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The Effect of Willow Short Rotation Coppice Cultivation on the Biodiversity Quality of Ground-Layer Invertebrates

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Abstract

The biodiversity quality of ground-layer invertebrates within the cropped area of a plantation of the biomass crop willow short-rotation coppice (SRC) grown within a floodplain was compared to the biodiversity quality of the neighbouring plots of floodplain grassland and a mixed deciduous woodland plantation. Pitfall traps were used to collect ground beetles (Carabidae) and arachnids (Araneae and Opiliones) in the plots over a period of two years. A range of biodiversity indices was used to assess the biodiversity quality of each of the three plots, and the willow SRC was compared to each of the controls using Mann-Whitney tests. The willow SRC transitioned from almost bare ground to young woodland during the two years of the study, which affected comparisons with alternative land uses as the habitat during the second year was very different from the habitat at the start of the study. Compared to plantation woodland, in the first year, the effect was mostly positive, but this declined in the second year. Compared to grassland there was a largely negative effect in both years. However, when in combination with other habitats, willow SRC cultivation on floodplain land may have an overall positive effect on invertebrate biodiversity quality.

Keywords

Biodiversity Quality, Biomass, Energy Crops, Rarity, Short Rotation Coppice

1. Introduction

With the utilisation of biomass as an energy source considered to be among the measures necessary to tackle climate change [1], it becomes important to understand the impact that biomass crops might have on biodiversity. Intensively-managed monocultures of willow short-rotation coppice (SRC) crops are one popular method of producing combustible biomass for bioenergy production. To date, there have only been limited studies on the effect on biodiversity of willow SRC cultivation, and fewer that compared willow SRC to the conventional land-uses it would in many cases be replacing. Studies on bees in willow SRC in Europe have produced varying results with one Danish study failing due to the local scarcity of bees [2] and a German study [3] recording 28 species, concluding that the local landscape context is an important factor. Species-richness and abundance of butterflies (Lepidoptera) have been found to be increased in willow SRC compared to arable controls with the difference significant ($P < 0.05$) [4], although this study was confined to the margins and headlands, which were wider in the willow SRC plots, and therefore did not account for the cropped habitat. Significant ($P < 0.05$) increases of winged Hymenoptera and large Hemiptera in willow SRC, when compared to arable crops, have also been recorded [5]. Thirty species of ground beetle were recorded from willow SRC at three sites [6]; however, the study was limited to just a few weeks in August. Previous studies found greater abundance and diversity amongst ground-dwelling arthropod predators in willow SRC plots compared to arable plots [7] [8]. Work by Haughton *et al.* [9] suggests that willow SRC supports greater invertebrate and "weed" biodiversity than arable crops, although habitats such as grassland and woodland were not included in their study.

In practice, willow SRC often replaces grassland [10] and has also shown promise as a flood control measure [11]. The impact on invertebrate biodiversity of replacing floodplain grassland with willow SRC has not previously been assessed. Furthermore, there is little data regarding the impact on the in-crop ground-dwelling invertebrate community of converting floodplain grassland to willow SRC.

Williams and Feest [12] showed that the growth of the biomass crop *Miscanthus* had a profound effect on in-crop biodiversity quality, which manifested itself in significant reductions of species richness, abundance and biomass compared to conventional land-uses (silage grass and mixed-use arable). This paper follows a similar pathway and similar methods to that used for *Miscanthus* but apply them to a different crop (willow) and comparator land-uses (floodplain grassland and deciduous plantation woodland).

Our research hypothesis was as in the Williams and Feest [12] paper:

The cultivation of Willow SRC has a significant effect on ground-layer invertebrate biodiversity quality in comparison to neighbouring alternative land-uses. Biodiversity quality is the holistic view of a variety of biodiversity indices as defined by Feest, Aldred & Jedamzik [13]. An effect would be shown by a statistically significant difference.

2. Materials and Methods

2.1. Comparison to Other Land Uses

We aimed to make an assessment of the effect of Willow SRC cultivation on the biodiversity quality of ground-layer invertebrates, which requires comparison with alternative land-uses that the land cultivated for biomass crops would otherwise be used for. This approach has been used in previous studies [4] [5] [14]. Control (non-biomass crop) sites ideally need to be subjected to as similar conditions to the biomass crop as possible. The biodiversity of a given area of habitat can be influenced by factors such as environmental conditions, adjacent land uses and geographical location, and therefore control sites within as close proximity to the studied biomass crop sites as possible are the best-suited, providing that the land is suitable for biomass crop cultivation and vice-versa. A willow SRC crop is compared to two adjacent land-uses—floodplain grassland and deciduous plantation woodland.

2.2. Taxonomic Groups Studied

For the purpose of this research, the taxonomic groups studied need to be comparable between sites. To be of use in evaluating the conservation value of localities, a taxonomic group must be understood reasonably well in terms of taxonomy and ecological, distribution and rarity status [15].

Two invertebrate groups largely fitting these criteria—ground beetles (Coleoptera: Carabidae) and spiders and harvestmen (Arachnida: Araneae and Opiliones)—were used to compare the biodiversity between willows SRC and adjacent land-uses (Due to the similar ecological niches of spiders and harvestmen, they have been grouped together in this study).

2.3. Sampling Methodology

Three plots (one a young tree plantation, 30 years old mixed species but largely Oak *Quercus* sp., one grass meadow and one a willow crop) separated by either a two metre wide Rhyne (grassland) or a four metre wide track (Oak plantation) at the Willows and Wetlands Centre, Stoke St. Gregory, Somerset, UK were utilized (**Figure 1**). Pitfall trap sampling took place between October 2008 (immediately following a harvest of the willow SRC) and October 2010 (immediately prior to the next harvest of the willow SRC), with traps emptied and reset each month. Twenty pitfall traps were deployed in each plot at 10 m intervals in linear transects [16]. The traps consisted of plastic beakers (7.5 cm top diameter, 9.5 cm deep), placed in holes dug with a similarly-sized bulb planter, with the rim of the beakers level with the surface. 10 cm^2 wire mesh squares used to cover the traps, with a 1cm gap between the squares and the rims of the beakers. Approximately a third of each beaker was filled with a preservative consisting of a mixture of one-part ethylene glycol to three-parts tap water. A small amount of the bittering agent quinine sulphate added to deter potential trap raiders. During periods of winter flooding, traps were not collected in the willow SRC or grassland, but collection continued in the woodland, which was not subjected to flooding. Species identification was undertaken using appropriate identification works [17] [18] [19].

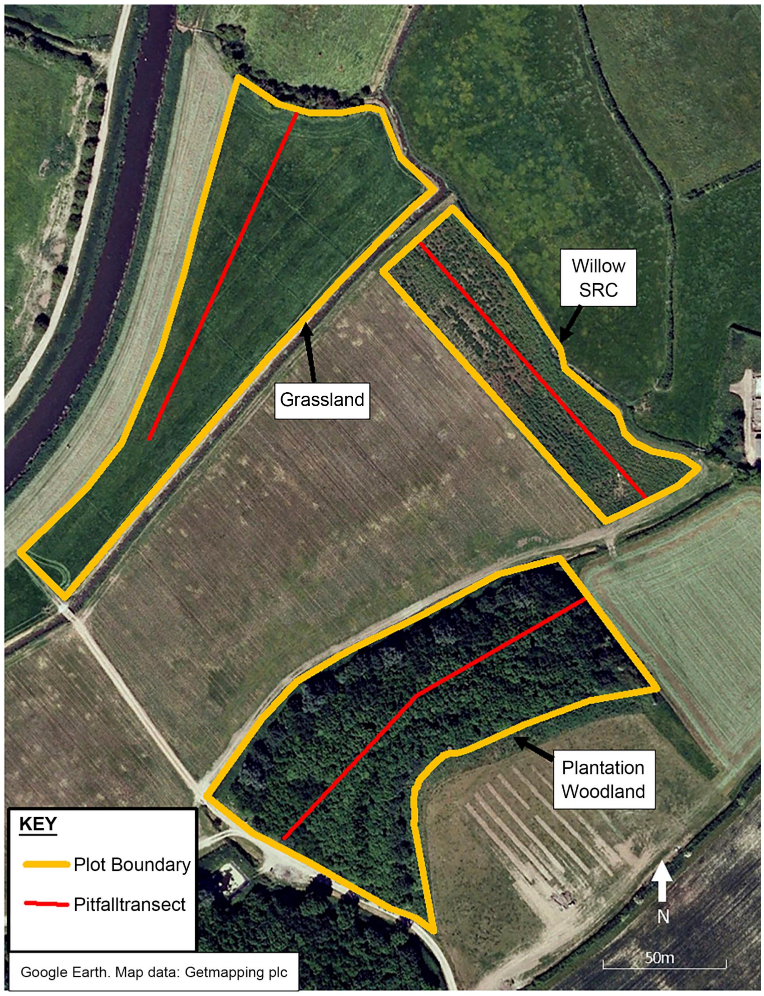

Figure 1. Plan of the three plots showing the position of the transects, from an aerial photograph in 2009.

2.4. Study Site

The three plots studied are located at the Willows and Wetlands at Meare Green Court, near Stoke St Gregory in the county of Somerset, UK. The biomass crop studied is willow SRC, specifically the species *Salix viminalis* L. (OS grid reference ST 337,273) and the adjacent plots are species-poor floodplain grassland (OS grid reference ST 335,273) and newly planted broadleaved woodland (ST 337,271). The grassland plot had been grassland for approximately 50 years, before which it was a willow bed, and there are plans to return the plot to willow cultivation in the future. The land on which the plantation woodland is situated is less suited to willow cultivation (and is unlikely to be used for it in the future), however due to the lack of another adjacent alternative land use, the opportunity to make a comparison between a commercial willow SRC plantation and a plantation of another species of broadleaved trees planted for conservation purposes was taken. A recent review of biodiversity studies in SRC [20] suggested that while SRC provided a higher biodiversity than agricultural crops, it was lower than in mixed deciduous forest. A young plantation, however, might have a considerably lower biodiversity than established woodland.

The willow bed was planted in 1999, before which it was grassland. Willows have been grown on the site since 1819. 17,000 willow saplings are planted per acre (approximately 42,000 per hectare) and are cut every two years in the winter for the purpose of basket-making. This density is greater than that typically planted for biomass, which is usually around 15,000 per hectare; however this was the only site available for study at the time. The plot was harvested October 2008, immediately before pitfall traps were placed on the site. No fertilisers or pesticides were sprayed on the willow bed. The willow bed and grassland field are subject to annual flooding from the River Tone during the winter months, which can reach a depth of almost 2 metres. The soil is typical of the Somerset Levels and Moors in being peat overlain with clay.

The woodland was planted in 1998 under the Woodland Grant Scheme on a north-west facing slope. Trees are of a roughly uniform height and very little understorey is present. Dominant tree species are oaks (*Quercus* sp.), plus Ash (*Fraxinus excelsior* L.), Hazel (*Corylus avellana* L.), Hornbeam (*Carpinus betulus* L.), Cherry (*Prunus avium* (L.) L.), Hawthorn (*Crataegus monogyna* Jacq.), Field maple (*Acer campestre* L.) and Snowberry (*Symphoricarpos albus* (L.) S. F. Blake).

The land on which the grassland plot is situated is generally flat with a small drain cut into the ground and leading to the rhyne to the south-east, bordering the willow bed. Immediately to the north-west of the grassland is a south-facing levee bordering the River Tone. The grassland is cut for silage in May and grazed by cattle from June up until the end of November, unless the land is flooded. The grassland and willow plots are subjected to similar levels of flooding in the winter. No fertilisers or pesticides or insecticides are sprayed on the grassland; however an herbicide (Mircam) was sprayed on the grassland in spring 2008 to control buttercups.

Being situated adjacent to each other, all plots were subjected to virtually identical weather conditions at the same time. Although micro-climates at ground-level may vary, all plots were surveyed during the same period of time and any variation is a result of the structure of each plot, rather than different weather conditions.

2.5. Biodiversity Quality

The biodiversity quality of each plot was calculated using the Biodiversity Quality Calculator (BQC) programme (http://www.ecosulis.co.uk) [13] [16], which calculates a range of indices discussed further below. Each of the indices for the willow SRC was compared to the corresponding indices from the other plots, using Mann-Whitney tests to test for significant differences (except for Simpson's Index, where bootstrap and permutation tests using the program PAST were used). The indices calculated by the BQC programme are:

- *Species Richness*: Total number of species within each sample.
- *Biomass*: Biomass estimates were calculated using length-mass formulae, with separate formulae used for Carabidae [21] for Carabidae, Araneae [22] and Opiliones [23]. Mean lengths were taken from the relevant identification literature.
- *Abundance*: Total number of individuals within each sample.
- *Simpson's Reciprocal Index* ($1/D$): A measure of diversity based on proportional abundances of species.
- *Species Conservation Value Index* (*SCVI*): An SCVI (rarity) value between 2 - 100 was assigned to each species, following the same approach used by Williams and Feest [12]. The mean value was calculated for each sample.

Additionally, Jaccard Index (with the table in Real [24] consulted to obtain a p-value) was also employed to test for similarity in species composition between the plots.

The annual data for each plot was entered into the BQC to calculate the indices.

Most previous studies on invertebrate indicators in willow SRC sampled for only part of the year and may exclude peaks in abundance of some species and certain species that are usually only found in the adult stage for short periods, or at other times of the year. Our data covers the entire year in order to account for such incidences.

3. Results

The raw data, including species lists, is included in **Table 1** and **Table 2** and in the supplementary material. The results of the statistical analysis are included in **Table 3** and **Table 4** and the supplementary material. The first-year willow SRC succeeded in the first year from almost bare-ground to a shrub-layer of approximately 100 - 150 cm. At the end of the first year the habitat bore little resemblance to how it began. During the second year, the willows increased in height to around 200 - 300 cm and were harvested shortly after the study finished.

Table 1. Carabid indices for all three plots in both years.

Year	Plot	Species Richness	Abundance	Biomass (mg)	Simpson's 1/D	SCVI
1	Willow	33	1335	27,416	3.788	3.818
	Woodland	16	887	20,522	1.152	3.312
	Grassland	28	2726	57,662	5.266	3.857
2	Willow	26	416	5304	11.149	3.846
	Woodland	15	1359	31,266	1.16	3.2
	Grassland	26	2625	64,995	2.759	3.692

Table 2. Arachnid indices for all three plots in both years.

Year	Plot	Species Richness	Abundance	Biomass (mg)	Simpson's 1/D	SCVI
1	Willow	27	407	1372	13.475	3.667
	Woodland	15	255	335	2.04	2.667
	Grassland	25	1077	3741	4.273	3.76
2	Willow	23	191	525	10.583	4.13
	Woodland	22	156	433	5.095	2.909
	Grassland	25	2469	7497	5.063	3.72

Table 3. Summary of ground beetle results for the willow SRC plot versus the neighbouring plantation woodland and floodplain grassland.

	Year	Species-richness	Biomass	Abundance	Simpson's 1/D	SCVI
Willows (W) vs Plantation Woodland (P)	1	W+++	X	W+	W+++	W+++
	2	W+	P+++	P+++	W+++	W+++
Willows (W) vs Grassland (G)	1	X	G+++	G+++	G+++	X
	2	G+++	G+++	G+++	W+++	W+

+: $P < 0.05$ and >0.01; ++: $P < 0.01$ and >0.001; +++: $P \leq 0.001$; X: Not significant.

Table 4. Summary of arachnid results for the willow SRC plot versus the neighbouring plantation woodland and floodplain grassland.

	Year	Species-richness	Biomass	Abundance	Simpson's 1/D	SCVI
Willows (W) vs Plantation Woodland (P)	1	W+++	W+++	W++	W+++	W+++
	2	X	X	X	W+++	X
Willows (W) vs Grassland (G)	1	X	G+++	G+++	W+++	G+++
	2	G+++	G+++	G+++	W+++	G+++

+: $P < 0.05$ and >0.01; ++: $P < 0.01$ and >0.001; +++: $P \leq 0.001$; X: Not significant.

3.1. Ground Beetles

3.1.1. Willow SRC vs. Plantation Woodland

The willow SRC and the plantation woodland plots had an overlap of 10 out of a total of 39 species in year 1 (Jaccard Similarity Index of 0.256) and 11 of a total of 30 species in year 2 (Jaccard Similarity Index of 0.367), which is not significant. In both years, greater carabid species richness, Simpson's Index and SCVI was recorded in the willow SRC, the differences being significant ($P < 0.05$) (Table 1 and Table 3). Abundance and biomass were highest in the willow SRC in year 1, with only biomass being significantly greater ($P = 0.026$). However, in year 2 the woodland had the greatest biomass and abundance, with the Mann-Whitney tests showing a very highly significant difference ($P < 0.001$).

3.1.2. Willow SRC vs. Grassland

The willow SRC and the grassland plots had an overlap of 24 species out of a total of 37 in year 1 (Jaccard Similarity Index 0.649) and 22 species out of a total of 30 in year 2 (Jaccard Similarity Index 0.733), both of which were very highly significant ($P < 0.001$). In both years 1 and 2, greater biomass and abundance was recorded from the grassland plot, the difference being very highly significant ($P < 0.001$). Species richness in the willow SRC was five species greater than in the grassland plot in year 1, but in year 2 the species richness was identical between the two plots. The Mann-Whitney tests showed no significant difference in year 1 ($P = 0.414$), but in the second year the difference was very highly significant. This is due to the greater species richness per trap in the floodplain grassland than in the willow SRC. Simpson's Index was highest in the grassland in year 1 ($P = 0.001$) but highest in the willows in the second year. In year 1 there was no significant difference between the SCVI of the two plots, but in year two the willow SRC had a higher SCVI and the difference was significant ($P = 0.027$).

3.2. Arachnids

3.2.1. Willow SRC vs. Plantation Woodland

The willow SRC and plantation woodland plots had an overlap of 8 species in year 1 (Jaccard Similarity Index 0.235) and 12 species in year 2 (Jaccard Similarity Index 0.364), neither were significant. In year 1, all indices were highest in the willow SRC plot and Mann-Whitney tests were either highly significant ($P < 0.01$) or very highly significant ($P < 0.001$). However, in year 2, despite all indices being highest in the willow SRC, Mann-Whitney tests did not show a significant difference except for Simpson's Index, which was very highly significant ($P < 0.001$).

3.2.2. Willow SRC vs. Grassland

In the first year there was an overlap of 21 species (Jaccard Similarity Index 0.667) which is very highly significant ($P < 0.001$). In the second year there was an overlap of 15 species (Jaccard Similarity Index 0.455), which was not statistically significant. As with carabids, the biomass and abundance in both years were highest in the grassland plot and Mann-Whitney tests showed the difference to be very highly significant ($P < 0.001$). Species richness was two species higher in the willow SRC than in the grassland in year 1, however two fewer species were recorded in year 2 (the grassland plot had the same species richness in both years). Mann-Whitney tests did not show a significant difference in year 1, but did so in the second year. The greatest Simpson's Index was recorded from the willow SRC in both years, with a very highly significant difference ($P < 0.001$). The grassland plot had a higher mean SCVI than the willow SRC in year 1, but the mean SCVI of the willow SRC in year 2 was higher than the grassland plot. Despite this, the Mann-Whitney tests of the samples showed that the SCVI of the grassland plot was very highly significantly ($P < 0.001$) greater than the willow SRC in both years, due to the mean SCVI of individual traps showing greater rarity in the grassland plot. In both years the willow SRC had a greater

Simpson's Index than the grassland plot, very highly significant ($P < 0.001$).

4. Discussion

Unlike our results for *Miscanthus*, which had a mostly negative impact, the effect on biodiversity of willow SRC vs. alternative land uses is mixed. Compared to young deciduous plantation woodland, with the exception of ground beetle biomass (for which there was no significant difference), willow SRC cultivation had a statistically significant positive effect on biodiversity across all of the indices in year 1. However, this effect declined in year 2 with no significant differences for all indices for arachnids except for Simpson's Index. Second year willow SRC retained a significant positive impact on carabid species richness, Simpson's Index and SCVI, but there was a negative effect on biomass and abundance. Compared to the grassland plot, there was no significant effect on the species richness of both ground beetles and arachnids in year 1, but there was a significant negative effect in year 2. Except for Simpson's Index and ground beetle SCVI in year 2, there was a significant negative effect across all indices in both years for ground beetles and arachnids. The hypothesis is therefore supported—willow SRC cultivation has a significant effect on biodiversity quality when compared to alternative land-uses; however this effect varies depending on the stage of cultivation and the land use it is being compared to.

The willow SRC transitioned from bare ground to young woodland over the course of the study. Although there was a mostly positive and no negative effect on any of the indices measured when compared to the adjacent young deciduous plantation woodland, over time the biodiversity in the woodland would likely improve, with higher biodiversity recorded in established forests [20]. Populations of many species found in the willow SRC crossed over into the adjacent woodland and/or grassland.

Besides tree cover and species, the most crucial difference between the willow SRC and the young deciduous plantation woodland is that the willow SRC was subjected to winter flooding. A large proportion of the species (see supplementary material) found in the willow SRC that were not found (or very rarely found) in the plantation woodland (specifically *Agonum emarginatum* (Gyllenhal, 1827), *A. marginatum* (Linneaus, 1758), *A. micans* (Nicolai, 1822), *Anisodactylus binotatus* (Fabricius, 1787), *Bembidion aeneum* Germar, 1824, *B. biguttatum* Fabricius, 1779, *B. guttula* (Fabricius, 1792), *B. lunulatum* (Geoffrey in Fourcroy, 1785), *Carabus granulatus* Linnaeus, 1758, *Chlaenius nigricornis* Fabricius, 1787, *Oodes helopioides* Fabricius, 1792, *Paranchus albipes* (Fabricius, 1796), *Pterostichus anthracinus* Illiger, 1798, and *P. nigrita* (Paykull, 1790)) are associated with damp ground and/or wetlands [25], many of which are fully-winged and highly mobile and therefore colonise suitable habitats with relative ease [26]. Many of the species found in the willow SRC are spring breeders with a life cycle specifically adapted to laying eggs in spring, so that eggs are laid at the beginning of the dry season and the adult stage is reached prior to the wet season, while the species found commonly within the woodland are predominantly autumn breeders, which over-winter as larvae [27]. The larvae are not as mobile as the adults and incapable of flight, and would be more at risk from flooding. It is notable that Sage & Tucker [6] did not record any of the wetland specialists recorded in the present study. Some of these species such as *Chlaenius nigricornis* Fabricius, 1787 are most abundant in the spring, whereas Sage & Tucker only collected in August.

The grassland plot studied was also subjected to winter flooding for approximately the same length of time as the willow SRC, which makes for easier comparisons between the two habitats. At the start of the project, the habitats within the two plots were structurally similar, in that they were two relatively two-dimensional habitats, however as the willows grew throughout the first year of study, they became less structurally alike. The willow SRC underwent rapid succession in year 1, and therefore throughout the course of the year provided habitat for a wider range of species than the grassland field, resulting in a higher species richness (Willow—33 species; Grassland—28 species), however in year 2, when habitat succession proceeded at a lower rate, the species richness of the two plots was the same (26 species). Spring breeders adapted to wet conditions made up a large proportion of the species list for both plots. Although the species composition between the plots was similar, there was a higher total biomass in the grassland plot in both years, and the Mann-Whitney tests showed a very highly significant difference ($P < 0.001$) between the two plots. The total Carabidae biomass in the grassland field increased by 11% between year 1 and year 2, while the biomass in the willow SRC decreased by 81%, the difference between the two plots being statistically significant ($P < 0.001$). As the two plots were subjected to similar abiotic factors (in particular winter flooding), the land-use is the likely cause of the differences in ground beetle biomass.

The willow SRC transitioned through several habitat types during the study, especially in year 1. While on the surface the biodiversity may seem high, this transitional habitat may not necessarily be ideal for all the species found there. Species of open habitats may have laid eggs at the beginning of the study, but the habitat would not have been ideal by the time they reached maturity. The ground beetle *Poecilus cupreus* (Linnaeus, 1758) is one such species that accounted for 50% of the total willow SRC biomass in year 1, but suffered a 96% reduction in year 2. This drastic decline of a dominant species positively affected the Simpson's Index in year 2, as there was greater evenness amongst the species recorded. Similar declines in species of open habitats that affect the overall abundance of Carabidae have been noted in regenerating forests [28], and the species richness of clear-felled forestry plantations have likewise been recorded to be higher than plantations at later stages of growth [29]. One impact of growing a dense, tall crop such as willow SRC is that the biodiversity might move upwards as the crop grows, and the most abundant types of predators may differ from those at ground level. A study by Björkman *et al.* [30] found that population of predatory Heteropterans feeding on pests of the willow plants crashed immediately following harvest, the reverse of what occurred with the mostly ground-level predators in the present study. Although often use to measure 'biodiversity', Simpson's Index essentially measures dominance/evenness, under the assumption that high evenness equates to high biodiversity. However, despite a reduction in both species richness and total ground beetle abundance, the Simpson's Index was significantly higher in the willow SRC in year 2 when the reverse was the case in year 1. The total biomass of this species slightly increased in the adjacent grassland in year 2 indicating that there was no local decline of *P. cupreus* (Linnaeus, 1758). However, the plot studied is just one of several at the site and a mosaic of plots harvested in different years and in close proximity would likely provide habitat continuity and greater biodiversity than if all the willow SRC was harvested at in the same year. The effect of an increasingly cluttered environment over time in the willow SRC, as well as a cooler environment due to shading, may have also had a negative impact on pitfall catches, resulting in a decrease in the recorded abundance and biomass.

A recent meta-study on various projects in central Europe [31] found that willow SRC plots mostly provide suitable habitat for rare carabid species in the establishment phase, and that plots are subsequently dominated by more common generalist species. However, that research was mostly conducted on relatively new willow SRC sites, the oldest site being 23 years and with most sites being below 10 years of age. In the present study, willows had been grown on the land for almost two centuries, in a region where the practice of willow cultivation is commonplace, and the local fauna has had time to adapt to the conditions of willow SRC cultivation. It is notable that in year 2 of the present study, the mean SCVI of the willow SRC for both carabids and arachnids increased.

The effect of willow density was not studied. At the study site, willows were grown in greater density than a typical willow SRC plantation. A less-dense plantation might have more gaps, allowing more light to reach the ground, potentially also affecting factors such as temperature and weed abundance and species composition. Further work would be necessary to assess the effect of willow density on ground-layer invertebrate biodiversity on floodplain land.

5. Conclusion

Neither ground beetle nor arachnid assemblages were significantly similar between the willow SRC and plantation woodland, but ground beetles in both years and arachnids in year 1 were significantly similar to the grassland plot ($P < 0.001$). In our study, the difference in species assemblages was likely to have been more greatly influenced by the winter flooding than the land use. The effect of the annual flooding may have been greater than that of the different land-uses, and willow SRC on drier land might differ in species composition and overall biodiversity. A recent study in Germany found that open-habitat gaps in terrestrial plantations of poplar SRC had a greater species-richness but a lower abundance of ground beetles than the plantation interiors [32]. Our study on floodplain land found a significantly greater abundance in an open habitat compared to a willow SRC, although overall species-richness was identical in the second year when the plantation was more established. Despite this difference, we agree with their conclusion that gaps of open habitats within SRCs would increase biodiversity. Floodplain land is unsuitable for many agricultural land-uses other than grazed grassland or willow SRC, and land used for cultivating willow SRC needs to be alternated with grassland periodically. While the willow SRC in this study had a greater species richness of both ground beetles and arachnids than the neighbouring grassland (likely to be even higher if the fauna above ground-level is taken into account), including several uncommon species not present in the grassland, the grassland had greater biomass and abundance of these groups, and also includes several uncommon species. When taken as a whole, a landscape mosaic across a large area of floodplain land composed of a patchwork of willow SRC at different stages of growth and grassland would increase overall biodiversity as opposed to a large area consisting solely of just one of these land-uses. Indeed, the data suggests that the practice of willow cultivation in floodplain land may be of overall benefit to biodiversity when in combination with other habitats. The site studied has had commercial willow plantations grown on it for a long time. At a recently-established willow SRC, it would be expected that the species-richness of ground-layer invertebrates would be lower than that of the plantation studied, but would increase over time.

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Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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