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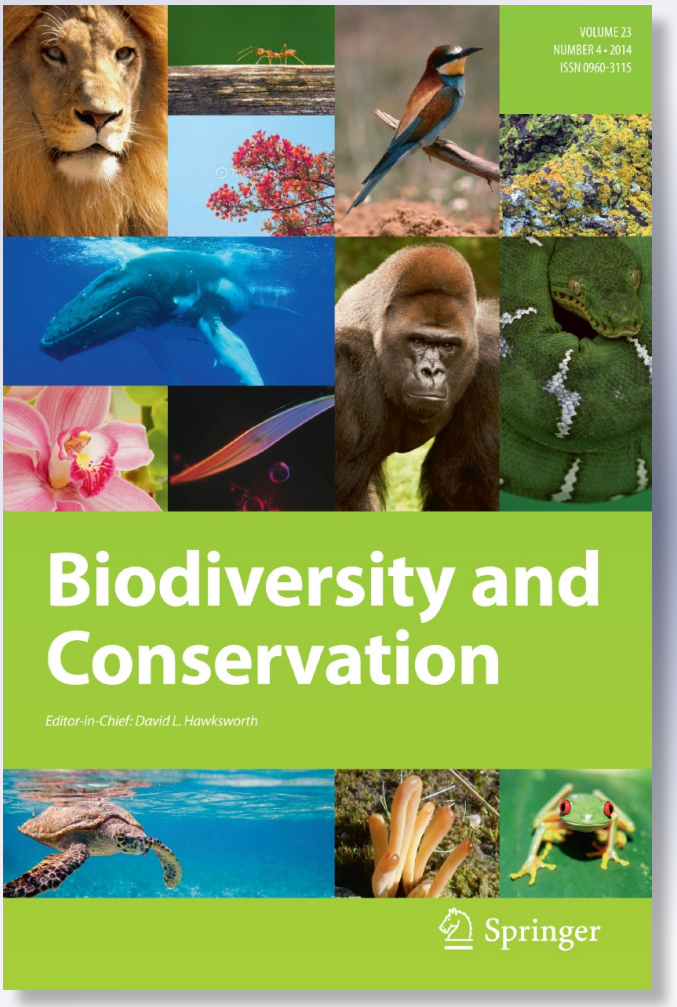

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ORIGINAL PAPER

Applying red lists to the evaluation of agricultural habitat: regular occurrence of threatened birds, vascular plants, and bryophytes in field margins of Poland

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Abstract Using the assessments of conservation status of flora and fauna, we discuss declining species in semi-natural field margins and stress the importance of these vanishing habitats. Seventy field margins in the diverse farmland of SW Poland were investigated with regard to their vascular plants, bryophytes and breeding birds. We checked the occurrence of threatened and conservation concern species, i.e. those listed in local, national or European threatened species lists, and birds with an unfavorable conservation status in Europe. Of a total of 673 species, 18 classified as threatened were recorded: 12 vascular plants (2.2 % of the total number of species), five bryophytes (5.6 %), and one bird species (2.0 %). Threatened plants occurred in 18.6 % of study plots, bryophytes in 20.0 % and birds in 12.9 %. Eleven bird species, noted in 95.7 % of study plots, had an

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unfavorable conservation status in Europe. Increasing volumes of trees and shrubs significantly increased the overall richness in each taxa. In percentage terms the occurrence of focal species in all three taxa tended to be higher in shrubby than in herbaceous and tree-lined margins. Our data demonstrate that field margins in Central European arable farmland regularly support rare and threatened species, and therefore deserve greater conservation efforts. Red lists along with alternative listing approaches can be employed to evaluate the biodiversity of fine-scale habitats, but their applicability depends on the taxonomic group and geographical scale of the lists, reflecting different conservation priorities.

Keywords Threatened species · Farmland biodiversity · Conservation priority setting · Birds of conservation concern · IUCN · Central Europe

Introduction

The presence of rare and threatened species is a measure of habitat quality and an indicator when setting conservation priorities. Sites with conditions supporting a range of such species receive more attention than sites dominated by common species (Brooks 2010). Red lists of threatened animals and plants are important tools in such evaluations. As defined by the International Union for Conservation of Nature and Natural Resources (IUCN), red lists are the most comprehensive resource detailing the global conservation status of different taxa. Developed primarily to assess the extinction risk to species, red lists are now being applied far beyond this initial goal: in conservation planning, policy and management, prioritizing sites for conservation, biodiversity evaluation, and monitoring (Rodrigues et al. 2006; Hoffmann et al. 2008). As a conservation tool, red list data are recommended to be used at various scales, including site level evaluations and national resource management and legislation (Rodríguez 2008; IUCN 2011). At the local level, the presence of species recognized as threatened by an authoritative system can be accurate pointers for prioritizing key habitats and their conservation (Niemelä and Baur 1998; Meynell 2005; Batáry et al. 2007). Multi-taxa evaluations are particularly desirable, since habitat characteristics and management prescriptions based on one taxonomic group may be insufficient (Larsen et al. 2007).

Agricultural intensification is one of the main drivers of worldwide biodiversity decline (Kleijn et al. 2006); an increasing number of threatened species are therefore linked to farmland. Although in the past the number of anthropogenic biotopes and of seminatural plant associations arose, and the diversity of the flora and fauna increased (Fukarek 1979; Meyer 2013), recently the strong, negative influences of agricultural activities on species are apparent across regions and taxa, while habitat loss due to agriculture is the most prevalent threat (Lenzen et al. 2009; Collen et al. 2012). These processes are less severe in regions with low-intensity farming systems; conservation initiatives implemented in low-intensity farmlands are therefore particularly desirable, successful and cost-effective (Kleijn et al. 2009). At a local scale, non-arable semi-natural lands are recognized biodiversity hotspots, standing in dramatic contrast with species-poor, homogenous "crop-seas". They may also be local centers of endangered species, but this aspect has been little studied (Zechmeister and Moser 2001; Diekötter et al. 2006). In many regions, field margins are the most common form of semi-natural habitat, having many agronomic,

environmental, recreational and wildlife functions (reviewed by Marshall et al. (2002)). For example, margins increase species richness, functional group diversity and the abundance of many taxa by providing seed banks, breeding and sheltering sites and food resources, practically unavailable in the adjoining cropland. On a landscape level margins provide linkages between habitats, maintain landscape diversity, harbor organisms of economic interest for farmers, such as pollinators and predators of pests, and have positive aesthetic effects (Jacot et al. 2006; Herzon and O'Hara 2007; Vickery et al. 2009; Morelli 2013).

However, boundary structures are also subject to strong agricultural pressure, and support mostly disturbance-tolerant generalist species (Liira et al. 2008). The occurrence of species of conservation interest in field margins is poorly understood. Specifically, no studies examining the numbers and distribution of threatened taxa in field margins have to our knowledge been conducted in central and eastern Europe. This is a notable gap, since this part of Europe, including Poland, is a large continental center where traditional landscape structures have survived (Palang et al. 2006; Batáry et al. 2007; Herzon and Helenius 2008; Sklenicka et al. 2009). With its large area (312,679 km^2) and with regions of extensively managed farmland, Poland plays an important role in the preservation of European biodiversity. Butler et al. (2010) assessed that land-use and -management changes in Poland have had the second-largest (after Spain) impact on European farmland bird populations among all EU Member States. The high degree of biological diversity, due primarily to the surviving variety of linear features (Sanderson et al. 2009; Kędziora et al. 2012), has facilitated studies of occurrence patterns of threatened taxa and recommendations for wider conservation practice.

A variety of environmental factors are likely to affect the occurrence of threatened species in field margins, the structure of tall vegetation being particularly important. Trees and shrubs play a decisive part in shaping overall biodiversity and the communities of particular taxa (Hinsley and Bellamy 2000; Pausas and Austin 2001; Zechmeister et al. 2002; Pykälä et al. 2005); evidence-based information regarding threatened species is rare, however (Banach 2008). Earlier data gathered in the field margins discussed in this paper indicated that the volume of tall vegetation was the most important predictor of bird abundance, bryophyte and plant diversity (Dajdok and Wuczyński 2008; Wierzcholska et al. 2008; Wuczyński et al. 2011); the response of rare species to this factor can therefore also be anticipated. The focus on tall vegetation is also important for practical reasons. Unlike constant features of the terrain like soil content, slope, roads or ditches, trees and shrubs are relatively easy to control. Farmers can therefore be asked to incorporate conservation measures relating to trees and shrubs in field margins and in other habitats supporting wildlife in agricultural landscapes (Tryjanowski et al. 2014).

Our overall objective was to assess the occurrence of threatened vascular plants, bryophytes, and breeding birds in field margins, providing further arguments for their conservation. Because of their acknowledged importance, we use the official classifications, lists of threatened and conservation concern species. Focus on priority species may motivate decision makers to engage in environmentally friendly behavior (Sinclair et al. 2003), and do so more readily than the justified though 'fuzzy' idea of ecosystem conservation, or total species numbers. The general public and conservation bodies grasp simple messages conveyed by rare and charismatic species and in practice often end up directing conservation actions targeted at species as tangible components of ecosystems (Mace et al. 2007). Outputs regarding farmland conservation practice are also desirable in view of the impending current reform of the European Union's Common Agricultural Policy (CAP) (ec.europa.eu/agriculture/cap-post-2013). A reduction of funding for agri-

environmental measures has been announced, which is the primary policy instrument for biodiversity conservation on farmland; payments are to be transferred from agri-environmental measures to direct support for farmers. Several adjustments are then expected at both European and national levels, and sound, regionally appropriate evidence on environmental resources is sought. We have formulated three research questions: (i) What role do field margins play as refuges of threatened and conservation-concern species? (ii) Which (if any) of the three types of field margins, distinguished according to their vegetation structure, is particularly valuable for the presence of these species? (iii) What is the applicability of red lists compiled at various spatial scales to the evaluation of fine-scale habitats? Finally, we discuss the possible implementation of our findings in the context of CAP reform.

Methods

Study area

Field data were collected in the patchy agricultural landscape of SW Poland, which is covered by a mosaic of small fields (0.1 ha up to several hectares) and a network of semi-natural habitats, matching the High Nature Value Farmland Type 2 (Paracchini et al. 2007). Agricultural land constitutes 48.7 % of the area and resembles other arable farmlands in Central Europe in terms of land use and indicators of agricultural production. For example, nitrogen inputs amounted to 96.0 kg N/ha, cereal yields 32.3 dt/ha, average utilized agricultural area per holding 8.4 ha (Dolnośląskie Province, 2006–2007, Central Statistical Office, http://www.stat.gov.pl). Respective figures in Central Europe were 100.0 kg N/ha, 34.5 dt/ha, and 21.4 ha (13.8 ha excluding the extreme value of 89.3 ha in Czech Republic) (means of ten EU countries, Estonia south to Bulgaria, 2006–2007, http://epp.eurostat.ec.europa.eu). Linear semi-natural habitats covered 6.9 % of the landscape, whereas crop fields dominated (79.1 %), followed by abandoned fields (8.6 %), meadows (4.4 %), copses (0.8 %) and other features (0.2 %) (measurements in six 50 ha plots situated within the study area, 2004).

On a total area of c. 400 km^2 we selected 70 study plots (Fig. 1)—500 m long sections of field margins sensu Marshall et al. (2002), i.e. the areas between adjacent fields, covered by spontaneous semi-natural vegetation and usually including a functional component (ditch, road). The plots reflected the most common type of field margins in agricultural landscapes in Poland and Central Europe: created by man for practical reasons (drainage, transportation, etc.) but later subject to natural succession. A survey of pre-1940 geodetic maps indicates that many field margins have existed at the same location for several decades, and some probably for several 100 years.

The margins were covered with lush vegetation with dominant perennial, native species in the herbaceous layer, and diverse, only deciduous species in the shrub and tree layers. The sections ranged in width from 4.9 to 29.0 m (av. 11.7 m; SD 5.1). They were not contiguous, except for two sections which adjoined perpendicularly. The average minimum distance between the midpoints of two neighboring sections was 774 m (range 155–4,177 m; SD 780, $N = 46$ margin pairs). For a more detailed description of the margin structure, vegetation and field methods, see Dajdok and Wuczyński (2008), Wierzcholska et al. (2008), and Wuczyński et al. (2011).

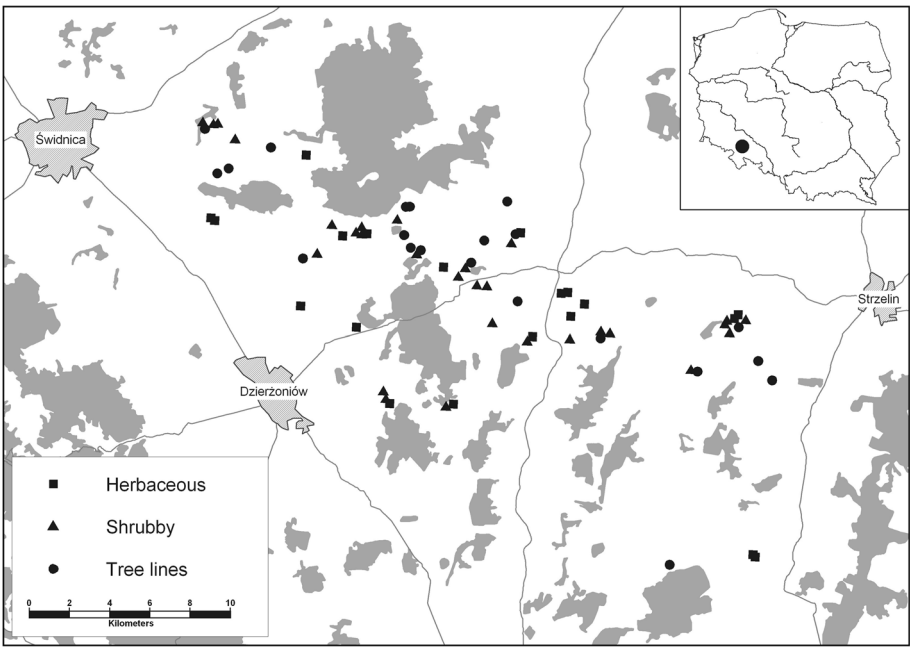

Fig. 1 Distribution of 70 field margins divided into three categories according to the volume of tall vegetation. Main forests, cities and roads are also shown. The *insert* shows the location of the study area on a map of Poland

Sampling

For the purpose of this evaluation, we chose three indicator taxa differing in biological attributes, well represented in field margins, and for which red lists have been compiled at various spatial scales. We aimed to assess the communities of these taxa i.e. the total number of species inhabiting field margins. Field procedures were fitted accordingly.

Birds

Field observations and analyses followed the rules of the simplified territory mapping method (Sutherland 2006). At the height of the breeding season in 2006 and 2007, three morning counts were conducted in each margin. We walked the whole 500 m section once, and marked the position of the birds encountered on a map (scale 1:2,000) using standard codes. Care was taken to record simultaneous territorial behavior and any other indications of breeding: found nests, social behaviours, birds carrying food, nesting materials, etc. The total time spent censusing (20–60 min) was roughly proportional to the vegetation density. After each season, all the records were transferred onto maps of individual species. On the basis of clusters of sightings, we designated breeding territories of individual pairs. For each plot, we calculated the total number of species in both seasons, and the mean number of breeding pairs of all species except Cuckoo *Cuculus canorus* because of its unusual breeding system.

Vascular plants

Two methods were used to list the plant species on each study plot in one of the growing seasons 2004–2007. First, on each 500 m section, three transverse transects were laid out at 100, 250, and 400 m. Ten m wide, each transect encompassed the whole width of the margin, perpendicular to its axis (so the transect length was equal to the width of the margin). Here, a detailed phytosociological description of the plant communities was made, which allowed us to identify the full species composition. Second, plant species growing beyond the transects were recorded during the thrice-yearly walks along the whole section in spring (April–May), summer (July–August) and fall (September–October) to draw up lists of species for the whole growing season. The lists of species obtained by the two methods were then combined to obtain the full species richness in each plot.

Bryophytes

The bryological survey took place during fall 2007. Specific floristic-ecological data were collected along the whole length of each 500 m section. Spontaneously growing bryophytes were searched for on different substrates: bare soil, the bark of snags and growing trees and shrubs, rotten wood, stones, anthropogenic substrates (rails, bridges, concrete, items of trash). The bryophyte species list was then compiled, with additional ecological data ascribed to each species.

Vegetation structure

The occurrence of threatened species was analyzed jointly for all 70 margins, and separately for the three types distinguished on the basis of tall vegetation volume (V). To calculate this, we used the formula: Volume (m^3) = Length (m) × Width (m) × Height (m), where Length is the sum of stretches with trees and shrubs along the whole 500 m section, whereas Width and Height are the mean measurements of the canopy outlines, measured at 5 points in each section: at 50, 150, 250, 350, and 450 m. Length was measured by step counting, Width with a tape, and Height with a scaled stick (lower shrubs) or a SUNTO PM5/1520 Height Meter. The following margin types were distinguished (Wuczyński et al. 2011):

(a) herbaceous (V mean = 1,596 m^3 ± 1,509 SD, range 0–5 × 10^3 m^3, $N = 21$), devoid of trees and shrubs, or with sparse, low shrubs;
(b) shrubby (V mean = 9,537 m^3 ± 4,143 SD, range 5–20 × 10^3 m^3, $N = 29$), low natural hedgerows, with infrequent trees,
(c) tree lines (V mean = 53,694 m^3 ± 31,420 SD, range 20–128,600 × 10^3 m^3, $N = 20$) with tall vegetation, usually (17/20) along watercourses, with many old trees and thickets.

Selection of focal species

From the lists of species found, we selected those in any category in published assessments of endangerment. We focused on species considered to be "threatened", as defined by either the recent IUCN criteria (IUCN 2001) (CR—critically endangered, EN—endangered, and VU—vulnerable), or the "old" criteria, applied in The IUCN Plant Red Data Book (IUCN 1978) (E—endangered, V—vulnerable, and R—rare). These old categories

were considered because they were used in red lists of bryophytes and national red list of plants (Table 1). We also give a list of species with lower threat categories: NT—near threatened and LC—least concern, (hereafter "lower threat"), and species of inadequate information (DD—data deficient), but these species were not used in any of the analyses.

For birds we also considered the assessment of the conservation status of European species (BirdLife International 2004). This authoritative source of information identifies Species of European Conservation Concern (SPECs) according to their global and European status and population trends, and incorporates the IUCN Red List Criteria. In the field margins we identified species belonging to two categories: SPEC 2 and SPEC 3; no species of global conservation concern (SPEC 1) were found. These are species which have an unfavorable conservation status in Europe, and whose global populations are concentrated (SPEC 2) or not concentrated (SPEC 3) in Europe. As the system provides a pan-European inventory, it also enables comparison of the percentages of species of conservation concern in field margins, in Poland and in Europe.

Hereafter, both groups, i.e. threatened species according to red list criteria, and birds of conservation concern, are jointly referred to as threatened and conservation concern species (TCCS).

Scale-dependent red listing data

Our aim was to identify species listed in red lists compiled at three spatial scales: local (provincial), national (Polish), and European; but the relevant red lists appeared to be very incomplete (Table 1). A local assessment was available only for vascular plants (Kącki et al. 2003) in Lower Silesia (19,948 km^2), i.e. the south-westernmost part of Poland, where our survey was conducted. Lists of nationally threatened species were compiled for each taxon studied, i.e. vascular plants (Zarzycki and Szeląg 2006), birds (Głowaciński 2002), and bryophytes divided into separate lists of threatened mosses (Żarnowiec et al. 2004), liverworts and hornworts (Klama 2006). All these assessments used the IUCN categories and criteria; however, because insufficient data were available on population sizes of particular taxa and no permanent monitoring was undertaken once the lists had been compiled, the classifications were based on expert estimates of particular organisms.

At the European scale, a complete assessment is available only for bryophytes (Schumacker and Martiny 1995). The threat status of European vascular plants was recently assessed (Bilz et al. 2011), but this compilation includes only 1,826 species (around 8 % of Europe's plant species). These are divided into three functional groups: plants listed in European and international policy instruments (PI), crop wild relatives (CWR), and European aquatic plants (AP). Although there is no comprehensive red list of European birds, all species meeting the IUCN Red List Criteria for the "critically endangered", "endangered", "vulnerable" or "near threatened" categories at a European level were identified by BirdLife International (2004).

Data analysis

We used selected spatial scales (local, national and European) to compare the occurrence of TCCS in three types of field margins on the one hand, and the percentages of TCCS in Europe, in Poland and in field margins on the other. We used the local red list for vascular plants, the national red list for bryophytes, and the assessment of conservation status at the European level for birds. Such an approach resulted in the highest number of species in

Table 1 Number of species recorded in field margins and listed in higher (Threatened) or lower extinction risk category, according to local (Lower Silesia region), national (Polish) and European red lists

Scale of the red list	Vascular plants			Bryophytes			Birds		
	Categories	Threatened	Lower threat	Categories	Threatened	Lower threat	Categories	Threatened	Lower threat
Local red list	new[a]	9	10						
National red list	old[b]	5	0	old	5	0	new	0	0
European red list	new	0	78	old	0	0	new	1	10

[a] Recorded species classified in one of the following threat categories defined by IUCN (2001): Threatened: *CR* critically endangered, *EN* endangered, and *VU* vulnerable; Lower threat: *NT* near threatened, *LC* least concern

[b] Recorded species classified in one of the following threat categories defined by IUCN (1978): Threatened: *E* endangered, *V* vulnerable, and *R* rare

each taxonomic group and lent itself to statistical evaluation. Since most variables had many zero values and skewed distributions, they were analyzed by using non-parametric tests. The Chi square test of independence was used to compare the percentages of TCCS in Europe, in Poland, and in field margins. The Kruskal–Wallis analysis of variance was used to compare the occurrence of TCCS in the three types of field margins. The parameters were the number of TCCS and breeding pairs in birds of conservation concern, and the mean percentage of TCCS (or breeding pairs) per margin, weighted by plot numbers. The number of species and breeding pairs in relation to the volume of tall vegetation was tested using rank correlation (Kendall's Tau). The statistical analyses were performed in the Statistica 9.0 package.

Results

We found 673 species in 70 field margins: 50 breeding birds, 533 vascular plants, and 90 bryophytes. Eighty of the bryophytes were mosses, 9 were liverworts, and 1 was a hornwort. There were 1,163 pairs of breeding birds, with a mean density of 33.2 pairs per 1 km^2 (95 % CI 29.7–36.8).

Threatened and conservation concern species in field margins

Threatened species

Eighteen species were listed as threatened on either local, national or European red lists, including 12 vascular plants (2.2 % of the total community), 5 bryophytes (5.6 %), and 1 bird (2.0 %) (Online Resource 1). Species placed in the two lower threat categories (V/EN or R/VU) accounted for 84 % of species (three taxa combined). The numbers of threatened species were related to the spatial scale of the red list. For vascular plants and bryophytes we found a higher number of species classified as threatened at the local and national level than at the European level (Table 1). None of the bird species met the criteria of the national red list, but one species from the European list—Grey Partridge (*Perdix perdix*)—was recorded. The indices of abundance of the threatened species were generally low (Table 2), but indicated a regular occurrence of these species in field margins. Vascular plant and bryophyte populations in the field margins contained significantly lower percentages of threatened species than flora of vascular plants and bryophytes in Europe and Poland (Table 3). With regard to threatened birds the difference was marginally significant.

Species of lower extinction risk

The group of species placed into lower threat categories contained ten bird species assessed as declining or depleted (equivalent of near threatened category) at the European level, and 86 vascular plants. The plant species were classified as being of least concern or near threatened in the local red list (10), and of least concern in the European red list, including 40 CWR, 38 aquatic species, and 2 species listed in PI (with several joint species, Online Resource 1). We did not record any bryophytes assigned to the lower threat categories. One bird species (the turtle dove *Streptopelia turtur*) was assessed as being of data deficient at the national level.

Table 2 Statistics on the TCCS species recorded in field margins, and listed in the assessments that gave the highest number of species in each taxonomic group, i.e. local red list of plants, national red list of bryophytes, list of birds threatened in Europe, and birds of unfavorable conservation status in Europe (SPECs)

Parameter	Vascular plants (threatened in Lower Silesia)	Bryophytes (threatened in Poland)	Birds (threatened in Europe)	Birds (SPECs)
No. of species (%)	9 (1.7)	5 (5.6)	1 (2.0)	11 (22.0)
No. of margins with species (%)	13 (18.6)	14 (20.0)	9 (12.9)	67 (95.7)
Mean no. of species per margin (range)	0.23 (0–2)	0.24 (0–2)	0.13 (0–1)	2.26 (0–5)
Mean percentage of species per margin (range)	0.21 (0–1.72)	1.01 (0–9.52)	1.23 (0–14.3)	18.94 (0–57.1)
Mean percentage of breeding pairs per margin (range)	–	–	0.36 (0–5.56)	14.59 (0.0–59.3)

Table 3 Percentages (and totals) of threatened and conservation concern species occurring in Europe, in Poland, and in the studied field margins

Taxonomic group	Europe	Poland	Study plots	Chi square test
Vascular plants	PI[a]—44.9 (400) CWR—11.5 (66) AP—6.6 (26)	19.9 (504)	1.7 (9)[b]	$\chi^2 = 104.02$; df = 1; $p < 0.001$
Bryophytes	24.1 (406)	34.4 (323)	5.6 (5)[c]	$\chi^2 = 141.60$; df = 2; $p < 0.001$
Birds (red listed)	12.8 (67)	11.1 (44)	2.0 (1)[d]	$\chi^2 = 5.31$; df = 2; $p = 0.070$
Birds (SPECs)[e]	43.1 (226)	38.0 (89)	22.0 (11)	$\chi^2 = 9.20$; df = 2; $p = 0.010$

[a] The functional groups of plants: *PI* plants listed in policy instruments, *CWR* crop wild relatives, *AP* aquatic plants

[b] Based on local red list of vascular plants

[c] Based on national red list of bryophytes

[d] Based on list of birds threatened in Europe

[e] *SPEC* species of European conservation concern

Birds of conservation concern

Eight of the eleven bird species of unfavorable conservation status were classed as SPEC 3 (9.7 % of breeding pairs) and three as SPEC 2 (3.2 % of breeding pairs). Birds of conservation concern were noted in 95.7 % of study plots. The most numerous species was the Red-backed shrike (*Lanius collurio)*, which bred in 80 % of field margins, and was one of six dominants (>5 % pairs) in the bird community (Online Resource 1).

Significance of vegetation structure

The volume of trees and shrubs was positively correlated with species richness in each of the three taxonomic groups and the number of breeding pairs in birds ($p < 0.001$ in each of the Kendall's tau correlations, Fig. 2A). The relationship between the volume of trees and shrubs and the number of TCCS was significant only with respect to the number of SPEC birds (Kendall's tau = 0.246, $p = 0.003$, $N = 70$) and marginally significant with respect

to the number of pairs of SPECs (Kendall's tau = 0.154, $p = 0.059$, $N = 70$) and number of threatened bryophytes (Kendall's tau = 0.146, $p = 0.073$, $N = 70$). These relationships imply that the increasing complexity of the vegetation structure led to an increase in total species richness, abundance of birds, and richness of SPECs. However, in percentage terms the occurrence of TCCS was nonlinearly related to the volume of trees and shrubs, with highest values recorded in the intermediate volume (Fig. 2B). Calculated separately in the three field margin types, the percentages of threatened vascular plants, bryophytes and birds of conservation concern tended to be higher in the shrubby margins (Table 4), but only the number of breeding pairs was significantly related. The numbers of threatened vascular plants and bryophytes were probably too low to reach the significance level.

Discussion

Field margins as refuges of rare and threatened species

We have demonstrated that field margins in Poland regularly support plants and animals recognized as conservation targets. Threatened birds occurred in 12.9 %, plants in 18.6 %, and bryophytes in 20.0 % of field margins, and birds of conservation concern were recorded in 95.7 % plots. These data contradict some earlier results suggesting that contemporary agro-ecosystems seldom host rarities (Manhoudt et al. 2005; Kleijn et al. 2006; Aavik et al. 2008; Liira et al. 2008). We also discovered a large number (78) of plant species listed as being of least concern in the European red list, including 40 CWR (Bilz et al. 2011). CWR are a major component of plant genetic resources for food and agriculture, providing crucial ecosystem services for humankind (Maxted et al. 2006). The high number of CWR in just a sample of field margins signifies the retained natural features of their vegetation, multifunctionality and importance in preventing loss of biodiversity. The findings suggest that almost every field margin in the Polish farmland provides a habitat for species of conservation importance. More generally, these data emphasize the remarkable heterogeneity of the agricultural landscape in this part of Europe and confirm regional differences in biodiversity patterns (Palang et al. 2006; Batáry et al. 2011; Cogălniceanu and Cogălniceanu 2010; Tryjanowski et al. 2011).

Importance of shrubby margins

The occurrence of the threatened species in farmland should be considered in a broader context of landscape and vegetation systems. The major role of semi-natural refuges is widely acknowledged, however their availability and importance are regionally uneven (Berg 2002; Manhoudt et al. 2005). For example, in farmlands where grasslands are the matrix, extensive wet meadows play an important role in maintaining threatened plants (Liira et al. 2008). In extensively cultivated landscapes fields may also host plant species of conservation importance, however threatened arable floras consist mainly of annual species, and their occurrence is rare and ephemeral (Wilson and Aebischer 1995). In the outermost zone of crops adjoining the 70 studied filed margins we noted 223 species of vascular plants, but only one species, the Rye Brome *Bromus secalinus*, was recognized as threatened (classed VU in the national and local red lists). Our data were collected within an arable production system, representative of many Central European landscapes (see Study area), where residuals of natural vegetation along edges are particularly common. Of them, woody edge habitats, such as tree lines and hedgerows, are of exceptional

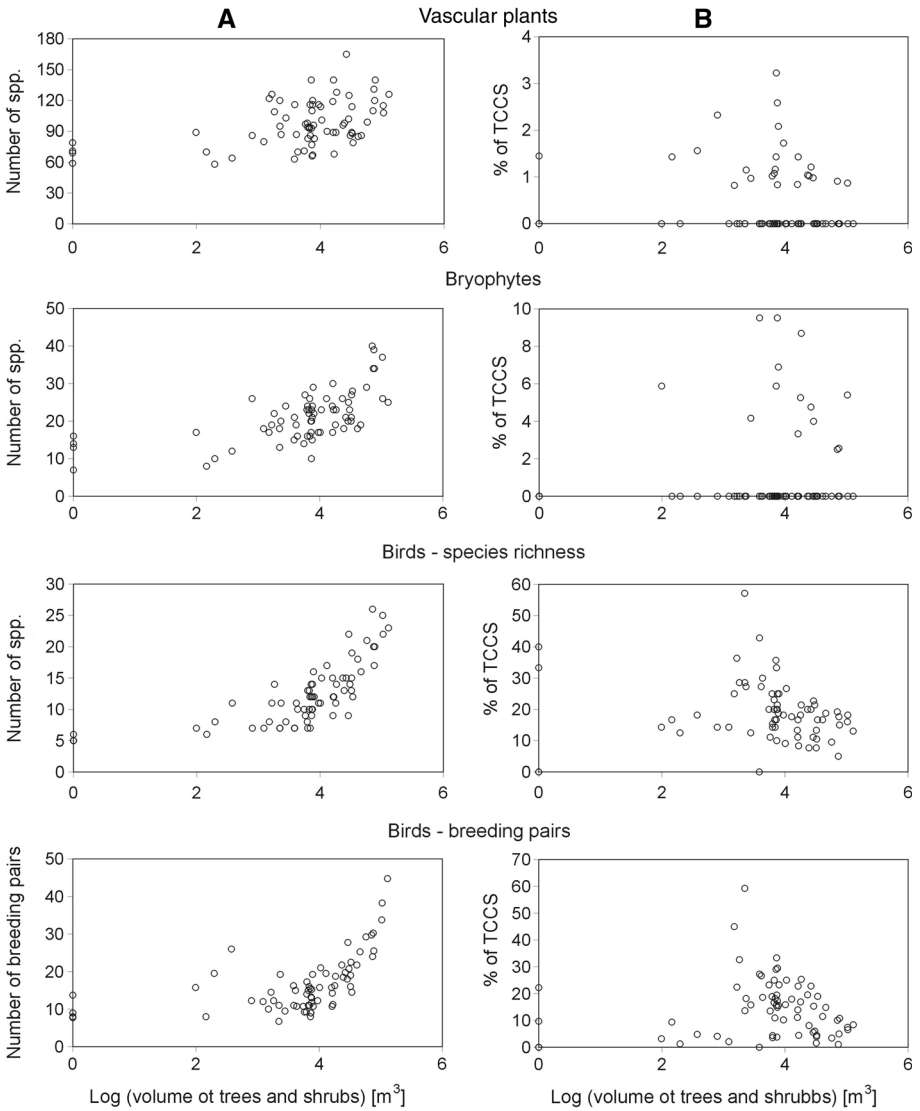

Fig. 2 Relationships between the total volume of trees and shrubs in the field margins and overall species richness (**A**) and percentages of TCCS (**B**) in vascular plants, bryophytes, birds, and breeding pairs of birds

importance for biodiversity, for example being the most consistent predictor of bird species richness on Polish farmland (Sanderson et al. 2009; Wuczyński et al. 2011).

In the present study overall species richness of birds, vascular plants and bryophytes also increased with the volume of trees and shrubs, although the TCCSs were most abundant (in percentage terms) in field margins with an intermediate volume. This tendency was common to each of the studied taxa, probably in response to the ecological characteristics of the focal species. Most of the TCCS are associated with open or mixed landscapes. These constituted 80 % of the threatened vascular plants, representative of different types of grasslands, thermophilous saum communities and threatened segetal

Table 4 Distribution of TCCS species in three types of field margins divided according to the volume of tall vegetation

Taxonomic group	Parameter	Herbaceous ($N = 21$)	Shrubby ($N = 29$)	Tree lines ($N = 20$)	Kruskal–Wallis test
Birds	Total no. of species	24	37	46	
	No. of SPECs	5	8	10	$H = 4.21$; $df = 2$; $p = 0.12$
	Percentage of SPECs	23.8[a]	19.1	15.2	$H = 5.26$; $df = 2$; $p = 0.07$
Birds	Total no. of pairs	268.3	393.8	501.0	
	No. of pairs of SPECs	37.5	67.75	45.0	$H = 2.44$; $df = 2$; $p = 0.29$
	Percentage of pairs of SPECs	14.0	**17.2**[b]	**9.0**[b]	**$H = 8.65$; $df = 2$; $p = 0.01$**
Vascular plants	Total no. of species	366	413	395	
	No. of threatened species	3	7	4	$H = 0.47$; $df = 2$; $p = 0.79$
	Percentage of threatened species at local level	0.16	0.28	0.23	$H = 0.30$; $df = 2$; $p = 0.86$
Bryophytes	Total no. of species	56	72	76	
	No. of threatened species	2	3	3	$H = 0.67$; $df = 2$; $p = 0.71$
	Percentage of threatened species at national level	1.16	1.47	1.13	$H = 0.45$; $df = 2$; $p = 0.80$

[a] The percentages denote mean weighted values per plot

[b] Significant difference is marked in bold (nonparametric multiple comparison test)

weeds. Four of the threatened bryophytes are associated with agricultural plant communities, and the fifth species, the Marble Screw-moss (*Syntrichia papillosa*) is an obligate epiphyte growing on solitary, old trees. Seven of the eleven bird species of conservation concern are classified as being typical of agricultural and grassland habitats (Tucker and Evans 1997).

Our findings suggest that shrubby margins can act as centers of endangered species in agro-ecosystems. Herbaceous margins, particularly strongly subject to agricultural impact, are usually poor in diversity and deprived of priority species, especially when dominated by common reed *Phragmites australis*, whereas dense tree lines are dominated by common species associated with forests. With regard to vascular plants, margins with an intermediate cover of tall vegetation represent successional stages in which species associated with open habitats are still able to occur, whereas shade-tolerant plants also appear. Pykälä et al. (2005) found that the low tree cover in semi-natural grasslands was beneficial to the total species richness and the occurrence of rare grassland plants. Likewise, in bryophytes of cultivated areas the coexistence of various habitats on a small scale and heterogeneous substrates within these habitats increased total richness and numbers of threatened species (Zechmeister and Moser 2001; Vanderpoorten and Engels 2003). In birds, too, the Red-backed Shrike, the most numerous species of conservation concern, depends on habitats with sparse shrubby vegetation (Kuzniak and Tryjanowski 2000; Tryjanowski et al. 2000; Ceresa et al. 2012). Apart from the general importance of shrubby margins to endangered

species, these data indicate the importance of the arrangement of shrubs within the margin. A mosaic layout suitable for species of different requirements is preferable (Hinsley and Bellamy 2000; Szymański and Antczak 2013).

In spite of their environmental role, shrubs scattered among fields are routinely being dug up, purportedly to facilitate cultivation; in any case, in Poland there are no regulations in place for protecting such vegetation. The arguments presented in this paper emphasize the need for such regulations.

Applicability of red lists in the conservation of fine-scale habitats

Red lists appear to be applicable to the evaluation of biodiversity and the prioritization species and margin types in the agro-ecosystems of Poland. The presence of species recognized as threatened, yet dependent on farming activities (e.g. management of tree and shrub cover next to crops), may be a point of departure for effective conservation. Wade et al. (2008) provided examples of threatened or rare taxa targeted in farmland ecological restoration programs across the world. We argue that in heterogeneous landscapes the presence of such species and their habitats should be compulsorily included in every inventory and also in subsequent agro-environmental activities (Meynell 2005). There is a need to redirect research efforts in vanishing habitats of acknowledged value. As well as or instead of counting species (Aavik et al. 2008), conservation scientists should seek arguments that will persuade policy makers to implement conservation measures. Thus, the red list system may be helpful for maximizing conservation efforts in landscapes still supporting threatened, rare and/or charismatic species.

However, the direct cross-taxonomic application of red lists to a fine-scale habitat turned out to be problematic (Miller et al. 2007) (Table 5). Difficulties arose from gaps in coverage in terms of taxonomy and geography, the different periods when assessments were compiled, i.e. various classifications and inconsistent treatment of the common species (Colyvan et al. 1999), the different assessors independently monitoring the threat (in bryophytes), and finally, from the insufficient representation of threatened species in the studied habitat. The selection of different geographical resolutions of red lists appeared helpful. Threatened species were better represented on the local than the national red list of vascular plants and on the national than the European red list of bryophytes. Overall, local and national lists are more relevant to fine-scale habitats than the lists compiled at wider, e.g. European scale (Batáry et al. 2007). This conclusion well reflects scale-dependent functions of the red lists—assessing species extinction risk at the global level and multiple conservation functions at the national and local levels. Although the red list species recorded in field margins are widely distributed and not facing high risk of extinction, the presence of these species perfectly emphasizes the importance of field margins and reports on the state of farmland ecosystems in this part of Europe.

We nonetheless recommend cross-taxonomic approaches, since some of the major processes endangering wildlife differ among taxa, and management prescriptions based on one taxonomic group may be insufficient (Larsen et al. 2007). In field margins lists of vascular plants and bryophytes contained a sufficient number of threatened species, allowing for some between-margin comparisons. In contrast, birds classed as threatened were almost absent from the lists, which is probably also the case with other vertebrates and, in general, with organisms that typically occupy large areas relative to a habitat under study (Purvis et al. 2000). We availed ourselves of the "bird of conservation concern" concept. Birds of unfavorable conservation status constituted 22 % of species and 13 % of breeding pairs, and this classification appeared appropriate for evaluating field margins.

Table 5 Difficulties in cross-taxonomic application of various red lists for characterizing the fine-scale habitat of field margins

Complication	Taxa affected
Gaps in taxonomic and geographical coverage	Birds—lack of full assessment at the European level Birds and bryophytes—lack of a local red list
Selective coverage of species	All taxa—limited number of species that have been put through a formal assessment, especially common species Vascular plants—European red list compiled for selected functional groups; Unknown precise number of species occurring in Europe
Classifications of threat outdated or different in collated assessments	Bryophytes—old classification in European and national red lists Vascular plants—new classification in local and European red lists, old classification in the national red list, All taxa—inconsistent treatment of the common and lower threat species in the subsequent red lists
Risk of subjectivity bias	Bryophytes—different assessors of taxonomic subgroups
Insufficient representation of threatened species	Birds—lack of threatened species at the national level Vascular plants and bryophytes—lack of threatened species at the European level

Conservation of field margins in the context of CAP reform

We have provided further arguments for including existing semi-natural habitats in farmland conservation policies, but successful protection is challenging, and must be fitted to regional contexts. In Europe, some hope is offered by the upcoming CAP reform, formally adopted by the Council of EU Agriculture Ministers on 16 December 2013. Basic Regulations for the reformed CAP (ec.europa.eu/agriculture/cap-post-2013) include measures aimed at the "greening" of direct payments in Pillar 1. One of these measures, the creation of ecological focus areas (EFA), intends to maintain at least 5 % (and possibly 7 % after 2017) of farmland for environmental purposes (Allen et al. 2012). Since EFA primarily include diverse semi-natural habitats, the maintenance of field margins should be a matter of the utmost importance.

At the national level the agri-environment-climate schemes (AES) in Pillar 2 have been recognized as having the greatest potential to address many environmental concerns (Wade et al. 2008). The variety of packages tailored to national circumstances targeted more or less threatened species; unfortunately, evidence from Western Europe indicates that these species have rarely benefitted from such schemes (Kleijn et al. 2006). Our study is particularly relevant to the measures aimed at maintaining various strips in the field or at the edge of the field, between the crop and the boundary (Vickery et al. 2009; Josefsson et al. 2013). In Polish AES these measures comprise the buffer zones scheme (BZ), present in the current program and until recently considered for the new version 2014-2020. Unfortunately, in the current program payment rates in BZ scheme were very low (20–50$ per 100 m) and were in conflict with direct payments (Keenleyside 2006). In the end, BZ was the scheme with the least uptake of all packages, appealing to a mere 0.002 % of the 117,000 farmers who applied for contracts in 2012 (The Agricultural Advisory Centre in Brwinów, unpubl. data). In consequence, the abandonment of this scheme, and also the margin strip scheme developed for the new AES, are being considered in the revised program. Even though the program is still under debate, in December 2013 these particular

schemes have been removed, which flies in the face of conservation evidence and thwart the principal aims of AES.

We argue that retaining the BZ and the related schemes aimed at creation of the margin strips, as well as a significant increase in payments are obvious prerequisites for accomplishing environmental benefits. Several targeted field-scale measures could be designated within these schemes. As a baseline they should promote and sustain a mosaic of field margins, from herbaceous boundaries, to multilayered tree lines, with particular attention given to shrubby margins. The proportion of these margin types in the landscape and detailed management recommendations, for example, leaving the outermost strip of field free of agrochemical input, partial cutting of margin vegetation and the removal of biomass, should be additionally drawn up.

The CAP reform has the potential to respond to many biodiversity concerns in Europe, but efforts should be adapted to regional circumstances. In complex agricultural landscapes, common in Central Europe, initiatives aimed at preventing landscape simplification are particularly important and should take priority over recovering complexity levels (Kleijn et al. 2006; Concepción et al. 2012). In such landscapes field margins are major agents of overall biodiversity, and of the species recognized as conservation targets by authoritative systems such as the IUCN red lists, even though the proportion of margins in the landscape is small. Management strategies relating to these habitats should be considered in a broader discussion concerning the methods, aims and effectiveness of ecological restoration in farmland.

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