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Original Research

Comparison of Methods for Restoring Meadows Invaded by *Solidago* Species

Sebastian Świerszcz[1]*, Magdalena Szymura[1], Karol Wolski[1], Tomasz H. Szymura[2]

[1]Department of Agroecosystems and Green Areas Management, Wrocław University of Environmental and Life Sciences, Wrocław, Poland
[2]Department of Ecology, Biogeochemistry and Environmental Protection, University of Wrocław, Wrocław, Poland

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Abstract

Semi-natural meadows are valuable for maintaining biodiversity and providing a range of ecosystem services. The majority of these communities are protected by the European Natura 2000 system. However, grasslands are threatened by invasions by alien species, particularly *Solidago* spp. The invaders should be eradicated because of their negative impact on biodiversity, the environment, and the economy. A field experiment was conducted to compare the effect of different treatments (scalping, rototilling, and use of herbicide) on restoration of a meadow seriously invaded by *Solidago* spp. Fresh hay was transferred to the experimental plots to provide target meadow species seeds. Significant differences in species composition and coverage were detected between the herbicide-treated and plots that received other treatments and between the use of a rototiller and the control. Applying the herbicide glyphosate quickly reduced the cover of *Solidago* spp. (0.5±0.4%) and increased target species cover (84.8±13.6%). The *Solidago* spp. cover rates were 79.5±17.1% and 65±31.4% when scalping and rototilling were used, respectively, whereas the target species cover rates were 25.8±16% and 30±15.8%, respectively. The sward that grew after applying glyphosate had the highest forage value and resistance to cutting. These results show that short-term eradication of invasive *Solidago* spp. and restoration of a meadow are possible using glyphosate. However, use of a herbicide may have a negative impact on the environment and native species.

Keywords: invasive species, semi-natural meadows, species composition, hay transfer, restoration

Introduction

Exotic plant species that spread into natural and semi-natural plant communities are a serious threat to native species and affect the structure and dynamics of the vegetation [1]. The majority of invasive plant species are strong competitors that displace native species, decrease biodiversity, and alter ecosystem services [2-3].

Traditional grasslands in Europe include some of the most species-rich habitats and richest soil biodiversity. A grassland provides a range of ecosystem services, from meat and dairy products to recreational and tourism opportunities, and also creates a considerable carbon sink. More than 80% of semi-natural grasslands have been

*e-mail: sebastian.swierszcz@upwr.edu.pl

lost in the last 100 years due to intensified production or abandonment. A large number of grassland species have declined or become extinct [4-7]. Therefore, many semi-natural grasslands in the pan-European Nature 2000 network are protected, as specified in Annex I of the Habitat Directive. Despite this protection, the effects of abandoning agriculture remain visible in Central and Eastern Europe. It is an effect of the collapse of the socialist regime in the early 1990s, which caused socioeconomic processes resulting in landscape-scale changes in biodiversity, ecosystem services, and agricultural production [8-10].

Invasion by alien species is among the processes causing the major environmental changes that are destroying biodiversity and the economy [11]. Increased competition with alien species threatens the less competitive European grassland species. In addition, competitive pressure reduces populations of specialized species and, consequently, they are wiped out by negative events, such as fluctuating climatic conditions, predators, loss of genetic diversity in a small population, or disease. In these cases, typical grassland species are likely to become extinct, although not immediately because of the time lag between the introduction of an invasive alien species and the disappearance of native grassland species. Moreover, alien species can attract pollinators and interrupt the mutualistic relationships between insects and native grassland plant species [6, 12-13].

One of the most common invasive plants on European grasslands is alien *Solidago* spp. Three *Solidago* spp. are naturalised North American species, such as *S. gigantea* Aiton, *S. canadensis* L., and *S. altissima* L. (*S. canadensis* var. *scabra* (Muhl.) Torr. and Gray) [14]. These species were introduced to Europe in the 18th century as ornamental plants that escaped from gardens into the natural environment. Nowadays, they are one of the most common invasive species in the world and are most often found on roadsides, railways, abandoned fields, and meadows [15-18]. These species have a strong ability to colonize new sites by producing a large number of light seeds, rapid clonal growth, high environmental plasticity, and high biomass production [16, 19]. The *Solidago* spp. invading abandoned semi-natural meadows negatively affect species richness and composition of plants and pollinators. *Solidago* spp. also change soil pH and nutrient levels, increase organic carbon content, and increase soil bacterial and fungal biomass [20-22]. The high proportion of *Solidago* spp. in abandoned meadow swards results in poor hay quality due to the high saponin content [16].

Consequently, it is necessary to restore areas occupied by *Solidago* spp., reducing invasive species over the long term is only possible after removing the invasive plant species and restoring the habitat [23]. Among mechanical methods to eliminate *Solidago* spp. are mowing, hand pulling, mulching, and ploughing the soil [24-27]. Herbicides produce rapid effects [28-30].

Eradicating invasive species is insufficient to restore a semi-natural grassland, as propagules of target meadow plants must be provided to regenerate the sward and compete effectively with any remaining invasive species [31]. A successful way to provide meadow species seeds is transferring fresh hay. Many studies have shown that plant species richness and the number of target species are higher on plots that have received fresh hay compared to control plots, where sowing of grass species or no seed was applied [32-34]. Moreover, mulching is an effective method to reduce growth and development of *Solidago* seedlings [16, 27], and hay can serve a similar purpose.

Many studies have investigated eliminating *Solidago* spp. and restoring grasslands, but few studies have been devoted directly to restoring meadows invaded by alien *Solidago* spp. In this study, we show the results of a field experiment in which grasslands were restored after being invaded by *Solidago* spp. using different methods to eliminate the *Solidago* spp. We focused on answering three questions:

1) Which of the treatments was the most effective for removing *Solidago* spp.?
2) Does applying fresh hay effectively restore the semi-natural meadows sward?
3) Which method of removing *Solidago* spp. combined with fresh hay results in the best forage value of sward?

Material and Methods

Study Site

The experiment was established in July 2013 in Wroclaw, Poland (N 51°09′41,5”, E 17°06′41,5”) in an abandoned meadow overgrown by invasive North American *Solidago* spp. (*S. gigantea* Aiton. and *S. canadensis* L.). The study site was located at an altitude of 118 m a.s.l. in a small river valley surrounded by suburban buildings and extensively used meadows. The surrounding meadows were *Molinion* and *Arrhenatherion* grasslands according to a phytosociological perspective. The mean annual temperature in the region is 11.6ºC (maximum in July, 18.8ºC; minimum in January, -0.8ºC), and the mean annual precipitation is 581.4 mm (maximum in July, 85.7 mm), as provided by the Agro- and Hydrometeorology Observatory in Swojec (N 51°06′56,6″, E 17°08′29,4″). The chemical properties of the soil in the upper layer (0-15 cm) recorded in 2014 were as follows: pH (measured in KCl) = 6.09, organic carbon = 29.7 $g \cdot kg^{-1}$, total nitrogen = 2.52 $g \cdot kg^{-1}$, available forms of phosphorus = 32.73 $mg \cdot kg^{-1}$, potassium = 51.56 $mg \cdot kg^{-1}$, and magnesium = 288.94 $mg \cdot kg^{-1}$.

Experimental Design and Data Collection

The field experiment was established using a randomised block design with four replications containing 2.5 × 2.5 m plots. The distance between blocks was 1 m. Plots within blocks contact each other, but the observations were performed on 2 × 2 m plots with a buffer zone between neighbouring plots with different

Table 1. *F*- (lower part of the matrix) and *p*- (upper part of the matrix) values for the post-hoc tests after PERMANOVA between treatments. Significant differences ($p<0.05$) are marked with an asterisk.

		p - values			
		Scalping	Glyphosate	Rototilling	Control
F - values	Scalping	-	0.027*	0.145	0.627
	Glyphosate	8.779	-	0.028*	0.029*
	Rototilling	1.369	8.536	-	0.030*
	Control	0.850	14.960	3.321	-

treatments. First, the entire experimental area was mowed and the biomass was removed in May 2014. One of the three treatments, including scalping (depth of sod cut approximately 1 cm), rototilling and a herbicide (glyphosate, 5 L ha^{-1}), as well as the control (no treatment) was applied to particular plots. Fresh hay was harvested from a meadow with similar habitat conditions and floristic composition as the meadows surrounding the experiment plots and was spread on the experimental plots. The donor site was approximately 30 km from the experimental site. The fresh hay was collected and applied at the end of July, when most of the target meadow species had mature seeds. Fresh hay was applied at a 1:1 ratio (donor:acceptor site area). In total, 16 plots were analysed (three treatments + control × four repetitions). The percentage cover of vascular plant species in each of the plots was assessed in June 2014 using a percentage scale.

Data Analysis

To evaluate the effect of the treatments on species composition, PERMANOVA and a post-hoc test were applied using the PAST package [35]. Non-metric multidimensional scaling (NMDS) ordination was used to visualise the results (CANOCO 5) [36]. The SIMPER test was applied to identify the plant species strongly related to a particular treatment [37]. All data were square root transformed before the computations. The means of the raw data and the transformed data are shown in Table 2 and Appendix 1 [38]. The Bray-Curtis distance was the background for all of the tests mentioned above.

To assess the effect of the treatments on the grassland utilisation value, the means of the mowing tolerance and forage value indicators were calculated for all treatments. The indicator values were determined using a nine-point scale, and mowing tolerance was rated from 1 (intolerant of mowing) to 9 (very tolerant of mowing), whereas the forage value was rated from 1 (poisonous to livestock and humans) to 9 (best forage value). The means weighted by species cover were calculated. The values of the indicators were derived from the BiolFlor database [39]. In addition, species were divided into four ecological groups: invasive *Solidago* spp. (*Solidago*), typical meadow species (target), ruderal, and other species. The target species considered were species typical of the *Molinio-Arrhenatheretea* class, whereas the ruderal species were *Stellarietea mediae* and *Artemisietea vulgaris*, according to Matuszkiewicz [40].

Table 2. Results of the SIMPER analysis. Nine species contributed more than 50% of the differences between treatments and the cumulative percentages (cumulative). The values in columns for particular treatments (scalping, glyphosate, rototilling, and control) show the mean cover of the species in a given treatment. Species that affected differences in the sward after fresh hay was transferred and made use of selected treatments. The analysis was performed on square root transformed data. The means of the raw data are shown in parenthesis. A list of all species is presented in Appendix 1.

Taxon	Contrib. %	Cumulative %	Scalping		Glyphosate		Rototilling		Control	
Solidago gigantea	14.65	14.65	8.70	(76.30)	0.60	(0.50)	7.50	(60.00)	9.87	(97.50)
Festuca pratensis	9.68	24.33	0.60	(0.75)	5.97	(36.30)	3.03	(10.80)	0.35	(0.50)
Poa trivialis	5.63	29.96	3.16	(11.30)	4.74	(23.80)	2.11	(4.50)	1.88	(5.25)
Alopecurus pratensis	5.49	35.46	0.56	(1.25)	3.51	(13.80)	-	-	0.25	(0.25)
Solidago canadensis	3.71	39.16	1.55	(3.25)	-	-	2.24	(5.00)	1.16	(1.75)
Vicia hirsuta	3.54	42.70	1.91	(5.00)	1.43	(3.77)	2.16	(5.25)	1.44	(2.38)
Artemisia vulgaris	3.25	45.96	0.61	(0.65)	-	-	2.19	(6.63)	0.08	(0.03)
Holcus lanatus	3.16	49.11	0.60	(0.50)	2.34	(5.75)	1.34	(2.13)	0.60	(0.50)
Scrophularia nodosa	2.69	51.80	0.08	(0.03)	0.08	(0.03)	1.85	(6.38)	0.25	(0.25)

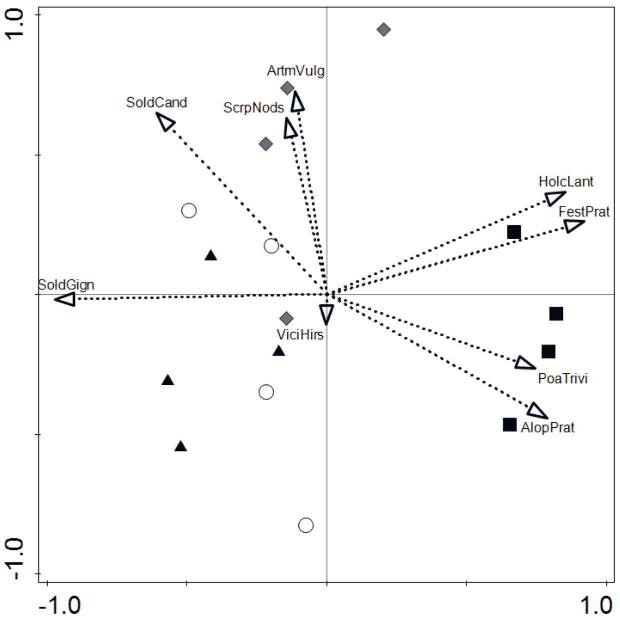

Fig. 1. Non-metric multidimensional scaling (NMDS) ordination based on the Bray-Curtis distance (stress value = 0.129) shows the effect of the treatments on the restored meadow (white circles, scalping; black squares, glyphosate; grey diamonds, rototiller; and black triangles, control). The nine species with the greatest impact on the differences between treatments are shown. Species abbreviations: AlopPrat, *Alopecurus pratensis*; ArtmVulg, *Artemisia vulgaris*, FestPrat, *Festuca pratensis*; HolcLant, *Holcus lanatus*; PoaTrivi, *Poa trivialis*; ScrpNods, *Scrophularia nodosa*; SoldCand, *Solidago canadensis*; SoldGign, *Solidago gigantea*; ViciHirs, *Vicia hirsuta*.

The Kruskal-Wallis rank test was applied to compare these characteristics using Statistica 12 [41].

Results

Effect of the Treatments on Species Composition

Species composition in the treatment plots differed significantly (F = 5.737, p = 0.0001), but no differences were detected between blocks (F = 0.634, p = 0.807).

Species composition and coverage were significantly different between the glyphosate and remaining treatments as well as between the rototiller treatment and control (Table 1). Nine species contributed to differences of more than 50% between treatments, including *S. gigantea, Festuca pratensis, Poa trivialis, Alopecurus pratensis, S. canadensis, Vicia hirsuta, Artemisia vulgaris, Holcus lanatus,* and *Scrophularia nodosa* (Table 2). Plots that received glyphosate were dominated by grass species, including *F. pratensis* (mean cover 36.3%), *P. trivialis* (23.8%), and *A. pratensis* (13.8%). The plots where rototilling was used were covered by *S. gigantea* (60%), *F. pratensis* (10.8%), and ruderal species such as *V. hirsuta* (5.25%), *A. vulgaris* (6.63%), and *S. nodosa* (6.38%). *S. gigantea* dominated (76.3%) the plots where scalping was applied, with a high proportion of *P. trivialis* (11.3%), whereas the control plots were dominated by *S. gigantea* (97.5%; Table 2). The differences were well illustrated by the NMDS ordination analysis. The first NMDS axis separated the plots treated with glyphosate from the others (scalping, rototilling, and control), whereas the second axis was associated with ruderal species cover (Fig. 1). Species with lower contributions in the plots were also taxa occurring exclusively on plots in specific treatments. *Lathyrus pratensis, Festuca rubra, Vicia cracca, Veronica chamaedrys*, and *Plantago lanceolata* occurred exclusively on glyphosate plots.

Effect on Species Group Coverage and Grassland Utilisation Values

The treatments that received fresh hay significantly affected the cover of *Solidago* spp. (H = 12.12, p = 0.007), target (H = 10.52, p = 0.015), and other (H = 9.25, p = 0.025) species, but did not affect the ruderal species group (H = 6.03, p = 0.109) (Table 3). Glyphosate had the best limiting effect (0.5±0.4%) on *Solidago* cover. *Solidago* cover was 65.0±31.4% after rototilling and 79.5±17.1% after scalping, whereas 99.3±2.2% coverage was observed on the control plots. The plots that received glyphosate also exhibited the highest target species coverage (84.8±13.6%). The target grasses with the highest cover were *F. pratensis, P. trivialis,* and *A. pratensis* (Table 2). These results differed significantly between the control

Table 3. Results of the Kruskal-Wallis analysis (H and p-values), means, and standard deviations of species groups coverage and grassland utilisation indicator values for the treatments. Different letters in a row indicate a significant difference (p<0.05) between groups.

		H	p	Scalping	Glyphosate	Rototilling	Control
Species groups	*Solidago* spp.	12.12	0.007*	79.5±17.1 **ab**	0.5±0.4 **c**	65.0±31.4 **b**	99.3±2.2 **a**
	Target	10.52	0.015*	25.8±16.0 **b**	84.8±13.6 **a**	30±15.8 **b**	11.0±10.4 **b**
	Ruderal	6.03	0.109	7.3±2.9	4.9±4.2	15.0±9.7	3.0±1.9
	Other	9.25	0.025*	7.5±1.3 **a**	1.1±0.6 **b**	12.5±13.1 **a**	3.1±2.9 **ab**
Grassland utilization indicator values	Forage value	10.85	0.013*	3.2±0.6 **ab**	7.5±0.3 **a**	3.4±0.8 **ab**	2.5±0.5 **b**
	Mowing tolerance	10.68	0.014*	4.7±0.3 **b**	6.6±0.4 **a**	4.4±0.3 **b**	4.3±0.3 **b**

plots (11.0±10.4%) and the scalping and rototilling plots (25.8±16% and 30±15.8%, respectively).

Differences in sward quality are shown in Table 3. The foraging value and mowing tolerance varied significantly by treatment (H = 10.85, p = 0.013; and H = 10.68, p = 0.014, respectively). The highest forage value was recorded in plots that received glyphosate, where the sward was assessed as high or the best forage value. The quality of the sward was rated between no and little forage value after scalping, rototilling, and in the control plot. Plots that received glyphosate had the highest mowing tolerance. The swards on plots that received the other treatments and the control were sensitive or moderately tolerant to mowing.

Discussion

It is important to provide the diaspores of meadow species to restore a meadow, which is usually accomplished by sowing a commercial seed mixture of meadow grasses. However, in this case, the restored meadow sward was poor in plant species [42-43] and did not increase biodiversity. Additionally, the *F. rubra* cultivars typically used to restore grasslands are no more competitive than plants originating from wild seed [44]. Thus, many semi-natural meadow restoration projects spread fresh hay, which contains the seeds of target species [32, 45-46]. Our experimental results show that fresh hay was an efficient source of target species propagules, even in grasslands seriously affected by invasive plant species, but the efficiency of target species emergence depends on the method used to remove the alien species.

Using a herbicide can quickly eradicate or limit invasive species [29-30, 47]. Our experiments reveal that *Solidago* spp. cover decreased rapidly after applying a glyphosate-based herbicide, and the dominant species were *F. pratensis*, *A. pratensis,* and *P. trivialis*. These perennial grass species are highly competitive and can effectively reduce the occurrence of non-target species [33, 47]. Other species, such as *L. pratensis* and *F. rubra,* along with dominant grasses resulted in good tolerance of mowing and a high forage value for the sward after applying glyphosate.

Seeds of non-target species will germinate if the method used to eradicate alien species causes a soil disturbance [32, 48]. Our results show a similar effect, as species composition of the swards in the rototilling and scalping treatments included a number of undesired species, such as *Equisetum arvense* and *Elymus repens*. Additionally, the rototiller caused species such as *A. vulgaris, S. nodosa, Rumex crispus, Epilobium palustre, Cirsium arvense,* and *Oxalis europea* to achieve greater coverage than those observed in the scalping-treated plots. The rototiller also resulted in less *S. gigantea* and target species coverage compared to that in plots that received the herbicide. In both cases, the sward had a low forage value and was sensitive to cutting because of species composition. Consequently, further mowing would promote coverage of unwanted species tolerant of cutting. These species are ultimately replaced by grassland species; however, this process can be prolonged.

Solidago spp. coverage was 99.3% in the control plots. The large percentage of *Solidago* spp. and the small number of target species resulted in the lowest sward utility value and was rated as no or low value as animal feed. Despite the expectation that fresh hay would reduce growth and the emergence of *Solidago* sprouts, we observed dense cover by *Solidago* spp., indicating that applying fresh hay alone cannot eradicate *Solidago* spp.

Eradicating *Solidago* spp. that invade natural and semi-natural ecosystems is difficult. Combining treatments is only the first stage of renovating a meadow ecosystem. The next step depends on annual mowing and removal of biomass, which help control unwanted, sensitive species, including invasive *Solidago* spp. The fastest result was achieved using the herbicide and is the cheapest method for eradicating invasive species [9]. However, it has a negative impact on the environment and native species [49-50]. This method is also restricted in protected areas and is only used with treatments that disturb soil structure. However, restoring valuable communities using mechanical methods to eliminate invasive species requires more time.

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Appendix 1. Results of the SIMPER analysis. Species contribution of the differences between treatments and the cumulative percentages (cumulative). The values in columns for particular treatments (scalping, glyphosate, rototilling, and control) show the mean cover of the species in a given treatment. Species affected differences in the sward after fresh hay was transferred and the use of selected treatments. The analysis was performed on square root transformed data. The means of the raw data are shown in parenthesis.

Taxon	Contrib. %	Cumulative %	Scalping		Glyphosate		Rototilling		Control	
Solidago gigantea	14.65	14.65	8.70	(76.30)	0.60	(0.50)	7.50	(60.00)	9.87	(97.50)
Festuca pratensis	9.68	24.33	0.60	(0.75)	5.97	(36.30)	3.03	(10.80)	0.35	(0.50)
Poa trivialis	5.63	29.96	3.16	(11.30)	4.74	(23.80)	2.11	(4.50)	1.88	(5.25)
Alopecurus pratensis	5.49	35.46	0.56	(1.25)	3.51	(13.80)	-	-	0.25	(0.25)
Solidago canadensis	3.71	39.16	1.55	(3.25)	-	-	2.24	(5.00)	1.16	(1.75)
Vicia hirsuta	3.54	42.70	1.91	(5.00)	1.43	(3.77)	2.16	(5.25)	1.44	(2.38)
Artemisia vulgaris	3.25	45.96	0.61	(0.65)	-	-	2.19	(6.63)	0.08	(0.03)
Holcus lanatus	3.16	49.11	0.60	(0.50)	2.34	(5.75)	1.34	(2.13)	0.60	(0.50)
Scrophularia nodosa	2.69	51.80	0.08	(0.03)	0.08	(0.03)	1.85	(6.38)	0.25	(0.25)
Rumex crispus	2.59	54.39	0.50	(0.50)	-	-	1.40	(4.50)	0.51	(0.40)
Arrhenatherum elatius	2.55	56.93	1.06	(1.50)	-	-	0.99	(2.00)	0.68	(0.63)
Cerastium holosteoides	1.97	58.90	0.26	(0.15)	1.16	(2.00)	0.53	(0.38)	0.26	(0.15)
Epilobium palustre	1.914	60.81	0.53	(0.38)	0.43	(0.38)	0.99	(2.00)	0.35	(0.25)
Cirsium arvense	1.85	62.67	0.61	(0.88)	0.26	(0.15)	0.91	(1.50)	-	-
Calamagrostis epigeios	1.80	64.47	0.60	(1.25)	0.18	(0.13)	0.25	(0.25)	0.56	(1.25)
Rubus sp.	1.73	66.20	0.71	(2.00)	-	-	0.18	(0.13)	0.35	(0.50)
Agrostis gigantea	1.70	67.90	0.79	(2.50)	-	-	-	-	0.56	(1.25)
Equisetum arvense	1.70	69.60	1.16	(1.75)	0.43	(0.28)	0.96	(1.38)	0.85	(0.75)
Phleum pratense	1.64	71.24	0.35	(0.50)	-	-	1.04	(1.50)	-	-
Elymus repens	1.63	72.88	0.56	(1.25)	-	-	0.74	(1.38)	0.08	(0.03)
Anthoxanthum odoratum	1.63	74.51	0.25	(0.25)	0.86	(1.13)	0.35	(0.25)	-	-
Deschampsia caespitosa	1.49	76.00	0.79	(2.50)	-	-	-	-	0.35	(0.50)
Trifolium dubium	1.41	77.41	0.35	(0.25)	0.18	(0.13)	0.56	(1.25)	0.18	(0.13)
Oxalis europaea	1.41	78.81	0.18	(0.13)	-	-	0.93	(1.25)	0.08	(0.03)

Appendix 1. Continued.

Urtica dioica	1.35	80.17	0.35	(0.50)	0.18	(0.13)	0.35	(0.25)	0.43	(0.38)
Alchemilla monticola	1.31	81.48	0.68	(0.63)	0.18	(0.13)	0.18	(0.13)	0.43	(0.38)
Vicia tetrasperma	1.19	82.66	0.18	(0.13)	0.71	(0.75)	-	-	0.08	(0.03)
Taraxacum officinale	1.08	83.74	0.78	(0.63)	0.18	(0.13)	0.53	(0.38)	0.53	(0.38)
Ranunculus acris	1.02	84.76	0.53	(0.38)	0.71	(0.50)	0.53	(0.38)	0.18	(0.13)
Campanula patula	0.89	85.66	0.35	(0.25)	0.18	(0.13)	0.34	(0.18)	0.08	(0.03)
Poa pratensis	0.87	86.53	0.35	(0.50)	-	-	0.18	(0.13)	0.18	(0.13)
Carex hirta	0.86	87.39	0.53	(0.63)	-	-	0.18	(0.13)	-	-
Plantago major	0.75	88.14	0.18	(0.13)	-	-	0.43	(0.38)	-	-
Lychnis flos-cuculi	0.714	88.86	0.35	(0.25)	0.08	(0.03)	0.18	(0.13)	-	-
Rumex acetosa	0.71	89.57	-	-	0.33	(0.28)	0.18	(0.13)	0.08	(0.03)
Heracleum sphondylium	0.67	90.24	0.18	(0.13)	-	-	0.08	(0.03)	0.25	(0.25)
Carex pallescens	0.66	90.89	0.35	(0.50)	-	-	-	-	0.16	(0.05)
Mentha arvensis	0.65	91.54	0.08	(0.03)	-	-	0.43	(0.75)	-	-
Galium aparine	0.63	92.16	0.18	(0.13)	0.18	(0.13)	0.18	(0.13)	-	-
Dactylis glomerata	0.62	92.79	-	-	-	-	0.33	(0.28)	0.18	(0.13)
Avenula pubescens	0.57	93.36	-	-	-	-	-	-	0.35	(0.50)
Stachys palustris	0.57	93.92	-	-	-	-	0.26	(0.15)	0.18	(0.12)
Trifolium pratense	0.48	94.40	-	-	0.18	(0.13)	0.18	(0.13)	-	-
Lathyrus pratensis	0.39	94.78	-	-	0.26	(0.15)	-	-	-	-
Lysimachia nummularia	0.37	95.15	0.08	(0.03)	-	-	-	-	0.18	(0.13)
Festuca rubra	0.36	95.51	-	-	0.25	(0.25)	-	-	-	-
Prunus sp.	0.35	95.86	-	-	0.24	(0.08)	-	-	-	-
Achillea millefolium	0.33	96.18	0.25	(0.25)	-	-	-	-	-	-
Erigeron annuus	0.33	96.51	-	-	-	-	0.26	(0.15)	-	-
Galium mollugo	0.29	96.80	-	-	-	-	-	-	0.18	(0.13)
Vicia cracca	0.27	97.06	-	-	0.18	(0.13)	-	-	-	-
Sonchus asper	0.27	97.33	-	-	0.18	(0.13)	-	-	-	-
Vicia species	0.26	97.59	-	-	0.18	(0.13)	-	-	-	-
Ranunculus repens	0.26	97.85	-	-	-	-	-	-	0.18	(0.13)
Veronica chamaedrys	0.25	98.10	-	-	0.18	(0.13)	-	-	-	-
Plantago lanceolata	0.25	98.35	-	-	0.18	(0.13)	-	-	-	-
Poa palustris	0.25	98.60	-	-	-	-	-	-	0.18	(0.13)
Leucanthemum vulgare	0.24	98.85	-	-	-	-	0.18	(0.13)	-	-
Luzula multiflora	0.24	99.08	0.18	(0.13)	-	-	-	-	-	-
Stellaria graminea	0.23	99.32	0.18	(0.13)	-	-	-	-	-	-
Trifolium repens	0.23	99.54	-	-	-	-	0.18	(0.13)	-	-
Lolium perenne	0.23	99.77	-	-	-	-	0.18	(0.13)	-	-
Acer pseudoplatanus	0.13	99.89	0.08	(0.03)	-	-	-	-	-	-
Trifolium hybridum	0.11	100.00	-	-	-	-	0.08	(0.03)	-	-