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Diversity and Composition of Breeding Bird Communities in Short Rotation Coppices and Surrounding Agricultural Landscape

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Diversität und Artenzusammensetzung von Brutvogelgemeinschaften auf Kurzumtriebsplantagen und der umgebenden Agrarlandschaft

Im Rahmen der Energiewende nimmt der Anbau von Energiepflanzen in Deutschland stark zu, ist aber aus naturschutzfachlicher Sicht zunehmend umstritten. Eine Form des Energiepflanzenanbaus sind Kurzumtriebsplantagen (KUP) mit schnell wachsenden Gehölzen wie Pappeln, Robinien oder Weiden. Eine abschließende Bewertung der Biodiversität derartiger Energieholzflächen und eine fundierte Prognose der ökologischen Effekte, die bei einem großflächigen Anbau zu erwarten sind, liegen bislang noch nicht vor.

Ziel dieser Studie war es, den Kenntnisstand über die ökologische Wertigkeit von Kurzumtriebsplantagen im Vergleich zu alternativen Landnutzungsformen bzw. derzeit die Kulturlandschaft prägenden Strukturelementen zu erweitern. Hierfür wurden Brutvögel als etablierte und aussagekräftige Biodeskriptoren gewählt.

In den Jahren 2007, 2008 und 2009 fanden flächendeckende Brutvogelerfassungen auf Energieholzflächen verschiedener Altersstadien und Ausprägungsformen sowie auf umliegenden Lebensraumstrukturen (Acker, Brache, Hecke) in den Bundesländern Hessen, Sachsen und Brandenburg statt. Die erhobenen Daten wurden hinsichtlich der Artenzusammensetzung und der Siedlungsdichte in Bezug auf die unterschiedlichen Habitattypen quantitativ und qualitativ miteinander verglichen.

Die Ergebnisse zeigen deutliche Unterschiede sowohl in der Artenzusammensetzung und den Siedlungsdichten zwischen den drei typischen Entwicklungsstadien einer KUP (Initialstadium, Gebüschstadium, Baumstadium) als auch im Vergleich zu Ackerland, Brachen und Hecken. Mit zunehmendem Alter der KUP bzw. dem entsprechenden Wandel der Struktureigenschaften (z. B. Wuchshöhe) fand eine sukzessive Verschiebung des Artenspektrums von Offenland- zu Waldarten und eine Veränderung der Artenzahlen und -dichten statt. Innerhalb der drei verschiedenen KUP-Strukturtypen zeigte das Gebüschstadium die höchsten Artenzahlen und Siedlungsdichten. Im Gesamtvergleich aller untersuchten Lebensraumtypen wurden diesbezüglich für Hecken die höchsten Werte ermittelt. Innerhalb der Gruppe der weitgehend offeneren Habitattypen (Initialstadium KUP, Acker, Brache) stellten Brachen deutlich die avifaunistisch reichhaltigsten Lebensräume dar. Demgegenüber wurden auf Ackerflächen im Gesamtvergleich die geringsten Artenzahlen und Siedlungsdichten festgestellt. Die Brutvogelgemeinschaften auf den untersuchten KUP wurden fast ausschließlich durch ubiquitäre Arten geprägt. Das Vorkommen spezialisierterer und gefährdeter Brutvögel, die hauptsächlich Offenland- oder Ökotonarten innerhalb des nachgewiesenen Spektrums umfassten, war bezüglich der KUP im Wesentlichen auf das Initialstadium oder auf die Randbereiche von älteren KUP-Entwicklungsstadien beschränkt. Die mit Abstand höchste Anzahl gefährdeter Arten wurde auf Brachen nachgewiesen. Avifaunistische Aufwertungseffekte durch die Etablierung von KUP sind zukünftig daher generell nur in sehr strukturarmen, intensiv genutzten Agrarlandschaften zu erwarten. Zudem dürfte sich eine positive Wirkung nur auf die Randbereiche (ggf. großflächiger KUP) und temporär auf frisch angelegte oder beerntete KUP-Flächen beschränken. Bei direkter Flächenkonkurrenz zu Brachen sind dagegen durch die Etablierung von Energiehölzern deutlich negative Effekte auf die lokale Bestandssituation insbesondere anspruchsvollerer und oftmals gefährdeter Brutvogelarten zu prognostizieren. Abschließend wurden daher Maßnahmen für die Anlage und Bewirtschaftung von KUP vorgeschlagen, um Negativeffekte auf Brutvögel zu minimieren.

Key words: avian fauna; woody biomass, fallow; hedge; cropland; conservational value

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Introduction

Contemporary agricultural activities are often accompanied by a profound loss of biodiversity (Henle et al. 2008, Flohre et al. 2011), the preservation of which is one of the main aims in nature conservation (Jackson 2011). Short rotation coppice (SRC) is a modern method of agriculture whereby fast growing trees (mainly poplar and willow) are cultivated for bioenergy. It is assumed that the growing production of biomass – and woody crops as a prime source – will increasingly compete with other habitat types and their environmental functions (Reeg et al. 2009). However, the impact of SRC on faunal diversity is still uncertain and research efforts so far have often been restricted to single small locations (Schulz et al. 2009).

The objective of the current study was to assess the impact of SRC on diversity and faunal composition using breeding birds as model taxa. Among species, breeding birds show a broad ecological amplitude indicative both of specific parameters and complex habitat structures. Furthermore, birds react comparatively expeditiously to ecological alternations. Therefore breeding birds are globally recognized bioindicators (Flohre et al. 2011, Billeter et al. 2008).

Thus far a number of studies have been conducted to examine how SRCs influence the avian fauna with contributions from the USA (Christian et al. 1997, Christian et al. 1998, Dhondt & Sydenstricker 2000, Dhondt et al. 2004, Dhondt et al. 2007, Hanowski et al. 1997), Great Britain (Sage & Robertson 1996, Sage et al. 2006, Anderson et al. 2004), Sweden (Göranson 1990, Göranson 1994, Berg 2002), Germany (Jedicke 1995, Liesebach & Mulsow 2003, Gruss & Schulz 2008, Gruss & Schulz 2011) and the Netherlands (Londo et al. 2005). The majority of these studies dealt with the avian fauna in the SRC itself. Hence, direct comparisons of diversity and the composition of breeding bird communities between SRC and the surrounding landscape in a specific area are limited (Berg 2002, Göranson 1990, Göranson 1994, Hanowski et al. 1997, Sage et al. 2006). However, such comprehensive studies are crucial for the faunal evaluation of SRC taking into account the distribution, local and regional population densities of breeding bird species as well as functional interrelations between SRC and adjacent structures.

In this study we investigated the species diversity and composition of breeding birds across various German SRCs (Brandenburg, Hesse and Saxony) differing in age, size and structure. We also studied their surrounding agricultural landscape. The aim of this study is to provide insights into breeding bird diversity in SRCs in Central Europe and to assess their ecological value compared with other typical elements of agricultural landscapes, such as crop fields, fallows and hedges.

Materials and Methods

Study Sites. Studies of breeding birds were conducted in several SRCs and their surroundings in the German federal states of Brandenburg, Hesse and Saxony during the years 2007, 2008 and 2009. Due to the high structural differences such as age, abiotic parameters, design and habitat potential for breeding birds, the SRC plots were classified into three main structure types (Tab. 1) according to Christian et al. 1998, Hanowski et al. 1997 and Londo et al. 2005: initial, shrub stage and tree stage. Altogether we studied four investigation sites, one each located in Hesse (Georgenhof: 51°27’00“N, 8°59’50“E) and Saxony (Thammenhain: 51°26’33“N, 12°51’20“E) and two in Brandenburg (Cahnsdorf: 51°51’30“N, 13°45’55“E, Jamikow: 53°10’25“N, 14°10’15“E)

Tab. 1. Classification and characterization of the three structure types which were found in the investigated short rotation coppices (SRC). – *Klassifikation und Charakterisierung der drei auf Kurzumtriebsplantagen festgestellten Strukturtypen bzw. Entwicklungsphasen (Initialstadium, Gebüschstadium, Baumstadium).*

classification	characterization
initial stage	• recently established SRC or harvested SRC in the first year of growth (poplar and willow) • height at the end of first vegetation phase: 0.5–max. 2.5 m, during breeding season (March–July) < 1.5 m • high coverage of grass-like and herbal vegetation • similar to pioneer habitats and early succession stages
shrub stage	• age of plantations (poplar and willow) mainly 2–5 years • max. height: > 1.5 m–5 m • only partially or marginally high coverage of grass-like and herbal vegetation • generally very dense (depending on hybrid selection and row spacing) • similar to shrubberies and early woody succession stages
tree stage	• age of plantations (only poplar SRCs studied) mainly > 5 years • max. height: > 5 m–18 m • sparse to minimal coverage of grass-like and herbal vegetation within plantation • similar to homogeneous young forests

including several plots of willow and poplar SRC. In total 15 plots of poplar and 11 plots of willow were included in this study. All plots were part of regional pilot research projects. Thus they differed greatly in age, size, shape and hybrid composition. Very sparse plantations (due to massive clonal failure) without typical SRC characteristics were not included in this study. We also integrated the comprehensive data gathered by Jedicke (1995) and Liesebach and Mulsow (2003), who investigated parts of the SRC plantation in Georgenhof (Hesse) in 1994 and 1998 to increase the data basis (Gruss & Schulz 2008). In total, 205 hectares of SRC were studied, including areal summations of plots investigated repeatedly (Fig. 1).

In addition we also studied the surroundings of SRCs including a wide range of habitat types (e.g. forests, wetlands). However, the number of relevant structures, which are assumed to be affected or replaced by the establishment of SRC, were limited. Such structures comprise croplands with a reference size of 515 hectares. This generalized habitat type contains cultivations of corn, cereals and oilseed rape. Furthermore set-asides and fallows (85 ha) were included in this study. This category integrated several plots with varying degrees of moisture. They were characterized as early succession stages (grass-like and herbal vegetation) without woody elements. Hedges (9 ha), which also occurred within the plots studied, were included in the evaluation of SRCs with regard to breeding bird community composition. Regarding SRCs, several plots were investigated repeatedly. As a result, the avian fauna was studied in several consecutive years at the same study sites.

Survey Methods. Breeding birds were surveyed using the census method of territory mapping and in accordance with recognized standards for central European avian fauna (Bibby et al. 2000, Gregory et al. 2004, Südbeck et al. 2005). Seven surveys were conducted during spring (March–June) on each plot. Mappings were undertaken in the morning and evening hours to coincide with species-specific activity peaks. Detected individuals were assigned to a certain structure if this was considered to be the crucial habitat factor for their occurrence or nesting site. We did not look for nests nor investigate the mating status of each detected individual. In accordance with the species-specific census standards (Bibby et al. 2000, Südbeck et al. 2005), a repeated detection of a certain behaviour, e.g. singing, calling, display, agonistic/reproductive behavior, led either to a status of suspicion of

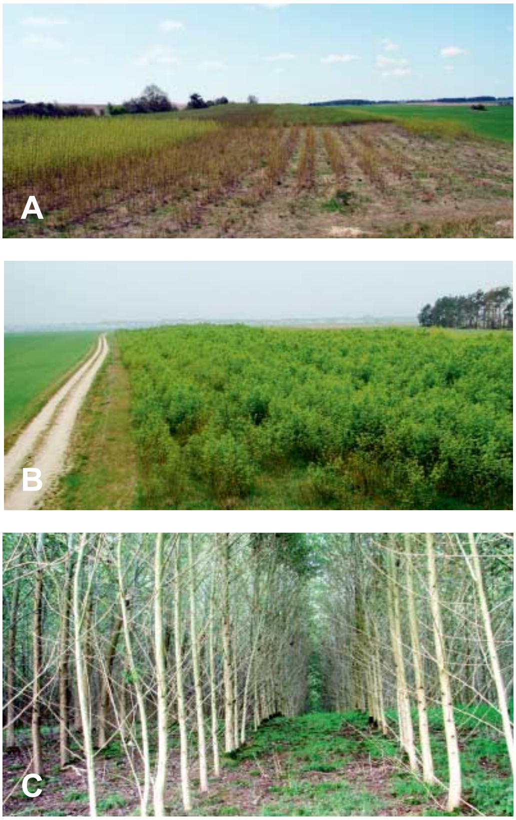

Photo 1. Some short rotation coppices studied: Jamikow, initial stage, willow (A); Cahnsdorf, shrub stage, poplar (B); Georgenhof, tree stage, poplar (C). – *Einige untersuchte Kurzumtriebsplantagen: Jamikow, Initialstadium, Weide (A); Cahnsdof, Gebüschstadium, Pappel (B); Georgenhof, Baumstadium, Pappel (C).* Phot.: H. Gruss

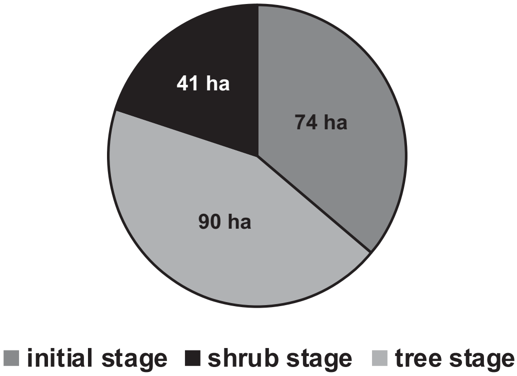

Fig. 1. Accumulated areal proportions (in ha = hectares) of the classified structure types within the studied short rotation coppices studied as reference sizes and calculation basis of breeding bird densities. – *Gesamtflächenanteile (in ha = Hektar) der drei KUP-Typen auf den untersuchten Flächen als Referenz und Grundlage für die Berechnung der Brutvogeldichten.*

breeding or breeding record. Only these two categories are equated with the status "breeding bird" in this study. Foraging or migrating birds were not considered in this study.

Single detections of breeding bird species whose appearance were due to extraordinary structures within the SRC investigated (e.g. single bushes), which do not appear regularly in the plantations, are not included in this study to avoid distortions as regards to a general evaluation of the various stages of SRC.

Data Compilation and Statistical Analyses. For the purposes of a generalized analysis breeding bird species were combined into guilds referring to their specific autecological habitat preferences (Glutz von Blotzheim et al. 2002) during the breeding season (Tab. 2):

Open land species (O in Tab. 2): This group includes species which are associated with open habitats with little vertical structure and a predominance of low grass-like and herbal vegetation

Shrub species (S in Tab. 2): This group includes species which reach their highest densities in low woody habitats, e. g. shrubs and bushes, undergrowth or in the early succession stages of (pioneer) forests.

Forest species (F in Tab. 2): This group includes species which are associated with higher woody structures. Most species are limited to tree lots or forested areas. The ubiquitous species in this group require at least a few trees within their habitat (e. g. cavity nesters) or show their highest abundance and consistencies in wooded habitats.

Tall herb /reed species (H in Tab. 2): This group includes species which are associated with open and semi-open habitats with higher vertical structuring of grass-like (including sedges and reed) and herbal vegetation but little coverage of woody elements.

Ecotone species (E in Tab. 2): This group includes species which are associated with semi-open habi-

Tab. 2. Breeding bird species within the classified types of short rotation coppices (SRC), their surrounding croplands, fallows and/or hedges including information on their vulnerability referring to the Red Lists of Germany (BRD) and those German federal states (BB = Brandenburg, HE = Hesse, SN = Saxony) which include investigation areas: ! = vulnerable, !! = endangered, !!! = critically endangered (grey shades = species recorded) and ecological classification (O = open land species, S = shrub species, F = forest species, H = tall herb/reed species, E = ecotone species). – *Brutvogelarten, die auf den drei KUP-Typen sowie auf den umliegenden Ackerflächen, Brachflächen und/oder Hecken festgestellt wurden unter Angabe der Einstufung in der bundesweiten (BRD) und/oder landesweiten Roten Liste (BB = Brandenburg, HE = Hessen, SN = Sachsen): ! = gefährdet, !! = stark gefährdet , !!! = vom Aussterben bedroht (grau schattiert = Bundesland mit Nachweis) sowie der ökologischen Einstufung (O = Offenlandarten, S = Gebüscharten, F = Waldarten, H = Arten der Röhrichte und Hochstaudenfluren, E = Ökotonarten).*

	vulnerability				**guilds**	**initial stage SRC**	**shrub stage SRC**	**tree stage SRC**	**cropland**	**fallow**	**hedge**
	BRD	BB	HE	SN							
Blackbird *Turdus merula*					S		X	X			X
Blackcap *Sylvia atricapilla*					S		X	X			X
Blue Tit *Cyanistes caeruleus*					F						X
Bullfinch *Pyrrhula pyrrhula*					S			X			
Chaffinch *Fringilla coelebs*					F		X	X			X
Chiffchaff *Phylloscopus collybita*					F		X	X			X
Common Starling *Sturnus vulgaris*					F						X
Corn Bunting *Emberiza calandra*	!		!!!	!!	E	X	X		X	X	X
Cuckoo *Cuculus canorus*					S						X
Dunnock *Prunella modularis*					S		X				X
Garden Warbler *Sylvia borin*					S		X	X			X
Golden Oriole *Oriolus oriolus*					F			X			
Goldfinch *Carduelis carduelis*					S						X
Grasshopper Warbler *Locustella naevia*					H	X	X	X		X	
Great Grey Shrike *Lanius excubitor*	!!		!!!	!!	E					X	X
Great Spotted Woodpecker *D. major*					F			X			
Great Tit *Parus major*					F			X			X
Greenfinch *Carduelis chloris*					S		X				X
Hawfinch *Coccothraustes coccothraustes*					F			X			
Icterine Warbler *Hippolais icterina*					S		X				X
Lapwing *Vanellus vanellus*	!!	!!	!!!	!!	O					X	
Lesser Whitethroat *Sylvia curruca*					S		X				X
Linnet *Carduelis cannabina*		!			S			X			X
Long-tailed Tit *Aegithalos caudatus*					S		X				X
Marsh Warbler *Acrocephalus palustris*					H	X	X	X	X	X	X
Meadow Pipit *Anthus pratensis*		!!	!!		O					X	
Mistle Thrush *Turdus viscivorus*					F			X			
Nightingale *Luscinia megarhynchos*					S		X				X
Quail *Coturnix coturnix*				!	O				X	X	
Red-Backed Shrike *Lanius collurio*					E					X	X
Reed Bunting *Emberiza schoeniclus*			!		H		X		X	X	
Reed Warbler *Acrocephalus scirpaceus*					H					X	
Robin *Erithacus rubecula*					F		X	X			X
Skylark *Alauda arvensis*	!	!			O	X	X		X	X	
Song Thrush *Turdus philomelos*					F		X	X			X
Stonechat *Saxicola torquatus*			!		H		X			X	

	vulnerability				**guilds**	**initial stage SRC**	**shrub stage SRC**	**tree stage SRC**	**cropland**	**fallow**	**hedge**
	BRD	BB	HE	SN							
Tree Pipit *Anthus trivialis*			!		E	X	X	X		X	X
Tree Sparrow *Passer montanus*					F						X
Whinchat *Saxicola rubetra*	!	!	!!!	!	H	X	X		X	X	
White Wagtail *Motacilla alba*					O	X			X	X	
Whitethroat *Sylvia communis*					E	X	X	X	X	X	X
Willow Tit *Poecile montanus*					F		X				
Willow Warbler *Phylloscopus trochilus*					S		X	X			
Wood Pigeon *Columba palumbus*					F			X			X
Woodlark *Lullula arborea*			!!!	!!	E	X	X			X	
Wren *Troglodytes troglodytes*					F		X	X			X
Yellow Wagtail *Motacilla flava*				!	O	X			X	X	
Yellowhammer *Emberiza citrinella*					E	X	X	X	X	X	X

tats. They need higher (woody) elements for nesting or song posts but use open patches with grass-like and herbal vegetation for foraging.

To calculate breeding bird densities we used the arithmetic mean. Therefore, data for the entire study period – including a summarization of areal sizes and breeding pair numbers – was incorporated. Thus, the distortive effect of very high densities in single plots was evened out by the occurrence of single breeding pairs in very small plots.

The Wainstein index was used to measure similarities and divergences between breeding bird communities with regard to the defined habitat types (Tab. 1). This index is a similarity coefficient which combines qualitative similarities based on Jaccard's coefficient and abundance values based on the Renkonen similarity index (Magurran 2004, Wainstein 1967).

Results

Qualitative and Quantitative Compositions. In SRCs and their agricultural surroundings, a total number of 48 breeding bird species were detected (Tab. 2) of which 38 species (79 %) appeared in at least one SRC stage and 10 species did not occur in any SRCs. There were significant differences in qualitative compositions and abundance between the classified stages of SRC in comparison with other predominant structures in the agricultural landscapes studied (Fig. 2).

With regard to the habitat quality, the initial stage of an SRC is similar to fallow or crop fields. During the breeding season all of these structures provide an open-habitat character with more or less low vegetation heights. Hence, there ought to be similarities in breeding bird compositions, as was substantiated by our study.

Shrub and forest species were completely absent in open-habitat types. Open land, tall herb/reed and ecotone species showed almost the same proportions in accordance with avian coenoses. However, the amounts of species and densities differed considerably (Fig. 2). The numbers of open land, tall herb/reed and ecotone species determined for the initial stage of SRCs are similar to those for the bird community of cropland. The number of open land species was slightly higher in croplands than in the initial stage of SRCs. However, the number of ecotone species increased in the initial stage of SRC in comparison with croplands. The densities of open land, tall herb/reed and ecotone species were higher in initial stage of SRCs than in croplands. When compared to these two habitat types though, fallows showed significantly higher levels of both species richness and densities. Nevertheless, cropland, fallows and the initial stage of SRC reveal a high similarity in species composition. This relatively strong faunal similarity was also supported by the Wainstein index (Fig. 3).

SRCs in the shrub stage displayed a high species richness in which, according to their struc-

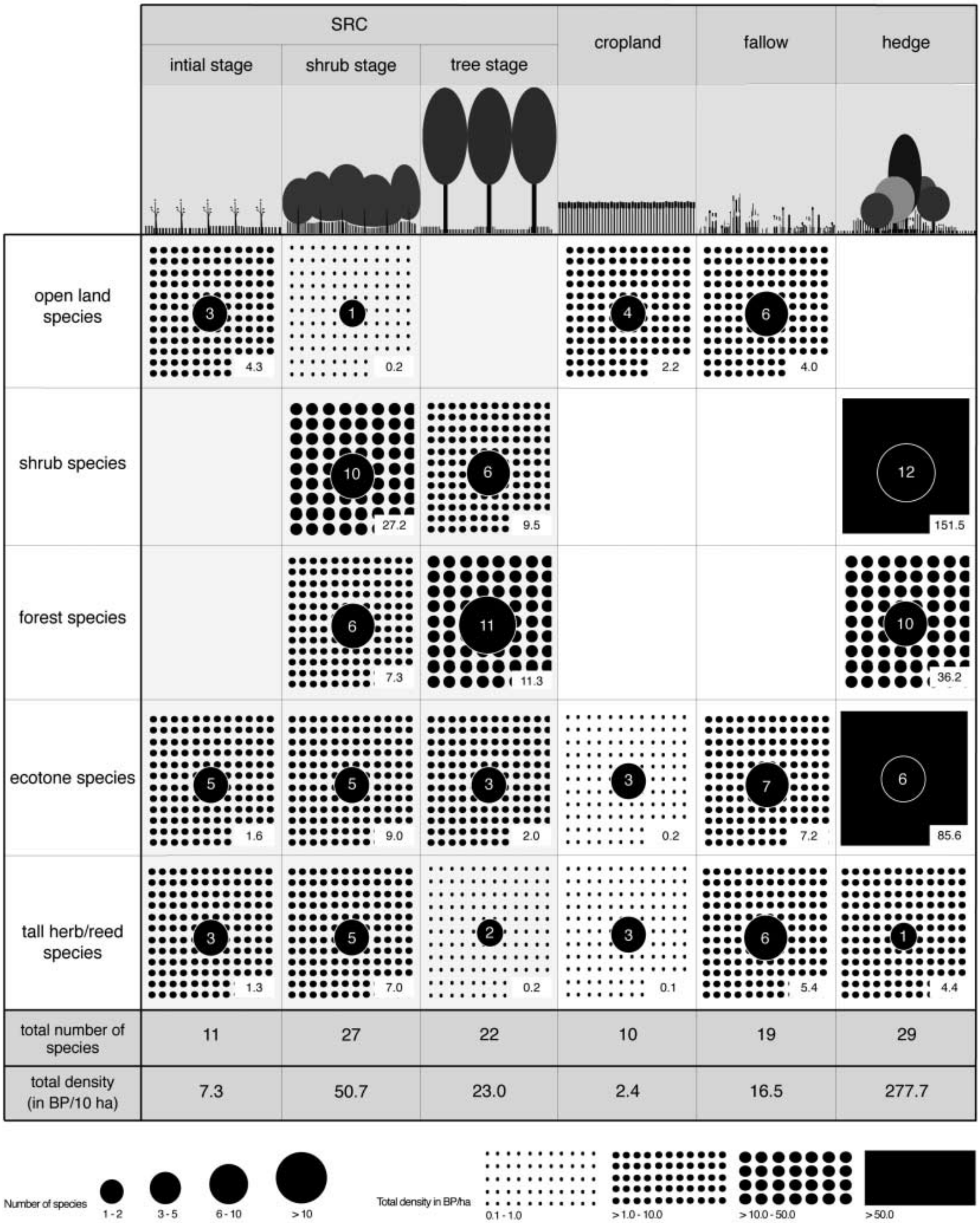

Fig. 2. Ecological guilds of breeding birds recorded within the classified types of short rotation coppices, their surrounding croplands, fallows and hedges – with information on species numbers and densities (breeding pairs/10 ha). – *Ökologische Brutvogelgilden innerhalb der drei KUP-Strukturtypen sowie der umliegenden Ackerflächen, Brachen und Hecken – mit Informationen zu Artenzahlen und Brutpaardichten (BP/10 ha).*

tural appearance, shrub species dominate the avian coenosis both qualitatively and quantitatively (Fig. 2). Furthermore elements of each avian guild were found in the shrub stage of SRC. However, the occurrence of open land and tall herb/reed species in the shrub stage was mainly limited to larger openings within the plantations, margins and very small or narrow SRC-plots with a band-like character. Compared with all main types of SRC the shrub-like stage featured the highest breeding bird densities and species richness. With regard to coenotic similarities, the shrub stage of SRC revealed the highest similarity to the avian fauna of hedges (Fig. 3). However, breeding bird numbers and abundances in hedges considerably exceeded those of the related SRC stage. This was most pronounced in the guilds of shrub nesting, ecotone and forest species.

habitat type	cropland	fallow	hedge	SRC initial stage	SRC shrub stage	SRC tree stage
cropland		17,1%		41,8%		
fallow	17,1%			34,9%	9,7%	
hedge	1,1%	4,2%			27,4%	12,8%
SRC initial stage	41,8%	34,9%	2,5%		8,1%	
SRC shrub stage	2,7%	9,7%	27,4%	8,1%		19,3%
SRC tree stage	0,5%	1,4%	12,8%	1,7%	19,3%	

(white)	**kleiner 5**
(light grey)	**größer 5 bis 10**
(grey)	**größer 10 -30**
(dark grey)	**größer 30**

Fig. 3. Similarities of breeding bird communities in classified habitat types – compared by using the Wainstein index (stating specific data and its illustration by shading scaled extents of similarity, white = < 5 %, light grey = > 5–10 %, grey = > 10–30 %, dark grey = > 30 % similarity). – *Ähnlichkeiten der Brutvogelgemeinschaften in den klassifizierten Habitattypen – Vergleich anhand Wainsteinindex (Ähnlichkeitsdarstellung mit Grauschattierungen, weiß = < 5 %, hellgrau = > 5–10 %, grau = > 10–30 %, dunkelgrau = > 30 % Ähnlichkeit).*

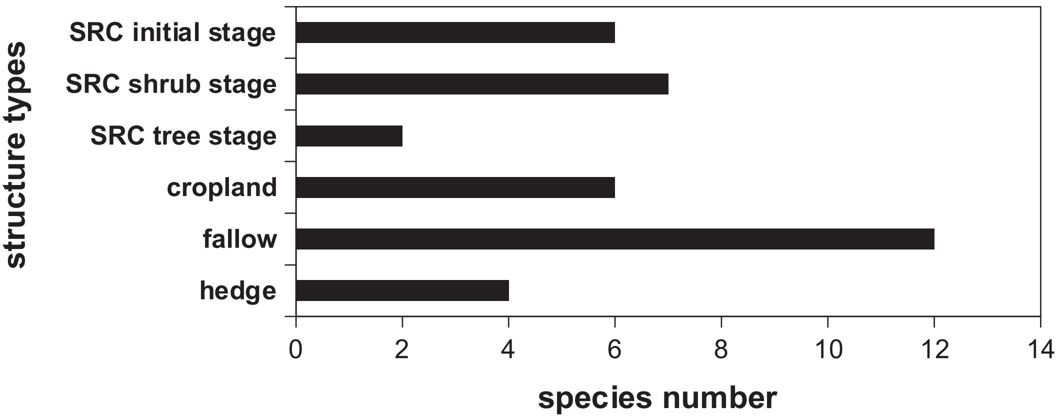

Fig. 4. Generalized numbers of vulnerable or endangered species listed in Red Lists of Germany and/or those federal states which include investigated plots (HGON & VSW 2006, Rau et al. 1999, Ryslavy & Mädlow 2008, Südbeck et al. 2007) referring to the three main types of SRC, surrounding croplands, fallows and hedges. – *Generalisierte Anzahl gefährdeter Arten auf den drei KUP-Typen Ackerland, Brachen und Hecken (Gefährdungseinstufung anhand Roter Liste gefährdeter Brutvogelarten in Deutschland und/oder den Bundesländern nach: HGON & VSW 2006, Rau et al. 1999, Ryslavy & Mädlow 2008, Südbeck et al. 2007).*

With increasing height of SRC the composition of the avian community shifted considerably. Forest species were the predominant ecological group with regard to species number and abundance in the tree stage of SRC. Open land species were completely absent and the presence of ecotone and tall herb/reed species was limited to margins and larger openings or aisles within the plantations. Shrub species were present with high consistency, but their presence was generally limited to lighter patches with undergrowth. The overall species richness and total density was significantly lower in the tree stage than in the shrub stage of SRC, but increased in comparison with the initial stages of SRC (Fig. 2).

Occurrence of Vulnerable or Endangered Species. Although endangered species occurred across all of the habitat types studied, there were qualitative and quantitative differences (Tab. 2, Fig. 4). Fallows hosted the highest number of vulnerable or endangered species, followed by the initial and shrub stage of SRC, whereas cropland and hedges were inhabited by considerably fewer endangered species. The lowest number was detected in the tree stage of SRC. However, the numerical differences between the habitat types considered – except fallows – are rather marginal. Most of the detected species are still generally widespread although their populations are in severe decline – at least in some regions (e.g. Skylark *Alauda arvensis*, Tree Pipit *Anthus trivialis* or Reed Bunting *Emberiza schoeniclus*). However, some of the vulnerable or endangered species detected (e. g. Great Grey Shrike *Lanius excubitor*) are more demanding regarding their habitat requirements. In our investigation the occurrence of such species was generally limited to species-rich fallows or small-scale habitat mosaics at least partially including high-quality biotopes such as wetlands. If demanding species inhabited SRC, those structures were mostly embedded or adjacent to valuable habitats. This applies especially to ecotone or tall herb/reed species.

Discussion

Composition of Avian Fauna and Habitat Suitability of SRC. The composition of avian fauna shifted significantly with the upcoming growth of SRC (Fig. 2). This is evidenced by several studies (Berg 2002, Dhondt & Sydenstricker 2000, Dhondt et al. 2007, Göranson 1994, Gruss & Schulz 2008, Gruss & Schulz 2011, Hanowski et al. 1997, Sage & Robertson 1996, Sage et al. 2006). The initial stage of SRC is predominated by species which prefer open habitats. The shrub stage is mainly inhabited by species which are associated with bushes, undergrowth or the early succession stages of (pioneer) forests (Fig. 2). The tree stages of SRC which exceeded the regular harvest cycles of 3 to 5 years (Reeg et al. 2009) are primarily characterized by forest species (Fig. 2).

The general habitat characteristics of the initial stage of SRC are similar to those of fallows and croplands. During the breeding season all of these structures provide an open habitat character with relatively low vegetation heights. Thus the breeding bird communities within these three habitats show a high degree of similarity (35 % and 42 %, see Fig. 3). Nevertheless, there are differences in species richness and specific densities. At present, breeding birds in croplands are exposed to the strong influence of intensive agricultural use and confronted with structural poverty (Vickery et al. 2002, Wilson et al. 2005). Due to this, habitat availability and reproductive success are generally low, which also has a negative effect on densities in the medium or long term, or may even lead to local extinction. Our results also indicated such conditions. The general breeding bird density in the croplands investigated, which were almost exclusively intensively used, was very low (2,4 BP/10 ha; Fig. 2). This fact applies to all of the species detected. Fallows or set asides offer less agricultural influence, higher structural varieties and better food sources than homogeneous croplands (Vickery et al. 2002, Wilson et al. 2005, Flade & Schwarz 2011, Flade 2012). Hence these structures were inhabited by more species and in higher abundances and included more demanding bird species, as is reflected by our results. The positive effects of reduced use intensity might be generally transferable to the initial stages of SRC (Sage & Tucker 1997). They provide higher structural richness and less negative influence than homogeneous and intensively used croplands. Therefore, avian diversity and abundance were increased in total in the initial stages of SRC in comparison with cropland, as our results confirmed. Sage et al. (2006) arrived at similar results.

However, species richness and densities in the initial stages of SRC were significantly lower than in fallows (Fig. 2). This might be due to the structural dynamics and characteristics of the

SRC itself depending on its use. During one breeding season, the fast growth of willow or poplar hybrids might cause profound changes in habitat qualities by increasing the vertical structure and coverage. As we discovered in individual cases, particularly species demanding low vegetation may leave SRCs at least for second breeding, most likely due to intolerable heights and coverage of fast growing hybrids, e.g. Skylark *Alauda arvensis* or waders such as Lapwing *Vanellus vanellus* (see also Sage et al. 2006). On the other hand, migratory species, which are associated with higher vertical structures, will not settle if the height increase of willow or poplar hybrids is not suitable at their time of (early) arrival. Therefore, the strong dynamics, primarily in the initial stages of SRCs, may have a negative effect on the habitat suitability for some breeding bird species. Furthermore, another fact should be considered in this context: a few bird species feature a high breeding philopatry and/or birth site fidelity (Glutz von Blotzheim et al. 2002). Therefore, more stable habitats such as fallows, which provide specifically suitable conditions for several years running, ought to have a higher potential of being populated than the unsteady habitats of SRC (Hanowski et al. 1997). This applies particularly to species with very low regional population densities. Furthermore, SRCs generally provide less floristic and invertebrate richness (e.g. butterflies in Brauner et al. 2011) than fallows even in the initial stages. This might diminish the attractiveness of SRCs, especially for demanding bird species. This assumption is substantiated by the detection of more specialized insectivores such as Shrikes *Lanius sp.*, which were only found in or adjacent to fallows, but not in the nearby early stages of SRCs. There were no significant differences in avian fauna between initial stages of willow and poplar SRCs (Gruss & Schulz 2011). As the initial stage turned into the shrub stage of SRCs, the number and density of open land species decreased. This development was confirmed in several other studies (Göranson 1990, Göranson 1994, Gruss & Schulz 2011, Sage et al. 2006) while Dhondt et al. (2007) noticed no qualitative descent.

Of all classified stages of SRC, the shrub stage showed the highest diversity, species richness and total density of breeding birds (Fig. 2). Species richness and abundance is significantly higher in SRCs planted with willow than in poplar plantations in the shrub stage (Gruss & Schulz 2011, Sage & Robertson 1996). However, its values were significantly exceeded by those of hedges (Fig. 2). This fact should be considered by regarding SRC as a beneficial structural enrichment in agricultural landscapes. Hedges, in comparison to SRC plantations, provide a higher structural diversity which promotes avian richness (Hanowski et al. 1997). Furthermore, due to the economic aim of maintaining high yields, SRCs develop into dense, homogeneous plantations. It is assumed that species richness and primarily specific densities will decrease or even disappear in the shrub-like stages of large-scale, homogeneous SRCs. This applies particularly to openland, ecotone and tall herb/reed species, whose occurrence was mainly limited to plantation margins (Berg 2002, Gruss & Schulz 2008, Gruss & Schulz 2011, Sage et al. 2006), but also to most other breeding bird species detected in SRC up to now. Several studies confirmed the decrease of avian density in plantation interiors (Christian et al. 1998, Cunningham et al. 2004, Gruss & Schulz 2008, Gruss & Schulz 2011, Sage et al. 2006).

When the tree stage of SRC was reached, species richness and abundance declined (Fig. 2) – at least in poplar SRCs (Gruss & Schulz 2008, Gruss & Schulz 2011). By contrast, in willow SRCs Dhondt et al. (2007) discovered "… a nearly linear increase as the vegetation matured". It is possible that the differences detected in avian diversity between willow and poplar SRC in the shrub phase (Gruss & Schulz 2011, Sage et al. 2006) apply to older plantations as well. At least under natural conditions, central European alluvial forests with willows as predominant tree species are inhabited by a rich avian fauna (Flade 1994). However, due to future short coppice rotations, a regular appearance of SRCs in the tree stage is not assumed to occur in conventionally exploited SRCs.

In general breeding bird communities in SRCs are "derivatives" of the local avian coenoses. Like Christian et al. (1998), we did not detect any bird species at any individual SRC study site which did not occur elsewhere in the surrounding landscape. Basically, breeding bird communities in SRC consisted of widespread, ubiquitous species. Only these species appeared with high consistencies and predominated the avian coenoses in the SRC plots studied (Gruss & Schulz 2008, Gruss & Schulz 2011). More demanding species only occurred in SRCs if they featured a high local population density and corresponding high population pressure.

SRCs did not "attract species unique to the local or regional diversity" as was also confirmed by Hanowski et al. (1997). Thus, SRCs offer at least average habitat suitability for breeding birds, but do not feature any specific habitat qualities.

Influence of adjacent habitats. Berg (2002) confirmed a high dependence of adjacent habitats on breeding bird compositions. In our study we discovered such effects in species which are associated with open and semi-open habitats (open land, tall herb/reed and particularly ecotone species). Many of the plots studied were relatively small and often had a band-like character. Furthermore, these plots are mostly adjacent to open habitat types such as cropland, fallows, reeds or ruderal patches. Thus, there are probably effects of the mutual influence of spatial closeness. Ecotone species benefited particularly from such constellations. As was observed, ecotone species such as the Corn Bunting *Emberiza calandra* and Yellowhammer *Emberiza citrinella,* but also tall herb species such as Stonechat *Saxicola torquatus* and Whinchat *Saxicola rubetra* or open land species such as Skylark *Alauda arvensis* or Yellow Wagtail *Motacilla flava* had their nesting sites within the initial stages or in the margins of the shrub stage of SRCs, but foraged in adjacent habitats. It can be assumed that the occurrence of such species is strongly dependent either on small-scale plantations in the shrub stage within an open landscape or a sufficient dimension of an initial-stage SRC due to their association with open habitats with relatively less vertical structure. Some other ecotone species, such as the Tree Pipit *Anthus trivialis* or Whitethroat *Sylvia communis,* benefited in our study from small-scale openings such as broad aisles within older SRC types (Gruss & Schulz 2011).

Considering species-specific habitat requirements and average territory sizes, we assume there to be a high independence of shrub and forest species from adjacent habitats of SRCs. The majority of shrub and forest species detected have specifically small territory sizes and inhabit naturally dense habitat structures as well. As our results showed, there were no significant differences in shrub or forest species composition and densities between SRC plots surrounded by high vertical structures such as woodland or the tree stage of SRC or small, narrow SRC plots embedded in open land. Only breeding bird species such as the Golden Oriole *Oriolus oriolus* or Great Spotted Woodpecker *Dendrocopos major* with larger specific territory sizes used adjacent patches of woodland for foraging but bred inside the SRC. Similarly, we found no clear beneficial effect on shrub or forest species in hedges adjacent to SRC. Avian richness and abundances are generally higher in hedges adjacent to the initial stages of SRCs due to the occurrence of more ecotone species for example. However, the same effects are apparent in hedges adjacent to other open habitats such as croplands. By contrast, hedges embedded in dense shrub or the tree stages of SRCs attracted fewer species due to the lack of avian elements such as ecotone species. We did not find a generally higher abundance of breeding birds in hedgerows adjacent to SRC as confirmed by Sage et al. (2006).

Conservational value of SRC. In general, breeding bird communities of SRC consist of widespread, ubiquitous species (Christian et al. 1998, Gruss & Schulz 2008, Gruss & Schulz 2011, Jedicke 1995). Basically, demanding vulnerable or endangered species (Tab. 2) only occurred in SRCs if they had a relatively stable local or regional population size. Consequently, the majority of endangered species with more specific habitat requirements were not endangered in the specific federal state or region of Germany where such species were detected. Furthermore, such species never occurred exclusively in SRC, but more breeding pairs settled in the surroundings in equal or higher densities. The occurrence of endangered species in SRCs was predominantly limited to the initial stage of SRCs, margins of larger plantations or small-scale SRC plots. Considering the ecological preferences of endangered breeding bird species detected in this study (see Tab. 1), this reveals that almost all species are associated with open habitats. This corresponds with the profound decline of such species due to the current intensification and homogenization of agricultural landscapes (Donald et al. 2001, Donald et al. 2006). Hence, the design and use of SRC should benefit such species or at least prevent further decline as a result of its establishment. To maintain adequate habitat qualities for demanding, vulnerable species, this must be given greater weight than the monocausal focus on maintaining avian richness. As our results and those of others confirmed (Berg 2002, Christian et al. 1998, Dhondt et al. 2007, Göranson 1990, Hanowski et al. 1997, Jedicke 1995, Sage et al. 2006), the establishment and successional alternation of SRC increases species richness and densities in comparison with croplands. However, this enrichment applies mainly to widespread habitat generalists of low conservational value. Thus, both the increase of avian richness in general and the support of demanding vulnerable species should be aimed for.

The occurrence of (vulnerable or endangered) open land species in SRCs is limited almost exclusively to the early stages of SRCs. Thus, (rare) openland species in particular might be affected negatively by SRCs due to their characteristics. Even in the first year after cutting, habitat qualities may decrease rapidly, which might lead to emigration. The shrub phase of SRC, which is the longest phase within the growth cycle, causes at least temporary habitat loss or even permanent absence. Therefore, a sufficient amount of usable habitat structures should be provided in a certain area. Furthermore, the establishment and management of SRCs should provide the highest heterogeneity to support general avian richness and (vulnerable) ecotone species in particular (Göranson 1994, Gruss & Schulz 2011, Hanowski et al. 1997, Jedicke 1995, Schulz et al. 2008, Schulz et al. 2009). Fallows or set asides are inhabited by a rich breeding bird community including several vulnerable species as our study confirmed. Therefore, they should not be completely replaced by SRC in terms of areal competition.

Conclusions and Recommendations. Due to rotation cycles and the planting of fast-growing poplar and willow hybrids in monocultures, SRCs offer rapidly changing habitat qualities for breeding birds. The rates of succession are significantly faster and more homogeneous than in natural or semi-natural habitats. Even permanently used croplands may provide more continuous habitat availability than SRCs. Due to this instability of habitat structures within a growth cycle, there are high turnover rates in the composition of breeding bird communities (Hanowski et al. 1997). In particular, the conversion from the open initial stage into shrub-like stands means profound changes in species composition and specific densities. As the age and heights increase, the avian composition shifts from open land species to shrub or forest species. Highest species richness and total densities within SRCs were found in the shrub stage. However, the breeding bird communities detected within SRC contained predominantly widespread generalists. This applies mainly to the dense, homogeneous interiors of larger blocks in the advanced stages, since the occurrence of more demanding, even vulnerable species was limited to the plantation margins or the initial stages of SRCs. For reasons of conservation value and structural enrichment, SRCs are not an adequate alternative to other typical elements of agricultural landscapes such as fallows and hedges. Species richness and specific densities were significantly lower in SRCs than in fallows or hedges, but higher than in surrounding croplands. Hence, SRCs only provide a significant structural improvement for breeding birds in uniform, poorly structured agricultural landscapes. The preservation of a sufficient amount of open structures (e.g. fallows or grasslands) which function as population sources, particularly for open land species, may diminish the negative effects of SRC establishment due to the reduced habitat availability during the shrub phase of SRCs.

These conclusions lead to the following recommendations being made regarding the establishment and management of SRCs to support avian richness and minimize the negative effects on breeding bird species – considering Berg (2002), Blei et al. (2011), Göranson (1994), Gruss & Schulz (2011), Hanowski et al. (1997), Jedicke (1995), Sage et al. (2006) and Schulz et al. (2009):

- No replacement of open high-quality habitats such as wetlands, wet meadows, sedge- or reedbeds, set asides, dry fallows and semi-natural grassland with SRCs
- Avoidance of planting SRCs within wooded areas (e. g. openings)
- Asynchronous harvest cycles to increase local heterogeneity and to provide a large amount of ecotones
- Short harvest cycles to increase the availability of open habitats (initial stage) in terms of areal and temporal presence
- Alley-cropping
- Preference of willow *Salix spec.* as opposed to poplar *Populus spec.*
- Large variety of willow hybrids with a wide range of flowering times within plantations
- Minimal or non-existent use of pesticides

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