quarters of the German Red Kite population (Cardiel & Vinuela 2009). Knott et al. (2009) see a second important threat: accidental poisoning from ingesting rodents (mainly voles and rats), which have themselves been, primarily legally, poisoned by anti-coagulant rodenticides laid in order to reduce rodent outbreaks (Berny & Gaillet 2008). Dietrich et al. (1995) report on poisoning of Common Buzzards by Carbofuran, an insecticide-nematicide applied for seed protection. Although no corpses were chemically analyzed, several dead Red Kites very likely had fallen victim to Carbofuran applications.

Besides indirect poisoning the application of rodenticides have the potential to reduce one of the main food sources (rodents) of Red Kites in Germany.

Given the small global population size of the species (19,000 – 25,000 pairs, BirdLife International 2004) the risk of losing even single individuals should be avoided. This means that applications of rodenticides should be prohibited within home ranges of Red Kites during all year.

Knott et al. (2009) consider other threats as much less serious at a population level, though they may be important in a local context. These include electrocution by power lines, habitat intensification and food availability as well as collisions at wind farms (see also Dürr (2004)). Moreover railroad tracks may cause extra mortality in Red Kites (Mammen et al. 2003).

The loss of suitable foraging habitats such as set-aside, grassland and alfalfa caused by changes in agriculture could become one of the most important threats to the population in Germany in future (Gelbke & Stübing 2009). During the second half of the breeding season Red Kites, as many other farmland bird species, find huge areas of uniformly dense and high crops such as autumn sown cereals, oilseed rape and maize where they cannot efficiently forage.

Only few crops offer suitable feeding grounds for Red Kites during the critical part of the breeding season (May to July). The provision of such crops, in particular alfalfa fields and grasslands, can improve the food supply for Red Kites. Both habitats are particularly attractive just after harvesting (mowing). Possibly all measures that increase the density of rodents such as set up of margins along farm tracks, field edges and ditches, setup of low intensity grassland, set aside and maintenance of stubbles after harvest help to improve the provision of food to the chicks (Sandkühler & Oltmanns 2009).

The borderlines between fields are preferred habitat for foraging Red Kites. Red Kites possibly benefit from all measures that increase the lengths of the borderlines such as a reduction of field sizes and an increase in crop diversity (Sandkühler & Oltmanns 2009). In general the maintenance of a diversified farmland structure (mixture of crops, grassland and woodland) helps to maintain high densities of Red Kites (Bezzel 2010).

Conclusions

The global population of Red Kites is so small that even losses of single individuals should be avoided. Therefore, rodenticides should not be applied within home-ranges of Red Kites (breeding and non-breeding season). The landscape within the breeding range of Red Kites should be made more Kite-friendly: increase of crop diversity, increase of grassland and/or alfalfa and set-aside. Threats by physical obstacles (e.g. wind farms) should be alleviated (e.g. by right siting).

6.2.3 Skylark

There are clear indications for an influence of pesticide application on the nestling condition of Skylarks (Wilson et al. 1997, Boatman et al. 2004). Moreover there is tremendous evidence that Skylark populations are considerably higher on organic than on conventional farms (Fuchs & Scharon 1997, Wilson et al. 1997, Hötker et al. 2004, Neumann & Koop 2004, Kragten et al. 2008). Although the preference for organic farming cannot be entirely attributed to the absence of pesticides, it strongly indicates some influence of pesticides on Skylark populations. It is likely, therefore, that Skylarks would benefit from reductions of pesticide applications in the breeding season. More organic farms would probably increase Skylark numbers.

The decline of the European Skylark population went in parallel to a shift from growing spring sown cereals to autumn sown cereals. The vegetation development in autumn sown cereals curtails the opportunity for breeding long before the end of the season and results in a poorer annual production (Wilson et al. 1997, Chamberlain et al. 1999b). The only western EU country with a relatively stable Skylark population is Denmark. Denmark still holds a high share of summer cereals.

During the breeding season Skylarks abandon winter cereals earlier than summer cereals. These results broadly support the suggestion that increases in winter cereals and loss of farm habitat diversity have contributed to the Skylark decline (Chamberlain et al. 2000). There is a coincidence, however, between survival rates of Skylarks in Britain and their population trends (Wolfenden & Peach 2001). An influence on the population of mortality rates, hence, cannot be ruled out.

In Germany, at present Skylark populations suffer from the loss of set-aside and grassland. Both habitats hold high densities of Skylarks. The general trend of intensification of agriculture which is characterized for example by the loss of field margins, a reduction of non-vegetated spots due to high precision farming and other developments still has negative impacts on Skylark populations in Germany. The general loss of open habitats due to urbanisation (currently ca. 100ha per day, http://www.umweltbundesamt.de/boden-und-altlasten/boden/gefaehrdungen/flaeche.htm) also contributes to the decline of the population, although probably still much less than the ongoing agricultural intensification.

Losses due to agricultural activities like mowing can greatly influence the breeding success (Fuchs & Saacke 1999, Helmecke et al. 2005). Nest predation has been increasing in Germany in recent years (Helmecke et al. 2005, Langgemach & Bellebaum 2005, Hötker et al. 2007).

Amongst the in-crop measures the establishment of set-aside clearly helps to increase Skylark populations (Boag 1992, Block et al. 1993, Joest 2011). Henderson et al. (2012) showed a clear relationship between the percentage of set-aside on the farm level and the densities of Skylarks on the whole farm. Densities doubled when the percentages of set-aside rose from 0-3% to more than 10%. Their data indicate that more than 10% stubbles during winter are optimal.

Skylarks generally seem to prefer field borders (Benton et al. 2003). Designing field margins for Skylarks has proven to be successful in many occasions. There is evidence that wildflower strips, grassy margins, strips sown with seed mixture and unmanaged strips help to increase the densities of Sklylarks (Jenny 1990, Edwards et al. 2001) resp. reduce territory sizes (Weibel et al. 2001).

In recent years so-called Skylark plots have been establish to help Skylarks on arable fields. These plots are small (size usually ca. 20 m2) patches scattered over the fields. The plots are not drilled but otherwise managed in the same way than the rest of the field. Skylarks have somewhat higher densities on fields with plots, in particular at the end of the season availability (Morris et al. 2004, Fischer et al. 2009, Morris 2009, Cimiotti et al. 2011).

Sowing seeds in wide rows has also been proposed as a measure to improve habitats for Skylarks on arable fields. Both summer and winter cereals sown in wide rows on organic farms or on fields without application of pesticides and chemical fertilizers led to very high densities of Skylarks (Hötker et al. 2004, Joest 2011). On conventional farms (Morris et al. 2004) found that spacing of rows had no effect. Food availability also did not seem to be linked to spacing of rows in conventional farms (Morris et al. 2004, Smith et al. 2009).

Decreasing intensity in grassland management in arable landscapes had a positive effect on population trends in the UK (Baker et al. 2012). Less intensively managed grassland generally holds higher skylark densities than intensively managed grassland (see Tab. Alar2, Annex 1). It may thus be assumed that reducing the intensity of grassland management is beneficial for Skylarks.

On cultures that are regularly mown a minimal time period between mowing dates of at least seven weeks is essential to complete successful breeding cycles (Fuchs & Saacke 1999).

In winter skylarks clearly prefer stubble field and probably also set-aside fields (Tab. Alar5, Annex 1). Baker et al. (2012) could show that population trends of skylarks breeding in UK were associated with the establishment of stubble fields through agri-environmental schemes.

Conclusions

There is a wide range of evidently useful risk management measures for Skylarks, ranging from refraining from pesticide applications, organic farming, reducing the intensity of management in grassland to on field measure like setting up flower strips and set-aside.

6.2.4 Linnet

There is no direct evidence of indirect effects of pesticides on Linnets. Many Linnets feed on arable fields. As the diet of adults and chicks contains many wild herb seeds, there is a risk that the food supply is reduced by herbicides. The possibility of an indirect effect of pesticides is supported by studies that report higher densities of Linnets on organic than on conventional fields (Chamberlain et al. 1999a), some of the results being statistically significant (Christensen et al. 1996).

As effects of pesticide applications cannot be ruled out, reductions in the application of herbicides would probably increase the availability of food for Linnets. Organic farming would probably also be beneficial for the population.

An analysis of ring recoveries in UK showed that insufficient survival rates can not be the sole cause for population trends (Siriwardena et al. 1998). The declines of Linnet populations in Europe are possibly associated with losses in farm weeds (Moorcroft et al. 2006) which provide critical food resources when crop seeds are not available. Losses of field margins, set-aside and non-intensive grassland are causes for these losses. Siriwardena et al. (2000a) stated that the fall in breeding performance of Linnets had occurred most clearly in arable regions and in grazing regions, but not mixed farmland. The ongoing specialisation of farms is seen as a threat to the population.

All management measures that favours farm weeds like set-aside or the establishment of unmanaged field margins such as flower strips, beetle banks, uncultivated strips along ditches and farm tracks are beneficial for Linnet populations (Ranftl & Schwab 1990). Mixed, unsprayed and unfertilised alfalfa cultures attracted Linnets, unsprayed cereals sown in wide rows and conventional winter cereals did not (Joest 2011). Wild bird cover crops increase densities in winter (Stoate et al. 2003). Henderson et al. (2012) found that farms with less than 7.5% un-cropped land held considerably lower Linnet densities than farms with more than 7.5% un-cropped land.

The loss of potential nest sites such as hedgerows may also affect local populations (Ranftl & Schwab 1990, Macdonald & Johnson 1995). When nest sites are in short supply, planting bushes and hedgerows can be essential for providing safe nest sites populations (Ranftl & Schwab 1990).

Conclusions

For halting the decline of Linnets care has to be taken that sufficient food (seeds of farm weeds) and safe nest sites are available. There are several ways of improving food supply: refraining from applying herbicides, organic farming, establishing flower strips and/or set-aside, reducing intensity of grassland management.

6.2.5 Corn Bunting

Boatman et al. (2004) and Brickle et al. (2000) could show that breeding performance of Corn Buntings was indirectly affected by pesticides. Arthropod abundance in the vicinity of nests had a significant effect on the survival of broods. Invertebrate density was significantly negatively correlated with the number of pesticide applications. In accordance with these results Christensen et al. (1996) found significantly more Corn Buntings on organic farms than on conventional farms.

There is no experimental evidence for managing the risks for Corn Buntings associated with pesticide applications. The studies of Boatman et al. (2004) and Brickle et al. (2000) show that breeding success of Corn Buntings could possibly be increased by refraining from spraying or by reducing the pesticide applications within Corn Bunting home ranges. Any measure which reduces the amount of pesticides within the feeding range of Corn Buntings pairs would probably be beneficial for the breeding success of the species.

In a broader context, agricultural intensification in general and changes in land use are thought to be important factor for the decline of Corn Bunting populations (Donald & Forrest 1995, Donald & Aebischer 1997, Brickle et al. 2000, Fox & Heldbjerg 2008). It is not exactly known, however, whether the main reasons for the observed declines occur during the reproductive season or during the non breeding season. Siriwardena et al. (2000b) did not find any associations between changes in breeding success and the trend of the population in UK. Baker et al. (2012) could show that both measures set up to improve winter survival (maintenance of stubbles throughout the winter) as well as measure set up to increase breeding habitats (field margin management) had a positive effect on the population trend.

Intensive fertilisation and the change from summer to winter crops has led to early harvesting dates which in turn may have caused additional nest destruction, a truncation of the breeding season and food shortage due to the lack of unripe grain in spring (Brickle & Harper 2002). Additionally the loss of rotational grassland seemed to have a negative effect on Corn Bunting populations (Ward & Aebischer 1994, Fox & Heldbjerg 2008). Frequent mowing causes many nest failures (Perkins et al. 2008, Perkins et al. 2011). A general tendency to increase field sizes which in turn means a loss of field edges, hedgerows and farmland tracks also reduces the availability of suitable habitats for Corn Buntings.

During the period of obligatory set aside due to EU market regulations Corn Bunting Populations increased in some regions (Eichstädt et al. 2006, Schwarz & Flade 2007). As the area covered by set aside and grassland has been decreasing since several years (Bundesministerium für Ernährung Landwirtschaft und Verbraucherschutz 2011) the German Corn Bunting population is threatened by a significant loss of habitats.

Corn Buntings prefer set aside, grasslands, field margins and other non-cultivated features (see above). The preservation and the set-up of such features are beneficial to Corn Bunting populations (Block et al. 1993). The same holds true for the maintenance of stubbles throughout winter (Baker et al. 2012).

Perkins et al. (2008) and Perkins et al. (2011) showed that agri-environmental schemes that were targeted for Corn Buntings and included measures to increase food availability (e.g. non-harvested crop patches) and measures to increase nest survival (late mowing) reversed population declines. Measures took place on about 10 % of the farm surface (own calculations). The authors estimated that 0.5% of the land in the current range of Corn Buntings in Scotland had to be managed in order to reverse the losses in the whole country. By comparing population trends in western Germany, eastern Germany and large biosphere reserves Flade et al. (2010) could show by that Corn Bunting population increased when the proportion of set aside exceeded 10% and decreased when it fell below 10%. Flade et al. (2003) state that set aside fields should be combined to form blocks of 15-20ha.

Conclusions

Reducing pesticide applications would probably be very beneficial to Corn Bunting populations. Besides restricting pesticide applications, the set-up of temporarily unused land like set aside, unmanaged headlands or flower strips and retaining stubble fields are effective risk management measures. The area covered by temporarily unmanaged land should exceed 10%.

6.2.6 Ortolan Bunting

In contrast to the closely related Yellowhammer, there is no direct evidence that Ortolan Buntings suffer from the application of pesticides. The diet and the foraging behaviour of Ortolan Buntings and Yellowhammers are very similar so that an indirect effect of insecticides on the breeding performance of Ortolan Buntings is very likely. Ortolan Buntings and Yellowhammers score high in the PPP sensivity index (see chapter 4.2). Moreover, Ortolan Buntings prefer organic fields over conventional fields (Christensen et al. 1996, Bernardy et al. 2006).

Ortolan Buntings nest on cropped fields. The nest cover could be reduced by herbicides. An indication of the effects of herbicides is the observation of an unusually high density of Ortolan Buntings on an unsprayed maize field (Dziewiaty & Bernardy 2007) although sprayed maize fields are usually avoided.

As for the Yellowhammer, a reduction in the application of insecticides and herbicides within the territories of Ortolan Buntings will probably improve food resources. Non-selective and systemic insecticides are probably most harmful. Herbicides that kill host plants for important food species or reduce the cover of nests may also be harmful. Reductions in herbicide use at nest sites might therefore also be beneficial. A total abandonment of spraying in organic farming seems to be beneficial for Ortolan Buntings during the breeding season (see above).

Any reduction of insecticide usage should focus on a wide strip at the edges of fields and at the breeding season. Systemic insecticides should not be applied within potential Ortolan Bunting territories at any time of the year.

The reasons for the decline of Ortolan Bunting Populations in Europe are not fully understood. Most authors consider changes in agriculture within the breeding range as the main driving force although losses on the migration route or in the winter quarters cannot completely be ruled out. In France 10thousands of Ortolan Buntings are killed annually (http://www.komitee.de/en/actions-and-projects/france/bird-trapping/south-france-ortolan-bunting, visited 6 Aug. 2012). The loss of fine scaled structures like small rye fields which have be replaced by large maize fields and the loss of crop diversity in general are probably the most important factors (Noorden 1991, 1999). Ikemeyer & Bülow (1995) suggest that due to the application of fertilizers the vegetation in the territories of Ortolan Buntings is too high at arrival from the winter quarters. In particular, winter wheat can be already too high and too dense for Ortolan Buntings after mild winters.

The general intensification agriculture and the loss of a high diversity of crops on a small spatial scale are still acting threats for Ortolan Bunting populations.

One of the main task of restoring habitats for Ortolan Buntings during the breeding season is to provide the right vegetation height, density and cover (Pille 2005). Bernardy et al. (2006) could show that a drastic reduction of fertilization together with refraining from spraying and mechanical herb control caused a quick positive response of the local Ortolan Bunting population. The crops became more open and soil dwelling prey for Ortolan Buntings became more abundant. Unsprayed and un-fertilized winter rye fields and mixed crops containing peas and summer cereals proved to be very attractive both for nesting and for foraging.

Undrilled patches (“Ortolan Bunting plots”, similar to Skylark plots) attracted some foraging Ortolan Buntings in the beginning and in the end of the breeding season (Gues & Pürckhauer 2011).

Besides managing single crops or sowing new particularly favorable crops, ensuring a high crop diversity and hence small field sizes are helpful in ensuring stable populations of Ortolan Buntings (Pille 2005, Bernardy et al. 2006). Song posts are essential for territory establishment. Where needed, single trees or small orchards should be planted. Elements offering additional variety like unpaved farm tracks should be preserved.

Conlusions

Probably Ortolan Bunting populations would benefit from a reduction of pesticide applications. Other effective risk management measures are restrictions in the application of fertilizers, the establishment of less densely growing cultures and the increase in crop diversity.

6.2.7 European Hamster

Due to their preference for intensively used deep loess soils, Hamsters come into contact with a wide range of applied pesticides (Kayser et al. 2001). Kayser et al. (2001) found residues of organochlorine only on a very low level and conclude that they can be classified as not dangerous for the Hamster. Direct damage (i.e. intake of presticide-treated food) is likely to be small or non-existent due to the short live span of Hamsters (Gall 2007). The application of rodenticides may have negative effects, but its extent is unknown. The damage may occur on a small scale; hence it is unlikely to have remarkable impact on whole populations (Gall 2007), but it could affect the survival of some of the remaining small Hamster populations in Germany.

Main causes of death are predation and hibernation (Weinhold 2008). Natural enemies are birds of prey (Red Kite, Common Buzzard), owls (mainly Eagle Owl *Bubo bubo*), and small to medium sized carnivores like Weasel, Polecat, Stoat and Red Fox.

However, the main endangerment derives from anthropogenic threats such as intensive agricultural management techniques like harvest, ploughing or cutting (Kayser et al. 2003), direct take (illegal killing and kills by traffic), habitat fragmentation and destruction (Meinig & Boye 2009). Hamsters are especially threatened in periods of low cover in early spring and after the harvest.

Gall (2007) describes higher mortality of young Hamsters and lower fitness of older individuals due to earlier and faster harvesting (especially of cereals and rape), larger field sizes and less edge structures as well as smaller crop diversity.

In their risk analysis for European Hamsters Ulbrich & Kayser (2004) name disturbances like agricultural management and highway construction as the most threatening factors for Hamsters during autumn.

Hamster populations seemed to be decreased by large sized and weed free arable crops in The Netherlands and north western Germany (Niethammer 1982).

In order to stabilize the remaining Hamster populations, the use of pesticides should be minimized, especially herbicides, and application of rodenticides should be prohibited in areas where Hamsters occur (Nechay 2000).

Female Hamsters are the most sensitive part of the population, therefore conservation actions should focus on female Hamsters, e.g. by safeguarding maternal burrows throughout the season (Ulbrich & Kayser 2004). This measure is highly effective in early summer since the first litter per year might be more important for the population survival. Other measures are protection of the burrows from ploughing in autumn by retaining patches of crop and arable weeds around the burrows to guarantee sufficient cover and food (Ulbrich & Kayser 2004). Late timing of harvest and following cultivations was most favorable for the survival of Hamster populations. Operations such as soil cultivation should be conducted after Hamsters started their hibernation (i.e. after mid October or the beginning of November) (Ulbrich & Kayser

2004). Protection measures implemented in autumn are most effective in increasing the chances of survival of Hamster populations.

Large habitat sizes are not sufficient for the survival of Hamster populations instead the connectivity between habitats might be even more important (Ulbrich & Kayser 2004). Therefore conservation measures ensuring the connection of suitable habitats such as tunnels or strips with high levels of vegetation cover between adjacent areas appear to be very effective.

Crops with a high degree of vegetation cover and height provide best living conditions for Hamsters (Kayser et al. 2003b; see also figure Crcr4 in Annex I).

Growing sugar beets in areas important to Hamster populations should be avoided. Sugar beet crops are linked to increased pesticide applications and higher loesses of Hamsters due to predation (Nechay 2000). Most favorable are winter wheat crops as well as perennial fodder-plant crops like lucerne (Nechay 2000).

Offering supplemental food sources and establishing perennial set-aside areas supports European Hamster populations (Boye 2011).

Conlusions

Where Hamsters occur, the use of herbicides should be minimized and no rodenticides should be applied. Maternal burrows should be protected throughout the season. Field management should ensure that habitats providing food and cover (e.g. stubbles, set-aside, lucerne) are available around the burrows.

6.2.8 Brown Hare

Herbicide applications reduce the availability of weeds which are an important food source for Hares. In general, Hares are threatened by the disappearance of a main food source when crops reach the tillering stage or are harvested followed by a lack of alternative food sources like wild herbs etc. due to herbicide application (Tapper & Barnes 1986, Averianov et al. 2003). This results in lack of food for leverets and higher energy investments to find adequate food.

Edwards et al. (2000) review reasons for the decline in Brown Hare numbers and conclude that the pesticide paraquat is not responsible for decreasing Hare populations in the UK (see review of PPP effects).

Hares need field margins with herbal undergrowth since the diet offered by large fields is too one-sided because of the rapid decline of herbs on arable land that derives from the application of herbicides and fertilizer (Grzimek 1984).

Anthropogenic threats are mainly structural changes in the Hare’s habitat.

The main cause for declining Hare populations throughout Europe are, according to Smith et al. (2005), changes in arable habitats through agricultural intensification.

Increasing intensification and mechanization of agricultural measures, climate change and growing numbers of Foxes and other predators threaten the species. One of the negative developments in agriculture is the loss of structural and plant species diversity, for example due to an increase of winter grains at the expense of summer grains and root crops or due to growing amounts of fertilizer and pesticide applications. Also the intensification of grassland utilization (earlier and more frequent mowing) has a negative impact on Hare populations.

Meinig & Boye (2009) define agriculture, habitat destruction, tourism and recreation and direct take (legal killing, kills by traffic) as potential threats for Hare populations.

Edwards et al. (2000) reviews reasons for Brown Hare population declines. Leveret losses are high in forage and grass fields and much lower in arable crops. In the UK higher numbers of Hares are found in arable crops than in pastoral landscapes (McLaren et al. 1997 in Edwards et al. 2000). Reasons for that might be grassland improvement which leads to higher livestock densities, higher leveret mortality from silage cutting and digestive problems from cultivated grasses (McLaren et al. 1997 in Edwards et al. 2000). Disease is a major source of Hare deaths as well as predation but the main cause for Hare population declines are probably changes in farmland management practices (Edwards et al. 2000).

The increase in winter sown crops results in a food shortage during summer when reproduction is at its peak and therefore most threatens Hare populations (Wincentz 2009; also Reichlin et al. 2006, Tapper & Barnes 1986). Further, mature cereal crops are too dense for Hares to move through. Along with the loss of field margins and hedgerows the problem of food shortage is increased and Hares need non-cropped habitats that provide corridors in fragmented landscapes (Wincentz 2009).

Further threats are reduced availability of weed abundance (Reichlin et al. 2006),decline of the amount of woodland, hedgerows and field margins (Günther et al. 2005) and changes in the acreage of grassland (Barnes et al. 1983). Loss of crop and landscape diversity is primarily responsible for the long-term decline in Hare populations in Europe, positive effect of arable farming decreased as field sizes increased and habitat diversity decreased (Tapper & Barnes 1986). According to the British Biodiversity Action Plan (BAP) reasons causing the decline of Hare populations are the conversion of grassland to arable land, the loss of biodiversity in agricultural landscapes and changes in cropping practices such as planting cereal crops in autumn and the move from hay to silage (Anonymous 1995, see Smith et al. 2004). Further explanations may be increasing predator populations (Tapper & Barnes 1986) and climate change (increased precipitation) (Hackländer et al. 2002, in Smith et al. 2004).

Dominating diseases are European Brown Hare-Syndrom (EBHS), Pseudotuberkolose and bacterial diseases (Staphylokokkose, Pasteurellose, Listeriose). These made three quarters of all analyzed dead Hares in Hesse (N=267) (Eskens et al. 1999).

Ahrens & Kottwitz (1997) name rising Fox densities (based on hunting statistics) and the monotony of diet, due to only a few dominating crop plants like winter wheat and sugar beet, as reasons for declines of Hare numbers. Harvesting operations are not considered to be a threat for adult Hares (Marboutin & Aebischer 1996).

The effects of land-use and agri-environmental scheme measures on Brown Hares were investigated in lowlands in Switzerland (Zellweger-Fischer et al. 2011). Extensively managed hay meadows had a positive impact on Hare densities particularly in arable land but also in grassland while hedgerows were positively associated with Hare densities only in arable land. Set-asides and wildflower strips seemed to have no effect but these measures were only present to a small scale in the studied areas (Zellweger-Fischer et al. 2011).

Year-round vegetative cover, important for protection against predators and unfavorable weather conditions, is most important for Hare populations along with predator control and sufficient food supply e.g. through the inclusion of arable land in mainly pastural habitats (e.g. Smith et al. 2004; Vaughan et al. 2003, Jennings et al. 2006). Management should aim at increasing the survival of leverets and adult Hares.

Edge habitat of crops bordering tree stands positively affected Hare growth probably due to the combination of increased food availability in the edge and the year-round shelter from weather and predation provided by woodlands (Wincentz 2009).

Holzgang et al. (2005) found that more than 5-8% of high quality compensation areas per farm are needed to establish sustainable Hare populations. These areas should include traditional and wildflower fallow land, hedges with herbaceous margins and non-intensive meadows with low livestock densities. Additional measures are the replacement of fences by hedgerows, late second mowing and/or high-cut (>10cm), for cereal crops large spacing between rows (>20cm) should be implemented. The spatial position of such areas to roads should be considered since compensation areas close to roads with permanent disturbances by vehicles, humans and dogs make those measures useless (Holzgang et al. 2005).

Possibilities to stabilize and rise Hare numbers are for example perennial fodder plant crops and set-aside, sowing of game-friendly food and cover plants on set-aside, late mowing (end of July/August)(Ahrens 2000).

The presence of set-aside is an important feature in arable landscapes due to the improved heterogeneity which has a positive impact on Hare densities (Smith et al. 2004).

Suitable management options are a late second cut or no cut at all to reduce leveret mortality, increasing plant diversity and creation of larger row spaces to enable free movements of Hares through crops (Fuchs & Stein-Bachinger 2008).

Rotational mowing, where areas are left un-mown at every cut on extensively managed hay meadows, cut improve the suitability of this habitat for Hares (Humbert et al. 2009).

Conlusions

Brown Hare populations would probably benefit from establishing herbicide-free areas (fields or field margins). Brown Hare habitats should be improved by establishing set-aside and/or wildflower fallow land, hedges with herbaceous margins and non-intensive meadows with low livestock densities. More than 5-8% of high quality compensation areas per farm are needed to establish sustainable Hare populations.

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7 Conclusions

In Germany and in most parts of Europe, farmland mammals and in particular farmland birds are more threatened than other groups of these taxa. Most farmland bird and mammal species have an unfavourable conservation status. They share this fate with several other biota occurring on farmland such as farmland plant species (Schumacher 2005) and pollinating insects (Biesmeijer et al. 2006, Klein et al. 2007). Both the EU Birds Directive and the EU Habitats Directive require measures to turn an unfavourable conservation status into a favourable one. These measures have to address threats to populations at local, national and global levels. In order to reach a favourable conservation status, most importantly populations should not be declining in terms of numbers and range (BirdLife International 2004, 2006). At the level of single sites (e.g. SPAs), populations must not drop below the population size at the time when the EU Birds Directive was implemented. Higher reference population sizes must be considered if there are good reasons to set reference values higher (BirdLife International 2006, see chapter 3.1). At the local level populations have to be large and dense enough to be viable on the long term.

Arable land plays a crucial role for the occurrence of farmland birds and mammals in Germany because it constitutes by far the largest part of agricultural area of the country. However, arable farming in Germany is subject to increasing intensification and almost all arable land is treated with plant protection products (PPPs). Unlike for grassland, there are no specialists for any arable crop type. The most widespread crops hold most individuals. Many bird species, however, show clear preferences for unsprayed habitats within the farmland texture: set-aside, unsprayed margins of fields, farmland tracks, ditches and grassland.

Pesticide application periods largely overlap with reproductive periods of birds and mammals. Exposure to pesticides and their indirect effects, therefore, is highest when the energetic requirements of birds and mammals peak.

Pesticides can affect birds and mammals directly by poisoning and indirectly by removing food and shelter. Pesticides also affect biodiversity by allowing farming practices that would not be possible without pesticides and that are harmful to birds and mammals (see chapter 4.5). Direct effects of PPP applications are dealt with during licensing procedures. Authorisation for new pesticides is usually issued only when the risk of direct and indirect poisoning of birds and mammals is negligible. Hence, documented cases of mortality usually are caused by abuse of pesticides (inadequate application, inadequate doses, see chapter 4.1). However, there is scientific evidence that at least four European farmland bird species (Grey Partridge, Skylark, Corn Bunting, Yellowhammer) suffer from indirect effects of PPP application (removal of food) at the population level.

In some species, other factors than pesticides evidently trigger the population declines, for instance the loss and degradation of grassland in Black-tailed Godwits and Lapwings. However, many other species with similar diets and similar preferences of feeding habitats as the four evidently affected species can be assumed to be under a similar risk. Boatman et al. (2004), Bright et al. (2008) and Morris (2002) list species which suffered from indirect PPP effects in parts of their life cycle but evidence for effects on the population level was lacking (see also chapter 4.1). Moreover, we could not find studies that conclusively excluded PPP effects on population development. The sensitivity index for indirect effects of PPPs (see chapter 4.2) indicates which farmland bird and mammal species might be affected.

Expert opinion considers the application of PPP as one of the most important cause for population declines in farmland birds. Other important factors mentioned are the loss of crop diversity and the predominance of tall and dense crops (autumn-sown cereals, oilseed rape, maize) which render the fields inadequate for nesting and foraging in the second half of the breeding season. Since 2007 (end of obligatory set-aside in the EU), a dramatic loss of set-aside (together with a slow and steady decrease in grassland) in Germany probably caused recent declines in many farmland birds. Monitoring data yet have to show the extent of the declines. Set-aside and grasslands are the last refuges of unsprayed land in many agricultural landscapes.

Although clear evidence for indirect PPP effects at the population level does not exist for more than four species, we assume that the application of PPPs is one of the most important causes for the unfavourable conservation status of many farmland species. In addition to the proven cases, there is much circumstantial evidence for this assumption:

- There are additional species indirectly affected by PPP during parts of their life cycles.
- The PPP sensitivity index indicates effects for many species.
- The generally higher densities of farmland birds on organic farms versus conventional farms indicate effects of pesticide applications.
- Many farmland birds prefer to forage on or to nest in unsprayed habitats such as set-aside and grassland.
- The loss of the last refuges of unsprayed habitats (set-aside, unfarmed margins, grassland) within the agricultural landscape texture has probably caused recent large scale declines of farmland bird populations.
- PPPs are a prerequisite for features of modern conventional agriculture, such as dense crop stands, which are harmful to farmland birds and mammals.

In order to ensure that the application of PPPs does not harm the biodiversity targets of the EU a better risk assessment and a better risk management has to be implemented. Risk assessment and risk regulation have to take into account the indirect effects of pesticides which, at present, obviously have a greater effect on populations of farmland birds and mammals than direct effects (poisoning).

Many risk management measures exist. On the one hand there are PPP-related risk management measures which aim to reduce the adverse effects of PPP application by avoiding negative side effects and by reducing those applications which are not absolutely necessary to achieve a sufficient harvest. On the other hand there are landscape-related and crop-related risk management measures which aim to compensate the negative effects of PPP applications. An analysis of their efficiency in protecting threatened farmland species and their acceptance by farmers revealed that both the efficiency and the acceptance of crop- and landscape-related risk management measures are greater than those of the directly PPP-related risk management measures (see chapter 5). However, both kinds of risk management measures are needed, but they are virtually not yet applied to date. The extent of certain agri-environmental measures which are dedicated to compensate adverse effects of modern agriculture comprise only about 0.5 % of the arable land in Germany. According to empirical evidence and expert opinion targeted measures on at least 10% of the arable land would be needed to achieve measurable effects (IFAB, ZALF, HFR 2012). There is a wide range of different risk management measures (e.g. flowering strips and set-aside fields, extensive cereal cropping in wide rows without PPP- and fertiliser-applications, creation of landscape elements and biotope networks) which can be applied at the landscape and at the farm level. Risk management plans should be developed and applied in all regions in order to achieve adequate effects at landscape and at population level for farmland mammal and bird species

When setting up risk management plans, a region-specific concept seems to be desirable. The measures have to be adapted to landscape- and farm-specific conditions and specific species present in the different landscapes have to be considered. For example the protection of the highly endangered European Hamster (*Cricetus cricetus*) requires other measures than the protection of the Corn Bunting (*Emberiza calandra*). Hence, there have to be specific local or regional adaptations in risk management plans to protect present populations of particularly endangered species. In general, however, a regionally applied umbrella species concept seems to be the most practicable approach. We propose Grey Partridge, Skylark, Linnet and Brown Hare for umbrella species. The risk management measures which have proved to be successful for these species cover most of the evidently efficient measures for all other species.

For the design of a strategy to implement risk management into agricultural practice, we analysed existing tools of risk management and considered different scenarios. It turned out that there are two possible ways to implement measures for risk management on a broad scale. One way would be a score system of risk management measures for all farmers buying and applying PPPs. Farmers would have to prove that they have reached enough score points for measures or surface devoted to risk management measures. The other way would be a voluntary implementation of risk management measures as is practice in present agri-environmental schemes. Both scenarios would require an adequate funding in order to cover the costs for the measures. Charging a levy on PPPs like several other European states do could provide funding. Levies on PPPs would implement the polluter-pays-principle and would create incentives to reduce (over-)usage of PPPs. We estimated that a levy on PPPs would have to be roughly 50 % of the PPP producer prices in order to finance a sufficient extent of risk management measures. Further calculation revealed that these costs, if translated into farm gross margins, would have no serious economic effect because they are markedly below the magnitude of year-to-year-fluctuations of crop prices.

The study presented here shows that an effective management to protect the populations of free living bird and mammal species from the risks of PPPs has to include the consideration of the indirect effects. Adequate risk management measures have to be set up at a landscape scale. Scientific knowledge about these indirect effects of PPPs at the population level, however, is scarce. Almost all relevant studies came from UK. Published studies from the European continent and on species not occurring in UK are nearly absent. More research has to be devoted to the indirect effects on wildlife in different European countries. Large scale field experiments are necessary and the results of these studies have to be published and not to be retained by the applicants for the admission of PPPs, as usual in current practice. The studies must include investigations on minimal viable population sizes and minimum densities. They have to take into account meta-population dynamics and they should help to optimise risk management measures. The results of the studies will be paramount for the implementation of both a concept of risk management and effective strategies for risk management.

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Protection of biodiversity of free living birds and mammals in respect of the effects of pesticides

„Das Schutzgut Biodiversität in der Umweltbewertung von Stoffen – Konzept für das Management des Risikos für freilebende Vögel und Säuger aus der Anwendung von Pflanzenschutzmitteln unter Berücksichtigung indirekter Wirkung (Nahrungsnetz-Effekte) und besonders geschützter Arten“

Annex I

Detailed species portraits – birds

by

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Table of Contents

1 Annex I: Introduction and general references

In Annex I we review the biology and the ecological requirements of the farmland bird and mammal species selected for this report. We focus on aspects relevant to the main task of this report. We give information on trend and Red List status on the level of German Federal Lands, Germany, Europe and, if applicable, worldwide. We summarize relevant data on diet, habitat with a special focus on crop use and finally we analyze potential threats for each species and review possible risk management strategies. This annex also serves to give the detailed references for the data and the expert opinions in the main part of the report where this information would impair readability. Besides specific papers and reports we often referred to general reviews such as handbooks. These are not cited in each portrait. Instead we list these publications once here in this introduction (see below).

The aim of this report is to review the situation of farmland bird and mammal species in relation to pesticide use in Germany. Most of the ecological research, however, was done outside Germany, in particular in the UK. Without taking into account the international literature a meaningful review on habitat requirements, threats and conservation measures would fail. We therefore included all data from neighbouring countries such as Italy, the UK, the Baltic Republics and Scandinavia in our analysis. We omitted those studies obviously referring to habitats non-existent in Germany such as uplands or Mediterranean habitats.

Information used in this report comes from a variety of sources. In addition to published sources, we use own unpublished or partly published data. Partially these data derived from a study on farmland birds in Trenthorst (Schleswig-Holstein, Germany, Hötker et al. 2004a,b). We re-evaluated data at species level. The results are cited as Trenthorst study. Another part of the data was collected during a study on farmland birds on maize fields in Schleswig-Holstein (Hötker et al. 2010), cited as Maize SH study. Furthermore we re-analyzed counts of breeding and resting birds in marshes and lowlands of Schleswig-Holstein (Köster et al. 2003, Köster & Hötker 2003, Hötker et al. 2005). Finally, we asked farmland bird experts for their opinions on the species portraits. We are thankful for comments from Petra Bernardy, Krista Dzieviaty, Dr. Martin Flade, Dr. Dr. Jörg Hoffmann, Dr. Volker Salewski and Florian Schöne.

In general we found more information for farmland bird species than for farmland mammal species. For mammal species we reviewed available information and give the references in the text. Following handbooks and publications were consulted for specific information on birds for the species portraits:

Geography, status in Germany and diet

Handbook of the Birds of Central Europe (Bauer & Glutz von Blotzheim 1968, Glutz von Blotzheim et al. 1971, 1973, Glutz von Blotzheim et al. 1975, Glutz von Blotzheim et al. 1977, Glutz von Blotzheim & Bauer 1985, 1988, 1991, 1993, 1997), Handbook of the Birds of Europe, the Middle East and North Africa (Cramp & Simmons 1977, 1980, 1983, Cramp 1985, 1988, 1992, Cramp & Perrins 1993, 1994a, b), Compendium of the Birds of Central Europe (Bauer et al. 2005a,b,c), Goose populations of the Western Palearctic (Madsen et al. 1999).

Life cycle

Sources as in chapter geography. Generation time, defined as the average age of the parents of the current cohort, is taken from BirdLife International (2004).

Population, trend and conservation status

The global conservation status refers to IUCN (2010). The European population estimates, trends and conservation status are taken from BirdLife International (2004) and Pan-European Common Bird Monitoring Scheme (PECBMS 2012). National population estimates and trends can be found in Südbeck et al. (2007). For national trend estimations, more recent data issued by the DDA (M. Flade & J. Schwarz in litt.) were taken. Most trends at the national and the European level had been estimated using the software TRIM (Strien et al. 2004). Information on population trends in different German Federal Lands/States was also extracted from Südbeck et al. (2007). More informations on population sizes, trends and Red List status (at the Länder level) were taken from the following publications: Rau et al. (1999), Eichstädt et al. (2003), Fünfstück et al. (2003), Dornbusch et al. (2004), Witt (2005), Hessische Gesellschaft für Ornithologie und Naturschutz & Staatliche Vogelschutzwarte für Hessen (2006), Mitschke (2006), Hölzinger et al. (2007), Krüger & Oltmanns (2007), Landesamt für Umwelt, Wasserwirtschaft und Gewerbeaufsicht Rheinland-Pfalz (2007), Ministerium für Umwelt (2008), Ryslavy & Mädlow (2008), Sudmann et al. (2008a,b), Weixler (2008), Frick et al. (2010), Knief et al. (2010), Landesamt für Umwelt, Landwirtschaft und Geologie (2011), Ornithologenverband Sachsen-Anhalt (2012).

In addition we used the information provided by the Pan-European Common Bird Monitoring Scheme (2012) to assess times of strong declines and recent trends of common farmland birds in Europe.

Habitat and densities

The main task of this chapter was to compile data on crop-specific densities and to assess the significance of a crop for the occurrence of farmland birds in Germany. The amount of data differ greatly both between species and crops. For only seven species (Common Quail, Lapwing, Skylark, Meadow Pipit, Yellow Wagtail, Whinchat and Corn Bunting) we found enough data to apply proper statistical models (mixed effects models) to assess the influence of crops on densities of breeding birds. Avian densities are known to be influenced by the size of the study site. Smaller study sites usually reveal higher densities (Flade 1994). Therefore we included the size of study plots as a fixed continous factor in our models. When study sites were composed of several sub-sites (fields, blocks of fields, farms) we took the mean size of the sub-sites as plot size. We included study site as a random categorical variable to correct for study-specific differences in field-methods, observers and the varying and the variation in habitat quality amongst study sites that was not captured by the applied field protocols. In order to avoid deviances from normal distributions we transformed densities (log(density + 1) and sizes of study plots (log (size of study plot)). Densities are always given in pairs/100 ha. All analyses were performed with the statistical programme R (R Development Core Team 2009). For the analyses of the data with mixed-effects models we used the library 'lme4'. Pairwise tests of crop types were done using the library 'lsmeans' and the statistical significance of fixed and random factors was analyzed using the library 'LMERConvenienceFunctions'. The accepted significance level accepted in this study was $p < 0.05$.

For other species and for other parameters than breeding density data were too sparse to apply statistical modelling. In these cases we simply reviewed and compiled available published and unpublished information. When more than one measurement of density of a crop was available we took arithmetic means without taking into consideration study plot size and differences between studies. In order to treat all species in the same way we used these simple crop-specific means even for those species for which we modelled the least minimum means.

We tried to estimate the percentages of farmland birds breeding on different crops in Germany by multiplying crop-specific densities and the extent of land covered by these crops in Germany (see Tab. 3.4, (Statistisches Bundesamt 2012). The estimates are relatively crude because the crop-specific densities are not based on a pre-determined sampling design and data on rare crops and rare species are very sparse. The main findings of the estimates (Tabs 3.5, 3.6, 3.7), however, are probably robust because differences in crop-specific coverage are very big and the differences in densities between crops are considerable.

For some species we present monthly data on occurrence or reproduction. The figures in the tables usually represent the arithmetic means of several studies. When studies differed greatly in their extents, sample sizes and/or size of study sites, we weighted the means by the number of individuals considered in the studies.

Threats / sensibility (pesticide effects)

We review the evidence for pesticide-related effects on the species. We also try to give the rationale for the assessment of parameters for the pesticide sensitivity index (chapter 4.2). Besides threats through pesticides we also review the significance of other threats. We try to distinguish between threat assessments based on evidence and threat assessments based on expert opinion. If possible we try to identify the critical threat which is responsible for the population trend of the past years.

Measures for risk-management

We review the literature on measures for risk-management. We try to assess the efficiency of measures. Again we distinguish between assessments based on evidence and assessments based on expert opinion only.

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2 Detailed species portraits - birds

2.1 Bewick's Swan (*Cygnus bewickii*) – Zwergschwan – Order: Anseriformes

Geography

- Breeding range: Arctic NW Russia
- Spring migration stopover sites in N Germany, wintering in NW Germany

Status in Germany

- Migratory (migration periods: February-March and October-November) and wintering

Bewick's Swans arrive first in NW Lower Saxony in October and November. The wintering population builds up until February. In February and March Bewick's Swans from more western wintering grounds stop over in central Schleswig-Holstein and at river Elbe. These outnumber the wintering populations (Tab. Cybe1).

Life cycle

- First breeding when 2 - 4 year old
- One brood per year, 3-5 eggs per clutch
- Life span: several years (max. 25 years)
- Generation length 9 years

Population, trend and conservation status

The flyway population comprises 20,000 individuals (Delany & Scott 2006, Nagy et al. 2011) of which up to 5,000 – 11,000 individuals occur in Germany during the non-breeding season. There is a steep decline of the flyway population since the mid 1990s whilst numbers in Germany are fluctuating partly according to the hardness of the winter. Germany has a great responsibility for the Eurasian flyway population by holding up to more than half of the individuals. In Europe the species is considered as a Spec3W species with the status vulnerable. Bewick's Swans are listed on the Annex I of the EU Birds Directive.

Tab. Cybe1: Seasonal variation in occurrence of Bewick's Swans in different habitats and cultures in Germany (percentages of maximum population in Germany). The first row shows the numbers present in Germany (percentages of the mean maximum number). Numbers in the rows beneath show which percentages of the maximum population occur in each habitat in each month. The column "Pref." ranks the habitats according to their usage (top usage 100) and the column "% of pop." Shows the proportion of usage of each habitat. Sources: Blüml & Brinkschröder (1995), Blüml et al. (2007), Wahl & Degen (2009), Meier-Peithmann (2011), MOIN (unpublished data).

Bewick's Swan	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Pref.	of pop.
Presence	26	58	100	8.9	0	0	0	0	0	0.2	10	22		
Autumn-sown cereals	0.6	5.6	8.7	0.3						0	0.4	2.1	8	6
Maize	1.2	0.2	0.6	0						0	1.8	2.4	5	4
Rape	3	13	3.8	2.3						0.1	1.5	3.4	11	8
Potatoes	0.3	0.9	0	0						0	0.1	0.2	1	1
Grassland	20	37	87	6.3						0.1	6.5	14	100	80
Water	1.3	1.2	0	0						0	0	0	1	1

Diet

Bewick's Swans are predominantly herbivorous. They feed on submersed plants, on grass and herbs, on sprouts and green leaves of winter cereals and oilseed rape, and on crop rests (maize, potatoes, vegetables). Bewick's Swans take their food from the ground or in shallow water. In absence of detailed analyses of diet in Germany, the overview of foraging habitats (Tab. Cybe2) allows an assessment of the importance of different food sources. Grasses and other plants growing on grassland are the most important components of the diet, followed by the leaves of oilseed rape plants, winter cereals and crop rests (maize).

Tab. Cybe2. Seasonal variation in the diet of Bewick's Swans in Germany (percentages of maximum population in Germany). The first row shows the numbers present in Germany (percentages of the mean maximum number, see Tab. Cybe1). Numbers in the rows beneath show which percentages of the maximum population use different food sources in each month. The column "Pref." ranks the food sources according to their usage (top usage 100) and the column "% of pop." shows the proportion of usage of each food source. Sources: Blüml & Brinkschröder (1995), Blüml et al. (2007), Wahl & Degen (2009), Meier-Peithmann (2011), MOIN (unpublished data).

Bewick's Swan	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Pref. BS	% of pop.
Presence	26	58	100	8.9	0	0	0	0	0	0.2	10	22		
crop (green leaves)	2.7	16	11	7.2						6.1	5.3	11	18	15
crop rests (maize)	1.1	1	0.6	0						3.4	5.3	5.4	6	5
Grass and herbs	15	31	80	17						10	18	28	100	80
Water plants	1	1	0	0						0	0	0	1	1

Bewick's Swans switch diet in the course of the season. Crops and crop rests are important in autumn while grass predominates in March (Tab. Cybe2). In the Netherlands pondweed and, when pondweed stocks are depleted, crop rests are far more important parts of the diet than in Germany (Nolet et al. 2002).

In terms of diet selection Bewick's Swans are not specialized. None of their preferred diets seems to be much affected by pesticides.

Habitat and densities

Wintering and stopover sites are characterized by flat open landscapes with foraging sites (grassland and arable crops) and nearby open roosting sites (lakes, inundated grasslands, slowly flowing rivers). In Germany Bewick's Swans mostly forage on farmland. Crops, especially oilseed rape, winter cereals and maize stubbles play an import role as feeding sites in Lower Saxony but not in Schleswig-Holstein, where nearly all Bewick's Swans forage on grassland. Other cultures visited by Bewick's Swans are beets, legumes and vegetables. The apparent seasonal shift towards grassland in late winter is related to a shift in distribution from Lower Saxony to Schleswig-Holstein (Tab. Cybe1). Outside Germany, Bewick's Swans more often feed in water or use other natural habitats (Beekman et al. 2002) or fields after harvest (Nolet et al. 2002).

Bewick's Swans feeding on oilseed rape and on winter cereals are potentially exposed to the effects of pesticide applications. Roughly 14% of the population in Germany forages on these cultures (Tab. Cybe1).

In Germany, Bewick's Swans are not strictly specialized on particular habitats. They forage on grassland more often than other swan species and most species of geese (MOIN, unpublished data).

Bewick's Swans do not require ground cover for hiding or for shelter.

Threats / sensibility (pesticide effects)

The reasons for the decline of the flyway population are poorly understood. Habitat destruction and degradation on staging and wintering sites such as loss of grassland, illegal hunting (outside Germany) and fragmentation of landscapes inducing mortality due to power lines and wind parks possibly also play a role (Nagy et al. 2012).

Measures for risk-management

In Germany Bewick's Swans winter and stop over during migration. For surviving the winter and refuelling energy for the spring migration, both sufficient food availability and safety from predators is required. In practice this means that feeding sites and safe night roosts have to be available within short distance. Feeding and roosting sites have to be undisturbed, in order to prevent loss of energy by alarm flights. Bewick's Swans require large open foraging sites which are not fragmented by traffic lines and physical obstacles like power lines or wind parks. The preservation of such sites is essential for the protection of Bewick's Swans in Germany. The protection of grassland as the most preferred feeding sites prior to spring migration is another important factor. The creation of flooded meadows as roosting sites next to feeding sites has been found to be particularly successful (MOIN unpublished, Jeromin 2008, Jeromin & Jeromin 2009).

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2.2 Barnacle Goose (*Branta leucopsis*) – Weißwangengans – Order: Anseriformes

Geography

- Breeding range: NW Russia, N Europe
- Germany: N Germany

Staging Barnacle Geese in Germany occur almost exclusively in mainland areas along the Wadden Sea coast of Schleswig-Holstein and Niedersachsen. Birds concentrate in large flocks at only a few main sites, separated by coastal areas almost devoid of Barnacle Geese. Smaller numbers can also occur on some German Wadden Sea island, on the Baltic coast of Germany and inland in the Lower Rhine area (Ganter et al. 1999).

Status in Germany

Migratory (passage in Germany March – May and September – November), wintering and breeding (April – July)

Life cycle

- First breeding when 2 or 3 year old
- Single brooded, 4-5 eggs per clutch
- Life span: several years (max. 27 years)
- Generation length 7 years

Population, trend and conservation status

The most recent published estimate of the flyway population of Barnacle Goose is 420,000 individuals (Delany & Scott 2006). Probably nearly all these Geese stop over in Germany during migration. 19,000 – 57,500 individuals winter in Germany. The flyway population and thus the number of birds staging in Germany has moderately increased in recent years. The numbers of pairs breeding in Germany has strongly increased so that the figures presented in Tab. Brle1 are probably already out of date. The species is listed on Annex I of the EU Birds Directive.

Tab. BrIe1: Populations (pairs), trends (mainly 1980 – 2005) and Red List status of Barnacle Geese breeding in Europe, Germany and the German federal states.

Barnacle Goose			Trend					
	Population (pairs)	Proportion of German population (%)	<-50%	-50% - -20%	stable	20% - 50%	>50%	Red List category
Baden-Württemberg	0	0						–
Bayern	2 - 5	1.3						–
Brandenburg + Berlin	0	0						–
Hessen	0	0						–
Mecklenburg-Vorpommern	0	0						–
Niedersachsen + Bremen	8	3.1						R
Nordrhein-Westfalen	19	7.3						R
Rheinland-Pfalz								–
Saarland								–
Sachsen	0	0						–
Sachsen-Anhalt	0	0						–
Schleswig-Holstein + Hamburg	231	88.3						–
Thüringen								–
Germany	**192 - 193**							**–**
Europe	**41,000 – 54,000**							**–**

Diet

Barnacle Geese feed on salt marsh grasses (mainly *Puccinellia maritima* and *Festuca rubra*), on cultivated grassland and in crops such as winter wheat and rape (Ganter et al. 1999).

The food of Barnacle Geese is not affected by pesticides.

Habitat and densities

Barnacle Geese are found on large contiguous stretches of coastal salt marsh in areas where there is access to brackish or fresh water and on inland pastures and fields in polders close to the coast. The combination of marine and freshwater influence that is preferred by Barnacle Geese often occurs in newly embanked areas. Roosting areas are often identical with feeding areas; at some sites sandbanks and mudflats in the vicinity of the feeding areas are used for roosting (Ganter et al. 1999). Inland areas are used more intensively in autumn and salt marshes in spring (Mock 1996). Barnacle Geese have been recorded on following crops: autumn and spring-sown cereals, maize, oilseed rape, beets, potatoes, legumes and vegetables. On the peninsula of Eiderstedt Barnacle geese preferred rape fields in October and grassland in April. Autumn-sown cereals and maize fields were less preferred (MOIN unpublished data). The amount of food taken from sprayed cultures is estimated as 10%.

In Germany Barnacle Geese breed since 1988 (Berndt et al. 2003). They nest on small islands within inland wetlands, usually close to the coast.

Threats / sensibility (pesticide effects)

There is no evidence that Barnacle Geese are threatened by pesticide applications. As their diet is not affected by pesticides, indirect effects of pesticides are not expected. General threats to Barnacle Geese populations are disturbance by humans and by wind farms (Hötker et al. 2006), hunting, and loss of wet grasslands (Bauer et al. 2005).

Measures for risk-management

Barnacle Geese may benefit from hunting bans, from limited access by the public to nesting and roosting sites and from keeping clear major staging sites from wind parks.

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2.3 Bean Goose (*Anser fabalis*) – Saatgans – Order: Anseriformes

Geography

- Breeding range: N Russia, N Europe
- In Germany mainly in E and N, localized in S Germany

Status in Germany

- Migratory (passage in Germany February – March and September – November), wintering

Life cycle

- First breeding when 2 or 3 years old
- One brood per year, 4-6 eggs per clutch
- Life span: several years (max. 29 years)
- Generation length 7 years

Population, trend and conservation status

The most recent estimate of the flyway population comprises 670,000 – 690,000 individuals with 170,000 – 290,000 individuals occurring in Germany during winter. The trends both of the flyway population and the German wintering population are considered to be stable (BirdLife International 2004, Delany & Scott 2006).

Diet

The diet of Bean Geese in Germany mainly consists of maize, other grains, harvest rests of sugar beets and potatoes and young autumn-sown cereal plant, oilseed rape, grass and herbs. There are no indications that food availability is affected by the application of pesticides.

Habitat and densities

Bean Geese roost on shallow parts and banks of lakes and other wetlands and disperse by day over the surrounding farmland to feed. In Germany, Tundra Bean Geese prefer large arable fields. In autumn, they feed mainly on crop rests such as maize, grain, sugar beet and potatoes, the latter two root crops gaining increasing importance in the course of the season. Also winter cereals, rape, grass, etc. are eaten during winter. In late winter and spring, Bean Geese feed mainly on pastures and winter cereals (van den Bergh 1999). The percentage of food taken from sprayed cultures is estimated as 60%.

Threats / sensibility (pesticide effects)

There is no evidence that Bean Geese are threatened by pesticide applications. As their diet is not affected by pesticides, indirect effects of pesticides are not expected. General threats to Bean Geese populations are hunting (van den Bergh 1999) and disturbance by electric power lines (Ballasus & Sossinka 1997) and wind farms (Hötker et al. 2006).

Measures for risk-management

Bean Geese may benefit from hunting bans, from limited access by the public to roosting sites and from keeping clear major staging sites from wind parks.

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2.4 White-fronted Goose (*Anser albifrons*) – Blässgans – Order: Anseriformes

Geography

- Breeding range: N Russia
- In Germany mainly in E and N

All the important White-fronted Goose haunts in Germany are situated in the states of Brandenburg, Mecklenburg-Vorpommern, Niedersachsen, Nordrhein-Westfalen, Sachsen, Sachsen-Anhalt and Schleswig-Holstein. Most important haunts occur in the valley of the Lower Odra River, the lowlands along the Baltic coast, the Elbe River basin, the mouth of Ems River and the Lower Rhine area (Mooij et al. 1999).

Status in Germany

- Migratory (passage in Germany Febr. - March and September - November), wintering

Life cycle

- First breeding when 2 or 3 year old
- 1 brood per year, 5-6 eggs per clutch
- Life span: several years (max. 25 years)
- Generation length 7 years

Population, trend and conservation status

- Flyway population: 1,000,000 individuals
- Non-breeding population in Germany: 210,000 – 450,000 individuals
- Flyway population trend: stable
- Trend in Germany: stable

Tab. AnaI1: Population size of White-fronted Geese in different months. The peek of population present in Germany is set at 100%. Sources: Mooij et al. (1999), Ballasus (2001), Kleefstra (2010), Meßer et al. (2011).

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Population size	100	97	48	2	0	0	0	0	0	15	82	99

Diet

White-fronted Geese mainly feed on grass. On arable land they also take winter cereals, oilseed rape, and crop rests. Their food is not affected by pesticides.

Habitat and densities

White-fronted Geese roost on shallow parts and banks of lakes and old river oxbows and disperse by day over the surrounding farmland to feed. In eastern Germany they feed about equally on arable land and grassland and in western Germany, about 60-80% on grassland. Most grassland used by White-fronted Geese are improved for dairy farming and on arable land the most important crops are winter cereals (barley and wheat), maize, fodder grass, rape and sugar beet remnants after harvest. The proportion of White-fronted Geese feeding on arable land increases during cold weather (Mooij et al. 1999). The percentage of food taken from sprayed cultures is estimated to be 40%.

Threats / sensibility (pesticide effects)

There is no evidence that White-fronted Geese are threatened by pesticide applications. As their diet is not affected by pesticides, indirect effects of pesticides are not expected. General threats to Barnacle Geese populations are hunting (Mooij et al. 1999), disturbance by wind farms (Hötker et al. 2006) and loss of grassland (Bauer et al. 2005).

Measures for risk-management

White-fronted Geese may benefit from hunting bans, from limited access by the public to nesting and roosting sites and from keeping clear major staging sites from wind parks.

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2.5 Greylag Goose (*Anser anser*) – Graugans – Order: Anseriformes

Geography

- Breeding range: N and central Europe, W Asia
- In Germany breeding all over the country, mainly in E Germany

Status in Germany

- Migratory (passage Feb. – March and September – November), wintering and breeding (Feb. – June)

Life cycle

- First breeding when 2 years old
- 1 brood per year, 4-6 eggs per clutch
- Life span: several years (max. 23 years)
- Generation length 7 years

Population and trend

Populations of Greylag Goose are increasing in all parts of Germany (Tab. Anan1).

Tab. Anan1: Populations (pairs), trends (mainly 1980 – 2005) and Red List status of Greylag Geese breeding in Europe, Germany and the German federal states.

Greylag Goose			Trend					
	Population (pairs)	Proportion of German population (%)	<-50%	-50% - -20%	stable	20% - 50%	>50%	Red List category
Baden-Württemberg	180	1.0					■	-
Bayern	250 - 350	1.6					■	-
Brandenburg + Berlin	1800 - 2000	10.3					■	-
Hessen	150 - 250	1.1					■	3
Mecklenburg-Vorpommern	2800 - 3400	16.8					■	-
Niedersachsen + Bremen	2400	13.0					■	-
Nordrhein-Westfalen	1200 - 1500	7.3					■	-
Rheinland-Pfalz							■	-
Saarland							■	-
Sachsen	500 - 700	3.2					■	-
Sachsen-Anhalt	600 - 1000	4.3					■	-
Schleswig-Holstein + Hamburg	6300	34.1					■	-
Thüringen							■	-
Germany	**17,000 - 20,000**						■	-
Europe	**120,000 - 190,000**						■	-

Table Anan2: Population size, start of breeding (clutch initiation), and percentages of Greylag Geese feeding on sprayed cultures. Peeks of population present in Germany and clutch initiation dates are set at 100%. Figures are rough estimates based on (Bauer, K.M. & Glutz von Blotzheim 1968, Nilsson et al. 1999, Bauer, H.-G. et al. 2005, Kleefstra 2010, Meßer et al. 2011) and own data (MOIN unpublished data).

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Population	89	91	79	35	33	33	45	55	65	100	78	70
Clutch initiation	0	1	100	30	1	0	0	0	0	0	0	0
Percentage on sprayed cultures	80	82	40	4	3	3	18	30	59	90	70	63

Diet

Greylag Geese mainly feed on grass and herbs and they frequently dig for roots. Outside the breeding season they take crops such as leaves of winter cereals and oilseed rape and they often feed on crop rests like grains or corncobs. The assessment of proportion of diet affected by pesticides is 0%.

Habitat and densities

Greylag Geese breed in bogs, marshes and around shallow eutrophic lakes and oxbows with emergent vegetation, reed beds and open grassland, mostly feeding on floating vegetation, fresh reed plants and grasses. If cereal fields are close to water, these are also used by feeding Greylag Geese (Nilsson et al. 1999). Nests are in the ground, often in reed beds. Grass or fresh reeds in walking distance to open water are essential features of breeding and moulting sites. Chicks and flightless moulting adults need open water as refuges from predation and disturbance (Nilsson et al. 1999). The amount of food taken from sprayed cultures is estimated to be 5% both for chicks and adults during the breeding season.

During summer and autumn most of the Greylag Geese are found on agricultural land, mainly feeding on harvested crop remains (e.g. sugar beet, maize, cereals) or on autumn-sown crops (MOIN unpublished). Maize fields are exploited shortly after harvest (MOIN unpublished). In winter and in early spring, geese feed on grassland, stubble, winter cereals and winter rape. Except during the breeding season, Greylag Geese roost along the edges of shallow water at night and fly to the surrounding fields to feed during the day. Feeding flights can extend to distances of 10 km (Nilsson et al. 1999). The amount of food taken from sprayed cultures is estimated to be 59% during the non-breeding season.

Threats / sensibility (pesticide effects)

There is no evidence that Greylag Geese are threatened by pesticide application. As their diet is not affected by pesticides, indirect effects of pesticides are not expected. General threats to Greylag Geese populations are disturbance, hunting, loss of grassland next to breeding sites and predation of eggs and chicks (Bauer et al. 2005).

Measures for risk-management

Greylag Geese may benefit from hunting bans, from limited access by the public to nesting and roosting sites and from the creation of breeding and moulting sites with easy access to grass close to the shorelines.

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2.6 Common Quail (*Coturnix coturnix*) – Wachtel – Order: Galliformes

Geography

- N Africa to N Europe
- In Germany all parts of the country

Status in Germany

- Breeding (May – September), migratory

Life cycle

- First breeding when <1 year old, highly variable pairing system
- 1-3 broods per year, 7-13 eggs per clutch
- Life span: few years (max. 8 years)
- Generation length <3.3 years

Population, trend and conservation status

Common Quail populations in Germany have slightly increased. The European population fluctuates (see Tab. Coco1).

Tab. Coco1: Populations (pairs), trends (mainly 1980 – 2005) and Red List status of Common Quails breeding in Europe, Germany and the German federal states.

Common Quail			Trend					
	Population (pairs)	Proportion of German population (%)	<-50%	-50% - -20%	stable	20% - 50%	>50%	Red List category
Baden-Württemberg	1000 - 3000	7.1						–
Bayern	2500 - 10000	22.3						V
Brandenburg + Berlin	3000 - 5000	14.3						–
Hessen	300 - 1500	3.2						V
Mecklenburg-Vorpommern	2000 - 3000	8.9						–
Niedersachsen + Bremen	800	2.9						3
Nordrhein-Westfalen	3000	10.7						2
Rheinland-Pfalz								3
Saarland								3
Sachsen	2000 - 4000	10.7						3
Sachsen-Anhalt	2000 - 6000	14.3						–
Schleswig-Holstein + Hamburg	300 - 1000	2.3						3
Thüringen								–
Germany	**18,000 - 38,000**							–
Europe	**2,800,000 – 4,700,000**				Fluct.			Spec3

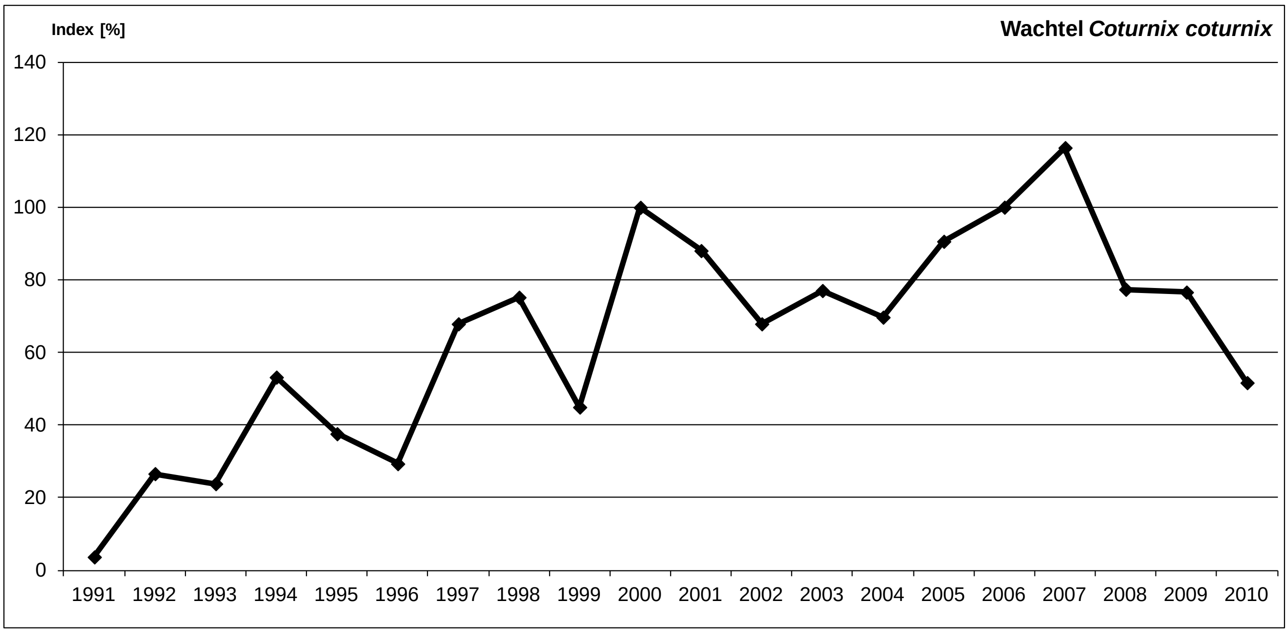

Fig. Coco1: Population trend (TRIM indexes) of Common Quails in Germany (DDA 2012).

Diet

At arrival Common Quails are more or less insectivorous (small beetles, ants) and occasionally take other small invertebrates. Later, herb seeds become very important. Cereal seeds become part of the diet after harvest, green parts of plants are not important. Chicks are more or less entirely insectivorous (Glutz von Blotzheim et al. 1973). Common Quails take their food from the ground or from plants. All food of chicks is scored to be potentially influenced by pesticides (insecticides) and 95% of the food of adults is estimated to be affected by pesticides (insecticides, herbicides).

Habitat and densities

Common Quails breed in open farmland on cereals and other crops, also on grassland. Nests are placed on the ground, usually within cultures. Densities are highest on rape fields and on set-aside. Maize, beets and sunflowers are less preferred (Tab. Coco2). An estimated 87% of the population in Germany can be found on cereals, rape and grassland.

The few published data did not allow the detection of significant changes in habitat occupancy in the course of the season. In Brandenburg Common Quails were not recorded on conventional maize and oilseed rape fields later than May (Hoffmann et al. 2012). Cereals obviously lost their attractiveness after harvest.

The proportion of time foraging on sprayed cultures is estimated by the proportions of the German population in different cultures (Tab. Coco2). Sprayed cultures account for 70% of the population.

Nests are placed on the ground, usually within cultures. As nests are usually well concealed but nevertheless face high predation rates, cover is considered as important for the hatching success. Cover may also be important for camouflaging adults. Its importance is scored as 0.2 for the index calculation.

Tab. Coco2: Mean densities of adult Common Quails (mostly calling males) in different habitats and cultures in Germany. Sources: Jansen et al. (2008) , Sellin (1994), George (1996), Hötker et al. (2004), Dziewiaty & Bernardy (2007), Hoffmann (2008), Kragten (2009), Hoffmann et al. (2012), MOIN (Trenthorst, unpublished). The column "% of pop." shows the estimated proportions of the German Common Quail population in each habitat.

Common Quail	Density (Males/100ha)	SD	n	% of pop.
Winter cereals	1.52	2.18	9	54
Summer cereals	1.05	0.64	3	4
Maize	0.30	0.54	6	5
Rape	0.37	0.43	5	3
Beets	0.20	0.34	4	1
Legumes	1.37	1.61	8	3
Potatoes	0.14	0.11	2	0
Sunflower	0	0	3	0
Alfalfa	1.30	1.54	4	0
Set aside	1.79	1.89	6	3
Grassland	0.85	1.77	5	27

Tab. Coco3: Seasonal occurrence and timing of reproduction of Common Quails in Germany. All figures are relative and refer to the maximum resident population of adults during the breeding season (100). The row "presence" gives an estimate of the total resident population. "Reproduction" gives the percentage of adults involved in reproduction. Sources: Glutz von Blotzheim et al. (1973), Vökler (1998), Hoffmann et al. (2012), MOIN (Trenthorst, unpublished).

Common Quail	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Presence	0	0	0	10	60	100	100	60	30	10	0	0
Reproduction	0	0	0	0	30	100	100	80	15	0	0	0

Statistics on crop-specific densities

The mixed effects model applied to the crop-specific densities revealed a significant effect of "Crop". The random factor "Study" and the continous fixed parameter "Plotsize" did not have a significant influence on densities (Tab. Coco4). Pairwise tests of crop types did not reveal significant differences. The differences between autumn-sown cereals and other crops as well as the differences between set-aside and other crops were close to significance ($p<0.08$).

Tab. Coco 4: Summary of a mixed effects model.

Factor	DF	F	Wald-Z	p
Plotsize	4.3; 1.0	2.02		0.223
Crop	42.5; 5.0	2.97		0.022
Study			0.82	0.411

Threats / sensibility (pesticide effects)

There is no experimental evidence of indirect effects of pesticides on Common Quails. Several studies, however, indicated that Common Quails benefit from organic farming. (Hötker et al. 2004, Neumann & Koop 2004, Kragten 2009) showed higher densities of Common Quails on organic fields compared to conventionally managed fields. Dziewiaty & Bernardy (2007) report on exceptionally high densities of Common Quails on an unsprayed maize field. None of the reported difference was statistically significant.

Among the threats for Common Quail populations mentioned in general overviews are:

intensification of agriculture, loss of herbaceous vegetation on fields, loss of set-aside and loss of crop diversity. As set-aside is preferred by Quails, the current loss of this habitat is a threat to the population. The fact that some cultures are obviously to high and too dense in the second part of the breeding season (Hoffmann et al. 2012) can also be considered as a threat because the cultivation area of crops for which this applies (maize, oilseed rape and probably also autumn-sown cereals) is increasing in Germany (Statistisches Bundesamt 2012).

Possible problems outside the breeding season (draughts in the Sahel Zone and persecution on migration) are also mentioned. The key factor for the population development is not clearly known.

Measures for risk-management

There are no experimentally tested measures to increase food availability and cover for Common Quails. The detailed analyses of habitat selection (see above), however, give some hints possible risk management tools.

Potentially a reduction of or totally refraining from spraying insecticides and herbicides can increase the food supply and the cover for Common Quails on crops. Organic farming also most likely has an effect.

Crop-related measures so far have not been tested for Common Quails. It is likely that Common Quails will benefit from all measures which increase the number and biomass of insects and the number of weed seeds. Among the potentially effective measures are set-aside, flower strips, grassy margins and comparable measures.

Landscape-related measures

It is likely that a decrease of field sizes and an increase of crop diversity will have a positive effect on the density of Common Quails.

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2.7 Grey Partridge (*Perdix perdix*) – Rebhuhn – Order: Galliformes

Geography

- W Europe to central Siberia
- In Germany all parts of the country

Status in Germany

- Breeding (April – August), sedentary

Life cycle

- First breeding when 1 year old
- Single brooded, 10-20 eggs per clutch
- Life span: few years (max. 7 years)
- Generation length < 3.3 years

Population, trend and conservation status

Populations of Grey Partridge have been declining all over Germany (Tab. Pepe1). The steepest declines took part in the 1980s or before and in the early 1990s (Fig. Pepe1).

Tab. Pepe1. Populations (pairs), trends (mainly 1980 – 2005) and Red List status of Grey Partridges breeding in Europe, Germany and the German federal states.

Grey Partridge			Trend					
	Population (pairs)	Proportion of German population (%)	<-50%	-50% - -20%	stable	20% - 50%	>50%	Red List category
Baden-Württemberg	1500 - 3000	2.5						2
Bayern	5000 - 12000	9.5						3
Brandenburg + Berlin	2000	2.2						2
Hessen	5000 - 10000	8.4						2
Mecklenburg-Vorpommern	1000 - 1500	1.4						2
Niedersachsen + Bremen	30000	33.5						3
Nordrhein-Westfalen	8000 - 12000	11.2						2
Rheinland-Pfalz								3
Saarland								2
Sachsen	200 - 400	0.3						3
Sachsen-Anhalt	2000 - 2500	2.5						2
Schleswig-Holstein + Hamburg	7800	8.7						V
Thüringen								2
Germany	**86,000 - 93,000**	**100%**						**2**
Europe	**1,600,000 - 3,100,000**							**Spec3, vulnerable**

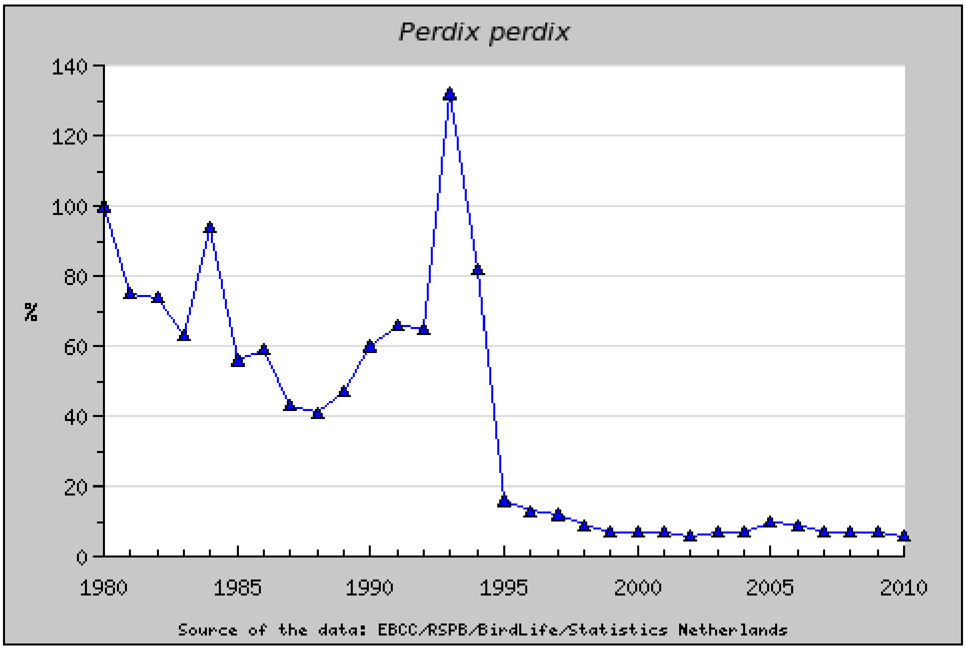

Fig. Pepe1. Population trend (TRIM indexes) of Grey Partridges in Europe (PECBMS 2012).

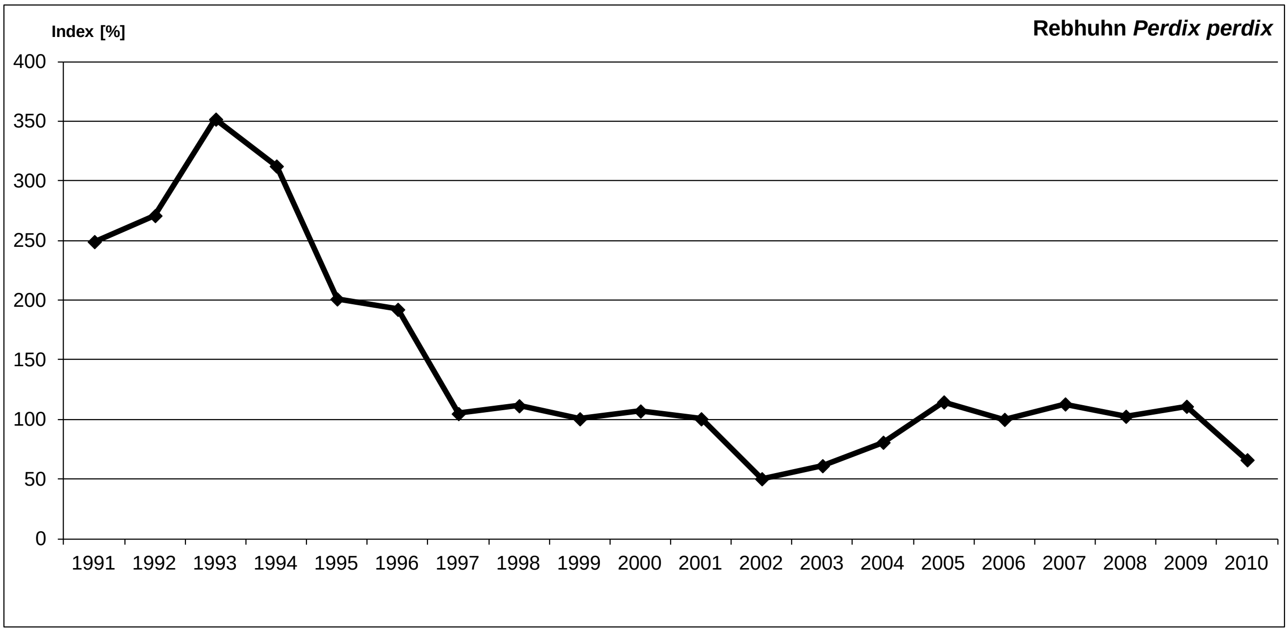

Fig. Pepe2. Population trend (TRIM indexes) of Grey Partridges in Germany (DDA 2012).

Diet

The diet of Grey Partridges differs considerably between sites and seasons. Grey Partridges do not seem to be very specialized but to behave more or less oportunistic. They mainly feed on seeds and green parts of plants, but they also take animal food, mostly arthropods up to the size of large beetles, but also worms and snails. Young chicks up to an age of four weeks almost entirely feed on small invertebrates which they pick up from plants or from the soil. Small insects dominate, but Borg & Toft (2000) showed that taking too many aphids (very small prey items) resulted in retarded growth of chicks. Seeds of weeds and green parts of plants, mainly also weeds, become more important as the chicks grow older. As weeds and invertebrates may be affected by pesticides, it is estimated that at least 95% of the food of chicks can be affected by pesticides.

Like the chicks, the adults forage by running on the ground. Adults also take invertebrates, weed seeds and green parts of plants. The latter become the most important food items during the non-breeding season. Green parts of crop fruits are also taken. In addition crop grains become a major part of the diet of adults. A rough estimate based on the data quoted in Glutz von Blotzheim et al. (1973, Table 12, p. 275) shows that the diet of adults in the breeding season is composed of 11% of animal food, 32% of weed seeds, 14% of crop seeds and 43% of green plant parts. During the non-breeding season the percentages are 1% of animal food, 21% of weed seeds, 21% of crop seeds and 57% of green plant parts. It is not clear what proportion of green plant material originates from crop plants. Under the assumption that half of green parts are weeds the percentage of adult food potentially affected by pesticides is 65% during the breeding season and 50% during the non-breeding season.

Habitat and densities

Grey Partridges live on open farmland. They occur both on arable land and on grassland. In general, mixed farming seems to be preferred (Potts 1971). Grey Partridges prefer set-aside over other arable fields (Sears 1992, Kaiser & Storch 1996, Watson & Rae 1997, Ellenbroek et al. 1998). Among arable crops oilseed rape seems to be somewhat preferred (Kaiser & Storch 1996). Fuchs (1997) found that hand-raised chicks could find sufficient food only on relatively few cultures: organic peas, organic spring-sown cereals, organic autumn-sown cereals, organic and conventional linseed, conventional (but non-intensively managed) triticale and set-aside. On all other (mostly conventional) fields intake rates were not sufficient for growth.

Grey Partridges are ground nesters. The nests are usually very well concealed in higher vegetation. Kaiser & Storch (1996) found that between 7 – 50% of nests are placed in crop fields. For nesting Partridges prefer plots covered by ruderal plant communities, including hedgerows and field edges (Kaiser & Storch 1996). Nest sites have to provide full cover but they also have to allow a clear view on approaching potential predators. Nests therefore are found within a comparatively narrow range of vegetation heights (15cm – 65cm) and cover density (leaf area index 1-3, Wübbenhorst & Leuschner 2006). These conditions are met on set-aside fields in Germany and on autumn-sown cereals in Poland, explaining a higher percentage of nests on cereals in Poland than in Germany (Wübbenhorst & Leuschner 2006).

Grey Partridges need sufficient cover for themselves and their nests and broods. This cover can be provided by unmanaged field margins, set-aside fields, scrub or hedgerows (Kaiser & Storch 1996). The amount of cover is a strong determinant for the quality of breeding territories. So Rands (1987) found a correlation between the amount of permanent nesting habitat (hedgerows/km^2 and percentage of hedge bottoms covered with dead grass) and recruitment. Panek (1997) found effects of nest cover on breeding success and assumes that the area of potential nest cover exceeds 8% in optimal Grey Partridge habitats. Döring & Helfrich (1986) found a (not statistically tested) relationship between the amount of cover and the development of the population. When the proportion of potential cover (mainly grassy strips without human disturbance) fell below 3% the local population started to decline.

During the non-breeding season Grey Partridges prefer stubble fields (Bauer & Ranftl 1996, Moorcroft et al. 2002), maize stubbles, oilseed rape, set-aside (Döring & Helfrich 1986, Kaiser &

Storch 1996) and farm tracks (Döring & Helfrich 1986) and avoid winter cereal fields (Kaiser & Storch 1996, Wilson et al. 1996) and spring-sown cereals (Döring & Helfrich 1986). Hedgerows, bushes and other structures that offer cover are also important for Grey Partridges in winter (Kaiser & Storch 1996), among them vineyards (Döring & Helfrich 1986).

Published data do not allow assessing precisely the proportion of food taken from sprayed cultures. Given the fact that sprayed cultures cover the by far biggest part of farmland in Germany 80% of food taken from sprayed cultures during the breeding season seems to be a realistic estimate. There are some hints that Grey Partridges spend more time on arable land during the non-breeding season. The estimate for the non-breeding season thus is 90%.

Threats / sensibility (pesticide effects)

There is clear evidence that pesticides reduce the food availability of Grey Partridge chicks and, hence, reduce chick survival (Potts 1971, Potts 1973). As chick survival has a significant effect on population growth, pesticides influence the population dynamics of the species. Pesticides thus very probably have contributed to the decline of the species in Europe (Potts 1986, Morris 2002, Boatman et al. 2004). The application of pesticides has also led to shifts in species composition of farmland insects (Smart et al. 2000). Borg & Toft (2000) could show that aphids which were favoured by pesticide applications were no sufficient supplementary food for Grey Partridge chicks because the intake rates were too small.

Other changes in agricultural practices also had negative effects on Grey Partridge populations. Among them are the loss of mixed farming and hence crop diversity (Potts 1971), the loss of undersown cultures (Potts 1973) and the loss of structures offering cover (Döring & Helfrich 1986, Panek 1997). The key factor for the population dynamics seems to be the survival of the chicks which is mainly influenced by food availability (Potts 1986).

In a study in France, Bro et al. (2000) showed that low hen survival during spring and winter was the main factor influencing the observed population decline. They assumed that increasing hen survival alone would not be sufficient to increase population size, hatching success and chick survival also had to be augmented.

A general increase in nest predation rate for ground nesting birds probably has also affected Grey Partridges (Langgemach & Bellebaum 2005).

Jenny et al. (2005) assumed that densities of a stable (meta)-population (reproduction outbalances mortality) should reach 5.5 – 8.5 pairs/100ha. Smaller densities would increase the risks of local extinctions. Such densities are not reached in many parts of Germany any more (studies cited in Dwenger 1991, Arbeitsgemeinschaft Rebhuhn 2004, Kaiser & Storch 1996, Eylert 2003).

Measures for risk-management

It is evident that refraining from applying insecticides and herbicides in potential Grey Partridge habitats would improve the food availability and, hence, the survival of chicks and the growth of the population. In accordance with these findings there is some (statistically not significant) evidence that Grey Partridges profit from organic farming (Christensen et al. 1996, Chamberlain et al. 1999). Joest (2011) could show that Grey Partridge densities where higher on plots that were not sprayed or fertilized and had wide spaces between rows of cereals. Growth rates of chicks were higher on organic fields than on conventional fields . Chicks kept on unsprayed flower strips grew in body mass whilst chicks forced to feed on cereal fields lost weight (Gottschalk & Beeke 2010). Organic farming can be seen as a useful approach for the conservation of Grey Partridges.

Potts (1986) estimated that 4% of the farmland should consist of non sprayed conservation headlands to reach population stability.

Given the strong preference for set-aside and the need for cover, increasing the area set-aside and establishing unmanaged field margins can be assumed (Kaiser & Storch 1996). The same holds true for the establishment of flower strips (Gottschalk & Beeke 2010) and of hedgerows and bushes (Kaiser & Storch 1996). According to Panek (1997) cover in optimal habitats exceeds a proportion of 8%.

The establishment of undersown cultures may also be beneficial for Grey Partridges (Potts 1971).

The high significance of field margins and mixed farming (see above) indicates that high crop diversity and relatively small field sizes could be beneficial to Grey Partridges.

Control of predators has been assumed to increase population size (Potts 1971). There is evidence that predator control can increase the breeding success (Tapper et al. 1996).

In winter stubble fields, set-aside and again structures that provide cover are important features in Grey Partridge territories. Their maintenance and establishment can be beneficial to Grey Partridge populations.

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2.8 Montagu's Harrier (*Circus pygargus*) – Wiesenweihe – Order: Accipitriformes

Geography

- Breeding range between Morocco and central Siberia
- In Germany localised in few sites throughout the country

Status in Germany

- Breeding (April – August), migratory

Life cycle

- First breeding when 1-3 years old, often bigyneous
- Single brooded, 3-5 eggs per clutch
- Life span: several years (max. 16 years)
- Generation length 6 years

Population, trend and conservation status

Mainly due to conservation efforts the of Montagu's Harriers pairs breeding in Germany has increased over the past decades (Tab. Cipy1). Due to small populations size and other factors the species remained red listed in all single federal states. Montagu's Harriers are listed in Annex I of the EU Birds Directive.

Tab. Cipy1: Populations (pairs), trends (mainly 1980 – 2005) and Red List status of Montagu's Harriers breeding in Europe, Germany and the German federal states.

Montagu's Harrier			Trend					
	Population (pairs)	Proportion of German population (%)	<-50%	-50% - -20%	stable	20% - 50%	>50%	Red List category
Baden-Württemberg	5 - 6	1.3						2
Bayern	102	23.2						1
Brandenburg + Berlin	50 - 70	13.6						2
Hessen	0 - 2	0.2						1
Mecklenburg-Vorpommern	32 - 38	8.0						1
Niedersachsen + Bremen	100	22.7						2
Nordrhein-Westfalen	30	6.8						1
Rheinland-Pfalz								1
Saarland								1
Sachsen	6 - 10	1.8						1
Sachsen-Anhalt	20 - 40	6.8						1
Schleswig-Holstein + Hamburg	60	13.6						2
Thüringen								1
Germany	**410 - 470**							**2**
Europe	**25,000 - 65,000**							**-**

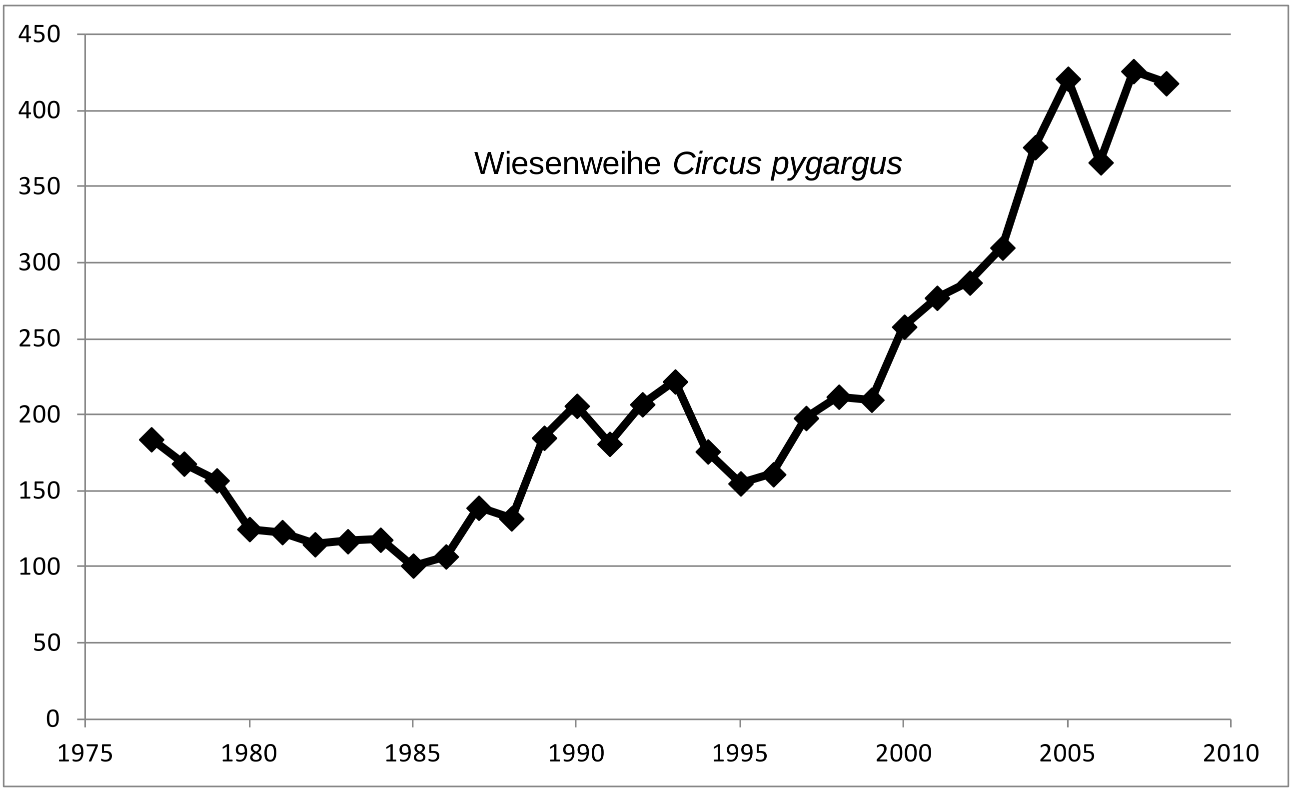

Fig. Cipy1: Population trend (pairs) of Montagu's Harriers in Germany (DDA 2012).

Diet

The diet of Montagu's Harriers in Europe is diverse and consists of small mammals, birds (often Skylarks and chicks and nestlings of other species), reptiles and large insects (Clarke 2002, Trierweiler 2010). In the winter quarters in Africa locusts may become important (Clarke 2002). Although birds seem to be the most important prey items, number of breeding Montagu's Harriers are locally correlated to vole cycles (Koks et al. 2007, Joest 2011). Montagu's Harriers hunt by flying low over the ground. The percentage of prey theoretically affected by pesticides (rodents and insects) is estimated to be 30%.

Habitat and densities

Montagu's Harriers live in open habitats. In central and western Europe these are most often arable and less often pastoral sites. Few pairs also nest on heathland or on moorland. Nests are placed on the ground, most often in cereal crops. The preference for different crops depends on the height of the vegetation in the nest initiation phase (preference for autumn-sown barley in northern Germany (Grajetzki & Nehls 2013) or rye in Frankonia (Krüger et al. 1999).

Until the beginning of the 1990s, most Montagu's Harriers had nested on uncropped land. The shift to cropland was rapid and occurred simultaneously in many European countries (Kitowski 2002, Koks & Visser 2002, Mrlik et al. 2002)

Montagu's Harriers forage on cropland but they strongly prefer set-aside, alfalfa and summer cereals (Trierweiler 2010), extensively managed grassland, structures like dikes, ditches, field margins and on some occasions natural habitats like salt marshes (Grajetzki & Nehls 2013, Joest 2011, Arroyo et al. 2002, Koks & Visser 2002). Montagu's Harriers also use many other crops for hunting, such as autumn-sown cereals, oilseed rape, maize, potatoes, vegetables and intensively managed grassland (Trierweiler 2010, own observations). On grassland habitats and on set-aside, hunting success was closely related to mowing (Trierweiler 2010). Trierweiler (2010) found that high percentages of set-aside and alfalfa crops close to the nest site were associated with high nesting success.

The percentage of time spent foraging on sprayed cultures and hence the percentage of prey taken from sprayed cultures is estimated to be 35% (Trierweiler 2010, Grajetzki & Nehls 2013).

Threats / sensibility (pesticide effects)

There is no evidence for direct (Denker et al. 2003) or indirect effect of pesticides on Montagu's Harrier populations. In theory a reduction of rodents by rodenticides and a reduction of insects by insecticides could have an influence on the population.

The greatest threats to the population are probably still the risks of nests to be destroyed by farming activities. Wind farms which are often close to nest sites pose a certain threat for lethal collisions of adults (Rasran et al. 2013). The ongoing loss of grassland and set-aside, both being preferred habitats of the species, may pose future risks to the population development. The breeding success of Montagu's Harriers depends on the availability of food (Trierweiler 2010). This means that all activities that reduce habitat features ensuring a rich farmland bird fauna and a rich farmland rodent fauna are detrimental to Montagu's Harrier populations as well. Where set-aside and grasslands are missing, Montagu's Harriers face a landscape where dense and high-growing crops like autumn-sown cereals, oilseed rape and maize dominate. Like other raptors, Montagu's Harriers will hardly be able to catch prey on such fields from June onwards.

As Montagu's Harriers react sensitively to vertical structures reducing the openness of their habitats such as buildings, tree rows and wind farms (Griesenbrock 2006), a decrease of openness due to urbanisation and other factors is a threat to the population.

Measures for risk-management

Nest protection which is usually set up in cooperation with farmers is seen as the most efficient protection measure in many European countries (Arroyo et al. 2002, Clarke 2002, García & Arroyo 2002, Kitowski 2002, Koks & Visser 2002, Mrlik et al. 2002). As most Montagu's Harriers breed on cropland and the breeding cycles are not concluded before harvest active protection is essential for the survival of the species in central and west Europe.

All measures that increase the food availability for Montagu's Harriers such as establishing set-aside, alfalfa and grassland (Arroyo et al. 2002, Koks & Visser 2002) and possibly also the set-up of non-managed field margins and grassy features along farm tracks, ditches and dikes contribute to improve the food availability. As Montagu's Harriers need to find food during the whole season, a diversification of crops that ensures the availability of shorter crops such as spring-sown cereals or shorter broad-leaved crops in the second half of the breeding season will be beneficial (Trierweiler 2010).

The protection of remaining semi-natural grassland or the set-up of low intensity grassland can help to ensure feeding grounds besides sprayed cultures.

The main breeding sites of Montagu's Harriers in Germany should be kept clear of wind farms and other potentially harmful structures.

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2.9 Red Kite (*Milvus milvus*) – Rotmilan – Order: Accipitriformes

Geography

- Nearly endemic in Europe
- In Germany throughout the country except North Sea coast, Germany holding the largest part of the global population

Status in Germany

- Breeding (March – June), migratory , few birds wintering

Life cycle

- First breeding when 2 years old
- Single brooded, 2-3 eggs per clutch
- Life span: several years (max. 30 years)
- Generation length 6 years

Population, trend and conservation status

The numbers of Red Kites breeding in Germany decreased in the 1990s but remained stable thereafter (Fig. Mimi1). Decreases have been reported from Bavaria and Sachsen-Anhalt (Tab. Mimi1). The Red Kite is listened on Annex I of the EU Birds Directive. The species is globally listed as near threatened.

Tab. Mimi 1: Breeding populations (pairs) and trends (mainly 1980 – 2005) of Red Kites in Europe, Germany and in the German federal states.

Red Kite			Trend					
	Population	Proportion of German population	<-50%	-50% - -20%	stable	20% - 50%	>50%	Red List category
Baden-Württemberg	1,000 – 1,100	8.8%						
Bayern	500-700	5.0%						
Brandenburg + Berlin	1,200 – 1,500	11.3%						2 (BE: 3)
Hessen	900 – 1,100	8.3%						3
Mecklenburg-Vorpommern	1,400 – 2,400	15.8%						3
Niedersachsen + Bremen	900	7.5%						
Nordrhein-Westfalen	350 - 400	3.1%						
Rheinland-Pfalz	400 - 500	4.2%						
Saarland								
Sachsen	800 – 1,000	7.5%						3
Sachsen-Anhalt	2400	17.6%						2
Schleswig-Holstein + Hamburg	120	1.0%						
Thüringen	800 – 1,000	8.0%						
Germany	**10,000 – 14,000**							**V**
Europe	**19,000 – 25,000**							**Spec2**
Global	**19,000 – 25,000**							**NT**

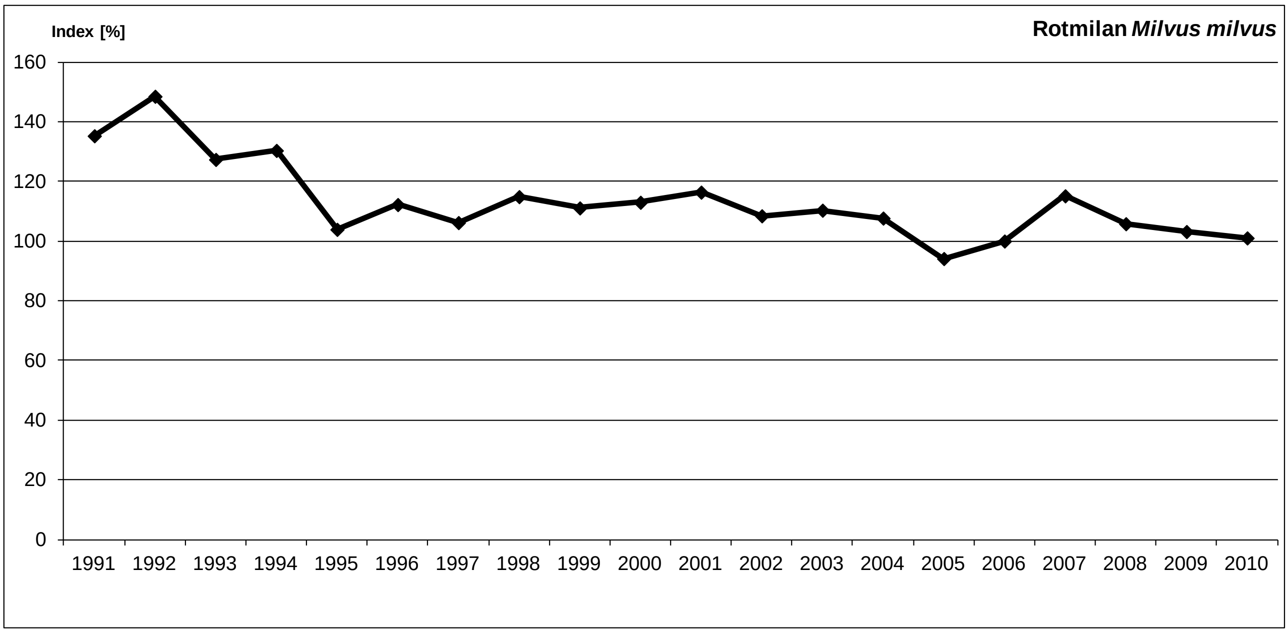

Fig. Mimi1: Population trend (TRIM indexes) of Red Kites in Germany (DDA 2012).

Diet

The diet of Red Kites in central Europe mainly consists of small vertebrates, often rodents and birds, which they catch on the ground. Carrion also plays an important role in the diet (Tab. Mimi2).

Tab. Mimi2: Diet (proportion of items found at nest sites) of Red Kites in Central Europe. Sources: Nachtigall (2008) and references therein (mean percentages of four different studies, Traue 1970, Ortlieb 1995, Weber 2002). The category "other mammals" includes an unknown percentage of carrion.

Food organisms	Proportion of diet (%)
Rodents	28.6
Other mammals	12.5
Carrion	16.0
Birds	27.8
Amphibians and reptiles	2.6
Fish	12.1
Invertebrates	0.3

Besides the relatively large proportion of carrion in the diet, specializations are not visible.

Rodents and carrion can be poisoned by rodenticides and, therefore, create a risk of direct poisoning. At least 44.5% of the diet is affected (Tab. Mimi2). Besides indirect poisoning the application of rodenticides have the potential to reduce one of the main food sources of Red Kites in Germany, about 29% of the prey being affected (Tab. Mimi2).

Habitat and densities

Red Kites breed in diversified farmland. Their nests are on trees in forests or tree lines. Red Kites forage on open fields, on places with high concentrations of food like rubbish dumps and composting plants. The nest sites remain an important part of the home range after the breeding season (Mammen et al. 2013).

Red Kites have huge home ranges both during the breeding and the non breeding season. Individuals differ strongly in the size of the area they overfly (Tab. Mimi2).

Tab. Mimi2: Home ranges (MCP, Minimum-Convex-Polygon) of Red Kites (Nachtigall 1999, Hagge et al. 2003, Nachtigall 2008, Mammen et al. 2013).

Source	MCP breeding season (km²)	MCP non-breeding season (km²)	n
Hagge et al. (2003)	1.9-62.1		12
Nachtigall (1999)	5.5-91.6	5.9-8.0	5
Nachtigall (2008), Nachtigall & Trapp (2006)	1.9-12.1	0.3-19.0	8
Mammen et al. (2012)	0.5-117.7	1.0-213.3	13

Red Kites need a good visibility of their prey. They usually hunt over bare ground or over patches of short vegetation. On farmland the availability of bare ground and short vegetation strongly varies within the season. Before the start of the breeding season almost all fields offer good conditions for foraging. Within the breeding season crops become higher and denser and suitable foraging plots become very scarce. After the start of the harvest bare ground or stubble again are available ad libitum. The habitat preferences of Red Kites follow the availability of foraging grounds. When the vegetation on most fields is high (June), road and field margins (borderlines) and grassland are the most preferred habitats (Klein et al. 2009, Schmidt 2009, Mammen et al. 2013, Tab. Mimi3). Maize fields demonstrate the effects of crop growth most clearly. Red Kites prefer maize as long as much bare ground is visible (until June) und clearly avoid it after plants have grown up (Tab. Mimi3). Fields harvested in June or July, before the start of the main harvest, attract many Kites. The strong preference of alfalfa fields results from the regular mowing for fodder production (Mammen et al. 2013). Other cultures offering bare ground throughout May, June and July like potatoes and beet are usually also preferred by foraging Red Kites (Nachtigall 2008).

Tab. Mimi 3: Seasonal variation in occurrence of Red Kites in Germany (percentages of maximum population in Germany, first row) and habitat preferences (mean Jacobs indexes). The column "Pref." gives the means over all months. Sources: Three studies in Sachsen-Anhalt (Nachtigall 2008, Mammen et al. 2013).

Red Kite	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Pref.
Presence	1	5	75	100	100	100	100	100	100	70	20	1	
Autumn-sown cereals			0.00	-0.49	-0.56	-0.27	-0.16	-0.26	-0.40	-0.55	-0.14		-0.31
Spring-sown cereals			0.14	-0.57	0.04	-0.04	-0.54	-1	-0.33				-0.33
Maize				0.52	0.57	0.61	-0.84	-0.75	-0.66	-0.10	-0.65		-0.16
Rape			-0.1	-0.8	-0.95	-0.5	0.20	0.27	-0.37	-0.53	-0.72		-0.39
Alfalfa			0.75	0.75	0.80	0.71	0.70	0.70	0.20				0.66
Set-aside			-0.30	0.05	-0.37	-0.27	-0.48	-0.83	-0.20	-0.30	-0.70		-0.38
Borderlines			-0.80	-0.65	0.60	0.75	0.65	0.22	-0.05	0.30	-0.51		0.06
Bare ground (tilled)			0.40	0.80	-1	-0.18	0.60	0.13	0.01	0.15	0.76		0.19
Grassland			0.14	0.14	0.63	0.63							0.39

Nachtigall (2008) found a negative correlation of crop diversity and home range. Red Kites in diverse landscapes needed smaller home ranges than in uniform landscapes. Gelpke (2008) found the breeding success to be positively correlated with the proportion of grassland in the vicinity of the nest. The proportion of arable land had a negative effect.

The amount of foraging time that Red Kites spend on non-crop sites depends on the availability of structures like composting plants, manure-piles or rubbish dumps in the vicinity of the nests (Mammen et al. 2013). As a rough estimate Red Kites spend 70% of their time for foraging on sprayed cultures. The proportion of food taken from sprayed cultures is likely about the same percentage.

Threats / sensibility (pesticide effects)

According to Knott et al. (2009, EU species action plan) the global Red Kite population is critically threatened by illegal poisoning from feeding on illegally poisoned carcasses laid in order to control predators such as foxes and wolves. Such practices are rare in Germany but still widespread in the winter quarters of the German Red Kite population (Cardiel & Vinuela 2009). Knott et al. (2009) see a second important threat: accidental poisoning from ingesting rodents (mainly voles and rats), which have themselves been, primarily legally, poisoned by anti-coagulant rodenticides laid in order to reduce rodent outbreaks (Berny & Gaillet 2008). Dietrich et al. (1995) report on poisoning of Common Buzzards (*Buteo buteo*) by Carbofuran an insecticide-nematicide applied for seed protection. Although no corpses were chemically analysed, several dead Red Kites very likely had fallen victim to Carbofuran applications.

Besides indirect poisoning the application of rodenticides have the potential to reduce one of the main food sources of Red Kites in Germany (see above).

Knott et al. (2009) consider other threats as much less serious at a population level, though they may be important in a local context. These include electrocution by powerlines, habitat intensification and food availability as well as collisions at windfarms (see also Dürr 2004). Moreover railroad tracks may cause extra mortality in Red Kites (Mammen et al. 2003).

The loss of suitable foraging habitats such as set-aside, grassland and alfalfa caused by changes in agriculture could become one of the most important threats to the population in Germany (Gelbke & Stübing 2009). During the second half of the breeding season Red Kites, as many other farmland bird species, find huge areas of uniformly dense and high crops such as autumn-sown cereals, oilseed rape and maize where they cannot forage efficiently.

Measures for risk-management

There are no experimentally tested measures to improve the conservation status of Red Kites. The analyses of threats and habitat requirements reveal several measures which are likely effective.

Rodenticides should not be applied at places where Red Kites forage.

Only few crops offer suitable feeding grounds for Red Kites during the critical part of the breeding season (May to July). The provision of such crops, in particular Alfalfa fields and grasslands, can improve the food supply for Red Kites. Both habitats are particularly attractive just after harvesting (mowing). Possibly all measures that increase the density of rodents such as set-up of margins along farm tracks, field edges and ditches, set-up of low intensity grassland, set-aside and maintenance of stubbles after harvest help to improve the provision of food to the chicks (Sandkühler & Oltmanns 2009).

The borderlines between fields are preferred habitat for foraging Red Kites. Red Kites possibly benefit from all measures that increase the lengths of the borderlines such as a reduction of field sizes and an increase in crop diversity (Sandkühler & Oltmanns 2009). In general the maintenance of a diversified farmland structure (mixture of crops, grassland and woodland) helps to maintain high densities of Red Kites (Bezzel, E. (2010).

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2.10 Common Crane (*Grus grus*) – Kranich – Order: Gruiformes

Geography

- Central Europe to E Siberia
- Breeding in NE Germany, migrating cranes in N and central Germany

Status in Germany

- Breeding (March – July), migratory, occasionally wintering

Life cycle

- First breeding when 2-6 years old
- Single brooded, 2 eggs per clutch
- Life span: several years (max. 17 years)
- Generation length 14 years

Population, trend and conservation status

In Germany and Europe populations of Common Cranes have strongly increased over the past decades. Long before monitoring data became available, Common Cranes were more widespread and probably more common in Germany as historical records of breeding in southern Germany show (Tab. Grgr1). The species is listed on Annex I of the EU Birds Directive. For details see Tab. Grgr1.

Tab. Grgr1: Populations (pairs), trends (mainly 1980 – 2005) and Red List status of Common Cranes breeding in Europe, Germany and the German federal states.

Common Crane			Trend					
	Population (pairs)	Proportion of German population (%)	<-50%	-50% - -20%	stable	20% - 50%	>50%	Red List category
Baden-Württemberg	0	0						ex
Bayern	0	0						ex
Brandenburg + Berlin	1700 - 1900	34.0					■	– (Be 2)
Hessen	0	0						–
Mecklenburg-Vorpommern	1900 - 2000	36.8					■	–
Niedersachsen + Bremen	439	8.3					■	–
Nordrhein-Westfalen	0	0						–
Rheinland-Pfalz	0	0						–
Saarland	0	0						–
Sachsen	200 - 250	4.2					■	2
Sachsen-Anhalt	173 - 224	3.7					■	–
Schleswig-Holstein + Hamburg	360	6.8					■	–
Thüringen								R
Germany	**5,200 - 5,400**	**100%**					■	–
Europe	**74,000 – 110,000**						■	**Spec2**

Diet

In the diet of Common Cranes vegetarian food slightly dominates: cereal seeds, crop rests, green plant parts (including crops). Animals are also taken, in particular during the breeding season: large insects, snails, worms and other invertebrates, but also small vertebrates. The percentage of food theoretically affected by pesticides is estimated to be 40% during the breeding season, both for adults and chicks. Outside the breeding season crop rests (maize, potatoes, beets, grains etc.) are the most important food items. Their availability is not affected by pesticides. All food is taken from the ground.

Habitat and densities

Common Cranes breed in wetlands where they nest on the ground, often on small islands. Typical habitats are peat bogs and swamps in forests. During the breeding season most food is taken from the wetlands. Occasionally adults and later in the season chicks visit arable fields for foraging.

Outside the breeding season, the huge numbers of Common Cranes visiting Germany on passage forage on arable fields, in particular on maize stubble fields. The preference for maize stubbles is highest just after the maize harvest und fades out during the autumn when autumn-sown cereals become more important. Cranes can also be found on spring-sown cereals, oilseed rape, beets, potatoes, legumes and vegetables. Grasslands and set-aside are avoided (Nowald 1996). Common Cranes seem to prefer wide open and uniform fields. Besides foraging grounds during daytime Common Cranes need safe night roosting sites. These consist of shallow water such as shallow fish ponds, lake shores, flooded meadows or shallow bays along the Baltic coast.

The percentage of food taken from non-sprayed habitats is estimated to be 5 % during the breeding season, both for adults and chicks. Outside the breeding season, it is estimated that cranes spend 95% of foraging on sprayed cultures.

Threats / sensibility (pesticide effects)

There is no experimental evidence of indirect effects of pesticides on Common Cranes.

Anthropogenic installations impose threats to Common Cranes. Collisions with power lines have been reported frequently (Janss & Ferrer 2000). There are indications of displacements by wind farms of breeding cranes (Scheller & Völker 2007) and cranes on passage (Nowald 1995, Brauneis 2000, Kriedemann et al. 2003, Hötker et al. 2006). Losses of wetlands may cause shortages of nesting sites.

Measures for risk-management

Maintenance of stubble fields in particular maize stubbles would be beneficial to Common Cranes. The protection from disturbance of wetlands serving as breeding sites or night roosts is essential for the population. The creation of small wetlands may offer new nesting sites.

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2.11 Corncrake (*Crex crex*) – Wachtelkönig – Order: Gruiformes

Geography

- W Europe to central Siberia
- In Germany in all parts of the country

Status in Germany

- Breeding (May – August), migratory

Life cycle

- First breeding when 1 year old, successive polygamy
- 1-2 broods per year, 7-12 eggs per clutch
- Life span: few years (max. >5 years)
- Generation length <3.3 years

Population, trend and conservation status

Corncrake populations in Germany fluctuate and do not show a clear trend. Severe declines are reported from Northrhine-Westphalia (see Tab. Crcr1). Globally, Corncraces are listed as Near Threatened. They are on Annex I of the EU Birds Directive.

Tab. Crcr1: Populations (pairs), trends (mainly 1980 – 2005) and Red List status of Corncrakes breeding in Europe, Germany and the German federal states.

Corncrake			Trend					
	Population (pairs)	Proportion of German population (%)	<-50%	-50% - -20%	stable	20% - 50%	>50%	Red List category
Baden-Württemberg	10 - 50	1.9						1
Bayern	164	10.3						1
Brandenburg + Berlin	250 - 410	20.6						1 (Ber. 2)
Hessen	10 - 40	1.6						1
Mecklenburg-Vorpommern	200 - 600	25.0						–
Niedersachsen + Bremen	400	25.0						2
Nordrhein-Westfalen	100 - 200	9.4						1
Rheinland-Pfalz								1
Saarland	0	0						ex
Sachsen	150 - 250	12.5						1
Sachsen-Anhalt	50 - 120	5.3						V
Schleswig-Holstein + Hamburg	140-200	10.6						1 (Hamb. 2)
Thüringen								2
Germany	**1,300 - 1,900**							**V**
Europe	**1,300,000 – 2,000,000**				**Fluct.**			**Spec1**
Global								**NT**

Table Crcr2: Seasonal occurrence of calling male Corncrakes in Brandenburg and West Germany (Bellebaum et al. 2005, Mammen et al. 2005, Schröder et al. 2007) and dates of 1st eggs recalculated from 11 broods in Brandenburg (Mammen et al. 2005). Peak numbers are set at 100%.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Calling males, Brandenburg	0	0	0	6	100	46	9,5	0	0	0	0	0
Calling males, West Germany	0	0	0	0	63	100	35	5	0	0	0	0
Laying of 1st egg, Brandenburg	0	0	0	0	100	45	?	0	0	0	0	0

Diet

During the breeding season Corncrakes mainly feed on insects. Seeds and other parts of plants also often found (up to 17.5% of samples). Locally molluscs form an important part of the diet (up to 100%, Glutz von Blotzheim et al. 1973, Schäffer 1999). The percentage of food estimated to be potentially influenced by pesticides is 100%.

Habitat and densities

In West and Central Europe Corncrakes inhabit open and semi-open landscapes (Mammen et al. 2005, Schröder et al. 2007). They nest on the ground. Most calling males and nests are found in grassland habitats and on sedge moors (Flade 1991, Mammen et al. 2005). Tall marshland vegetation and grass taller than 20 cm in summer seem to be preferred habitats (Flade 1991, Green 1996, Williams et al. 1997, Schäffer 1999, Bellebaum et al. 2005). The vegetation should not be so dense that it hinders Corncrake from walking (Green et al. 1997, Williams et al. 1997, Schäffer 1999). Moist situations are preferred but Corncrakes do not live on inundated soils (Green et al. 1997, Schäffer 1999). Set-aside grassland (Flade 1991, Bellebaum 2008), low-intensity pastures (Bellebaum et al. 2005, Neumann & Holsten 2009) can also hold high Corncrake densities. Arable land, in particular if stocked with perennial crops like alfalfa, and set-aside on arable fields is used at the end of the breeding season when grasslands become unsuitable due to mowing (Schröder et al. 2007 and citations therein).

In some parts of Germany, Corncrake breed on arable land (Müller & Illner 2001). In central Westphalia calling males were recorded mainly on wheat fields and to a lesser extent on barley fields. The population living on arable fields in Westphalia consists of about 120 calling males. Probably few more Corncrakes live on arable fields in other parts of Germany. The percentage of time spent foraging on arable fields and hence the amount of food taken from arable fields is estimated at 10% (German population 1,300 – 1,800 calling males, see above). Occurrence on arable fields is more common in other countries, e.g. Estonia (Keiss 1997).

Threats / sensibility (pesticide effects)

There is no direct evidence for the effect of pesticides on Corncrake populations. Those Corncrakes living on arable crops might be affected by food shortage due to the application of insecticides and molluscicides and indirectly by the application of herbicides.

Stowe & Green (1997a) found no indication for major threats outside the breeding range on the migration to and from the African winter quarters. The main reasons for the declines of Corncrake populations in Western Europe are the agricultural activities, mowing in particular, that destroy clutches and broods and sometimes even adults of Corncrake (Green & Stowe 1993, Green et al. 1997). Loss of habitats due to drainage (O'Brien et al. 2006), ploughing or abandonment (Keiss 1997) also had negative effects on Corncrake populations (Crockford et al.

1996). The recent loss of set-aside in Germany, considering the preference of the species for this habitat (see above), can also be seen as a threat to the population.

Measures for risk-management

As pesticides might reduce the food supply of Corncrakes on arable land, refraining from spraying could be beneficial.

Successful measures include Corncrake-friendly mowing regimes and the restoration of suitable wet grassland habitats (Stowe & Green 1997b, Williams et al. 1997, Mammen et al. 2005). High water tables and less intensive management of grasslands have been shown to be successful managing options for Corncrakes (Puchstein 1999, Arkenau & Strüßmann 2001, Poppen et al. 2001, Mammen et al. 2005). Temporal set-aside of grasslands and arable land can create new habitats (Keiss 1997).

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2.12 Golden Plover (*Pluvialis apricaria*) – Goldregenpfeifer – Order: Chradriiformes

Geography

- N Eurasia
- Germany: few pairs in Lower Saxony
- On passage mainly coastal regions of northern Germany

Status in Germany

- Rare breeding bird (April – July), migratory, common on passage, occasionally wintering

Life cycle

- First breeding when 1 year old
- 1 brood per year, 3-4 eggs per clutch
- Life span: several years (max. 12 years)
- Generation length 4 years

Population, trend and conservation status

The population breeding in Germany has been declining since many years and now is almost extinct. On passage the numbers seem to be stable. Germany holds a significant part of the Scandinavian and Siberian population of the species (Rasmussen & Gillings 2008) outside the non-breeding species. Number peek around 200,000 individuals in autumn which is about one quarter of the flyway population. The Golden Plover is listed on Annex I of the EU Birds Directive.

Tab. Plap1: Populations (pairs), trends (mainly 1980 – 2005) and Red List status of Golden Plovers breeding in Europe, Germany and the German federal states.

Golden Plover			Trend					
	Population (pairs)	Proportion of German population (%)	<-50%	-50% - -20%	stable	20% - 50%	>50%	Red List category
Baden-Württemberg								
Bayern								
Brandenburg + Berlin								
Hessen								
Mecklenburg-Vorpommern	0							ex
Niedersachsen + Bremen	8	100%	■					1
Nordrhein-Westfalen	0							ex
Rheinland-Pfalz								
Saarland								
Sachsen								
Sachsen-Anhalt								
Schleswig-Holstein + Hamburg	0							ex
Thüringen								
Germany	**8**		■					**1**
Europe	**460,000 – 740,000**				**?**			**–**

Diet

The diet of Golden Plovers consists of worms, insects and other invertebrates, rarely berries and seeds. Prey is taken from the ground or pulled out of the soil. All prey can is theoretically be effected by pesticides.

Habitat and densities

The extremely small German breeding population is restricted to very few peat bogs. Adults forage on the peat bogs and on adjacent grassland (Degen 2008, NLKWN 2012).

During the non-breeding season, Golden Plovers inhabit very open uniform habitats. They clearly prefer arable fields holding no vegetation or a very short vegetation swart (< 9cm) and they prefer big fields (Mason & MacDonald 1999, Tucker 1992). Set-aside is avoided and grassland is less preferred (Tucker 1992, MOIN unpublished). Grassland may be of great significance, however, at very dry weather when the surface of arable fields becomes too dry for earthworms (personal observations). In some regions and some seasons Golden Plovers forage on mudflats in estuaries and within the Wadden Sea.

In Germany 53% of Golden Plover counted during autumn passage in October 2003 were found on arable land (potentially affected by pesticides), 33% on grassland and 14% in coastal habitats like mudflats and salt marshes (Hötker 2004).

Threats / sensibility (pesticide effects)

The few Golden Plovers breeding in Germany all occur on semi-natural habits and on grassland. Therefore, they are not threatened by pesticides. The severe decline in numbers in Germany has been caused by habitat loss (Exo 2005).

The majority of birds on passage feed on arable land. In theory these birds might be affected by pesticides which are harmful to their main prey, earthworms and ground dwelling arthropods. However, there is no evidence for such a pesticide effect.

The habitats Golden Plover feed and rest in during the non-breeding season are largely unthreatened. Golden Plovers are sensitive to vertical structures such as wind farms (Hötker 2008).

Measures for risk-management

Pesticides with the potential to kill earthworms and ground-dwelling insects should not be applied on resting sites for Golden Plover. When planning wind farms sufficient space for Golden Plovers should be ensured. Grasslands should be protected because they offer an important supply of food during periods of dry weather when earthworms disappear deep into the soil on arable land.

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2.13 Lapwing (*Vanellus vanellus*) – Kiebitz – Order: Charadriiformes

Geography

- W Europe to Siberia
- Germany: all over the country

Status in Germany

- Breeding (March – June), migratory, occasionally wintering

Life cycle

- First breeding when 1 year old
- 1 brood per year, 3-4 eggs per clutch
- life span: several years (max. 24 years)
- Generation length 5 years

Population, trend and conservation status

Lapwing populations in all parts of Germany are strongly decreasing (Tab. Vava1).

Tab. Vava1: Populations (pairs), trends (mainly 1980 – 2005) and Red List status of Lapwings breeding in Europe, Germany and the German federal states.

Lapwing			Trend					
	Population (pairs)	Proportion of German population (%)	<-50%	-50% - -20%	stable	20% - 50%	>50%	Red List category
Baden-Württemberg	2000 - 3000	3.3						2
Bayern	5000 - 12000	11.3						2
Brandenburg + Berlin	2200	2.9						2
Hessen	200 - 300	0.3						1
Mecklenburg-Vorpommern	2400 - 4000	4.2						2
Niedersachsen + Bremen	25000	33.1						3
Nordrhein-Westfalen	12000 - 16000	18.5						3
Rheinland-Pfalz								-
Saarland								1
Sachsen	400 - 800	0.8						2
Sachsen-Anhalt	800 - 1500	1.5						2
Schleswig-Holstein + Hamburg	12500	16.6						3
Thüringen								1
Germany	**68,000 - 83,000**							**2**
Europe	**1,700,000 - 2,800,000**							**Spec2, vulnerable**

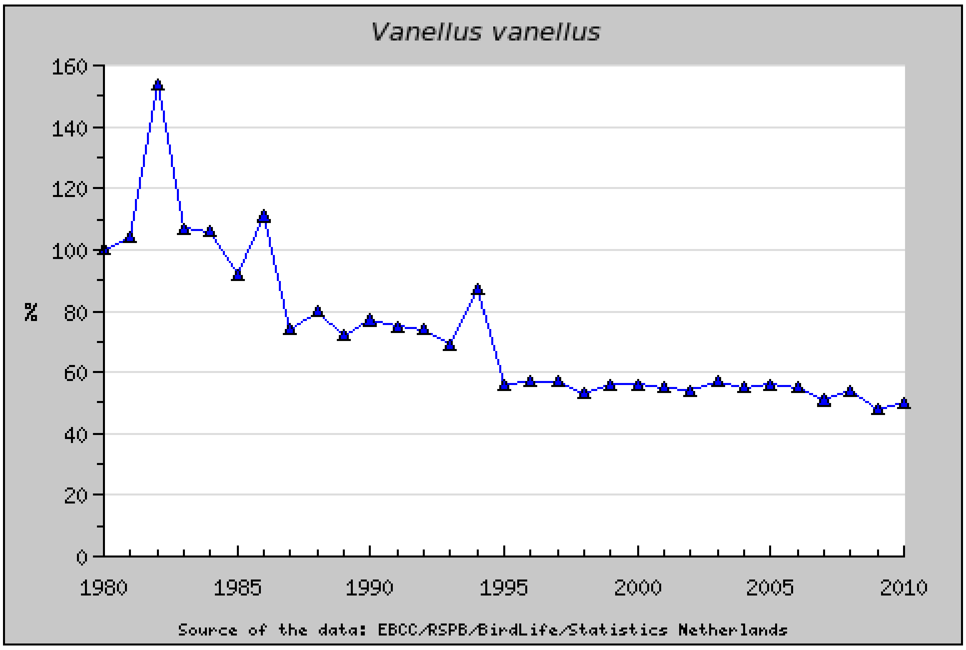

Fig. Vava1: Population trend (TRIM indexes) of Lapwings in Europe (PECBMS 2012).

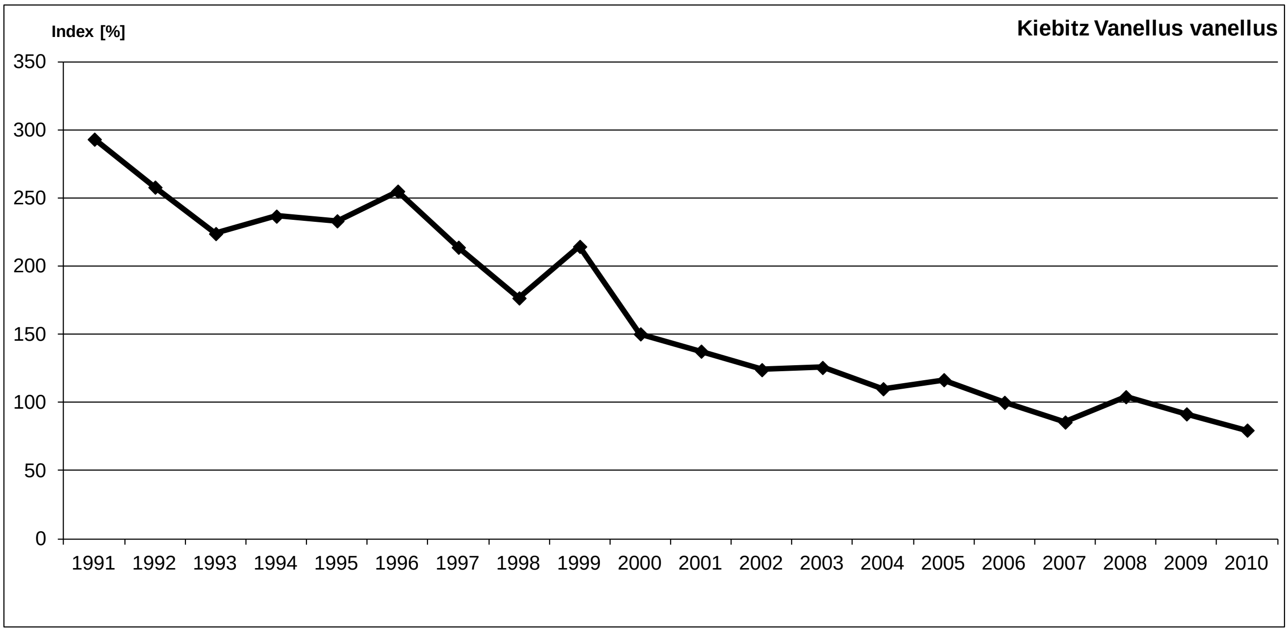

Fig. Vava2: Population trend (TRIM indexes) of Lapwings in Germany (DDA 2012).

Diet

Lapwings feed on worms (most often earthworms), insects and their larvae and other invertebrates. Adults take their food by standing and running on the ground and pecking food items from the ground or by pulling them out of the ground. Chicks also walk on the ground for feeding. They take small prey items from the ground surface or from plants (Belting & Belting 1999). All prey is potentially affected by pesticides.

Habitat and densities

Lapwings breed in open flat landscapes. They avoid hedges, bushes or trees. Most territories are established on grassland, where colonies tend to be bigger than on arable land (Füller 1992), but arable fields are also occupied. At a landscape level, highest densities are reached in areas of wet grasslands and in sites with mixed farming where meadows and arable fields form a mosaic (Wilson et al. 2001). Non-intensively managed grassland often is preferred over intensively managed grassland (Baines 1990, Johansson & Blomqvist 1996, Henderson et al. 2002). In Scotland, Baines (1990) found a higher breeding success on unimproved than on improved grassland. Lapwings breed only on fields with low swards which is a requirement particularly for the chicks (Devereux et al. 2004). Grazed meadows are preferred, in particular where the density of cattle is medium or low (Triplet et al. 1997). Beintema & Müskens (1987) and Bairlein & Bergner (1995) found negative correlations of hatching and breeding success and stock densities. High Lapwing densities can be found in areas which have been flooded during the non-breeding season because predators visit such sites less frequently due to lack of rodents (Bellebaum et al. 2005). In a study site in Lower Saxony the food intake rate of chicks was found to be higher on winter flooded meadows and moist meadows compared to dry meadows (Belting & Belting 1999). Lapwing families are often associated with wet features in meadows such as paddles, shallow ponds and open edges of ditches (Ranftl & Schwab 1990, Thomsen et al. 2002, Eglington et al. 2008). Peck rates of chicks were higher at ditches than on fields (Devereux et al. 2004).

Besides on grasslands, Lapwings increasingly often nest on arable fields (Kraft 1993). They prefer spring-sown cereals over autumn-sown cereals (Salek 1993, Wilson et al. 2001, Tab. Vava 2). Maize is a strongly preferred crop (Kooiker 1990, own observations, Tab. Vava2). Sugar beets may also be important habitats (Bollmeier 1992). Set-aside is preferred over arable (Watson & Rae 1997, Ellenbroek et al. 1998) and can enable a higher breeding success (Bollmeier 1992). Lapwings frequently shift habitats within the breeding season. Chicks hatched on arable land often move to grassland for foraging. Several crops such as winter cereals, oilseed rape and also intensively managed silage meadows do not allow nesting in the second half of the breeding season because swards are too high (own observations). Late nesting attempts therefore can often be found on set-aside or on lapwing plots or on low-intensity grassland (own observations).

The percentage of food taken from sprayed cultures is assumed to be the same as the percentage of Lapwings breeding on sprayed cultures, about 50% (Tab. Vava2).

In his classical work on habitat selection of Lapwings (Klomp 1954) emphasized the preference of the species for spots with short vegetation and a generally brown appearance. These findings originate from a time with much less intensive agriculture when these features signalized retarded vegetation growth and hence good habitats for the chicks. Nowadays, some of the habitat preferences of Lapwings mentioned above, may be explained by Klomp's observations, for example the preference for bare spots (Wilson et al. 2005). In areas of intensive grassland, single arable fields look like brown spots in a fresh green surrounding. Maize fields are probably particularly attractive because they are still unploughed in the beginning of the season and have paddles and small patches of low vegetation on them. It can be assumed that the breeding success on arable fields is lower than on grassland (Kooiker 1990) especially when chicks cannot easily reach foraging habitats on grasslands next to the fields.

Tab. Vava2: Densities of Lapwings (territories/100ha) on different cultures. Sources: Zijlstra (1990), Salek (1993), Schmidt & Strache (1997), Triplet et al. (1997), Wakeham-Dawson & Aebischer (1997), Watson & Rae (1997), Wilson et al. (2001), Neumann & Koop (2004), Petry & Hoffmann (2004), Bellebaum et al. (2005), Hoffmann (2008), Kragten (2009), Neumann et al. (2009), Hoffmann (2011).

	n	Mean density (pairs/100ha)	SD (pairs/100ha)	Percentage of population
Autumn-sown cereals	11	3.3	4.5	13.0
Spring-sown cereals	6	11.0	11.9	4.4
Maize	8	15.5	18.0	25.1
Oilseed rape	5	0.2	0.5	0.2
Beets, potatoes, vegetables	7	9.5	9.6	7.4
Set-aside	6	13.9	14.9	2.5
Grassland	10	13.3	21.7	47.3

Outside the breeding season Lapwings can be found in open landscapes where they forage both on grassland and also extensively on arable land. Natural and semi-natural habitats like mudflats in estuaries and salt marshes are also used by Lapwings to a great extent. Lapwings prefer large fields over small fields (Tucker 1992, Mason & Macdonald 1999). There are no obvious preferences for crop types. Lapwings seem to avoid oilseed rape and set-aside (Tab. Vava3). This observation is consistent with the fact that Lapwings prefer very short swards (Mason & Macdonald 1999, Wilson et al. 2005).

As there is no evidence for strong selection for grassland and natural habitats, the estimation of the percentage of Lapwings occurring on sprayed cultures during the non-breeding season equals the percentage of sprayed areas in open habitats in Germany which is about 70%.

Tab. Vava3: Numbers of studies which showed preferences and avoidances for fields with different crop types. Sources: Tucker (1992), Mason & Macdonald (1999), MOIN (unpublished).

Crop	Preference	Avoidance
Autumn-sown cereals	3	3
Maize	3	2
Oilseed rape	1	6
Beets, potatoes, vegetables	0	2
Set-aside	0	3
Grassland	3	4

Statistics on crop-specific densities

The mixed effects model applied to the crop-specific densities revealed a significant effect of the fixed factor "Crop" and the random factor "Study". The continous fixed parameter "Plotsize" did not have a significant influence on densities (Tab. Vava4). Pairwise tests of crop types showed significant differences ($p<0.05$) between maize and autumn-sown cereals and between maize and other crops (spring-sown cereals, oilseed rape, beets, potatoes and vegetables pooled).

Tab. Vava4: Summary of a mixed effects model.

Model	DF	F	Wald-Z	p
Plotsize	19.2; 1.0	0.51		0.481
Crop	35.1; 6.0	3.10		0.015
Study			2.19	0.029

Threats / sensibility (pesticide effects)

There is no direct evidence of indirect effects of pesticides on Lapwings. Many Lapwings nest and feed on arable fields. As the diet of adults and chicks nearly entirely consists of invertebrates, there is a risk that the food supply is reduced by insecticides or molluscicides. Furtheron, herbicides potentially destroy host plants for insects that might have served as food for Lapwings. The possibility of an indirect effect of pesticides is supported by several studies that report higher densities of Lapwings on organic than on conventional fields, some of the results being statistically significant (Christensen et al. 1996, Neumann & Koop 2004, Kragten 2009). Kragten & Snoo (2007), however, found a lower breeding success on organic fields due to more mechanical activities.

Studies of survival and reproductive rates of Lapwings over the past decades showed that decreasing breeding success and not increasing mortality of adults explains the population declines (Roodbergen et al. 2012). The reasons for the population declines are most probably the loss and the degradation of breeding habitats, mostly due to intensification of agriculture (Beintema et al. 1997). Draining wet grasslands, removal of open water, reduction of flooding and eventually transferring grassland into arable land reduces the quality and the size of suitable breeding habitat (Reichholf 1996, Nehls et al. 2001). Intensified management on grasslands that often includes application of big amounts of fertilizers leads to a forward shift in agricultural activities such as mowing. Early mowing kills many chicks and destroys the shelter and the food resources for the surviving chicks (Beintema et al. 1997, Nehls et al. 2001, Schekkerman et al. 2009). High stocking rates on pastures can cause problems in nest survival (Beintema & Müskens 1987). In recent years nest predation by mammalian predators such as Red Foxes (*Vulpes vulpes*) became an important factor in many breeding sites (Hötker et al. 2007, Bellebaum & Bock 2009, Roodbergen et al. 2012).

In the second half of the breeding season, fast and high growing grasslands and crops such as autumn-sown cereals and oilseed rape neither offer nest sites with a sufficient view for incubating adults nor habitats where chicks can run on the ground and forage (see above).

Measures for risk-management

The creation of wet features on grassland has been shown to increase density (Eglington et al. 2008). Creation of small open wetlands led to increases in local Lapwing populations in Southern Germany (Ranftl & Schwab 1990). Water management in general is seen as a key element in the restoration of Lapwing habitats (Guldemond et al. 1995, Belting et al. 1997). Gras management (restriction of chemicals, diversification of sward) had positive effects on population in mixed farming areas in UK (Baker et al. 2012).

On arable land, Lapwing plots (plots opened in the beginning of the season and remaining uncultivated) have proved to be able to attract Lapwings (Chamberlain et al. 2009). An agri-environmental scheme involving winter stubble, light soil cultivation in March and set-aside thereafter has been success in improving breeding success (Sheldon et al. 2007).

Nest protection by volunteers can positively influence hatching success (Guldemond et al. 1995, Hönisch & Melter 2006). Continuously protecting clutches and broods from harmful agricultural practices like rolling or mowing could stabilize or increase Lapwing populations in study sites in Schleswig-Holstein (Jeromin 2006).

Several studies showed that measures to improve habitats in reserves led to an increase in the numbers of Lapwings breeding in the site which was followed by a fall in numbers several years after the management actions had taken place (Zijlstra 1990, O'Brien & Self 1994, Hötker et al. 2007). Obviously habitat management has to be repeated from time to time, and is has to be continuously fine-tuned to the requirements of the populations.

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2.14 Black-tailed Godwit (*Limosa limosa*) – Uferschnepfe – Order: Charadriiformes

Geography

- Island to E Siberia
- Germany: N Germany, isolated populations in S Germany

Status in Germany

- Breeding (April – July), migratory

Life cycle

- First breeding when 1-2 year old
- Single brooded, 3-4 eggs per clutch
- Life span: several years (max. 19 years)
- Generation length 5 years

Population, trend and conservation status

In Germany Black-tailed Godwits are categorized critically endangered and the population breeding in Germany shows a steep decline. For detailed information on the Länder level and on the European level see Table Lili1. Populations in Europe seem to be declining since the 1960s (Beintema et al. 1995). The status of the Black-tailed Godwit on the global red list is Near Threatened.

Tab. Lili1: Populations (pairs), trends (mainly 1980 – 2005) and Red List status of Black-tailed Godwits breeding in Europe, Germany and the German federal states.

Black-tailed Godwit			Trend					
	Population (pairs)	Proportion of German population (%)	<-50%	-50% - -20%	stable	20% - 50%	>50%	Red List category
Baden-Württemberg	0	0						ex
Bayern	50	1.1						1
Brandenburg + Berlin	70 - 95	1.8						1
Hessen	3	0.1						1
Mecklenburg-Vorpommern	63 - 82	1.5						1
Niedersachsen + Bremen	3000	63.8						2
Nordrhein-Westfalen	370	7.9						1
Rheinland-Pfalz	0	0						ex
Saarland	0	0						2
Sachsen	0	0						ex
Sachsen-Anhalt	5 - 6	0.1						1
Schleswig-Holstein + Hamburg	1250	26.6						2
Thüringen	0	0						ex
Germany	**4700**							**1**
Europe	**99,000 - 140,000**							**Spec2, vulnerable**
Global	**709,000 - 805,000**							**NT**

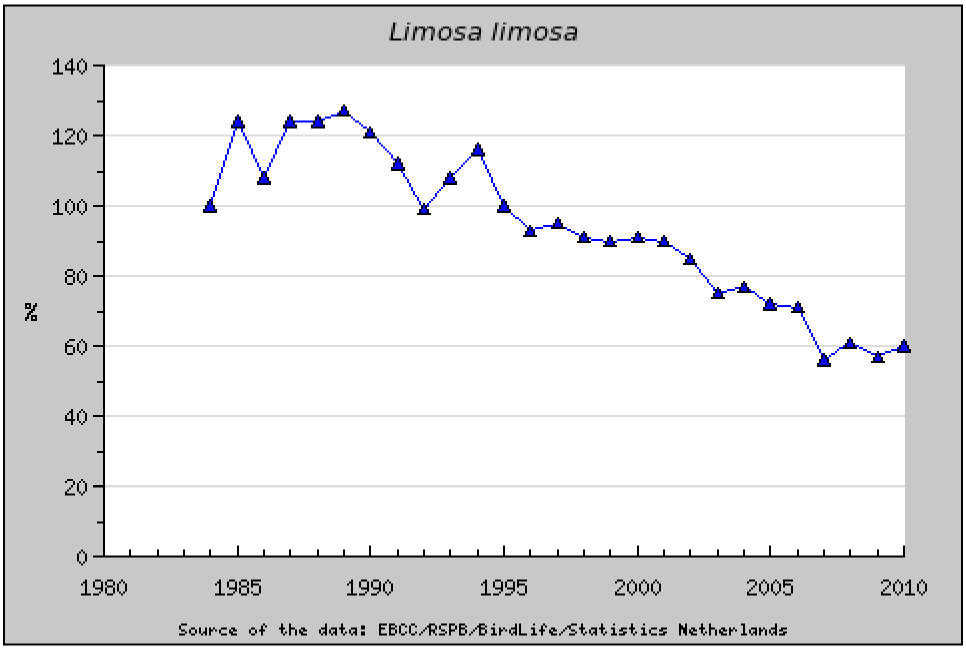

Fig. Lili1: Population trend (TRIM indexes) of Black-tailed Godwits in Europe (PECBMS 2012).

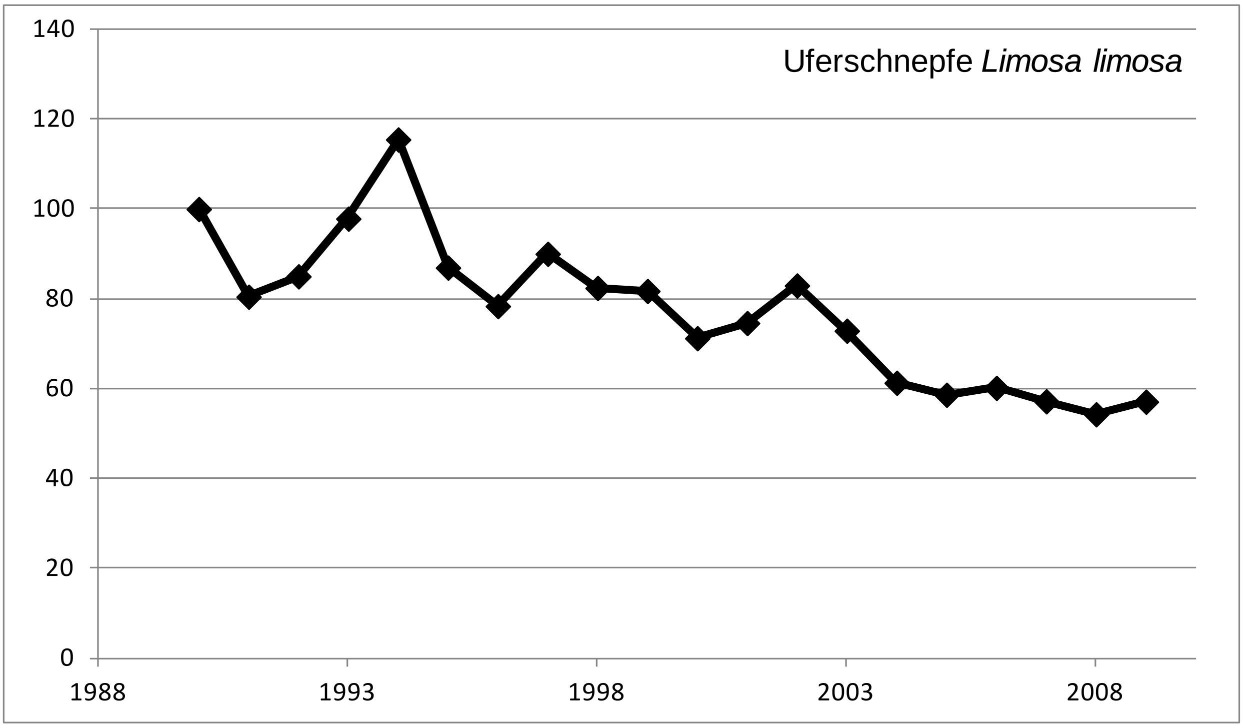

Fig. Lili2: Population trend (TRIM indexes) of Black-tailed Godwits in Germany (MOIN unpublished 2012).

Diet

During the breeding season the food of adult Black-tailed Godwits consist of worms, insects and other invertebrates. Besides earthworms and leatherjackets, Chironomid larvae are important prey items. The prey is taken by probing with the bill in the ground or in the bottom of shallow water. Outside the breeding season in the winter quarters and partly on migration stopovers, a substantial part of the diet consists of grains, in particular rice grains left over after harvest. Adults of the subspecies *L. l. islandica* also feed on mollusks and worms in intertidal flats.

The chicks collect insects from plants, often flowers or from the ground. They start probing shortly before fledging (Beintema et al. 1991, Belting & Belting 1999). Schekkerman & Boele (2009) found that chicks mainly (76%) feed on arthropods above ground up to “head-high” and only 22% higher; only 1.3 % was skimmed from the ground. Size of prey items lay dominantly between 4 – 8 mm.

During the breeding season all of the diet can theoretically be affected by pesticides.

Habitat and densities

In central and west Europe Black-tailed Godwits almost exclusively breed on grassland. Very few territories are established on natural habitats like peat bogs or salt marshes alongside the Wadden Sea. The occurrence on arable land (autumn-sown cereals and spring-sown cereals, maize (MOIN unpublished)) is an exception. Black-tailed Godwits prefer wet meadows and less intensively managed meadows which are rich in flowers (Belting & Belting 1999, Groen et al. 2012). Dry meadows which are managed very intensively are often avoided by adult Black-tailed Godwits and in particular by Black-tailed Godwit families (Bräger & Meissner 1990). If the intensity of management falls beneath a certain level and high growing plant species and Soft Rush (*Juncus effusus*) invade the field Black-tailed Godwits leave (MOIN unpublished). Black-tailed Godwits nest both on grazed and on mown meadows. The preference for either of both seemes to be site-specific and time-specific (Zijlstra 1990, Teunissen & Hagemeijer 1999, MOIN unpublished). Grasslands occupied by Black-tailed Godwits are usually very open (MOIN unpublished).

Nests are placed on the ground. Nests are often concealed by high grass.

Before and after the breeding season and sometimes within the breeding season Black-tailed Godwits visit shallow ponds or lakes for feeding or resting (MOIN unpublished).

As most Black-tailed Godwits do not feed on arable land, the proportion of diet taken from sprayed cultures is assessed to be 5% for the adults and 2% for the chicks.

Threats / sensibility (pesticide effects)

As grassland habitats are usually not sprayed Godwits obviously are little affected by pesticides. Tennekes (2010), however, suggests that neonicotinoid insecticides may penetrate with the water into Black-tailed Godwit habitats and cause food shortage there. However, there is no evidence for such an effect so far.

Studies of survival and reproductive rates of Black-tailed Godwits over the past decades showed that decreasing breeding success and not increasing mortality of adults explained the population declines (Roodbergen et al. 2008, Roodbergen et al. 2012). The reasons for the population declines are most probably the loss and the degradation of breeding habitats, mostly due to intensification of agriculture (Beintema et al. 1997, Witt 1991). Draining wet grasslands, removal of open water, reduction of flooding and eventually transferring grassland into arable land reduces the quality and the size of suitable breeding habitat (Nehls et al. 2001, Gerdes 1995). Intensified management on grasslands that often includes extensive application of fertilizers leads to a forward shift in agricultural activities such as mowing. Early mowing kills many chicks and destroys the protection and the food resources for the surviving chicks (Beintema et al. 1997, Nehls et al. 2001, Schekkerman et al. 2009). High stocking rates on pastures can cause problems in nest survival (Beintema & Müskens 1987). In recent years nest predation by mammalian predators such as Red Foxes (*Vulpes vulpes*) became an important factor in many breeding sites (Hötker et al. 2007, Roodbergen et al. 2012).

Measures for risk-management

So far there is no evidence that direct or indirect effects caused by pesticides affect the population of Black-tailed Godwits. The high concentrations of systemic insecticides reported by Tennekes (2010) in surface water samples in the Netherlands give reasons for concern. Measures should be taken to ensure that no insecticides pollute the water bodies Black-tailed Godwits feed in.

The preservation and the creation of Black-tailed Godwit friendly breeding habitats are the by far most efficient measures to stabilize the declining Black-tailed Godwit populations (Wymenga et al. 2001). One of the most important factors is the water management. Often water tables have to be increased and bodies of shallow water such as permanent and non-permanent shallow paddles, enlarged ditches, open foot drainage systems (opening and widening of ditches) should be created. The management has to be adapted to the soil conditions. The intensity of management has to be chosen in a way that, on the one hand, it ensures an optimal structure and height of the sward and a high number and a high diversity of flowering plants and prevents losses due to trampling or mowing. On the other hand the invasion of unwanted plant species like Soft Rush has to be prevented and the sites has to be kept in a state, that management does not cease (e.g. because the soil gets too wet for agricultural machinery). Unfertilized field margins were found to be very attractive for Black-tailed Godwits (Oosterveld et al. 2009). Removal of trees and bushes helps to increase the general attractiveness of sites for Black-tailed Godwits (Belting, personal communication).

Agri-environmental schemes that do not address the above-mentioned factors often fail to protect Black-tailed Godwits (Kleijn et al. 2001, Verhulst et al. 2007).

Protection by volunteers of single nests and broods from harmful agricultural activities such as mowing can have a positive effect on breeding success and hence on population growth of Black-tailed Godwits (Guldemond et al. 1995, Teunissen & Hagemeijer 1999, Jeromin 2006)

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2.15 Little Owl (*Athene noctua*) – Steinkauz – Order: Strigiformes

Geography

- N Africa, large parts of Europe to China
- Mainly in W Germany and parts of S Germany

Status in Germany

- Breeding (March – July), sedentary (partly migratory)

Life cycle

- First breeding when 1 year old
- Single brooded, 3-5 eggs per clutch
- Life span: few years (max. 15 years)
- Generation length <3.3 years

Population, trend and conservation status

Within Germany, population trends differ between single federal states. In most states populations are declining. The by far most important population in Northrhine-Westfalia, however, is increasing.

Tab. Atno1: Populations (pairs), trends (mainly 1980 – 2005) and Red List status of Little Owls breeding in Europe, Germany and the German federal states.

Little Owl			Trend					
	Population (pairs)	Proportion of German population (%)	<-50%	-50% - -20%	stable	20% - 50%	>50%	Red List category
Baden-Württemberg	420 - 450	5.2						V
Bayern	100 - 150	1.5						1
Brandenburg + Berlin	11 - 15	0.2						2
Hessen	400 - 800	7.2						3
Mecklenburg-Vorpommern	2	0						1
Niedersachsen + Bremen	200	2.4						1
Nordrhein-Westfalen	4500	54.2						3
Rheinland-Pfalz								2
Saarland								2
Sachsen	3 - 6	0.1						1
Sachsen-Anhalt	10 - 15	0.2						1
Schleswig-Holstein + Hamburg	135	1.6						2
Thüringen								1
Germany	**8200 - 8400**							**2**
Europe	**560,000 - 1,300,000**							**Spec3**

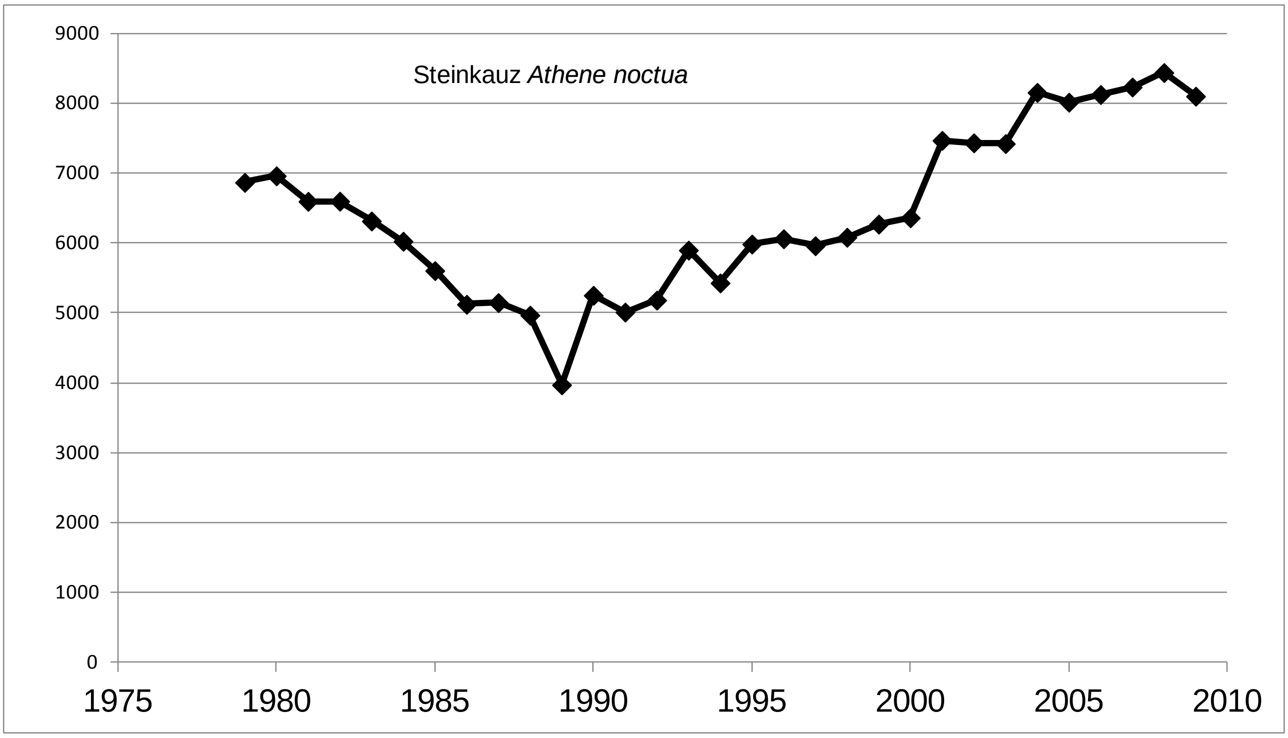

Fig. Atno1: Population trend (pairs) of Little Owls in Germany (DDA 2012).

Diet

The diet of Little Owls consists of small vertebrates (often Common Voles, rarer birds) and large invertebrates such as earthworms and large insects (Hounsome et al. 2010). Little Owls usually take their prey by flying to the ground. An estimated 70% of the prey can be theoretically affected by pesticides.

Habitat and densities

Little Owls inhabit semi-open landscapes. They nest in holes which they find in trees or in buildings. In Germany many Little Owls breed in nest boxes. Little Owls forage on open ground, preferably on grassland within a few hundred meters around the nest sites (Exo 1983, Exo 1987, Finck 1990, Dalbeck et al. 1999, Sunde et al. 2009). Arable seems to be less suitable for foraging, but borders between arable fields and meadows are preferred foraging sites (Exo 1987). Typical habitats of Little Owls in Germany are villages and orchards. Little Owls territories are often associated with pollard willows or other pollard trees. The coverage of pastures and orchards within villages, the percentage of fields bordered by walls and hedges and the number of nest boxes were found to have positive effects on densities of Little Owls (Dalbeck et al. 1999). Little Owls catch most of their prey on the ground. A too high ground cover impairs hunting (Luder & Stange 2001). Pastures with livestock within villages are preferred habitats.

As Little Owls prefer to forage on grassland, the proportion of prey taken from sprayed cultures is estimated to be 20%.

Threats / sensibility (pesticide effects)

There is no evidence that Little Owls are affected by pesticides. They use sprayed cultures to some extent (arable land and ochards) and part of their diet consists of insects that may be negatively affected by insecticides and indirectly by herbicides. Rodenticides obviously have the potential to reduce food availability for Little Owls.

Habitat loss seems to be the most important threat to Little Owl populations in Germany. In detail Little Owls suffer from a loss of grassland within or next to villages (Dalbeck et al. 1999, Bauer et al. 2005). In particular the abandonment of animal husbandry within villages reduces the availability of short grass as a favourable habitat for hunting (Luder & Stange 2001). Losses of traditional orchards and losses of pollard trees can be responsible for local population declines (Martinez & Zuberogoitia 2004, Bauer et al. 2005).

As field edges are preferred habitats for foraging (Exo 1987), loss of field edges due to increased field sizes and decreased crop diversity also potentially has a negative effect on Little Owl populations. Obviously tall growing crops like autumn-sown cereals, oilseed rape and maize are not suitable for foraging late in the breeding season. As these cultures have increased in extend in Germany (Statistisches Bundesamt 2012) foraging habitats of Little Owls are further reduced.

Measures for risk-management

Refraining from pesticide application in and next to territories of Little Owls possibly helps to increase food availability. Unsprayed field margins may also be beneficial as field borders are preferred foraging habitats (Exo 1987).

The maintenance or establishing of grassland next to nesting sites and keeping livestook outdoors can be important measures to support Little Owl populations. Small field sizes (and hence long borderlines) are also beneficial to foraging Little Owls (Dalbeck et al. 1999).

The maintenance and the establishing of orchards and pollard trees may offer habitats and nest sites. Ultimately, shortages of nest sites can be overcome by setting up nest boxes.

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2.16 Red-backed Shrike (*Lanius collurio*) – Neuntöter – Order: Passeriformes

Geography

- Europe to central Asia
- All over Germany

Status in Germany

- Breeding (May – July), migratory

Life cycle

- First breeding when 1 year old
- Single brooded, 4-7 eggs per clutch
- Life span: few years (max. 8 years)
- Generation length <3.3 years

Population, trend and conservation status

After a steep decline in the 1980s the population in Europe seems to be stable (Fig. Laco1). The species is listened on Annex I of the Birds Directive.

Tab. Laco1: Populations (pairs), trends (mainly 1980 – 2005) and Red List status of Red-backed Shrikes breeding in Europe, Germany and the German federal states.

Red-backed Shrike			Trend					
	Population (pairs)	Proportion of German population (%)	<-50%	-50% - -20%	stable	20% - 50%	>50%	Red List category
Baden-Württemberg	10000 - 12000	8.1						V
Bayern	12000 - 15000	10.0						–
Brandenburg + Berlin	12000 - 20000	11.9						V
Hessen	5000 - 8000	5.6						–
Mecklenburg-Vorpommern	20000 - 25000	16.7						–
Niedersachsen + Bremen	4000	3.0						3
Nordrhein-Westfalen	3000 - 5000	3.0						V
Rheinland-Pfalz								3
Saarland								V
Sachsen	10000 - 15000	9.3						–
Sachsen-Anhalt	15000 - 20000	12.2						–
Schleswig-Holstein + Hamburg	3500	2.6						V
Thüringen								–
Germany	**120,000 - 150,000**							–
Europe	**6,300,000 - 13,000,000**							**Spec3**

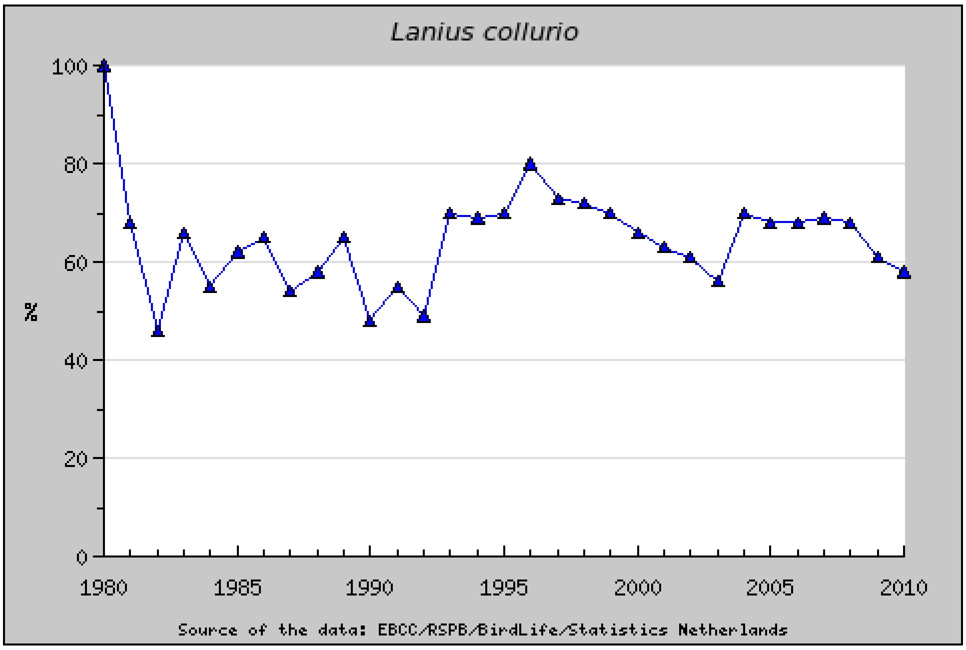

Fig. Laco1: Population trend (TRIM indexes) of Red-backed Shrikes in Europe (PECBMS 2012).

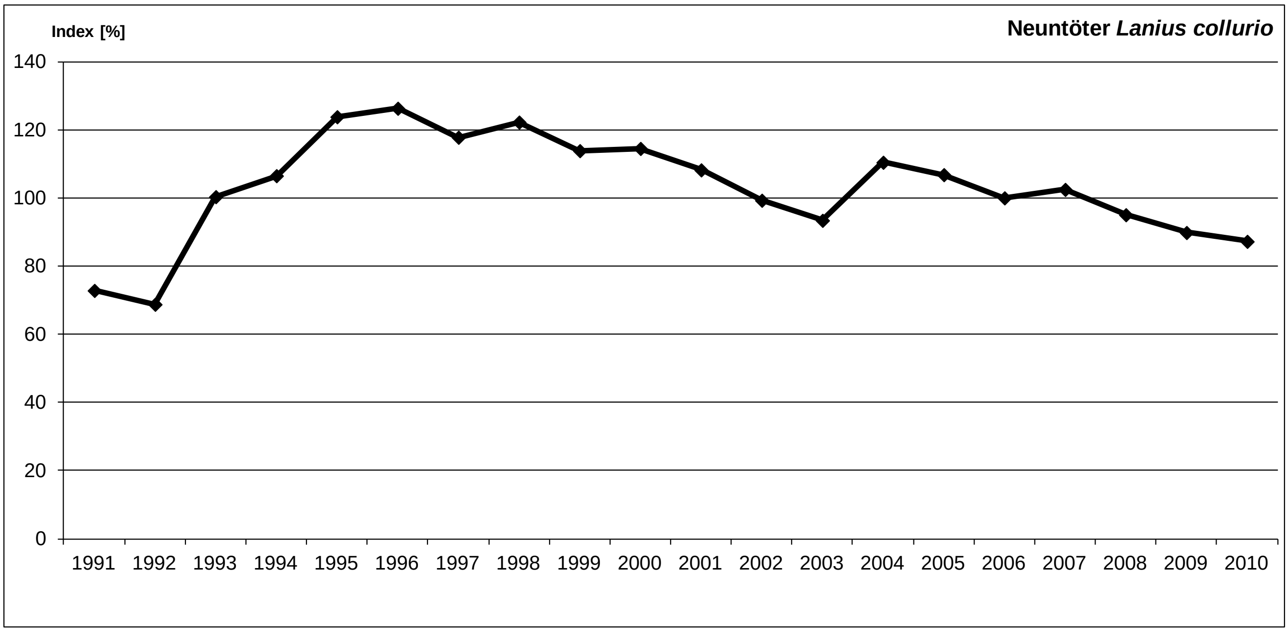

Fig. Laco2: Population trend (TRIM indexes) of Red-backed Shrikes in Germany (DDA 2012).

Diet

Red-backed Shrikes feed on large insects (often beetles >10cm, but also grasshoppers (Rudin 1990)), small mammals (often Microtus) and small birds or nestlings (Glutz von Blotzheim & Bauer 1993). Diet of Red-backed Shrike nestlings is composed from mostly insects and occasionally small mammals. It is assumed that all this diet could in theory be affected by pesticides. Adults during the breeding season take more often birds. Prey is often taken in flight. As insects and small rodents remain the staple food, the percentage of food theoretically being affected by pesticides is estimated to be 90%.

Habitat and densities

Red-backed Shrikes live in semi-open habitats like farmland with many bushes or hedgerows, heath and moorland, forest clearings and tree nurseries, vineyards and orchards (Jakober & Stauber 1987). Nests are built within hedges, bushes or small trees. Red-backed Shrikes prefer hedges with field margins and thorny bushes, and they avoid sites with many big trees. The optimum coverage of bushes and hedges in the landscape level was found to be about 4% in a study in Switzerland (Pfister et al. 1986) and 15%-20% in an Italian study (Brambilla et al. 2007) and an Austrian study (Vanhinsbergh & Evans 2002).

Red-backed Shrikes prefer areas with low intensity farming over high intensity farming (Leugger-Eggimann 2001, Brambilla et al. 2007). There is a clear preference for set-aside (Golawski & Golawska 2008, Hoffmann 2008, Neumann & Holsten 2009, Hoffmann 2011) and low intensity grassland, in particular pastures (Nitsche 2001, Vanhinsbergh & Evans 2002, Golawski & Golawska 2008, Neumann & Holsten 2009, Husek et al. 2010, Neumann 2011) whilst maize seems to be avoided (Hoffmann 2011).

There is little information on the percentage of Red-backed Shrike breeding in unsprayed habitats like moorlands or extensive grasslands. There is also little information on the percentage of food is taken from sprayed cultures in territories in arable sites, in vineyards or orchards. The very rough estimate is 50%.

Threats / sensibility (pesticide effects)

There is no evidence of direct or indirect pesticide effects on Red-backed Shrike populations. Most authors see a relationship between the decline of Red-backed Shrike populations in Germany and the loss of their preferred habitats: extensively managed pastures with many thorny bushes (Jakober & Stauber 1987, Pfister & Naef-Daenzer 1987, Vanhinsbergh & Evans 2002, Husek et al. 2010). Other possible threats for the population are climate change (Bibby 1973) and, locally, egg collectors (Bibby 1973). Locally, abandonment of farming and subsequent overgrowing of habitats may also be important.

Measures for risk-management

The effect of refraining from pesticide applications on Red-backed Shrike populations has not yet been tested. Due to the mostly insectivorous food effects are likely. The effect of organic farming on Red-backed Shrike populations is unclear. Christensen et al. (1996) found (insignificantly) more Red-backed Shrike on organic rather than on conventional farms.

As Red-backed Shrikes prefer set-aside and extensively managed pastures, any measures to preserve or to set up these habitats will be beneficial to the species. There is evidence that extensive animal husbandry has helped to increase local Red-backed Shrikes populations (Neumann & Holsten 2009, Neumann 2011). Unused field margins, beetle banks and comparable structure are also likely to contribute to the quality territories in arable landscapes, although their effect has not yet been tested.

Obviously, protection the remaining natural and semi-natural habitats like moorlands and heathlands or extensively managed pastoral landscapes is one of the most urgent measure to protect Red-backed Shrikes. Planting bushes and hedgerows, preferably thorny species, where there are in short supply, has proven to be an effective measure to protect Red-backed Shrikes (Laußmann & Plachter 1998, Flöter 2002).

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2.17 Woodlark (*Lullulea arborea*) – Heidelerche – Order: Passeriformes

Geography

- Europe, Middle East and N Africa
- All over Germany

Status in Germany

- Breeding (March – July), migratory

Life cycle

- First breeding when 1 year old
- 1-2 broods per year, 3-6 eggs per clutch
- Life span: 1-4 years (max. 9 years)
- Generation length <3.3 years

Population, trend and conservation status

Populations of Woodlarks have been stable in Europe since about 1990. In Germany the declines in the South were more than counterbalanced by increases in the Northeast where the biggest part of the population occurs (Tab. Luar1). The species is on Annex I of the EU Birds' Directive.

Tab. Luar1: Populations (pairs), trends (mainly 1980 – 2005) and Red List status of Woodlarks breeding in Europe, Germany and the German federal states.

Woodlark			Trend					
	Population (pairs)	Proportion of German population (%)	<-50%	-50% - -20%	stable	20% - 50%	>50%	Red List category
Baden-Württemberg	100 - 150	0.2						1
Bayern	300 - 400	0.7						1
Brandenburg + Berlin	12000 - 20000	30.8						– (Be: 3)
Hessen	50 - 100	0.1						1
Mecklenburg-Vorpommern	4000 - 5000	8.7						–
Niedersachsen + Bremen	6250	12.0						3
Nordrhein-Westfalen	800 - 1000	1.7						3
Rheinland-Pfalz								3
Saarland								2
Sachsen	1600 - 3200	4.6						2
Sachsen-Anhalt	10000 - 14000	23.1						–
Schleswig-Holstein + Hamburg	278	0.5						3
Thüringen								2
Germany	**44,000 - 60,000**							**V**
Europe	**1,300,000 - 3,300,000**							**Spec2 Depleted**

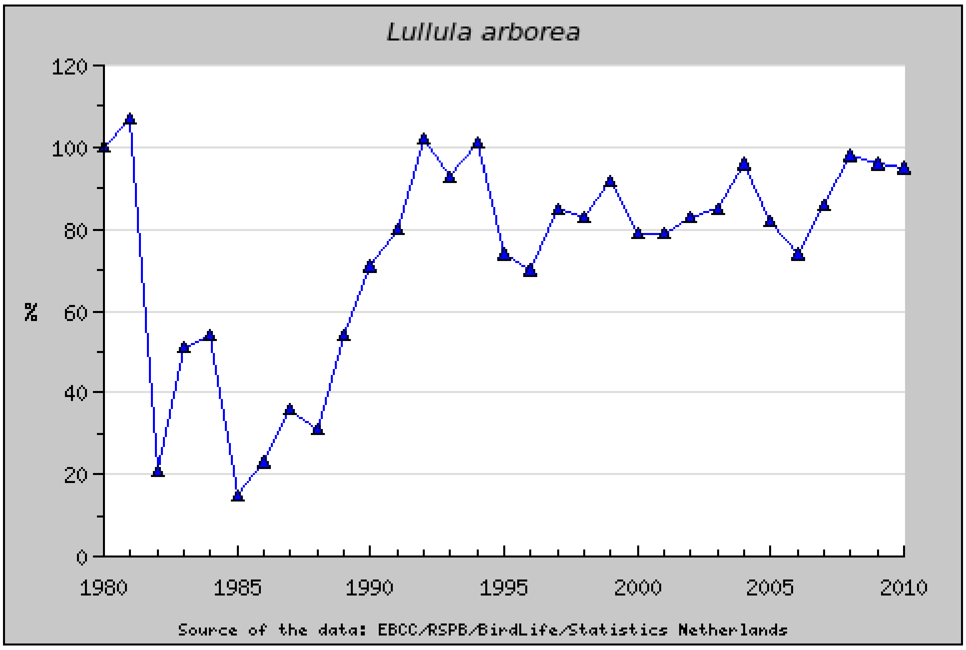

Fig. Luar1: Population trend (TRIM indexes) of Woodlarks in Europe (PECBMS 2012).

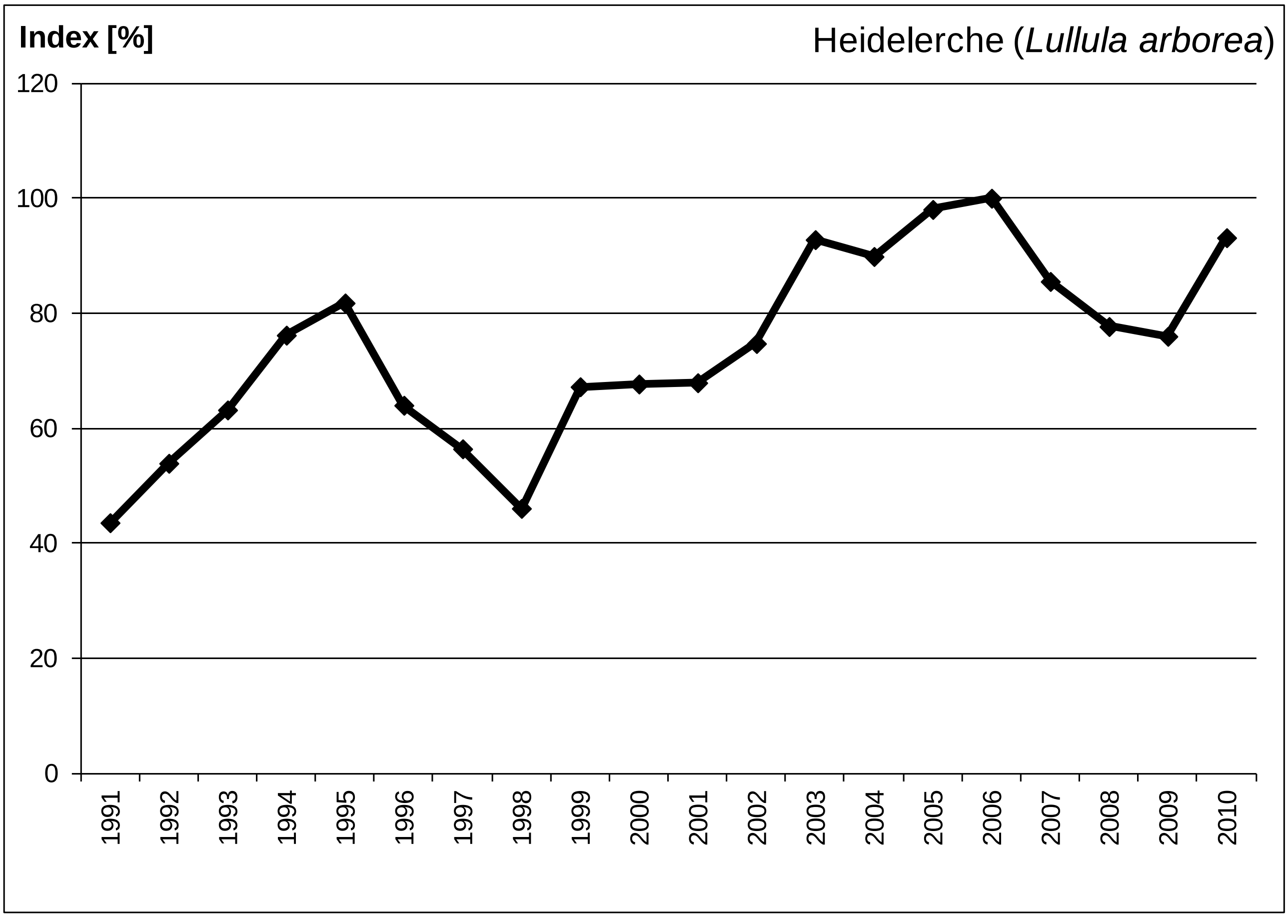

Fig. Luar2: Population trend (TRIM indexes) of Woodlarks in Germany (DDA 2012).

Diet

Woodlarks take their food by walking on the ground. During the breeding season the adults mainly consume insects and other invertebrates, seeds (from trees, from farmland weeds and from crops), buds and green parts of plants. The percentage of adult diet potentially affected by pesticides is estimated to be 80%. The nestling diet mainly consists of insects and other invertebrates (often Arachnida) and seeds (seeds of trees and farmland weeds). The percentage of nestling food potentially affected by pesticides is estimated to be 90%.

Habitat and densities

Woodlarks inhabit semi-open habitats like forest edges, open forests and forest clearings, heath- and moorland, dry grasslands and arable fields close to forest edges or hedgerows (Kieckbusch & Rohman 2000, Blüml & Röhrs 2005). The presence of Woodlark territories is clearly associated with light sandy soils (Daunicht 1985). Patches of short vegetation or bare soil seem to be important features within Woodlark territories (Daunicht 1985, Sitters et al. 1996, Blüml & Röhrs 2005, Mallord et al. 2007). In Lower Saxony, forests, heath- and moorlands and other non-farmed habitats accounted for 37% of the breeding sites, 10% of the breeding sites were found on dry grassland and 52% consisted of arable land including set-aside. About 75% of territories were close to forests and 19% of territories were within military training areas and (Blüml & Röhrs 2005). In Schleswig-Holstein fewer territories (13%) consisted of arable land, and 18% were within military training sites (Daunicht 1985). Military training sites locally are even more important in other regions. In Britain, heath and woodland were still by far the most important und most preferred habitats (Wright et al. 2009), but the percentages of territories on stubble-fallow and grass increased between 1997 and 2006 (Wright et al. 2007). Nests are always on the ground. They are often on cropped land.

Among arable land, set-aside is clearly preferred over all other field types (Wright et al. 2007, Wright et al. 2009, Hoffmann et al. 2012). Venne (2003) and Hoffmann et al. (2012) found that Woodlarks abandoned maize fields in the course of the breeding season because the plants grew too tall.

Although many territories are established on arable land (Blüml & Röhrs 2005) it can be supposed that field margins, non-cropped forest edges and other non-sprayed feature are disproportionally more often used for foraging than would be expected by their percentage of land cover. Taking this into account, a rough estimate the percentage of prey taken from sprayed cultures is 30%.

During the non-breeding season Woodlarks prefer stubble fields and set-aside.

Threats / sensibility (pesticide effects)

There is no evidence for pesticide-related effects on the population of Woodlarks in Germany. Given the predominantly insectivorous diet during the breeding season, effects of pesticides cannot be ruled out.

Wright et al. (2009) showed that variations in breeding success and first year survival were the most important factors determining the population trend in England. Breeding success was strongly affected by nest predation. One of the most important threats to the population of Woodlarks in Germany is the loss of breeding habitat. In particular patches of bare soil or very short vegetation become less common due to a general eutrophication of farmland and heathland (Daunicht 1985) and also due to abandonment of grazing dry grassland (Richter 1998). The abandonment of many military training areas after the end of the cold war has caused considerable losses of semi-open habitats. Loss of uncultivated field margin due to the extension of fields up to very edge of farm tracks and losses of field borders due to increase of field size and loss of crop diversity were assumed to be important factors in Schleswig-Holstein (Daunicht 1985). Recent losses of the most preferred habitats within farmland, grassland and set-aside, will probably negatively affect the population in future.

Mallord et al. (2007) showed that disturbance by the public within a heathland in England significantly reduced breeding success.

Measures for risk-management

Although there is no evidence for pesticide effects on Woodlark populations, it seems very probable that refraining from insecticide and herbicide applications within Woodlark territories increases food availability and nest cover and, hence, breeding success. Daunicht (1985) cites observations of reduced used of frequently sprayed tree nurseries in contrast to normally sprayed tree nurseries.

All measures that create habitats with patches of bare soil or short-swarded vegetation within suitable habitats (arable fields and set-aside next to forests) will probably attract Woodlarks (Venne 2003). Measures that open forests and create suitable habitats within forest are also considered to be useful (Daunicht 1985). Richter (1998) found that re-opening of dry grassland by sheep grazing could greatly increase the local breeding population. The minimum size of grazed patches had to be 3 ha (Richter 1998).

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2.18 Skylark (*Alauda arvensis*) – Feldlerche – Order: Passeriformes

Geography

- All Europe to E Siberia
- All over Germany

Status in Germany

- Breeding (April – August), migratory, some birds wintering

Life cycle

- First breeding when 1 year old
- Up to three broods per year, 2-5 eggs per clutch
- Life span: 1-5 years (max. 10 years)
- Generation length <3.3 years

Population, trend and conservation status

Populations of Skylarks are declining in Europe and in Germany. The steepest decline occurred in the early 1980s or before (Fig. Alar1).

Tab. Alar1: Populations (pairs), trends (mainly 1980 – 2005) and Red List status of Skylarks breeding in Europe, Germany and the German federal states.

Skylark			Trend					
	Population (pairs)	Proportion of German population (%)	<-50%	-50% - -20%	stable	20% - 50%	>50%	Red List category
Baden-Württemberg	150000 - 250000	7.5						3
Bayern	80000 - 120000	3.8						3
Brandenburg + Berlin	300000 - 400000	13.2						3
Hessen	>10000	>0,4						V
Mecklenburg-Vorpommern	600000 - 1000000	30.2						–
Niedersachsen + Bremen	180000	6.8						3
Nordrhein-Westfalen	116000	4.4						3
Rheinland-Pfalz								–
Saarland								V
Sachsen	100000 - 300000	7.5						–
Sachsen-Anhalt	150000 - 300000	8.3						V
Schleswig-Holstein + Hamburg	30000	1.1						3
Thüringen								–
Germany	**2,100,000 - 3,200,000**							**3**
Europe	**40,000,000 - 80,000,000**							**Spec3**

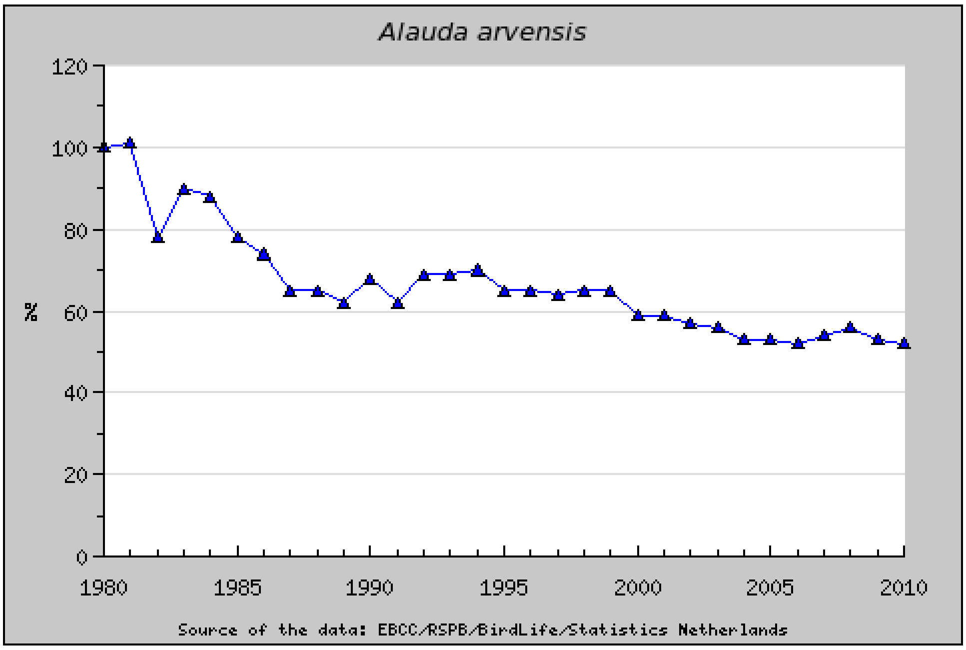

Fig. Alar1: Population trend (TRIM indexes) of Skylarks in Europe (PECBMS 2012).

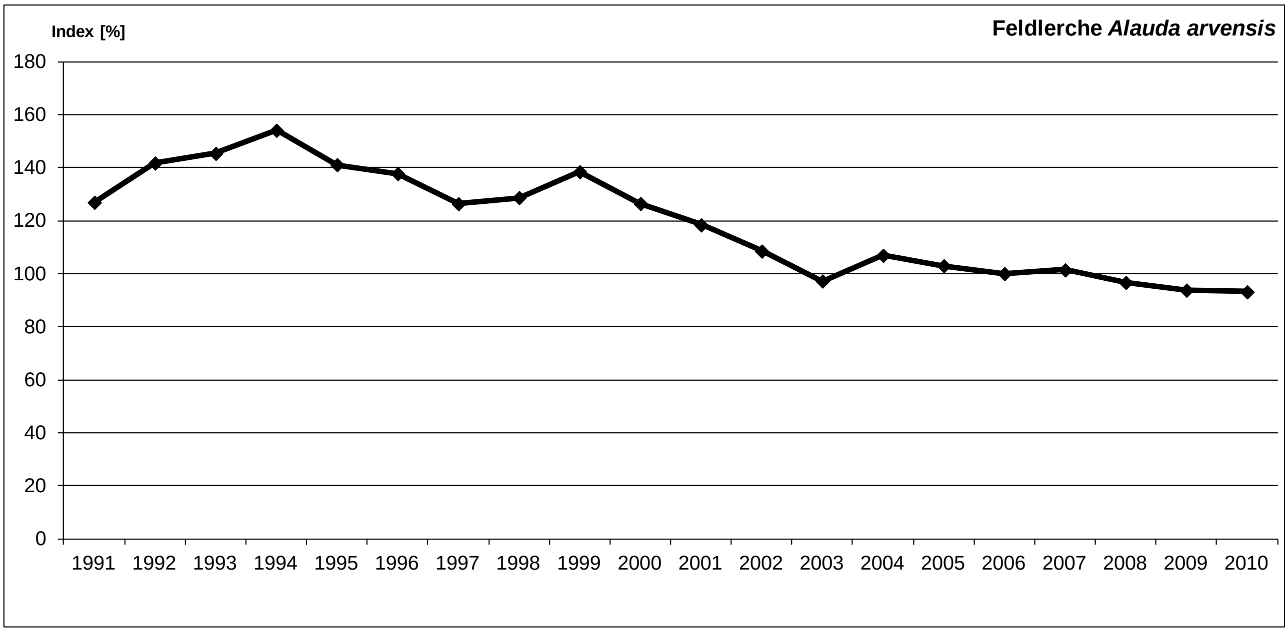

Fig. Alar2: Population trend (TRIM indexes) of Skylarks in Germany (DDA 2012).

Diet

During the breeding season, Skylarks mainly feed on insects and other vertebrates. They also take some seeds, both from crops and farm weeds, and green parts of plants (Green 1978). The nestlings receive a similar diet, with just fewer seeds and no green plant parts (Donald et al. 2001c, Jenny 1990a, Jeromin 2002, Poulsen et al. 1998). During the non-breeding season grains (mostly of crops) and green parts of plants become dominant. Invertebrates are still taken but to a much lesser extend than in spring and summer (Green 1978). The percentage of diet potentially affected by pesticides (arthropods and weed seeds) is estimated as follows: nestlings 95%, adults during the breeding season 70% and adults during the non-breeding season 20%.

Habitat and densities

Skylarks nest in open landscapes on farmland, both on arable land and on grassland, and on open semi-natural or natural habitats such as heath, peat bogs, dunes and salt marshes. Skylarks avoid trees, bushes and hedgerows (Chamberlain et al. 2009).

Nests are placed on the ground. They are usually well concealed by vegetation. Clutches and broods suffer from high predation rates. Nest concealment is therefore regarded as important.

Tab. Alar2: Densities (Pairs/100ha, arithmetic means of different studies) of Skylarks on different crops and estimated percentages of Skylarks breeding in different habitats in Germany. N: number of studies. Sources: Chamerlain et al. (1999), Daunicht (1998), Donald et al. (2001b), Dreesmann (1995), Dziewiaty & Bernardy (2007), Edwards et al. (2001), Eraud & Boutin (2002), Fletcher et al. (2005), Fuchs & Scharon (1997), Fuchs & Saacke (1999), George (2003), Hoffmann (2008), Hoffmann (2011), Hoffmann et al. (2012), Jansen et al. (2008), Klinner-Hötker & Petersen-Andresen (2011), Kragten (2009), Litzbarski et al. (1993), Neumann (2011), Neumann & Koop (2004), Neumann et al. (2009), Poulsen et al. (1998), Schläpfer (1988), Toepfer & Stubbe (2001), Töpfer (1996), Wakeham-Dawson et al. (1998), Watson & Rae (1997), Wilson et al. (1997), MOIN (unpublished, SH study).

Crop	N	Mean density (Pairs/100ha)	SD density (Pairs/100ha)	Percentage of German population
Autumn-sown cereals	24	18.1	14.6	24.1
Spring-sown cereal	14	32.1	23.4	4.4
Maize	14	33.7	18.6	18.3
Oilseed rape	10	20.0	24.6	7.0
Beets	8	15.7	14.5	1.4
Potatoes	3	15.2	22.3	0.9
Sunflowers	4	42.2	12.9	0.2
Vegetables	6	29.8	40.9	0.9
Alfalfa	2	79.0	56.6	2.1
Set-aside	19	73.5	52.6	4.4
Field margin (fallow, gras)	6	147.9	226.5	
Grassland, intensively managed	25	28.7	39.6	34.3
Grassland, extensively managed	6	47.8	43.6	
Moorland, heath, saltmarsh		(47.8)		2.0

Skylarks nest on all crop types. Densities tend to be relatively low on autumn-sown cereals, oilseed rape, beets and potatoes, whereas spring-sown cereals and maize seem to be preferred (Tab. Alar2). Within arable areas uncultivated or grassy field margins are clearly preferred for nesting and foraging (Edwards et al. 2001, Parish et al. 1995). Set-aside field usually hold the highest Skylark densities. Densities on set-aside fields are on average three times higher than on cropped fields (Tab. Alar2). Watson & Rae (1997) found higher Skylark densities on younger rather than older set-aside fields and on un-mown rather than mown fields. Wilson et al. (1997) showed that the total arthropod density was significantly greater in fields of set-aside than in any other of the crop types. In general the breeding success was higher in set-aside fields than on intensively managed cereals.

The percentage of prey taken from sprayed cultures during the breeding season and the percentage of nests on sprayed cultures is estimated by the percentage of the German population found on sprayed habitats (Tab. Alar2: 59%).

Skylarks also nest on grassland. The densities vary according the type of grassland. Wakeham-Dawson et al. (1998) found that low intensity grazing producing a long swart, 15-25cm held six times more singing Skylarks and two times more invertebrates than intensive grazing resulting in a short swart. Poulsen et al. (1998) reported higher densities on permanent than on other types of grassland.

Skylarks prefer medium vegetation heights. Different authors give different values: of 15cm – 25cm (Jenny 1990b), 10 – 25 cm (Schläpfer 1988), 15cm – 60cm (Toepfer & Stubbe 2001) and below 50 cm (Eraud & Boutin 2002). Donald et al. (2001b), however, found the optimal height to be 55 cm in the middle of the breeding season (July). Crop height explained variation in densities late but not early in the season. Diversity of crop heights on the farm level seemed to enhance density (Donald et al. 2001b). The vegetation should not be too dense so that the larks are not hindered from walking on the ground. Töpfer (1996) found highest densities when vegetation ground cover was between 30% and 70%. Jenny (1990b) stated 20% – 50% to be optimal. Open plots on fields attract Skylarks (Chamerlain et al. 1999, Henderson et al. 2001, Saacke & Fuchs 1998). Schön (1999) found that naturally occurring plots (caused by wetness or lack of nutrients) where more important than artificial plots (caused by activities of agricultural machinery).

Throughout spring there is a clear seasonal shift in the preference for different cultures (Tab. Alar3 and Alar4, see also Chamberlain et al. 2000, Eraud & Boutin 2002,Toepfer & Stubbe 2001,Töpfer 1996). Autumn-sown cereals and oilseed rape lose their attractiveness from the beginning to the end of the breeding season (Chamberlain et al. 2000, Schläpfer 1988) whilst grassland, grassy structures like field margins, farm tracks and maize increase in importance for breeding Skylarks in the course of the breeding season (Chamberlain & Gregory 1999). Some crops like summer cereals and sugar beets seem to be attractive mainly in the middle of breeding season. In contrast to most crops, set-aside and grassland offer a high attractiveness for Skylarks throughout the entire breeding season.

Tab. Alar3: Seasonal preferences of crop types by Skylarks. The maximum densities per crop are set as 100%. Densities were calculated as arithmetic means from different studies. N gives the number of studies. Sources: Chamberlain et al. (2000), Daunicht (1998), Eraud & Boutin (2002), Fuchs & Scharon (1997), Fuchs & Saacke (1999), Jenny (1990a), Kragten (2009), Poulsen et al. (1998), Schläpfer (1988),), Toepfer & Stubbe (2001), Töpfer (1996), Wakeham-Dawson et al. (1998), Wilson et al. (1997), MOIN (unpublished, maize SH study).

Crop	N	April	May	June	July
Autumn-sown cereals	14	100	78	53	39
Spring-sown cereals	8	81	95	100	62
Maize	10	43	55	87	100
Oilseed rape	7	100	38	29	0
Beets	4	27	64	100	30
Sunflower	3	70	85	100	61
Legumes	2	83	100	72	0
Alfalfa	1	90	80	100	77
Set-aside	5	98	98	100	73
Field margin	4	29	75	100	93
Grassland	12	74	73	100	86

Tab. Alar4: Estimated percentages of Skylarks breeding in different habitats in Germany for each month. Data from Tab. Alar2 and Alar3.

Crop	April	May	June	July
Autumn-sown cereals	32	27	16	14
Spring-sown cereals	5	6	6	4
Maize	10	14	20	27
Oilseed rape	9	4	3	0
Beets	0	1	2	1
Sunflower	0	0	0	0
Legumes	0	0	0	0
Alfalfa	2	2	3	2
Set-aside	6	6	6	5
Grassland	33	36	43	44
Natural and seminatural habitats	2	2	3	3

The seasonal shift in preference can be partly explained by the preference of Skylarks for different vegetation heights and densities. Autumn-sown crops such as oilseed rape and winter cereals "grow out" of the optimal window in the beginning of the breeding season. Summer cereals reach an optimal vegetation height in the middle of the breeding season and become too high just at the end of the season. Maize fields are bare and without any vegetation in the beginning of the season and reach a sufficient vegetation cover at the end of the season. Own observations reveal that in north west Germany maize gets too high for Skylarks already by the end of June. Skylarks are rarely observed on Maize fields in July so that Tabs. Alar3 and Alar4 are probably over-estimating the significance od maize.

Skylark territories usually include different crops (Daunicht 1998, Eraud & Boutin 2002), probably in order to insure that during all parts of the breeding season at least some spots of optimal vegetation are available. Chamberlain et al. (2000) found significant positive effects of crop diversity on Skylark densities and Schläpfer (1988) and Weibel et al. (2001) showed negative effects of crop diversity on skylark territory sizes. Densities are often negatively correlated with field sizes (Donald et al. 2001b, Eraud & Boutin 2002, Schläpfer 1988). In the UK regions with mixed farming held higher Skylark densities than pure arable or grassland regions (Gregory & Baillie 1998). Fuchs & Saacke (1999) found higher densities on poor soils compared to rich soils.

Breeding success varies between sites and crops. Eraud & Boutin (2002) found highest success rates on set-aside and alfalfa, whilst Donald et al. (2002) and Chamberlain & Crick (1999) reported higher breeding success on cereal fields than on set-aside or grassland. Bradbury et al. (2003), Poulsen et al. (1998) and (Donald et al. 2001c) found no significant effects of crops on nestling conditions. Densities of successful nest were higher in unmanaged field margins than on fields (Edwards et al. 2001).

During the non-breeding season Skylarks show a strong preference for stubble fields (Bauer & Ranftl 1996, Donald et al. 2001a, Gillings & Fuller 2001, Green 1978, Robinson 2001,Wilson et al. 1996) and set-aside (Buckingham et al. 1999,Donald et al. 2001a). Grassy field margins are also selected (Parish et al. 1995) whilst grassland itself is often avoided (Tab. Alar5). The percentage of food taken from sprayed cultures outside the breeding season is roughly estimated to be 90%.

Tab. Alar5: Numbers of studies that report avoidance or preference of Skylarks for different field types during the non-breeding season. Sources: Bauer & Ranftl (1996), Buckingham (2001), Buckingham et al. (1999), Donald et al. (2001a), Gillings & Fuller (2001), Green (1978), Parish et al. (1995), Robinson (2001), Vickery & Buckingham (2001), Wilson et al. (1996), Wilson et al. (2005), MOIN (unpublished, maize SH study).

	Avoidance	Preference
Fields with bare soil	5	1
Stubbles	0	8
Set-aside	0	3
Other arable fields	11	8
Grasys field margins	0	2
Grassland	12	4

Statistics on crop-specific densities in the breeding season

The mixed effects model applied to the crop-specific densities revealed a significant effect of the fixed factor "Crop" and the random factor "Study". The continous fixed parameter "Plotsize" did not have a significant influence on densities (Tab. Alar6). Pairwise tests of crop types showed significant differences in densities between set-aside and autumn-sown cereals (p<0.001), oilseed rape (p<0.001) and grass (p=0.002) and between spring-sown cereals and oilseed rape (p=0.022).

Tab. Alar6: Summary of a mixed effects model.

Model	DF	F	Wald-Z	p
Plotsize	23.8; 1.0	0.2		0.655
Crop	108.3; 6.0	6.43		<0.001
Study			2.64	0.008

Threats / sensibility (pesticide effects)

There are clear indications for an influence of pesticide application on the nestling condition of Skylarks (Boatman et al. 2004, Wilson et al. 1997). Moreover there is tremendous evidence that Skylark populations are considerably higher on organic than on conventional farms (Fuchs & Scharon 1997, Hötker et al. 2004, Kragten et al. 2008, Neumann & Koop 2004, Wilson et al. 1997). Although the preference for organic farming cannot be entirely attributed to the absence of pesticides, it strongly indicates at least some influence of pesticides on Skylark populations. In wintering Skylarks, McKenzie et al. (2011) found a negative effect on feeding sites selction of pesticides but not fertilizers. It is likely, therefore, that Skylarks would benefit from reductions of pesticide applications in the breeding season.

The decline of the European Skylark population went in parallel to a shift from growing spring-sown cereals to autumn-sown cereals. The vegetation development in autumn-sown cereals curtails the opportunity for breeding long before the end of the season and results in a poorer annual production (Chamberlain et al. 1999, Wilson et al. 1997). The only western EU country with a relatively stable Skylark population is Denmark. Denmark still holds a high share of summer cereals.

During the breeding season Skylarks abandon winter cereals earlier than summer cereals. These results broadly support the suggestion that increases in winter cereals and loss of farm habitat diversity have contributed to the Skylark declines (Chamberlain et al. 2000). There is a coincidence, however, between survival rates of Skylarks in Britain and their population trends (Wolfenden & Peach 2001). An influence on the population of mortality rates, hence, cannot be ruled out.

In Germany, at present, Skylark populations suffer from the loss of set-aside and grassland. Both habitats hold high densities of Skylarks. The general trend of intensification of agriculture which is characterized for example by the loss of field margins, a reduction of non-vegetated spots due to high precision farming and other developments continues to have negative impacts on Skylark populations in Germany. The general loss of open habitats due to urbanisation (currently ca. 100ha per day, http://www.umweltbundesamt.de/boden-und-altlasten/boden/gefaehrdungen/flaeche.htm) also contributes to the decline of the population, although probably still much less than the ongoing agricultural intensification.

Losses due to agricultural activities like mowing can greatly influence the breeding success (Fuchs & Saacke 1999, Helmecke et al. 2005). Nest predation has been increasing in Germany in recent years (Hötker et al. 2007, Langgemach & Bellebaum 2005, Helmecke et al. 2005).

Measures for risk-management

As Skylarks obviously suffer from indirect effects of pesticide applications, it is likely that they would benefit from reductions of pesticide applications in the breeding season.

Skylarks are among the bird species that are most positively affected by a shilft from conventional to organic farming. Densities of breeding Skylarks on organic farms can be several times as high as on comparable conventional farms (see above). The set-up of more organic farms would probably increase Skylark numbers in wide regions.

Amongst the in-crop measures the establishment of set-aside clearly helps to increase Skylark populations (see reference in chapter “Habitat” and Block et al. 1993, Boag 1992, Joest 2011). Henderson et al. (2012) showed a clear relationship between the percentage of set-aside and the densities of Skylarks at farm level. Densities doubled when the percentages of set-aside rose from 0-3% to more than 10%. Their data indicate that more than 10% stubbles set-aside are optimal.

Skylarks generally seem to prefer field borders (Benton et al. 2003). Designing field margins for Skylarks has proven to be successful in many occasions. There is evidence that wildflower strips, grassy margins, strips sown with seed mixture and unmanaged strips help to increase the densities of Sklylarks (Edwards et al. 2001, Jenny 1990, Weibel et al. 2001).

In recent years so-called Skylark plots have been established to increase habitat quality for Skylarks on arable fields. These plots are small (usually ca. 20m^2) patches scattered over the fields. The plots are not drilled but otherwise managed in the same way than the rest of the field. Skylarks have slightly higher densities on fields with plots, in particular at the end of the season availability (Cimiotti et al. 2011, Fischer et al. 2009, Morris et al. 2004, Morris 2009).

Sowing seeds in wide rows has also been proposed as a measure to improve habitats for Skylarks on arable fields. Both summer and winter cereals sown in wide rows on organic farms or on fields without application of pesticides and chemical fertilizers led to very high densities of Skylarks (Hötker et al. 2004, Joest 2011). Morris et al. (2004), however, found that spacing of rows had no effect on conventional farms. Food availability also did not seem to be linked to spacing of rows in conventional farms (Morris et al. 2004, Smith et al. 2009).

Reducing intensity of grassland management in arable landscapes had positive effects on population trends in the UK (Baker et al. 2012). Less intensively managed grassland generally holds higher Skylark densities than intensively managed grassland (Tab. Alar2). It may thus be assumed that reducing the intensity of grassland management is beneficial for Skylarks.

On cultures that are regularly mown a minimal time period between mowing dates of at least seven weeks is essential to complete successful breeding cycles (Fuchs & Saacke 1999).

In winter skylarks clearly prefer stubble field and probably also set-aside fields (Tab. Alar5). Baker et al. (2012) could show that population trends of skylarks breeding in UK were associated with the establishment of stubble fields through agri-environmental schemes.

Skylarks avoid to nest next to trees, bushes, hedgerows and other vertical structures (Dreesmann 1995, Glutz von Blotzheim & Bauer 1985). Establishing such features is disadvantageous for Skylarks.

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2.19 Barn Swallow (*Hirundo rustica*) – Rauchschwalbe – Order: Passeriformes

Geography

- Holarctic temperate and subarctic
- All over Germany

Status in Germany

- Breeding (April – July), migratory

Life cycle

- First breeding when 1 year old
- 1-3 broods per year, 3-6 eggs per clutch
- Life span: 1-4 years (max. 16 years)
- Generation length <3.3 years

Population, trend and conservation status

In Germany Barn Swallows are categorized near threatened and the population breeding in Germany shows a moderate decline. For detailed information at the Länder level and at the European level see Tab. Hiru1. There are indication that the European Barn Swallow population had been declining before monitoring data became available (BirdLife International 2004).

Tab. Hiru1: Populations (pairs), trends (mainly 1980 – 2005) and Red List status of Barn Swallows breeding in Europe, Germany and the German federal states.

Barn Swallow			Trend					
	Population (pairs)	Proportion of German population (%)	<-50%	-50% - -20%	stable	20% - 50%	>50%	Red List category
Baden-Württemberg	80000 - 120000	8.3						3
Bayern	200000 - 300000	20.8						V
Brandenburg + Berlin	50000 - 100000	6.3						3
Hessen	> 10000	>0.8						–
Mecklenburg-Vorpommern	100000	8.3						–
Niedersachsen + Bremen	100000	8.3						3
Nordrhein-Westfalen	50000 - 80000	5.4						3
Rheinland-Pfalz								–
Saarland								3
Sachsen	40000 - 120000	6.7						–
Sachsen-Anhalt	60000 - 100000	6.4						–
Schleswig-Holstein + Hamburg	48500	4.0						V
Thüringen								–
Germany	**1,000,000 - 1,400,000**	**100%**						**V**
Europe	**16,000,000 – 36,000,000**							**–**

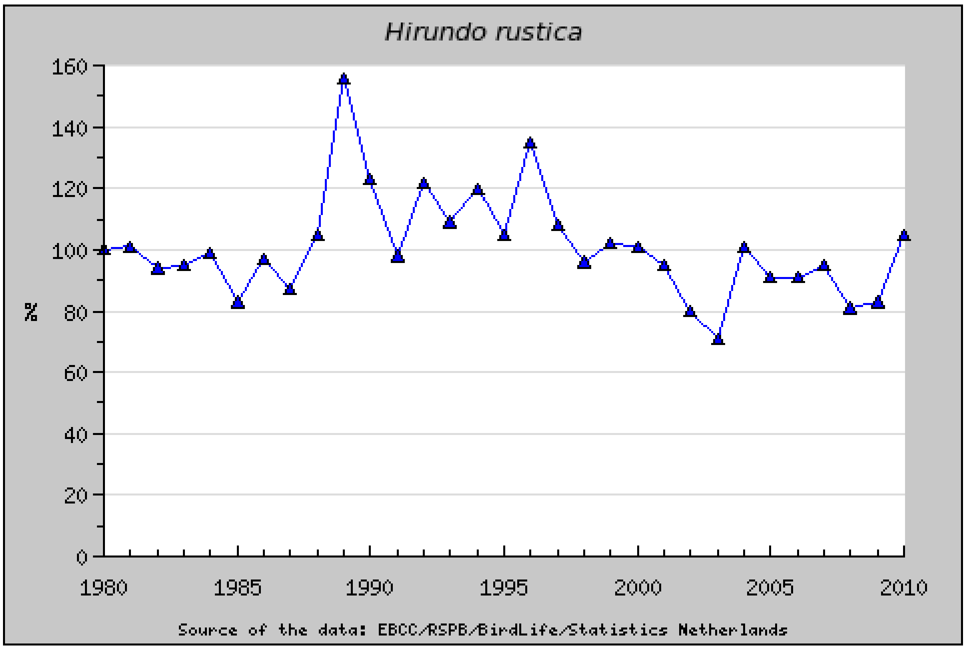

Fig. Hiru1: Population trend (TRIM indexes) of Barn Swallows in Europe (PECBMS 2012).

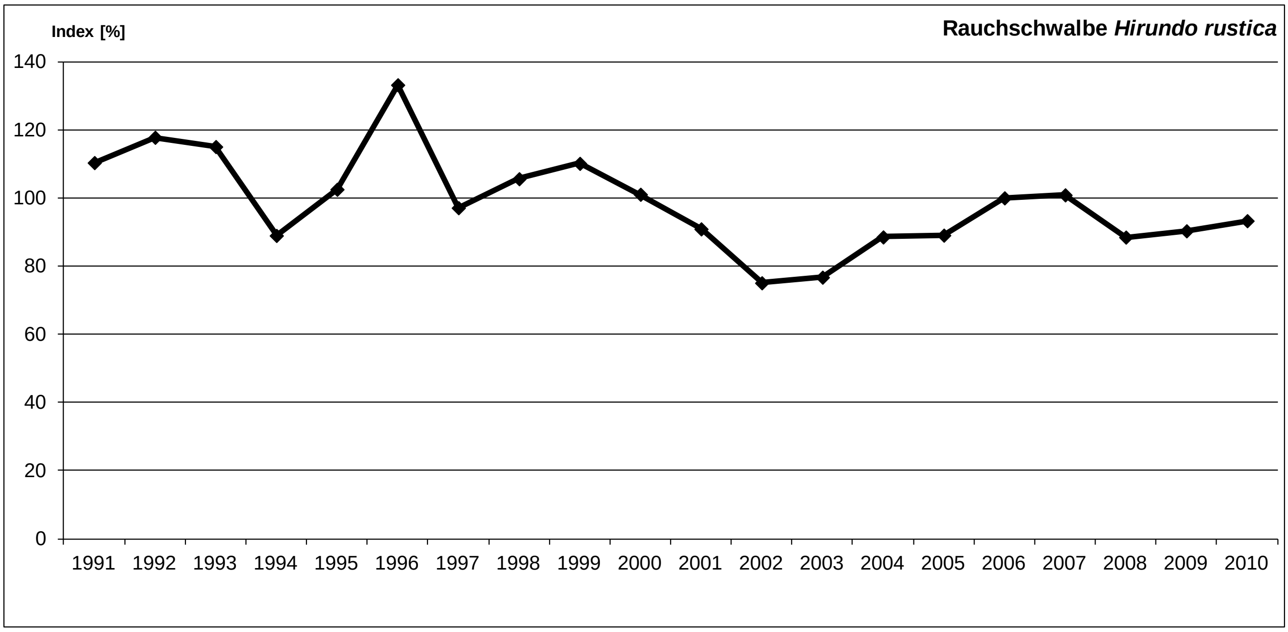

Fig. Hiru2: Population trend (TRIM indexes) of Barn Swallows in Germany (DDA 2012).

Diet

Throughout the year Barn Swallows feed almost exclusively on flying insects, the by far most important group being Diptera. Prey is caught in flight or less often picked from walls or from the vegetation. Chicks are fed with the same organisms that form the diet of adults (Glutz von Blotzheim & Bauer 1985, Loske 1992). As the diet more or less entirely consists of insects, 100% of the diet is potentially affected by pesticides (insecticides).

Habitat and densities

Nearly all European Barn Swallows nest in or at human buildings. They prefer rural over urban settlements. A crucial factor for the occurrence of Barn Swallows is animal husbandry (Møller 1983, 2001, Ambrosini et al. 2002, Lühr & Gröschel 2006, Lubbe & Snoo 2007, Grüebler et al. 2010).

Barn Swallows forage in or close to the buildings they nest in, on farm yards (Ambrosini et al. 2002), over wetlands (Lühr & Gröschel 2006), at forest edges or next to hedgerows (Evans et al. 2003) and over crops (Ambrosini et al. 2002). Barn Swallows use all crop types considered in this report, including orchards, vineyards and hops fields. Foraging usually takes place within 500 m around the nest site (Møller 1983, Ambrosini et al. 2002). The choice of foraging patches partly depends on the weather; hedgerows became particularly important during bad weather (Evans et al. 2003, Loske 2008). Barn Swallows almost exclusively forage in flight.

After arrival in spring many Barn Swallows first visit wetlands where they feed on emerging insects or they stay close to the farms. Arable fields where the vegetation is usually still sparse and low in the first months of spring are rarely visited in the beginning of the season. Foraging over cropped fields becomes more important as the season progresses and the biomass of crops increases (Tabs. Hiru2 and Hiru3). Foraging over crops ceases after harvest with the exception of grassland, clover and stubble fields (Tab. Hiru2, Hötker et al. 2004a). Among crops, grassland, clover and stubbles (pooled in order to increase sample sizes) clearly attract more Barn Swallows than arable fields (Tab. Hiru3, see also Ambrosini et al. 2002, Lühr & Gröschel 2006). Henderson et al. (2007) state that grasslands are only preferred when grazed. Besides grassland, other cultures are much less preferred, in particular maize (see also Ambrosini et al. 2002). Barn Swallows are more numerous in regions with mixed farming than in regions with pure grassland or arable farming (Henderson et al. 2007).

Table Hiru2. Mean densities (Individuals/100 ha per visit) of foraging Barn Swallows over different crops in the course of the season in Schleswig-Holstein/Germany. Each value is a mean of two to four different data points. Sources: MOIN (unpublished, Trenthorst study and maize SH study).

Barn Swallow	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Mean density April-Sept.
Autumn-sown cereals	0	0	0	0	5.3	46.2	9.1	0	0	0	0	0	10.1
Rape	0	0	0	0	12.5	3.0	46.4	0	0	0	0	0	10.3
Maize	0	0	0	0.1	0	0.1	?	?	?	0	0	0	0.1
Beets	0	0	0	0	5.0	41.3	0	16.4	0	0	0	0	10.4
Legumes	0	0	0	0	5.1	94.5	3.4	0	0	0	0	0	17.2
Grassland	0	0	0	0	24.2	44.2	42.4	74.6	116.4	0	0	0	50.3

In absence of detailed studies the proportion of food taken from cultures is difficult to access. In view of large concentrations of foraging Barn Swallows over lakes and ponds and close to tree rows and hedgerows in all parts of the season we estimate that adults during the breeding season take 30% of their food from crops including grassland. The food for the nestlings is collected during a period of time (May to July) when crop fields are more frequently visited by Barn Swallows. The amount of nestling food taken from crops, therefore, is estimated to be higher, at 40%.

Table Hiru3: Seasonal variation in occurrence of adult Barn Swallows in different habitats and cultures in Germany (percentages of maximum population in Germany). The first row shows the number present in Germany (percentages of the mean maximum number, birds on passage not considered). Numbers in the rows beneath show which percentage of the maximum population occurs in each habitat in each month. The column "Pref." ranks the habitats according to their usage (top usage 100) and the column "% of pop." shows the proportion of foraging time spent in each habitat. The figures for "others" are rough estimates. The figures for the different cultures are estimates based on Tab. Hiru2 and references in the text.

Barn Swallow	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Pref.	% of pop.
Presence	0	0	5	90	100	100	100	90	50	5	0	0		
Autumn-sown cereals	0	0	0	0	2	11	4	0	0	0	0	0	4.4	6
Rape	0	0	0	0	5	1	11	0	0	0	0	0	4.4	1
Maize	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Beets	0	0	0	0	2	5	7	5	0	0	0	0	5.1	0.4
Legumes	0	0	0	0	2	25	1	0	0	0	0	0	7.6	0.6
Grassland	0	0	0	0	10	13	17	25	15	1	0	0	21.3	22
Others	0	0	5	90	79	45	60	60	35	4	0	0	100	70

As (unsprayed) grassland is by far the most important crop used by foraging Barn Swallows (22% of foraging time) the amount of food taken from sprayed cultures is estimated at 8% for adults in summer (30% foraging over crops minus 22% foraging over unsprayed grassland) and 10% for reproduction (40% foraging over crops minus 30% foraging over unsprayed grassland).

Ground cover does not have an obvious affect on foraging Barn Swallows.

Threats / sensibility (pesticide effects)

There is no direct evidence for pesticide effects on the food of Barn Swallows. Barn Swallows could in theory be affected by insecticides which directly reduce the food availability or by herbicides which kill potential host plants for insects and thus indirectly reduce food availability. Morris (2002) did not find a relationship between the number and timing of sprayings and food availability for Barn Swallows. The breeding success of Barn Swallows strongly depends on food availability (Turner 1983). A reduction of the food supply thus can potentially reduce the breeding success.

There is evidence that Barn Swallows prefer (unsprayed) organic field over conventionally managed fields (Hötker et al. 2004b). At the farm scale, however, differences between organic and conventional agriculture were not visible. Kragten et al. (2009) and Lubbe & Snoo (2007) found no significant differences in the occupancy and the colony size of Barn Swallows in farm buildings on conventional and organic farms.

Barn Swallow populations seem to be mostly threatened by abandonment of livestock husbandry (Møller 2001, Ambrosini et al. 2002, Loske 2008). Losses of potential nest sites, e.g. farm buildings which are accessible for Swallows, and losses of preferred feeding sites like hedgerows are locally important factors (Loske 2008). As Barn Swallows are associated with high crop diversity (see above) the loss of such diversity might impair foraging.

Measures for risk-management

There are no experimentally tested measures to increase food availability for Barn Swallows. The analyses of habitat selection (see above), however, allow conclusions to be drawn on possible risk management tools.

Potentially a reduction of or totally refraining from spraying insecticides and herbicides can increase the food supply for Barn Swallows on crops. Organic farming also most likely has an effect.

Crop-related measures so far have not been tested for Barn Swallows. It is likely that Barn Swallows will benefit from all measures which increase the number and biomass of flying insects such as flower strips, grassy margins and related measures. Stubbles and fields with undersown clover provide more food than fields ploughed and left with bare ground after harvest.

Regarding the habitat choice of Barn Swallows, it is obvious that measures to keep and expand animal husbandry, grassland (in particular if grazed), hedgerows and probably also small wetlands improve habitat for Barn Swallows. Providing access to indoor nest sites (stables) or even artificial nest sites (Willi et al. 2011) can also increase the breeding success. Small loamy puddles can be helpful for providing nest material.

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2.20 House Martin (*Delichon urbicum*) – Mehlschwalbe – Order: Passeriformes

Geography

- Europe, NW Africa to E Siberia
- All over Germany

Status in Germany

- Breeding (May – Sept.), migratory

Life cycle

- First breeding when 1 year old
- 1-2 broods per year, 3-5 eggs per clutch
- Life span: 1-4 years (max. 14 years)
- Generation length <3.3 years

Population and trend

Populations in most federal states are declining (Tab. Deur1).

Tab. Deur1: Populations (pairs), trends (mainly 1980 – 2005) and Red List status of House Martins breeding in Europe, Germany and the German federal states.

House Martin			Trend					
	Population (pairs)	Proportion of German population (%)	<-50%	-50% - -20%	stable	20% - 50%	>50%	Red List category
Baden-Württemberg	90000 - 140000	11.3	■					3
Bayern	140000 - 240000	18.7		■				V
Brandenburg + Berlin	50000 - 100000	7.4	■					–
Hessen	>10000	1.0		■				3
Mecklenburg-Vorpommern	150000 - 180000	16.3					■	–
Niedersachsen + Bremen	70000	6.9		■				V
Nordrhein-Westfalen	98000	9.7		■				3
Rheinland-Pfalz								–
Saarland				■				V
Sachsen	30000 - 60000	4.4		■				–
Sachsen-Anhalt	60000 - 10000	7.9			■			–
Schleswig-Holstein + Hamburg	43000	4.2			■			–
Thüringen								–
Germany	**830,000 - 1,200,000**			■				**V**
Europe	**9,900,000 - 24,000,000**				■			**Spec3**

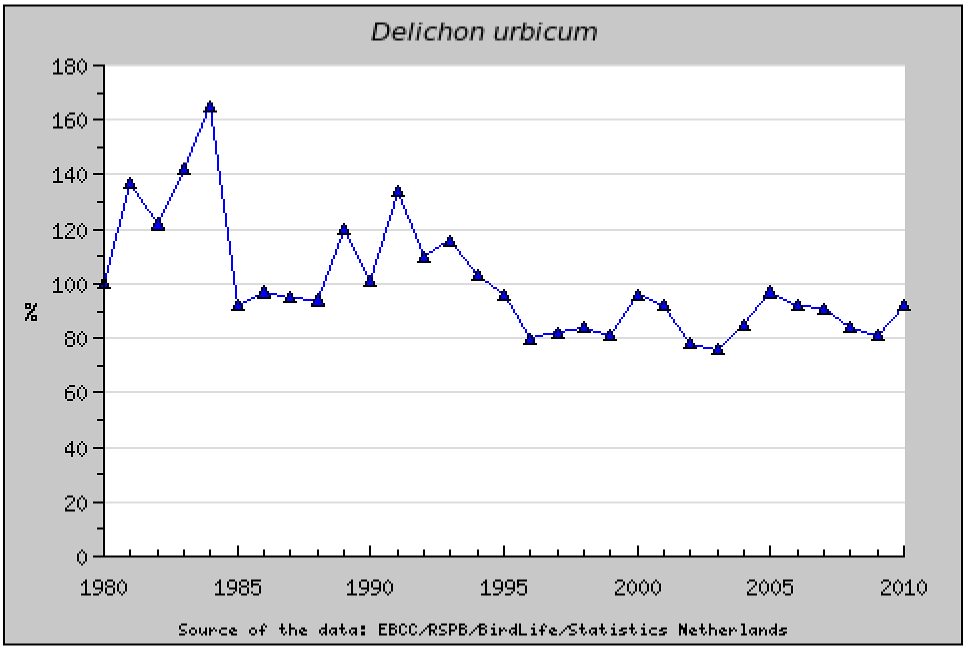

Fig. Deur1: Population trend (TRIM indexes) of House Martins in Europe (PECBMS 2012).

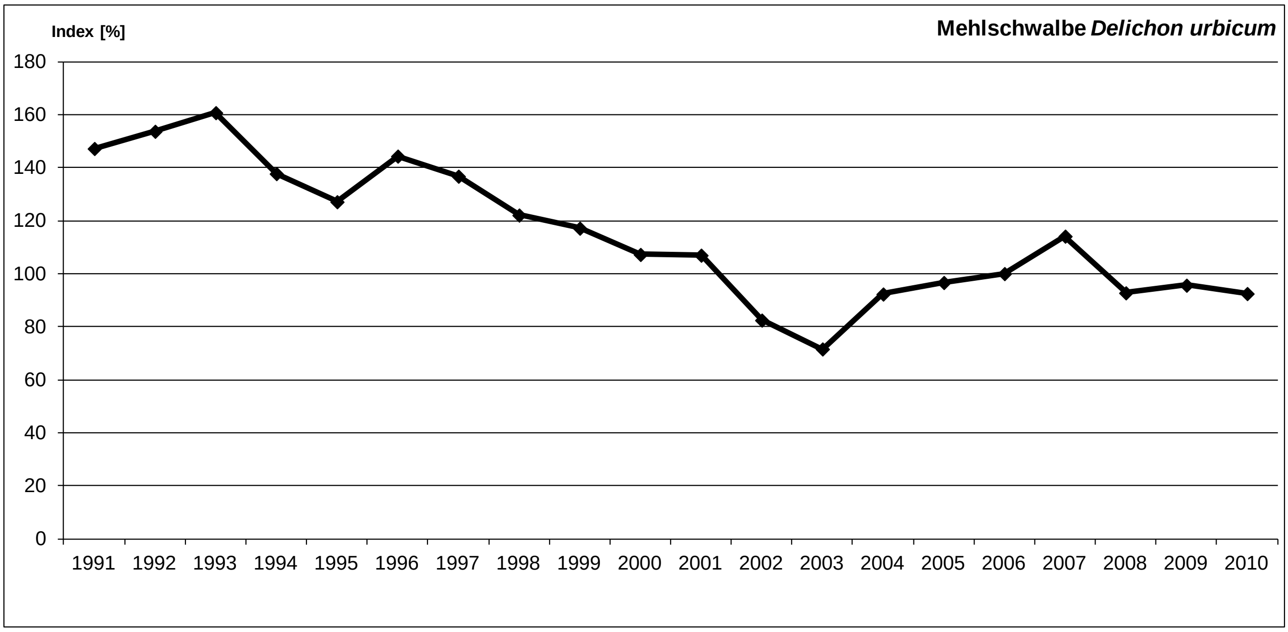

Fig. Deur2: Population trend (TRIM indexes) of House Martins in Germany (DDA 2012).

Diet

House Martins feed almost exclusively on flying insects throughout the year (Bryant 1973), the most important group being Diptera, followed by Hemiptera. Prey is caught in flight. Chicks are fed with the same organisms that form the diet of adults (Glutz von Blotzheim & Bauer 1985). As the diet more or less entirely consists of insects, 100% of the diet is potentially affected by pesticides (insecticides).

Habitat and densities

House Martins build their nests on walls of buildings, usually in rural environments, but also in urban settlements. House Martins forage in open and semi-open habitats: grassland, arable land, wetlands. During bad weather House Martins are often seen close to trees and in villages. Most often they feed within 450m of nest sites (Bryant 1973, Bryant & Turner 1982).

After arrival in spring many House Martins first visit wetlands where they feed on emerging insects. Arable fields where the vegetation is usually still sparse and low in the first months of spring are rarely visited in the beginning of the season. Foraging over cropped fields becomes more important as the season progresses and the biomass of crops increases (Tab. Deur2). Foraging over crops ceases after harvest with the exception of grassland, clover and stubble (Tab. Deur2, Hötker et al. 2004). Autumn-sown cereals and maize are obviously avoided by foraging House Martins (Tab. Deur2). The apparent selection of beets in June is based on few observations and should not be over-interpreted. House Martins profit from set-aside (Sears 1992).

Tab. Deur2: Mean densities (Individuals/100 ha per visit) of foraging House Martins over different crops in Schleswig-Holstein/Germany during the course of the season. Each value is a mean of two to four different data points. Sources: MOIN (unpublished, Trenthorst study and maize SH study).

House Martin	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Mean density April-Sept.
Autumn-sown cereals	0	0	0	0	0.2	8.1	2.1	0	0	0	0	0	1.7
Rape	0	0	0	0	0	21.5	5.8	0	0	0	0	0	4.5
Maize	0	0	0	0	0	0	0	0	0	0	0	0	0.0
Beets	0	0	0	0	7.4	72.9	0	10.0	0	0	0	0	15.1
Legumes	0	0	0	0	0	45.3	0	0	0	0	0	0	7.5
Grassland	0	0	0	0	3.5	16.1	3.6	25.8	1.5	0	0	0	8.4

In absence of detailed studies the proportion of food taken from cultures is difficult to access. In view of large concentrations of foraging House Martins over lakes and ponds and close to tree rows and hedgerows in all parts of the season we estimate that adults during the breeding season take 20% of their food from crops including grassland. The food for the nestlings is collected during a period of time (May to July) when crop fields are more frequently visited by House Martins. The amount of nestling food taken from crops, therefore, is estimated to be higher, at 30%.

Table Deur3: Occurrence of adult House Martins in different habitats and cultures in Germany (percentages of maximum population in Germany). The column "Pref." ranks the habitats according to their usage (top usage 100) and the column "% of pop." shows the proportion of foraging time spent in each habitat. The figures for "others" are rough estimates. The figures for the different cultures are estimates based on Tab. Deur2 and references in the text.

House Martin	Pref.	% of pop.
Autumn-sown cereals	1	3.6
Rape	3	1.8
Maize	0	0.0
Beets	10	1.8
Legumes	5	0.8
Grassland	6	12.0
Others	100	80.0

As (unsprayed) grassland is a crop frequently used by foraging House Martins (12% of foraging time) the amount of food taken from sprayed cultures is estimated at 8% for adults in summer (20% foraging over crops minus 12% foraging over unsprayed grassland) and 12% for reproduction (30% foraging over crops minus 18% foraging over unsprayed grassland).

Ground cover does not have an obvious affect on foraging House Martins.

Threats / sensibility (pesticide effects)

Poulin et al. (2010) showed that spraying wetlands with *Bacillus thuringiensis israelensis* (Bti) in order to control mosquitoes in Southern France significantly reduced the prey intake and the breeding success of House Martins. House Martins could in theory be affected by all insecticides which directly reduce the food availability or by herbicides which kill potential host plants for insects and thus indirectly reduce food availability. As the breeding success of House Martins strongly depends on food availability (Bryant & Westerterp 1983), a thinning of the food supply can potentially reduce the breeding success.

There is some evidence that House Martins prefer organic over conventional fields. Hötker et al. (2004) found higher densities (no statistical difference, however) of foraging House Martins over organic than conventional fields.

Besides pesticides, declines in House Martin numbers were attributed to the lack of suitable nest sites (modern walls often are to smooth for nest construction) and to the loss of insect abundance due to the loss of insect-rich features such as wetlands (including the draining of wet grasslands), tree rows and set-aside. Population declines were also related to reductions of domestic livestock (Glutz von Blotzheim & Bauer 1985, Bauer et al. 2005).

Measures for risk-management

There are no experimentally tested measures to increase food availability for House Martins. The analyses of habitat selection (see above), however, allow some conclusions to be drawn on possible risk management tools. Potentially a reduction of or totally refraining from spraying insecticides and herbicides can increase the food supply for House Martins on crops. Organic farming also probably has an effect.

Crop-related measures so far have not been tested for House Martins. It is likely that House Martins will benefit from all measures which increase the number and biomass of flying insects such as flower strips, grassy margins and related measures. Stubbles and fields with undersown clover provide more food than fields ploughed and left with bare ground after harvest.

Providing artificial nest sites can help to increase House Martin populations at many places (Willi et al. 2011). Small loamy puddles can provide nest material. As the breeding success of House Martins is strongly linked to food availability (see above), all measures to increase insect densities in the vicinity of nest sites have the potential to increase the breeding success: maintenance or expansion of wetlands including wet grasslands, animal husbandry, tree rows and hedgerows, set-aside.

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2.21 Whinchat (*Saxicola rubetra*) – Braunkehlchen – Order: Passeriformes

Geography

- Europe to central Asia
- All over Germany

Status in Germany

- Breeding (May – July), migratory

Life cycle

- First breeding when 1 year old
- Single brooded, 5-7 eggs per clutch
- Life span: few years (max. 8 years)
- Generation length <3.3 years

Population, trend and conservation status

Whinchat populations in Europa and most parts of Germany are declining (Tab. Saru1). The steepest decline ocurred in the early 1980s or before (Fig. Saru1).

Tab. Saru1: Populations (pairs), trends (mainly 1980 – 2005) and Red List status of Whinchats breeding in Europe, Germany and the German federal states.

Whinchat			Trend					
	Population (pairs)	Proportion of German population (%)	<-50%	-50% - -20%	stable	20% - 50%	>50%	Red List category
Baden-Württemberg	500 - 700	1.1						1
Bayern	1500 - 2500	3.5						2
Brandenburg + Berlin	6000 - 10000	14.2						2
Hessen	400 - 600	0.9						1
Mecklenburg-Vorpommern	20000 - 30000	44.0						–
Niedersachsen + Bremen	3000	5.3						2
Nordrhein-Westfalen	330	0.6						1
Rheinland-Pfalz								3
Saarland								1
Sachsen	2500 - 5000	6.6						3
Sachsen-Anhalt	4000 - 8000	10.6						3
Schleswig-Holstein + Hamburg	3200	5.7						3
Thüringen								2
Germany	**45,000 - 68,000**							**3**
Europe	**5,400,000 - 10,000,000**							

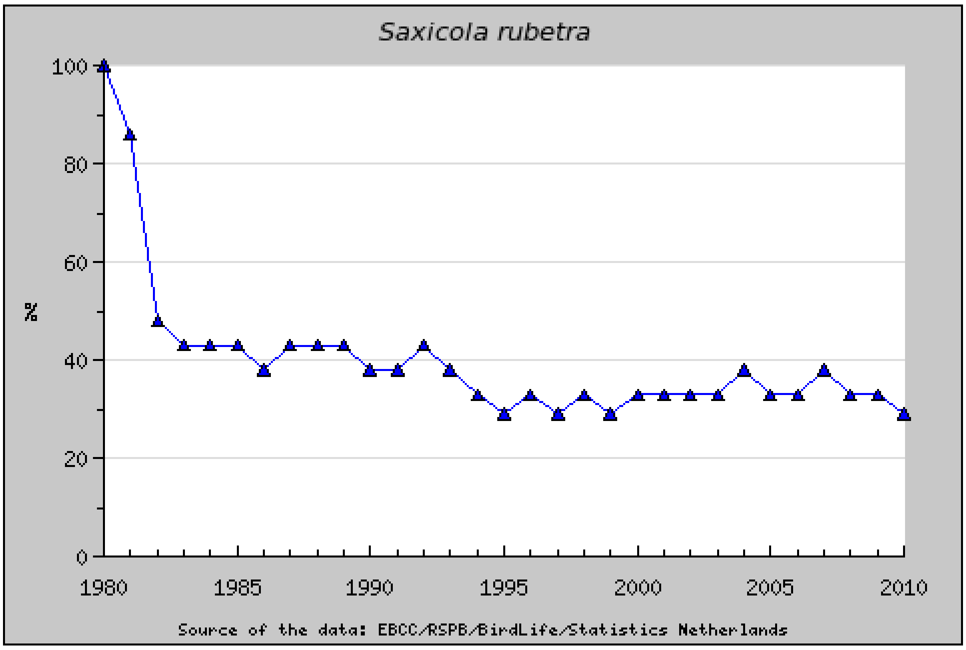

Fig. Saru1: Population trend (TRIM indexes) of Whinchats in Europe (PECBMS 2012).

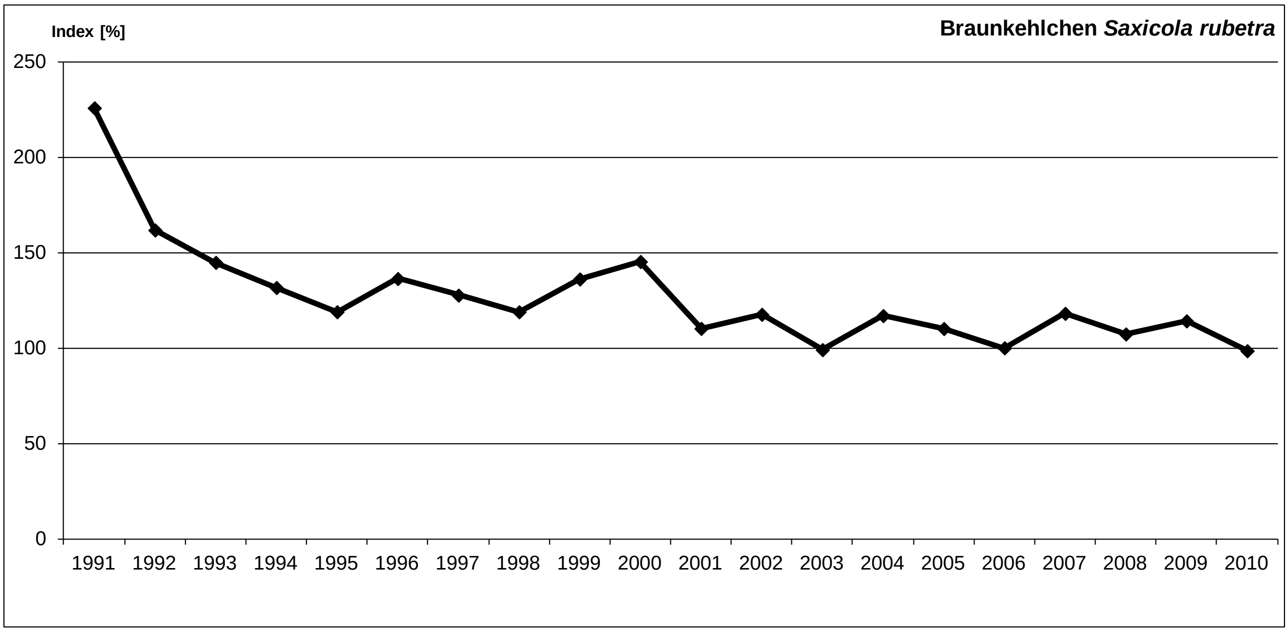

Fig. Saru2: Population trend (TRIM indexes) of Whinchats in Germany (DDA 2012).

Diet

Whinchats exclusively feed on invertebrates, mostly insect, but also arachnidae, snails and worms. Whinchats usually hunt from perches and take their prey in flight or from the ground. All prey is potentially affected by pesticides.

Habitat and densities

Whinchats breed in open habitats such as grasslands, arable land and natural and semi-natural habitats like moorland or forest clearings. Whinchats require at least some taller herbaceous vegetation as perches for singing and foraging (Andersson 1981, Feulner & Förster 1995, Richter & Düttmann 2004). The nests are on the ground, often next to field margins or ditches but also on fields.

Most Whinchats in Germany breed on non-intensive grassland and other semi-natural habitats (Tab. Saru2). Intensively managed grassland is avoided. Whinchats also occur on arable land. Here they breed mainly on set-aside. Although set-aside covered not more than 2.2% of arable land in Germany (2011, Statistisches Bundeamt 2012), an estimated 28% of the population bred in this habitat (Tab. Saru2). Cropped land holds very low densities of breeding Whinchats. Hoffmann et al. (2012) report relatively high densities on oilseed rape. Due to the large extension of cropped land 31% of the population use this habitat. This percentage is also taken as an estimate of the proportion of prey taken from sprayed cultures.

In other countries the pattern of habitat use may be different. In the UK by far most Whinchats breed in semi-natural habitats such as moorland, heathland, bogs and marshes while agriculture land is used to a lesser extend (BTO 2012, http://blx1.bto.org/birdfacts/results/bob11370.htm).

Tab. Saru2: Densities (Pairs/100ha, arithmetic means of different studies) of Whinchats on different habitats and estimated percentages of Skylarks breeding in different habitats in Germany. N: number of studies. Sources: Jansen et al. (2008), Litzbarski et al. (1993), Dziewiaty & Bernardy (2007), Hoffmann (2008), Neumann & Holsten (2009), Hoffmann (2011), Neumann (2011), Hoffmann et al. (2012).

Crop	N	Mean density (Pairs/100ha)	SD density (Pairs/100ha)	Percentage of German population
Cropped arable	12	0.3	0.3	31
Non-intensive grassland, natural and semi-natural habitats	3	5.4	3.3	41
Set-aside	8	10.0	5.2	28

In general, Whinchats prefer low intensity over medium intensity and high intensity agriculture (Schifferli et al. 1999). In particular in grassland regions, sites with a non-intensive management are preferred (Feulner & Förster 1995, Oppermann 1999, Priednieks et al. 1999, Richter & Düttmann 2004). Britschgi et al. (2006) found that traditional low intensity management of grassland held higher densities of relatively large-sized prey items. Whinchat occurrence is partly explained by the density and diversity of large-sized insects (Bastian et al. 1994).

In arable regions, set-aside is not only strongly preferred (Berg & Part 1994, Feulner & Förster 1995, Priednieks et al. 1999, Orlowski 2004, Nagy et al. 2009) but probably a pre-requisite for the occurrence of Whinchats. Grassy field edges and grassland fallow may also be important habitat features (Richter & Düttmann 2004). The same holds true for ditches (Theiß 1993). Whinchats only occasionally settle in normal crops such as maize or autumn-sown cereals (Dziewiaty & Bernardy 2007, Hoffmann 2011). A high crop diversity seems to be important (Feulner & Förster 1995).

Statistics on crop-specific densities in the breeding season

The mixed effects model applied to the crop-specific densities revealed a significant effect of the fixed factor “Crop”. The continous fixed parameter “Plotsize” and the random factor “Study” did not have a significant influence on densities (Tab. Saru3). Pairwise tests of crop types showed highly significant differences between all crop categories (cropped arable, set-aside, grassland).

Tab. Saru3: Summary of a mixed effects model.

Model	DF	F	Wald-Z	p
Plotsize	2.2; 1.0	8.01		0.096
Crop	16.4; 2.0	49.29		<0.001
Study			0.33	0.738

Threats / sensibility (pesticide effects)

There is no direct evidence for pesticide effects on the food of Whinchats. Whinchats could in theory be affected by insecticides which directly reduce the food availability or by herbicides which kill potential host plants for insects and thus indirectly reduce food availability. Herbicides could also destroy the nest cover which can be seen as essential for successful breeding. Christensen et al. (1996) found a significantly positive effect of organic farming on Whinchat numbers during the breeding season.

The main reason for the decline of the species is the loss of breeding habitat and habitat degradation through agricultural intensification. In particular non-intensively managed grassland has been lost, mostly due to intensification and drainage, but also due to abandonment and subsequent overgrowth by bushes or destruction by forestry activities. An increase in frequency of agricultural activities, especially earlier and more frequent mowing has probably reduced the food availability and may have caused nest losses. These problems have been amplified by soil eutrophication due to increased application of fertilizers (Bastian et al. 1994).

It is likely that the recent loss of grassland and set-aside and the ongoing loss of crop diversity in Germany will contribute to further reductions in population size.

Measures for risk-management

We found no direct evidence for the efficacy of pesticide-related measures for risk management. It is likely that leaving out from spraying of stripes along potential breeding sites (ditches, grassy margins, uncultivated strips) would increase the availability of food and nest cover. The chance of unintentional spraying of ditches and strips between fields would be reduced. Any reduction of spraying would probably lead to a higher availability of food and cover.

There is direct evidence that reducing the intensity of grassland management and set-aside increases the breeding density of Whinchats. Block et al. (1993) found an increase in density within five years after a formerly intensively managed grassland had gone under an extensive management including set-aside. Saacke & Fuchs (1998) report on positive effects of 10m set-aside field margins.The clear preference of set-aside over arable fields (see Tab. Saru2) also shows that set-aside can be regarded as a suitable measure to increase Whinchat populations. The introduction of extensive grazing may also help to improve Whinchat populations (Neumann & Holsten 2009).

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2.22 Meadow Pipit (*Anthus pratensis*) – Wiesenpieper – Order: Passeriformes

Geography

- NW and N Europe, widespread throughout farmland in North Germany and parts of South Germany

Status in Germany

- Breeding (April – August) and migratory (March –May and September-November), some birds wintering

Life cycle

- First breeding when 1 year old
- Up to 3 broods per year, 4-6 eggs per clutch
- Life span: 1-4 years (max. 8 years)
- Generation length <3.3 years

Population, trend and conservation status

With few exceptions, populations of Meadow Pipits are declining in most parts of Germany and Europe (Tab. Anpr1). The decline has occurred steadily at least since 1980. Populations dropped particularly sharply around 1995 (Fig. Anpr1). In Germany Meadow Pipits on passage outnumber breeding populations.

Tab. Anpr 1: Populations (pairs), trends (mainly 1980 – 2005) and Red List status of Meadow Pipits breeding in Europe, Germany and the German federal states. Sources: Red Lists of federal states.

Meadow Pipit			Trend					
	Population (pairs)	Proportion of German population (%)	<-50%	-50% - -20%	stable	20% - 50%	>50%	Red List category
Baden-Württemberg	700 - 900	0.8						–
Bayern	6000 - 10000	7.8						V
Brandenburg + Berlin	2000 - 4000	2.9						2
Hessen	500 - 600	0.5						2
Mecklenburg-Vorpommern	30000 - 60000	43.7						V
Niedersachsen + Bremen	30000	29.1						3
Nordrhein-Westfalen	3000 - 5000	3.9						2
Rheinland-Pfalz		small						3
Saarland		small						2
Sachsen	2500 - 5000	3.9						–
Sachsen-Anhalt	2000 - 3000	2.2						V
Schleswig-Holstein + Hamburg	10000	9.7						V
Thüringen		small						3
Germany	**96000 - 13000**							**V**
Europe	**7,000,000 - 16,000,000**							**–**

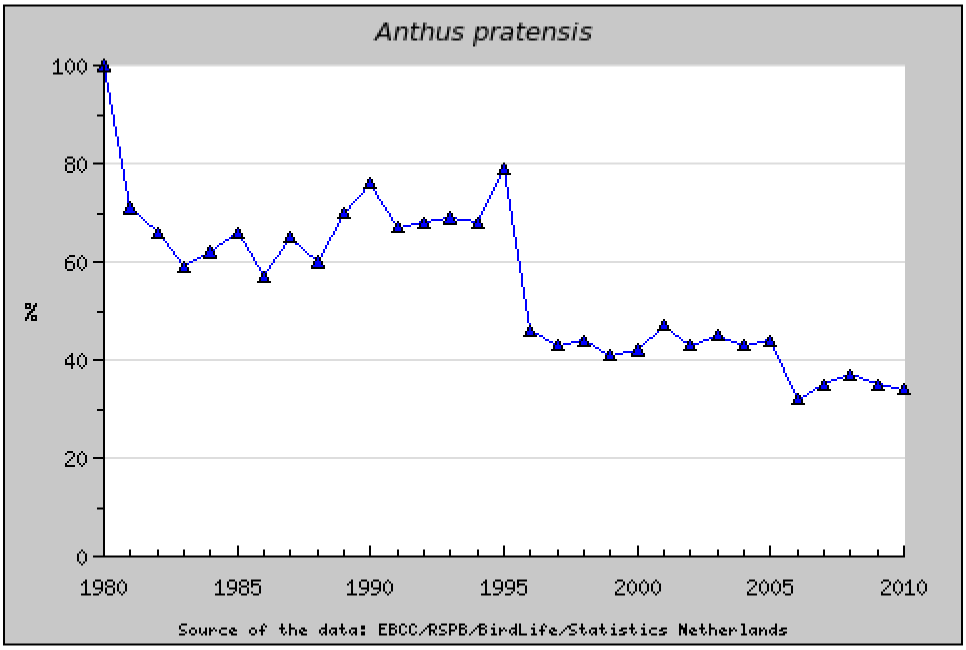

Fig. Anpr1: Population trend (TRIM indexes) of Meadow Pipits in Europe (PECBMS 2012).

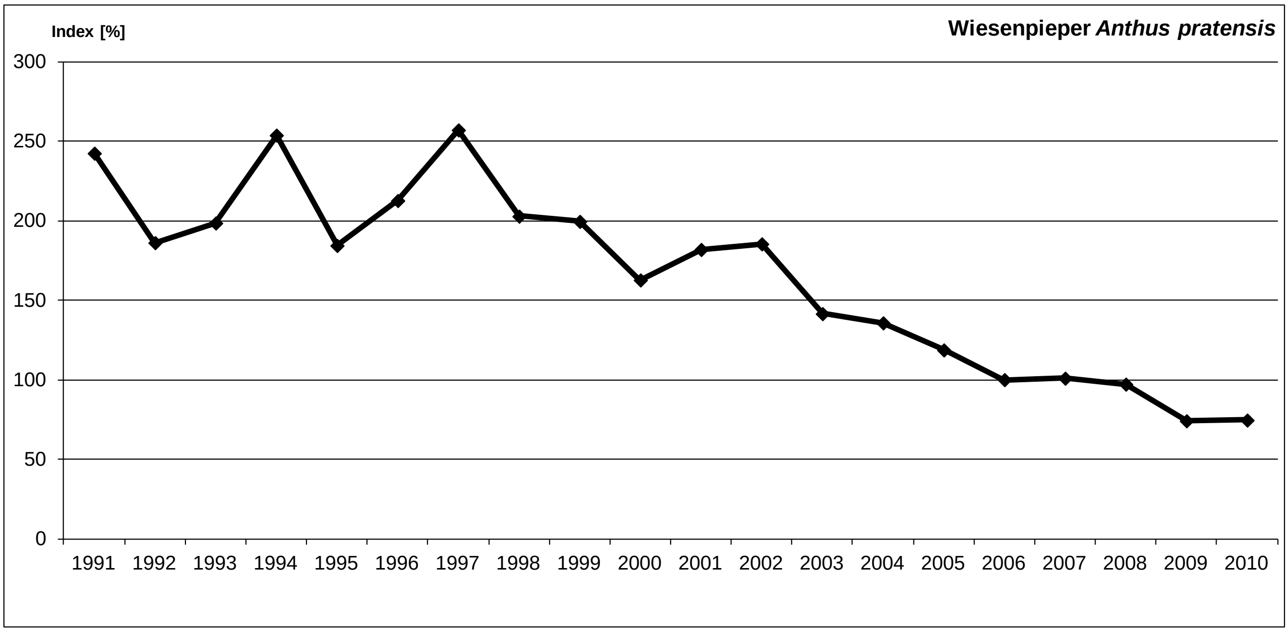

Fig. Anpr2. Population trend (TRIM indexes) of Meadow Pipits in Germany (DDA 2012).

Diet

During the breeding season Meadow Pipits nearly entirely feed on insects and other invertebrates, Tipulida (imagines und larvae) can be particularly important at some places (Douglas et al. 2008). In general Meadow Pipits seem to be opportunistic in their food choice. Nestlings in general are fed with the same diet which adults take but items tend to be larger (Hötker 1990). In winter a few grains supplement the mainly insectivorous diet (Glutz von Blotzheim & Bauer 1985, Hötker 1990). Nearly 100% of the diet can be regarded as being potentially affected by pesticides.

Foraging takes place on the ground and food is taken from the ground and from ground dwelling plants. Sometimes flying insects are caught by jumping from the ground or by short flights. Meadow pipits usually forage within their territories close to their nest sites.

Habitat and densities

Meadow Pipits breed in open habitats. In West and Central Europe Meadow Pipits reach highest densities on moor- and heathlands, saltmarshes and grasslands (Tab. Anpr2, Priednieks et al. 1999). Mosaics of heather, bog and grassland seem to be optimal habitats (Vanhinsbergh & Chamberlain 2001). In Germany, by far most of the Meadow Pipits breed on grasslands. Densities on semi-natural grasslands are generally higher than on intensively used grasslands (Hötker 1990). Meadow Pipits can also be found breeding on arable land, but the densities tend to be lower than on grassland and other more natural habitats (Tab. Anpr2). On arable farms, the nests, however, are most often not placed directly on the fields but on strips of grassland along ditches or farm tracks. Openness and the availability of grassy margins are a prerequisite for nesting on arable farms (Hötker 1990). Densities on set-aside are usually higher than on used arable land (Tab. Anpr2), see also Ellenbroek et al. (1998). The availability of song posts has an influence on the density (Priednieks et al. 1999).

The proportion of grassland with a very short sward during the peak of the breeding season has a strong effect on the breeding density of Meadow Pipits (Hötker 1990, Douglas et al. 2008). In a site in NW Germany the minimum percentage of short grass during the peak of the breeding season was approximately 5% (Hötker 1988).

Nests are placed on the ground, nearly exclusively in grassland or in moor, heat or dune vegetation. In arable sites and on intensively farmed grassland, nests are built most often on the grassy banks of irrigation ditches or in grassy margins of ditches and farmland tracks. Nests are usually well hidden in the vegetation. Nest cover, therefore, seems to be an important factor for avoiding nest predation.

When foraging in arable sites, Meadow Pipits usually use field margins and grassy strips between fields, rather than crops themselves. So in theory, hardly any of their prey items are affected by pesticide application. In practice, however, margins and grassy strips are often sprayed unintentionaly. As an estimate for the proportion of diet affected we therefore assume that half of the prey of Meadow Pipits breeding in arable sites (29%) are theoretically affected by pesticides (14.5%).

Cover for Meadow Pipit nests may only be affected by pesticides in arable sites as well. As Meadow Pipits usually do not breed on fields but in ditches and grassy strips, which may be affected by unintentional spraying, the chance of a pesticide effect on nest cover is less than the chance of an effect on food. As a rough estimate we consider 5% of Meadow Pipit nests in Germany nest cover as being potentially affected by pesticides.

Outside the breeding season, in winter in particular, oilseed rape, beets and maize stubbles become relatively important habitats for Meadow Pipits (MOIN unpublished). Grassland, however, remains to be the most often visited habitat. As habitat selection of Meadow Pipits in Germany in the non-breeding season has not yet been studied in detail, it is assumed to be roughly the same as in the breading season.

Tab. Anpr2: Densities of Meadow Pipits breeding in different habitats in West and Central Europe and estimated percentages of pairs in different habitats in Germany. Sources: Litzbarski et al. (1993), Bairlein & Bergner (1995), Slotta-Bachmayr (1996), Wakeham-Dawson & Aebischer (1997), Watson & Rae (1997), Alkemeier (2003), Exo & Thyen (2003), Oltmanns (2003), Schrader (2003), Thyen & Exo (2003), Dziewiaty & Bernardy (2007), Hoffmann (2008), Kragten (2009), Neumann & Holsten (2009), Hoffmann (2011), Neumann (2011) and references in Hötker (1990, Table 14).

Crop/Habitat	n	Mean density (Pairs/100ha)	SD	Percentage of population
Autumn-sown cereals	6	3.3	5.2	19
Spring-sown cereals	4	6.3	7.5	4
Maize	3	0	0	0
Oilseed rape	2	0.02	0.02	0
Beets	2	7.8	0.4	3
Potatoes	2	6.5	2.1	2
Sunflowers	1	0		0
Vegetables	2	5.5	4.9	1
All arable fields	34	4.0	6.7	29
Set-aside	15	8.3	11.7	2
Heathland, highland	4	70.3	39.9	4
Grassland intensive use	46	12.2	14.2	61
Grassland extensive use	6	16.5	16.3	
Saltmarsh	7	31.0	42.4	1
Moorland	9	39.6	20.7	5

Tab. Anpr3: Seasonal occurrence of Meadow Pipits in Germany. All figures are relative and refer to the maximum resident population of adults during the breeding season (100) or to the maximum number of migrants (column "Migration"). The row "presence" gives an estimate of the total resident population. "Reproduction" gives the percentage of adults involved in reproduction. The figures for the crops give estimates for the percentage of the German Meadow Pipit population present in each month. % of pop. gives the equivalent figure for the whole breeding season. "Preference (breed. Seas.)" ranks the habitats according to the density of breeding Meadow Pipits (maximum density set at 100). Sources see Table Anpr2.

Meadow Pipit	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Preference (breed. seas.)	% of pop.
Presence	2	5	80	100	100	100	100	100	100	80	10	5		
Reproduction	0	0	0	100	100	100	90	60	1	0	0	0		
Migration	0	0	0	100	70	0	0	0	60	100	5	0		
Cereals	0	0	7	23	23	23	23	23	11	0	0	0	5	23
Beets, Rape, Maize, others	2	2	2	6	6	6	6	6	6	3	1	3	2	6
Set aside	0	1	2	2	2	2	2	2	2	0	0	1	12	2
Grassland	0	2	61	61	61	61	61	61	73	69	5	1	18	61
Others	0	0	8	8	8	8	8	8	8	8	4	0	100	8

Statistics on crop-specific densities in the breeding season

The mixed effects model applied to the crop-specific densities revealed highly significant effects of the fixed factor "Crop" and the random factor "Study". The continous fixed parameter "Plotsize" did not have a significant influence on densities (Tab. Anpr4). Pairwise tests of crop types showed significant differences in densities between cropped arable land and intensively managed grassland, non-intensively managed grassland, heath- and moorland and saltmarshes and between set-aside and intensively managed grassland, non-intensively managed grassland, heath- and moorland and saltmarshes and between intensively managed grassland and heath- and moorland.

Tab. Anpr4: Summary of a mixed effects model.

Factor	DF	F	Wald-Z	p
Plotsize	68.0; 1.0	0.65		0.421
Crop	79.3; 5.0	14.43		<0.001
Study			3.35	0.001

Threats / sensibility (pesticide effects)

There is no direct evidence for pesticide effects on the food of Meadow Pipits. Meadow Pipits in theory could be affected by insecticides which directly reduce the food availability or by herbicides which kill potential host plants for insects and thus indirectly reduce food availability. Herbicides could also destroy the nest cover which can be seen as essential for successful breeding.

Braae et al. (1988) found a significantly positive effect of organic farming on Meadow Pipit numbers during the breeding season whilst Kragten (2009) found no difference in densities between conventional and organic farms in the Netherlands. Wilson et al. (1996) showed a significantly positive effect of organic farming on Meadow Pipits outside the breeding season.

The main threats for Meadow Pipits in Germany are habitat loss and habitat degradation. The proportion of grassland with a very short sward during the peak of the breeding season has a strong effect on the breeding density of Meadow Pipits (Hötker 1990, Douglas et al. 2008). Most of those crops that dominate the present agricultural landscape in Germany (autumn-sown cereals, oilseed rape, maize are too tall to allow foraging in the second half of the breeding season. Both set-aside and grassland are preferred breeding habitats (Tab. Anpa2). It is likely that the recent loss of grassland and set-aside in Germany will contribute to further reductions in population size.

Measures for risk-management

We found no direct evidence for the efficacy of pesticide-related measures for risk management. It is likely that leaving out from spraying of stripes along potential breeding sites (ditches, grassy margins) would increase the availability of food and nest cover. The chance of unintentional spraying of ditches and strips between fields would be reduced. Any reduction of spraying would probably lead to a higher availability of food and cover.

There is direct evidence that reducing the intensity of grassland management and set-aside increases the breeding density of Meadow Pipits. Block et al. (1993) stated a twofold increase in density within five years after a formerly intensively managed grassland had gone under an extensive management including set-aside. The clear preference of set-aside over arable fields (Litzbarski et al. 1993, Watson & Rae 1997, Ellenbroek et al. 1998, Hoffmann et al. 2012) also shows that set-aside can be regarded as a suitable measure to increase Meadow Pipit populations. The fact that Meadow Pipit nests in arable areas are situated nearly exclusively in ditches and grassy margins (Hötker 1990 and own data) shows the importance of these features for the occurrence of Meadow Pipits.

Meadow Pipits prefer short grass (see references above). Rewettening of grasslands usually results in retarded growth of grass. Increasing the groundwater level, therefore, is very often beneficial for Meadow Pipits. The same holds true for reducing the intensity of grassland management. Meadow Pipits are often associated with extensive grassland (see Tab. Anpr2).

Outside the breeding season Meadow Pipits prefer stubbles over bare ground (MOIN unpublished, Trenthorst study, Buckingham et al. 1999). Thus, stubbles may aid winter survival in Meadow Pipits.

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2.23 Yellow Wagtail (*Motacilla flava*) – Wiesenschafstelze – Order: Passeriformes

Geography

- NW Africa, Europe, N Asia to Alaska
- All over Germany

Status in Germany

- Breeding (May – July), migratory (passage: April – May and August – September)

Life cycle

- First breeding when 1 year old
- 1-2 broods per year, 5-6 eggs per clutch
- Life span: 1-4 years (max. 9 years)
- Generation length <3.3 years

Population, trend and conservation status

Populations of Yellow Wagtails breeding in Europe declined in the 1980s and remained stable afterwards.

Tab. MofI1: Populations (pairs), trends (mainly 1980 – 2005) and Red List status of Yellow Wagtails breeding in Europe, Germany and the German federal states.

Yellow Wagtail			Trend					
	Population (pairs)	Proportion of German population (%)	<-50%	-50% - -20%	stable	20% - 50%	>50%	Red List category
Baden-Württemberg	5000 - 7000	4.4						–
Bayern	15000 - 20000	13.0						3
Brandenburg + Berlin	8000 - 15000	8.5						V
Hessen	>10000	7.4						–
Mecklenburg-Vorpommern	15000 - 20000	13.0						V
Niedersachsen + Bremen	25000	18.5						–
Nordrhein-Westfalen	3000 - 5000	2.9						3
Rheinland-Pfalz								3
Saarland								1
Sachsen	4000 - 8000	4.4						3
Sachsen-Anhalt	15000 - 30000	16.6						V
Schleswig-Holstein + Hamburg	8500	6.3						–
Thüringen								–
Germany	**120,000 - 150,000**	**100%**						**–**
Europe	**7,900,000 - 14,000,000**							**–**

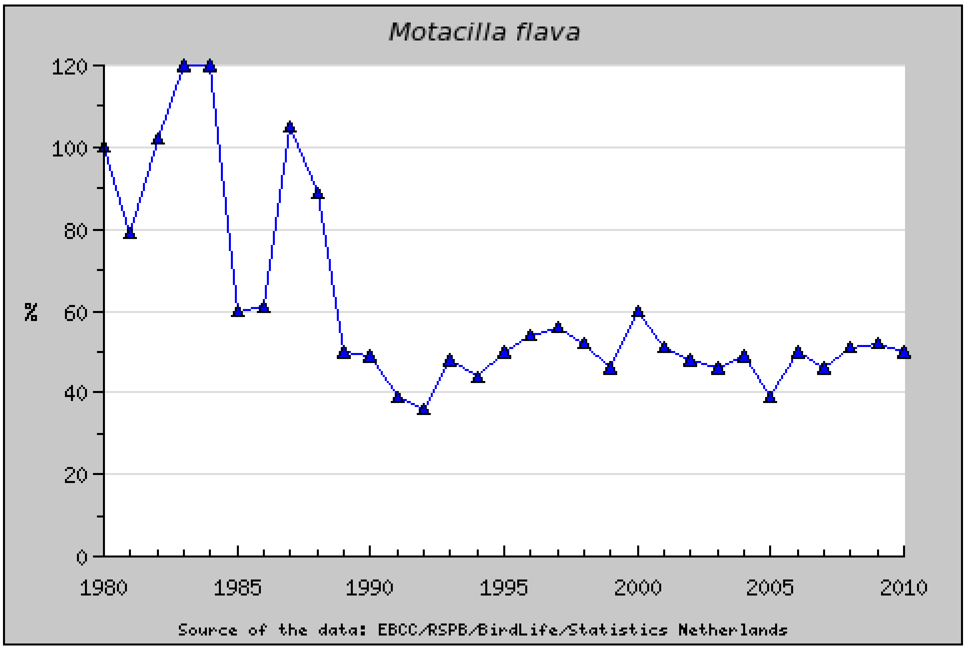

Fig. Mofl1: Population trend (TRIM indexes) of Yellow Wagtails in Europe (PECBMS 2012).

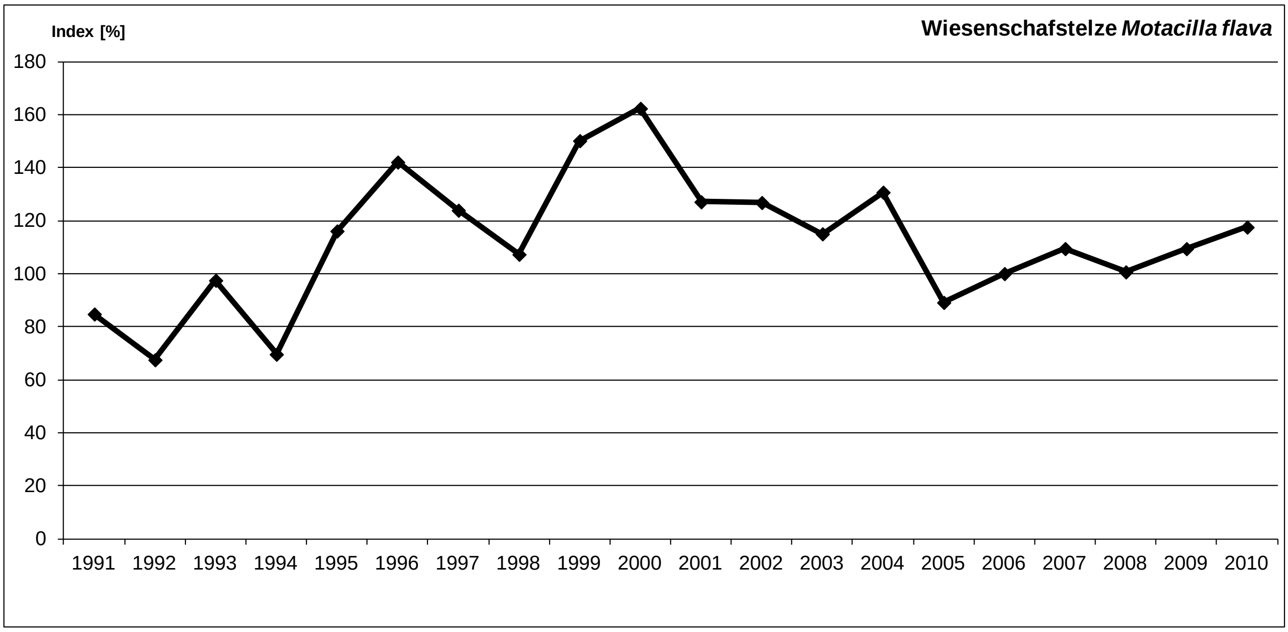

Fig. Mofl2: Population trend (TRIM indexes) of Yellow Wagtails in Germany (DDA 2012).

Diet

Yellow Wagtails feed on insects and other small invertebrates throughout the year. They take their prey from the ground, from plants and occasionally in flight. All their prey is potentially influenced by pesticides.

Habitat and densities

Yellow Wagtails live in open habitats, mostly on grassland and on arable fields. A small part of the population inhabits natural habitats such as salt marshes and moorlands. Nests are built on the ground within fields. Densities differed between studies but not very much between crops.

Highest densities were reported from spring-sown cereals, oilseed rape, autumn-sown cereals and alfalfa fields (see Tab. Mofl2 and references therein). Maize is a less preferred crop (Hötker et al. 2010). In the course of the season there is a clear shift in preference from autumn-sown cereals and oilseed rape towards lower crops such as potatoes and beets (Stiebel 1997, Kragten 2011, MOIN unpublished).

Tab. Mofl2. Densities (Pairs/100ha, arithmetic means of different studies) of Yellow Wagtails in different habitats and estimated percentages of Yellow Wagtails breeding in different habitats in Germany. N: number of studies. The density in natural und semi-natural habitats was assumed to be the same as in grassland. Sources: Dziewiaty & Bernardy (2007), Fuchs & Saacke (1999), Hoffmann (2008), Jansen et al. (2008), Joest (2011), Kragten (2009), Litzbarski et al. (1993), Neumann et al. (2009), Tryjanowski & Bajczyk (1999).

Crop	N	Mean density (Pairs/100ha)	SD density (Pairs/100ha)	Percentage of German population
Cereals	10	15.8	11.1	47
Maize	7	7.5	8.1	8
Other crops	12	13.5	9.4	18
Set-aside	6	8.3	13.3	1
Grassland	5	10.3	11.9	25
Natural and semi-natural habitats		(10.3)		1

Although densities are not particularly high, several authors consider set-aside fields to be important habitats for Yellow Wagtails (Block et al. 1993, Ellenbroek et al. 1998, Litzbarski et al. 1993, Sears 1992). Yellow Wagtails prefer first year set-aside (Stiebel 1997). Bare spots on the ground are important (Wilson et al. 2005) and crops with a ground cover of at least 60% are preferred (Kragten 2011).

The percentage breeding on sprayed cultures is estimated to 73% (Tab. Mofl2).

Statistics on crop-specific densities in the breeding season

The mixed effects model applied to the crop-specific densities did not reveal significant effects of the fixed factor "Crop", the random factor "Study" and the continous fixed parameter "Plotsize" (Tab. Mofl3).

Tab. Mofl3: Summary of a mixed effects model.

Factor	DF	F	Wald-Z	p
Plotsize	6.5; 1.0	0.49		0.508
Crop	35.5; 2.0	1.62		0.212
Study			0.80	0.422

Threats / sensibility (pesticide effects)

There is no evidence for pesticide-related effects on the population of Yellow Wagtails in Germany. Yellow Wagtails do not consistently profit from organic farming. Populations on organic fields were found to be lower than on conventional fields by Kragten (2009), Neumann & Koop (2004), MOIN (unpublished) but higher by Christensen et al. (1996).

Kragten (2011) showed a shift in habitat preference of Yellow Wagtails during the breeding season. Yellow Wagtails can change breeding habitat only if suitable habitats are available within their territories. This implies a certain crop diversity. If this diversity is lost, Yellow Wagtails will lose breeding sites. Further threats Yellow Wagtails face are the loss of set-aside, the loss of grassland, in particular low intensity grassland, and the loss of grassy margins around farm tracks, field edges and ditches. The loss of animal husbandry which in itself is one of the causes for the loss of grassland has negative effects particularly of Yellow Wagtails because they are often associated with grazing animals (own observations).

Measures for risk-management

Breeding habitats of Yellow Wagtails can be preserved by the protection of remaining semi-natural grassland or by set-up of low intensity grassland. The creation of extended grass-dominated margins of fields and along roads, ditches and water courses can create foraging and breeding habitats. Extensified grassland management, that means retarded mowing and non or late second mowing (7 to 8 weeks after first mowing) can increase the breeding success in mown cultures (Fuchs & Saacke 1999).

Gras management (reduction of chemical input, diversification of sward) had a positive effect on the occurrence of Yellow Wagtails in areas of mixed farming in the UK, but had a negative effect in areas of pure arable farming (Baker et al. 2012).

Yellow Wagtails would also profit from increasing set-aside and increasing crop diversity. In particular low growing cultures as potatoes or beet seem to be crucial in the second half of the breeding season (Kragten 2011).

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2.24 Linnet (*Carduelis cannabina*) – Bluthänfling – Order: Passeriformes

Geography

- Europe, NW Africa to central Siberia
- All over Germany

Status in Germany

- Breeding (April – Aug.), migratory, some birds wintering

Life cycle

- First breeding when 1 year old
- 1-2 broods per year, 4-6 eggs per clutch
- Life span: 1-4 years (max. 12 years)
- Generation length <3.3 years

Population, trend and conservation status

Most populations of Linnets breeding in Germany and Europe are declining (Tab. Caca1). In Europe the decline started in the mid 1990s (Fig. Caca1).

Tab. Caca1: Populations (pairs), trends (mainly 1980 – 2005) and Red List status of Linnets breeding in Europe, Germany and the German federal states.

Linnet			Trend					
	Population (pairs)	Proportion of German population (%)	<-50%	-50% - -20%	stable	20% - 50%	>50%	Red List category
Baden-Württemberg	20000 - 45000	5.4						V
Bayern	30000 - 60000	8.8						3
Brandenburg + Berlin	10000 - 20000	2.9						3
Hessen	>10000	>2.0						–
Mecklenburg-Vorpommern	100000 - 130000	22.5						–
Niedersachsen + Bremen	80000	15.7						V
Nordrhein-Westfalen	31.000	6.1						V
Rheinland-Pfalz								–
Saarland								V
Sachsen	9000 - 18000	2.6						–
Sachsen-Anhalt	40000 - 60000	10.0						V
Schleswig-Holstein + Hamburg	15000	2.9						V
Thüringen								–
Germany	**440,000 - 580,000**							**V**
Europe	**10,000,000 - 28,000,000**							**Spec2**

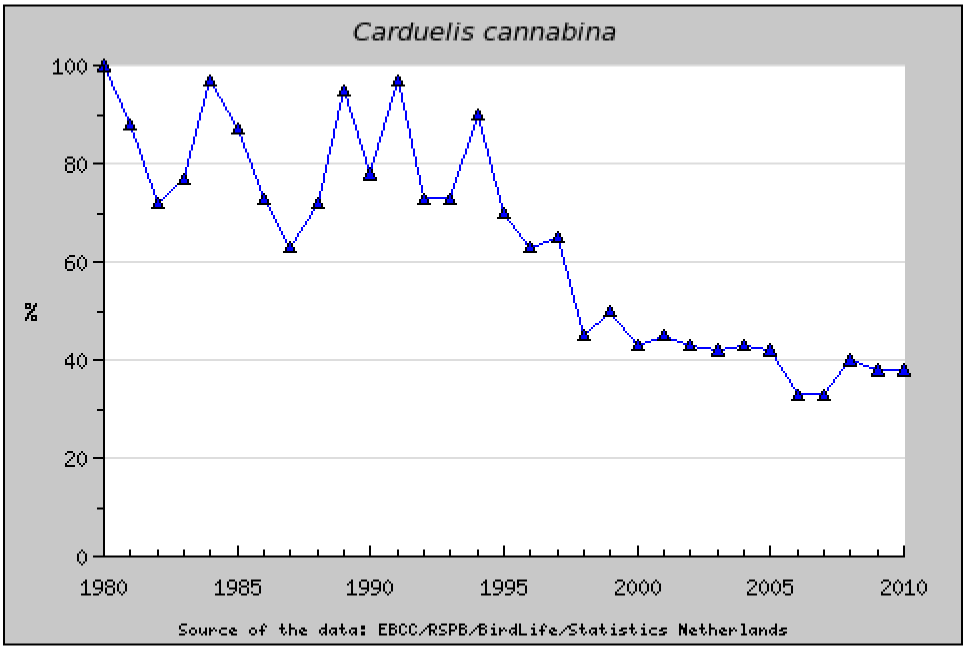

Fig. Caca1: Population trend (TRIM indexes) of Linnets in Europe (PECBMS 2012).

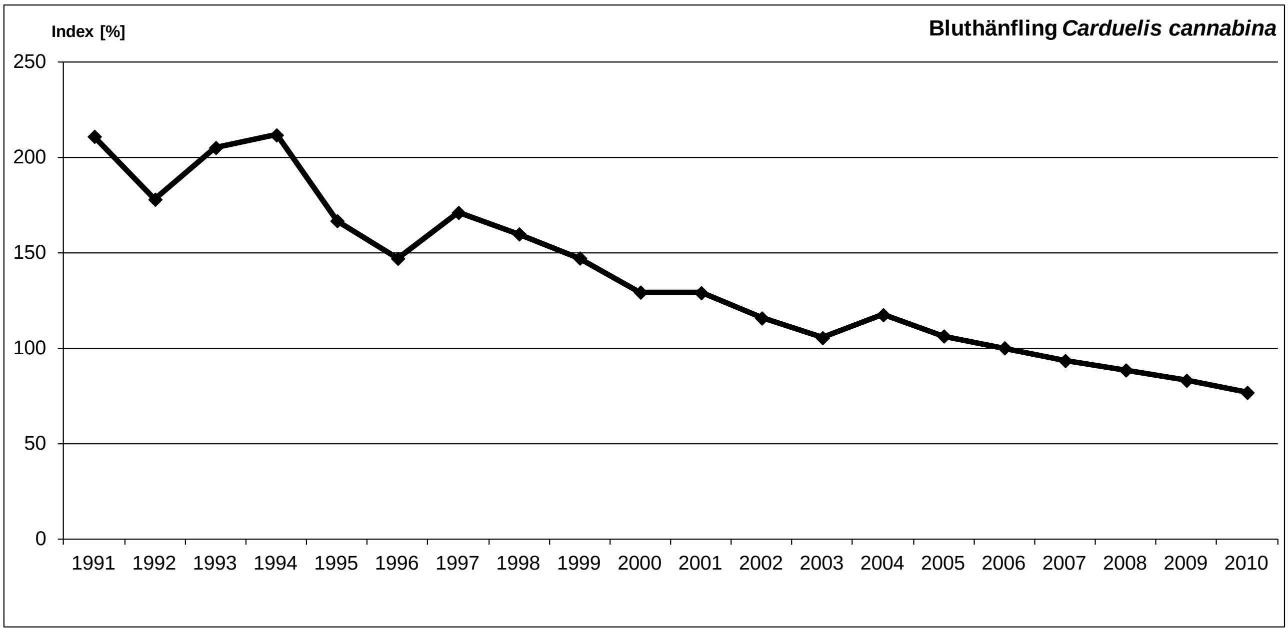

Fig. Caca2: Population trend (TRIM indexes) of Linnets in Germany (DDA 2012).

Diet

Linnets nearly exclusively feed on seeds of many taxa of herbaceous plants and grasses (Eybert et al. 1995a). They prefer milk-ripe seeds. In summer, Linnets usually take the seeds from the plants, more rarely from the ground. Ground feeding prevails in winter. Insects, seeds of trees and other fruits play a marginal role in the diet of both adults and nestlings.

Crop seeds can form a substantial part of the diet. This holds especially true for oilseed rape seeds which regularly formed more than 70% of the nestling diet in an English study site (Moorcroft et al. 2006, see also Bradbury et al. 2003). It is unlikely, however, that Linnets can nourish their offspring entirely by crop seeds in all parts of the breeding season. A rough estimate of the percentage of food potentially affected by pesticides is 50%.

Habitat and densities

All the year around, Linnets occur in open landscapes. They feed on grassland and arable land. Linnets build their nests in bushes, hedges and trees. Nest sites are often relatively far away from feeding grounds.

Linnets nest in hedgerows and bushes, other stands of dense vegetation and rarely on the ground. Nests are placed outside cropped fields. Nest site selection seems to be more influenced by the quality of the hedgerow than by the surrounding crops (Green et al. 1994). Gaßmann & Glück (1993) found a relationship between the visibility of the nest in the hedgerow and the breeding success.

During the breeding season linnets clearly preferred set-aside fields over arable fields for foraging (Sears 1992, Berg & Part 1994, Eybert et al. 1995, Nagy et al. 2009). Grassland was preferred over arable areas (Sears 1992, Eybert et al. 1995, Parish et al. 1995). In the UK areas with mixed farming held higher densities than pure grassland or pure arable areas (Gregory & Baillie 1998, Gregory 1999). At farm scale densities of breeding Linnets increased with the percentages of un-cropped land within farms. Farms with less than 7.5% un-cropped land held considerably lower Linnet densities than farms with more than 7.5% un-cropped land (Henderson et al. 2012).

Among arable crops Linnets strongly preferred oilseed rape (Eybert et al. 1995). Rape seeds were the most important chick diet at the end of the season (Moorcroft et al. 2006). Siriwardena et al. (2001), however, found a negative effect of rape cultivation on breeding performance, whilst Bradbury et al. (2003) could show that nestlings were not affected by the crop types in the vicinity of their nests (see also Green et al. 1994).

During the non-breeding season Linnets prefer stubble fields and set-aside (Wilson et al. 1996, Buckingham et al. 1999). In a study in UK, field occupancy by Linnets was found to be associated with high abundance of seeds known to be important parts of the diet (Moorcroft et al. 2002).

Linseed and rape stubbles are strongly preferred in the first weeks after harvest (Butler et al. 2010). Linnets preferred grassland and especially grassy margins over arable land (Parish et al. 1995). Autumn-sown cereals were avoided. Linnets preferred organically farmed fields (Wilson et al. 1996). Bare or short vegetated spots were important feeding sites (Wilson, J. D. et al. 2005).

There are few data that help assessing what percentage of food Linnets take from sprayed cultures in Germany. As most Linnets forage on arable fields, but prefer to feed on non-sprayed plots like set-aside, the share of food Linnets take from sprayed fields is probably somewhat less than the share of sprayed fields among open habitats in Germany (ca. 70%). The rough estimate for Linnets is 60%.

Threats / sensibility (pesticide effects)

There is no direct evidence of indirect effects of pesticides on Linnets. Many Linnets feed on arable fields. As the diet of adults and chicks contains many wild herb seeds, there is a risk that the food supply is reduced by herbicides. The possibility of an indirect effect of pesticides is supported by studies that report higher densities of Linnets on organic than on conventional fields (Chamberlain et al. 1999), some of the results being statistically significant (Christensen et al. 1996).

An analysis of ring recoveries in UK showed that insufficient survival rates can not be the sole cause for population trends (Siriwardena et al. 1998). The declines of Linnet populations in Europe are possibly associated with losses in crop weeds (Moorcroft et al. 2006) which provide critical food resources when crop seeds are not available. Losses of field margins, set-aside and non-intensive grassland are causes for these losses. Siriwardena et al. (2000) stated that the fall in breeding performance of Linnets had occurred most clearly in arable and in grazing areas, but not in mixed farmland. The ongoing specialisation of farms is seen to be a threat to the population.

The loss of potential nest sites such as hedgerows may also affect local populations (Ranftl & Schwab 1990, Macdonald & Johnson 1995).

Measures for risk-management

As effects of pesticide applications cannot be ruled out reductions in the application of herbicides would probably increase the availability of food for Linnets. Organic farming would probably also be beneficial for the population.

All management that favours farm weeds like set-aside or the establishment of unmanaged field margins such as flower strips, beetle banks, uncultivated strips along ditches and farm tracks are beneficial for Linnet populations (Ranftl & Schwab 1990, Joest 2011)). Mixed, unsprayed and unfertilized alfalfa cultures attracted Linnets, unsprayed cereals sown in wide rows and conventional winter cereals did not (Joest 2011). Wild bird cover crops increased densities in winter (Stoate et al. 2003). As mentioned above, Henderson et al. (2012) found that farms with less than 7.5% un-cropped land held considerably lower Linnet densities than farms with more than 7.5% un-cropped land.

When in short supply, planting bushes and hedgerows is essential for providing safe nest sites populations (Ranftl & Schwab 1990).

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2.25 Corn Bunting (*Emberiza calandra*) – Grauammer – Order: Passeriformes

Geography

- Europe, Middle East, N Africa
- All over Germany, rare in the western part of the country

Status in Germany

- Breeding (May – Aug.), sedentary (partly migratory)

Life cycle

- First breeding when 1 year old
- 1-2 broods per year, 4-5 eggs per clutch
- Life span: few years (max. 10 years)
- Generation time <3.3 years

Population, trend and conservation status

Corn Bunting populations in Germany have been stable (between 1990 and 2010) whilst the European population has steeply declined (see Tab. Emca1). The mayor decline in Europe occurred in the 1980s or earlier (Fig. Emca1). In Germany populations developed differently in different parts of the country. The large increase in Brandenburg has been caused by a relatively high percentage of set-aside (Schwarz & Flade 2007, Ryslawy & Mädlow 2008). In general Corn Bunting populations showed more positive trends in the eastern federal states compared to the western federal states.

Tab. Emca1: Populations (pairs), trends (mainly 1980 – 2005) and Red List status of Corn Buntings breeding in Europe, Germany and the German federal states.

Corn Bunting			Trend					
	Population (pairs)	Proportion of German population (%)	<-50%	-50% - -20%	stable	20% - 50%	>50%	Red List category
Baden-Württemberg	500 - 800	2.4	■					2
Bayern	200 - 400	1.1	■					1
Brandenburg + Berlin	8000 - 15000	44.0					■	–
Hessen	200 - 300	0.9					■	–
Mecklenburg-Vorpommern	10000 - 14000	46.0			■			–
Niedersachsen + Bremen	50	0.2	■					1
Nordrhein-Westfalen	400 - 600	1.9	■					1
Rheinland-Pfalz								–
Saarland			■					2
Sachsen	1000 - 1500	4.8			■			2
Sachsen-Anhalt	2000 - 4000	11.5		■				3
Schleswig-Holstein + Hamburg	155	0.5				■		1
Thüringen								–
Germany	**21,000 - 31,000**	**100%**			■			**3**
Europe	**7,900,000 - 22,000,000**		■					**Spec2**

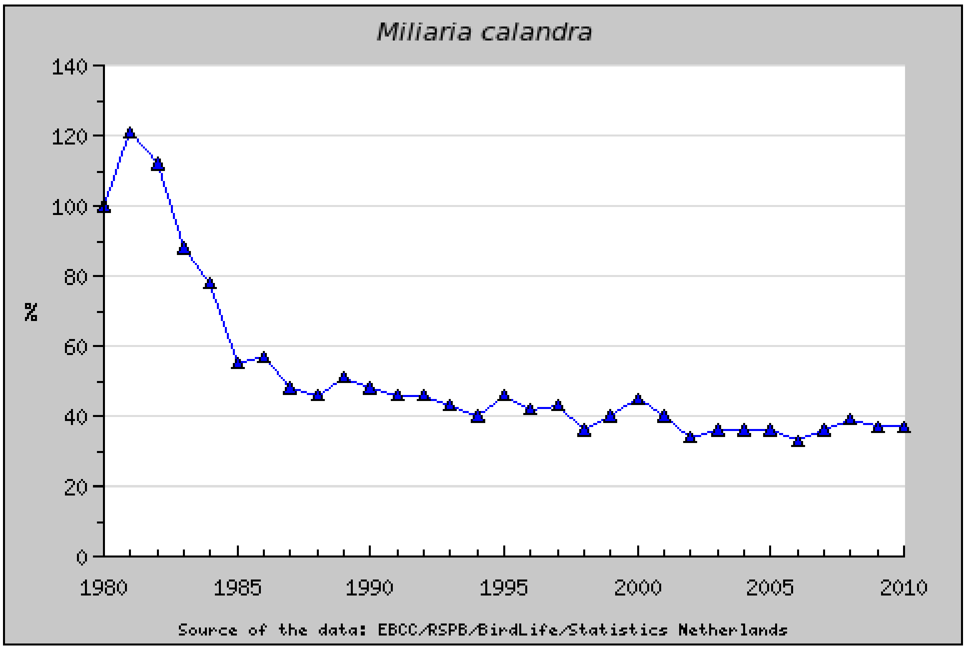

Fig. Emca1: Population trend (TRIM indexes) of Corn Buntings in Europe (PECBMS 2012).

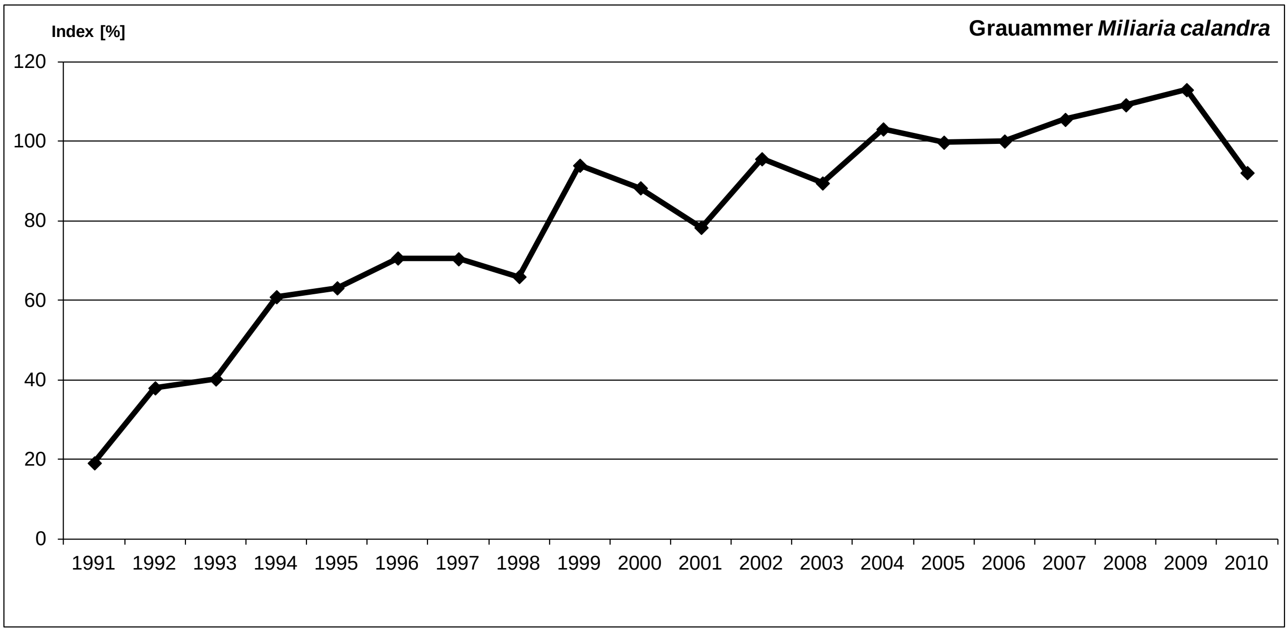

Fig. Emca2: Population trend (TRIM indexes) of Corn Buntings in Germany (DDA 2012).

Diet

Corn Buntings feed on seeds and arthropods. Seeds dominate the diet outside the breeding season. Cereal grains are preferred (wheat, oats, barley, Perkins et al. 2007). During the breeding season adults take more arthropod food than during the non-breeding season. Seeds from non-crop species are particularly important and comprise, together with invertebrates, almost 100% of the diet (Glutz von Blotzheim & Bauer 1997). Arthropods are the most important food items for the chicks (Tab. Emca2, Ward & Aebischer 1994). Although chick diet may vary between sites according to the availability of different arthropod taxa, animal food seems to be crucial for chick development. Animal food items accounted for 82% of chick food items in central European studies (summarized in Tab. Emca2) and for 90% in an UK study (Ward & Aebischer 1994). The percentage of diet affected by pesticides is estimated as 82% for chicks, 95% for adults during the breeding season (allowing for some cereal grains taken) and 5% during the non-breeding season.

Tab. Emca2: Food of Corn Bunting chicks (mean percentages of sources cited in Glutz von Blotzheim & Bauer 1997).

Food	% of items
Insects	69.7
Worms	2.0
Arachnida	9.7
Gastropodes	0.7
Cereal seeds	16.1
Other seeds	0.1
Green plant parts	0.0
Others	1.8

Habitat and densities

During the breeding season Corn Buntings live in open habitats, usually on arable land or grassland with some song posts (Jansen 2001, Bezzel et al. 2005, Eichstädt et al. 2006). Hedges and trees are avoided (Mason & MacDonald 2000, Wakeham-Dawson & Aebischer 1997). Corn Buntings need low swards or even bare ground for foraging (Wilson et al. 2005). The nests are built on the ground where they are usually well concealed in higher vegetation. Nest sites are relatively often but not exclusively outside arable fields (Tab. Emca3) but on field margins and next to ditches. Exceptions are set-aside and grassland where nests are often on the fields (Glutz von Blotzheim & Bauer 1997). On average 39% of nests were found on arable fields (Tab. Emca3). Nests in crops are more endangered by agricultural activities (Crick et al. 1997).

Tab. Emca3: Habitats of Corn Buntings nests. Sources (Hegelbach 1984, Glutz von Blotzheim & Bauer 1997, Brickle, N.W. & Harper 2002, Suter et al. 2002).

Site	% nests on arable land	N	Source
East Germany	15	39	Gliemann 1973 (cited by Glutz von Blotzheim & Bauer 1997)
Rheinland, Germany	45	129	Mildenberger 1984 (cited by Glutz von Blotzheim & Bauer 1997)
Reusstal, Switzerland	0	113	Hegelbach 1984
West Sussex, UK	69	120	Brickle & Harper 2002
Grosses Moos, Switzerland	66	35	Suter et al. 2002

Set-aside is the widely preferred field type (Watson & Rae 1997, Hoffmann et al. 2012, Tab. Emca4). Many Corn Bunting territories contain fallow and/or grassland (Eislöffel 1996). In Thüringen more than half of the grassland settled by Corn Buntings is not intensively managed (Jansen 2001). Hoffmann et al. (2012) found that in an intensively managed arable site most Corn Bunting territories contained more than 27% of set-aside and less than 10% of maize. The percentages of set-aside and maize in the study site were 12% and 23% respectively. In Denmark high densities of Corn Buntings are associated with mixed farming, which includes relatively high proportions of grassland (both permanent and rotational) and spring-sown cereals (Fox & Heldbjerg 2008).

Wakeham-Dawson & Aebischer (1997) found higher densities of Corn Bunting territories on summer cereals than on winter cereals. Other authors found little preference for particular crops or other land-uses during the breeding season but a strong preference for territories encompassing field boundaries without hedges (Mason & MacDonald 2000, see also Tab. Emca5). Ditches and farm tracks are also preferred features (Eislöffel 1996, Jansen 2001).

Suter et al. (2002) found that the first nests were initiated on wheat fields and on grassland. Potatoes became the most important habitat in the second half of the season.

Brickle et al. (2000) found that invertebrate density in non-intensified grassland and field margins was almost eight times higher than the poorest habitats (intensively managed grass and winter sown wheat) and site selection for foraging was significantly correlated with food availability. Corn Buntings foraged preferably in cereal fields that had received fewer applications of pesticides (herbicides, fungicides and insecticides). Foraging areas had significantly higher densities of food items. Boatman et al. (2004) showed that arthropod abundance in the vicinity of nests had a significant effect on the survival of broods.

In Germany, nearly 89% of Corn Buntings breed on arable fields (Tab. Emca4). Some of these fields are not sprayed and some food is taken from field margins, grasslands and other habitats that are not or only occasionally or accidentally sprayed. The percentage of food taken from sprayed cultures can only be estimated. The estimate used here is 75%. As there is little evidence on switches of habitat preference throughout the season and between the breeding and the non-breeding season, this value is used for all seasons.

Tab. Emca4: Mean densities of Corn Buntings breeding in different habitat types in Europe and percentage of Corn Buntings breeding in these crop types in Germany. Sources: Jansen et al. (2008) , Litzbarski et al. (1993), Fischer & Schneider (1996), Wakeham-Dawson & Aebischer (1997), Watson & Rae (1997), Fuchs & Saacke (1999), Dziewiaty & Bernardy (2007), Hoffmann (2011), Hoffmann et al. (2012).

Crop/Habitat	n	Mean density (Pairs/100ha)	SD	Percentage of population
All arable fields	23	1.3	2.2	88.7
Grassland	5	2.7	2.2	9.7
Set-aside	17	8.7	11.1	1.6

Tab. Emca5: Mean densities of Corn Buntings breeding in different crop types in Europe. Sources: Jansen et al. (2008) , Litzbarski et al. (1993), Fischer & Schneider (1996), Wakeham-Dawson & Aebischer (1997), Watson & Rae (1997), Fuchs & Saacke (1999), Dziewiaty & Bernardy (2007), Hoffmann (2011), Hoffmann et al. (2012).

Crop/Habitat	n	Mean density (Pairs/100ha)	SD
Autumn-sown cereals	8	2.0	1.8
Spring-sown cereals	1	9.2	
Maize	4	0.7	1.2
Oilseed rape	2	1.5	0.0
Sunflowers	1	0.0	
Grassland intensive use	2	1.5	2.1
Grassland extensive use	3	3.4	2.3

Outside the breeding Corn Buntings basically occur in the same habitats than during the breeding season. Grassy features within arable areas and stubbles are preferred (Mason &

MacDonald 2000), probably because they are associated with high seed abundances (Moorcroft et al. 2002).

Corn Buntings avoid non-mown stripes (Bellebaum 2008).

Statistics on crop-specific densities in the breeding season

The mixed effects model applied to the crop-specific densities revealed a nearly significant effects of the fixed factor "Crop" and the random factor "Study". The continous fixed parameter "Plotsize" did not have a significant influence on densities (Tab. Emca6) and the random factor "Study" could not be modelled due to lack of data. Pairwise tests of crop types showed significant differences in densities between set-aside and maize.

Tab. Emca6: Summary of a mixed effects model.

Factor	DF	F	Wald-Z	p
Plotsize	25.0; 1.0	1.5		0.232
Crop	25.0; 4.0	2.8		0.05
Study			-	-

Threats / sensibility (pesticide effects)

Boatman et al. (2004) and Brickle et al. (2000) could show that breeding performance of Corn Buntings was indirectly affected by pesticides. Arthropod abundance in the vicinity of nests had a significant effect on the survival of broods. Invertebrate density (combining the four main food items) was significantly negatively correlated with the number of pesticide applications. In accordance with these results Christensen et al. (1996) found significantly more Corn Buntings on organic farms than on conventional farms.

In a broader context, agricultural intensification in general and changes in land use are thought to be an important factor for the decline of Corn Bunting populations (Donald & Forrest 1995, Donald & Aebischer 1997, Brickle et al. 2000b, Fox & Heldbjerg 2008). It is not exactly known, however, whether the main reasons for the observed declines occur during the reproductive season or during the non breeding season. Siriwardena et al. (2000) did not find any associations between changes in breeding success and the trend of the population in UK. Baker et al. (2012) could show that both measures set up to improve winter survival (maintenance of stubbles throughout the winter) as well as measure set up to increase breeding habitats (field margin management) had a positive effect on the population trend.

Intensive fertilization and the change from summer to winter crops has led to early harvesting dates which in turn may have caused additional nest destruction, a truncation of the breeding season and food shortage due to the lack of unripe grain in spring (Brickle & Harper 2002). Additionally the loss of rotational grassland seemed to have a negative effect on Corn Bunting populations (Ward & Aebischer 1994, Fox & Heldbjerg 2008). Frequent mowing causes many nest failures (Perkins et al. 2008, Perkins et al. 2011). A general tendency to increase field sizes which in turn means a loss of field edges, hedgerows and farmland tracks also reduces the availability of suitable habitats for Corn Buntings.

During the period of obligatory set-aside due to EU market regulations Corn Bunting populations increased in some regions (Eichstädt et al. 2006, Schwarz & Flade 2007). As the area covered by set-aside and grassland has been decreasing since several years

(Bundesministerium für Ernährung Landwirtschaft und Verbraucherschutz 2011) the German Corn Bunting population is threatened by a significant loss of habitats.

Measures for risk-management

There is no experimental evidence for managing the risks for Corn Buntings associated with pesticide applications. The studies of Boatman et al. (2004) and Brickle et al. (2000) show that breeding success of Corn Buntings could possibly be increased by refraining from spraying or by reducing the pesticide applications within Corn Bunting home ranges. Any measure which reduces the amount of pesticides within the feeding range of Corn Bunting pairs would probably be beneficial for the breeding success of the species.

Corn Buntings prefer set-aside, grasslands, field margins and other non-cultivated features (see above). The preservation and the set-up of such features are beneficial to Corn Bunting populations (Block et al. 1993). The same holds true for the maintenance of stubbles throughout winter (Baker et al. 2012).

Perkins et al. (2008) and Perkins et al. (2011) showed that agri-environmental schemes that were targeted for Corn Buntings and included measures to increase food availability (e.g. unharvested crop patches) and measures to increase nest survival (late mowing) reversed population declines. Measures took place on about 10% of the farm surface (own calculations). The authors estimated that 0.5% of the land in the current range of Corn Buntings in Scotland had to be managed in order to reverse the losses in the whole country. By comparing population trends in western Germany, eastern Germany and large biosphere reserves, Flade et al. (2010) could show by that Corn Bunting population increased when the proportion of set-aside exceeded 10% and decreased when it fell below 10%. Flade et al. (2003) state that set-aside fields should be combined to blocks of 15-20 ha.

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2.26 Yellowhammer (*Emberiza citrinella*) – Goldammer – Order: Passeriformes

Geography

- Europe to central Siberia
- All over Germany

Status in Germany

- Breeding (April – Aug.), migratory (partly sedentary)

Life cycle

- First breeding when 1 year old
- 2 broods per year, 3-5 eggs per clutch
- Life span: few years (max. 13 years)
- Generation length <3.3 years

Population, trend and conservation status

Populations of Yellowhammers breeding in Europe have been more or less continuously declining since at least the beginning of the 1980s (Fig. Emci1).

Tab. Emci1: Populations (pairs), trends (mainly 1980 – 2005) and Red List status of Yellowhammers breeding in Europe, Germany and the German federal states.

Yellowhammer			Trend					
	Population (pairs)	Proportion of German population (%)	<-50%	-50% - -20%	stable	20% - 50%	>50%	Red List category
Baden-Württemberg	200000 - 300000	15.6						V
Bayern	250000 - 500000	23.4						V
Brandenburg + Berlin	70000 - 130000	6.3						–
Hessen	>10000	>0,6						–
Mecklenburg-Vorpommern	170000 - 200000	11.6						–
Niedersachsen + Bremen	200000	12.5						–
Nordrhein-Westfalen	173000	10.8						V
Rheinland-Pfalz								–
Saarland								–
Sachsen	25000 - 50000	2.3						–
Sachsen-Anhalt	50000 - 100000	4.2						V
Schleswig-Holstein + Hamburg	31000	1.9						V
Thüringen								–
Germany	**1,200,000 - 2,000,000**							–
Europe	**18,000,000 - 31,000,000**							**–**

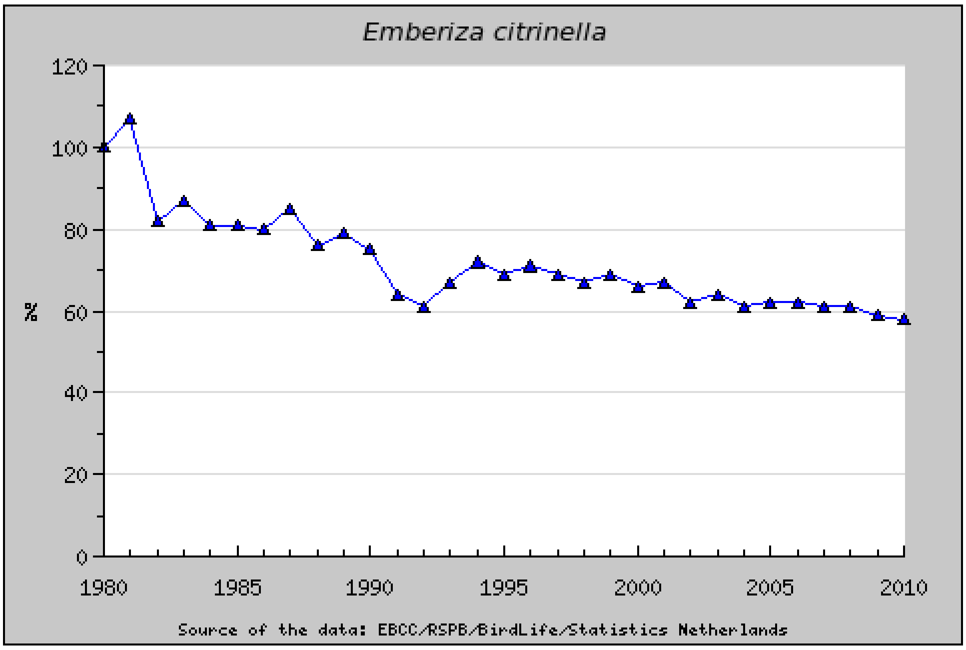

Fig. Emci1: Population trend (TRIM indexes) of Yellowhammers in Europe (PECBMS 2012).

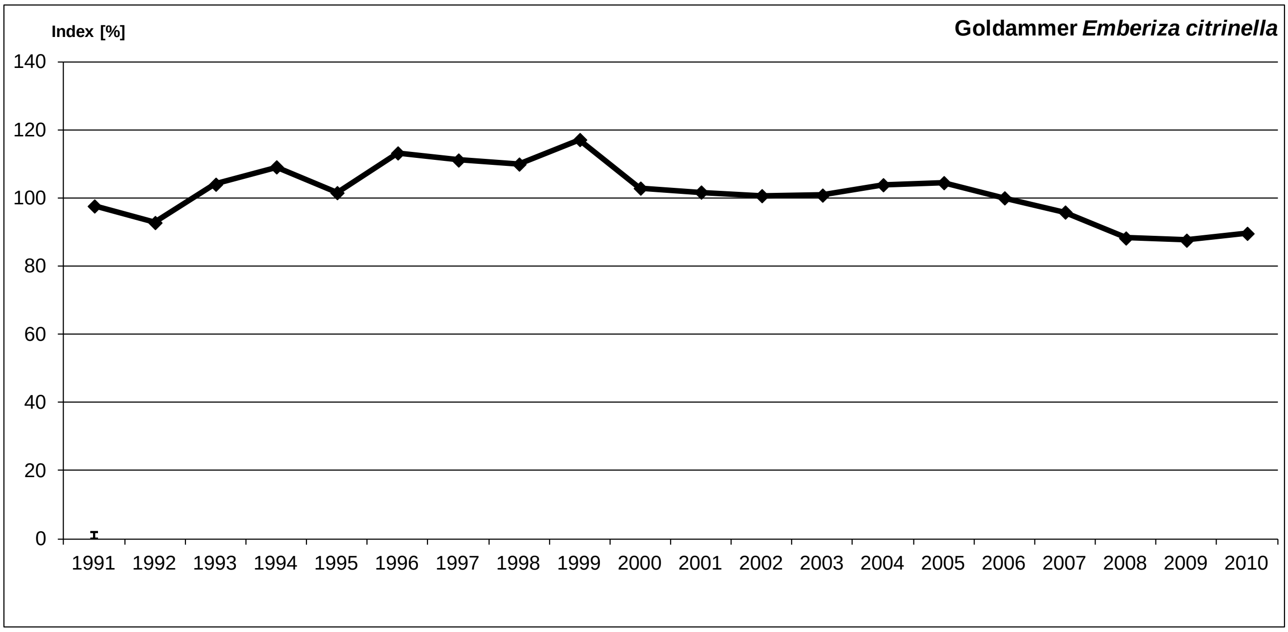

Fig. Emci2: Population trend (TRIM indexes) of Yellowhammers in Germany (DDA 2012).

Diet

Yellowhammers take their food from the ground and from plants. During the breeding season, they mainly feed on insects and other small invertebrates. Seeds of farmland weeds and, when available, crop seeds are also taken. Nestlings are almost entirely fed with insect larvae, insects and other small invertebrates. Larvae of Coleoptera, Lepidoptera, Diptera as well as Archnida predominate (Stoate et al. 1998, Hart et al. 2006a). Cereal grains usually comprise less than 10% of the diet of nestlings (Lille 1996a).

During the non-breeding season, seeds become more important and insects loose their importance. Yellowhammers prefer cereal grains (wheat, oats > barley) and avoid other weeds (Perkins et al. 2007).

From literature data (see above and Glutz von Blotzheim & Bauer 1997) following percentages of diet theoretically affected by pesticides (invertebrates, seeds of farmland weeds) are estimated: nestlings 95%, adults during the breeding season 80% and adults during the non-breeding season 30%.

Habitat and densities

Yellowhammers nest in open landscapes. Densities are generally higher in less intensively farmed sites than in intensively farmed sites (Schifferli et al. 1999). In general, Yellowhammers prefer arable landscapes over grasslands (Gregory 1999). Small plots of grass vegetation within arable field, however, may be preferred for foraging (Table Emci2). Yellowhammers also breed in natural and semi-natural habitats like forest clearings, moorlands and heathlands. They also occur on vineyards and on the edges of orchards and hops fields.

Tab. Emci2: Seasonal occurrence of Yellowhammers in Germany and preference for different habitats as feeding sites. Sources: Lille (1996), MOIN (unpublished).

Yellowhammer	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Pref.
Presence	1	5	75	100	100	100	100	100	100	70	20	1	
Autumn-sown cereals			0.00	-0.49	-0.56	-0.27	-0.16	-0.26	-0.40	-0.55	-0.14		-0.31
Spring-sown cereals			0.14	-0.57	0.04	-0.04	-0.54	-1	-0.33				-0.33
Maize				0.52	0.57	0.61	-0.84	-0.75	-0.66	-0.10	-0.65		-0.16
Rape			-0.10	-0.80	-0.95	-0.50	0.20	0.27	-0.37	-0.53	-0.72		-0.39
Alfalfa			0.75	0.75	0.80	0.71	0.70	0.70	0.20				0.66
Set-aside			-0.30	0.05	-0.37	-0.27	-0.48	-0.83	-0.20	-0.30	-0.70		-0.38
Borderlines			-0.80	-0.65	0.60	0.75	0.65	0.22	-0.05	0.30	-0.51		0.06
Bare ground (tilled)			0.40	0.80	-1	-0.18	0.60	0.13	0.01	0.15	0.76		0.19
Grassland			0.14	0.14	0.63	0.63							0.39

Nests are situated on the ground, usually outside crop fields on field margins or at ditches, often beneath bushes or hedgerows. Yellowhammer territories are usually associated with hedgerows or bushes (Green et al. 1994, Berg & Part 1994, Pfister et al. 1986, Nicklaus 1992, Dornberger 1993, Parish et al. 1995). The kind and the size of bushes and hedgerows influences the occurrence of Yellowhammers, thorny plants are preferred (Pfister et al. 1986, Green et al. 1994). A coverage of 4% of hedgerows on a landscape scale was associated with the highest densities (Pfister et al. 1986).

Besides the simple occurrence of hedgerows and bushes, uncultivated strips of field margins associated with hedgerows and bushes seem to be an essential requirement for the breeding of Yellowhammers (Biber 1993b, Stoate & Szczur 2001a). Several authors report positive correlations between the width or the extent of field margins and breeding density of Yellowhammers (Stoate & Szczur 2001a, Hötker et al. 2004a, Whittingham et al. 2005).

Yellowhammers forage on open ground, both on crops and on field margins. Preferences for different crops seem to be sites-specific rather than general (Pfister et al. 1986, Biber 1993b, Berg & Part 1994, Hoffmann et al. 2012). Some patterns, however, are consistent between different studies: Yellowhammers prefer field margins, borderlines and patches with open ground (Biber 1993b, Lille 1996, Stoate et al. 1998). The breeding success of Yellowhammers seems to be largely unaffected by the composition of crops in the surroundings (Biber 1993a, Bradbury et al. 2000). Whittingham et al. (2005) could show that breeding density of Yellowhammers in UK was associated with the presence of rotational set-aside fields in winter. Biber (1993b) noticed a shift in field use from tall-growing crops (autumn-sown cereals, maize) to shorter crops (spring-sown cereals, beets and grassland) towards the end of the breeding season.

During the non-breeding season, Yellowhammers inhabit open and semi-open landscapes. For foraging, they strongly prefer stubble fields over most other field types (Bauer & Ranftl 1996, Wilson et al. 1996, Buckingham et al. 1999, Bellebaum 2008). Stubbles with naturally established weeds were preferred over sown cover (Wilson et al. 1996). Stubble fields are often visited shortly after harvest (Butler et al. 2010). Moorcroft et al. (2002) showed that field occupancy in Yellowhammers was often associated with high seed abundance on the fields.

In the studies of Lille (1996) and Biber (1993b) 58% and 72%, respectively, of the foraging trips (own calculations) ended on sprayed cultures. The percentage of food taken from sprayed cultures was estimated to be 65% (mean value for both studies). Outside the breeding season, Yellowhammers obviously spent more time on sprayed cultures. The rough estimate for the percentage of food taken from sprayed cultures is 90%.

Threats / sensibility (pesticide effects)

Morris et al. (2005) presented evidence for some indicators of an indirect effect of insecticides on the breeding success of Yellowhammers in the UK. Arthropod food of Yellowhammers and chick condition were poorer at sites that had received insecticide applications in summer compared to plots which had not been sprayed in summer. Boatman et al. (2004) were able to present a link between spraying and brood reductions that were likely a result of the food reduction through spraying. Hart et al. (2006) showed that insecticide application reduced food availability for Yellowhammers during the chick rearing period. They also could show a correlation between body weight and food availability. Greater mean body mass and condition corresponded with a lower incidence of brood reduction. Hence, there is evidence for a negative effect of insecticide application on the breeding performance of Yellowhammers.

In accordance with this finding, organic farming seems to have a positive effect on breeding performance and density of breeding Yellowhammers. Petersen et al. (1995) found significantly higher clutch sizes on organic rather than on conventional farmland. Christensen et al. (1996) and Chamberlain et al. (1999) found higher (although not significantly) densities of Yellowhammers breeding on organic than on conventional farms. During the non-breeding season results did not consistently show higher densities on organic than on conventional fields (Wilson et al. 1996, Chamberlain et al. 1999, Hötker et al. 2004b).

The main reasons for the decline of the European Yellowhammer populations, however, are not absolutely clear. In the UK changes of population indexes over time fit better with changes in adult survival than with changes of breeding performance (Siriwardena et al. 1998, Siriwardena et al. 2000). Population declines were associated with loss of food both inside and outside the breeding season (Hart et al. 2006b).

According to Bradbury et al. (2000) removal of hedgerows, abandonment of hedge management, filling or cleaning of ditches, intensification of grassland management and cropping or grazing right up to the field edge are likely to have adversely affected yellowhammers on lowland farmland in southern England. Pfister et al. (1986) consider the loss of hedges and bushes as a main problem for Yellowhammers. Biber (1993b) showed a shift in preference from tall growing towards short growing crops throughout the breeding season. Obviously Yellowhammers have difficulties in foraging in very tall stands of vegetation. The predominance of tall growing crops (autumn-sown cereals, oilseed rape and maize), therefore, could negatively affect populations of Yellowhammers. Borderlines between fields and cultures are preferred foraging sites of Yellowhammers (see above). The lengths of borderlines decrease with increasing field size and decreasing crop diversity. Both parameters, therefore, may affect population sizes of Yellowhammers.

Measures for risk-management

Given the sensitivity of Yellowhammers against low densities of their arthropod food during the breeding season (see above), it can be expected that Yellowhammers would profit from refraining from applying insecticides within their feeding range. Non-selective and systemic insecticides are probably most harmful to Yellowhammers. Herbicides that kill host plants for important food species or reduce the cover of nests at field edges may also be harmful. Reductions in herbicide use at nest sites might therefore also be beneficial. A total abandonment of spraying in organic farming seems to be beneficial for Yellowhammers during the breeding season (see above).

Reduction of insecticide usage should focus on a wide strip at the edges of fields and at the breeding season. Systemic insecticides should not be applied within potential Yellowhammer territories at any time of the year.

There is much evidence that the set-up of extended non-cultivated field margins and uncultivated strips help to increase the breeding density of Yellowhammers (Franz & Sombrutzki 1992, Hötker et al. 2004a). Stoate & Szczur (2001b) advice at least 2m strip width and Franz & Sombrutzki (1992) report that an increase of the margins from 1 to 5-10m along ditches increased the local population by the factor 12 within 4 years.

At farm scale Henderson et al. (2012) found a more or less linear relationship between the percentage of un-cropped land within a farm and the density of Yellowhammers, densities at farms with more than 10% un-cropped land holding about twice as high densities as farms with 0-3% of uncropped land.

During the non-breeding season the maintenance of stubbles throughout the winter is probably a way to ensure food resources throughout the winter in order to improve adult survival (Baker et al. 2012). Additionally sowing food plants may increase the density of overwintering Yellowhammers (Stoate et al. 2003).

Planting of bushes and hedgerows in open landscapes is an obvious measure to create new habitats for Yellowhammers, provided the surface of such structures has not yet reached 4% (Pfister et al. 1986, Dornberger 1993, Laußmann & Plachter 1998, Flöter 2002). If there are no additional on crop measures like the set-up of unmanaged field margins, comparable structures like ditches with weedy banks or wide margins alongside watercourses (Franz & Sombrutzki 1992, Stoate & Szczur 2001b) are often prerequisites for territory establishments.

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2.27 Ortolan Bunting (*Emberiza hortulana*) – Ortolan – Order: Passeriformes

Geography

- Europe to SW Asia
- Eastern parts of Germany

Status in Germany

- Breeding (May – Aug.), migratory

Life cycle

- First breeding when 1 year old
- 1-2 broods per year, 3-6 eggs per clutch
- Life span: few years (max. 8 years)
- Generation length < 3.3 years

Population, trend and conservation status

The population of Ortolan Buntings breeding in Europe is depleted since the 1980s. The same probably holds true for Germany where regular monitoring started in 1989. The Ortolan Bunting is listed on Annex I of the EU Birds Directive.

Tab. Emho1: Populations (pairs), trends (mainly 1980 – 2005) and Red List status of Ortolan Buntings breeding in Europe, Germany and the German federal states.

Ortolan Bunting			Trend					
	Population (pairs)	Proportion of German population (%)	<-50%	-50% - -20%	stable	20% - 50%	>50%	Red List category
Baden-Württemberg	0	0						ex
Bayern	400 - 500	3.8						2
Brandenburg + Berlin	3700 - 5200	37.1						V
Hessen	0	0						ex
Mecklenburg-Vorpommern	1000 - 1200	9.2						–
Niedersachsen + Bremen	1400	11.7						1
Nordrhein-Westfalen	50 - 60	0.5						1
Rheinland-Pfalz	0	0						ex
Saarland	0	0						–
Sachsen	400 - 600	4.2						2
Sachsen-Anhalt	3000 - 5000	33.3						V
Schleswig-Holstein + Hamburg	18	0.2						2
Thüringen	0	0						ex
Germany	**10,000 - 14,000**							**3**
Europe	**5,200,000 - 16,000,000**							**Spec2**

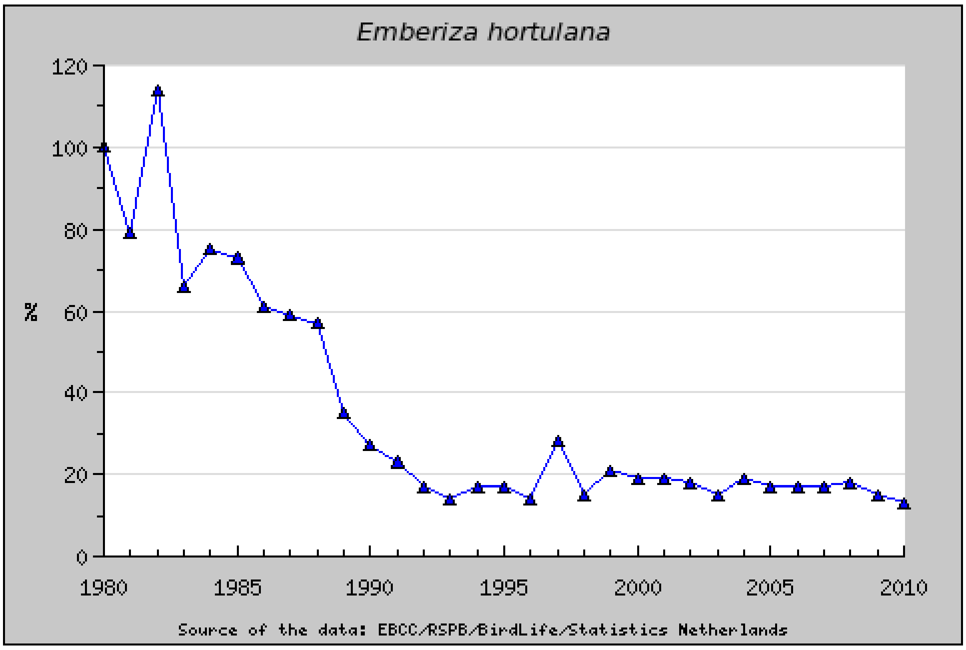

Fig. Emho1: Population trend (TRIM indexes) of Ortolan Buntings in Europe (PECBMS 2012).

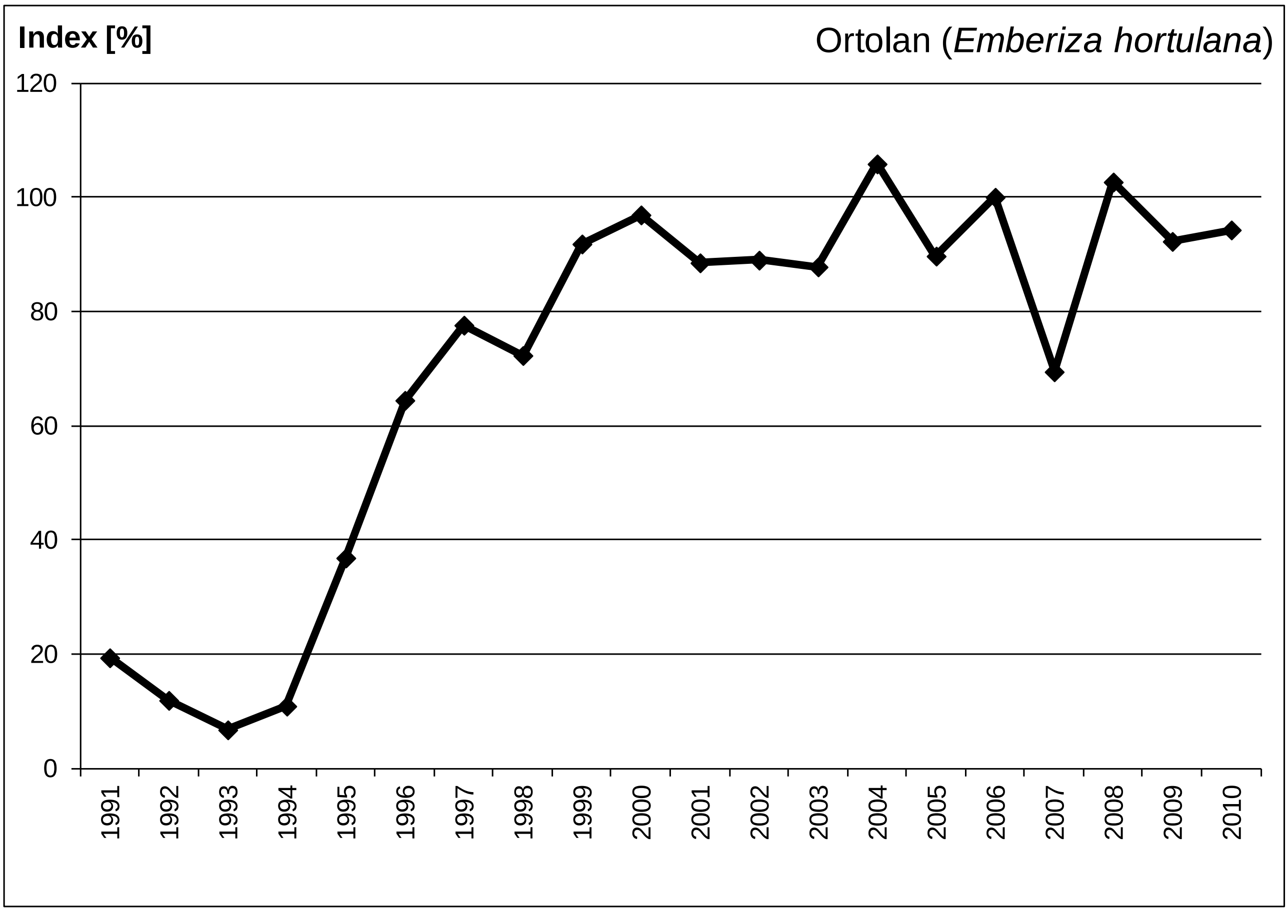

Fig. Emho2: Population trend (TRIM indexes) of Ortolan Buntings in Germany (DDA 2012).

Diet

During the breeding season Ortolan Buntings mainly feed on insects and other small invertebrates and on seeds of crops, of farmland weeds and of trees. Chicks receive an almost completely insectivorous diet. Saltatoria often form the biggest part of the items brought to the nest. Outside the breeding season, seeds and green parts of plants become more dominant. Based on Glutz von Blotzheim & Bauer (1997) the percentages of diet theoretically affected by pesticides are estimated as follows: nestings: 100%, adults during the breeding season: 80%, adults during the non-breeding season: 20%.

Habitat and densities

In central and west Europe Ortolan Buntings settle in well structured arable landscapes with a mix of different crop types, among them summer cereals, legumes, potatoes and/or beets. Rows of trees or forest edges and field margins with weeds and flowers are typical for Ortolan Bunting territories (Flade 1994, Grützmann et al. 2002, Hänel 2004, Bernardy et al. 2006, Bernardy et al. 2008). In Germany the occurrence of Ortolan Buntings is associated with light, sandy soils and a relatively dry climate (Glutz von Blotzheim & Bauer 1997, Grützmann et al. 2002). In Northern Europe Ortolan Buntings also occur in peat bogs (Dale 2000).

Nests are built on the ground. In a study in Lower Saxony, Bernardy et al. (2006) found most nests in crops, usually in cereal, legume, potato or beet fields. Nests were preferably placed at vegetation heights of 20 – 50 cm and in relatively open stands. The percentage of nests on sprayed crops is estimated to be 95%.

According to Bernardy et al. (2006) Ortolan Bunting pairs forage mainly within an area of 250m around song posts. The preference of crops for foraging differs between studies. Lang et al. (1990), Berg (2008) and Gues & Pürckhauer (2011) show avoidances for winter cereals whilst Bernardy et al. (2006), Dziewiaty & Bernardy (2007) and Hoffmann (2011) include winter cereals in the group of preferred crops. Summer cereals were avoided in the studies of Berg (2008), Gues & Pürckhauer (2011) but preferred in the studies of Lang et al. (1990) and Bernardy et al. (2006). Maize fields (Dziewiaty & Bernardy 2007, Hoffmann 2008, 2011) and rape fields (Berg 2008) were generally avoided. Beets (Gues & Pürckhauer 2011), potatoes (Bernardy et al. 2006), legumes (Bernardy et al. 2006) and sunflowers (Dziewiaty & Bernardy 2007) were reported to be preferred. Except Berg (2008, in Sweden) all authors provide evidence for an avoidance of set-aside by Ortolan Buntings (Dziewiaty & Bernardy 2007, Hoffmann 2008, 2011). Gues & Pürckhauer (2011) report a shift in preference throughout the breeding season from hedges and forest edges to beet crops.

A high spatial variety of crops and a high degree of dovetailing of suitable nest and foraging sites as well as suitable trees as song posts seems to be essential for the occurrence of Ortolan Buntings (Lang et al. 1990, Pille 2005, Bernardy et al. 2006, Gues & Pürckhauer 2011).

Due to the clear preference for cropped land the percentage of food taken from sprayed fields is estimated to be 90%.

Threats / sensibility (pesticide effects)

In contrast to the closely related Yellowhammer, there is no direct evidence that Ortolan Buntings suffer from the application of pesticides. The diet and the foraging behaviour of Ortolan Bunting and Yellowhammer are very similar so that an indirect effect of insecticides on the breeding performance of Ortolan Buntings is very likely. Moreover, Ortolan Buntings prefer organic fields over conventional fields (Christensen et al. 1996, Bernardy et al. 2006).

Ortolan Buntings nest on cropped fields. The nest cover could be reduced by herbicides. An indication of the effects of herbicides is the observation of an unusually high density of Ortolan Buntings on an unsprayed maize field (Dziewiaty & Bernardy 2007) although sprayed maize fields are usually avoided (see above).

The reasons for the decline of Ortolan Bunting populations in Europe are not fully understood. Most authors consider changes in agriculture within the breeding range as the main driving force although losses on the migration route or in the winter quarters cannot completely be ruled out. In France 10thousands of Ortolan Buntings are killed annually (http://www.komitee.de/en/actions-and-projects/france/bird-trapping/south-france-ortolan-bunting, visited 6 Aug. 2012). The loss of fine scaled structures like small rye fields which have be replaced by large maize fields and the loss of crop diversity in general are probably the most important factors (Noorden 1991, 1999). Ikemeyer & Bülow (1995) suggest that due to the application of fertilizers the vegetation in the territories of Ortolan Buntings is too high at arrival from the winter quarters. In particular, winter wheat can be already too high and too dense for Ortolan Buntings after mild winters.

The general intensification of agriculture and the loss of a high diversity of crops on a small spatial scale are still acting threats for Ortolan Bunting populations (see above).

Measures for risk-management

As for the Yellowhammer, a reduction in the application of insecticides and herbicides within the territories of Ortolan Buntings will probably improve food resources. Non-selective and systemic insecticides are probably most harmful. Herbicides that kill host plants for important food species or reduce the cover of nests may also be harmful. Reductions in herbicide use at nest sites might therefore also be beneficial. A total abandonment of spraying in organic farming seems to be beneficial for Ortolan Buntings during the breeding season (see above).

Any reduction of insecticide usage should focus on a wide strip at the edges of fields and at the breeding season. Systemic insecticides should not be applied within potential Ortolan Bunting territories at any time of the year.

One of the main task of restoring habitats for Ortolan Buntings during the breeding season is to provide the right vegetation height, density and cover (Pille 2005). Bernardy et al. (2006) could show that a drastic reduction of fertilization together with refraining from spraying and mechanical herb control caused a quick positive response of the local Ortolan Bunting population. The crops became more open and soil dwelling prey for Ortolan Buntings became more abundant. Unsprayed and un-fertilized winter rye fields and mixed crops containing peas and summer cereals proved to be very attractive both for nesting and for foraging.

Undrilled patches ("Ortolan Bunting plots", similar to Skylark plots) attracted some foraging Ortolan Buntings in the beginning and in the end of the breeding season (Gues & Pürckhauer 2011).

Besides managing single crops or sowing new particularly favourable crops, ensuring a high crop diversity and hence small field sizes are helpful in ensuring stable populations of Ortolan Buntings (Pille 2005, Bernardy et al. 2006). Song posts are essential for territory establishment. Where needed, single trees or small orchards should be planted. Elements offering additional variety like unpaved farm tracks should be preserved.

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Project No. (FKZ) 3710 63 411

Protection of biodiversity of free living birds and mammals in respect of the effects of pesticides

„Das Schutzgut Biodiversität in der Umweltbewertung von Stoffen – Konzept für das Management des Risikos für freilebende Vögel und Säuger aus der Anwendung von Pflanzenschutzmitteln unter Berücksichtigung indirekter Wirkung (Nahrungsnetz-Effekte) und besonders geschützter Arten“

Annex II

Detailed species portraits – mammals

by

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ON BEHALF OF THE

FEDERAL ENVIRONMENT AGENCY

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Table of Contents

1 Annex II. Detailed species portraits of farmland mammals

1.1 European Hamster (*Cricetus cricetus*) – Feldhamster – Order: Rodentia

Geography: Europe

Geographically, the main distribution area of the European Hamster concentrates on zones of black earth in Eastern Europe and Asia. The most western populations occur in Belgium, The Netherlands, eastern France and Germany (Niethammer 1982).

Geography: Germany

In Germany the Hamster has its western distribution border in Lower Saxony. It is absent in Upper Bavaria and in the northern parts of Germany. Its northern distribution border corresponds to the occurrence of black earth soils (Weidling & Stubbe 1998).

Weinhold (2008) describes the core area of distribution to include Lower Saxony, Thuringia, Saxony-Anhalt and Saxony. Other federal states have only small and isolated Hamster occurrences (Weinhold 2008).

One of the main distribution areas is the Magdeburger Börde in Saxony-Anhalt (Kayser et al. 2003a). Other classical distribution areas in Germany are Hildesheimer Börde, Thüringer Becken, Untermainebene and Vordertaunus (Gall 2007).

Population, trend and conservation status

- Red List Germany: category 1 (critically endangered)
- EU Habitat & Species Directive, Annex IV
- BNatSchG §7 Abs.2: streng geschützt (s)
- Bern Convention, Appendix II

Tab. Crcr1: Red List-classifications of the status of European Hamster populations in total Germany and the federal states (n.a.= information not available).

State	G	BB	BW	BY	HE	MV	NI	NW	RP	SH	SL	SN	ST	TH
Year	2008	2003	2001	2003	1995	1991	1991	2010	1987	2000	2008	1999	2004	2001
Category	1	1	1	2	3	1	2	1	G (4)	-	n.a.	1	1	1

European Hamster populations are strongly decreasing in Central Europe and already locally extinct in Western Europe (Lung 2004). In Germany, Hamsters were considered as agricultural pest species until 1980 and therefore target of pest control measures to decrease losses in agriculture and collect fur (Kayser et al. 2003b). Today the species is classified as critically endangered (category 1 - Red List Germany; Meinig et al. 2009) and listed in Appendix IV of the FFH-directive. Seven federal states list the European Hamster under category 1 in their Red Lists (see also Tab. Crcr1). Both for the short- and long-term population numbers of the Hamster are expected to decline dramatically in Germany (Red List Germany; Meinig et al. 2009).

The upgrading in red list categories points out decreasing population sizes and increasing endangerment of the European Hamster over the last 15 years in Germany.

Seluga (1998) reviewed different sources about population densities in Saxony-Anhalt in the last centuries and found a drastic decline of den numbers per hectare (Tab. Crcr2).

Tab. Crcr2: Changes in densities of European Hamsters in Saxony-Anhalt, Germany (after Seluga 1998).

Time	Density per ha
till end of 19th century	20
1900-1965	30-50
1980-1883	10
1993-1996	>1-2

Further Pott-Dörfer & Heckenroth (1994) found a negative trend of Hamster populations in the 1980s in their extensive study in Lower Saxony (Fig. Crcr1).

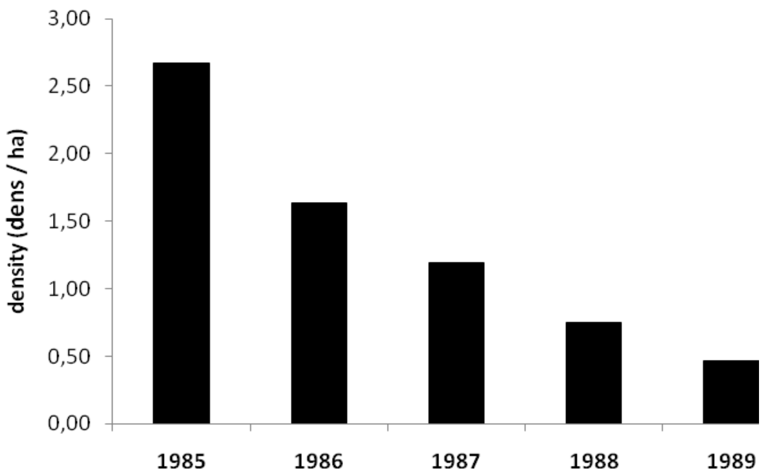

Fig. Crcr1: Mean Hamster densities in a study area in Lower Saxony (after Pott-Dörfer & Heckenroth 1994).

Life cycle

The breeding season of Hamsters lasts from April to August or September. Two litters per year are possible, each with about eight young. Young females become sexually mature after 2.5 months (Grzimek 1984).

Kayser et al. (2003a) mention an average life span of 1 year and maximum age of three.

Adult Hamsters start hibernating in September or October while subadult individuals start a bit later (Ulbrich & Kayser 2004). Hibernation lasts until April (adult males) or even May/June (adult females and subadults).

Dispersal

Little data is available on the territorial behavior and home range sizes of the Hamster.

Foraging ranges are within 500 m distance from the den (Grulich 1978 in Niethammer 1982).

Diet

Predominant components of the diet are vegetative parts of plants, seeds and fruits of many wild herbs and cultivated plants, but Hamsters consume earthworms, slugs, arthropods (larvae) and young mice as well (Röser 1995). Animal protein makes up about 10-13% of its diet (Weinhold 2008).

In summer the Hamster mainly feeds on the green parts of herbs, grasses and cereals. During the rest of the year increases the consumption of seeds, fruits and roots. In late summer and the beginning of autumn the Hamster collects up to several kilograms of oats, wheat, pieces of sugar beet and other field crop as winter stock (Pott-Dörfer & Heckenroth 1994).

Consumed crop plants are stems and leaves of maize, rye, barley, wheat, oats; peas, pieces of beets, carrots, potatoes, clover and alfalfa (Petzsch 1964 in Niethammer 1982). Furthermore, Hamsters feed on various wild plant species, invertebrates (mollusks, Lumbricidae, coleoptera (adults and larvae), Lepidoptera larvae, locusts) and vertebrates (frogs, amphibian eggs, young birds) (Petzsch 1964 in Niethammer 1982).

Hamsters are mainly nocturnal (Niethammer 1982).

Habitat and densities

The European Hamster occurs in Central Europe almost exclusively on intensively used crop land (Seluga 1998). It lives in burrows in open agricultural landscapes and prefers deep and relatively warm soils of high quality (Weidling & Stubbe 1998). This soil layer has to be at least one meter deep and the groundwater level needs to be no lower than 1.20m beneath the surface (Grulich 1975 in Niethammer 1982). Grassy field margins and slopes are also chosen as habitat (Röser 1995).

Vegetation cover is highly important for Hamsters to avoid the risk of predation. Best cover in May (spring), and therewith a reduced predation risk, is found in winter wheat, triticale and alfalfa, whereas in late summer maize and sugar beet offer better protection (Kayser et al. 2003b).

Crops with year-round cover like clover and alfalfa are preferred habitats as well as hedges and field margins, but also cereals and beet root crops are inhabited during the harvest (Niethammer 1982). The Hamster prefers wheat more than sugar beet and winter barley (Pott-Dörfer & Heckenroth 1994; Fig. Crcr2). Other crops where Hamsters find adequate living conditions are rape, potatoes, pulses or trefoil (Gall 2007).

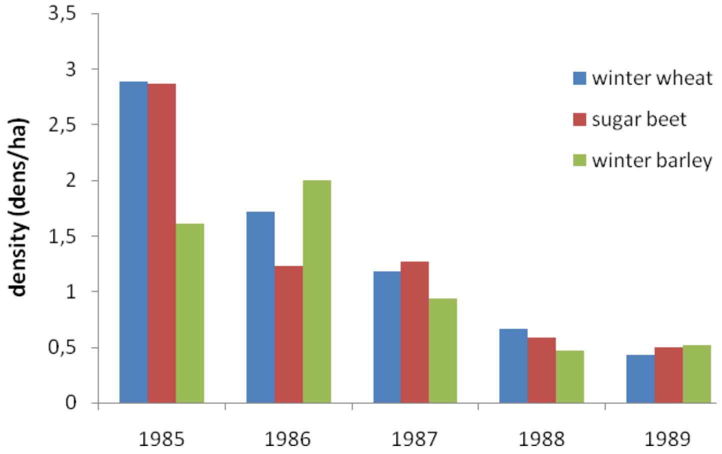

Fig.Crcr2: Hamster densities in three different crop types and population trend over five years in a study area in Lower Saxony (after Pott-Dörfer & Heckenroth 1994).

Gall (2007) states that preferred crops and habitats of Hamsters are winter cereals (and rape and marginal structures) in spring, cereal crops during summer with refuge habitats in marginal structures and forage crops, and cereals, beet root and to a minor extent maize in late summer.

During late summer especially young Hamsters are highly dependent on soil cover since they face a higher predation risk than adults and their burrows are less deep and therefore more endangered by agricultural operations (Ulbrich & Kayser 2004). The importance of cover is expressed by a value of 0.7 in the index calculation.

We estimate the amount of diet taken from sprayed cultures to be about 90%.

The mean density of Hamsters in arable fields in Poland was 0,66 Individuals per ha (Gorecki 1977).

Threats / sensibility (pesticide effects)

Due to their preference for intensively used deep loess soils, Hamsters come into contact with a wide range of applied pesticides (Kayser et al. 2001). Kayser et al. (2001) found residues of organochlorine only on a very low level and conclude that they can be classified as not dangerous for the Hamster. Direct damage (i.e. intake of presticide-treated food) is likely to be small or non-existent due to the short live span of Hamsters (Gall 2007). The application of rodenticides may have negative effects, but its extent is unknown. The damage may occur on a small scale; hence it is unlikely to have remarkable impact on whole populations (Gall 2007).

Other threats

Main causes of death are predation and hibernation (Weinhold 2008).

Natural enemies are birds of prey (red kite, common buzzard), owls (mainly eagle owl), and small to medium sized carnivores like the weasel, polecat, stoat and red fox.

However, the main endangerment derives from anthropogenic threats such as intensive agricultural management techniques like harvest, ploughing or cutting (Kayser et al. 2003b), direct take (illegal killing and kills by traffic), habitat fragmentation and destruction (Meinig & Boye 2009). Hamsters are especially threatened in periods of low cover in early spring and after the harvest.

Gall (2007) describes higher mortality of young Hamsters and lower fitness of older individuals due to earlier and faster harvesting (especially of cereals and rape), larger field sizes and less edge structures as well as smaller crop diversity.

In their risk analysis for European Hamsters Ulbrich & Kayser (2004) name disturbances like agricultural management and highway construction as the most threatening factors for Hamsters during autumn.

Hamster populations seemed to be decreased by large sized and weed free arable crops in The Netherlands and north western Germany (Niethammer 1982).

Measures for risk-management

Aim: Reduction of threats associated with pesticide applications

Minimize the use of pesticides, especially herbicides, and avoid application of rodenticides (Nechay 2000).

Aim: Improvement of food availability and nesting habitats

Female Hamsters are the most sensitive part of the population, therefore conservation actions should focus on female Hamsters, e.g. by safeguarding maternal burrows throughout the season (Ulbrich &Kayser 2004). This measure is highly effective in early summer since the first litter per year might be more important for the population survival. Other measures are protection of the burrows from ploughing in autumn by retaining patches of crop and arable weeds around the burrows to guarantee sufficient cover and food (Ulbrich & Kayser 2004). Late timing of harvest and following cultivations was most favorable for the survival of Hamster populations. Operations such as soil cultivation should be conducted after Hamsters started their hibernation (i.e. after mid October or the beginning of November) (Ulbrich & Kayser 2004). Protection measures implemented in autumn are most effective in increasing the chances of survival of Hamster populations.

Large habitat sizes are not sufficient for the survival of Hamster populations instead the connectivity between habitats might be even more important (Ulbrich & Kayser 2004). Therefore conservation measures ensuring the connection of suitable habitats such as tunnels or strips with high levels of vegetation cover between adjacent areas appear to be very effective.

Crops with a high degree of vegetation cover and height provide best living conditions for Hamsters (Kayser et al. 2003b; see also Fig. Crcr3).

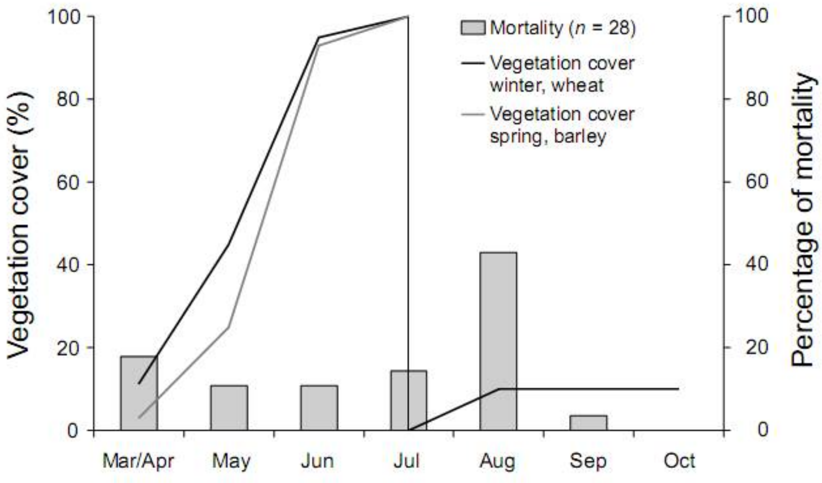

Fig. Crcr3: Mortality of the European Hamster over the year in comparison with vegetation cover (adopted from Kayser et al. 2003b).

Avoid growing sugar beet in areas important to Hamster populations. Sugar beet crops are linked to increased pesticide applications and higher loesses of Hamsters due to predation (Nechay 2000). Most favorable are winter wheat crops as well as perennial fodder-plant crops like lucerne (Nechay 2000).

Offering supplemental food sources and establishing perennial set-aside areas supports European Hamster populations (Boye 2011).

See Gall (2007) for detailed information on conservation measures implemented in several Projects in Germany, Weinhold (2008, p. 23 ff.) for different measures and their effectiveness, Enziger et al. (2010) for conservation measures in Austria, Nechay (2000) for a list of conservation measures.

1.2 Field Vole (*Microtus agrestis*) – Erdmaus – Order: Rodentia

Geography: Europe

The Field Vole is distributed throughout the continent. It is missing in Ireland, Southern Europe, the lowlands of central and most south-eastern Europe and northern Russia. Its distribution center is located more to the north than the one of Common Voles (Krapp & Niethammer 1982).

Geography: Germany

Field Voles occur all over Germany.

Population, trend and conservation status

- Red List Germany: least concern

Tab. Miag1: Red List-classifications of the status of Field Vole populations in total Germany and the federal states (n.a.= information not available).

State	G	BB	BW	BY	HE	MV	NI	NW	RP	SH	SL	SN	ST	TH
Year	2008	2003	2001	2003	1995	1991	1991	2010	1987	2000	2008	1999	2004	2001
Category	-	-	-	-	-	-	-	-	-	-	n.a.	-	-	-

The long term population trend of Field Voles is considered to be slowly decreasing (Meinig et al. 2009).

Life cycle

Field Voles reproduce from March till October. Several litters are born each with 4 to 7 young. New born voles may participate in reproduction in the same year. They may reach a maximum age of 18 months (Krapp & Niethammer 1982).

Dispersal

In two consecutive years Erlinge et al. (1990) recorded mean home range sizes for Field Vole males of 660 and 1371m and of 557 and 776m for females during the non-breeding season on homogeneous wet meadows in southern Sweden. During the breeding season males had mean ranges sizes of 1477 and 1231m and females of 913 and 868m. At high population densities home ranges were smaller than at low Field Vole densities (Erlinge et al. 1990).

Home range sizes vary between seasons and are smallest in winter and largest in autumn (Yletyinen & Norrdahl 2008).

Borowski (2003) recorded home range size for males that ranged between 87 and 1037m and for females ranges between 31 and 225m.

Diet

The Field Vole feeds mainly on stems and leaves of grasses, also moss and to a lesser extent grass seeds and rarely arthropods (Ferns 1976). Grasses were more important in autumn and early winter than in summer. Field Voles are extreme herbivores than prefer grass species that are easy to digest. Dicotyledons made half of the consumed food in late summer (Hansson 1971). Field Voles are specialists in grass eating (Brakes & Smith 2005).

Primarily during winter Field Voles consume seedlings and saplings of woody species (Yletyinen & Norrdhal 2008).

Field Voles may consume large amounts of crops plants. Therefore about 30% of the diet is considered to be affected by pesticides.

Field Voles are both, nocturnal and diurnal (Brakes & Smith 2005).

Habitat and densities

The Field Vole inhabits moist habitats with rich grass cover, like rough ungrazed grasslands, grassy woodlands, marshes, peat-bogs, wet meadows or river banks (Krapp & Niethammer 1982). It prefers border habitats containing shrubs and undergrowth.

Hansson (1977) states that Field Voles are strongly associated with habitats with ground cover of at least 80 to 90 % of herbs and grasses. Another important habitat feature is the occurrence of graminids and forbs that provide continuous food. The need for cover determines the preference of Field Voles for rather wet and productive areas and the avoidance of forests (Hansson 1977).

Field Voles are more typically found in uncultivated and field-edge habitat (Barber et al. 2003).

Boye (2003) caught 97.5% of all caught Field Voles (N=244) in ditch margins.

Borowski (2003) radio-tracked Field Voles in Poland and found a preference for ecotone and meadow habitats while Voles were less present in an alder community and reed stand. The two favored habitats provided higher food supply (Borowski 2003).

In an experimental study in Finland radio-tracked Field Voles preferred buffer zones with vegetative cover over crop lands. Wide buffer zones of more than 15m were more attractive habitats than narrow filter strips of 5m with open grassy vegetation adjacent to crop fields. Of all treatment patches mowed areas were most avoided (Yletyinen & Norrdhal 2008).

Field Voles build tunnels under ground which are connected with corridors on the surface (Krapp & Niethammer 1982). Their grassy nests may be under ground, beneath roots or between thick grass.

Due to the lack of data we can only estimate the amount of diet taken from sprayed cultures to be about 50% considering the importance of grassland, set-aside and border habitats. In the non-breeding season this value decreases to 30%.

Field Vole populations in road verges had densities of 29.5 individuals per km in summer and of 47.2 individuals per km in autumn (Bellamy et al. 2000).

Field Vole densities may reach 100 or even 300 individuals per ha (Krapp & Niethammer 1982). Densities are increasing in summer and autumn and decrease over winter. They are lowest in early spring.

Threats / sensibility (pesticide effects)

Brakes & Smith (2005) report that 19.5% of caught Field Voles consumed rodenticide baits (see review).

Measures for risk-management

Aim: Improvement of food availability and nesting habitats

Tattersall et al. (2000) analyzed benefits of set-aside management for Field Voles. The abundance of Field Voles was influence by vegetative characteristics and increased with the proportion of grasses and litter in the set-aside sward. Voles were not present on set-aside during the first nine months of establishment. Population numbers began to increase only after two years. The authors suggest management practices such as sowing with grass seed mix, mowing at least once annually and leaving set-aside in place for more than two years to increase Vole numbers (Tattersall et al. 2000). However, these measures contradict management practices that benefit for example a number of ground-nesting birds.

1.3 Common vole (*Microtus arvalis*) – Feldmaus – Order: Rodentia

Geography: Europe

The Common Vole is endemic to Europe. It occurs further to the South than the Field Vole (Niethammer & Krapp 1982).

Geography: Germany

Common Voles occur all over Germany.

Population, trend and conservation status

- Red List Germany: least concern
- Common Vole populations are currently not considered as being endangered.

Tab. Miar1: Red List-classifications of the status of Common Vole populations in total Germany and the federal states (n.a.= information not available).

State	G	BB	BW	BY	HE	MV	NI	NW	RP	SH	SL	SN	ST	TH
Year	2008	2003	2001	2003	1995	1991	1991	2010	1987	2000	2008	1999	2004	2001
Category	-	-	-	-	-	-	-	-	-	-	n.a.	-	-	-

Microtus arvalis is very common all over Germany. However, since the 1970s its population might be strongly decreasing especially in north western Germany where no cyclic increases occur anymore (Meinig et al. 2009). Therefore, in the future there might be the need of including this species in a red list category (Meinig et al. 2009). Recently high densities were recorded only in Thuringia (Jacob 2000).

Life cycle

The Common Vole reproduces from March till October. Two to four litters are born per year, each with two to eight young. New born voles usually survive until the next summer when they participate in reproduction (Niethammer & Krapp 1982). Common Voles usually die before their second winter.

Dispersal

Briner et al. (2005) found home ranges of Common Voles in wildflower strips to be rather small with a median size of 125m (MCP) compared to other habitats like winter corn (350m), woodland (300-500m) or pine plantation (1200-1500m) but comparable to sizes in alfalfa and pasture (145m) (other sources, see Briner et al. 2005).

Home ranges have sizes of 0.1-0.15ha for males and 0.03-0.04ha for females (Grzimek 1984).

Before farming practices on agricultural land the mean home range size was 202m for males (N=20) and 196m for females (N=41; Jacob & Hempel 2003). The authors found a positive correlation of home range size and vegetation height.

Diet

Common Voles mainly consume green parts of grasses (mainly in spring and winter) and herbaceous dicotyledons but also seeds (mainly in late summer), below ground parts of plants (mainly in winter), mosses, bark and animals food such as Arthropods (mainly in summer; Niethammer & Krapp 1982).

They may persist for a rather long time on a very one-sided diet (Stein 1958 in Niethammer & Krapp 1982).

Among crops, Common Voles favor winter rapeseed, red clover, alfalfa and carrots. Root crop, like potatoes and beet are less preferred (Niethammer & Krapp 1982).

Analyses of the diet of Common Voles in rape fields show that green leaves of winter rape form the dominant part of its diet in spring and autumn (Heroldova et al. 2004).

Main diet components are cereal heads, the green parts of rape, red clover, alfalfa, wild herbs and grasses and to a lesser extent root crop (Röser 1995).

Since the diet of Common Voles consists of large amounts of crops plants. Therefore about 30% of the diet is considered to be affected by pesticides.

Habitat and densities

Common Voles inhabit numerous arable cultures and open grassland that is not too wet until a height of 2000m above sea level (Balmelli et al. 1999). They occur in field margins and headland, but avoid woodland, forests and moist areas (Röser 1995).

Boye (2003) described the habitat of Common Voles as open grasslands that are not too wet and where the vegetation is not too high. In his study he caught most of the Voles in the margins of ditches (72.4%, N=1421). During crop season Common Voles were also found on arable land, mainly on winter cereal crops, until the crops were harvested in July or August. 7% of Voles were caught in sugar beet and cabbage and 14% in cereals (Boye 2003).

Voles move into wheat and barley fields when the crops are ripening and are harvested and stay there until the time of ploughing (Heroldova et al. 2007).

Fischer et al. (2011) found Common Vole numbers to increase with increasing percentage of arable land. Voles occurred in simplified landscapes with more than 90% of arable land while they disappeared in complex landscapes with more than 50% of arable land. The species is highly adapted to continuous and open agricultural landscapes (Delattre et al. 1996).

Jacob (2000) found Voles to be the dominant species in five differently managed agricultural and natural areas. On agricultural plots and mulched grassland almost only Common Voles were caught. Common Voles occurred nearly exclusively on conventional grasslands.

Heroldova et al. (2004) studied rodent populations in winter rape stands in South Moravia, Czech Republic. They found that winter rape fields are an important habitat for Common Voles and that the species is dominant in this crop in autumn and spring. When the rape plants are flourishing and ripening the decreased availability of green food at the ground level makes the crop less attractive and Voles migrate into neighboring fields. After the harvest of winter rape Voles may live again in these crops feeding on newly growing plants from seeds shed during the harvest (Heroldova et al. 2004). The authors state that high population numbers of

Common Voles may cause damage to rape crops because the rodents are present inside these crops for such a long period.

During winter Common Voles occur mainly in perennial forage crops, on grassland, pastures or set-aside and in field margins (Niethammer & Krapp 1982).

The estimated amount of diet taken from sprayed cultures is about 50% considering the importance of grassland, set-aside and border habitats. In the non-breeding season this value decreases to 30%.

The presence of sufficient cover is, like for the field vole, very important for this species.

Common Voles dig short tunnels which are connected by corridors above the ground (Niethammer & Krapp 1982).

From May till September relative high densities of Common Voles can be found that start to decrease from October on (Balmelli et al. 1999). In March they reach their minimum.

After the harvest of cereal fields, Voles migrated into field margins (Baumann 1996 in Balmelli et al. 1999).

Briner et al. (2005) recorded high densities of up to 650 individuals per ha within wildflower strips.

On agricultural lands like crops, pastures and grassland, densities increased over summer and decreased during winter and spring (Jacob 2000). Populations crashed in winter except for those that occurred on mulched land. Highest densities of 750 individuals per ha were recorded in grasslands (Jacob 2000).

Butet & Leroux (2001) studied Vole population dynamics in relation to agricultural changes and conservation of Montague's harrier in western France. Agricultural changes (conversion of pastures into drained agricultural crops) caused a decrease of the frequency and intensity of Vole population peaks. Further, they found differences in Vole densities between three habitat types. Abandoned pastures, which were the lest disturbed habitat, hold highest densities of an average of 102 individuals per ha (max. 400 indiv./ha), on grazed and mowed grasslands intermediate densities of 51 individuals per ha were recorded with less intensively grazed pastures showing higher numbers. The lowest values of 43 individuals per ha were found cultivated areas with many crops (see also Fig. Miar1). These habitats were not colonized at all in years with overall low densities of Common Voles (Butet & Leroux 2001).

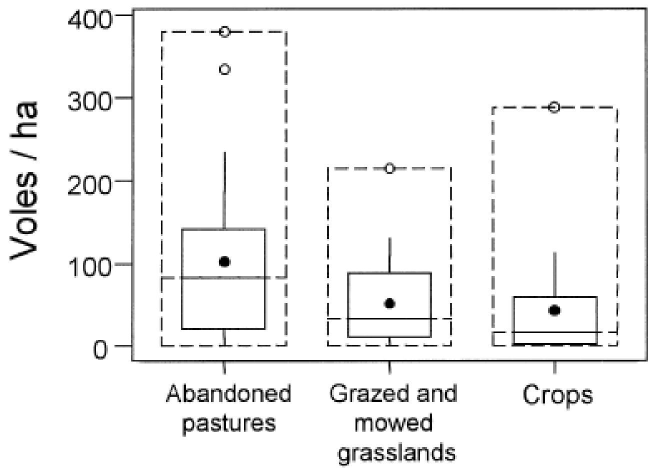

Fig. Miar1: Differences in voles densities between habitat types (adopted from Butet & Leroux 2001).

Vole populations may reach densities between 100 and 300 individuals per ha with peak numbers of 3100 Individuals per ha (Niethammer & Krapp 1982)

In Poland a field trial in a fenced 1ha alfalfa crop recoded minimum densities of 55-71 individuals per ha in April and maximum densities of 227-646 individuals per ha in October (Adamczewska-Andrzejewska & Nabaglo 1977 in Niethammer & Krapp 1982).

Jacob & Halle (2001) recorded densities in grassland of up to 450-510 individuals per ha.

Jacob & Hempel (2003) studied the influence of farming practices on Common Vole densities and found population densities to be very high on cattle pastures, moderately high on mulchland and relatively low on other plots such as arable land.

Threats / sensibility (pesticide effects)

Due to agricultural intensification many agricultural crop lands are not suitable as habitat for Common Voles anymore (Meinig et al. 2009) and the species is driven into hedgerows and other fringe structures (Boye 2003). Jacob (2000) describes good chances of survival on arable land during summer but decreased survival rates after the harvest.

Main natural enemies are birds of prey, least weasel, stoat, cats, wild boar and others. Young Voles may be eaten by shrews (Röser 1995).

Population growth was permanently slowed down only by conventional managed arable fields where agricultural operations such as harvesting, ploughing and harrowing appeared to reduce the survival of Common Voles (Jacob & Halle 2001).

Low vegetation caused limited spatial activity of Common Voles on agricultural land. After harvesting or mowing range sizes decreased probably as a reaction to less cover and therewith a higher risk of predation. Voles did not shift their ranges and centers of activity and showed no evasive movements after farming practices (Jacob & Hempel 2003).

Measures for risk-management

Aim: Improvement of food availability and nesting habitats

Mulching of grassland provides a dense layer of grass on the ground and creates favorable conditions for common voles (Jacob 2003). Jacob & Halle (2001) conclude that the mulching of grassland may increase numbers of pest rodents, such as common voles, in winter and spring which subsequently spread into adjacent crops. Ploughing is the only farming practice that can suppress common vole populations other practices are considered to be not appropriate (Jacob 2003).

Briner et al. (2005) studied home range size of Common Voles and found that wildflower strips function as high-quality habitats for the species. Due to high food abundance, which is related to small home range sizes, the wildflower strips sustained high densities of Voles. The animals stayed predominantly in these areas and were not attracted by the adjacent crops like sugar beet and maize (Briner et al. 2005). Therefore wildflower strips seem to reduce Vole damage in nearby strips and are considered to be valuable ecological compensation areas.

1.4 Striped field Mouse (*Apodemus agrarius*) – Brandmaus – Order: Rodentia

Geography: Europe

The Striped field Mouse occurs in central and eastern Europe (Böhme 1978).

Geography: Germany

The species has its western distribution border in central Germany (Meinig et al. 2009). However this border is rather unstable and some isolated occurrences of Striped field Mice exist beyond this border. Only small numbers occur in Schleswig-Holstein, Lower Saxony and Hesse (Grzimek 1984).

Population, trend and conservation status

- Red List Germany: least concern
- BNatSchG §7 Abs.2: besonders geschützt (b)

Tab. Apag: Red List-classifications of the status of Striped field mouse populations in total Germany and the federal states (n.a.= information not available).

State	G	BB	BW	BY	HE	MV	NI	NW	RP	SH	SL	SN	ST	TH
Year	2008	2003	2001	2003	1995	1991	1991	2010	1987	2000	2008	1999	2004	2001
Category	-	-	-	R	G	G (4)	-	-	-	3	n.a.	-	V	-

The Striped field Mouse is common in Germany but data on population sizes and trends is missing.

Life cycle

The time of reproduction of Striped field Mice is between April and September when a female may produce up to four litters with three to nine young (Böhme 1978). The maximum life span is estimated to be around 18 months.

Dispersal

Home range sizes in Eastern Europe range on average between 0.32 ha and 0.79ha for males and between 0.08 ha and 0.13ha for females (Böhme 1978).

Diet

The diet consists mainly of seeds and fruits, green plant parts are less important (Böhme 1978). A relatively high proportion of food of animal origin is characteristic for the mouse’s diet (Holisova 1967 in Böhme 1978). Insects and other invertebrates form an important part of the diet, mainly during the reproduction period in spring and summer.

The percentage of diet affected by pesticides is estimated as 50%, since approximately half of the specie’s diet consists of crop plants (predominantly seeds).

Striped field Mice are predominantly diurnal (Böhme 1978).

Habitat and densities

The Striped field Mouse occurs in a wide range of habitats, especially in more continental zones towards its distribution center (Böhme, 1978). In north western areas the species chooses more dry habitats to compensate for the oceanic climate. However, more to the south, e.g. in Hesse, it moves closer to humid regions like river valleys (Pelz 1976 in Böhme 1978).

It prefers habitats with a high percentage of cover and relatively high soil humidity and occurs often in littoral zones of streams but also in forest edges (Kraft 2003).

The species is absent in very simplified landscapes with more than 90% of arable land (Fischer et al. 2011). Striped field Mouse abundance decreased with increasing percentage of arable land (decreasing landscape complexity).

Kozakiewicz et al. (1999) studied rodent populations on farmland consisting of field and forest habitats. They found Striped field Mouse densities to be positively correlated to the quality of woodlots and distance to a large forest complex which corresponds to a higher proportion of arable fields. The species does not permanently depend on forest habitats and is mainly found inside crops during the growing period of crops from spring to autumn (Kozakiewicz et al. 1999). After the harvest in autumn it moves into forests for overwintering.

The species digs own tunnels but more often uses the tunnel systems of other small mammals (Böhme 1978). Nests and hidings above ground are less often found than for A. flavicollis or A. sylvaticus. During winter it stays in buildings like barns and sheds.

The percentage of food taken by Striped field Mice from sprayed cultures can only be estimated and is set here to be about 50% during the breeding season and 30% during the non-breeding season, when the species moves out of the crops.

Since no data is available for the extent of Striped field Mice breeding on sprayed cultures but crops are an important habitat especially during the breeding season from April till September we estimated an index-value of 0.6. Ground cover is an important factor for the Striped field Mouse. Its importance is scored as 0.8 for the index calculation.

Threats / sensibility (pesticide effects)

No information available.

Measures for risk-management

Aim: Improvement of food availability and nesting habitats

A certain amount of landscape complexity is important for the Striped field Mouse (Fischer et al. 2011).

1.5 Yellow-necked mouse (*Apodemus flavicollis*) – Gelbhalsmaus – Order: Rodentia

Geography: Europe

A. flavicollis is distributed in central and eastern Europe. It is absent from the west of France and on the Iberian Peninsula. In Great Britain it occurs only in the South. It occurs more to the north and in higher elevations than A. sylaticus (Niethammer 1978).

Geography: Germany

It is distributed all over Germany.

Population, trend and conservation status

- Red List Germany: least concern
- BNatSchG §7 Abs.2: besonders geschützt (b)

Tab. Apfl1: Red List-classifications of the status of Yellow-necked Mouse populations in total Germany and the federal states (n.a.= information not available).

State	G	BB	BW	BY	HE	MV	NI	NW	RP	SH	SL	SN	ST	TH
Year	2008	2003	2001	2003	1995	1991	1991	2010	1987	2000	2008	1999	2004	2001
Category	-	-	-	-	-	-	-	-	-	-	n.a.	-	-	-

The Yellow-necked Mouse still is common in Germany but its population numbers are decreasing, to what extent is unknown (Meinig et al. 2009).

Life cycle

A. flavicollis breeds between February and October. Per year two to three litters may be born each with four to seven young (Niethammer 1978). The maximum life span is 18 months.

Dispersal

Kotzageorgis & Mason (1996) radio-tracked six Yellow-necked Mice in hedgerows. They recorded home range sizes between 60 and 70m for females and between 110 and 225m for males. The minimum distances traveled per day by females lay between 5 and 260m and between 120 and 500m for males (Kotzageorgis & Mason 1996).

Yellow-necked Mice are highly mobile (Kozakiewicz et al. 1999).

Diet

The diet is similar to the diet of Wood Mice but contains more tree seeds instead of grass seeds (Mayershofer 1974 in Niethammer 1978). Animal food was found in 60% of the stomachs (in average 27% of the volume, highest volume in early summer). A. flavicollis mainly consumed Lepidoptera larvae and adults, Opiliones, larvae and adults of Coleopterans, Centipede and Arachnids (Obrtel 1973 and Mayershofer 1974 in Niethammer 1978).

Yellow-necked Mice consume are large amount of tree seeds (about 30% of their diet) but depend also on arthropods and wild plant parts. The amount of crop plants in the diet is estimated to be about 10-20%. Therefore we set a value of 0.5 for the diet affected by pesticides in the index calculation.

The species is mainly nocturnal (and crepuscular) (Niethammer 1978).

Habitat and densities

The Yellow-necked Mouse lives in forests mainly on the ground but also climbing. It prefers mature and tall tree stands mainly of deciduous species like beech and oak (Niethammer 1978).

Yellow-necked Mice inhabited two midfield shelterbelts of different age (Lecki 2004). The species was more common in the older one.

Kotzageorgis & Mason (1997) found hedgerows to be permanent habitats for Yellow-necked Mice. Important was a good structure of the hedge without many gaps.

Heroldova et al. (2007) found that the Yellow-necked Mouse was the most abundant species in small forests.

The amount of diet taken from sprayed cultures is estimated to be about 30%, since Yellow-necked Mice predominantly depend on forest habitats. A differentiation between the seasons was not possible. However, ground cover is an important factor and therefore gets a value of 0.7 in the index calculation.

Its nests can be found between roots or tree stumps but also in nesting boxes for birds (Grzimek 1984).

Kotzageorgis & Manson (1997) recorded densities between 0.4 and 20.8 individuals per 1000m in hedgerows bordering arable land.

In the Czech Republic densities ranged between 0.9 and 14.3 individuals per ha in different forest types (Niethammer 1978).

Threats / sensibility (pesticide effects)

The Yellow-necked Mouse has many natural enemies. Meinig & Boye (2009) define forest management and habitat fragmentation as human made threats.

Kotzageorgis & Mason (1997) found management operations to have a marked effect on Yellow-necked Mice. The species abandoned hedgerows after coppicing. In general, the loss of hedgerows in agricultural landscapes threatened Yellow-necked Mice populations.

Measures for risk-management

Aim: Improvement of food availability and nesting habitats

Old, well-established hedgerows without gaps are very important to Yellow-necked Mouse populations in agricultural landscapes (Kotzageorgis & Mason 1997). The careful consideration of the location and timing of hedgerow management is essential in relation to tree fruiting and breeding. The Height and continuity as well as species composition inside the hedge are important components too (Montgomery & Dowie 1993; Kotzageorgis & Mason 1997 in MacDonald et al. 2007).

1.6 Wood mouse (*Apodemus sylvaticus*) – Waldmaus – Order: Rodentia

Geography: Europe

The Wood Mouse has populated almost the entire European continent (Niethammer 1978). It is absent from northern Scandinavia.

Geography: Germany

The Wood Mouse occurs all over Germany.

Population, trend and conservation status

- Red List Germany: least concern
- BNatSchG §7 Abs.2: besonders geschützt (b)

Tab. Apsy1: Red List-classifications of the status of Wood Mouse populations in total Germany and the federal states (n.a.= information not available).

State	G	BB	BW	BY	HE	MV	NI	NW	RP	SH	SL	SN	ST	TH
Year	2008	2003	2001	2003	1995	1991	1991	2010	1987	2000	2008	1999	2004	2001
Category	-	-	-	-	-	3	-	-	-	-	n.a.	-	-	-

The Wood Mouse is a common rodent in agricultural landscapes all over Germany. Its populations are stable, though there might be a trend of slightly decreasing numbers towards Western Europe (Lung 2004).

In small mammal communities in agricultural habitats Wood Mice are one of the most abundant and dominant species (Kotzageorgis & Mason 1997;Tattersall et al. 2002; Krug & Hübner 2011).

Life cycle

Wood Mice reproduce between February and September (Niethammer 1978). Green (1979) found in his study in the UK that the breeding season of Wood Mice lasts from April till November. One to three litters are born per year, each with four to seven young (Niethammer 1978). The maximum life span of a Wood Mouse is about twelve months.

Wood Mouse population sizes show a typical pattern of large numbers in autumn and winter followed by a decline in spring.

Dispersal

In winter home ranges of Wood Mice were smaller and predominantly in hedgerows while sizes increased in summer and more habitats were included in a home range (Tew & Macdonald 1994 in Todd et al. 2000).

Its optimal range needs a size of a minimum of 0.05ha and up to 4ha (Lung 2004).

Green 1979: in arable land, winter males average of 3416m , female 4561m ; breeding season 12151m males, 6337m females.

Diet

Most important in the diet of Wood Mice are seeds of a variety of plants (Niethammer 1978). They also feed on animal material, mainly arthropods but also mollusks and oligochaeta.

From October till February Wood Mice consumed predominantly seeds, while from May till July animal food was more important, compensating for the shortness of seeds in spring and early summer. The consumption of fruits increased during August till October while from March till May green plant parts occurred more often (Watts 1968).

The Wood Mouse forages on arable land all year by consuming seeds, grasses and herbs, fruits, insect larvae and earthworms depending on local and seasonal abundance (see Barber et al. 2003).

Green (1979) found the main food components of Wood Mouse diet to be grain, waste sugar beet roots, weed seeds and soil invertebrates in winter. During spring and early summer Wood Mice mainly consumed seeding weeds and preferred winter wheat fields.

The percentage of diet affected by pesticides is estimated as 50%, since approximately half of the specie's diet consists of crop plants (predominantly seeds).

Wood Mice are mainly nocturnal (Niethammer 1978). They are mainly granivorous (Hansson 1971) and forage more terrestrial than Yellow-necked Mice.

Habitat and densities

The Wood Mouse occurs in various habitats like woodland, cereal fields, urban parks or gardens and prefers border habitats containing hedgerows, shrubs and undergrowth. Dense forests are only populated where A. flavicollis is missing (Niethammer 1978). Wood Mice avoid swamps, heath and spruce forests.

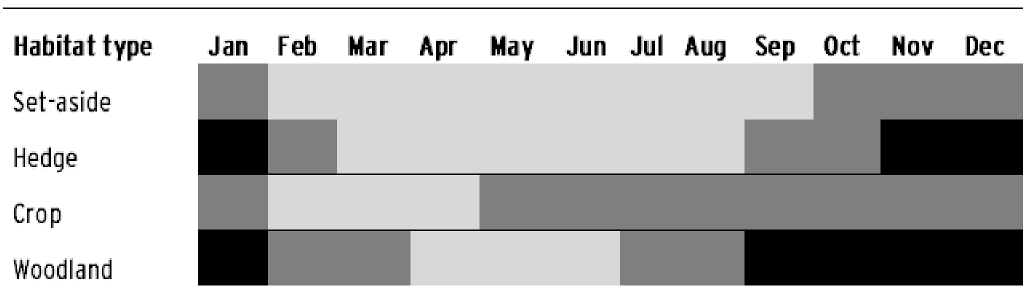

Fig. Apsy1: Occurrence of Wood Mice in different habitats over the year (darker shading indicates higher abundance).

Year-round the spatial distribution of Wood Mice covers all types of arable land (also fields after harvest and vegetation free areas) and structural field habitats (Boye 2003). However,

Montgomery & Dowie (1993) found, that abundances of Wood Mice in the field margins of pastures were negatively related to the percentage of pasture land and distance from woodland, while the variables food supply and cover had a positive effect on Wood Mouse abundance.

In his extensive study, Boye (2003) caught 37.2% of all Wood Mice in sugar beet fields and 52.8% in road margins and ditch edges.

Figs. Apsy2 A and B show the results of two different studies investigating occurrence and habitat selection of Wood Mice. Heroldova et al. (2007) studied small mammal communities in agricultural landscapes in the Czech Republic over six years and found that 77% of the community found in crops consisted of thee rodents (Apodemus sylvaticus, Apodemus microps and Microtus arvalis), while communities in permanent habitats (like windbreaks, small woods and fallow land) were much more abundant and diversified. The Wood Mouse was most often caught in windbreaks followed by maize and cereal fields (Heroldova et al. 2007).

A radio-tracking study in the UK found that Wood Mice spend most of their time in hedges and other non-crop habitat. They were most frequently caught in hedges followed by cereal crops. However, in newly-drilled cereal fields only 10% of the mean proportion of time was spent, while 43% of all individuals did not spend any time in these fields (DEFRA 2009; Fig. Apsy2 B).

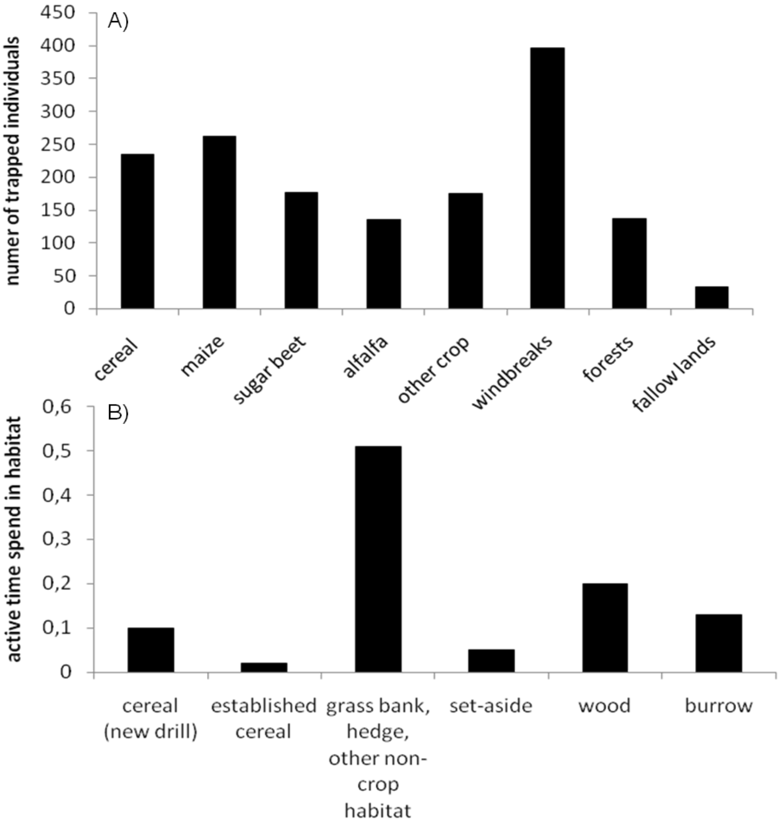

Fig. Apsy2: Occurrence and habitat selection by Apodemus sylvaticus in various habitat and crop types (A) Heroldova et al. 2007; B) after DEFRA 2009).

The Wood Mouse exploits both cultivated field and hedge habitats, but seems able to exist in cultivated areas independently of the presence of hedges (Pollard & Relton 1970). Wood Mice were found to live inside wheat fields (up to 100m from the verge) immediately following drilling, feeding on the newly sown grain (Pollard & Relton 1970).

Ouin et al. (2000) studied phenological abundance and habitat preference of Apodemus sylvaticus applying life-trapping in an arable landscape in France. The Abundance of Wood Mice peaked in crops in May while the rate of captures in hedges decreased (see Fig. Apsy3 A).

Activity appeared to be more centered on hedgerows in autumn (Ouin et al. 2000; Shore et al. 1997).

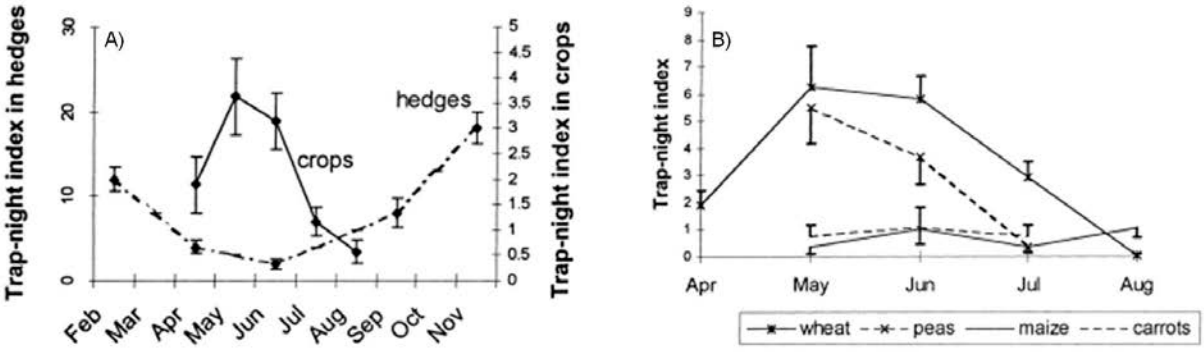

Fig. Apsy3: A) Wood Mouse trap-night index (number of Wood Mice trapped per night per 100 traps; with standard error) in crops and hedges over the year (after Paillat & Butet 1997). B) Monthly variation of Wood Mouse abundance (mean ± standard variation in different crops) (adopted from Ouin et al. 2000).

Todd et al. (2000) radio-tracked 79 Wood Mice in arable habitats (hedgerow, wheat, barley and oil-seed rape) in the UK. They studied the presence of and preference for habitat types in home ranges in winter (November-March) and summer (June-August). Hedgerows ranked highest in preference both in summer and winter. During winter home ranges contained significantly more hedgerows than barley and wheat as well as significantly more rape than wheat (Todd et al. 2000). Hedgerows were the main over-wintering habitat but were also used in summer since they are a good source of invertebrate prey and provide shelter. In summer home ranges contained less rape than other habitats. The authors suggest that this was due to the very dense cover with rape plants which inhibits the growth of other food plants below.

Wood Mice used their habitats in proportion to their availability during summer and spent most of their time in crops. However hedgerows were still highest ranked in preference but comprised only little of the landscape.

Seasonal patterns in habitat use seemed to be largely a response to seasonal disturbance by agricultural operations (harvesting, ploughing and sowing) and the availability of food and cover in the fields (Todd et al. 2000).

Tew et al. (2000) radio-tracked 48 Wood Mice in arable fields to study their habitat use at the microhabitat level. They found that Wood Mice preferred to forage in weedy patches within superficially homogeneous crops. The mice strongly responded to this kind of variation within fields. Areas with a high abundance of bare soil were avoided, probably due to higher risk of predation or decreased food availability. Instead Wood Mice selected areas with a high abundance of Alopecurus myosuroides, Stellaria media, Avena fatura, Galium aparine or Bromus sterilis (Tew et al. 2000). All of these species are considered to be agricultural pests.

The results suggest that while the heterogeneity on the scale of the mosaic of crop fields does not influence habitat use of Wood Mice, they strongly react to the dispersion of food plants within the superficially homogeneous crop itself (Tew et al. 2000).

Green (1979) trapped Wood Mice and found their burrows in open fields throughout the year. He recorded no preferences of Wood Mice for either ploughed land or winter wheat which were the main field types available in winter. Winter wheat fields were increasingly populated during spring and in summer greater densities were found here than in spring-sown cereals. During these seasons densities in sugar beet fields were relatively low but numbers increased in autumn when the crop provided thick cover and late-germinating weeds seeded (Green 1979).

Macdonald et al. (2000) studied the effects of crop type, habitat type (field edge or center), season and year on numbers and movements of wood mice in edges and centers of winter wheat, winter barley or oil-seed rape fields (3 year rotation). They applied radio-tracking on the individual level and live-trapping to study Wood Mice on the population-level.

Populations were largest from April to July when the crops were tall. During winter densities were highest in field edges compared with the centers. Rape field centers and edges had significantly lower numbers than the edges and centers of barley or wheat fields. Wood Mice also moved most quickly in rape fields, probably due to the low foraging value of these crops. The dense standing rape crops may contain less weed patches, which are favored by Wood Mice (see Tew et al. 2000), compared to barley and wheat fields. This might also be a result from specific herbicide spraying regimes in this crop type (Macdonald et al. 2000). Rape fields including adjacent hedgerows seemed not to be suitable habitats for breeding Wood Mice.

Wood Mouse populations showed a higher increase in woodlands surrounded by a high percentage of wheat fields (Fitzgibbon 1997). During spring, when crops provided sufficient cover, more Wood Mice were caught in arable crops than in woodlands. After the harvest Wood Mice moved into woodlands.

Tattersall et al. (2001) assessed the impact of the change of crop land into set-aside on Wood Mice. They radio-tracked Wood Mice to compare their use of set-aside, crops and hedgerows before and after harvest. Before harvest Wood Mice had larger home ranges and were more mobile. They used habitats within their ranges at random and the ranges contained a high proportion of cropped area. After the harvest home range sizes and the proportion of crops within their ranges decreased. Wood Mice preferred hedgerows and uncut set-aside and avoided margin and cut set-aside during this period probably due to increased predation risk and low food availability (Tattersall et al. 2001).

Wood Mice appear to spend more time on crops during the breeding season than in winter, therefore we set values for the index calculation of 60% and 40% of diet taken from sprayed cultures respectively. Cover determines the occurrence of Wood Mice and gets a score of 0.7.

The species builds, also on crop fields, tunnel in the soil including a nesting chamber. In winter it moves occasionally into houses (Niethammer 1978).

Densities of Wood Mice in winter wheat fields increased during spring and summer. Densities were higher than in spring sown wheat (Green 1979). Sugar beet crops on the other hand were relatively low inhabited by Wood Mice on spring and summer but held higher densities in autumn when ground cover provision was high and late germinating weeds seeded (Green 1979).

Over the year, Wood Mouse populations show a typical pattern of large numbers in autumn and winter and a decline in numbers in spring (Kotzageorgis & Mason 1997; Haberl & Krystufek 2003). In March and April densities of 0.6 to 2.3 individuals per hectare were found in an area in western Germany (Boye 2003). Kotzageorgis & Mason (1997) recorded mean and maximum densities of Wood Mice per 1000m between 24.4 and 77.2 (mean values) and between 80 and 200 (maximum values) in eight hedgerow habitats bordering farmland in the UK.

On German beet fields maximum numbers of 40 Individuals per ha were reached in October (Niethammer, 1978).

According to Green (1979) the lowest density on arable fields was 0.46 individuals/ha in June/July and the highest 17.54 individuals/ha in December on arable fields in the UK.

Threats / sensibility (pesticide effects)

Several studies investigated the impact of pesticides on Wood Mice. Because of their high abundances and frequent occurrence on arable land this species is a good study object.

Shore et al. (1997) found in their study decreases in numbers of Wood Mice on arable fields after pesticide (methiocarb, molluscicide) application (Fig. Apsy4). The decline was greater in autumn (73%) than in spring (33%).

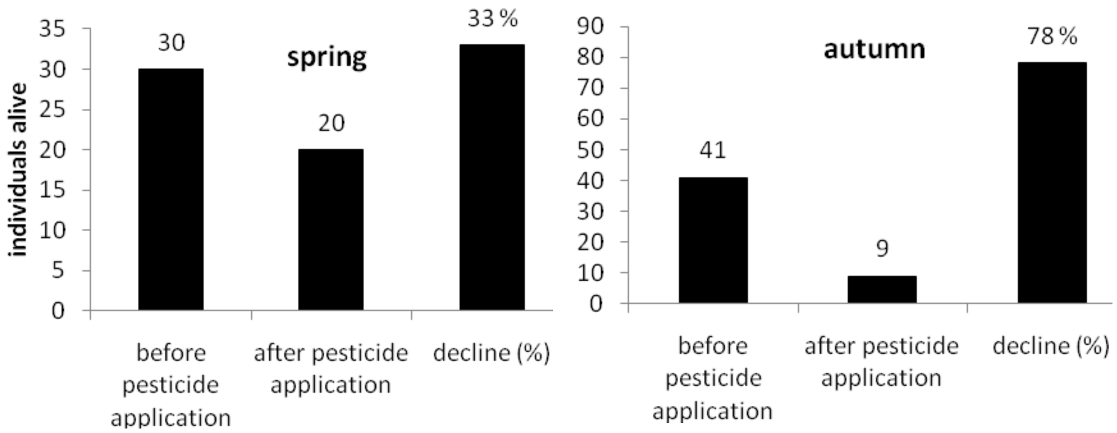

Fig. Apsy4: Occurrence of Wood Mice in crop before and after pesticide application (after Shore et al. 1997).

A study on habitat selection of Wood Mice in relation to pesticide application investigated headlands of cereal crops under different agrochemical treatments by radio-tracking in England. The animals significantly preferred unsprayed and selectively sprayed (conservation headlands) areas over sprayed headlands and mid-field areas (Tew et al. 1992; Fig. Apsy5).

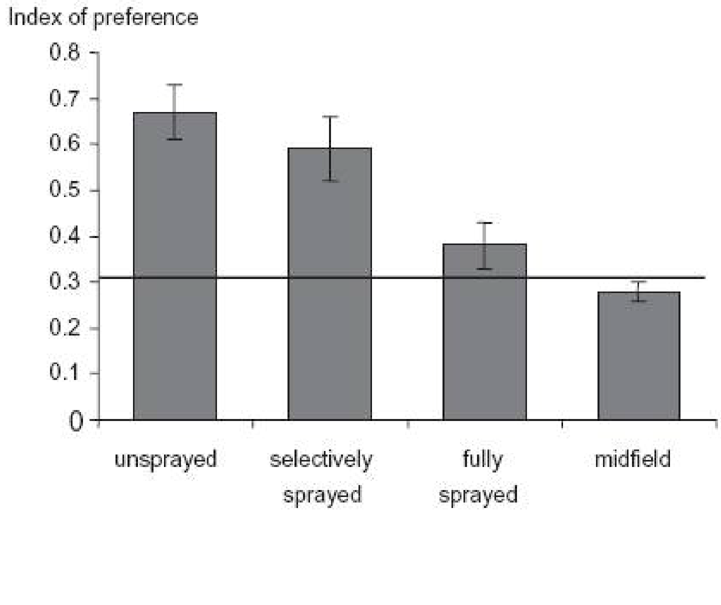

Fig. Apsy5: Normalized preference indices (mean + S.E.) for different habitat types for 12 radio-tracked Wood Mice. Values above 0.3 indicate selection, values below 0.3 indicate avoidance (after Tew et al. 1992; from MacDonald et al. 2007).

Experiments about risks to small mammals from utilizing caches of pesticide treated seeds undertaken by DEFRA (2005) showed that pesticide treatments did not inhibit Wood Mice from hoarding seeds. Though pesticides slowed the rate of utilization, because they reduced the palatability when freshly applied to seeds, the treated seeds appeared to become more acceptable to mice after some time. Whether the toxicity had already decreased during this time is uncertain (DEFRA 2005). Most mice created relatively small caches of seeds that lasted no longer than a few days.

Barber et al. (2003) studied the exposure of Wood Mice, amongst others, to pesticide seed treatments by snap-trapping them inside arable fields and hedges. They found, that 80% of the animals trapped in hedges consumed no seeds, while 90% of animals trapped in crop had consumed seed, though 90% of these animals had less than 20% seed in their stomach. Residues of fungicide in stomach tissues were lower than expected and the researchers concluded a connection to the behavior of dehusking seeds before consumption.

Other threats

Wood Mice have many natural enemies. Anthropogenic hazards are for example the intensification of land use and agriculture or the elimination of wild herbs and their seeds and fruits (Lung 2004).

Tew & Macdonald (1993) found, that the removal of cover provided by the crop greatly increased predation pressure on mice, while the process of harvesting itself had little direct effect. Radio-tracking Wood Mice showed that the mice either emigrated from arable lands after harvest or reduced their activity. Increased predation (>50%) and emigration produced an 80% decrease in the population on crop land (Fig. Apsy6).

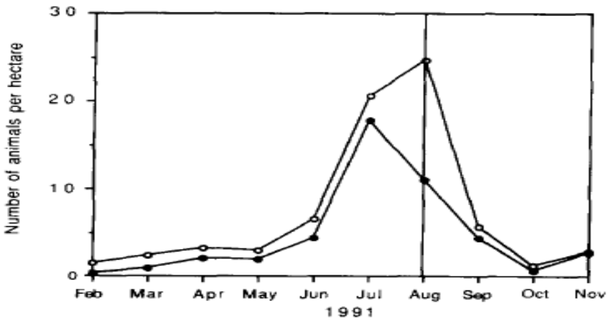

Fig. Apsy6: Monthly population size (o) and recruitment (•), calculated by Jolly-Seber capture-mark-recapture analyses. Time of harvest is indicated by solid vertical line (adopted from Tew & Macdonald 1993).

Macdonald et al. (2000) indentified oil-seed rape crops as not being suitable for breeding Wood Mice. They conclude that growing numbers and larger sizes of rape crops, and probably also of other dicotyledonous crops, might cause reductions in Wood Mouse populations in arable landscapes.

Measures for risk-management

Aim: Reduction of threats associated with pesticide applications

Wood Mice significantly selected unsprayed and selectively sprayed headlands as habitat. Leaving plots in headlands without herbicide application (conservation headlands) increases Wood Mouse populations and therewith positively affects populations of predators, like the Least Weasel or Barn Owls, especially if those measures are situated close to hedgerows and field margins, where they prefer to hunt (Tew et al. 1992).

Aim: Improvement of food availability and nesting habitats

A small-scale study on the effects of organic farming on Wood Mouse populations carried out by Madonald et al. (2007) showed that organic fields hold higher numbers of Wood Mice. The number of females in breeding condition was higher in most months on the organic farm, they were significantly heavier and started earlier to breed. Consequently more juveniles were present on organic fields.

Fitzgibbon (1997) showed that woodlands as small as 0.1 ha form an important habitat for Wood Mice, which use this habitat a refuge after crop fields have been harvested. Therefore woodland and hedgerows should be an abundant habitat type in agricultural landscapes to support rodent populations especially during the winter (Fitzgibbon 1997). The author mentions specific management measures to improve the suitability of woodlands for small mammals such as the clearing of understory hawthorn, promotion of a mosaic of dense undergrowth and herb areas to provide both protection and food and planting more hedges to provide safe access routes to the woods.

Tattersall et al. (2001) assessed the impact of the change of crop land into set-aside on Wood Mice. They radio-tracked Wood Mice to compare their use of set-aside, crops and hedgerows before and after harvest. Before harvest Wood Mice had larger home ranges and were more mobile. They used habitats within their ranges at random and the ranges contained a high proportion of cropped area. After the harvest home range sizes and the proportion of crops within their ranges decreased. Wood Mice preferred hedgerows and uncut set-aside and avoided margin and cut set-aside during this period probably due to increased predation risk and low food availability (Tattersall et al. 2001).

Radio-tracked Wood Mice selected set-aside on the basis of plant species diversity and amount of cover caused by different seed mixtures (Tattersall et al. 1999).

Wood Mice tended to avoid set-aside and rather selected hedgerow and crop habitats (Tattersall & Macdonald 2003 in Macdonald et al. 2007).

The width of field margins had no effect on Wood Mouse abundance (Shore et al. 2005).

1.7 Harvest Mouse (*Micromys minutus*) – Zwergmaus – Order: Rodentia

Geography: Europe

The Harvest Mouse occurs from eastern to central Europe. In West Europe its distribution reaches until the South of England, The Netherlands and the North of Spain (Böhme 1978). It is absent in the Alps and most of Italy.

Geography: Germany

Harvest Mice occur all over Germany.

Population, trend and conservation status

- Red List Germany: category G (endangerment to an unknown extent);
- BNatSchG §7 Abs.2: besonders geschützt (b)

Tab. Mimi1: Red List-classifications of the status of Harvest Mouse populations in total Germany and the federal states (n.a.= information not available).

State	G	BB	BW	BY	HE	MV	NI	NW	RP	SH	SL	SN	ST	TH
Year	2008	2003	2001	2003	1995	1991	1991	2010	1987	2000	2008	1999	2004	2001
Category	G	-	3	V	3	G (4)	-	G	3	-	n.a.	-	3	-

The Harvest Mouse is moderately common in Germany. However, population numbers seem to decline on the long term to an uncertainty degree (Meinig et al. 2009). The situation of its population is worse than in 1998, when it was still classified as vulnerable (Red List category V).

The Harvest Mouse is considered the most rare mouse species (Lung 2004).

Life cycle

Harvest Mice reproduce between April and October. They may have several litters per year each with about two to six young (Böhme 1978). Maximum life spans of 16 to 18 months are recorded.

Dispersal

No information available.

Diet

The Harvest Mouse primary consumes seed of grasses, cereals and herbs but also insects and its larvae (Grzimek 1984).

The diet consists mainly of seeds from tall grasses and insects (Piechocki, 1958 in Böhme, 1978). Among crop plants all cereals, alfalfa and seeds of beets may be consumed. During winter the diet may consist almost exclusively of animal food.

The diet of harvest mice consists of about 30% crop plants (Böhme 1978). Therefore 70% of the diet is potentially affected by pesticides. During winter, when animal food becomes more important this value rises to 80%.

Habitat and densities

The Harvest Mouse prefers high growing cereal fields or grassland as well as reed or sedge beds along shore areas or on flooded grounds (Lung 2004). It is an excellent climber and builds its round nests in strong stems; therefore it needs relatively humid areas with long lasting grass growth (Grzimek 1984). After the harvest of cereals the species depends on hedgerows. In winter it stays on the ground and in buildings (Grzimek 1984).

Harvest Mice are primary stenoecious since they are highly specialized spear climbers (Böhme 1978). Their main habitats are reed and sedge stands of Calamagrostis, Typha and Carex species. Especially in northwestern Europe Harvest Mice commonly enter cereal and beet fields and may reach high densities in these secondary habitats (Böhme 1978).

Boye (2003) caught Harvest Mice in autumn in sugar beet fields, 10-15 cm high winter barley and cabbage. But the main part of his catches (79.7%) of Micromys minutus was in the vegetation along ditches.

In a study of the small mammal community of different habitat types in a nature reserve in Austria, the Harvest Mouse was the most dominant species (Haberl & Krystufek 2003). Further they found a positive association of Harvest Mice with reed stands, where it exclusively occurred in spring (see Fig. Mimi1).

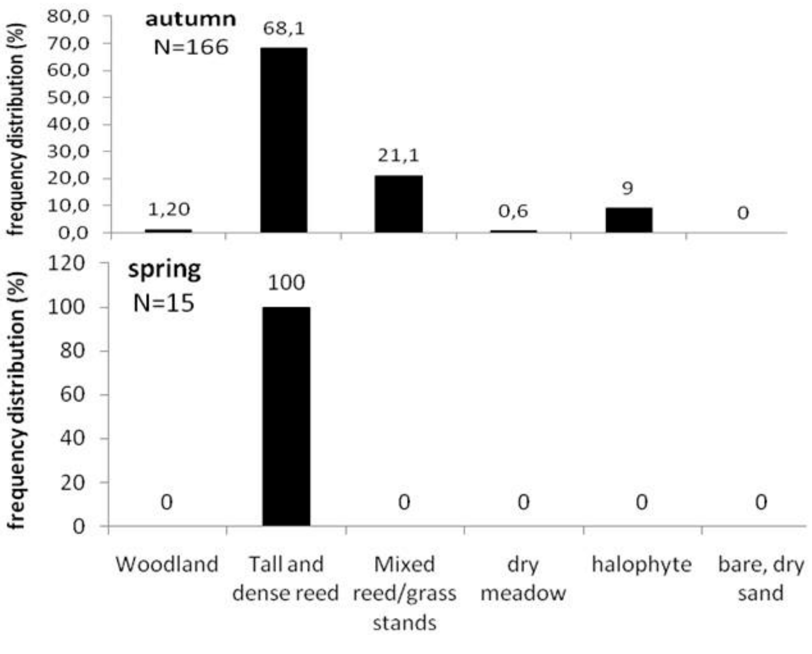

Fig. Mimi1: Habitat selection by Harvest Mice in six different natural habitats (N= number of captures, pooled data of two years; after Haberl & Krystufek 2003).

Harvest Mice were the most frequently caught species in farm woodlands surrounded by agricultural land (Moore et al. 2003). Individuals caught inside the crops were only found close to the field edges and few numbers of harvest mice were caught in hedgerows.

Most types of crops are inhabited by Harvest Mice, except for sweet corn (Harris 1979).

Harvest Mice dominated habitats in the ruderal stage with annual and perennial forbs while they were absent from mid-successional stage (Churchfield et al. 1997).

Harvest Mice build characteristic nests above the ground in the stems of strong tall grass species (Böhme 1978). Surmacki et al. (2005) studied nest sites of Harvest Mice midfield marsh patches and ditches in intensively use farmland in Poland. They found that 98% of nests were attached to reed stems. The Mice favored reed-beds with low, thin and sparse stalks while they avoided areas with a high density of herbaceous vegetation (Surmacki et al. 2005).

During winter they often stay in grain-barns or haystacks (cereal ricks) (Böhme 1978).

The proportion of food taken from cultures is difficult to access. In view of the preference of Harvest Mice for thigh growing grass stands we estimate that adults during the breeding season take 30% of their food from crops including grassland. The amount of nest in sprayed crops is estimated to be about 10%. During winter the amount of diet taken from crops decreases (10%) because Harvest Mice often move into buildings.

The Harvest Mouse shows a relatively high proportion diurnal activity to cover its high nutritional demand which is due to its small body size. Harvest Mice therefore need a high percentage of cover which is provided by the stems of tall growing grasses (Böhme 1978). For the importance of cover we set a value of 0.7 in the index calculation.

Densities of Harvest Mice in grassland areas in Southern England were highest in autumn and winter and lowest over the summer months (Trout 1978; Fig. Mimi2).

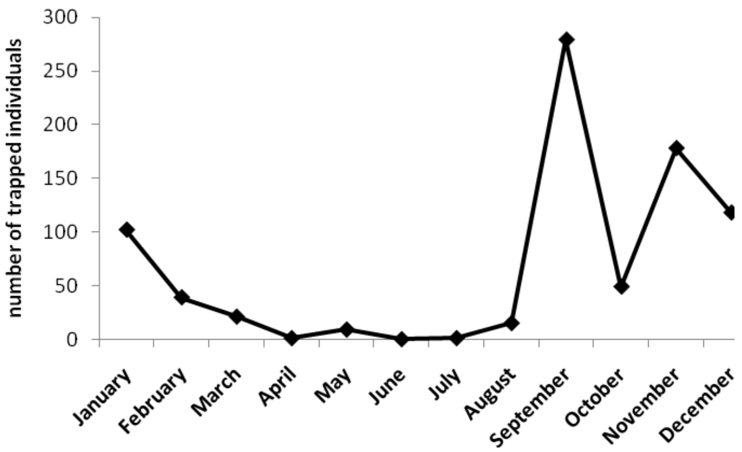

Fig. Mimi2: Seasonal variation in number of Harvest Mice trapped (pooled data of three years; after Trout 1978).

Densities may be high in suitable habitats, e.g. up to 200 Individuals per ha in Southern England (Grzimek 1984). Their populations follow regular three (or more) year cycles of abundance.

Haberl & Krystufek (2003) recorded densities of 52 and 45 individuals per hectare in November in two consecutive years and of 27 individuals per hectare in March in a nature reserve in Austria.

Threats / sensibility (pesticide effects)

The Harvest Mouse has several natural enemies. An anthropogenic threat is the habitat destruction that limits the amount of suitable nest sites and general living space (Meinig & Boye 2009).

Measures for risk-management

Aim: Improvement of food availability and nesting habitats

Harvest Mice were the species most caught in woodlands in arable lands. The newly planted farm woodlands seemed to provide an important habitat for Harvest Mouse populations in the UK (Moore et al. 2003).

In Japan Hata et al. (2010) investigated grassland management measures to provide Harvest Mice with sufficient breeding habitat. They found, that phased mowing (mowing of sections of embankments at intervals in spring and autumn) allowed grasses to recover which increased the nesting habitat suitability for Harvest Mice (Hata et al. 2010).

Bence et al. (2003) investigated the suitability of arable field margins and beetle banks as nesting habitat for Harvest Mice. These habitats contained higher proportions of strongly stemmed herbaceous plants and grasses than the comparison sites.

Bramble, thorns and Prunus spinosa were the main species supporting nests in field margins. Nests occurred in the densest vegetation and in higher densities in beetle banks than in field margins (Bence et al. 2003).

Creating beetle banks and field margins seemed to enhance the availability of nesting sites for Harvest Mice and therefore is considered as a suitable management practice. Bence et al. (2003) further suggest that hedges should not be cut after the harvest when the Mice have their peak of the breeding season. Cutting of hedges should occur in late winter instead.

1.8 Bicoloured Shrew (*Crocidura leucodon*) – Feldspitzmaus – Order: Insectivora

Geography: Europe

Bicoloured white-toothed Shrews are widely distributed in Europe but are absent from the South of France and the Iberian Peninsula.

Geography: Germany

The Bicoloured Shrew has its distribution border in Western Germany (Meinig et al. 2009).

The exact distribution of this species is unclear. According to Krapp (1990) the species occurs all over Germany and has its northern distribution border in Schleswig-Hollstein. The species' distribution may be influenced by the occurrence of the Greater white-toothed Shrew which has the same size and weight and therefore might compete with Bicoloured Shrews (Krapp 1990).

Population, trend and conservation status

- Red List Germany: category V (near threatened)
- BNatSchG §7 Abs.2: besonders geschützt (b)
- Bern Convention, Appendix III

The Bicoloured Shrew is classified as near threatened in the latest Red List for Germany. In 1998 the species was listed as vulnerable (category 3). The upgrading of the classification can be attributed to methodological improvements (Meinig et al. 2009).

Eight federal states of Germany include the Bicoloured Shrew in their red lists, Mecklenburg-Vorpommern classifies it as critically endangered (category 1; see Tab. Crle1).

Tab. Crle: Red List-classifications of the status of Bicoloured Shrew populations in total Germany and the federal states (n.a.= information not available).

State	G	BB	BW	BY	HE	MV	NI	NW	RP	SH	SL	SN	ST	TH
Year	2008	2003	2001	2003	1995	1991	1991	2010	1987	2000	2008	1999	2004	2001
Category	V	-	3	-	2	1	3	V	2	3	n.a.	-	V	-

The status of Bicoloured Shrew populations is described as moderately common but slowly decreasing on the long term (Meinig et al. 2009).

Life cycle

The time of reproduction of Bicoloured Shrews lasts from April to September/October. There may be two to four litters per year, with 3-10 young born per litter. After about 20 day the young are independent and with 8-10 month they are able to reproduce. Bicoloured Shrews may reach an age of up to three years (Krapp 1990).

Dispersal

No information available.

Diet

Kuvikova (1987, in Krapp 1990) analyzed the contents of 37 stomachs and found as main components Coleopterans, Diplopods and larvae of Bibionidae. From the occurrence of the two latter species he concluded that Bicoloured Shrews feed not only on the soil surface but also in the upper soil layer.

We estimate that, due to the high proportion of insects in the diet, about 90% are potentially affected by pesticides.

Bicoloured Shrews are mostly nocturnal (Krapp 1990).

Habitat and densities

The Bicoloured Shrew lives in open landscapes and mainly occurs on arable land, like the other Crocidura species (Krapp 1990). It tolerates even lower proportions of ground cover than the other two species. The value for the importance of cover is therefore set at 0.4 in the index calculation.

Mortelliti & Boitani (2009) found that Bicoloured Shrews show generalist behaviour and are not associated with any particular habitat characteristic.

It prefers dry areas, hills and edges of woods as well as road edges and hedgerows (Grzimek 1984).

Favored habitats of Bicoloured Shrews are drywalls, poor grassland, open hedges and smaller semi-natural structures (Güttinger et al. 2008).

Crops do not belong to the Bicoloured Shrew's favored habitats; however the species is present in adjacent structures and habitats. Therefore we estimate the amount of diet taken from sprayed cultures to be about 40%.

The occurrence of Bicoloured Shrews is negatively associated with the abundance of Sorex minutus (Mortelliti & Boitani 2009).

Densities (measured by captures) in woodland were lowest in spring and summer. They increased till autumn, when they peaked, and decreased again over winter (Mortelliti & Boitani 2009).

Threats / sensibility (pesticide effects)

Common natural enemies are owls, reptiles and other predators (Grzimek, 1984).

The Bicolored Shrew is listed as being threatened by agriculture in a study by Meinig & Boye (2009) about negative impact factors threatening mammal populations in Germany.

Günther et al. (2005) list the removal of hedgerows, field margins and other structural elements as main threat for wildlife in open landscapes like the Bicoloured Shrew.

Güttinger et al. (2008) conclude that Bicoloured Shrews are endangered through their limited distribution and the loss of semi-natural habitats.

A study about the ability of recolonization of an isolated woodlot by shrews showed that the species is facing problems to overcome large areas of agricultural land which functions as a barrier (Ylönen et al. 1991).

Measures for risk-management

Aim: Improvement of food availability and nesting habitats

Favored habitats of Bicoloured shrews are drywalls, poor grassland, open hedges and semi-natural smaller structures (Güttinger et al. 2008).

1.9 Greater white-toothed Shrew (*Crocidura russula*) – Hausspitzmaus – Order: Insectivora

Geography: Europe

Occurs in the Atlantic and Mediterranean Western Europe, in Austria and Switzerland (Genoud & Hutterer 1990). It is absent from Great Britain and South of the Alps.

Geography: Germany

In Germany it has its distribution border in the North (Meinig et al. 2009).

Population, trend and conservation status

- Red List Germany: least concern
- BNatSchG §7 Abs.2: besonders geschützt (b)
- Bern Convention, Appendix III

Tab. Crru1: Red List-classifications of the status of Greater white-toothed Shrew populations in total Germany and the federal states (n.a.= information not available).

State	G	BB	BW	BY	HE	MV	NI	NW	RP	SH	SL	SN	ST	TH
Year	2008	2003	2001	2003	1995	1991	1991	2010	1987	2000	2008	1999	2004	2001
Category	-	-	G	-	D	-	G	-	-	R	n.a.	-	3	-

C. russula is common but slowly declining in the long term (Meinig et al. 2009). However due to the lack of data the actual trend of its population sizes is unknown.

Life cycle

Greater white-toothed Shrews reproduce from February till October in Central Europe. They have 2 to 4 litters per year each with 3 to 6 young (Genoud & Hutterer 1990). C. russula may have a life span of 24 to 32 months, however most individuals do not seem to survive a second winter.

C. russula is active all year round.

Dispersal

Home range sizes may range from 56 to 395 m, daily movements may be between 208 and 1074 m (Genoud & Hutterer 1990).

C. russula has its main activity phase at night and is least active during the morning (Genoud & Hutterer 1990).

Diet

The Greater white-toothed Shrew is an opportunistic predator that feeds on a wide range of invertebrate species, mainly arthropods (larvae), earthworms and mollusks. It may also feed on plant pieces including seeds and vertebrates.

Main components of the diet are myriapods, isopods, lepidoptera larvae, gastropods and araneae (Bever 1983 in Genoud & Hutterer 1990).

The percentage of diet affected by pesticides is estimated as 90% for *C. russula.*

Habitat and densities

C. russula is common in semi open and open landscapes, like set-aside, grassland and hedgerows, while it avoids woodland (Genoud & Hutterer 1990). It often lives close to human settlements in gardens or parks (Grzimek 1984). Güttinger et al. (2008) mentions a habitat preference for compost heaps.

The species has its nests below ground or hidden by stones or similar objects (Genoud & Hutterer 1990). In winter they move closer to human settlements into houses, barns or compost heaps.

We estimate the amount of diet taken from sprayed cultures to be about 40% in the breeding season and about 20% in winter. The presence of cover is classified to be slightly more important than for the Bicoloured Shrew and is therefore represented by a value of 0.5 in the index calculation.

Maximum densities occur in summer and autumn. Winter densities of 100 individuals per ha were estimated (Genoud & Hutterer 1990).

Threats / sensibility (pesticide effects)

The species faces the risk of secondary poisoning.

Other threats

Natural enemies are for example owls and reptiles (snakes) (Grzimek 1984).

Measures for risk-management

No information available.

1.10 Lesser white-toothed Shrew (*Crocidura suaveolens*) – Gartenspitzmaus – Order: Insectivora

Geography: Europe

The Lesser white-toothed Shrew is distributed over wide parts of Europe and Asia (Vlasak & Niethammer 1990).

Geography: Germany

C. suaveolens has its distribution border in north western Germany (Meinig et al. 2009).

Its distribution is parapatric with the occurrence of C. russula which seems to limit its range (Vlasak & Niethammer 1990).

Population, trend and conservation status

- Red List Germany: category D (data deficient)
- BNatSchG §7 Abs.2: besonders geschützt (b)
- Bern Convention, Appendix III

Tab. Crsu1: Red List-classifications of the status of Lesser white-toothed Shrew populations in total Germany and the federal states (n.a.= information not available).

State	G	BB	BW	BY	HE	MV	NI	NW	RP	SH	SL	SN	ST	TH
Year	2008	2003	2001	2003	1995	1991	1991	2010	1987	2000	2008	1999	2004	2001
Category	D	-	1	3	-	1	-	-	-	-	n.a.	-	R	R

The Lesser white-toothed Shrew is described as a rare species but comprehensive data is missing (Meinig et al. 2009). Observations of population trends vary between Bavaria and East Germany (Meinig et al. 2009).

Life cycle

The reproduction period of *C. suaveolens* is between April and October. A female might give birth to one to five litters per year, each with three to five young (Vlasak & Niethammer 1990). *C. suaveolens* usually may not survive a second winter so that its life span is around 12-15 month (Vlasak & Niethammer 1990).

Dispersal

No information available.

Diet

The Lesser white-toothed Shrew mainly consumes insects. It prefers small (<1cm) and soft prey food (Vlasak & Niethammer 1990).

Main components of diet derived from a stomach content analysis were Coleopterans (adults and larvae), Diptera (adults and larvae), Gastropods, Arachnidan and Chiropterans (Kuvikova 1987 in Vlasak & Niethammer 1990).

Approximately 90% of the shrews' diet is affected by pesticides (insecticides).

C. suaveolens is active by day and night but nocturnal activities dominate. The shrew searched pro its prey on the soil surface but also in the upper soil layers (Vlasak & Niethammer 1990).

Habitat and densities

C. suaveolens occurs in a wide range of habitats and only avoids large forest areas (Vlasak & Niethammer 1990). They prefer warm and dry areas with adequate cover and occur in woodlands, gardens, hedgerows, grasslands and set-aside. Suitable habitats are also recently cut woodland patches with typical structural features like high shrub cover, low tree height and small dbh values (Mortelliti & Boitani 2009). Relevant crop types may be cereals and foliage plant crops as well as rye, alfalfa and vine. It often occurs in the vicinity of humans (synantrophy).

We estimate the amount of diet taken from sprayed cultures to be about 40% in the breeding season and about 20% in winter. The presence of cover is classified to be slightly more important than for the Bicoloured Shrew and is therefore represented by a value of 0.5 in the index calculation.

Depending on the surrounding habitat the Shrews build their nests out of soft tissue on the ground (Vlasak & Niethammer 1990).

Densities of C. suaveolens captured in woodland were lowest in spring, increased until autumn when they peaked and decreased afterwards during winter (Mortelliti & Boitani 2009).

Threats / sensibility (pesticide effects)

Meinig & Boye (2009) name agriculture and habitat destruction as threats.

Poisoning due to pesticides as well as the removal of structural elements like hedgerows and field margins threaten small mammal species like the Lesser white-toothed Shrew (Günther et al. 2005).

Measures for risk-management

No information available.

1.11 Common Shrew (*Sorex araneus*) – Waldspitzmaus – Order: Insectivora

Geography: Europe

Common Shrews are absent in western European countries like Spain or Ireland. Some isolated populations occur in the Pyrenees and southern Italy (Hausser et al. 1990).

Geography: Germany

Common Shrews occur all over Germany (Hausser et al. 1990).

Population, trend and conservation status

- Red List Germany: least concern
- BNatSchG §7 Abs.2: besonders geschützt (b)
- Bern Convention, Appendix III

Tab. Soar1: Red List-classifications of the status of Common Shrew populations in total Germany and the federal states (n.a.= information not available).

State	G	BB	BW	BY	HE	MV	NI	NW	RP	SH	SL	SN	ST	TH
Year	2008	2003	2001	2003	1995	1991	1991	2010	1987	2000	2008	1999	2004	2001
Category	-	-	-	-	-	-	-	-	-	-	n.a.	-	-	-

Common Shrews, also named Eurasian Shrew, occur in stable populations all over Germany. However, data on the population trends is missing (Meinig et al. 2009).

Life cycle

First young are born in April or May and the latest in November. During the first three months (April-June) reproduction is most intensive. In total there may be two to three or even up to five litters per year, each with 4-8 young. After 20 days they are able to leave the nest. They participate in reproduction normally in the year after they are born. Information about the maximal life span varies between 11 and 16 months (see Hausser et al. 1990).

Dispersal

Home ranges had a size of 370-630m in dunes in the Netherlands (Croin Michielsen 1966 in Hausser et al. 1990).

Common Shrews may move 1.1 to 2.5km during 24 hours and 830m during one activity-phase (Karulin et al. 1997 in Hausser et al. 1990). Smaller home ranges and reduced activity are found in winter.

Diet

Pernetta (1976) studied gut and stomach contents from Shrews inhabiting grasslands in Oxfordshire, UK. Common Shrews mainly consumed Lumbricids, adult coleopteran and opilions. Earthworms form a main part of the diet and are more important during winter than in summer month (Pernetta 1976). Coleopteran adults and larvae are a key part of the diet during summer while the consumption of Opilions increases in autumn and Spiders are important during winter (Pernetta 1976).

In all seasons, main diet components were adult coleopterans, insect larvae, araneids, opilionids and isopods (Churchfield 1982). The author analyzed faecal pellets from shrews in a shrub-grassland habitat in the UK and found that 41% of the prey items had a body length less than or equal to 5mm.

The proportion of seeds is highest in autumn and winter, while Shrews consume mainly insects during spring and more gastropods later in the year (Hausser et al. 1990).

Due to the high amount of insects in the Shrews' diet we estimate the amount of diet affected by pesticides to be about 90% in summer and about 80% during the non-breeding season allowing for a higher consumption (crop) seeds.

The focus of activity is during night time but Common Shrews may be also active during the day (Hausser et al. 1990)

Habitat and densities

Common Shrews mainly inhabit moist and cool habitats with dense vegetation (Hausser et al. 1990). They live under ground and in self build corridors in the upper grass and foliage layer. The species lives more under the ground than Sorex minutus. In Northern Europe Common Shrews may also occur in more open landscapes like dunes and even beaches on the shores of the North Sea (Heydemann 1960 in Hausser et al. 1990). In Central Europe S. araneus occur in the edges of water bodies or in bogs but also on grassland (Yalden 1974 in Hausser et al. 1990). Further they inhabit deciduous forests, windbreaks and set-side.

The Common Shrew occurs in forests, wetlands and grasslands with thick undergrowth (Grzimek 1984). It is more typically found in uncultivated or field-edge habitat (Barber et al. 2003).

Fischer et al. (2011) studied small mammals in organic and conventional winter wheat fields along a gradient of structural complexity of the landscape in Lower Saxony and found that Common Shrews disappeared in complex landscapes with less than 50% of arable land.

In an investigation by DEFRA (2009) Common Shrews were most often caught in hedges and grassy margins, while they occurred less in cereal fields. Among leafy crops, shrews were most often found in sugar beet (DEFRA 2009; Fig. Soar1).

Common Shrews are more active during summer. During winter they stay more in corridors underground or in dense vegetation. In periods of very cold weather they may move into barns or houses but can also survive in corridors beneath the snow in contrast to Crocidura sp. which rely on human settlements (Genoud & Hausser 1979 in Hausser et al. 1990).

We estimate the amount of food taken from sprayed cultures to be about 40% since the species is more present in edge structures and non-crop habitats. During the non-breeding season this amount probably decreases to 30%. Cover is an important factor and is therefore scored as 0.7 in the index calculation.

Over the year, Common Shrews were found to be most numerous in summer in arable landscapes in Eastern England. Numbers declined rapidly in autumn (Kotzageorgis & Mason 1997; see Fig. Soar2).

Densities decrease during winter along with a decrease in body weight (Chruchfield 1982).

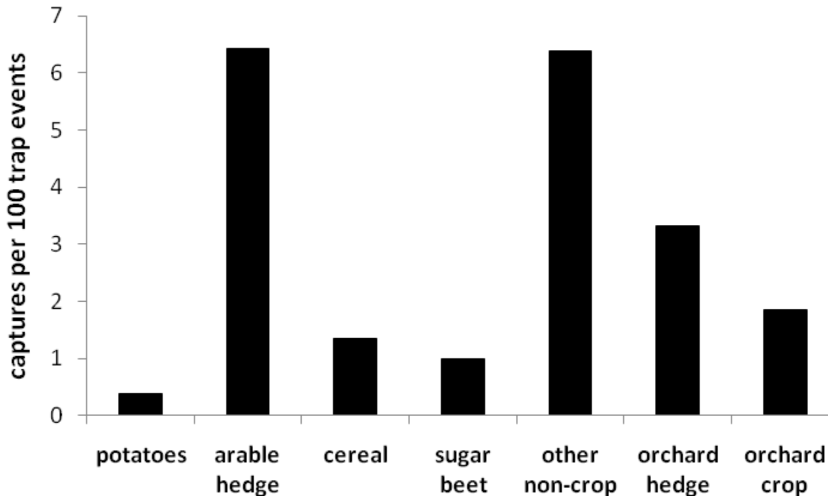

Fig. Soar1: Occurrence of Common Shrews in different arable habitats ("other non-crop" = mostly grassy or weedy field-edge strips and banks; after DEFRA 2009).

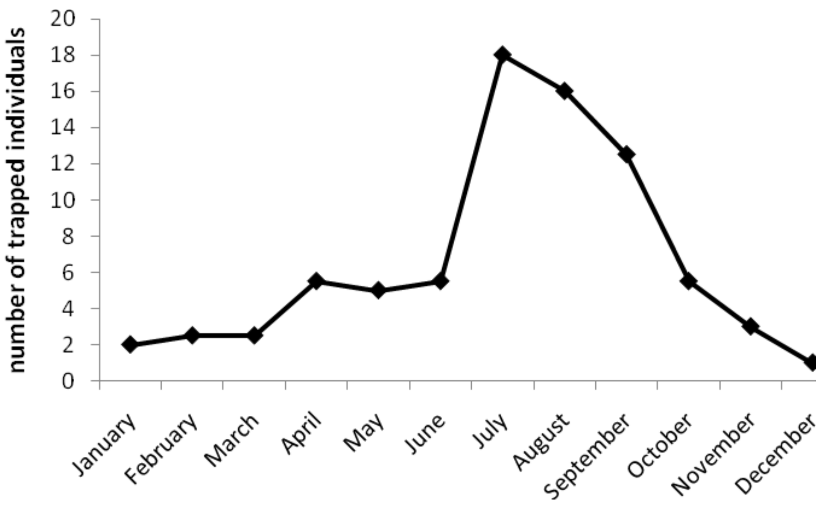

Fig. Soar2: Number of Common Shrews caught in hedgerows over the year (after Kotzageorgis & Mason 1997).

In the periods from September to December and in July Pernetta (1977 in Hausser et al. 1990) found densities of 6-12 individuals per ha on grasslands in the UK while Yalden (1974 in Hausser et al. 1990) reports densities of 42 individuals per ha on grassland during July and August.

Threats / sensibility (pesticide effects)

A study applying population models for risk assessment to model pesticide effects on Shrews revealed that pesticide applications in July caused stronger decline in Common Shrews than applications in April (Wang & Grimm 2010). During the summer application (July) the Shrew population consisted mainly of offspring and juveniles while in April adult shrews were just starting to reproduce. The authors conclude that landscape structure and the timing of pesticide applications have a great impact on the recovery of small mammal populations.

Other threats

Common natural enemies are owls, reptiles and other predators (Grzimek 1984).

Ylönen et al. (1991) report only a small ability of Common Shrews to colonize isolated woodlots in an intensive agricultural landscape.

Measures for risk-management

Aim: Improvement of food availability and nesting habitats

The loss of field boundary structures negatively effects Shrew abundance. Therefore hedgerows and field margins are very important conservation measures to enhance Shrew numbers (Pocock & Jennings 2008).

Shore et al. (2005) found that Common Shrews responded positively on field margins as part of a conservation measure. Significantly higher abundances of Common Shrews occurred in wide grassy strips (3 and 6 meter) than in conventional margins (0 meter; Fig. Soar3) in autumn (Shore et al. 2005).

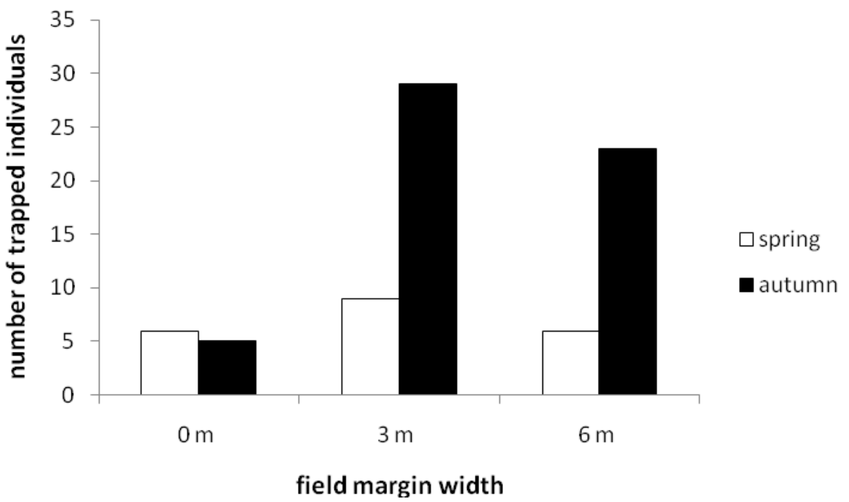

Fig. Soar3: Occurrence of Common Shrews in relation to field margin width between arable land (after Shore et al. 2005).

1.12 Pygmy Shrew (*Sorex minutus*) – Zwergspitzmaus – Order: Insectivora

Geography: Europe

The Pygmy Shrew, also Eurasian Pygmy Shrew, is distributed all over Europe, mainly in low lands of the North and secondary mountains (Hutterer 1990).

Geography: Germany

Pygmy Shrews are widely and continuously distributed in Germany.

Population, trend and conservation status

- Red List Germany: least concern
- BNatSchG §7 Abs.2: besonders geschützt (b)
- Bern Convention, Appendix III

Tab. Somi1: Red List-classifications of the status of Pygmy Shrew populations in total Germany and the federal states (n.a.= information not available).

State	G	BB	BW	BY	HE	MV	NI	NW	RP	SH	SL	SN	ST	TH
Year	2008	2003	2001	2003	1995	1991	1991	2010	1987	2000	2008	1999	2004	2001
Category	-	-	-	-	-	-	-	-	-	-	n.a.	-	3	-

Pygmy Shrews are common in Germany but data on long-term population trends is missing (Meinig et al. 2009).

Life cycle

Time of reproduction is between April and October (Hutterer 1990). Up to three litters per year may be born each with about two to five young. The life span may reach a maximum of 13 to 16 month. 50% however become only seven months old or less (Hutterer 1990).

Dispersal

Most of the year Pygmy Shrews are territorial (Hutterern 1990). Pernetta (1977 in Hutterer 1990) recorded territory sizes of 172 m in November and December and of 143 m from January till March.

Home ranges may have sizes of 530 to 1800 m (Grzimek 1984).

Diet

An analysis of gut contents by Pernetta (1976) revealed that Pygmy Shrews took Opiliones, Araneae and adult Coleoptera throughout the year. Earthworms were completely absent and slugs occurred only in very small numbers.

Pygmy Shrews prey on small items (spiders 2-3mm, adult Coleoptera 2-6mm, Opiliones 4mm) (Pernetta 1976).

Pygmy Shrews mainly feed on coleoptera, arachnids, opiliones and insect larvae (Hutterer 1990). It has a relatively narrow diet spectrum since earthworms and mollusks are widely missing and it consumes less plant items than the Common Shrew (Hutterer 1990).

As the diet more or less entirely consists of insects, 100% of the diet is potentially affected by pesticides (insecticides).

Activity: Mainly nocturnal, in winter and spring also diurnal (Hutterer 1990)

Habitat and densities

The Pygmy Shrew prefers grassland with dense vegetation, reed and swamps (Hutterer 1990). It is widespread wherever there is thick ground cover that provides a cool and moist soil climate. Pygmy Shrews also occur in coastal areas, in dunes and even in tidelands where a lack of ground cover is compensated by the humid oceanic climate (Hutterer 1990).

In comparison to the Common Shrew which stays mainly in tunnels under ground, Pygmy Shrews live and nest on or above the ground (Hutterer 1990).

Pygmy Shrews prefer typical mature woodland patches characterized by low shrub cover and tree density (Martelliti & Boitani 2009).

Due to its habitat preferences the Pygmy Shrew presumably takes only about 30% of its diet from sprayed cultures. However, cover is a very important factor and is scores as 0.8 in the index calculation.

Nests: Pygmy Shrews build nests out of leaves and moss. The main proportion of their nests was located above ground (Hutterer 1976 in Hutterer 1990).

Croin Michielsen (1966 in Hutterer 1990) recorded peak densities of 10 individuals per ha in August. The lowest densities of 4-5 individuals per ha were found in March. Densities seem to be lower than Common Shrew densities.

Threats / sensibility (pesticide effects)

No information available.

Measures for risk-management

No information available.

1.13 European Hedgehog (*Erinaceus europaeus*) – Westeuropäischer Igel – Order: Insectivora

Geography: Europe

The Hedgehog is endemic to Europe and occurs all over the continent.

Geography: Germany

Hedgehogs are common and present in total Germany.

Population, trend and conservation status

- Red List Germany: least concern
- BNatSchG §7 Abs.2: besonders geschützt (b)
- Bern Convention, Appendix III

Tab. Ereu1: Red List-classifications of the status of European Hedgehog populations in total Germany and the federal states (n.a.= information not available).

State	G	BB	BW	BY	HE	MV	NI	NW	RP	SH	SL	SN	ST	TH
Year	2008	2003	2001	2003	1995	1991	1991	2010	1987	2000	2008	1999	2004	2001
Category	-	-	-	-	D	3	-	-	3	-	n.a.	-	V	3

The European Hedgehog is a very common mammal in Germany. Meinig et al. (2009) mention a clear increase in the long-term population development.

Life cycle

Breeding season is between May and September. Two to seven young are born which become sexually mature after one year (Grzimek 1984). Hedgehogs may reach an age of seven years.

Hibernation lasts from the middle of November until March (Holz & Niethammer 1990).

Dispersal

Home ranges of hedgehogs may have sizes of 1.8-2.5 ha (Grzimek 1984).

Diet

The European Hedgehog feeds mainly on insects. In May Hedgehogs consume mainly Coleoptera larvae, Dermaptera and Diplopods. During July and August Earthworms form an important part of the diet while fruits and seeds have their maxima in June and September (Grosshans 1978 in Holz & Niethammer 1990).

We estimate that the diet of Hedgehogs is affected by pesticides by 70%.

Hedgehogs are predominantly nocturnal and they forage exclusively on the soil surface (Holz & Niethammer 1990).

Habitat and densities

Hedgehogs occur in a wide range of habitats where they can find enough cover except for coniferous forests and swamp lands (Grzimek 1984). They prefer open forests, gardens and parkland as well as hedgerows, field margins and headlands.

Associated crops are primary orchards and vineyards. However the inside of crops does not seem to be of high importance for Hedgehogs, we therefore estimate the amount of diet taken directly from sprayed cultures to be about 20%. The importance of cover is scored as 0.5 for the index calculation.

They build nests for giving birth and for hibernation underneath thorny shrubs and roots, in nettle clusters or in thick undergrowth (Holz & Niethammer 1990; Röser 1995).

Densities seem to be higher in urban areas than in rural areas (Holz & Niethammer 1990).

Threats / sensibility (pesticide effects)

Direct and secondary poisoning by pesticides (rodenticides, molluscicides) has an adverse impact on Hedgehogs.

Other threats

Cars are of the main threats for Hedgehogs (Meinig & Boye 2009). Natural enemies are carnivores, owls and birds of prey (Holz & Niethammer 1990).

Measures for risk-management

No information available.

1.14 European Mole (*Talpa europaea*) – Maulwurf – Order: Insectivora

Geography: Europe

European Moles are widely distributed in Europe, except for the north where they have their distribution border in southern Sweden and Finland. In the south Moles only occur in the northern parts of Spain, Italy and Greece (Niethammer 1990).

Geography: Germany

Moles occur all over Germany.

Population, trend and conservation status

- Red List Germany: least concern
- BNatSchG §7 Abs.2: besonders geschützt (b)

Tab. Taeu1: Red List-classifications of the status of European Mole populations in total Germany and the federal states (n.a.= information not available).

State	G	BB	BW	BY	HE	MV	NI	NW	RP	SH	SL	SN	ST	TH
Year	2008	2003	2001	2003	1995	1991	1991	2010	1987	2000	2008	1999	2004	2001
Category	-	-	-	-	-	-	-	-	-	-	n.a.	-	V	-

The European Mole is common in Germany but the short- and long-term population trend are classified as slowly decreasing (Meinig et al. 2009).

Life cycle

Breeding season of Moles is between April and July, when two to nine young are born (Niethammer 1990). Young participate in reproduction after their first winter. They may reach an age of three to four years.

Dispersal

Moles had an average home range size of 2324m (MacDonald et al. 1997).

Diet

Earthworms, especially Lumbricus terrestris, are the main food source of Moles (Mellanby 1971 in MacDonald et al. 1997). After Lumbricidae come insect larvae, mainly of Coleoptera, Lepidoptera and Dipterans. Adult insects, other arthropod, Gastropods and small vertebrates form only a minor part (Niethammer 1990).

Generally, Moles feed on all animals that fall into their tunnel systems or which they find while digging (Niethammer 1990).

100% of the Mole’s diet taken from sprayed cultures is potentially affected by pesticides.

Moles have three periods of activity per day (Niethammer 1990).

Habitat and densities

Moles occur in moderately humid to dry grassland and generally in most habitats where the soil is deep enough to allow tunneling (Röser 1995). They inhabit pastures, fallow land, grassland, parks, gardens and woodland (mainly deciduous forests and clearings, but rare in coniferous forests) as well as head lands and field margins of arable lands (Grzimek 1984; Niethammer 1990). After harvest they move into crops (cereals, foliage plants).

The distribution of Moles is determined by the abundance of their main prey (earthworms) which is related to soil type and condition (Funmilayo 1977). The occurrence of vegetation is of minor importance (Niethammer 1990).

During summer Moles dig 10 to 40 cm into the soil where they move in tunnels and build nests and food chambers (Grzimek 1984). In winter tunnels may reach 1m deep under the surface.

Moles are considered as pest species in agricultural land and urban areas.

We estimate that Moles take about 20% of their diet from sprayed cultures. Ground cover does not have an effect.

MacDonald et al. (1997) mention densities between 6 and 8.5 individuals per ha.

Threats / sensibility (pesticide effects)

Natural enemies are birds of prey (Common Buzzard), owls, White Storks and carnivores like Weasels or Foxes (Grzimek 1984). Meinig & Boye (2009) mention agriculture and direct take through illegal killing as factors threatening European Moles.

Measures for risk-management

No information available.

1.15 Brown Hare (*Lepus europaeus*) – Feldhase – Order: Lagomorpha

Geography: Europe

Originally, Brown Hares were distributed in grasslands and other open landscapes in South East and Central Europe and further to the East in Russian lowlands and the Caucasus. Today it is widely distributed all over Europe except for parts of the Iberian Peninsula and Northern Scandinavia and Russia. The species was introduced in New Zealand, Australia, South and North America and West Siberia (Averianov et al. 2003).

Geography: Germany

Brown Hares are widespread throughout farmland landscapes in Germany.

Population, trend and conservation status

- Red List Germany: vulnerable (category 3)
- Bern Convention, Appendix III

Currently the Brown Hare, also named European Hare, is listed as vulnerable in three federal states; Brandenburg and Saxony-Anhalt classify the species as endangered (category 2; Tab. Leeu1).

Tab. Leeu1: Red List-classifications of the status of Brown Hare populations in total Germany and the federal states (n.a.= information not available).

State	G	BB	BW	BY	HE	MV	NI	NW	RP	SH	SL	SN	ST	TH
Year	2008	2003	2001	2003	1995	1991	1991	2010	1987	2000	2008	1999	2004	2001
Category	3	2	V	-	3	3	-	V	-	V	n.a.	3	2	-

Brown Hare populations are decreasing in many European countries (Mary & Trouvilliez 1995 in Edwards et al. 2000).

Holzgang et al. (2005) reports decreasing Hare densities since 1993 in Switzerland. In Switzerland mean Brown Hare densities were about 4.5 individuals per 100ha in 1991, in 1998 3 individuals per 100ha and after that mean densities varied between 3 and 3.5 individuals per 100ha (Jenny & Zellweger-Fischer 2011). In 2010 densities reached a mean of 2.5 individuals per 100ha.

In grassland areas densities decreased since 1991 from 3.8 to 1.2 individuals per 100ha in 2010 while in arable lands densities were first decreasing from 5 individuals per 100ha to 3.5 per 100ha in the middle of the 1990. After that decrease followed a light increase of numbers between 4 and 4.7 individuals per 100ha. In 2010 mean densities of 3.7 individuals per 100ha were recorded in arable land (Jenny & Zellweger-Fischer 2011).

In Germany the Brown Hare is moderately frequent but strongly decreasing on the long-term (Meinig et al. 2009).

In some areas population numbers were increasing between 2001 and 2006, which was related to the good weather conditions in the year 2003 that favored Hare growth rates (Bartel et al. 2007; Fig. Leeu1). The spotlight estimations carried out by WILD (=Wildtier-Informationssystem der Länder Deutschlands 2009) showed a small decline in Hare numbers in 2009 in comparison to the year 2008, while 2007 was a particular good year for Hares (see also Fig. Leeu1).

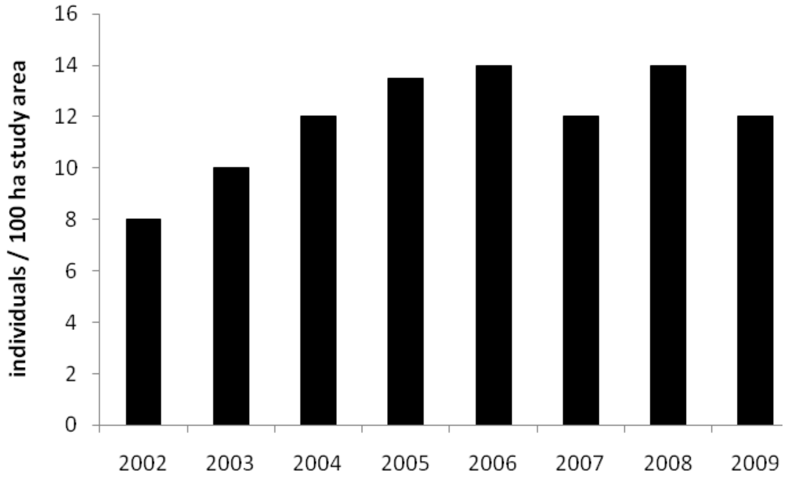

Fig. Leeu1: Development of Brown Hare populations from 2002 to 2009 in Germany (spotlight estimations; after Wild 2009).

Fig. Leeu2 shows the development of the Brown Hare population in Baden-Wuerttemberg from 2003 to 2007 and differences between Hare population densities in spring and autumn (Pegel 2008).

In Brandenburg occur about 9000 Hares in open land (1.4 Million ha) and woodlands (1 Million ha) according to Ahrens & Goretzki (2001 in Bischoff 2006).

In Germany high Hare densities of 100 individuals per 100ha at least in autumn are restricted to certain regions, e.g. areas in the Oberrheinebene, Rheinhesse and the lower Inntal in Bavaria (sources in Averianov et al. 2003). Hare numbers have declined in other regions with high Hare densities in earlier times like the Magdeburger and Braunschweiger Börde (e.g. Ahrens & Kottwitz 1997).

Ahrens & Kottwitz (1997) studied the development of Hare populations in Sachsen-Anhalt and found Hare numbers to be at a low level with only a small proportion of young Hares.

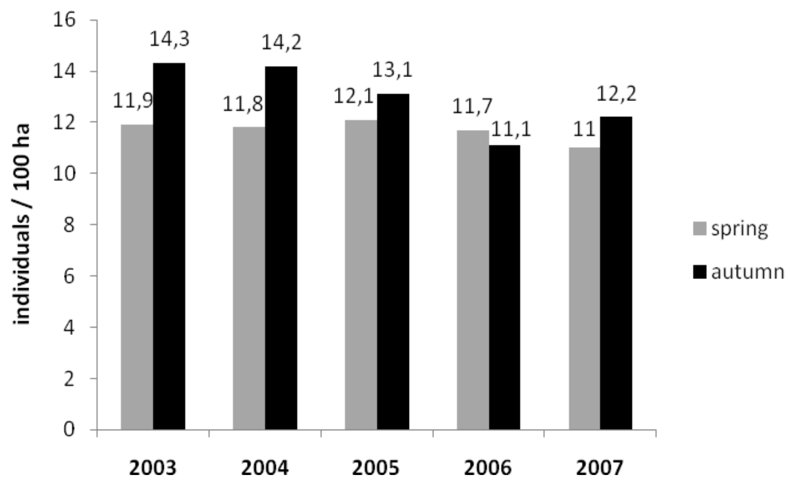

Fig. Leeu2: Population density of Brown Hares in spring and autumn in Baden-Wuerttemberg (spotlight estimations; after Pegel 2008).

Life cycle

Breeding season of Brown Hares lasts from February till October (Averianov et al. 2003). Most young are born between April and July. One to four litters may be born per year each with one to five leverets (Averianov et al. 2003). The leverets are precocial. Hares first reproduce at the age of one year.

Hares have an average life span of one year but may reach an age of 12 years (Grzimek 1984). Hare populations are estimated to be completely replaced after 5 to 6 years (Petrusewicz 1970 in Averianov et al. 2003).

Dispersal

Hares do not show territorial behaviour. In heterogeneous habitats seasonal ranges may be smaller than 20ha while in areas with intensive agriculture ranges may exceed more than 100ha (Averianov et al. 2003).

Mean home range size was 34ha and winter and spring ranges were larger than summer and autumn ranges (Smith et al. 2004). This cannot be explained by food availability which should be lower during summer and autumn when arable crops are not suitable as forage and vegetation growth stops at the end of the growing season (Smith et al. 2004). The authors conclude that the large ranges can be explained by behavioural changes during the breeding season which begins in late winter and peaks in spring.

Home ranges are larger in areas of intensively managed arable farmland with large crops (Marboutin & Aebischer 1996). Hares probably have to increase their home ranges in these regions to include a diversity of habitats for sufficient food (Smith et al. 2004).

Tapper & Barnes (1986) report a home range size of 38ha for the UK. Hares select their ranges according to the access to a range of field types.

Hares moved on average 226m between consecutive day- and nighttime positions and 172m between successive daytime fixes (Rühe & Hohmann 2004). Two-month home ranges had an average size of 21ha. Home range sizes decreased with increasing population density (Rühe & Hohmann 2004).

Diet

Hares mainly consume green non-woody plant parts. Poaceae form the biggest group of consumed plants, mainly Fabaceae, Asteraceae, Brassicacea and Plantaginaceae (Averianov et al. 2003). In agricultural regions crop plants dominate the diet as well as wild weeds and herbs of grasslands and field margins. The composition of the diet shows seasonal variation and depends on the habitat's food availability.

Crop plants like barley, wheat and rapeseed are preferred in autumn, winter and spring, covering about 80% of the Hare's diet (Brüll 1973, 1976 in Averianov et al. 2003). During late spring, summer and early autumn wild weed and herbs become more important. Dicotyledonous species like Trifolium sp., Achilles millefolium, Bellis perennis or Plantago sp. represent 40% to 60% of the diet in this time.

Zörner (1996 in Averianov et al. 2003) analyzed the diet of Hares in a forest-crop habitat in Saxony-Anhalt and found a composition of 90.1% green parts of plants, 5.5% wooden plants, 2.2% root crops (potato and beet), 1.7% grain fruits and 0.5% forest fruits (acorns). Green plant parts were the main diet component all over the year and mainly originated from crop plants. During winter wooden parts were most common in the diet. From December till March winter grain was the main element in the diet.

Generally, Hares prefer young and tender plant shoots, therefore the composition of their diet is mainly determined by the availability of such resources (Averianov et al. 2003). Crop plants provide good food sources during some seasons of the year. However, due to the conformity of the development of crop plants on large fields main food sources may drop out after the plants reach a certain height or are harvested (Averianov et al. 2003). Hares prefer to feed on short crops. Once they developed beyond the tillering stage the Hares' preference for cereal crops declined (Tapper & Barnes 1986). When winter grain growths to tall in late spring the Hares lose an important food source which they had used all autumn and winter. This gap needs to be filled by wild herbs or other young crop plants. However, in arable landscapes where large monocultures and herbicide applications are most common alternative food sources may be lacking, especially for less mobile leverets. When crops mature and are harvested the food supply goes up again due to grain seeds, catch crops and later the sowing of winter wheat and rapeseed (Averianov et al. 2003).

Frylestam (1986) analyzed the frequency of occurrence of plant species in stomachs of Brown Hares shot during the hunting season from October till December in relation to agricultural land use. The largest variety of plants was eaten in pasture land. In mixed farmland Hares used twice as much plant species as in monoculture land. Here, 86% of the diet consisted of wheat and rape and wheat was eaten twice as frequently as in mixed farmland. It was also a relatively important diet component in pasture land, indicating that Hares also foraged in surrounding agricultural land. The predominance of wild plants was significantly higher than cultivated plants in pasture land and mixed farmland. The reverse was found in monoculture land. Here, the situation will be aggravated in late spring and summer since mature crops are unsuitable as food for Hares. In all areas wild plants were preferred over cultivated crops, indicating the importance of a rich wild flora to Brown Hares (Frylestam 1986).

During autumn and winter Hares preferred cultivated crops (winter wheat) and food items provided by hunters (tubers of sugar beet and carrot in November and February), in spring and summer, apart from soy, only weeds (e.g. clover and corn poppy) were positively selected, especially after the harvest of cereal crops (Reichlin et al. 2006).

Average stomach contents in February (N=37) were 57% winter wheat sprouts, 24% sugar beet tubers, about 10% alfalfa. In May (N=28) stomachs contained 50% winter wheat, 13% spring barley, 11% soy, in August (N=32) 39% alfalfa, 25% spring barley, 14% sugar beet and in November (N=20): 52% winter wheat, 22% sugar beet tubers, 17% alfalfa (Reichlin et al. 2006).

The analysis of stomach contents of Brown Hares in an arable landscape in Lower Austria showed that Hares preferred sugar beet in winter, soybeans and corn poppy in spring and summer and sugar beet and already germinated winter wheat in winter (Hackländer 2006).

The most important forage for Hares from October till May is winter cereals (Chapuis 1990 in Edwards et al. 2000).

Hares are mainly nocturnal but may also be active during daytime (Averianov et al. 2003).

Due to the high amount of crop plants in the diet of Hares in agricultural landscapes we estimate that about 50% is affected by pesticides during the breeding season and 40% in winter.

Habitat and densities

Brown Hares live in open, steppe-like landscapes and use ranges smaller than 50 ha. They prefer crop types like rape, cabbage, beet, trefoil and alfalfa (Grzimek 1984).

Vaughan et al. (2003) conducted a questionnaire study on farmers who reported frequent Hare sightings on arable farms to be associated with wheat, sugar beet or fallow land. Hares were less common on pastural farms and sightings were related to the availability of woodland and improved grassland.

In a study about habitat selection by Brown Hares carried out in spring in an arable landscape in Lower Saxony hares avoided inner areas of maize fields while they showed a high preference for maize field borders and specially created succession lanes in the field (=Maisinnenrand, Fig. Leeu3; Tillmann & Voigt 2011).

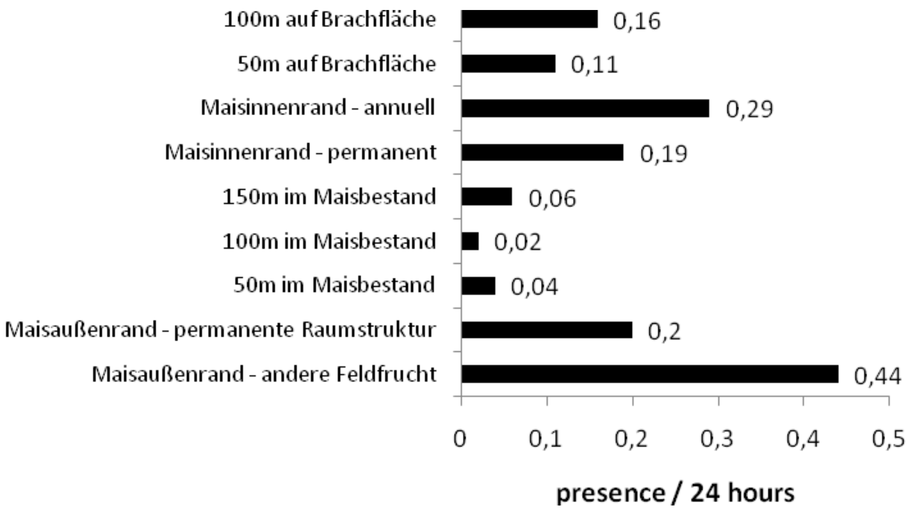

Fig. Leeu3: Habitat preference of Brown Hares in an arable landscape in Lower Saxony expressed as average presence per 24 hours in different habitat types (after Tillmann &Voigt 2011).

Jennings et al. (2006) compared demography, body condition and dietary quality of Hares from high-density and low-density populations, in agricultural and pastoral landscapes respectively, in Wales and England. They found lower recruitment in pastural than in arable habitats, further, Hares living in pastural land were lighter and smaller. Conditions in pastural habitats, especially climatic ones, seem to be less suitable to Brown Hares, since these areas are warmer and receive more precipitation (Jennings et al. 2006). Furthermore, pastural areas contain higher numbers of Foxes than arable areas.

The Brown Hare prefers open landscapes. In arable lands areas with mainly crop production and a low amount of grasslands are preferred (Averianov et al. 2003). Its high adaptability allows the occurrence in a wide range of habitat types like dunes and heath lands, vine and green space in urban areas. It prefers low and hill lands but is found also in low mountain ranges and valleys of the Alps. In central Europe Hares reach highest densities in broad, large-scale and intensively used arable lands with little woodlands on loess and black earth soils (Averianov et al. 2003).

Smith et al. (2004) studied the habitat selection of radio tracked Hares on pastural farmland in the UK. They found cattle pasture and fallow land to be the highest ranking habitat types in all seasons except in winter when Hares selected sheep pastures more often than fallow land.

Hare densities are significantly higher in unstocked pastures than in those with stock (Barnes et al. 1983). However Smith et al. (2004) found that Hares selected pastures regardless of cattle density and did not seem to avoid stocked pastures. The intensity level of the management may explain these different results, since on intensively used pastures the availability of sufficient cover can determine the occurrence of Hares.

In winter home ranges of Hares always included crop land. Crops were only selected above other habitats when they were short and suitable as forage (Smith et al. 2004; Tapper & Barnes 1986). Hares preferred habitats with taller vegetation in spring and summer and avoided short and even vegetation as well as pastures grazed by sheep (Smith et al. 2004). Different levels of grazing pressure and fields used for hay provided a heterogeneous vegetation structure that was preferred by Hares in pastural landscapes (Smith et al. 2004). During the breeding season Hares choose habitat structures which provide cover from predations and unfavorable weather conditions especially to protect the leverets (Tapper and Parsons 1984 in Smith et al. 2004). Arable crops provide sufficient cover for Hares during the breeding season and forage in winter (Smith et al., 2004). Hares in pastural landscapes are in poorer condition than Hares in arable landscapes (Frylestam 1980, in Smith et al. 2004).

Crops form an important habitat for Brown Hares both during spring and autumn (Holzgang et al. 2005). In spring along with crops (vegetables, cereals, catch crops and rape) also set-aside was the most favored habitat type.

Small woodlands and hedgerows in predominantly agricultural landscapes are positively associated with Hare abundance (Smith et al. 2005). Hare densities in pastural habitats are low. Arable areas have significantly higher numbers of Hares in spring than mixed areas.

According to Tapper & Barnes (1986) Hares need two basic habitat features, an area with open ground and short growing crop that provide good vision to avoid enemies as feeding habitat and a resting area with sufficient shelter provided by tall, dense crops, hedgerows or woodland. Hares inhabit areas where they have access to a variety of crops. They often extend their home ranges to include this diversity.

The authors found that during most of the summer Hares avoided winter cereals. Winter as well as spring cereals were preferred only during their main tillering periods when the crops were short in length. Cover by cereal fields was only provided between mid-April and mid-July to mid-August when the plants were tall enough (Tapper & Barnes 1986).

Rühe & Hohmann (2004) radio tracked 38 Hares in an arable region in central Germany. During nights in May and June they mainly located Hares in sugar beet fields and field edges while beet crops were avoided during daytime, presumably due to the lack of cover. Instead Hares stayed in tall and dense stands of cereal crops during the day. The situation changed in July and August when Hares used beet fields also during the day since the crop then provided both food and shelter (Rühe & Hohmann 2004).

Hares did not avoid crops treated with plant protection chemicals (Rühe 2002 in Rühe & Hohmann 2004).

Since no detailed data on the amount of diet of Hares taken from cultures is available we estimate the value to be about 60%. Cover is a very important factor for Hares and its importance is therefore reflected by a value of 0.7 in the index calculation.

Averianov et al. (2003) report average spring densities of 20 to 30 individuals per 100ha in suitable habitats. Under good conditions densities of 100 individuals per ha may be reached. Even populations with a density of less than one Hare per 100ha are supposed to be viable (Averianov et al. 2003). Densities double by the end of the reproduction period.

Holzgang et al. (2005) studied the population development of Brown Hares in Switzerland over a period of 12 years. Hare densities were determined by spotlight counting and related to different levels of ecological compensation areas in the studied regions. They found higher densities in arable crop land than in grasslands and a positive correlation between Hares densities and compensation areas in crop land, though numbers did not increase due to compensation measures. Fallow lands were favored in spring (Holzgang et al. 2005).

Positive effects on Hares numbers: mild climate (average annual temperature > 8°C), low annual precipitation (<500mm), black earth and loess soils and absence of forests (Rieck 1987 in Averianov et al. 2003).

Ahrens & Goretzki (2001, in Bischoff 2006) calculated a general density of 4 individuals per 100ha, 5.5 Hares per 100ha in open landscapes and 1.75 Hares per 100ha in woodlands. However, these numbers are questioned by other authors who estimate densities to be not higher than 1 Hare per 100ha.

Strauß & Pohlmeyer (2001) found average densities of 11-13 individuals per 100ha of Hares populations in Lower Saxony. They state that spring densities have stabilized compared to the tremendous declines in the 1980s. Hunting bags however show a significant decline (Strauß & Pohlmeyer 2001).

In Brandenburg Ahrens (2000) recorded (spot light counting) average spring densities of 5.6 and 5.5 individuals per 100ha in two consecutive years and autumn densities of 5.2 and 6.5 individuals per 100ha. Densities were higher in the middle and south of Brandenburg than in the south. The author states that, judged from populations levels, Hares should not be listed on the Red List of Brandenburg (Ahrens 2000).

Spring densities in four different regions were between 9.3 and 18.2 individuals per 100ha, autumn densities between 3.1 and 24.7 individuals per 100ha (Ahrens & Kottwitz 1997).

Densities are highest in autumn, comprising a high proportion of juveniles (Edwards et al. 2000).

Threats / sensibility (pesticide effects)

Herbicide applications reduce the availability of weeds which are an important food source for Hares. In general, Hares are threatened by the disappearance of a main food source when crops reach the tillering stage or are harvested followed by a lack of alternative food sources like wild herbs etc. due to herbicide application (Tapper & Barnes, 1986, Averianov et al. 2003). This results in lack of food for leverets and higher energy investments to find adequate food.

Edwards et al. (2000) review reasons for the decline in Brown Hare numbers and conclude that the pesticide paraquat is not responsible for decreasing Hare populations in the UK (see review of PPP effects).

Hares need field margins with herbal undergrowth since the diet offered by large fields is too one-sided because of the rapid decline of herbs on arable land that derives from the application of herbicides and fertilizer (Grzimek 1984).

Other threats

Natural enemies are mainly the Red Fox, Stoats and large birds of prey (Grzimek 1984).

Anthropogenic threats are mainly structural changes in the Hare's habitat.

The main cause for declining Hare populations throughout Europe are, according to Smith et al. (2005), changes in arable habitats through agricultural intensification.

Increasing intensification and mechanization of agricultural measures, climate change and growing numbers of Foxes and other predators threaten the species. One of the negative developments in agriculture is the loss of structural and plant species diversity, for example due to an increase of winter grains at the expense of summer grains and root crops or due to growing amounts of fertilizer and pesticide applications. Also the intensification of grassland utilization (earlier and more frequent mowing) has a negative impact on Hare populations.

Meinig & Boye (2009) define agriculture, habitat destruction, tourism and recreation and direct take (legal killing, kills by traffic) as potential threats for Hare populations.

Edwards et al. (2000) reviews reasons for Brown Hare population declines. Leveret losses are high in forage and grass fields and much lower in arable crops. In the UK higher numbers of Hares are found in arable crops than in pastoral landscapes (McLaren et al., 1997 in Edwards et al. 2000). Reasons for that might be grassland improvement which leads to higher livestock densities, higher leveret mortality from silage cutting and digestive problems from cultivated grasses (McLaren et al. 1997 in Edwards et al. 2000). Disease is a major source of Hare deaths as well as predation but the main cause for Hare population declines are probably changes in farmland management practices (Edwards et al. 2000).

The increase in winter sown crops results in a food shortage during summer when reproduction is at its peak and therefore most threatens Hare populations (Wincentz 2009; also Reichlin et al. 2006, Tapper & Barnes 1986). Further, mature cereal crops are too dense for Hares to move through. Along with the loss of field margins and hedgerows the problem of food shortage is increased and Hares need non-cropped habitats that provide corridors in fragmented landscapes (Wincentz 2009).

Further threats:

Reduced availability of weed abundance (Reichlin et al. 2006).

Changes in the acreage of grassland (Barnes et al. 1983).

Loss of crop and landscape diversity is primarily responsible for the long-term decline in Hare populations in Europe, positive effect of arable farming decreased as field sizes increased and habitat diversity decreased (Tapper & Barnes 1986).

According to the British Biodiversity Action Plan (BAP) reasons causing the decline of Hare populations are the conversion of grassland to arable land, the loss of biodiversity in agricultural landscapes and changes in cropping practices such as planting cereal crops in autumn and the move from hay to silage (Anonymous 1995, see Smith et al. 2004).

Further explanations may be increasing predator populations (Tapper & Barnes 1986) and climate change (increased precipitation) (Hackländer et al. 2002, in Smith et al. 2004).

Dominating diseases: European Brown Hare-Syndrom (EBHS), Pseudotuberkolose, bacterial diseases (Staphylokokkose, Pasteurellose, Listeriose); made three quarters of all analyzed dead Hares in Hesse (N=267) (Eskens et al. 1999)

Decline of the amount of woodland, hedgerows and field margins (Günther et al. 2005)

Ahrens & Kottwitz (1997) name rising Fox densities (based on hunting statistics) and the monotony of diet, due to only a few dominating crop plants like winter wheat and sugar beet, as reasons for declines of Hare numbers

harvesting operations are not a threat for adult Hares (Marboutin & Aebischer 1996)

Management implications

Aim: Improvement of food availability and nesting habitats

The effects of land-use and agri-environmental scheme measures on Brown Hares were investigated in lowlands in Switzerland (Zellweger-Fischer et al. 2011). Extensively managed hay meadows had a positive impact on Hare densities particularly in arable land but also in grassland while hedgerows were positively associated with Hare densities only in arable land. Set-asides and wildflower strips seemed to have no effect but these measures were only present to a small scale in the studied areas (Zellweger-Fischer et al. 2011).

Year-round vegetative cover, important for protection against predators and unfavorable weather conditions, is most important for Hare populations along with predator control and sufficient food supply e.g. through the inclusion of arable land in mainly pastural habitats (e.g. Smith et al. 2004; Vaughan et al. 2003, Jennings et al. 2006). Management should aim at increasing the survival of leverets and adult Hares.

Edge habitat of crops bordering tree stands positively affected Hare growth probably due to the combination of increased food availability in the edge and the year-round shelter from weather and predation provided by woodlands (Wincentz 2009).

Holzgang et al. (2005) found that more than 5-8% of high quality compensation areas per farm are needed to establish sustainable Hare populations. These areas should include traditional and wildflower fallow land, hedges with herbaceous margins and non-intensive meadows with low livestock densities. Additional measures are the replacement of fences by hedgerows, late second mowing and/or high-cut (>10cm), for cereal crops large spacing between rows (>20cm) should be implemented. The spatial position of such areas to roads should be considered since compensation areas close to roads with permanent disturbances by vehicles, humans and dogs make those measures useless (Holzgang et al. 2005).

Possibilities to stabilize and rise Hare numbers are for example perennial fodder plant crops and set-aside, sowing of game-friendly food and cover plants on set-aside, late mowing (end of July/August)(Ahrens 2000).

The presence of set-aside is an important feature in arable landscapes due to the improved heterogeneity which has a positive impact on Hare densities (Smith et al. 2004).

Suitable management options are a late second cut or no cut at all to reduce leveret mortality, increasing plant diversity and creation of larger row spaces to enable free movements of Hares through crops (Fuchs & Stein-Bachinger 2008).

Rotational mowing, where areas are left un-mown at every cut on extensively managed hay meadows, cut improve the suitability of this habitat for Hares (Humbert et al. 2009).

1.16 Greater mouse-eared Bat (*Myotis myotis*) – Großes Mausohr– Order: Chiroptera

Geography: Europe

M. myotis is widely distributed in Europe reaching into Israel, Ukraine and Belarus. The species is extinct in the UK since 1985 and missing in Denmark (Güttinger et al. 2001). Single individuals were recorded in Sweden.

Geography: Germany

The Mouse-eared Bat isdistributed all over Germany and occurs till the north of Schleswig-Holstein. Its main distribution areas lay however in the central and southern parts of Germany (BY, BW, HE, TH, RP; Schnitter et al. 2006).

Population, trend and conservation status

- Red List Germany: category V (near threatened)
- FFH-directive listed in Appendix II, IV
- BNatSchG §7 Abs.2: streng geschützt (s)
- Bern Convention, Appendix II

Tab. Mymy1: Red List-classifications of the status of Greater mouse-eared Bat populations in total Germany and the federal states (n.a.= information not available).

State	G	BB	BW	BY	HE	MV	NI	NW	RP	SH	SL	SN	ST	TH
Year	2008	2003	2001	2003	1995	1991	1991	2010	1987	2000	2008	1999	2004	2001
Category	V	1	2	V	2	2	2	2	2	1	n.a.	2	1	3

Meinig et al. (2009) indicate a strong responsibility for this species in Germany since its population is strongly decreasing in the long term. Nonetheless, population numbers recently are increasing probably due to positive impacts of nature conservation measures (Meinig et al. 2009). Therefore the species status on the Red List improved from vulnerable (category 3) to near threatened (category V).

In Bavaria, which is a central area of distribution in Central Europe, population numbers are increasing since 1985 in the north and stable in the south of the federal state (Bayerisches LfU 2010). The authors name an average number of 241 colonies in summer in Bavaria and a total of 135700 individuals including males.

A strong decline of populations due to the intensification of agriculture is presumably occurring in the western federal states (Lung 2004).

Life cycle

In Germany, the young are born between end of May and July. The majority is born in June (Güttinger et al. 2001). Usually one young is born per year which are nursed for six to seven weeks. Some female take part in reproduction the fist autumn. Life span is between 2 and 6.6 years for females and between 1.6 and 3.2 years for males (Steffen & Hiebsch 1989 in Güttinger et al. 2001).

Dispersal

Feeding habitats may be at distances up to 15km from the roosts (Lung 2004). The species moves between 4 and 17km from roosts to feeding grounds every night (Güttinger et al. 2001).

Greater mouse-eared Bats show movements between summer and winter roost (Grzimek 1984). Distances between summer and winter roosts are higher in northern Germany than in alpine areas (Güttinger et al. 2001). The seasonal movement distance lies between 20 and 100km.

Diet

Greater mouse-eared Bats are opportunistic and generalistic predators that are able to prey on the largest members of European arthropods (Arlettaz 1996). This feeding behavior is energetically very beneficial.

Feed mainly on large insects of more than 1cm that live on the ground (Güttinger et al. 2001). Adults of Carabidae form a dominant and important group of prey items in Central and East Europe. Many of the Carabidae species occur in forests. Additionally, Greater mouse-eared Bats feed opportunistically on other orders of insects, like Melolontha or Acrididae (Güttinger et al. 2006). Other prey items are the larvae of Carabidae and Lepidoptera, Chiloptera, Araneae or Opiliones (Güttinger et al. 2001).

Güttinger et al. (2006) found in their study about the diet and feeding habitats of Greater mouse-eared Bats that the consumed prey items occurred in forests and open landscapes. Three Carabidae species that were found in the faecal analysis occur only in open landscapes (*Carabus auratus, Harpius* sp., *Poecilus* sp.). M. myotis prefers large insects.

In the Swiss Alps the main prey items were Carabids (46% by volume) (Arlettaz 1996). Other items were Lepidopteran larvae (19%) and mole crickets (10%). In July and August carabids were predominant in the bat's diet. Crane flies (Tipulidae) were consumed in September in intensively cultivated orchards.

The species is able to hunt in the air as well as on the ground.

As the diet entirely consists of insects, 100% of the diet is potentially affected by pesticides (insecticides).

Habitat and densities

Greater mouse-eared Bats prefer open structured forests, freshly mowed grasslands and pastures as feeding habitat (Brinkmann 2000). They need free access to the ground to hunt on their favorite prey, Carabidae adults. Feeding grounds have a distance up to 10-15km to the roost sites.

The species prefers more or less open landscapes like forest edges, crop cultures with sparse tree standings (horticulture) and meadows with high abundance of carabidae (Lung 2004).

Mouse-eared Bats hunt mainly on open deciduous forests with sparse ground cover as well as in open landscapes (Güttinger et al. 2006). In Switzerland, Güttinger (1997 in Güttinger et al. 2001) found radio tracked M. myotis on freshly mown grassland, pastures and harvested crop land. As 'ground gleaner' M. myotis depends on free access to its prey on the ground and therefore needs a low degree of ground cover.

M. myotis avoided systematically dense grass vegetation of unmowed meadows and concentrated its activity exclusively on freshly cut meadows (high density in first 3 nights after mowing) (Arlettaz 1996). Primary foraging habitats were freshly-cut meadows, mown grass in intensively cultivated orchards and forests without undergrowth (Arlettaz 1999).

Ground cover has adverse effects on the hunting strategy of *M. myotis* since it tends to glean its prey from the ground. Therefore we scored the importance of cover as 0 in the index calculation.

Since no detailed information is available on the proportion of food taken from cultures we estimate a value of 40%. The same estimates were used for the other two bat species described below.

Nursery roosts are located in attics and warm caves (Grzimek 1984).

In central Europe nursing colonies occur mainly in the attics of buildings like churches (Güttinger et al. 2001).

Greater mouse-eared Bats often use natural caves or artificial tunnels, mines, large cellars or military bunkers as winter roosts (Güttinger et al. 2001).

For population numbers and densities mainly females and young in nursing roosts are recorded. For the south of Germany Rudolph (2000 in Güttinger et al. 2001) gives densities between 0.22 and 4.35 individuals per km . The actual population density is probably by 1.6 to 1.8 higher than the density of nursing roosts individuals (Helversen 1989 in Güttinger et al. 2001).

Threats / sensibility (pesticide effects)

Secondary poisoning due to the consumption of insects contaminated with insecticides may lead to damage and death of Greater mouse-eared Bats.

A threat to *M. myotis* is the poisoning through pesticides in agriculture and timber protection agents.

Since they feed mainly on insects living on the ground the risk of being poisoned might be higher for this species (see also Stahlschmidt & Brühl 2012).

Other threats

Other threats are collisions, death in autumn and winter due to missing fat reserves, wrong choice of winter roosting place and others (Güttinger et al. 2001). Natural enemies are beech martins, birds of prey, owls and house cats.

The lack of prey species may threaten Greater mouse-eared Bats (Carabidae) (Lung 2004).

Measures for risk-management

Aim: Improvement of food availability and nesting habitats

Meadows and pastures form an important hunting area for *M. myotis*. For successful hunting the bats need such areas to be regularly used to keep the vegetation short (Güttinger et al. 2006). However treatments like short mowing intervals prevent large arthropods to develop on these grounds, resulting in a low abundance of prey for *M. myotis* (Güttinger et al. 2006).

The promotion of large-scale, non-intensive management of meadows and especially pastures (results in higher biomass and diversity of large arthropods) is a suitable option. Forest management should create open forests with sparse ground vegetation, high proportion of deciduous species (beech) and wood pastures (Güttinger et al. 2006).

The creation of habitat islands close to nature in intensively used arable landscapes as a compensation measure can support M. myotis. Management actions only make sense when they are implemented on a relatively large area of some thousand km , since the bats use hunting areas of hundreds to thousands of km (Güttinger et al. 2006).

Those habitat types that are selected by bats as feeding areas should be improved and protected for a successful habitat management (Russ & Montgomery 2002). Additionally, management should focus on the maintenance and enhancement of connecting linear habitats (hedgerows).

Stahlschmidt et al. (2012) investigated the benefits of wetland creation in agricultural landscapes for several bat species. They compared bat activity and food availability between retention-ponds and neighbouring vineyards. Bats were significantly more active and nocturnal prey densities significantly higher above the constructed water bodies than above the vineyard sites. Retention-ponds, though they covered an area of less than 0.1% of the available foraging habitat, were more important as hunting area than the dominating vineyards (Stahlschmidt et al. 2012). The authors recommend creating ponds in areas dominated by agriculture to enhance the food availability for local bat populations.

1.17 Natterer's Bat (*Myotis nattereri*) – Fransenfledermaus– Order: Chiroptera

Geography: Europe

The Natterer's Bat is distributed almost all over Europe, missing only in northern Scandinavia (Topál 2001).

Geography: Germany

In Germany the species is widely distributed.

Population, trend and conservation status

- Red List Germany: least concern
- FFH-directive listed in Appendix IV
- BNatSchG §7 Abs.2: streng geschützt (s)
- BernConvention Appendix II

Tab. Myna1: Red List-classifications of the status of Natterer's Bat populations in total Germany and the federal states (n.a.= information not available).

State	G	BB	BW	BY	HE	MV	NI	NW	RP	SH	SL	SN	ST	TH
Year	2008	2003	2001	2003	1995	1991	1991	2010	1987	2000	2008	1999	2004	2001
Category	-	2	2	3	2	3	2	-	1	3	n.a.	2	2	3

In 1998 Natterer's Bats were listed as threatened (category 3) on the Red List of Germany.

Natterer's Bats are moderately common with slowly decreasing population numbers on the long term. However, short term population trends show an increase, probably due to conservation activities (Meinig et al. 2009).

Life cycle

Usually one young is born between June and July (Topál 2001). The bats may reach an age of up to 15 years (Topál 2001).

M. nattereri hibernate from November till April. The first individuals may start to move into wintering roosts in the end of September (Topál 2001).

Dispersal

Little is known about this species migration behavior since it is usually occurring in low numbers (Topál 2001).

Diet

M. nattereri mainly preys on diurnal diptera which are gleaned from their resting places at night. Important prey items are amongst others muscidae, anthomyiidae, brachycera, calyptratae, calliphoridae, syrphidae, empididae and dolichopodiae (Vaughan 1997).

According to Wickramasinghe et al. (2004) tipulidae, sciaridae and dolichopoidae are the key insect families making up over 10% of the diet of Natterer`s Bats in Britain.

Swift (1997) states that *M. nattereri* is able to vary its diet according to prey availability. In general, important prey groups are Diptera, Trichoptera, Coleoptera and non-flying groups such as Hemiptera, Dermeptera and Archnida (Swift 1997).

M. nattereri feeds by gleaning insects from the surface of leaves (Topál 2001).

As the diet entirely consists of insects, 100% of the diet is potentially affected by pesticides (insecticides).

Habitat and densities

The Natterer's Bat prefers open forests and parkland (Grzimek 1984). It occurs in large forests (also coniferous), close to water bodies, in park landscapes and also in proximity to human settlements (Lung 2004).

Foraging habitats of M. nattereri are woodland edges, parkland, roadside vegetation and sheltered areas of water (Swift 1997).

A radio-tracking study revealed that Natterer's Bats selected mixed agricultural areas and preferred to forage over broad-leaved woodland but also pastures, arable land and open-water habitats (Parsons & Jones 2003).

Ground cover has adverse effects on the hunting strategy of M. nattereri since it tends to glean its prey from the ground.

Nursery roosts are found in tree caves, nesting boxes, attics and cellars (Topál 2001).

Swift (1997) names attics, bridges, locations in between stone walls and roof beams. The roosts are connected to foraging areas by flyways along streams, hedges or treelines. In central Scotland the size of nursery colonies varied between 25 and 80 adults. About three quarters were females and one quarter adult or immature males. Male colonies were located in crevices between walls and roof beams in barns and tunnels. Their size was between eight and 28 bats (N=4).

As winter roosts the species uses caves, cellars and tunnels (Grzimek 1984).

A density of 2.88 bats per km and an average of 35 individuals were recorded by Smith & Racey (2000 in Pasons & Jones 2003) for a study area in the UK.

Threats / sensibility (pesticide effects)

The Natterer’s Bat might be at risk due to the fact that it feeds mainly on diurnal diptera (Vaughan 1997) which may be reduced by insecticide applications.

The species faces probably a higher risk due to gleaning prey from leaves. A study by Stahlschmidt & Brühl (2012) found higher pesticide residues on those insects on the ground and leaves than on flying insects.

Other threats

Meinig & Boye (2009) mention forest management, agriculture, habitat fragmentation as well as tourism and recreation as human made threats for this species.

In Mecklenburg-Vorpommern, population decreases were observed in areas with intensive agriculture while populations stayed stable in those regions with no agricultural intensification (Lung 2004).

Measures for risk-management

Aim: Improvement of food availability and nesting habitats

The species requires woodland habitats in a matrix of arable and pastural areas. These habitats should be protected and enhanced by conservation management (Parsons & Jones 2003).

Natterer's Bats build colonies in nesting boxes for birds or special bat boxes (Topál 2001).

The creation of linear structures (hedgerows) supports Natterer's Bats (Russ & Montgomery 2002).

Stahlschmidt et al. (2012) investigated the benefits of wetland creation in agricultural landscapes for several bat species. They compared bat activity and food availability between retention-ponds and neighbouring vineyards. Bats were significantly more active and nocturnal prey densities significantly higher above the constructed water bodies than above the vineyard sites. Retention-ponds, though they covered an area of less than 0.1% of the available foraging habitat, were more important as hunting area than the dominating vineyards (Stahlschmidt et al. 2012). The authors recommend creating ponds in areas dominated by agriculture to enhance the food availability for local bat populations.

1.18 Common Noctule (*Nyctalus noctula*) – Großer Abendsegler – Order: Chiroptera

Geography: Europe

The Common Noctule occurs all over Europe, in North Africa and wide parts of Asia (Gebhard & Bogdanowicz 2004).

Geography: Germany

The distribution area of Common Noctules spreads all over Germany (Gebhard & Bogdanowicz 2004).

Population, trend and conservation status

- Red List Germany: category V (near threatened)
- FFH-directive listed in Appendix IV
- BNatSchG: streng geschützt (s)
- Bern Convention Appendix II

Tab. Nyno1: Red List-classifications of the status of Common Noctule populations in total Germany and the federal states (n.a.= information not available).

State	G	BB	BW	BY	HE	MV	NI	NW	RP	SH	SL	SN	ST	TH
Year	2008	2003	2001	2003	1995	1991	1991	2010	1987	2000	2008	1999	2004	2001
Category	V	3	I	3	3	3	2	V	3	-	n.a.	3	3	2

In Germany the Common Noctules's status is classified as near threatened (category V=Vorwarnliste, Red List Germany) (Meinig et al. 2009), which means that the Noctule`s situation improved in comparison to 1998, when it was still listed as vulnerable. The reason for this development might be intensified conservation measures for bat species but extensive data is missing (Meinig et al. 2009). Schleswig-Holstein might have a special responsibility for the Common Noctule population (Meinig et al. 2009). However, so far this federal state does not include this species in their red list, since it occurs in steady numbers (BMU 2010; see also Tab. Nyno2).

Tab. Nyno2: Status of Common Noctule populations in the federal states of Germany (BMU 2010).

Species	BB	BW	By	NI	NW	SH	SL	SN	ST	TH
Common noctule	occur-ring	occur-ring	large, population trend unclear	occur-ring	occurring, population decreasing	frequent	common, population trend unclear	occurring, population trend unclear	stable	few nursing roosts

Life cycle

Young are born between June and August. One to two young are born per year, which become sexually mature in their first year (Gebhard & Bogdanowicz 2004). Common Noctules have a relatively short life span of less than ten years (Gebhard & Bogdanowicz 2004). Hibernation starts in November or December and lasts until April.

Dispersal

An 62.75km large home range (MCP) used by an entire colony consisted of 11.21km woodland, 23.97km moorland, 17.63km pasture, 8.16km arable land and 1.78km classified as other (Mackie & Racey 2007).

Main hunting areas (lake and bordering lowland) had a size of 450ha, while less important areas at the edges of forests were smaller (200ha) and visited for a shorter time (Schwarz 1988 in Gebhard & Bogdanowicz 2004).

Migratory movements occur over long distances but the Alps are not crossed (Gebhard & Bogdanowicz 2004).Common Noctules may move over very long distances of more than 1000km to their winter roosts. They therefore have a good potential to switch to new areas (Lung 2004).

Diet

Common Noctules mainly consume diptera, other important families are coleoptera and lepidoptera (Vaughan 1997).

On farmland in Britain the insect families of carabidae, scarabaeidae, tipulidae, culicidae, anisopodidae and chironomidae made up more than 10% of the diet (Wickramasinghe et al. 2004).

Common Noctules hunt exclusively in free air and feed on medium to small insects (Gebhard & Bogdanowicz 2004).

As the diet entirely consists of insects, 100% of the diet is potentially affected by pesticides (insecticides).

Habitat and densities

The Common Noctule occurs in sparse woods and park-like open landscapes, especially above clearings close to bodies of waters (Lung 2004).

Common Noctules hunt over large heterogeneous areas. Linear habitats that function as movement corridors are not needed (de Jong & Ahlen 1991 in Mackie & Racey 2007).

By radio-tracking Common Noctules Mackie & Racey (2007) found that broadleaved woodland and pastures were ranked highest in their habitat choice while moorland and arable land were avoided. Non-lactating bats used these less preferred habitats significantly more often than lactating ones.

Hunting habitats are homogeneous structured plains with deciduous forests and standing or slowly flowing water bodies (Gebhard & Bogdanowicz 2004). Common Noctules hunt opportunistic in those areas where prey abundance is high. They use large water bodies, forest edges, parks and grassland as well as crop land.

The species used clearings and edges of forests. In arable land the bats used linear habitat structures to travel through arable land, they were never detected directly over a crop (Gaisler & Kolibac 1992 in Gebhard & Bogdanowicz 2004).

Noctules mainly use tree caves and sometimes rock caves (Grzimek 1984).

Winter roosts are in natural caves in trees and rocks as well as in buildings (Grzimek 1984).

Densities of hunting Common Noctules were ten times lower over arable land than over a conservation area (0.0001 and 0.001 individuals per ha respectively) in the Czech Republic (Gaisler & Kolibac 1992 in Gebhard & Bogdanowicz 2004).

Threats / sensibility (pesticide effects)

Meinig & Boye (2009) define forest management as well as direct take through kills by wind turbines as threatening factors for Noctules. Other hazards are the application of chemicals in agriculture and silviculture and the destruction of basics on which their life depends, like accommodation possibilities or food supply (lack of large insects; Lung 2004).

Pocock & Jennings (2008) investigated the sensitivity of several species to agricultural changes like increased agrochemical inputs (comparison of conventional and organic fields), the switch from hay to silage and boundary loss. They found substantial variations in sensitivity to the three aspects of agricultural intensification. Mammals proved to be relatively insensitive to increased agrochemical inputs and the switch from hay to silage but showed strong sensitivity to boundary loss (Pocock & Jennings 2008). For the Common Noctule differences between organic and conventional cereal field did not seem to have a significant influence but the species appeared to prefer to stay close to boundaries (Fig. Nyno1).

A study implemented in an arable landscape in England showed however, that bat activity including foraging activity was significantly higher (by 61%) over organic farms than over conventional farms (Wickramasinghe et al. 2003).

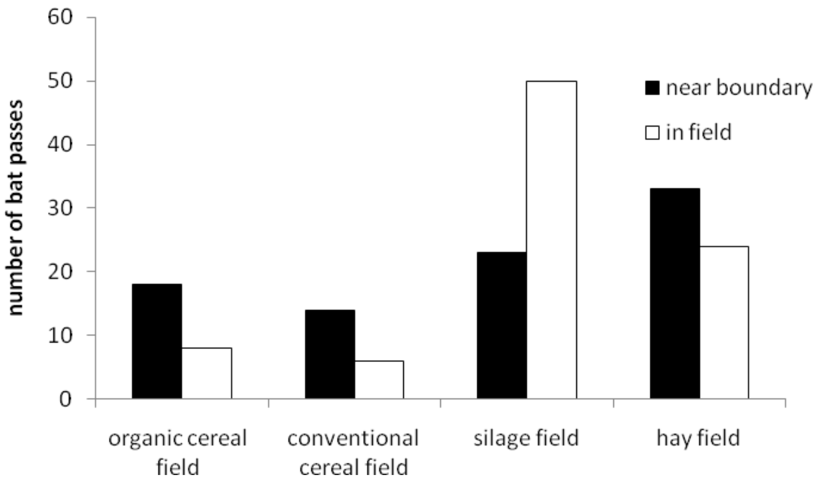

Fig. Nyno1: Numbers of bat passes as index for abundance of Common Noctule in different habitats (after Pocock & Jennings 2008).

Measures for risk-management

Aim: Improvement of food availability and nesting habitats

Common Noctules require broadleaved woodland and surrounding pastures as key foraging habitats for survival in cultural landscapes (Mackie & Racey 2007). The extent of such habitat types should be enlarged and they should be located in close proximity. Agricultural practices that reduce the number and diversity of insects on pastureland (e.g. reseeding, applying fertilizers, hedge removal and the use of systematic endectocides) should be minimized (Mackie & Racey 2007).

Stahlschmidt et al. (2012) investigated the benefits of wetland creation in agricultural landscapes for several bat species. They compared bat activity and food availability between retention-ponds and neighbouring vineyards. Bats were significantly more active and nocturnal prey densities significantly higher above the constructed water bodies than above the vineyard sites. Retention-ponds, though they covered an area of less than 0.1% of the available foraging habitat, were more important as hunting area than the dominating vineyards (Stahlschmidt et al. 2012). The authors recommend creating ponds in areas dominated by agriculture to enhance the food availability for local bat populations.

1.19 Stoat (*Mustela erminea*) – Hermelin – Order: Carnivora

Geography: Europe

The Stoat is present in the complete northern Holartic zone and distributed all over North-, West-, Central- and East-Europe but missing in the Mediterranean region (Reichstein 1993).

Geography: Germany

- In Germany it is widely distributed.

Population, trend and conservation status

- Red List Germany: category D (data deficient)
- Bern Convention, Appendix III

Tab. Muer1: Red List-classifications of the status of Stoat populations in total Germany and the federal states (n.a.= information not available).

State	G	BB	BW	BY	HE	MV	NI	NW	RP	SH	SL	SN	ST	TH
Year	2008	2003	2001	2003	1995	1991	1991	2010	1987	2000	2008	1999	2004	2001
Category	D	-	-	V	D	-	-	D	-	-	n.a.	-	-	3

According to Meinig et al. (2009) the current situation of Stoat populations is unknown. On the long term populations seem to be decreasing to an unknown extent. Data on population sizes is missing.

Hunting bags are decreasing, for example in Baden-Württemberg from 3596 individuals in 1990/91 to 330 individuals in 2008/09 (Stoats and Least Weasels) and in Schleswig-Holstein from 24729 Weasels and Stoats in 1990/91 to 573 Stoats and 761 Weasels in 2009/10 (Elliger et al. 2010; Mlur 2010).

Life cycle

Stoats have a relatively high short live span and reproduction rate. In April and May about 4-13 (average 6.9, N=15) young are born (Stubbe, 1989 in Reichstein 1993). Stoats have only one liter per year (King and Moors, 1979). The lactation period lasts at least six to seven weeks. The average life span is between 1 and 1.5 years (Reichstein 1993).

Dispersal

Home range sizes vary according to prey abundance, habitat structure and season from 11 to 160 ha and 5 to 200ha (Waisfeld 1972; Heptner et al. 1974 in Reichstein 1993). Erlinge et al. (1982 in Reichstein 1993) found home range size of five recaptured females in autumn to be between 2 and 7ha large. Three males had winter ranges of 8 to 13ha.

Diet

According to Reichstein (1993) Stoats are specialized on preying on small mammals with their main food source being rodent species of *Arvicola* and *Microtus*. An analysis of Stoat faeces revealed that in January and February they mainly consume water and Field Voles while during spring and summer the proportion of young lagomorphs, birds and eggs increases (Erlinge 1981 in Reichstein 1993). Later in the year voles form the main component of the Stoat's diet again. Stoats that lived in hedgerows in agricultural landscapes consumed mainly *Apodemus* (32%) and Lagomorpha (28%) and to a lesser extend *Microtus* (14%), *Clethrionomys* (9%) and *Arvicola* (Erlinge, 1981 in Reichstein 1993). Occasionally Stoats may also prey on amphibians, fish or insects (Reichstein 1993).

The diet composition varies between the European continent and the UK, where the amount of lagomorphs and birds is larger (Reichstein, 1993). An analysis of gut contents of British Stoats revealed that the diet consisted of 65% lagomorphs, 17% birds and eggs and 16% small rodents (McDonald et al. 2000; see also Tab. Muer2).

Tab. Muer2: Distribution of main diet components in the different seasons in the UK (after McDonald et al., 2000).

	Lagomorphs (%)	Small rodents (%)	Birds & eggs (%)
Spring	80	10	10
Summer	60	15	25
Autumn	55	20	25
Winter	60	30	10

About 20% of the Stoat's diet is potentially affected by pesticides (rodenticides) during the breeding season. Due to the increase of small rodents in the diet during winter we estimate that 30% are affected by pesticides during the non-breeding season.

During winter Stoats are more nocturnal while they are mainly diurnal in spring and summer (Reichstein 1993).

Habitat and densities

Stoats are very adaptable in their choice of habitat and the suitability of an area depends more on the preferences of its prey (Reichstein 1993). Therefore, Stoats prefer those habitats that are formed by hedgerows and other linear structures and thus provide cover for rodents and other small mammals. Ranges in proximity to water bodies with dense vegetation are favored. Other suitable habitats are woodland, clear cuts, hedgerows and grasslands (Reichstein 1993). Stoats avoid open spaces and therefore need structural elements like hedgerows or stone walls for travelling. Sufficient cover is essential for successful hunting on prey and safety from enemies. We therefore gave the importance of cover a value of 0.7 in the index calculation.

Stoats as well as weasels preferred farmland habitats over woodland (Klemola et al. 1999).

On arable crops Stoats may use tunnels and dens of Moles and Hamsters or extended vole corridors (Stubbe 1989 in Reichstein 1993).

Because Stoats mainly occur in edge structures where they also find most of their diet we estimated the amount of diet taken from sprayed crops to be about 40%.

Threats / sensibility (pesticide effects)

Residues of rodenticides were detected in 23% if investigated Stoats and the authors also indicate that indirect effects through reduction of prey population may have an impact on Stoat (and Weasel) populations (McDonald et al. 1998, see chapter 3.1).

Other threats

Human hunting activities are one of the main threats for Stoats (Reichstein 1993). Meinig & Boye (2009) mention agriculture and legal killing as main human-made threats. Natural enemies are larger carnivores and birds of prey.

Measures for risk-management

Aim: Improvement of food availability and nesting habitats

Measures that increase rodent abundances like conservation headlands, cover crops and beetle banks support Stoat populations in arable landscapes (McDonald et al. 2000).

1.20 Least Weasel (*Mustela nivalis*) – Mauswiesel – Order: Carnivora

Geography: Europe

Least Weasels occur circumpolar and almost all over Europe except for Ireland (Reichstein 1993).

Geography: Germany

Least Weasels inhabit total Germany.

Population, trend and conservation status

- Red List Germany: category D (data deficient)
- Bern Convention, Appendix III

Tab. Muni1: Red List-classifications of the status of Least Weasel populations in total Germany and the federal states (n.a.= information not available).

State	G	BB	BW	BY	HE	MV	NI	NW	RP	SH	SL	SN	ST	TH
Year	2008	2003	2001	2003	1995	1991	1991	2010	1987	2000	2008	1999	2004	2001
Category	D	3	-	3	D	3	-	D	-	-	n.a.	-	V	2

The Least Weasel is listed in the Red List of Germany under category D, which means the available “data is insufficient” (Meinig et al. 2009). In 1998 it was still listed under least concern in Germany. However, several federal states classify this species as vulnerable or even endangered, like for example Thuringia (see Tab. Muni1).

The hunting bag statistics, given for both Stoat and Least Weasel, show a strong decline in numbers in Schleswig-Holstein (Fig. 22). In Baden-Württemberg numbers of Weasels killed by hunting activities or traffic declined as well.

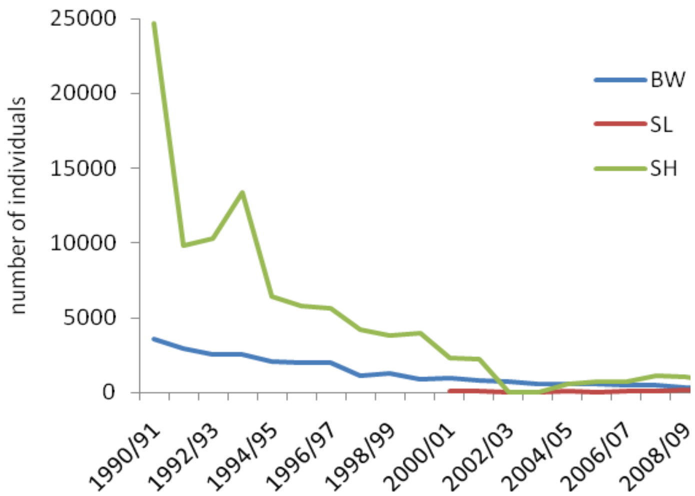

Fig. Muni1: Hunting bags of Least Weasels and Stoats from 1990/91 till 2009/10 for three federal states of Germany (sources hunting bags of federal state hunting societies).

Life cycle

Least Weasels reproduce from March till October, they have one to two litters per year (Reichstein 1993). Between 4 and 7 young are born per litter, mainly in July and August. They are nursed for about ten weeks (Reichstein 1993). A successful reproduction is only possible when rodent densities are high enough (about 10 individuals per ha; Erlinge, 1974 in Reichstein 1993). Weasels have an average life span of one year and usually do not survive a third winter (Reichstein 1993).

Dispersal

Home range sizes depend on prey densities and structural features of the habitat (Reichstein 1993).

Magrini et al. (2009) found a mean home range size of 82.6ha (100% MCP) in spring/summer and a 7.6ha large home range during autumn and winter. Home range sizes varied greatly between non-breeding season and breeding season. The seasonal variation of home range sizes was 90.7% (Magrini et al. 2009).

Males had larger home range sizes than females or sub-adult males (MacDonald et al. 2004).

Diet

Least Weasels are extremely specialized in their diet choice (Reichstein 1993). Their diet consists of voles (about 50-80%, mainly Microtus species), Muridae, birds (10%) and amphibians (Röser 1995; Grzimek 1984). They also prey on young Lagomorphs, mainly during winter, while Microtus and Apodemus species dominated summer and autumn (Reichstein 1993).

In the UK the diet of Least Weasels contained 68% small rodents (mainly Common Voles), 25% Lagomorphs and 5% birds and eggs (McDonald et al. 2000; see also Tab. Muni2).

According to gut content analyses of Tapper (1979), the diet of Weasels consisted of 58% small rodents (*Microtus* 37%, *Clethrionomys* 9%, *Apodemus* 5%), 19% birds (songbirds 15%, gamebirds 2%, eggs 1,9%), 17% Lagomorphs (consumed mainly be male Weasels), 2% Water Voles and rats and 2% insectivores. When vole densities are low the proportion of consumed birds rises (Tapper 1979).

Tab. Muni2: Distribution of main diet components of least weasels in the different seasons in the UK (after McDonald et al., 2000).

	Lagomorphs (%)	Small rodents (%)	Birds & eggs (%)
Spring	40	50	10
Summer	5	90	5
Autumn	20	80	-
Winter	25	55	20

Least Weasels consume a higher amount of small rodents that Stoats and therefore about 70% of the diet is potentially affected by pesticides (rodenticides) during the breeding season while it is 80% during winter.

Weasels are mainly diurnal (Brandt & Lambin 2005). MacDonald et al. (2004) assume that the predation risk for Least Weasels is lower during daytime than during night or that they adopted an efficient hunting strategy to prey on Wood Mice inside their burrows. Weasels search tunnels of voles and mice for prey and can also climb to reach nesting boxes and swim (Reichstein 1993).

Habitat and densities

The Least Weasel occurs in forests, grasslands, hedges and on arable land (Reichstein 1993). Its habitat preferences are similar to those of its prey. A radio-tracking study in Austria found that least Weasels show a strong preference for habitats formed by natural residual edges between crops and meadows which also influence the shape of their home ranges (Magrini et al. 2009). Fig. Muni2 shows a relatively low utilization of cultivated fields and meadows and a high preference for corridors of natural environment, which is defined as woodland and hedges, including spaces between fields or fields and road etc. (Magrini et al. 2009).

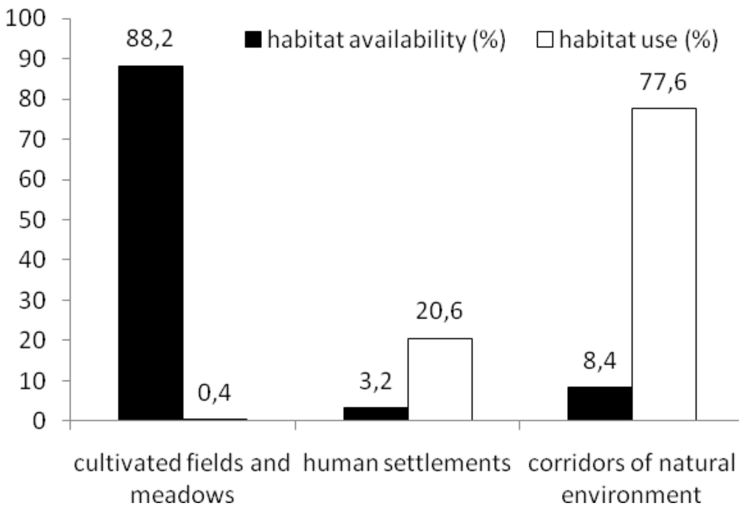

Fig. Muni2: Habitat availability and selection by the Least Weasel (after Magrini et al. 2009).

In a mixed farmland in the UK radio-tracked Least Weasels preferred linear structures like woodland edges and hedges with ditch. They rarely moved more than 5m from these structures which had relatively high prey (small mammal) abundance (MacDonald et al. 2004).

Zub et al. (2008) investigated habitat selection of Least Weasels. Weasels preferred open areas over forests. They occurred in areas with dense vegetation and avoided areas with poor plant cover due to the lack of protection from predation.

Least Weasels build their nests preferably beneath roots, piles of stone or wood (Reichstein 1993).

Weasels may take about 40% of their diet (rodents) from sprayed cultures. The presence of cover is very important and therefore scored as 0.7 in the index calculation.

In Southern Sweden Weasel densities of 15 individuals per km were recorded by Erlinge (1974 in Zub et al. 2008) and 11 to 22 individuals per km in the UK (King, 1975 in Zub et al. 2008).

Threats / sensibility (pesticide effects)

Residues of rodenticides were detected in 30% investigated Weasels in a study in the UK (McDonald et al. 1998, more details see chapter 3.1).

Other threats

Natural enemies of the Least Weasel are Foxes, Polecats and birds of prey (Grzimek 1984).

Meinig & Boye (2009) list agriculture and direct take through legal killing as threats that pressure Weasel populations. Indirect poisoning due to chemical rodent control, traps and traffic are other potential dangers (Lung 2004).

Losses through trapping activities are high and a bigger threat than natural enemies (Reichstein 1993).

Günther et al. (2005) mention the Least Weasel as one of the species that suffer from the elimination of hedgerows, field margins and other structural elements in agricultural landscapes, besides that the applications of poison (rodenticides) and traps threaten weasels as well.

Measures for risk-management

Aim: Improvement of food availability and nesting habitats

Measures that increase rodent abundances like conservation headlands, cover crops and beetle banks support Weasel populations in arable landscapes (McDonald et al. 2000).

1.21 Fallow Deer (*Dama dama*) – Damhirsch – Order: Artiodactyla

Geography: Europe

The Fallow Deer is present in countries all over Europe.

Geography: Germany

The Fallow Deer occurs all over Germany. Its main occurrence is in the north of Germany (Grauer et al. 2008).

Population, trend and conservation status

- Red List Germany: least concern
- Bern Convention, Appendix III

Tab. Dada1: Red List-classifications of the status of the Fallow Deer populations in total Germany and the federal states (n.a.= information not available).

State	G	BB	BW	BY	HE	MV	NI	NW	RP	SH	SL	SN	ST	TH
Year	2008	2003	2001	2003	1995	1991	1991	2010	1987	2000	2008	1999	2004	2001
Category	-	-	-	-	-	-	-	-	-	-	n.a.	-	-	-

In Germany Fallow Deer populations are still moderately common but strongly increasing on the long term (Meinig et al. 2009).

Life cycle

Mating season is from September till February. From May till August usually a single fawn is born. Young male Fallow Deer participate in reproduction in their third year, females become sexually mature by the end of their first year (Heidemann 1986). Fallow Deer have a life span of 10 to 15 years.

Dispersal

Fallow Deer are non-territorial. Their ranges have sizes from 50 to 100ha.

Diet

Grasses are the most important food plants (Petrak 1987). In northern Germany the diet of Fallow Deer consists to a large part of plants from crop lands, mainly from grassland (Heidemann 1986). We therefore estimate that about 20% of the species' diet is affected by pesticides (herbicides).

Fallow Deer are predominantly crepuscular and rest during the day.

Habitat and densities

Fallow Deer are highly adaptable and can survive in a wide range of habitats except for alpine regions. They prefer mature deciduous and mixed forests over coniferous forests (Heidemann, 1986). Fallow Deer need areas with sufficient cover like woodlands or agricultural land during the growing period but do also use grassland and crop land during winter (Heidemann 1986).

Grasslands are important habitats for sufficient food supply (Petrak 1987).

We estimate that Fallow Deer take about 30% of their diet from sprayed cultures.

Densities of 3 -10 individuals per 100ha are seen as economically reasonable (Heidemann 1986).

Threats / sensibility (pesticide effects)

Meinig & Boye (2009) name forest management as a threatening factor.

Measures for risk-management

No information available.

1.22 Wild Boar (*Sus scrofa*) – Wildschwein – Order: Artiodactyla

Geography: Europe

The Wild Boar occurs in wide parts or Europe, is absent from Denmark, main parts of Scandinavia and the UK (Herre 1986). It is native in Corsica and Sardinia.

Geography: Germany

Wild Boars are distributed all over Germany.

Population, trend and conservation status

- Red List Germany: least concern

Tab. Susc1: Red List-classifications of the status of Wild Boar populations in total Germany and the federal states (n.a.= information not available).

State	G	BB	BW	BY	HE	MV	NI	NW	RP	SH	SL	SN	ST	TH
Year	2008	2003	2001	2003	1995	1991	1991	2010	1987	2000	2008	1999	2004	2001
Category	-	-	-	-	-	-	-	-	-	-	n.a.	-	-	-

In Germany, Wild Boars are very common. Their population numbers show a strong increase (Meinig et al. 2009)

Life cycle

The peak of the mating season is between November and January. Generally one litter is born per year with 4 to 8 young. The young are mainly born in March and April but also later in the year (Herre 1986). Wild Boars may have a maximum life span of nine years.

The young are secondary altricial (Herre 1986).

Dispersal

No information available.

Diet

Wild Boars consume a wide range of food sources and are generally omnivorous. They prefer acorns and beechnuts. Wild Boars forage on the soil surface or in the upper soil layers (Herre 1986).

Today, Wild Boars cannot find sufficient food when they forage in forests exclusively and therefore take a high proportion of crop fruits as well (Herre 1986).

We estimate the amount of diet affected by pesticides to be about 10%.

Wild Boars are mainly active during twilight and night.

Habitat and densities

Wild Boars mainly inhabit large deciduous and mixed forests and older coniferous stands with sufficient understory for shelter (Herre 1986).

In summer they seek for shelter in large maize crops (Hertweck 2009). Other visited cultures are cereals, rape and potatoes.

The amount of diet taken from sprayed cultures is estimated to be about 40%.

About 20 individual per 1000ha are regarded as convenient density of Wild Boars in spring (Herre 1986).

Threats / sensibility (pesticide effects)

Meinig & Boye (2009) name forest management as a threatening factor.

Measures for risk-management

No information available.

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Environmental Research

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Protection of Biodiversity

Project No. (FKZ) 3710 63 411

Protection of biodiversity of free living birds and mammals in respect of the effects of pesticides

„Das Schutzgut Biodiversität in der Umweltbewertung von Stoffen – Konzept für das Management des Risikos für freilebende Vögel und Säuger aus der Anwendung von Pflanzenschutzmitteln unter Berücksichtigung indirekter Wirkung (Nahrungsnetz-Effekte) und besonders geschützter Arten“

Annex III

Tab. 5.1: Effects of risk management measures on birds and mammals

by

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ON BEHALF OF THE

FEDERAL ENVIRONMENT AGENCY

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1 Annex III Tab. 5.1: Effects of risk management measures on birds and mammals

Explanations

Scores for the predicted effects of RMM on farmland birds and mammals	
Score	**Effect**
2	Slightly positive effect
1	Positive effect
0	No effect or not relevant
-1	Slightly negative effect
-2	Negative effect
1)	moist breeds only
na	not applicable
Quality of evidence for the predicted effects of RMM on farmland birds and mammals	
	1. direct evidence from literature
	2. indirect evidence (e.g. by habitat preferences)
(no color)	3. no evidence but logical

Threats, short descriptions	Threats / risks arising from pesticides, full description
Herbicides	Herbicides
Insecticides	Insecticides
Fungicides	Fungicides
Rodenticides	Rodenticides
Molluscicides	Molluscicides
Growth regulators	Growth regulators
Acaricides	Acaricides
Nematocides	Nematocides
Risk management measures	**Risk management measures**
Pesticides – agent-related measures	**Pesticides – agent-related measures**
No non-selective herbicides	No application of non-selective, broad-spectrum herbicides
Restr. pre-sowing, pre- and post-emerg. herb.	Restricted application of pre-sowing, pre- and post- emergence herbicides
Appl. targeted herbicides against key weeds	Application of highly targeted herbicides against key weed species
Restr. appl. of insecticides	Restricted application of insecticides
Restr. appl. of of fungicides	Restricted application of fungicides
Restr. appl. of of rodenticides	Restricted application of rodenticides
Restr. appl. of of molluscicides	Restricted application of molluscicides
Restr. appl. of other PPPs	Restricted application of other pesticides (growth regulators, etc.)
Restr PPP seed treatments	Restricted usage of plant protection agents (fungicides, insecticides) for seeds treatment
Pesticides – application-related measures	**Pesticides – application-related measures**
No appl. of PPPs during reproductive season	No application of pesticides during the breeding period (birds) and the gestation and lactation period (mammals)
No appl. of PPPs in ecological hot spots	No application of pesticides in ecological hot spots (nesting places, burrows)
Selective control of target weed species	Only selective control of target weed species
Selective control of weed clusters	Only selective control of weed clusters
Appl. of biol. and biotech. Methods	Application of biological and biotechnical methods of plant protection in agriculture, fruit crops and viticulture
Spatial restrictions	Spatial restriction (unsprayed field edges and headlands)
Crop-related measures (in-crop)	**Crop-related measures (in-crop)**
Higher crop diversity	Cultivation of at least four different crop types (diversified crop rotation) in spatial proximity
Catch cropping	Catch cropping after main fruit harvest for winter greening
Stubbles	Keeping stubble fields until next seeding in the following spring
Wide rows	Creation of sparsely sown field crops (defined areas or strips) with reduced fertilization (in wide rows)
Extensive farming (no PPP)	Extensive arable farming (minimal use of fertilizers, no use of pesticides)
Flower strips	Creation of flower areas or flower strips
Fallow strips on field edges	Creation of fallow strips on crop edges
Beetle banks, bee banks)	Creation of fallow strips inside crops (beetle banks / bee banks)
Set-aside for one year	Conversion of arable land into fallow land / set-aside for one year
Perennial set-aside	Conversion of arable land into fallow land / set-aside for a couple of years
Skylark plots	Creation of so-called „skylark windows“
No farming in spring	Temporary interruption of crop management in spring
Landscape-related measures (off-crop)	**Landscape-related measures (off-crop)**
Biotope networks	Creation of biotope networks in order to enhance biodiversity (e.g. sowing of wild herbs from autochthonous seeds)
Planting of trees and hedgerows	Planting of individual trees, field trees (woodland), hedges and scrubs
Set-up of orchards	Creation of meadow orchards, as well as nest and hollow trees
Set-up of stone walls and heaps	Creation of dry stone walls and stone heaps
Grass verges along roads and streams	Creation of road-, water- and bank-verges with extensive grassland
Reed verges	Creation of water- and bank-verges with reeds / tall forbs
Tree and shrub verges	Creation of water- and bank-verges with trees/shrubs
Wet places in grassland	Creation of moist sink areas with utilisation (crop and grassland)
Unfarmed wet places (ponds)	Creation of still water bodies (pond biotopes) and wetlands without utilization
Re-wetting of grassland	Renaturation and re-wetting of drained grassland areas
Non-intensive grassland management	Extensive grassland: restriction in farming periods, mowing, stock densities and usage of synthetic fertilizers
Small field sizes	Small-scale crops (small field sizes)

Threats	Bewick's Swan	Barnacle Goose	Bean Goose	White-fronted Goose	Greylag Goose	Common Quail	Grey Partridge
Herbicides	0	0	0	0	0	2	2
Insecticides	0	0	0	0	0	2	2
Fungicides	0	0	0	0	0	0	0
Rodenticides	0	0	0	0	0	0	0
Molluscicides	0	0	0	0	0	0	0
Growth regulators	0	0	0	0	0	0	0
Acaricides	0	0	0	0	0	1	1
Nematocides	0	0	0	0	0	0	0
Risk management measures							
Pesticides – agent-related measures							
No non-selective herbicides	0	0	0	0	0	2	2
Restr. pre-sowing, pre- and post-emerg. herb.	0	0	0	0	0	2	2
Appl. targeted herbicides against key weeds	0	0	0	0	0	2	2
Restr. appl. of insecticides	0	0	0	0	0	2	2
Restr. appl. of of fungicides	0	0	0	0	0	0	0
Restr. appl. of of rodenticides	0	0	0	0	0	0	0
Restr. appl. of of molluscicides	0	0	0	0	0	0	0
Restr. appl. of other PPPs	0	0	0	0	0	0	0
Restr PPP seed treatments	0	0	0	0	0	1	1
Pesticides – application-related measures							
No appl. of PPPs during reproductive season	0	0	0	0	0	2	2
No appl. of PPPs in ecological hot spots	0	0	0	0	0	2	2
Selective control of target weed species	0	0	0	0	0	2	2
Selective control of weed clusters	0	0	0	0	0	2	2
Appl. of biol. and biotech. Methods	0	0	0	0	0	2	2
Spatial restrictions	0	0	0	0	0	1	2
Crop-related measures (in-crop)							
Higher crop diversity	0	0	0	0	0	1	2
Catch cropping	2	1	1	1	1	0	2
Stubbles	2	2	2	2	2	0	2
Wide rows	0	0	0	0	0	1	1
Extensive farming (no PPP)	0	0	0	0	0	2	2
Flower strips	0	0	0	0	0	2	2
Fallow strips on field edges	0	0	0	0	0	2	2
Beetle banks, bee banks)	0	0	0	0	0	2	2
Set-aside for one year	0	0	0	0	0	2	2
Perennial set-aside	0	0	0	0	0	2	2
Skylark plots	0	0	0	0	0	0	0
No farming in spring	0	0	0	0	0	1	1
Landscape-related measures (off-crop)							
Biotope networks	0	0	0	0	0	0	2
Planting of trees and hedgerows	-2	-2	-2	-2	-2	-2	2
Set-up of orchards	-2	-2	-2	-2	-2	-2	0
Set-up of stone walls and heaps	-1	0	0	0	0	0	0
Grass verges along roads and streams	2	2	2	2	2	1	0
Reed verges	-1	2	2	2	2	-2	0
Tree and shrub verges	-2	-2	-2	-2	-2	-2	0
Wet places in grassland	2	2	2	2	2	0	0
Unfarmed wet places (ponds)	1	1	1	1	1	0	0
Re-wetting of grassland	2	2	0	0	2	0	0
Non-intensive grassland management	0	0	0	0	0	1	1
Small field sizes	-1	2	1	1	0	1	2

Threats	Montagu's Harrier	Red Kite	Common Crane	Corncrake	Golden Plover	Lapwing	Black-tailed Godwit
Herbicides	0	0	1	2	0	1	0
Insecticides	0	0	1	2	1	2	1
Fungicides	0	0	0	0	0	0	0
Rodenticides	2	2	0	0	0	0	0
Molluscicides	0	0	0	2	1	1	0
Growth regulators	0	0	0	0	0	0	0
Acaricides	0	0	0	0	0	0	0
Nematocides	0	0	0	0	0	0	0
Risk management measures							
Pesticides – agent-related measures							
No non-selective herbicides	0	0	0	2	0	1	0
Restr. pre-sowing, pre- and post-emerg. herb.	0	0	0	2	0	0	0
Appl. targeted herbicides against key weeds	0	0	0	1	0	0	0
Restr. appl. of insecticides	0	0	0	2	1	2	0
Restr. appl. of of fungicides	0	0	0	0	0	0	0
Restr. appl. of of rodenticides	2	2	0	0	0	0	0
Restr. appl. of of molluscicides	0	0	0	2	1	1	0
Restr. appl. of other PPPs	0	0	0	0	0	0	0
Restr PPP seed treatments	1	1	0	0	0	0	0
Pesticides – application-related measures							
No appl. of PPPs during reproductive season	0	1	0	2	0	2	1
No appl. of PPPs in ecological hot spots	2	0	0	2	0	2	2
Selective control of target weed species	0	0	0	1	0	0	0
Selective control of weed clusters	0	0	0	1	0	0	0
Appl. of biol. and biotech. Methods	0	0	0	0	0	0	0
Spatial restrictions	0	0	0	0	0	0	0
Crop-related measures (in-crop)							
Higher crop diversity	1	2	-1	0	0	1	0
Catch cropping	0	0	0	0	0	0	0
Stubbles	0	1	2	0	0	1	0
Wide rows	0	0	0	0	0	1	0
Extensive farming (no PPP)	0	0	0	1	0	1	0
Flower strips	2	1	0	0	0	0	0
Fallow strips on field edges	2	2	0	0	0	0	0
Beetle banks, bee banks)	2	2	0	0	-1	0	0
Set-aside for one year	2	2	0	0	-2	2	0
Perennial set-aside	2	1	0	1	-2	1	0
Skylark plots	0	0	0	0	0	0	0
No farming in spring	0	0	0	2	0	2	2
Landscape-related measures (off-crop)							
Biotope networks	1	1	0	0	0	0	0
Planting of trees and hedgerows	0	1	-2	-1	-2	-2	-2
Set-up of orchards	-2	0	-2	-1	-2	-2	-2
Set-up of stone walls and heaps	0	0	0	0	-1	-1	-1
Grass verges along roads and streams	2	0	1	2	0	2	2
Reed verges	0	0	-1	0	-1	-1	-1
Tree and shrub verges	-2	1	-1	-1	-2	-2	-2
Wet places in grassland	1	1	2	2	1	2	2
Unfarmed wet places (ponds)	1	1	2	0	0	2	2
Re-wetting of grassland	1	1	2	2	2	2	2
Non-intensive grassland management	0	0	0	2	0	2	2
Small field sizes	0	2	-2	0	-2	0	-1

Threats	Little Owl	Red-backed Shrike	Woodlark	Skylark	Barn Swallow	House Martin	Winchat
Herbicides	1	1	2	2	1	1	1
Insecticides	2	2	2	2	2	2	1
Fungicides	0	0	0	0	0	0	0
Rodenticides	2	0	0	0	0	0	0
Molluscicides	0	0	0	0	0	0	0
Growth regulators	0	0	0	0	0	0	0
Acaricides	0	0	0	0	0	0	1
Nematocides	0	0	0	0	0	0	0
Risk management measures							
Pesticides – agent-related measures							
No non-selective herbicides	0	2	2	2	1	1	1
Restr. pre-sowing, pre- and post-emerg. herb.	0	2	1	1	1	1	1
Appl. targeted herbicides against key weeds	0	1	2	2	1	1	1
Restr. appl. of insecticides	2	2	2	2	2	2	1
Restr. appl. of of fungicides	0	0	1	1	0	0	0
Restr. appl. of of rodenticides	2	0	0	0	0	0	0
Restr. appl. of of molluscicides	1	0	0	0	0	0	0
Restr. appl. of other PPPs	0	0	0	0	0	0	0
Restr PPP seed treatments	1	1	2	2	0	0	0
Pesticides – application-related measures							
No appl. of PPPs during reproductive season	2	2	2	2	2	2	1
No appl. of PPPs in ecological hot spots	2	2	2	2	0	0	2
Selective control of target weed species	0	1	1	1	1	1	1
Selective control of weed clusters	0	1	1	1	1	1	1
Appl. of biol. and biotech. Methods	2	2	2	2	1	1	1
Spatial restrictions	1	2	2	2	2	2	2
Crop-related measures (in-crop)							
Higher crop diversity	1	1	2	2	2	2	1
Catch cropping	-1	0	2	2	1	1	0
Stubbles	2	0	2	2	0	0	0
Wide rows	0	1	2	1	1	1	0
Extensive farming (no PPP)	2	1	2	2	2	2	1
Flower strips	1	1	2	2	2	2	0
Fallow strips on field edges	1	2	2	2	2	2	2
Beetle banks, bee banks)	1	2	2	2	2	2	1
Set-aside for one year	1	2	2	2	2	2	2
Perennial set-aside	0	2	2	2	2	2	2
Skylark plots	0	0	0	1	0	0	0
No farming in spring	0	0	0	1	0	0	0
Landscape-related measures (off-crop)							
Biotope networks	1	1	0	1	1	1	0
Planting of trees and hedgerows	1	2	1	-2	2	2	-2
Set-up of orchards	2	2	0	-2	1	1	-2
Set-up of stone walls and heaps	2	1	0	0	1	1	0
Grass verges along roads and streams	1	2	2	2	2	2	2
Reed verges	0	0	0	-1	2	2	2
Tree and shrub verges	1	1	0	-2	2	2	-2
Wet places in grassland	0	0	0	2	2	2	2
Unfarmed wet places (ponds)	0	0	0	0	2	2	2
Re-wetting of grassland	2	0	0	1	2	2	2
Non-intensive grassland management	0	2	1	2	1	1	1
Small field sizes	2	1	2	2	2	2	0

Threats	Meadow Pipit	Yellow Wagtail	Linnet	Corn Bunting	Yellow-hammer	Ortolan Bunting
Herbicides	1	2	2	2	1	2
Insecticides	1	2	0	2	2	2
Fungicides	0	0	0	0	0	0
Rodenticides	0	0	0	0	0	0
Molluscicides	0	0	0	0	0	0
Growth regulators	0	0	0	0	0	0
Acaricides	1	0	0	0	0	0
Nematocides	0	0	0	0	0	0
Risk management measures						
Pesticides – agent-related measures						
No non-selective herbicides	1	2	2	2	2	2
Restr. pre-sowing, pre- and post-emerg. herb.	1	2	2	2	2	2
Appl. targeted herbicides against key weeds	1	2	2	1	1	1
Restr. appl. of insecticides	1	2	0	2	2	2
Restr. appl. of of fungicides	0	0	0	0	0	0
Restr. appl. of of rodenticides	0	0	0	0	0	0
Restr. appl. of of molluscicides	0	0	0	0	0	0
Restr. appl. of other PPPs	0	0	0	0	0	0
Restr PPP seed treatments	0	2	0	1	1	1
Pesticides – application-related measures						
No appl. of PPPs during reproductive season	1	2	1	2	2	2
No appl. of PPPs in ecological hot spots	2	2	1	2	2	2
Selective control of target weed species	1	2	2	1	1	1
Selective control of weed clusters	1	2	2	1	1	1
Appl. of biol. and biotech. Methods	1		2	2	2	2
Spatial restrictions	2	2	2	2	2	2
Crop-related measures (in-crop)						
Higher crop diversity	1	2	0	1	1	2
Catch cropping	0	0	1	1	2	0
Stubbles	1	0	2	2	2	0
Wide rows	0	0	0	1	1	2
Extensive farming (no PPP)	1	1	2	2	2	2
Flower strips	0	1	2	1	2	2
Fallow strips on field edges	2	2	2	2	2	2
Beetle banks, bee banks)	1	2	2	2	2	2
Set-aside for one year	2	2	2	2	2	2
Perennial set-aside	2	2	2	2	2	-1
Skylark plots	0	1	0	0	0	1
No farming in spring	0	2	0	1	1	2
Landscape-related measures (off-crop)						
Biotope networks	0	0	2	1	1	1
Planting of trees and hedgerows	-2	-2	2	-2	2	2
Set-up of orchards	-2	-2	1	-2	-2	0
Set-up of stone walls and heaps	0	0	0	0	0	0
Grass verges along roads and streams	2	2	2	2	2	0
Reed verges	-2	-2	1	-2	-2	-2
Tree and shrub verges	-2	-2	1	-2	-2	-2
Wet places in grassland	2	2	1	1	1	0
Unfarmed wet places (ponds)	0	2	2	0	0	0
Re-wetting of grassland	2	2	0	1	0	0
Non-intensive grassland management	1	2	0	2	0	0
Small field sizes	0	2	0	1	1	2

Threats	European Hamster	Field Vole	Common Vole	Striped Field Mouse	Yellow-necked Mouse	Wood Mouse	Harvest Mouse
Herbicides	2	2	2	2	2	2	2
Insecticides	1	1	1	1	2	2	2
Fungicides	1	1	1	1	1	1	1
Rodenticides	2	2	2	2	2	2	2
Molluscicides	1	1	1	1	1	1	1
Growth regulators	0	0	0	0	0	0	0
Acaricides	0	0	0	0	0	0	0
Nematocides	0	0	0	0	0	0	0
Risk management measures							
Pesticides – agent-related measures							
No non-selective herbicides	2	2	2	2	2	2	2
Restr. pre-sowing, pre- and post-emerg. herb.	2	2	2	2	2	2	2
Appl. targeted herbicides against key weeds	2	2	2	2	2	2	2
Restr. appl. of insecticides	2	2	2	2	2	2	2
Restr. appl. of fungicides	0	1	1	1	1	1	1
Restr. appl. of rodenticides	2	2	2	2	2	2	2
Restr. appl. of molluscicides	1	1	1	1	1	1	1
Restr. appl. of other PPPs	0	0	0	0	0	0	0
Restr PPP seed treatments	2	2	2	2	2	2	2
Pesticides – application-related measures							
No appl. of PPPs during reproductive season	na	na	na	na	na	na	na
No appl. of PPPs in ecological hot spots	2	0	0	0	0	0	1
Selective control of target weed species	2	2	2	2	2	2	2
Selective control of weed clusters	2	2	2	2	2	2	2
Appl. of biol. and biotech. Methods	1	2	2	2	2	2	2
Spatial restrictions	2	2	2	2	2	2	2
Crop-related measures (in-crop)							
Higher crop diversity	2	2	2	2	1	2	1
Catch cropping	2	2	2	2	2	2	2
Stubbles	2	2	2	2	2	2	2
Wide rows	2	1	1	2	0	2	0
Extensive farming (no PPP)	2	2	1	2	2	2	2
Flower strips	2	2	2	2	2	2	2
Fallow strips on field edges	2	2	2	2	2	2	2
Beetle banks, bee banks)	2	2	2	2	0	2	2
Set-aside for one year	2	1	2	2	1	2	2
Perennial set-aside	2	2	2	2	1	2	2
Skylark plots	1	0	0	0	0	0	0
No farming in spring	1	0	0	0	0	0	0
Landscape-related measures (off-crop)							
Biotope networks	2	2	2	2	2	2	2
Planting of trees and hedgerows	1	2	1	2	2	2	2
Set-up of orchards	0	0	0	1	1	1	1
Set-up of stone walls and heaps	0	0	0	0	0	0	0
Grass verges along roads and streams	0	2	2	2	0	2	2
Reed verges	0	2	1	2	0	2	2
Tree and shrub verges	0	2	1	2	2	2	2
Wet places in grassland	-2	2	-1	2	0	0	1
Unfarmed wet places (ponds)	-2	2	-1	2	0	0	2
Re-wetting of grassland	0	2	-1	2	0	0	1
Non-intensive grassland management	0	2	0	1	1	1	2
Small field sizes	2	2	1	2	2	2	2

Threats	Bicoloured shrew	Greater White-toothed Shrew	Lesser White-toothed Shrew	Common Shrew	Eurasian Pygmy Shrew	European Hedgehog	European Mole
Herbicides	1	1	1	2	2	1	1
Insecticides	2	2	2	2	2	2	2
Fungicides	1	1	1	1	1	1	1
Rodenticides	1	1	1	1	1	2	1
Molluscicides	2	2	2	2	2	2	2
Growth regulators	0	0	0	0	0	0	0
Acaricides	0	0	0	0	0	0	0
Nematocides	0	0	0	0	0	0	0
Risk management measures							
Pesticides – agent-related measures							
No non-selective herbicides	1	1	1	2	2	1	0
Restr. pre-sowing, pre- and post-emerg. herb.	1	1	1	2	2	1	0
Appl. targeted herbicides against key weeds	1	1	1	2	2	1	0
Restr. appl. of insecticides	2	2	2	2	2	2	2
Restr. appl. of fungicides	0	0	0	0	0	1	0
Restr. appl. of rodenticides	1	1	1	1	1	2	2
Restr. appl. of molluscicides	2	2	2	2	2	2	2
Restr. appl. of other PPPs	0	0	0	0	0	0	0
Restr PPP seed treatments	1	1	1	1	1	1	1
Pesticides – application-related measures							
No appl. of PPPs during reproductive season	na	na	na	na	na	1	0
No appl. of PPPs in ecological hot spots	0	0	0	0	0	0	0
Selective control of target weed species	1	1	1	2	2	1	0
Selective control of weed clusters	1	1	1	2	2	1	0
Appl. of biol. and biotech. Methods	2	2	2	2	2	2	1
Spatial restrictions	2	2	2	2	2	2	1
Crop-related measures (in-crop)							
Higher crop diversity	0	0	0	0	0	0	0
Catch cropping	1	1	1	1	1	0	0
Stubbles	1	1	1	1	1	0	0
Wide rows	1	1	1	1	1	1	0
Extensive farming (no PPP)	2	2	2	2	2	2	2
Flower strips	2	2	2	2	2	2	1
Fallow strips on field edges	2	2	2	2	2	2	2
Beetle banks, bee banks)	1	1	1	1	2	2	1
Set-aside for one year	2	2	2	2	2	1	2
Perennial set-aside	2	2	2	2	2	1	2
Skylark plots	0	0	0	0	0	0	0
No farming in spring	0	0	0	0	0	0	0
Landscape-related measures (off-crop)							
Biotope networks	2	2	2	2	2	1	0
Planting of trees and hedgerows	2	2	2	2	2	2	2
Set-up of orchards	0	1	1	1	1	2	1
Set-up of stone walls and heaps	2	2	2	0	0	0	0
Grass verges along roads and streams	1	2	2	2	2	2	2
Reed verges	1	1	1	2	2	0	0
Tree and shrub verges	1	1	1	2	2	1	1
Wet places in grassland	-1	0	-1	2	2	0	-1
Unfarmed wet places (ponds)	-1	0	-1	2	2	0	-1
Re-wetting of grassland	-1	0	-1	2	2	0	-1
Non-intensive grassland management	1	2	2	2	2	0	2
Small field sizes	1	1	1	1	1	1	0

Threats	Greater Mouse-eared Bat	Natterer's bat	Common Noctule	Stoat	Least Weasel	Fallow Deer	Wild Boar
Herbicides	1	1	1	1	1	1	0
Insecticides	2	2	2	1	1	0	0
Fungicides	0	0	0	1	1	0	0
Rodenticides	0	0	0	2	2	1	1
Molluscicides	0	0	0	1	1	0	0
Growth regulators	0	0	0	0	0	0	0
Acaricides	0	0	0	0	0	0	0
Nematocides	0	0	0	0	0	0	0
Risk management measures							
Pesticides – agent-related measures							
No non-selective herbicides	1	1	1	1	1	1	0
Restr. pre-sowing, pre- and post-emerg. herb.	1	1	1	1	1	0	0
Appl. targeted herbicides against key weeds	1	1	1	1	1	0	0
Restr. appl. of insecticides	2	2	2	1	1	0	0
Restr. appl. of fungicides	0	0	0	1	1	0	0
Restr. appl. of rodenticides	0	0	0	2	2	1	1
Restr. appl. of molluscicides	0	0	0	1	1	0	0
Restr. appl. of other PPPs	0	0	0	0	0	0	0
Restr PPP seed treatments	0	0	0	0	0	0	0
Pesticides – application-related measures							
No appl. of PPPs during reproductive season	1	1	1	na	na	0	0
No appl. of PPPs in ecological hot spots	0	0	0	0	0	0	0
Selective control of target weed species	1	1	1	1	1	1	0
Selective control of weed clusters	1	1	1	1	1	1	0
Appl. of biol. and biotech. Methods	2	2	2	1	1	0	0
Spatial restrictions	2	2	2	2	2	1	1
Crop-related measures (in-crop)							
Higher crop diversity	0	0	0	0	0	2	2
Catch cropping	0	0	0	2	2	2	2
Stubbles	0	0	0	2	2	2	2
Wide rows	0	0	0	1	1	0	0
Extensive farming (no PPP)	2	2	2	1	1	0	0
Flower strips	2	2	2	2	2	1	1
Fallow strips on field edges	2	2	2	2	2	1	1
Beetle banks, bee banks)	1	1	1	2	2	1	1
Set-aside for one year	1	1	2	2	2	1	1
Perennial set-aside	1	1	2	2	2	2	1
Skylark plots	0	0	0	0	0	0	0
No farming in spring	0	0	0	0	0	0	0
Landscape-related measures (off-crop)							
Biotope networks	1	1	1	1	1	1	1
Planting of trees and hedgerows	2	2	2	2	2	2	2
Set-up of orchards	1	2	2	1	1	0	0
Set-up of stone walls and heaps	0	0	0	2	2	0	0
Grass verges along roads and streams	1	2	2	2	2	0	0
Reed verges	0	0	2	2	2	0	0
Tree and shrub verges	2	2	2	2	2	0	0
Wet places in grassland	2	2	2	2	2	0	1
Unfarmed wet places (ponds)	2	2	2	2	2	0	1
Re-wetting of grassland	2	2	2	1	1	0	1
Non-intensive grassland management	?2/-1*	?2/-1*	0	0	0	0	0
Small field sizes	1	2	0	2	2	1	0