Securing Sustainable Dendromass Production with Poplar Plantations in European Rural Areas

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Deliverable

D1.8: Biodiversity Monitoring:

Final Results

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Contributing partners:	IKEA Industry (providing basic data on field localisation)
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Document History

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0.1	25.05.2022	Rastislav Lasák	Initial draft
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0.3	16.06.2022	Matthias Meyer	Revised version
1.0	17.06.2022	Sandra Liebal, Rastislav Lasák	Final version

List of Abbreviations

Abbreviation	Denotation
D4EU	Dendromass4Europe
INV	Invasive plant species
NAT	Natural plant species
OBV	Optimal biodiversity vertex
PGS	Plant species group
RUD	Ruderal plant species
SRWC	Short rotation woody crops – fast-growing poplar trees plantation
WP	Work package

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1 Role and relevance of the deliverable within the project

The investigation summarised in D1.8 Biodiversity Monitoring has been carried out as part of the WP1 - Land Evaluation / Remediation and Farm Cooperation, Task 1.3: Environmental Impact Assessment and monitoring (M2-M60). The main role of this deliverable was the elaboration of the conceptual framework for and the evaluation of biodiversity data collected during the project D4EU to inform other project partners about the biodiversity value of SRWC localities. The present results were complemented by recommendations that can lead SRWC operators who seek to increase the biodiversity value of these areas in order to achieve positive effects for nature. The biodiversity monitoring results have frequently been used for the communication with official environmental authorities in Slovakia and with public stakeholders.

2 Responsibilities

Within the project D4EU, the work package WP1 “Land evaluation, remediation and farm cooperation” (WP leader IKEA Industry) comprises task T1.3 “Environmental Impact Assessment and Monitoring”. The present deliverable D1.8 on D4EU’s biodiversity monitoring summarises the investigations of the partner DAPHNE Institute of Applied Ecology. This partner is responsible for gathering and evaluation of biodiversity data required for the assessment of the impact of D4EU’s SRWC localities on biodiversity. The following experts were involved in drafting the conceptual framework, in biodiversity data acquisition, and in data evaluation:

+ Mgr. Rastislav Lasák, Mgr. Viera Šefferová Stanová, PhD. – vegetation
+ Mgr. Jozef Tomeček – Amphibians
+ Ing. Tomáš Olšovský, PhD. – Lepidoptera and Coleoptera
+ Mgr. Rudolf Jureček – birds
+ Mgr. Rastislav Lasák, RNDr. Ján Šeffer, CSc.– methodological approach, data evaluation

3 Task, problem definition and research objectives

Biodiversity is an important topic for determining areas for SRWC expansion. Fast-growing trees are more competitive over native plants and therefore they have led to increasing concerns of nature conservation authorities or scientists about the direct effects that the expansion of energy cropping or of tree plantations could have on biodiversity. The independent assessment of impacts on SRWC plantation in Slovakia on biodiversity was one of the basic requirements of the project. Two types of monitoring were done:

1. Regular monitoring of selected indicator animal groups and vegetation for a period of 4 years from 2018 to 2022.
2. Ad hoc independent assessment of species/habitat realised before planting of SRWC plantation as this was requested from project partners by official environmental authorities.

The availability of specific information about the effect of D4EU’s SRC plantations on biodiversity is essential for IKEA communication strategies, because in most cases the new, visible activities in the landscapes, that are yet unknown to local residents, are commonly rejected by the public.

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To gather and evaluate appropriate data is the main goal of the project task T 1.3 - Environmental impact assessment and monitoring.

As it is not possible to cover all species, or all aspects of biodiversity, the representative species groups – vegetation, birds, amphibians, butterflies and beetles – were chosen as main targets of research and monitoring. Additional research objects were specimens that can be easily determined in the field such as mammals, reptiles or insects. They were classified at least at the taxonomic level of the order that they belong to.

Description of the approach:

1. Preparation of monitoring methodologies for each group – vegetation, birds, amphibians, butterflies, and beetles, including field form with defined monitoring parameters.
2. Preparation of the information system for data collection.
3. Field monitoring, input of data into the database, evaluation and reporting.

4 Theoretical background, scope and limitations

The status of the biodiversity is the key factor needed to understand the potential impact of poplar plantations on the biotic nature and to deduce recommendations for the SRWC practice. It can be evaluated at landscape level or at species level. In the scope of the present project, the species level is used because it offers detailed information needed for such dynamic ecosystem like fast-growing tree species' plantations.

Data was acquired by means of regular monitoring of important biodiversity groups in SRWC localities. For monitoring all SRWC localities and all species groups, the limited expert and time capacities had to be considered. Therefore, the following groups of biota were selected as representative groups, and the monitoring and investigation results are separately described in the subsequent chapters:

- Plants (*Planta*)
- Birds (*Aves*)
- Amphibians (*Amphibia*)
- Butterflies (*Lepidoptera*)
- Beetles (*Coleoptera*)

All SRWC localities in D4EU were surveyed by means of a baseline plant and vegetation inventory in the year 2018 and by subsequent monitoring in each of the years till 2021 at the size level of individual SRWC localities.

Reference monitoring for birds, amphibians, beetles and butterflies was carried out on selected representative SRWC localities with reference control samples outside the SRWC localities, in the years 2018 - 2022.

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5 Research design and methods

5.1 Vegetation monitoring (*Planta*)

By **plant and vegetation monitoring,** information on the overall status of biodiversity was gathered on 86 SRWC localities in the years 2018 – 2022 (See Fig.1). Monitoring uses the method of repeating biotope mapping, described in the Catalogue of Biotopes of Slovakia (Stanová, Valachovič 2002), where the presence of all **vascular plant** species is recorded passing through transect over whole area of **each D4EU SRWC locality**. For each plant species, the abundance in Tansley scale (1 = less than 1%, 2 = over 1% and less than 50%, 3 = over 50%) is also recorded. On the same transect the recordings of presence of specimens of additional species groups; mainly **mammals, reptiles, insects** and **molluscs** were collected. Data from plant and vegetation monitoring was entered in a MS Access database.

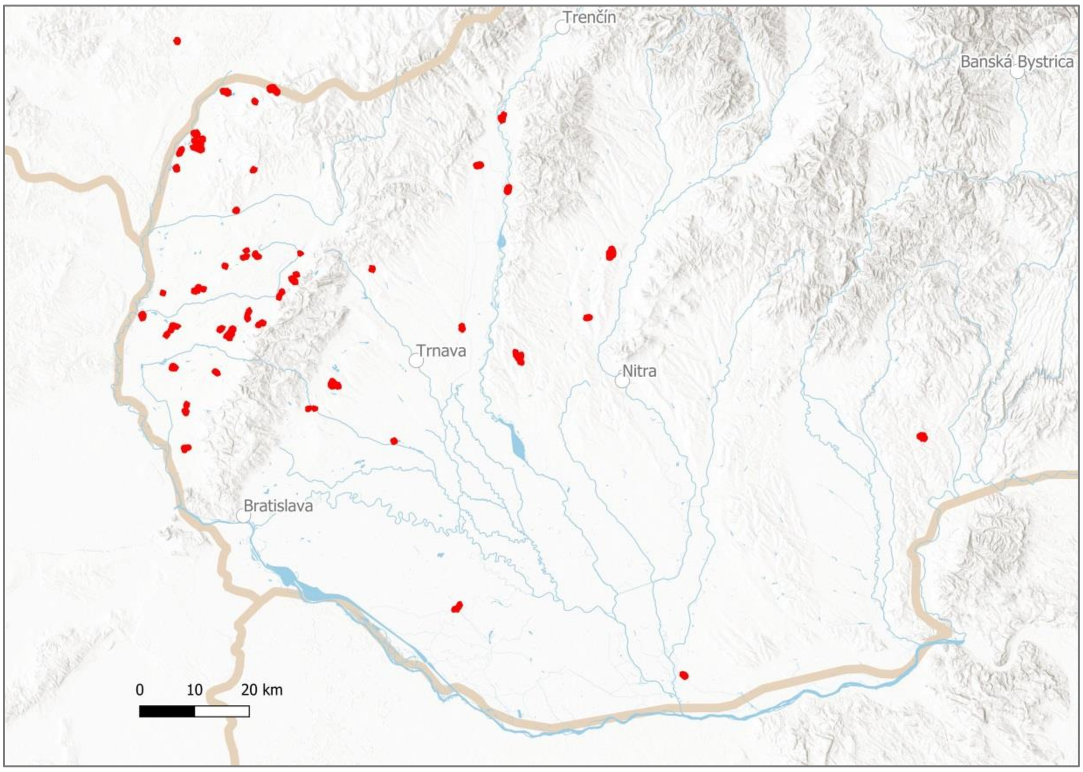

Figure 1: 86 SRWC localities with realised vegetation monitoring are marked by red color (Brown lines indicate the borders of the Slovak Republic (Capital Bratsilava) with Austria in the West, Hungary in the South, and Czechia in the North.

The main purpose of **Reference monitoring** realised on animal groups was to describe the differences between SRWC localities and their surrounding reference biotopes, allowing an assessment of the status of biodiversity in the area. It was done for 4 animal species groups: **birds, amphibians, butterflies** and **beetles**. For each of the animal species groups, the representative SRWC localities were selected based on occurrence of neighbouring biotopes, of the type of prior land use before plantation and of the suitability for a particular species group (See Fig.1). For each selected SRWC locality at least one transect within the area of SRWC and at least one transect per neighbouring biotope were defined as reference or control samples. The geographical position of transects was recorded by GPS. Data were

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entered in spreadsheets and then imported into the information system which is based on MS Access and was developed specifically for this task. Each record contains information about the site visit (locality ID, transect ID, date, mapper name) and information on species occurrence (taxon name, character of occurrence, abundance).

5.2 Birds (*Aves*)

For reference monitoring of birds, 17 SRWC localities were selected (Fig. 2). These were visited at least 3 times per year: first visit was done during the winter season from December till February. The following two visits were done during the birds nesting season from (April – June). Each SRWC locality was monitored by passing through a defined transect inside the area of the respective SRWC locality and one within the neighboured biotope as reference control sample. All visual and acoustic signs of activities of bird species were recorded. In some cases, bird species in surrounding biotopes were recorded that can potentially occur in SRWC localities.

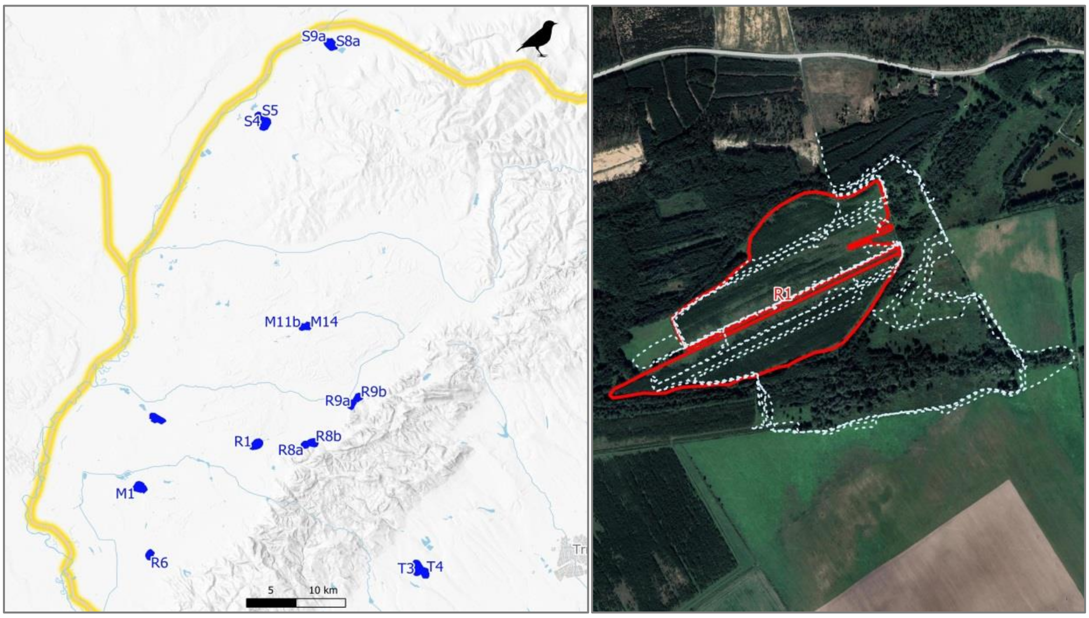

Figure 2: 17 SRWC localities for reference monitoring of bird species (left). Example of several bird monitoring transects of locality R1 (right)

5.3 Butterflies (*Lepidoptera*)

For the reference monitoring of butterflies, 11 SRWC localities were selected (Fig. 3). Those were visited 3 times within the season from April till September. Transects within the area of SRWC locality and in reference neighbouring biotope were passed by zigzag method observing activities of butterfly species. Individual specimens were caught with an entomological net and were freed after taxonomic determination and data recording.

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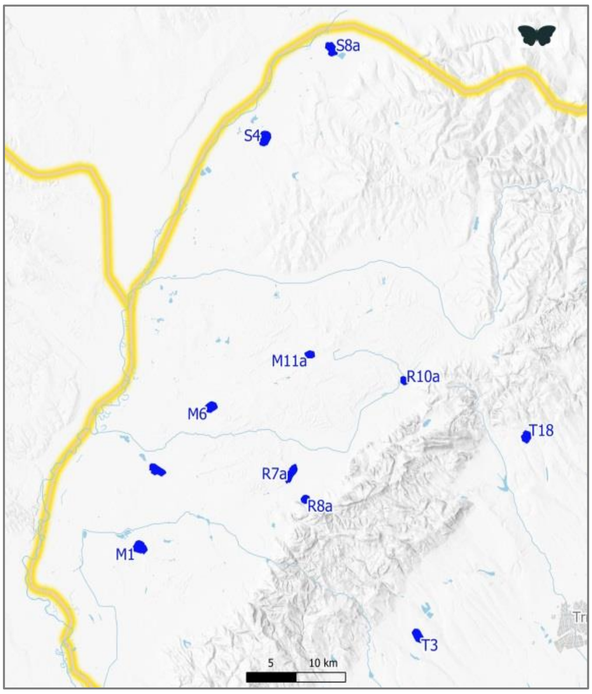

Figure 3: 11 SRWC localities for reference monitoring of butterflies (left). An example of butterflies monitoring transects of locality S4 – one within SRWC locality and two controls in adjacent habitats (right)

5.4 Amphibians (*Amphibia*)

For the reference monitoring of amphibians, 11 D4EU SRWC localities were selected (Fig. 4). These were visited minimum 3 times per year. Two visits were done in period March-June, and one during July-September. The minimum length of both transects – that within the SRWC field and that in the reference biotope – was 400 m and the width was approx. 5 m. Passing through defined transects, all visual and acoustic activities of amphibian species were recorded. Each transect was visited in both, day and in night-time.

To record more amphibian species, traps and sound recorders were installed in the 2nd and 3rd project years. Traps were 15 m long foil barriers with a plastic tub at the end (Figure 5). Caught individuals were recorded and freed.

Installed sound recorders (Figure 6) were helpful for capturing of nocturnal activities of amphibians within SRWC localities as well as activities of amphibians in peripheral biotopes. Recorded sounds were analysed with the help of Audacity software (https://www.audacityteam.org).

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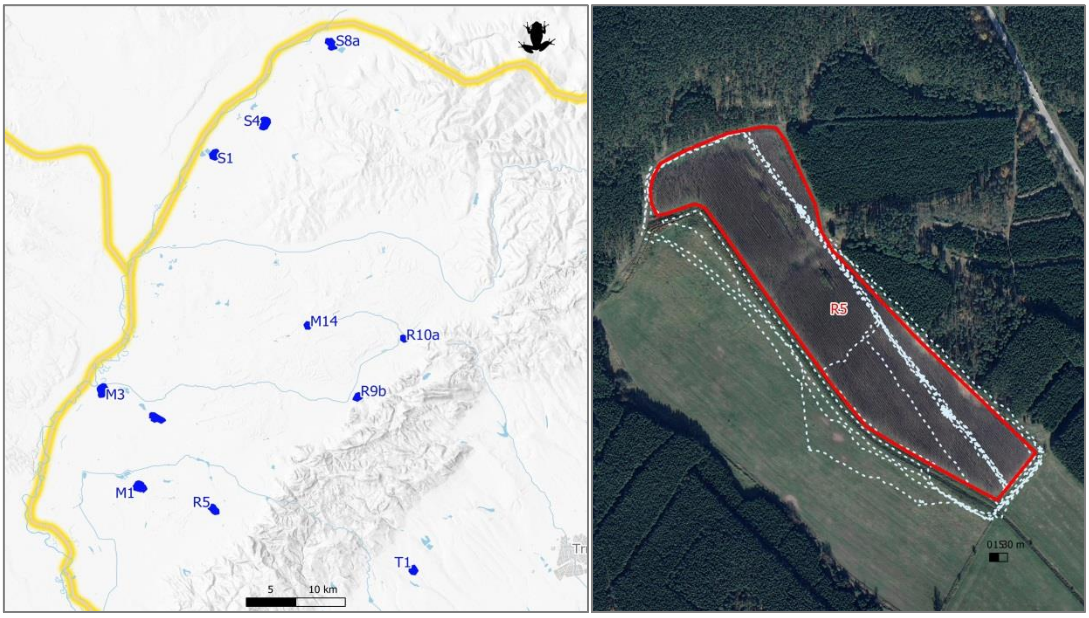

Figure 4: 11 SRC localities for reference monitoring of amphibian species (left). An example of amphibian monitoring transects in SRWC locality R5 and its neighborhood (right)

Figure 5: Example of trap for amphibian species in locality S8a

Figure 6: Sound recorder

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5.5 Beetles (*Coleoptera*)

For reference monitoring of beetles, 11 SRWC localities were selected (Fig. 8). Those were visited 4 times within the period from April till October. For monitoring were used standardized inventarisation rules according to Ministry of Environment, Land and Parks, Victoria, BC, Canada, 1998.

Terrestrial species were hunted with a sweep net (perimeter 35 cm), with beating nets (100 cm), by using leaf litter sieves and by catching individuals.

Ground traps were used for epigeic species of beetles (see schematic image of a trap on Figure 7). 10 traps were placed, one for every 10 m of the transect. They were checked 2-3 days after installation.

Endangered, protected and easily determined species were immediately freed after determination. Other species were determined in laboratory with a help of microscope.

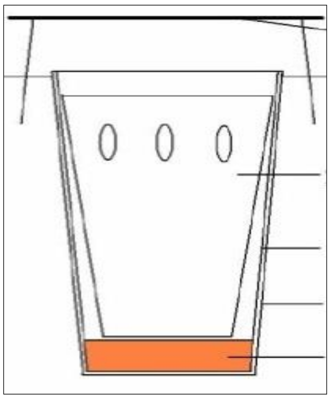

Figure 7: Beetle trap schema

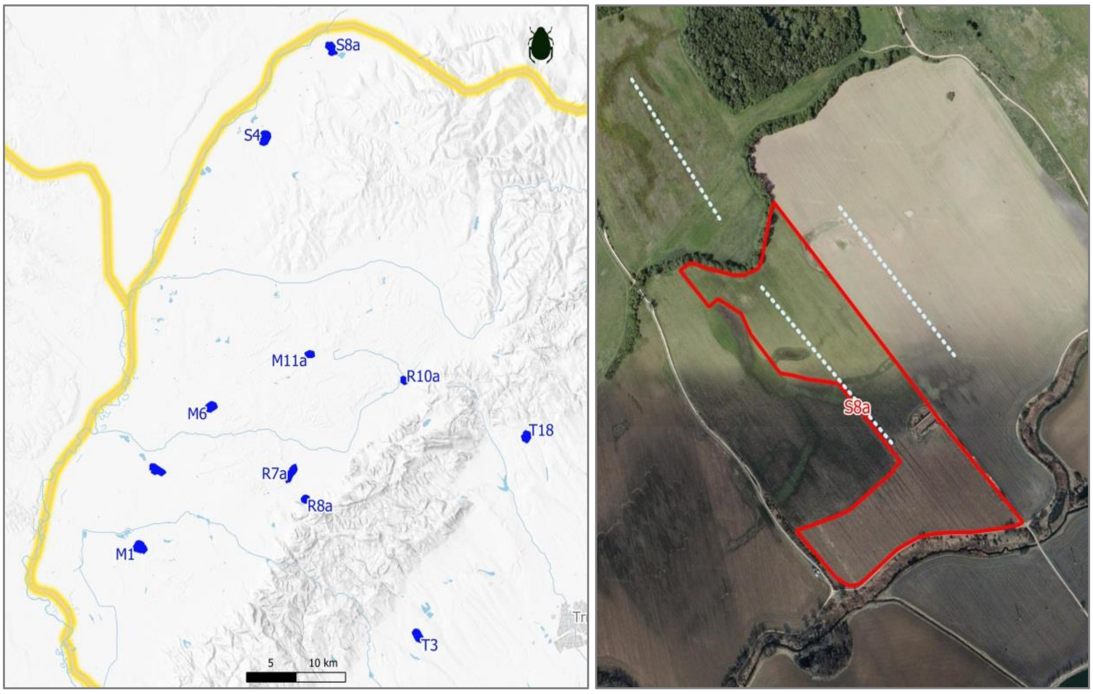

Figure 8: 11 SRWC localities for reference monitoring of beetles (left). An example of beetles monitoring transects of locality S8a – one within SRWC locality and two reference plots in adjacent habitats (right)

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6 Results

All biodiversity data collected in the field was stored in the information system/database created for the project's D4EU purposes. The major part of this data is published on the webpage http://daphne.sk/d4eu/index.html, being accessible for D4EU project partners and for the community of biodiversity experts. An overview over the entire project activities for data collection during the inventory monitoring and the reference monitoring is given in Table 1.

Table 1: Overview of collected data from all monitoring seasons and all monitoring localities for the project D4EU, separately discussed in following chapters.

Inventory monitoring	n localities				n records				n different species			
	2018	2019	2020	2021	2018	2019	2020	2021	2018	2019	2020	2021
Plant species records	74	84	76	87	2489	3155	3732	4207	311	342	404	403
Animal species records					668	273	354	345	102	44	48	45

Reference monitoring	n localities				n records				n species in SRWC (and in control sites)			
	2018	2019	2020	2021	2018	2019	2020	2021	2018	2019	2020	2021
Birds	11	12	13	14	1171	1247	2030	1724	34 (67)	37 (61)	49 (74)	37 (71)
Amphibians	8	9	10	11	145	247	514	566	6 (4)	6 (1)	8 (5)	10 (5)
Butterflies	8	9	10	11	380	431	310	359	29 (37)	37 (38)	29 (41)	29 (41)
Beetles	8	9	10	11	978	1326	2254	3159	161 (194)	207 (208)	237 (233)	231 (228)

6.1 Birds (*Aves*)

In total, 151 different bird species were recorded during all four seasons in 14 localities (see Map 5.2). 65 of them were recorded at SRWC localities, 112 at control transect biotopes and 137 species were found in surrounding biotopes. The higher number of species in areas outside of the monitored SRWC localities is due to the fact that there is a greater diversity of habitats such as fields, shrubs, grasslands and ruderal areas.

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Table 2: Overall numbers of different bird (*Aves*) species / number of bird species with nesting activities, and the (number of bird individuals), separately for all monitoring localities (coded locality names; M = Malacky, R = Rohožník, S = Skalica, T = Trnava), and for all four annual monitoring seasons.

Locality (code)	2018-2019		2019-2020		2020-2021		2021-2022	
	Reference plot	SRWC	Reference plot	SRWC	Reference plot	SRWC	Reference plot	SRWC
M1	17 / 3 (1623)	17 / 3 (231)	11 / 1 (68)	15 / 1 (78)	7 / 0 (25)	11 / 4 (33)	7 / 0 (21)	9 / 2 (27)
M2b	9 / 1 (71)	9 / 2 (28)	8 / 0 (31)	12 / 2 (24)	9 / 2 (57)	10 / 2 (29)	15 / 3 (40)	10 / 4 (25)
R1	40 / 3 (560)	19 / 4 (54)	40 / 3 (734)	14 / 0 (43)	41 / 3 (283)	23 / 5 (61)	39 / 2 (169)	13 / 3 (26)
R8a	15 / 1 (42)	3 / 0 (6)	7 / 0 (20)	2 / 0 (6)	20 / 2 (96)	4 / 0 (8)	24 / 0 (69)	3 / 1 (6)
R8b	15 / 0 (53)	4 / 0 (13)	1 / 0 (5)	5 / 2 (11)	16 / 2 (77)	10 / 1 (38)	5 / 2 (12)	5 / 1 (12)
R9a	16 / 1 (25)	3 / 0 (10)	24 / 1 (55)	1 / 0 (6)	38 / 2 (158)	7 / 0 (11)	35 / 4 (139)	2 / 0 (2)
R9b	6 / 0 (37)	6 / 2 (11)	12 / 0 (43)	6 / 1 (15)	27 / 1 (77)	7 / 2 (12)	26 / 1 (129)	6 / 1 (9)
S4	28 / 3 (64)	7 / 4 (39)	27 / 1 (65)	9 / 4 (44)	36 / 3 (223)	12 / 3 (78)	31 / 4 (79)	8 / 1 (37)
S5	20 / 2 (43)	8 / 2 (14)	24 / 2 (56)	6 / 0 (40)	24 / 3 (66)	6 / 1 (12)	22 / 5 (51)	4 / 1 (8)
S8	22 / 2 (326)	9 / 2 (26)	16 / 1 (150)	13 / 1 (77)	18 / 3 (148)	18 / 3 (122)	16 / 3 (61)	11 / 3 (56)
T234	4 / 0 (20)	4 / 0 (11)	11 / 1 (62)	7 / 1 (37)	9 / 0 (88)	13 / 4 (55)	10 / 0 (57)	13 / 2 (41)
M11b			5 / 0 (31)	4 / 2 (13)	6 / 2 (23)	14 / 2 (77)	5 / 1 (11)	10 / 3 (26)
M14					8 / 0 (93)	8 / 1 (84)	6 / 1 (26)	8 / 1 (12)

A detailed graphical visualization of Table 2 is given in Figure 9. The graph shows the number of (nesting and non-nesting) bird species in SRWC localities and in their respective reference plots located within different biotopes.

In most cases regarding localities where an arable field was selected as reference biotope (M1, M11b, M2b, R9b, S4, M14, R6, T234 - coded locality names, M = Malacky, R = Rohožník, S = Skalica, T = Trnava), the number of bird species, and also of bird species with nesting activities, is equal or even higher inside the SRWC localities than in the reference arable fields. On the other hand, and as expected, the number of bird species is lower in SRWC localities as compared with reference plots in semi-natural habitats such as forests, wetlands or grasslands.

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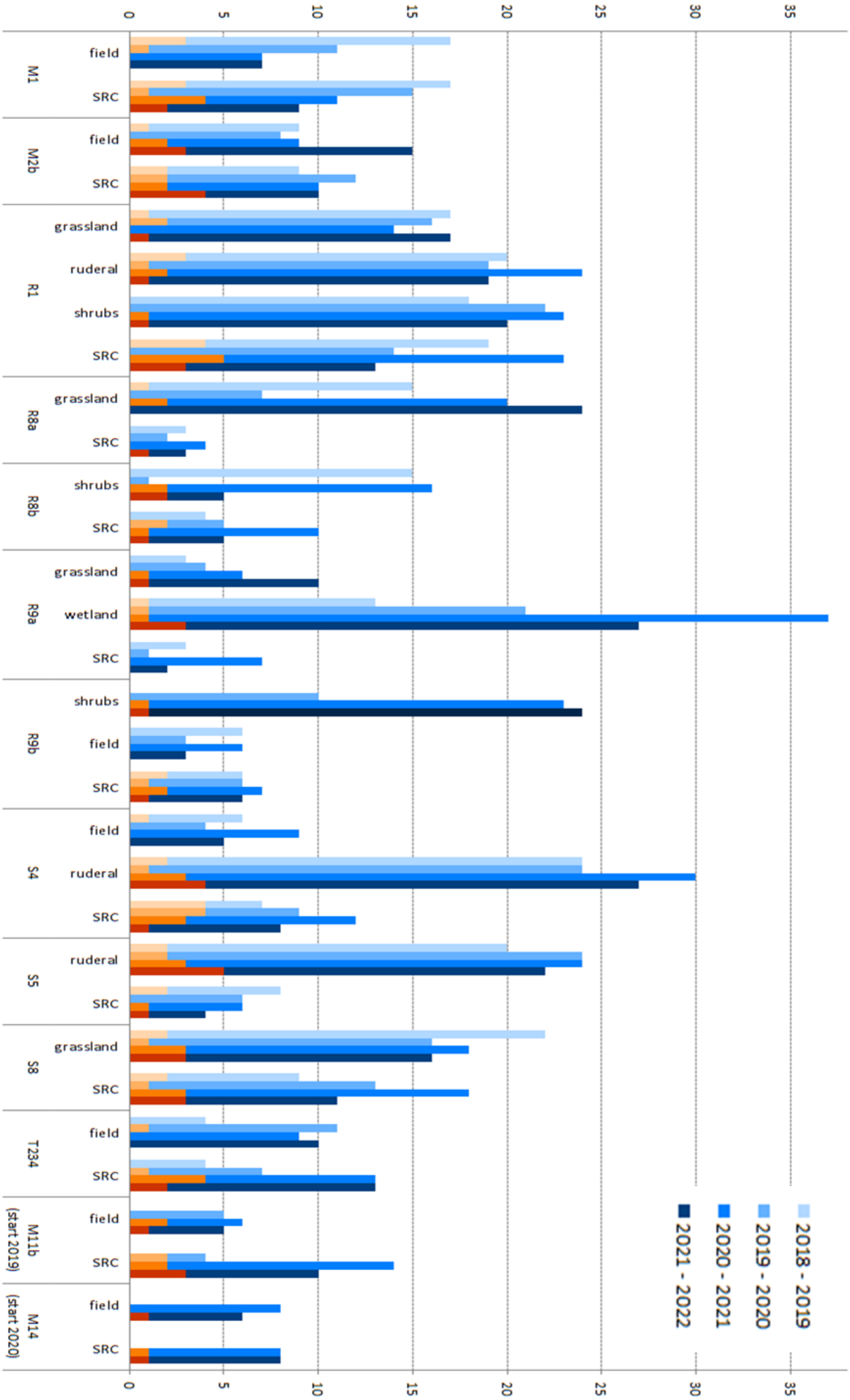

Figure 9: Number of different bird species in SRWC and reference transects during four D4EU project seasons. Different blue colours refer to the overall number of bird species in different years, orange colours to the number of bird species with nesting activities. (Coded locality names; M = Malacky, R = Rohožník, S = Skalica, T = Trnava.)

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Figure 10 shows the same categories of of bird species numbers (non-nesting and nesting) as shown in Figure 9, but the focus is on the records from SRWC localities only, excluding data from reference transects. It shows that bird species were recorded in all SRWC localities in the SRWC crops. Furthermore, in all localities except R9a, nesting activities were recorded for several of the species found.

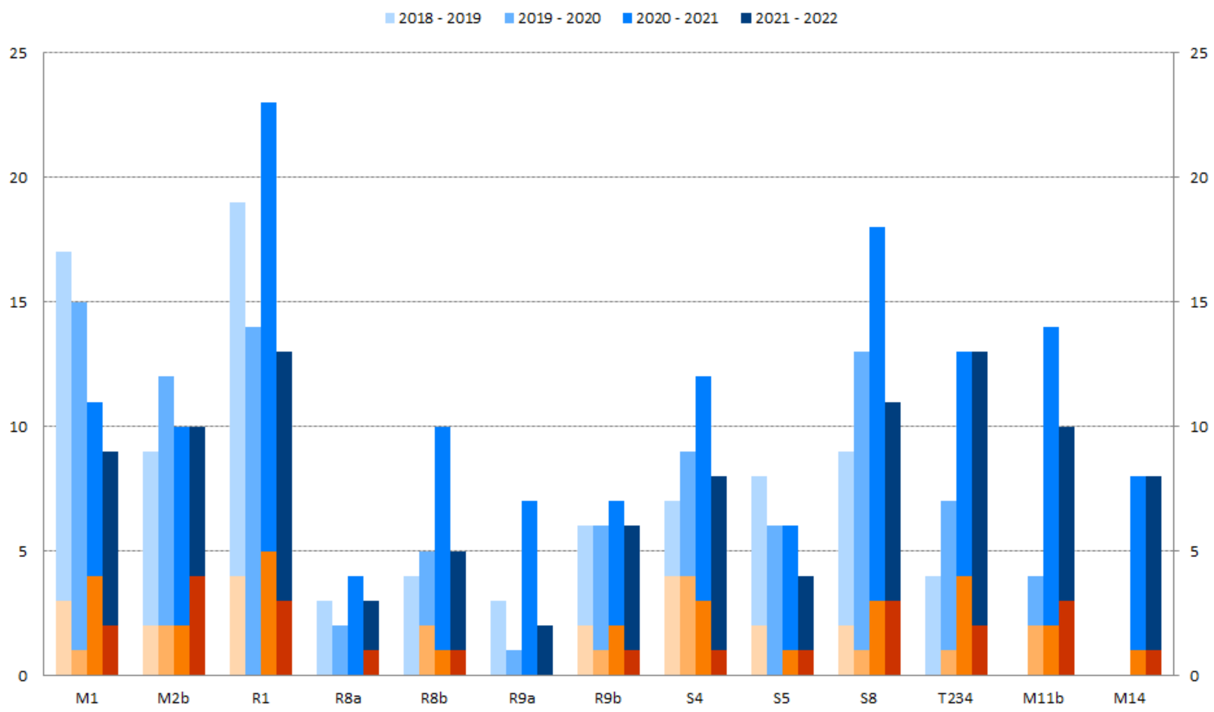

Figure 10: Number of bird species during all four seasons in SRWC localities only (excluding those records from neighboured reference transects) during four D4EU project seasons. Different blue colours refer to the overall number of bird species in different years, orange colours to the number of bird species with nesting activities.

The overall presentation of different characteristics of bird species data is shown in Figure 11. It covers 7 characteristics of bird species records: 5 attributes of nesting ('non-nesting', 'assumed', 'possible', 'probable' and 'confirmed'), as well as 'migration' and 'wintering'. As it turned out, the number of individuals is higher in reference plots while the number of different species is mostly equal or even higher inside the SRWC localities.

There were overall 30 different bird species recorded with nesting activities in SRWC localities and in their reference habitats. The number of individuals of these species is shown separately for biotope types in Figure 12. 20 of these bird species occurred in SRWC localities and in other (reference) biotopes, while 10 bird species were recorded only in SRWC localities. Three of the most abundant species with nesting activities were the western yellow wagtail (*Motacilla flava)* (106 individuals), the common pheasant (*Phasianus colchicus)* (26 individuals) and the European stonechat (*Saxicola rubicola)* (23 individuals). Nesting has been confirmed in the European stonechat species. The species with the 'confirmed' nesting characteristic that were recorded only in SRWC localities allow the conclusion that SRWC sites can serve as alternative nesting habitat for birds.

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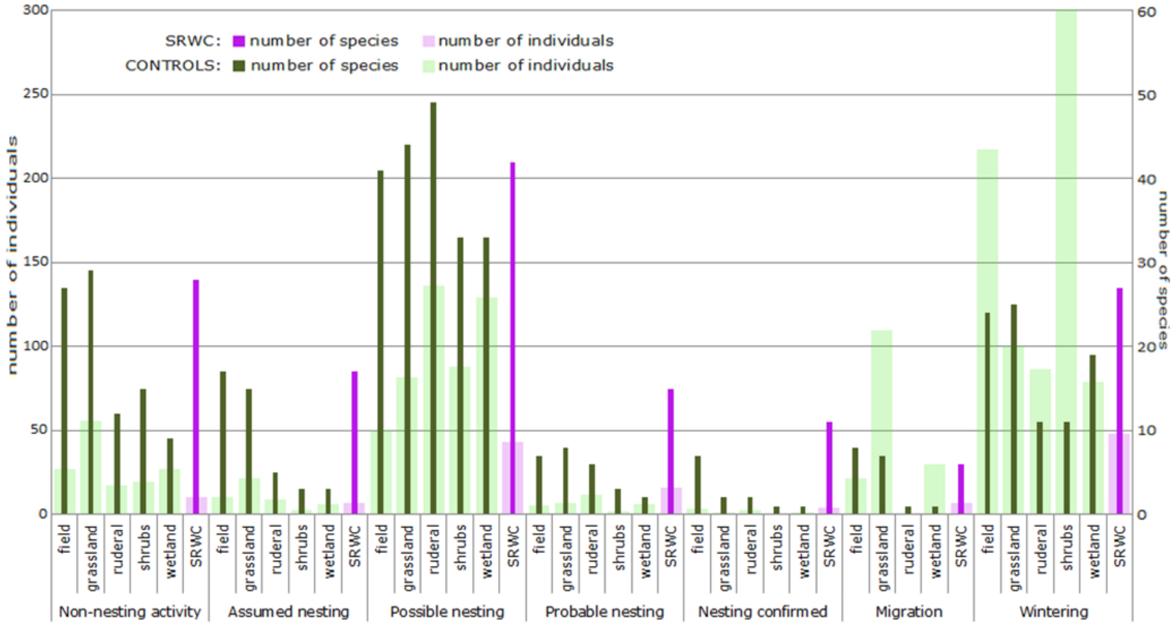

Figure 11: Summary of 7 characteristics of bird species records (migration, wintering and 5 nesting characterstics) represented with the number of species and the average number of individuals (violet = SRWC, green = reference biotopes)

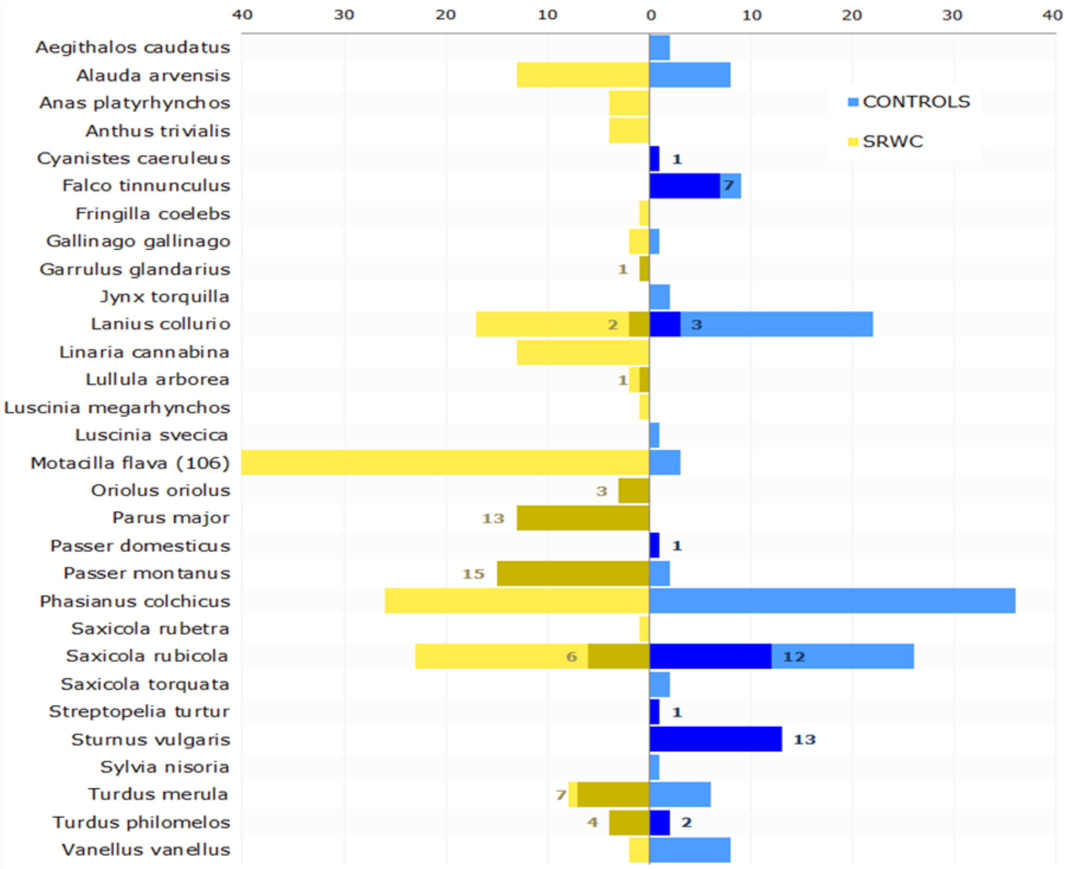

Figure 12: Number of individuals of bird species recorded with their nesting activities in SRWC (yellow) and reference/control (blue) plots. Dark colors and the respective numbers represent the species with confirmed nesting.

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More details about (i) different SRWC localities used by bird species with nesting activities and about (ii) nesting differences between the different monitoring seasons are given in Table 3 and Table 4. The most frequent species are *Phasianus colchicus*, confirmed in 8 SRWC sites, and Lanius collurio, confirmed in 7 sites. The nesting of the species *Parus major, Oriolus oriolus, Turdus philomelos, Lullua arborea, Passer montanus* and *Turdus merula* was confirmed at all localities of occurrence. One half of these species occurs in the SRWC locality R1, but nesting was not confirmed there. This locality was originally established on abandoned grassland, and it is surrounded by rather natural biotopes.

Table 5 shows the overall number of records collected for all bird species inside D4EU SRWC localities. The three species with the highest frequency over all monitoring localities in SRWC only are:

- Common blackbird (*Turdus merula*) on 12 sites,
- Yellowhammer (*Emberiza citrinella*) on 11 sites,
- Red-backed shrike (*Lanius collurio*) on 10 sites.

The three species with the highest number of records inside SRWC localities, over all monitoring sites, are listed below, while several larger or relatively rare bird species, sauch as some bird of prey species and the Common quail, were recorded only once:

- Skylark (*Alauda arvensis*) 77
- Western yellow wagtail (*Motacilla flava*) 50
- Yellowhammer (*Emberiza citronella*) 48

The locality with the lowest number of records was R6 (Rohožník 6) with 6 records, while the average number of records per locality was 49.9 (± SE 31.2). The localities with relatively high over-all numbers of bird records were:

- M1 (Malacky 1) – 96 records
- R1 (Rohožník 1) – 95 records
- S8 (Skalica 8) – 78 records
- T234 (Trnava 234) – 77 records

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Table 3: Summary of bird species recorded with nesting activities in SRWC per monitoring locality (coded locality names in the header of the table; M = Malacky, R = Rohožník, S = Skalica, T = Trnava.) (Number of records with confirmed nesting is given behind slashs, marked with grey colour.)

Species / Taxon	M1	M11b	M14	M2b	R1	R8a	R8b	R9b	S4	S5	S8	T234
Alauda arvensis	2	1			1			2	7			
Anas platyrhynchos					2						2	
Anthus trivialis				4								
Fringilla coelebs					1							
Gallinago gallinago					2							
Garrulus glandarius	1/1											
Lanius collurio	2			2	6		2	2		2/2	1	
Linaria cannabina		5			4						2	2
Lullula arborea									2/1			
Luscinia megarhynchos										1		
Motacilla flava							3	1	37		65	
Oriolus oriolus	1/1								1/1			1/1
Parus major						3/3	6/6			4/4		
Passer montanus				15/15								
Phasianus colchicus	4	1		7	1			1	4		1	7
Saxicola rubetra					1							
Saxicola rubicola		10	7/1	1					5/5			
Turdus merula	1/1			1	2/2			2/2		2/2		
Turdus philomelos	3/3											1/1
Vanellus vanellus					2							

Table 4: Summary of bird species recorded with nesting activities in SRWC during different monitoring seasons. (Number of records with confirmed nesting behind slash, marked grey.)

Species / Taxon	2018	2019	2020	2021
Alauda arvensis	6	7		
Anas platyrhynchos				4
Anthus trivialis				4
Fringilla coelebs				1
Gallinago gallinago			2	
Garrulus glandarius			1/1	
Lanius collurio		2	15/2	
Linaria cannabina	2	2	4	5
Lullula arborea	1/1	1		
Luscinia megarhynchos	1			
Motacilla flava	14	17	38	37
Oriolus oriolus			3/3	
Parus major				13/13
Passer montanus	9/9	6/6		
Phasianus colchicus	9	6	3	8
Saxicola rubetra			1	
Saxicola rubicola			12/5	11/1
Turdus merula	2/2		2/2	4/3
Turdus philomelos	1/1		2/2	1/1
Vanellus vanellus	2			

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Table 5: Overall numbers of records for all bird species collected inside D4EU SRWC localities. f = Frequency per all localities. (Coded locality names in the table header; M = Malacky, R = Rohožník, S = Skalica, T = Trnava.)

Taxon valid	f	n records	M1	M11b	M14	M2b	R1	R6	R8a	R8b	R9a	R9b	S4	S5	S8	T234
Accipiter nisus	1	1														1
Acrocephalus palustris	2	3					1								2	
Acrocephalus scirpaceus	1	1													1	
Alauda arvensis	9	77	11	7	1		7			5		8	13		9	16
Anas platyrhynchos	2	2					1								1	
Anthus pratensis	3	4				1	1								2	
Anthus trivialis	5	18				6	5	2			1		4			
Asio flammeus	1	1											1			
Buteo buteo	5	6				1				2			1		1	1
Carduelis carduelis	8	13	2	1	2	1	1				1	2			3	
Coccothraustes coccothraustes	2	2				1									1	
Columba palumbus	4	8	5							1				1	1	
Corvus corax	1	1		1												
Coturnix coturnix	1	1											1			
Cuculus canorus	1	1													1	
Curruca communis	3	5		1			2								2	
Cyanistes caeruleus	2	2	1												1	
Dendrocopos major	3	5											2	1	2	
Dryobates minor	1	1					1									
Emberiza calandra	1	2								2						
Emberiza citrinella	11	48	9	1		6	3		4	2	3	3		3	5	9
Emberiza schoeniclus	7	16	2		1	2	4						3		3	1
Erithacus rubecula	2	2	1										1			
Falco tinnunculus	4	6	2	1								2				1
Fringilla coelebs	8	21	8		1	2	2		1				2		2	3
Fringillidae sp.	1	1													1	
Gallinago gallinago	1	1					1									
Garrulus glandarius	2	3	2							1						
Hippolais icterina	2	2													1	1
Hirundo rustica	1	1					1									
Chloris chloris	1	1					1									
Jynx torquilla	1	1			1											
Lanius collurio	10	29	3	2	3	5	7			1		3	1	1	3	
Lanius excubitor	5	6	1				1						1		2	1
Linaria cannabina	6	14		5	1		3						1		3	1
Locustella naevia	1	4					4									
Lullula arborea	8	32	5	5	1	12	2		1				5	1		
Luscinia megarhynchos	1	2												2		
Luscinia svecica	1	1					1									
Milvus milvus	1	1					1									
Motacilla alba	9	19	7	2	2	1	1				1	2	1			2
Motacilla flava	8	50	4	2			8			5	1	2	13		15	
Oriolus oriolus	7	18	4			1		2					4	2	2	3
Parus major	9	16	2		1		1	1	1	3				4	1	2
Passer domesticus	1	1				1										
Passer montanus	4	15	7			4				3			1			
Passeriformes sp.	1	1									1					
Phasianus colchicus	9	38	4	1		7	2					1	3	4	2	14
Phylloscopus trochilus	1	1	1													
Picus viridis	2	2							1						1	
Rallus aquaticus	1	1					1									
Saxicola rubetra	5	9		1		1	5					1			1	
Saxicola rubicola	9	27	4	4	3	5	4			2	1	3	1			
Saxicola torquata	2	3					2			1						
Scolopax rusticola	1	1					1									
Serinus serinus	4	6		1	1	2	2									
Streptopelia turtur	5	9	2	2	1							1				3
Sturnus vulgaris	9	19		2			5		1		1	1	1	2	2	4
Sylvia atricapilla	6	11	2				2			1				1	1	4
Sylvia communis	4	9				1	3						1		4	
Troglodytes troglodytes	3	6				1	4							1		
Turdus merula	12	28	3			2	2	1	3	2	3	3	1	4	1	3
Turdus philomelos	8	16	3	1		1	1				1	2		2		5

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Turdus pilaris	1	1													1	
Turdus sp.	1	2														2
Upupa epops	1	1	1													
Vanellus vanellus	1	1					1									
Total	**254**	**657**	**96**	**40**	**19**	**64**	**95**	**6**	**12**	**31**	**14**	**34**	**62**	**29**	**78**	**77**

6.2 Amphibians (*Amphibia*)

6.2.1 Overall amphibian record data

Monitoring results over four monitoring seasons have shown that amphibians can successfully use ecological conditions in fast-growing tree crops (see Table 6 and Figure 13). During these 4 seasons, applying a combination of direct observation methods on transects with trap capturing and with acoustic monitoring at the selected 11 localities within D4EU SRWCs, 10 species of amphibians were found.

Table 6 shows total number of records, and the total number of individuals in brackets, that were recorded during all monitoring seasons in SRWC, reference plots and periphery. Table 7 summarises the records and total numbers of amphibians per monitoring season from 2018 till 2021. As a remarkable result, Figure 14 shows a significant preference of for SRWC sites by amphibian species.

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Table 6: Total number of individual records for amphibian species, and total number of amphibian individuals per species in brackets, recorded during all seasons insinde D4EU SRWC amphibian monitoring sites, separately for the SRWCs (= S), for the reference plots (= r) and for the periphery plots (= p). Species recorded within SRWC are marked by bold letters. (Coded locality names in the table header; M = Malacky, R = Rohožník, S = Skalica, T = Trnava.)

Monitoring locality (amphibians)	plot	***Bombina bombina***	***Bufo bufo***	***Bufo viridis***	***Hyla arborea***	***Pelobates fuscus***	***Pelophylax esculentus***	***Pelophylax lessonae***	***Pelophylax ridibundus***	***Rana arvalis***	***Rana dalmatina***	*Rana temporaria*	*Triturus vulgaris*	no Amphibians
M1	r			2 (2)			1 (3)							23
	p		3 (3)	6 (6)	7 (61)	1 (1)	34 (68)							
	S		9 (9)	26 (38)	7 (37)	4 (4)	11 (52)				3 (5)			37
M14	r			7 (8)										4
	p			2 (2)	11 (23)									
	S			2 (2)	1 (1)									4
M2b	r		1 (1)			2 (2)	2 (2)							31
	p	2 (3)	11 (233)	21 (28)	36 (264)	7 (37)	17 (24)				14 (709)		10 (62)	
	S		1 (1)	18 (27)	17 (81)	11 (48)	9 (11)			1 (1)	1 (1)			14
M3	r		1 (1)				1 (3)				1 (2)			18
	p	4 (11)	1 (1)	9 (13)	40 (449)		22 (133)	3 (36)		3 (3)				
	S		1 (1)	1 (1)	13 (19)	1 (1)	13 (200)		2 (2)		6 (7)			16
R10a	r			4 (4)	11 (14)		7 (7)				5 (14)			13
	p		1 (30)	8 (8)	16 (50)		27 (172)							
	S		2 (2)	17 (28)	8 (11)		3 (5)				13 (1112)			10
R5	r			4 (4)										25
	p			4 (4)	3 (3)		4 (34)				3 (90)	2 (150)		
	S		1 (1)	32 (44)	5 (7)	1 (1)					2 (2)			21
R9b	r			1 (2)										10
	p				43 (258)		7 (12)							
	S			5 (7)	23 (48)									10
S1	r													21
	p				17 (90)	2 (1100)	34 (55)	1 (1)						
	S	1 (1)		3 (4)	9 (18)	1 (1)	1 (3)							23
S4	r			3 (3)			1 (1)							22
	p			1 (1)			21 (113)							
	S		1 (30)	15 (50)	5 (37)	2 (105)	10 (17)		1 (1)					16
S8a	r	2 (2)		2 (2)							1 (1)			22
	p	5 (39)		11 (44)	39 (616)		43 (318)							
	S	11 (72)	1 (1)	23 (76)	23 (202)		19 (32)		1 (1)	4 (6)	3 (4)	1 (1)		23
T1	r													16
	p			3 (3)	6 (10)		33 (200)							
	S			3 (3)	4 (7)		3 (3)							16

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Table 7: Total annual (2018 – 2021) number of individual records for amphibian species, and total number of amphibian individuals per species in brackets, recorded insinde D4EU SRWC amphibian monitoring sites, separately for the SRWCs (= S), the reference plots (= r) and the periphery (= p). Species recorded within SRWC are marked by bold letters.

Year	plots	*Bombina bombina*	*Bufo bufo*	*Bufo viridis*	*Hyla arborea*	*Pelobates fuscus*	*Pelophylax esculentus*	*Pelophylax lessonae*	*Pelophylax ridibundus*	*Rana arvalis*	*Rana dalmatina*	*Rana temporaria*	*Triturus vulgaris*	no Amphibians
2018	r		1 (1)			2 (2)	1 (1)				1 (1)			46
	p	1 (8)	1 (1)	6 (14)	6 (43)	1 (30)	13 (99)	1 (8)						
	S		1 (1)	9 (15)		5 (42)	8 (88)		2 (2)		4 (5)			34
2019	r						3 (5)							46
	p	1 (1)	1 (1)	10 (36)	20 (93)	2 (1100)	39 (310)	1 (1)						
	S		6 (6)	12 (21)	10 (72)	12 (115)	14 (61)				5 (7)			62
2020	r		1 (1)	3 (3)	6 (6)		5 (5)				4 (11)			60
	p		4 (114)	32 (40)	91 (652)	2 (2)	122 (516)			3 (3)	5 (33)		5 (26)	
	S	1 (1)	3 (3)	46 (64)	42 (64)	2 (2)	17 (125)			1 (1)	5 (1103)			54
2021	r	2 (2)		20 (22)	5 (8)		3 (5)				2 (5)			53
	p	9 (44)	10 (151)	17 (19)	101 (1036)	5 (6)	68 (204)	2 (28)			12 (766)	2 (150)	5 (36)	
	S	11 (72)	6 (35)	78 (180)	63 (332)	1 (1)	30 (49)		2 (2)	4 (6)	14 (16)	1 (1)		40

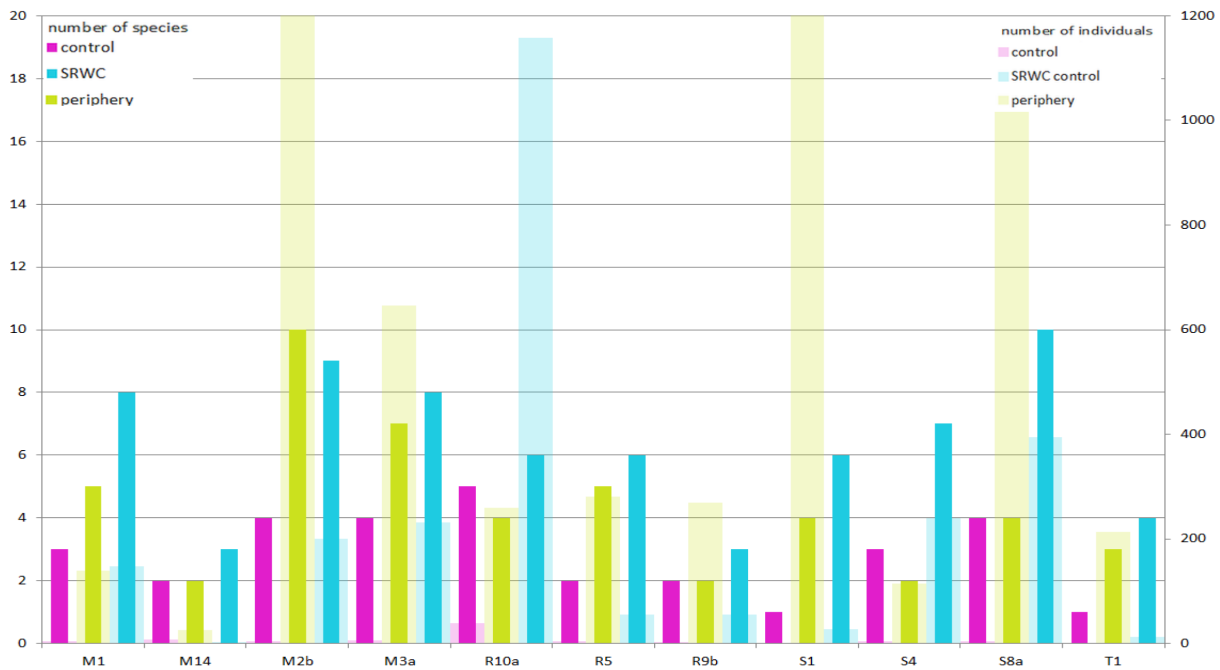

Figure 13: Number of individuals (pale color with scale on right axes) and number of differenet amphibian species (dark color with scale on left axes), separately for SRWC, control and periphery plots of monitoring localities (coded locality names on the x-axis; M = Malacky, R = Rohožník, S = Skalica, T = Trnava).

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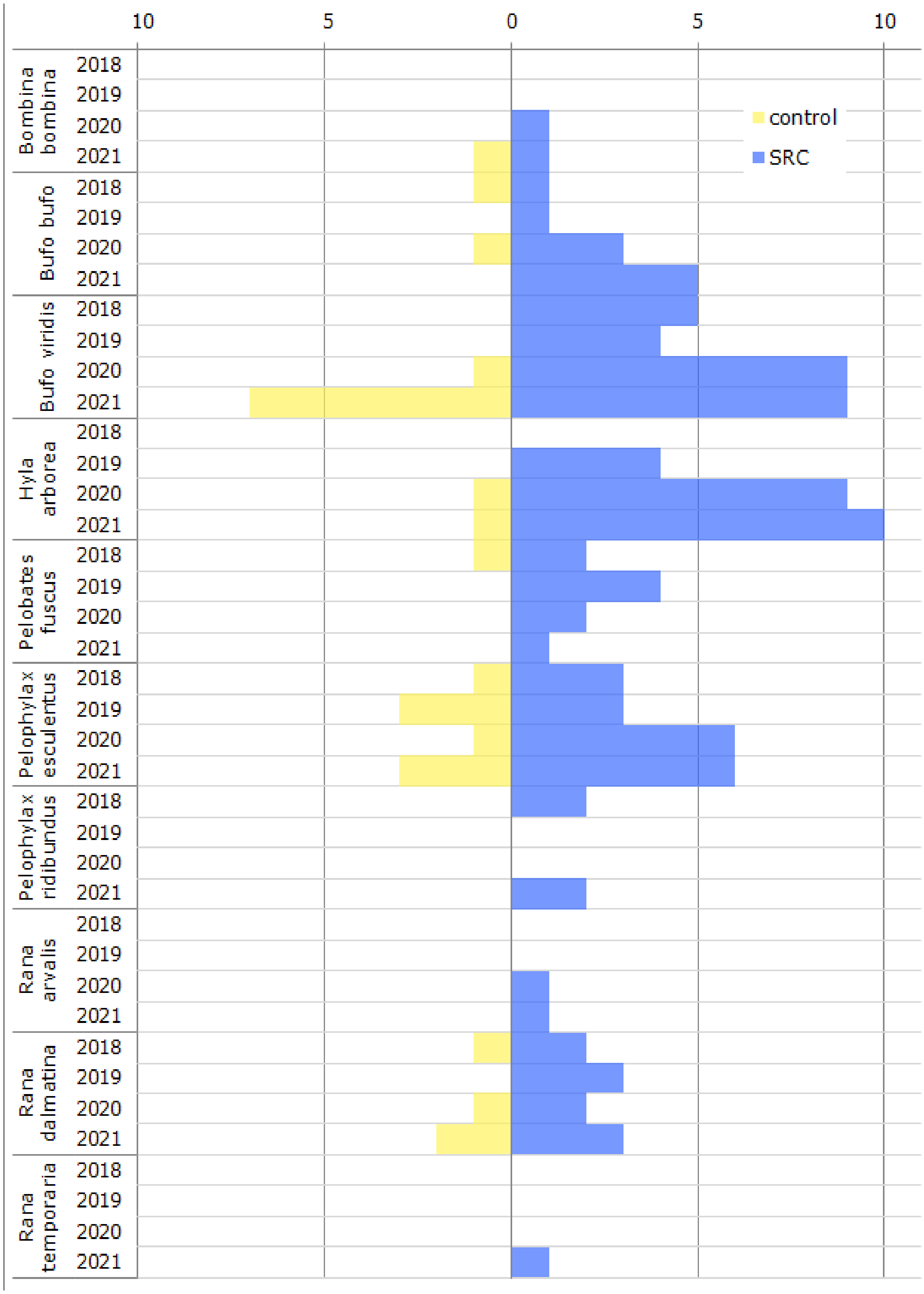

Figure 14: Number of localities of individual amphibian species recorded in SRWC and reference (control) plots

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6.2.2 Species-specific amphibian record descriptions

In the following subsections, species-specific findings and records at specific sites in D4EU SRWC localities are described. The localities are coded in accordance with a project specific internal system, while M denotes Malacky, R = Rohožník, S = Skalica, T = Trnava.

The presence of the European fire-bellied toad (*Bombina bombina*) requireswater and wetlands. This species has been recorded so far near the localities M2b - North of Kostolište, M3 - North of Gajary, in 2020 at locality S1 – Adamov, and in 2021 at locality S8a - North of the village Kátov. Its occurrence in D4EU SRWC is rather random and does not correspond well with the dry character of many SRWC areas of the project.

Common toad (*Bufo bufo*) occurs at several D4EU SRWC sites, and it can use SRWC permanently, with the exception of its reproduction stage, or respectively, only in cases where there wet area inside the SRWC. It is a species that has also been recorded on the edge zone of the fields, and it is among the amphibian species that can adapt well to different conditions of the respective habitat. Within SRWC, it was recorded not only on the edges, but also right in the middle of involved stands.

The European green toad (*Bufotes viridis*) is almost ubiquitous, but its frequency is quite variable. In some localities, it was recorded more or less once only. In other localities, the species is recorded repeatedly. The frequency can relate to the size of the existing population and to the suitability of individual sites for its permanent occurrence. The presence of potential breeding sites (wetlands) and the proximity of watercourses have a positive effect on its occurrence. The gree toad can survive in drier and warmer localities if it finds suitable shelter there. It occured more regularly and more frequently in D4EU localities with SRWC than on the respective control areas planted with cereals, maize or dry meadows.

The European tree frog (*Hyla arborea*) prefers edges and non-connected parts in particular stands. It occurs less frequently and resounds from grown-up cultures with closed canopy. The occurrence of species draws benefit from the presence of wetlands, respectively from suitable breeding sites in the vicinity from where they can actively occupy in particular the younger parts of SRWCs. They can also use small dug ponds in the middle of SRWC for their reproduction.

The European common spadefoot (*Pelobates fuscus*) has been recorded in six D4EU localities, more specifically in areas with light and sandy soil where it finds suitable conditions for burrowing.

The occurrence of the edible frog (*Pelophylax esculentus*) is water-related. But due to their mobility, particularly the younger age groups also occur in SRWC areas, more specifically on wet places and occasional wetlands where they stay during their migration.

The marsh frog (*Pelophylax ridibundus*) was not recorded in control areas. And in D4EU SRWCs it was found only in localities directly adjacent to its typical habitats, such as oxbow-lakes or wetlands at alluviums, and only on the edge of SRWC areas.

The moor frog (*Rana arvalis*) is a species that prefer wetlands. Therefore, its occurrence within the SRWC areas was limited and rather marginal. It was found near more permanent water bodies.

The agile frog (*Rana dalmatina*) was recorded within SRWC areas mainly during its migration, or it used the SRWC as a food habitat.

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The common frog (*Rana temporaria*) was recorded in SRWC only once on a wetland area, which was its breeding habitat, and once in the vicinity of a SRWC, again breeding in a stream near the edge of the SRWC. Obviously, this species does not occur continuously in the territory of the investigated localities.

Seven amphibian species were identified within the control areas in adjacent habitats with classic agricultural crops, or respectively in habitats that corresponded to the previous land use before an SRWC was planted:

1. The European fire-bellied toad (*Bombina bombina*)
2. The common toad (*Bufo bufo*)
3. The European green toad (*Bufotes viridis*)
4. The European tree frog (*Hyla arborea*)
5. The European common spadefoot (*Pelobates fuscus*)
6. The edible frog (*Pelophylax esculentus*)
7. The agile frog (*Rana dalmatina*)

6.2.3 Groups of amphibian species showing different SRWC use

In terms of the way how SRWC land is used by amphibians, it can be divided into three groups:

1) Species that use the SRWC throughout the year as a residential and food habitat (as well as for overwintering)

In particular, species that are relatively drought-resistant can be included in this group. They overcome even longer periods without moisture as tthey use the loose soil substrate of locations where they can benefit from surface disturbance that facilitates the burial of the amphibians. Also, edge strips without vegetation will be inhabited, where the surface is also kept uncompacted or disturbed. Longer periods of adverse conditions can be overcome by estivation and / or burial in deeper soil layers, possibly by hiding in various cracks. Mainly the species *Pelobates fuscus, Bufotes viridis* and *Bufo bufo* belong to this group. These species use SRWC habitats as a shelter and, at the same time, they obtain food in it, mainly insects. Into this group, also a tree frog (*Hyla arborea*) would be included, which uses a large leaf area at SRWC localities with deciduous trees. According to previous observations, young and younger stands, or respectively parts of the treesbecome involved over a number of years. The lower and middle parts of the poplar trunks remain without the foliage, which is important for the tree frog.

2) Species that use SRWC partly at a certain time of year

This group includes species that are not directly occurring all year round in SRWC stands, but the SRWC are used within a year during a certain period, e.g. for migration or as a temporary shelter and food habitat. This amphibian group includes, in particular, the agile frog (*Rana dalmatina*) and the edible frog (*Pelophylax esculentus*). These species appeared on SRWC areas during the season of migration and of dispersion of juveniles. It can be assumed, especially in comparison with standard control areas in agricultural crops, that the undergrowth of SRWC provides more suitable conditions not only in terms of humidity and shading, but also in terms of shelter and food availability. In these habitats, they were recorded more frequently and repeatedly. Hence, it was not just a quick move through an unsatisfactory habitat, but rather the specific use of site conditions during a certain stage. The advantage of

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these species of amphibians is their high mobility. Thanks to it, they can do both, leave an inappropriate site in time, e.g. extinct sites, but also quickly utilze newly created wetlands. They prefer occupying occasional wetlands on the edges of SRWC.

3) Species whose occurrence in SRWC is rather accidental, caused by unintentional entrance from another habitat

This group can include the European fire-bellied toad (*Bombina bombina*), the moor frog (*Rana arvalis*), and the marsh frog (*Pelophylax ridibundus*). These species are apparently attracted e.g. by temporary flooding of the site due to (heavy) precipitation, or respectively by raising groundwater tables, and they will visit the site in such particular situations during the reproduction period, under way to search for breeding sites. Alternatively, within the movement in natural habitats occurrence find themselves in the fringes of SRWC.

As part of the monitoring, we could record only fewer species at the control areas as compared with SRWC sites (7 vs. 10). In terms of abundance and number of occurrence records, the areas planted with SRWC are also significantly richer. Although we considered that – due to practical reasons – the monitoring was on control areas partly limited (e.g. no traps could be installed), the numbers of positive records from SRWC areas confirm that SRWC habitats provide amphibians with better conditions than intensively managed, classic agricultural monocultures.

Meadow habitats in the monitored areas did not provide due to specific conditions at specific localities - dryness and overheating of localities (S1 - Adamov, R5 - West of the village Pernek) suitable conditions for amphibians. Therefore, only minimum of amphibians (*Bufo viridis* only) was recorded.

The ruderal habitat type is evaluated very well, with the presence of different areas as overgrowth, reedbeds and the presence of water. This provides enough shelter and food options. In particular, this was found at the specific monitoring site R10a - Prievaly.

6.2.4 Discussion of D4EU amphibian monitoring results

An overall assessment of the four monitoring seasons shows that, in addition to the reduction or termination of agrochemical application, the benefits of SRWC can result also from a structural differenciation – that is the improved spatial structure of the habitat as compared with classical agricultural fields. The main advantage is the maintenance of free space between the rows of trees – in particular when comparing with the high density cereal and oilseed rape crops, which provide only a minimum of space. The contribution of SRWC mainly concerns amphibian species that bury themselves in lighter, sandy soil (e.g. the European common spadefoot, the European green toad). The advantage is more pronounced in areas with lighter soil and around suitable wetlands. The European green toad is using the areas of SRWC, where it occurred, more frequently and in higher numbers relative to standard agricultural fields.

Similarly, in comparison with annual crops, the existence of SRWC stands is advantageous for the European tree frog (*Hyla arborea*) due to the presence of deciduous trees, especially in the younger stands with open canopy. This species does not find a suitable habitat in classical fields. In the later stage with closed canopy the species occurs less frequently. Due to the short cycle of this species, where at least two different parts of the SRWC area with different age or growth of the poplar trees would be available, the species would always find young trees of appropriate size as well as small-scale open areas.

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Unfortunately, despite the fact that SRWC are deciduous cultures, it does not remain on the surface soil rake, which could suit e.g. a species of brown frogs (*Rana* sp.). Those have been so far recorded predominantly as juveniles (species *Rana arvalis* and *Rana dalmatina*), which migrate to other, more suitable sites through SRWC. On the other hand, based on monitoring results, we know that abiotic factors such as humidity, microclimate, shade, availability of food such as the presence of insects as well as the availability of shelter from predators could be factors that increase the probability of minimally seasonal occurrence of juveniles of brown frogs, but also of green frogs, compared to cereal, rapeseed or maize fields. Apparently, the conditions in SRWC also allow these species to stay here longer and use the area as a food habitat, especially in cases where there is moist herbal undergrowth below the trees.

The occurrence of the agile frog (*Rana dalmatina*) in the site R10a – Prievaly, and its presence in the autumn time and also during tree plantations on several locations may also mean that, under certain conditions, they could use SRWC areas to a greater extent. In detail, this could include the reproduction stage, wherever aquatic areas generate. For comparison, within the cereal field, this species was recorded only once, within the part adjacent to the riparian vegetation of an oxbow-lake.

The availability of spatial structures, respectively increasing the diversity of shelter options and reducing the degree of uniformity of the surfaces (e.g., free edges, strips), significantly contribute to the improvement of biological functionality of SRWC stands for amphibinas and also by reptiles that were observed on the sites. It is especially advisable to leave heaps of wood on the edges and to preserve existing tree groups within and near SRWC sites. Small scale lakes in SRWC localities would not only attract individuals for seasonal use, but in case of suitable location and sufficiently long presence of water in the season, they would become ideal reproduction / mating habitats ties for amphibians. In some places, they can also be quite significant breeding sites, especially in the event of scarcity or extinction of suitable areas in the surroundings.

The importance of of water for the occurrence of amphibians was documented by means of the occurrence of up to 9 species of amphibians (highest number of amphibian species captured in one locality) recorded in 2021 in the area of the former, long-extinct arm of Moravia at the locality S8a -North of the village of Kátov. There, a temporary wetland appeared after the winter season. The results from previous years were quite weak (three species of amphibians). As it turned out still during the ongoing evaluations, this was due to a combination of severe drought with the character of the soil, which formed a very strong layer during dry periods that is not suitable for burying. The primary factor for the occurrence of so many species was the creation of suitable ecological conditions. The second most important factor is the existence of populations of species in the vicinity as they move only on land and for limited distances. Only where these factors concide, the positive impact of the SRWC stand structure can be expected. On the control area of the wet field, two species of *Bufotes viridis* and *Bombina bombina* were recorded. But their number was low, compared with the SRWC site. But even where waterlogged areas are preserved, as shown on several localities in the previous seasons , in case of the a lack of precipitation and groundwater table drawdown, some shallower and smaller water bodies may also become an ecological trap. Premature drying of reproductive sites may thus be another of the identified adverse effects of current farming and water management in the agricultural landscape.

In addition to the predominantly positive effect of SRWC for amphibians (as compared to classical monocultures of annual cereals), this effect was also found for reptiles that were recorded during the

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biodiversity monitoring in D4EU SRWCs. Especially the sand lizard (*Lacerta a*gilis), and at some sites also the green lizard *(Zootoca viridis*), can use the more open and dry parts of the SRWC areas. In wet areas, the grass snake (*Natrix natrix*) has been observed several times.

6.2.5 Recommendations for the further management of SRWC sites regarding amphibians

To support the amphibian population, creating a breeding pond is advantageous in localities with a close-to-surface, lower-level groundwater. This can strengthen the places of the population, and for some species can use the improved conditions from the egg stage to the mature stage, and for reproduction. Based on our previous observations and findings, it is necessary to avoid tampering the ground cover on the waterlogged parts in already settled localities. Disking or plowing directly threaten the existence of amphibians that occur in waterlogged areas. It would be suitable at known sites (e.g. identified from an orthophotomap, or previous inspection of these parts) to verify the presence of standing water in advance, and to omit the relevant areas from intervention. It is also necessary to prevent drainage of sites by land reclamation systems, or by restoring and cleaning such existing land reclamation systems.

A suitable solution to prevent the amphibian killing is to use a certain area of land by a breeding ground where amphibians can concentrate and would not be endangered in the rest of the site. That way, the required area would be almost negligible in terms of the total area of the site. Several species can use a pond a few meters square in size for successful reproduction, which were created on some sites before planting of poplars, e.g. on the power game. Places that are more difficult to grow can also be used for this purpose or management (e.g. due to the fitting of the technology into the wet terrain, etc.)

Other interventions with anticipated adverse effects are deep plowing, excessive frequent disking, or disking and plowing of wetlands. Completely inappropriate is too deep intervention in the soil cover, reaching a depth of several tens of cm, i.e. the depths in which amphibians remain buried during the growing season, or during wintering.

Factors that could have a positive effect on the occurrence of amphibians could be included higher structural diversity (partly disturbed soil, partly herbaceous undergrowth, various size of woody plants and its canopy), open areas, possible marginal effect of leaving parts of open areas, local presence of water, replacement of deep plowing by shallow discing, or mowing or mulching, lower chemical load of pesticides.

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6.3 Butterflies (*Lepidoptera*)

6.3.1 Overall butterfly record data

In total, 45 different butterfly species were recorded during all four D4EU monitoring seasons. 39 of them were recorded at SRWC localities and 43 at control transect biotopes (fields - 7, shrubs - 32, grasslands - 42). The overall data are shown in Table 8.

Table 8: Overall numbers of different butterfly (*Lepidoptera*) species / number of species with entire lifecycle within SRWC and the number of individuals in brackets, for all monitoring localities and all seasons. (Coded locality names; M = Malacky, R = Rohožník, S = Skalica, T = Trnava.)

Locality (code)	2018		2019		2020		2021	
	Reference plot	SRWC	Reference plot	SRWC	Reference plot	SRWC	Reference plot	SRWC
M1	6 (6)	10 / 2 (16)	6 / 1 (22)	23 / 6 (72)	3 (8)	9 / 4 (22)	3 (7)	9 / 2 (32)
M2b	4 (5)	11 / 3 (24)	4 (5)	14 / 6 (49)	2 (4)	6 / 3 (19)	2 (3)	6 / 3 (11)
M6	26 / 22 (105)	16 / 7 (35)	26 / 22 (138)	16 / 7 (60)	28 / 24 (155)	4 / 3 (13)	28 / 24 (50)	4 / 3 (13)
R7a	26 / 21 (114)	26 / 20 (40)	27 / 21 (100)	20 / 14 (88)	27 / 21 (95)	14 / 8 (35)	27 / 21 (56)	14 / 8 (28)
R8a	32 / 28 (139)	20 / 10 (37)	32 / 28 (160)	20 / 10 (81)	33 / 29 (121)	8 / 5 (32)	32 / 28 (56)	8 / 5 (21)
S4	22 / 12 (58)	22 / 13 (51)	22 / 11 (87)	32 / 21 (240)	20 / 12 (95)	19 / 15 (93)	20 / 12 (46)	19 / 15 (52)
S8a	48 / 36 (123)	22 / 10 (34)	49 / 35 (229)	12 / 5 (36)	40 / 32 (171)	4 / 2 (12)	48 / 37 (87)	4 / 2 (6)
T3	36 / 29 (95)	23 / 14 (29)	36 / 29 (135)	23 / 14 (56)	33 / 29 (136)	10 / 7 (45)	34 / 30 (111)	10 / 7 (22)
M11a			21 / 13 (77)	20 / 3 (51)	21 / 11 (81)	20 / 2 (73)	21 / 11 (48)	20 / 2 (40)
T18						4 / 1 (29)		4 (14)
R10a							30 / 24 (65)	13 / 1 (29)

A detailed graphical visualization of Table 8 is given in Figures 15, 16 and 17. The first graph shows the number of butterfly species (orange) and number of individuals (blue) in SRWC localities and their reference control plots of different biotopes. The next two bar charts highlight the number of species that spent their entire lifecycle in the respective D4EU monitoring localities.

In all cases, where the arable field was selected as control biotope (M1, M2b, S4, S8, T3), the number of butterfly species, and also the number of butterfly species spending their entire lifecycle within the locality, were higher inside SRWC localities than in arable control fields.

In contrast, the number of butterfly species inside D4EU SRWC localities is lower than inside the reference plots representing semi-natural biotopes such as shrubs or grassland. One exception is locality S4 where the number of species is higher at SRWC site than in both types of reference control plots.

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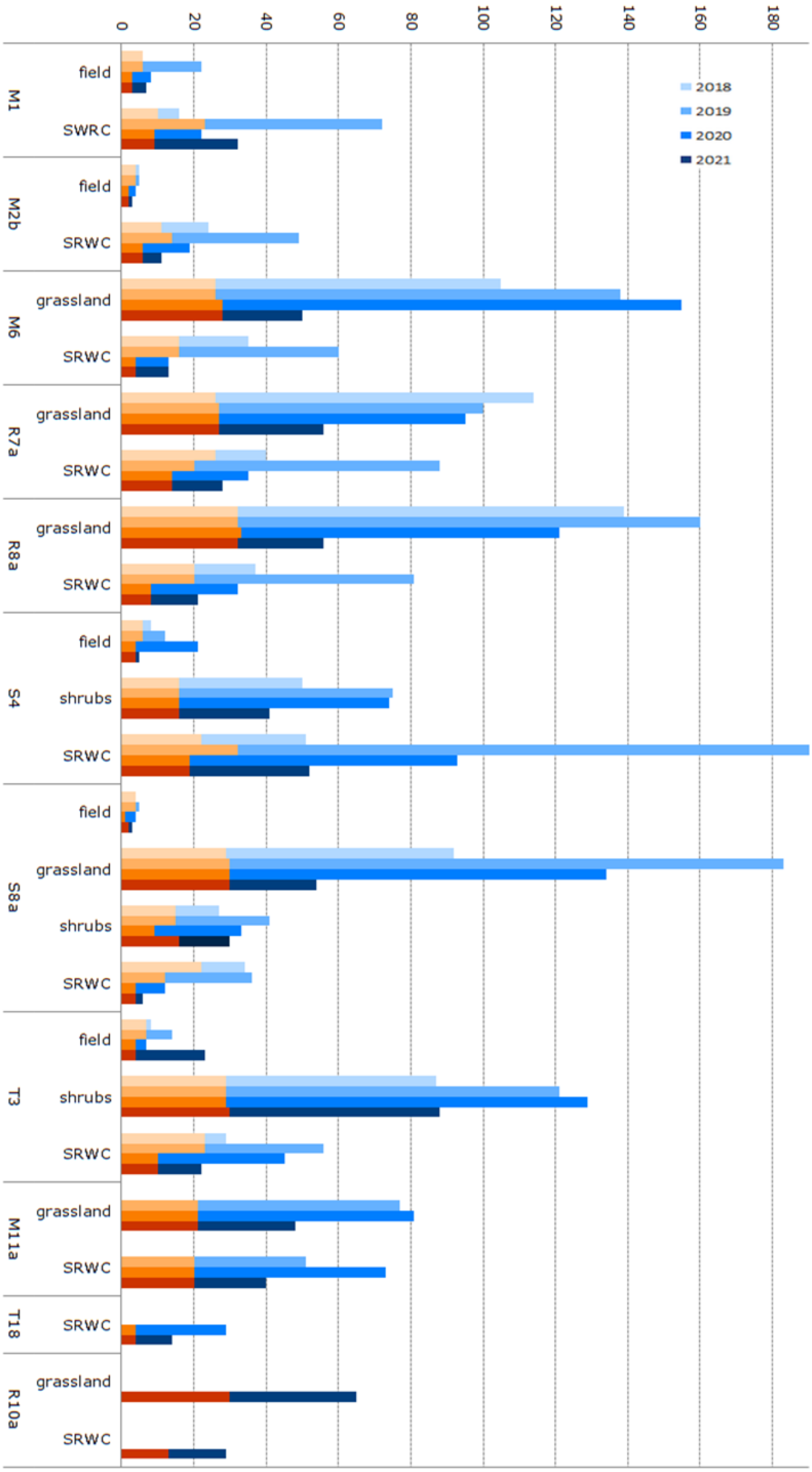

Figure 15: Number of different butterfly species (orange) and number of individuals (blue) in 4 monitoring seasons. Coded locality names on the x-axis; M = Malacky, R = Rohožník, S = Skalica, T = Trnava, separately for the SRWC and reference plots (agrculturalk fields, grassland, shrubs).

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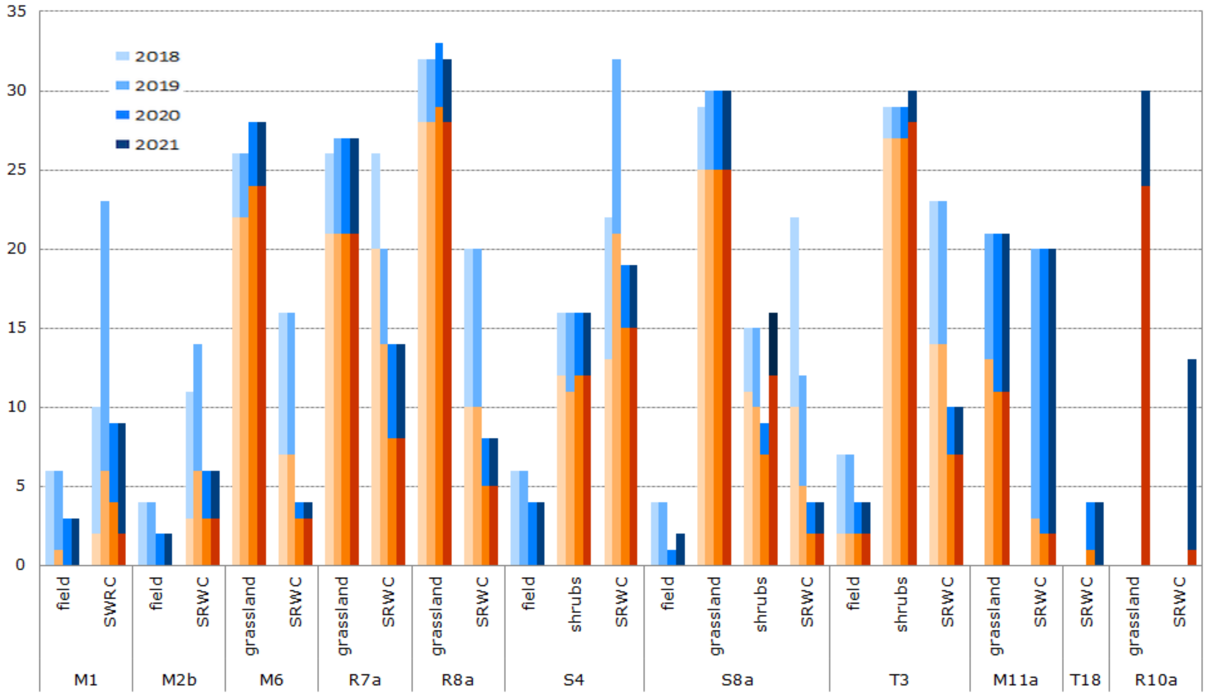

Figure 16: Number of species (blue) and number of species with entire lifecycle spent in monitored site (orange) for all monitored localities and control plots. (Coded locality names; M = Malacky, R = Rohožník, S = Skalica, T = Trnava.)

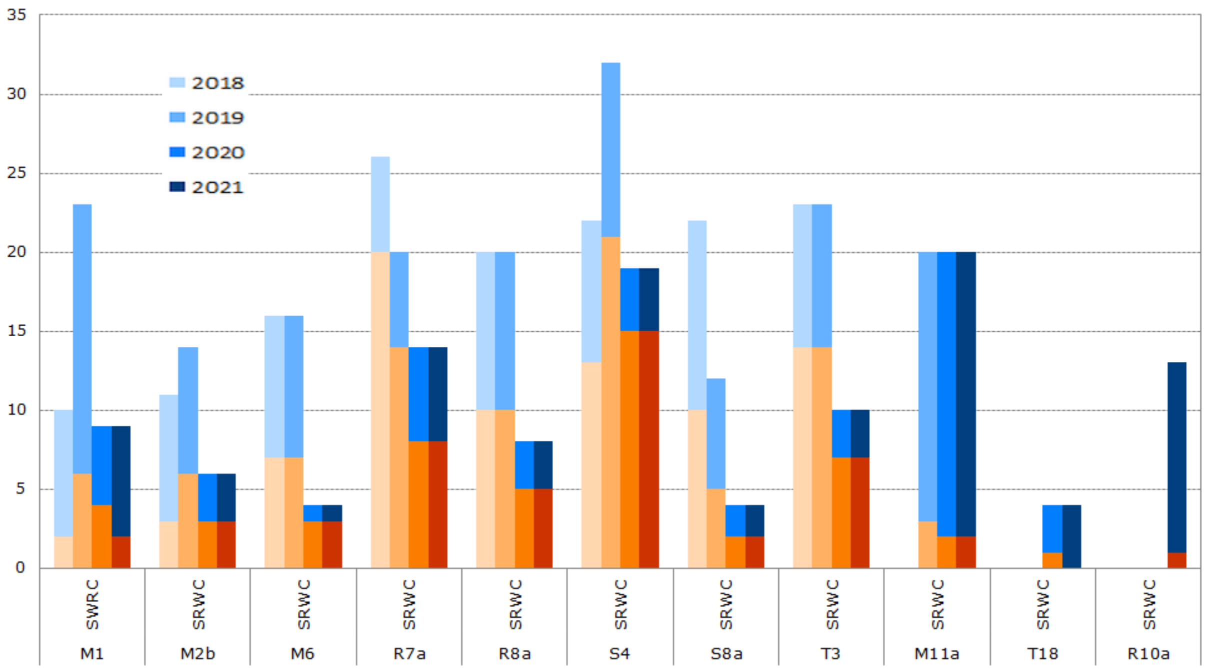

Figure 17: Number of species (blue) and number of species with entire lifecycle spent in SRWC localities (orange) only. (Coded locality names; M = Malacky, R = Rohožník, S = Skalica, T = Trnava.)

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Table 9: The number of specimens of butterfly species recorded within SRWC sites. The cells with shaded background indicate occurrence of species with all lifecycle stages. The cells with white background colour are species with temporary occurrence in SRWC localities. (Coded locality names; M = Malacky, R = Rohožník, S = Skalica, T = Trnava.)

Taxon	M1	M11a	M2b	M6	R10a	R7a	R8a	S4	S8a	T18	T3
Anthocharis cardamines (Linnaeus, 1758)		6		7	2	11	10	3	9		7
Apatura ilia (Denis & Schiffermuller, 1775)								7			
Aphantopus hyperantus (Linnaeus, 1758)					1			17			
Araschnia levana (Linnaeus, 1758)	3	10	6	2		17	4	12	6		11
Argynnis paphia (Linnaeus, 1758)	5					8		3	6		
Coenonympha pamphilus (Linnaeus, 1758)	5	12		12	1	7	24	44	6		4
Colias crocea (Fourcroy, 1785)	2		2	3		4	2	2	2		2
Colias erate (Esper, 1805)	2	3	6	3		5	2	2	2	2	2
Colias hyale (Linnaeus, 1758)	2		2	2		4	2	2	1		2
Cupido decoloratus (Staudinger, 1886)	1										
Erebia medusa (Denis & Schifferm., 1775)		5									
Erynnis tages (Linnaeus, 1758)				6		1	9	9	1		2
Gonepteryx rhamni (Linnaeus, 1758)	8	17	16	15	1	16	14	38	4		15
Heteropterus morpheus (Pallas, 1771)						1					
Inachis io (Linnaeus, 1758)	11	6	9		1	6	6	9	7		8
Iphiclides podalirius (Linnaeus, 1758)	5		1				3	1	1		2
Issoria lathonia (Linnaeus, 1758)	1	6		3		11	6	22	1		6
Lasiommata megera (Linnaeus, 1767)		7		4	2	2	4	6	1		3
Leptidea sinapis (Linnaeus, 1758)	2		2	4		1	3	10			4
Lycaena alciphron (Rottemburg, 1775)						2					
Lycaena dispar (Haworth, 1803)	2					4					
Lycaena phleas (Linnaeus, 1761)		21	2			12	8	16	2		3
Lycaena tityrus (Poda, 1761)		6									
Lycaena virgaureae (Linnaeus, 1758)											6
Maniola jurtina (Linnaeus, 1758)	6	10			4			27			
Melanargia galathea (Linnaeus, 1758)	2	7						11			
Minois dryas (Scopoli, 1763)	1	5			4			5			
Nymphalis antiopa (Linnaeus, 1758)	5				2	8		8	1		
Ochlodes faunus (Turati, 1905)								2			
Papilio machaon (Linnaeus, 1758)						1		2			
Pararge aegeria (Linnaeus, 1758)		5		3		3	3	14	1		4
Pieris brassicae (Linnaeus, 1758)	20		20	15	4	16	13	22	5	19	9
Pieris rapae (Linnaeus, 1758)	14	6	10	21	4	13	16	26	4	15	13
Polygonia c-album (Linnaeus, 1758)	10	9	6			7		31	6		15
Polyommatus icarus (Rottemburg, 1775)	2					1		3	1		3
Thymelicus lineola (Ochsenheimer, 1808)								10			
Thymelicus sylvestris (Poda, 1761)		9		13	2	3	11	13	1		10
Vanessa atalanta (Linnaeus, 1758)	10	5	9			12	9	10	11		7
Vanessa cardui (Linnaeus, 1758)	23	9	12	8	1	15	22	49	9	7	14

In monitored localities, where poplar plantations were planted in meadows, there was a significant decrease in the species diversity of daytime butterfly species (*Papilionoidea* = the butterflies in the narrow sense, that contrast to the nighttime moths, *Heterocera*) after planting SRWC. These were mainly the sites M6, R7a, R8a, R10a (M = Malacky, R = Rohožník). This was confirmed by comparative transects in the remaining meadow habitats in the vicinity of the respective planted SRWC, where the number of detected daytime butterfly species does not decrease, but on the contrary, new rare species are constantly emerging.

Comparing the species diversity of daytime butterfly species in areas of planted SRWC with intensively used arable land, there was an increase in the species diversity on SRWC. However, the diversity in SRWC areas is gradually decreasing due to the canopy growth and shading of planted trees. This was found at all monitored D4EU sites (M6, R7a, R8a, M1, M2b, S8a, T3, R10a; M = Malacky, R = Rohožník,

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S = Skalica, T = Trnava). In the area of site M11a, the decrease in the diversity of daytime butterflies is not yet noticeable, because the canopy of planted poplars is very sparse. In the area of site S4, the decline in species diversity of butterflies has not yet manifested significantly. This is due to the orientation of the SRC planting (north-south direction), where more light can penetrate the vegetation inside the SRWC stand. At the same time, the canopy of poplars is not so significantly causing worse habitat conditions here. And in the vicinity of the locality, there is no space for suitable non-forest habitats (see Fig. 4). Hence, the S4 locality seems to be a refugium for butterfly species.

The area of the site was heavily overgrown with invasive neophyte (*Solidago gigantea*), R7a in 2019 and also in 2020, 2021. This resulted in a reduction in the species diversity of butterflies. In terms of comparing species diversity of the SRWC area with that of the meadow habitat west of the R7a SRWC, there was a significant decrease in the species diversity of daytime butterflies in 2020.

In the area of site S8a, parts of the poplar logging have already taken place, but they did not affect the diversity of daytime butterfly species. There was no increase in species diversity, as weeds, invasive plant species and poplar seedlings occupied the undergrowth quickly.

6.3.2 Conclusions and recommendations towards more biodiversity of daytime butterfly species (*Papilionoidea*)

- Prior to the intention to establish a SRWC with fast-growing tree species, a thorough inventory of valuable habitats (especially meadow habitats and wetlands) shall be ensured, as well as an inventory of the protected plant and animal species inside the plots and in their vicinity. This would prevent SRWC from being planted on valuable habitats, such as in areas M6, R7a, R8a (M = Malacky, R = Rohožník), where there was a significant negative impact on the diversity of daytime butterfly species.
- By establishing new SRWC stands on intensively managed and agro-chemically treatedareas formed by classic cropland (e.g. fields with maize, rapeseed), in terms of the occurrence of daytime butterfly species, a positive impact was recorded especially during the first two years of SRWC monitoring (e.g. sites S4, M1, M2b, S8a, T3; M = Malacky, R = Rohožník, S = Skalica, T = Trnava). Over longer periods, however, these areas of SRWC with the gradual growth of poplars and with the closing canopy, result in a decline in the diversity of daytime butterfly species.
- Areas in the first year after felling are occupied often mainly by invasive plant species, ruderal species and poplar shoots.
- Disking the vegetation between different SRWC stands is an unsuitable management method that reduces plant communities and therefore also the food plants of daytime butterflies or the species that provide bee pasture.
- The application of agro-chemical substances (potentially total herbicides) was found in some SRWC areas (e.g. the M1 area near Jakubovské rybníky in spring 2020), which is expunging populations of daytime butterfly species.
- To support the diversity of butterfly species, it would be an appropriate means to keep meadow corridors (in north-south orientation) with a minimum width of 5 to 10 m between the poplar rows planted. One such corridor would suffice per 50 m poplar field width. Preferably, these corridors could be sown with a suitable meadow mixture of bee pasture species and they should be mowed once a year until the end of the growing season. In moist habitats,

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it is appropriate to create small wetlands without poplar planting, which could also be mowed once a year until the end of the growing season.

6.4 Beetles (*Coleoptera*)

6.4.1 Overall beetle record data

In total, 267 different species of beetles were recorded during all four seasons in all 11 localities (see Fig. 8), 254 of them were recorded at SRWC localities and 247 at reference habitats (agricultural fields – 54 species, grasslands – 247 species). 20 species were found only on SRWC localities. Table 10 provides the annual record data for each of the 11 D4EU beetle monitoring localities, while the species and individuals numbers are compared between the reference habitat and the respective SRWC.

Table 10: Overall numbers of different beetle (*Coleoptera*) species and the number of individuals in brackets, for all monitoring localities and all seasons. (Coded locality names; M = Malacky, R = Rohožník, S = Skalica, T = Trnava.)

Locality (code)	2018		2019		2020		2021	
	Reference habitat	SRWC	Reference habitat	SRWC	Reference habitat	SRWC	Reference habitat	SRWC
M1	5 (50)	20 (150)	11 (52)	56 (292)	16 (139)	49 (328)	23 (121)	51 (220)
M2b	5 (45)	23 (214)	9 (46)	58 (308)	19 (179)	109 (760)	24 (100)	105 (371)
M6	146 (696)	96 (539)	153 (1209)	106 (598)	178 (1742)	144 (1035)	174 (595)	144 (737)
R7a	110 (629)	110 (536)	122 (595)	122 (481)	172 (1417)	156 (1557)	178 (737)	165 (660)
R8a	87 (399)	65 (196)	98 (365)	75 (219)	164 (1754)	137 (1493)	170 (705)	147 (734)
S4	14 (95)	57 (390)	17 (53)	123 (696)	27 (158)	167 (1527)	33 (196)	158 (627)
S8a	94 (549)	54 (404)	108 (581)	70 (392)	150 (2025)	104 (916)	141 (722)	98 (477)
T3	4 (50)	27 (283)	9 (65)	33 (194)	24 (186)	79 (641)	27 (154)	77 (429)
M11a	-	-	68 (309)	78 (364)	87 (865)	111 (1157)	86 (331)	106 (416)
T18	-	-	-	-	-	48 (267)	-	49 (182)
R10a	-	-	-	-	-	-	156 (721)	136 (619)

A detailed graphical representation of Table 10 is given in Figure 18 and 19. The first graph shows the number of beetle species (orange) and number of individuals (blue) in SRWC localities and their reference control plots in different biotopes. The next graph (Figure 19) focuses on SRWC localities only. In all SRWC localities, the overall trend of the number of different beetle species is increasing with time. This trend, as well as the relatively high numbers of different beetle species, indicate that D4EU SRWC localities wee suitable biotopes for these beetle species.

In all cases, where the arable field was selected as control biotope (M1, M2b, S4, S8, T3; M = Malacky, S = Skalica, T = Trnava), the number of species and the number of individuals are significantly higher in SRWC localities than in reference arable fields. In the locality M11a, the number of beetle species inside the SRWC is even higher than in the intensive grassland reference habitats M = Malacky, R = Rohožník, S = Skalica, T = Trnava (just few plant species were present in the grassland). The main reason for the postivie outcome was the absence of agro-chemicals and the occurrence of various plant species inside the SRWC localities.

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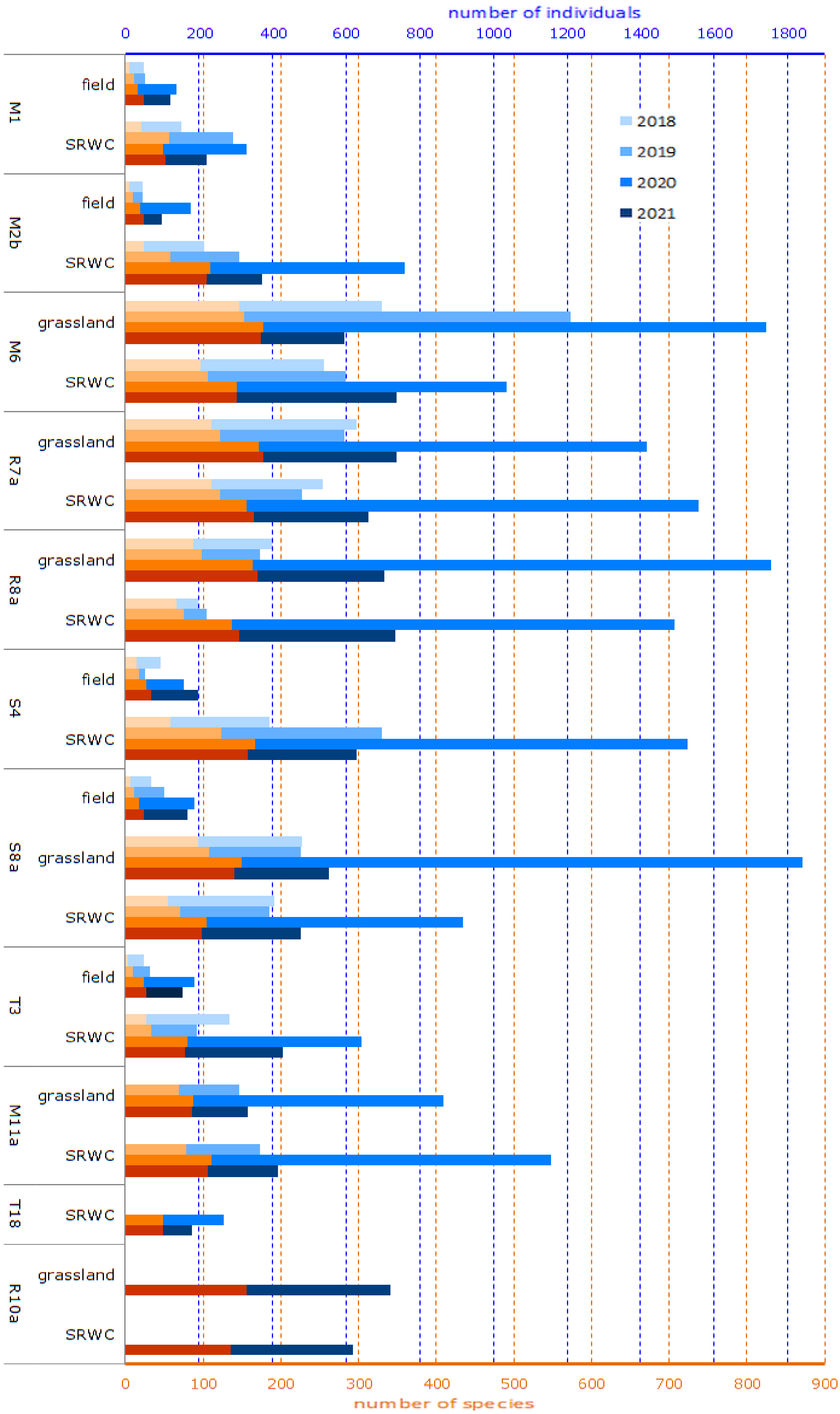

Figure 18: Number of individuals (blue – scale at the top axes) and number of different species (orange – scale at the bottom axes) in 4 monitoring seasons. (Coded locality names; M = Malacky, R = Rohožník, S = Skalica, T = Trnava.)

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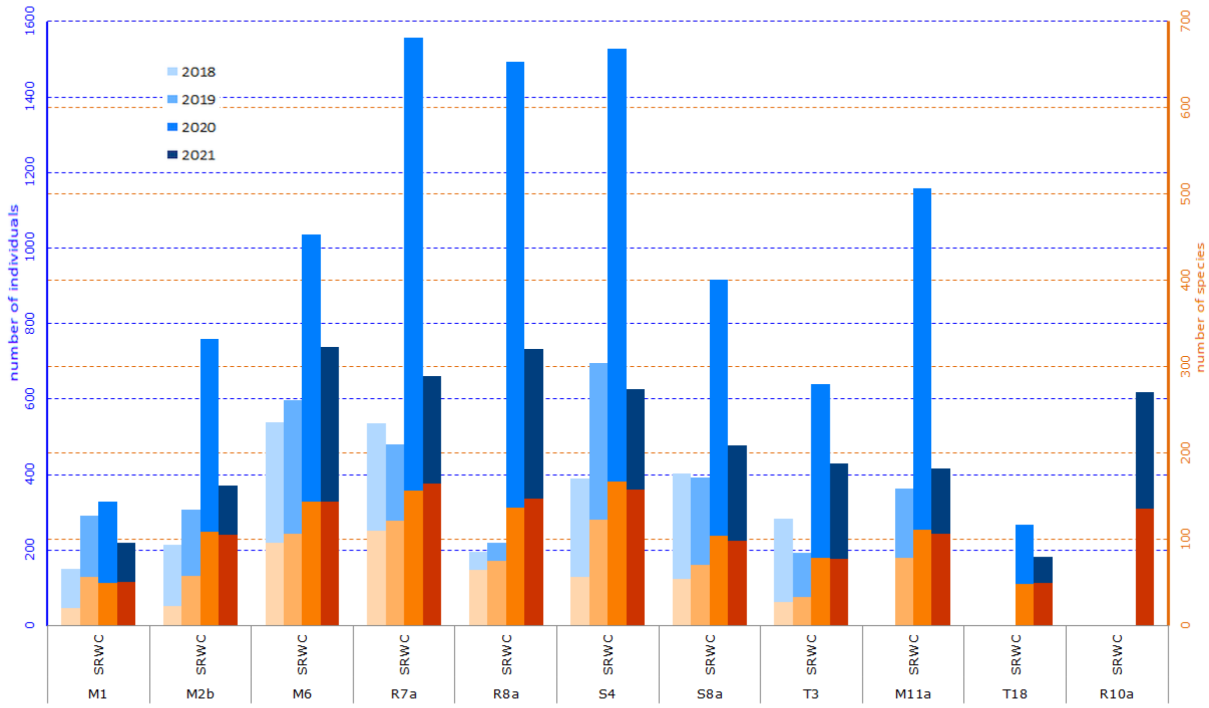

Figure 19: Number of individuals (blue – scale on the left axes) and number of different species (orange – scale on the right axes) in 4 monitoring seasons only in SRWC transects. (Coded locality names; M = Malacky, R = Rohožník, S = Skalica, T = Trnava.)

6.4.2 Specific beetle record descriptions

All localities were examined for the occurrence of 14 coprophagous beetle species (*Onthophagus nuchiconis, O. vacca, O. fracticornis, O. illyricus, O. taurus, O. coenobita, Aphodius coenosus, A. paracoenosus, A. haemorrhoidalis, A. erraticus, A. depressus, A. luridus, A.prodromus, A. distinctus*). The result is shown in Figure 20. The occurrence of those beetle species also indicates the presence of even-toed ungulate mammals, such as deers or the wild boar. The increase of number of species from 0 or 2 in the seasons 2018 and 2019 to values of almostthe maximum of 14, indicates that SRWC localities are attractive for deer species. With their occurrence, the population of coprophagous beetle species also increased in the reference sites. It obvious that SRWC localities are attractive for and often used by these larger mammals, in some cases even though the SRWCs were protected by fencing.

A comparable examination, but with psamophytic beetle species (*Cicindela hybrida hybrida, Sibinia unicolor, Maladera holosericea, Cardiophorus asselus*), was done on all localities record data. There were four localities identified with presence of these (sand-) specific species. Psamophytic species are phytophagous beetles that need psamophytic plants like *Corynephorus canescens* or *Spergula morisoni* for their lifecycle. In Figure 21. is shown that these beetle species are in dominance in SRWC sites in opposite to reference grasslands or fields. The main reason are probably disturbances caused by the management of the SRWC sites (disking) which are beneficial for psamophytic vegetation.

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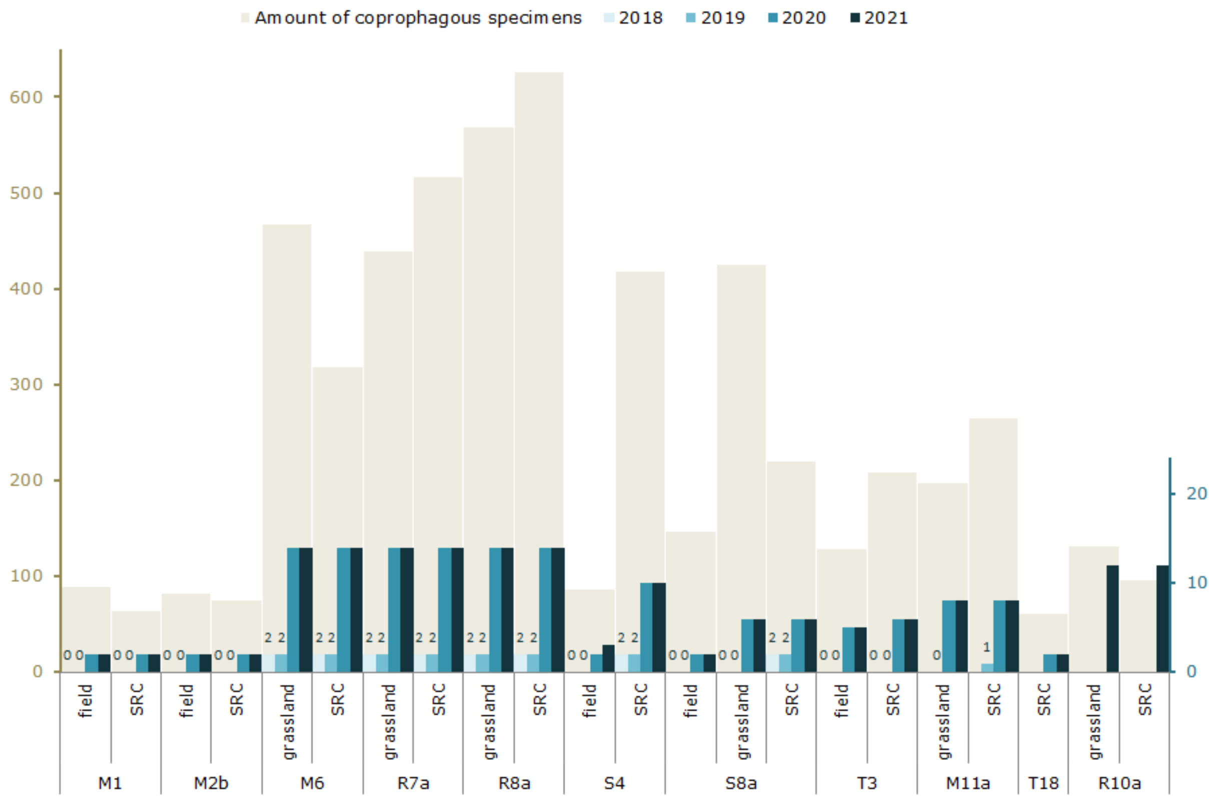

Figure 20: Number of coprophagous beetle species (max 14) in four seasons (cyan colors with scale on the right axes, digits are displayed only for seasons 2018 and 2019) and number (beige color with scale on the left axes) of coprophagous beetle individuals summarized for all seasons. (Coded locality names; M = Malacky, R = Rohožník, S = Skalica, T = Trnava.)

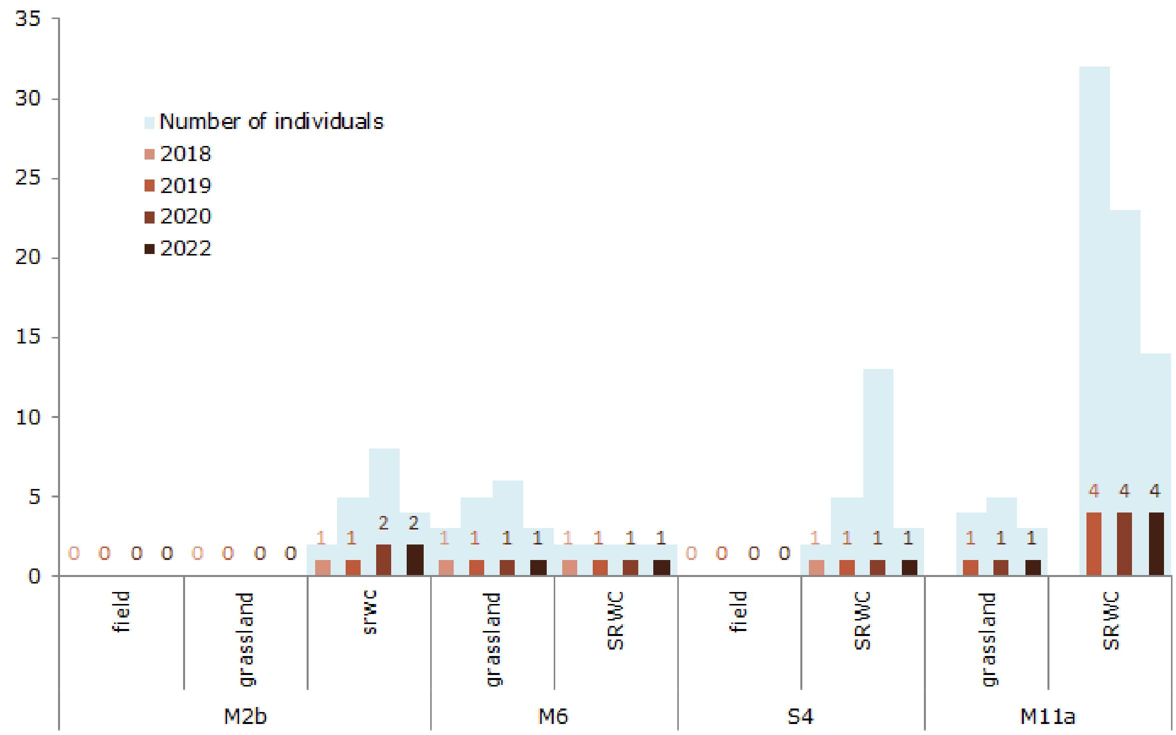

Figure 21: Number of psamophytic beetle species (max 4, brown colors, digits show their values) and number (light blue color) of psamphytic beetle individuals in four seasons in SRWC localities and reference plots. (Coded locality names; M = Malacky, R = Rohožník, S = Skalica, T = Trnava.)

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The following 8 beetle species (*Carabus scheidleri, Carabus ulrichii, Carabus coriaceus , Diachromus germanus, Dolichus halensis, Panageus bipustulatus, Pterostichus macer, Pterostichus cylindricus*) are very sensitive to agro-chemicals (pesticides, herbicides) in soils. Their presence was examined in all locality recordings. The result is displayed in Figure 22. It became evident that there was no record of any of these species in reference field sites, but they occurred in all grassland sites and all SRWC localities. The occurrence of these species in SRWC sites is specific, because on the localities established on arable field, the presence of these species is recorded only in the second or third year after an SRWC was established. Hence, the results indicat that soils in SRWC localities can recover over time. There was a specific situation in the SRWC locality M1, where the occurrence of the examined species was recorded only in 2019. It is an example that using of herbicides (in spring 2020 in this case) in SRWC locality or its vicinity can cause a local biodiversity loss.

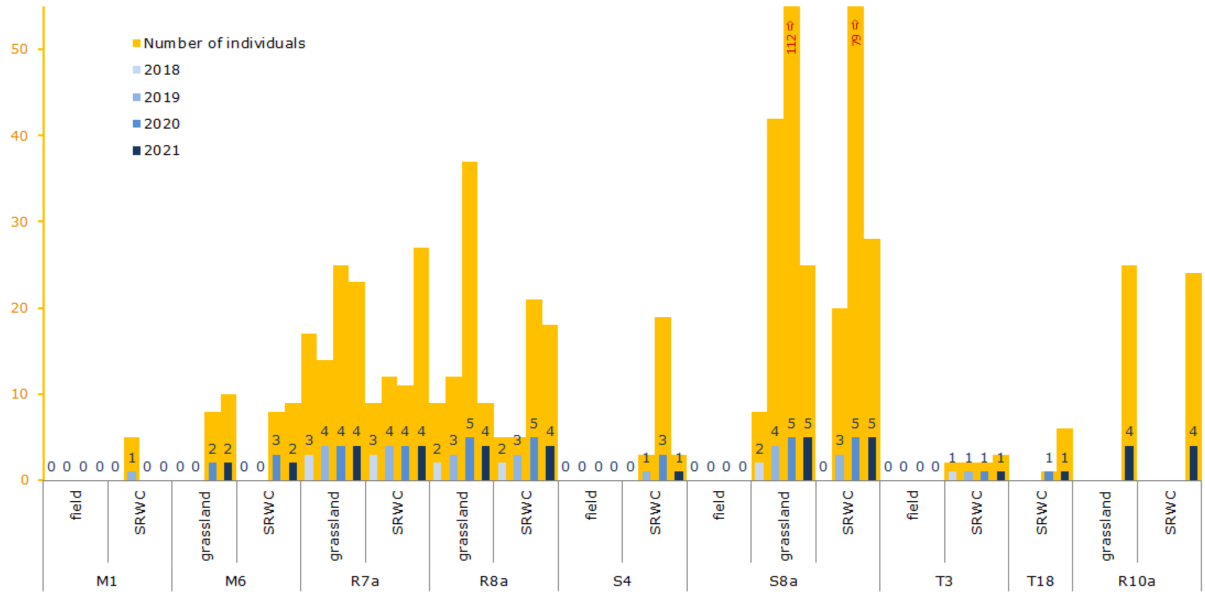

Figure 22: Number of beetle species – indicators of chmicals in soil (max 8, blue colors, the digits show their amount) in four different seasons and number of specimens (orange color) in SRWC localities and reference plots. (Coded locality names; M = Malacky, R = Rohožník, S = Skalica, T = Trnava.)

Two nationally protected beetle species, *Meloe proscarabaeus* and *Meloe violaceus* were recorded in reference plots and two specimens were found also in the SRWC locality R7a during theseason 2020. These species live in grassland biotopes and their occurrence in SRWC localities was somehat unexpected. Locality R7a is not fully covered by poplar trees and it is surrounded by grassland biotopes.

To draw an overall conclusion, we summarize that the SRWC localities are suitable habitats for beetle species and in cases where the SRWC locality is established on land previously used as classic arable land, the SRWC increases biodiversity of these species group.

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Table 11: List of all 259 beetle (*Coleoptera*) species found on D4EU SRWC localities, given with their recorded individual numbers. (Coded locality names; M = Malacky, R = Rohožník, S = Skalica, T = Trnava.)

Latin name of species	M1	M11a	M2b	M6	R10a	R7a	R8a	S4	S8a	T18	T3	Frequency	Total
Acupalpus flavicollis					5	15	10			5		4	35
Acupalpus meridianus					3	6	13		9			4	31
Adosomus roridus											5	1	5
Agapanthia dahli dahli			3		1	8	4	6				5	22
Agapanthia villosoviridescens	7		8	5	1	6	7	9				7	43
Agapanthia violacea	6		10	3	2	4	4	8	11			8	48
Agriotes obscurus	9	13	6	7	5	6	13	4	4		6	10	73
Agriotes sputator	6	7	5	9	1	11	10	7	9	4		10	69
Agriotes ustulatus	11	8	9	16	2	4	10	10	12	8	10	11	100
Agrypnus murinus		10	7	10	5	9	12	10	10	6	9	10	88
Alosterna tabacicolor tabacicolor				4		16	11	8				4	39
Alphitophagus bifasciatus				2	5	1	4					4	12
Amara apricaria								2				1	2
Amara fulva		15		9								2	24
Amara ovata	11	34	21	23	7	19	43	43	43	13	17	11	274
Amara similata	16	22	17	9	7	24	16	38	35	15		10	199
Amara spreta		17		7	4	8	19	9	20			7	84
Amphimalon soltistiale soltistiale		27		13				40				3	80
Anchonemus dorsalis		5				6	3	5				4	19
Anconemus dorsalis		16					8	6				3	30
Anomala dubia		31		33				36				3	100
Anoplotrupes stercorosus				44	7	46	18	24				5	139
Anthaxia godeti		7										1	7
Anthaxia morio		4										1	4
Anthaxia nitidula						12						1	12
Anthaxia quadripunctata		5										1	5
Anthicus antherinus	29	20	24	72	1	39	43	31	38	7	23	11	327
Aphodius ater				24	3	7	18	8	8		9	7	77
Aphodius coenosus		28		12	4	24	30	36	23			7	157
Aphodius depressus				24	6	32	26					4	88
Aphodius distinctus	29	57	38	48	28	101	141	151	76	27	61	11	757
Aphodius erraticus				16	4	18	32	15			14	6	99
Aphodius fasciatus				7	4	12	9					4	32
Aphodius foetens					4	5	5					3	14
Aphodius granarius		6		8	6	7	9	11	9	10	12	9	78
Aphodius haemorrhoidalis				15	3	32	25	24	13		19	7	131
Aphodius immundus						8						1	8
Aphodius luridus		8		11	5	24	29	12				6	89
Aphodius paracoenosus		57		40	3	56	37	33			18	7	244
Aphodius prodromus	35	62	38	90	21	103	141	99	95	34	88	11	806
Aphtona cyparissiae		10						11				2	21
Aphtona euphorbiae		6						15				2	21
Apion brevirostre							20					1	20
Apion rubens		10										1	10
Apion simum		11										1	11
Apion violaceum						17	18					2	35
Astenus brevelytratus		9		9	2	8	12	12			10	7	62
Atholus bimaculatus		6		7	2	2	9	2			7	7	35
Atholus duodecimstriatus duodecimstriatus	6	5	4	6	3	2	7	6	2			9	41
Athous subfuscus			3	8		16	9	11	6			6	53

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Atomaria affinis			7	29	2	31	12	8	16	4		8	109
Atomaria fuscata			2	9			11	6	4			5	32
Badister lacertosus									6			1	6
Badister meridionalis	12		9	15	4	22	5		10			7	77
Badister sodalis									3			1	3
Bembidion assimile	18	19	34	23	4	81	64	64	45	15		10	367
Bembidion decoratum					10	3	8		4			4	25
Bembidion gilvipes			7	1	6	16	6	11	18		11	8	76
Bembidion guttula					5		8					2	13
Bembidion properans	11	19	13	15	4	16	18	11	15		16	10	138
Bembidion quadrimaculatum				17	8	15	13	15	20		15	7	103
Bothynoderes affinis	5	9	6	9		7	11	9	7	7	7	10	77
Brachinus crepitans	8	10		70	6	17	20	18	23	11	46	10	229
Brachinus explodens				26	23	11	18	25	31	14	85	8	233
Brachygluta helferi						20			4			2	24
Brachygluta helferi longispina						3			2			2	5
Broscus cephalotes			9	6				14				3	29
Bruchidius varius		5	1					6			5	4	17
Bryaxis bulbifer			3		1	21			4			4	29
Bryaxis clavicornis					2		3					2	5
Byrrhus fasciatus									2			1	2
Byrrhus pustulatus				4				5	4			3	13
Calamobius filum			7	8	2	16	24	19				6	76
Calanthus ambiguus	14	19	18	28	7	14		53			32	8	185
Calanthus cinctus	26	8	27	17	4	27	15	58	49		101	10	332
Calanthus erratus erratus	28	30	33	22	2	46	35	91	31	18	49	11	385
Calanthus fuscipes fuscipes	3	11	13	13	6	50	17	23	35	10	4	11	185
Calanthus melanocephalus		12		8	5	17	15	15	19		13	8	104
Carabus coriaceus				4	8	13	16	8	24	7		7	80
Carabus granulatus granulatus					4	23	7	2				4	36
Carabus scheidleri						5	2		5		6	4	18
Carabus scheidleri scheidleri					2	7	3		6		3	5	21
Carabus ulrichii				11	8	24	8	4	11			6	66
Carabus violaceus violaceus				8	6	11	8	9	27		8	7	77
Cardiophorus asselus		6										1	6
Carpophilus hemipterus		5		14	2	11	9				5	6	46
Carpophilus sexpustulatus				14	3	7	13	6				5	43
Cassida nebulosa		11	4	4				6		8	11	6	44
Cassida sanguinolenta		6	7			13	9	10				5	45
Cetonia aurata	24		10	9		10	16	7			8	7	84
Ceutorhynchus floralis		7						9		10		3	26
Ceutorhynchus pleurostigma						11	10					2	21
Chaetocnema chlorophana		9						8				2	17
Chaetocnema concinna						12						1	12
Chaetocnema picipes						7						1	7
Chaetopteroplia segetum segetum		17	10	58		7		47				5	139
Chlaenius spoliatus									5			1	5
Chlorophorus sartor			7									1	7
Chlorophorus varius			6									1	6
Chrysanthia nigricornis								5				1	5
Chrysanthia viridissima								4				1	4
Chrysolina fastuosa					2	11		7	12			4	32
Chrysolina herbacea						21						1	21
Chrysolina hyperici hyperici		10						5				2	15
Chrysomela tremulae					3				45			2	48
Cicindela hybrida hybrida		20	12									2	32
Cidnopus pilosus				5	1	13	6	10				5	35
Clytra quadripunctata			7	7	2	7	6	4				6	33
Coccinella septempunctata		8		14	3	14	12	10	7			7	68

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Conosoma testaceus	10	12	12	63	3	23	15	25	19	4	5	11	191
Corticaria longicollis						10						1	10
Creophilus maxillosus				6	2	7		6	4		3	6	28
Crepidodera aurata	14		25	21	4	9	9	16	38		35	9	171
Crepidodera aurea	7		16	11	5	6	26	11	40		33	9	155
Crioceris duodecimpunctata		7										1	7
Crypticus quisquilius	38	45	63	140	5	38	31	84	14	7	27	11	492
Cryptocephalus bipunctatus						16		5				2	21
Cryptocephalus fulvus		10										1	10
Cteniopus sulphureus								12				1	12
Dalopius marginatus			7	10		14	8	4				5	43
Dermestes frischi				9	2			13				3	24
Diachromus germanus	5				6	10	15					4	36
Dicronychus cinereus		11		13			4	4				4	32
Dicronychus rubripes	1											1	1
Dolicaon biguttulus	3		9	10	3			6				5	31
Dolichosoma lineare	13	8	9	11	2	32	7	7				8	89
Dolichus halensis								13				1	13
Drasterius bimaculatus	21	18	16	46		14	11	42	15	3	8	10	194
Drypta dentata				14	6	15	10		10			5	55
Dyschirius globosus	26		37	30	6	55	75		43			7	272
Eucinetus haemorrhoidalis				2	2			10				3	14
Europhilus fuliginosus						24	5					2	29
Formicomus pedestris			7		4	12		18	35	5	14	7	95
Galeruca tanaceti tanaceti	39	18	50	47			33	90	24	6	44	9	351
Glischrochilus quadriguttatus				10	2	7	10	9	10			6	48
Gonodera luperus								7				1	7
Harmonia axiridis		8			2			11	6	4	4	6	35
Harpalus autumnalis		28		14				6				3	48
Harpalus distinguendus		11	16	7				11				4	45
Harpalus flavescens		17		9								2	26
Harpalus picipennis	27	68	49	52	8	65	18	46	4	8	45	11	390
Harpalus serripes	2	11	12	14				16				5	55
Harpalus servus		10		16								2	26
Harpalus smaragdinus		41		24				17				3	82
Hispa atra		12						9				2	21
Hister unicolor				5		3						2	8
Hymenalia rufipes								11				1	11
Isomira murina				2	3	2	2					4	9
Kibunea minuta			4	2		8	6	5				5	25
Lagria hirta			3		2	14	6	7				5	32
Lamia textor			5		3	6	6					4	20
Larinus obtusus	7		11	21	4	17	12	7	11			8	90
Leistus ferrugineus	18		20	20	4	33	32	39	62			8	228
Lepirus palustris						20						1	20
Litargus connexus					2		2					2	4
Lixus fasciculatus		9	6	6	3	14	7	10	9	9	4	10	77
Lixus filiformis			2		2	17	7	4			5	6	37
Longitarsus lycopi						12						1	12
Longitarsus nasturtii						12						1	12
Loricea pilicornis					6	41	10		19			4	76
Lythraria salicariae						17						1	17
Maladera holosericea		28	7	8				23				4	66
Mantura chrysanthemi		11										1	11
Melanimon tibiale	49	95	58	67	4	14	56	70	15	6	7	11	441
Melanotus crassicollis		9	3		2			5				4	19
Melasoma populi	49		57	122	2	43	22	50	92		39	9	476
Melasoma tremulae	45		65	76	12	67	19	62	83		52	9	481
Meligethes aeneus			7	11	5	9	6			5	9	7	52

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Meloe violaceus						2						1	2
Melolontha hippocastani	5	67	14	59		42	16	76				7	279
Microhoria unicolor		22	5	18	1			8				5	54
Microlestes minutulus	2	10	20	18	8	35	15	17	15	11	12	11	163
Nebria brevicollis			25	26	17	47	35	16	35			7	201
Necrobia violacea		58	5	31	5	4	5	12			3	8	123
Neocrepidodera ferruginea						6						1	6
Neocrepidodera transversa						9						1	9
Nicrophorus humator				1	5	2	2					4	10
Nicrophorus vespillo				25	2	1	3					4	31
Notiophilus biguttatus	16	44	56	26	4	41	58	26	21	9	17	11	318
Notoxus monoceros	3	11	7	14	2	17	28	20		3	10	10	115
Ochodaeus chrysomeloides						1						1	1
Oedemera croceicollis			14			22		5				3	41
Oedemera femorata		14						8			3	3	25
Oedemera podagrariae		8	7	12			20	9		8		6	64
Oiceoptoma thoracica				4		6			3		7	4	20
Oiceoptoma thoracicum			4	6	3	3	7	6	4		7	8	40
Onthophagus coenobita		30		10	4	19	33	15			9	7	120
Onthophagus fracticornis		12		22	6	44	51	18				6	153
Onthophagus furcatus		57		22		17	10					4	106
Onthophagus illyricus				7		14	14					3	35
Onthophagus nuchicornis		11		11	4	32	39	15	7			7	119
Onthophagus ovatus		27	12	30	6	78	31	31	16	11	18	10	260
Onthophagus semicornis						2						1	2
Onthophagus taurus				8		8	14					3	30
Onthophagus vacca				5	9	10	14		6			5	44
Opatrum sabulosum	15	26	23	12			12	32	13			7	133
Ophonus nitidus				4				7			6	3	17
Otiorrhynchus ligustici	7		12	23	1	13	13	9	9		16	9	103
Oulema melanopus	5	10	4	4		17		12	9		10	8	71
Oxyomus sylvestris		6		6		6	7	3	4		7	7	39
Oxypselaphus obscurus			9	7	4	60	9		11			6	100
Panageus bipustulatus				2			5					2	7
Paradromius linearis		13	10	7	4	27	12	14	18	14	13	10	132
Paratachys bistriatus	4		25	16	6	12	13	18	22		23	9	139
Philonthus atratus	7	11	15	18	2			7	6	8	7	9	81
Philonthus nitidus	11	9	16	11				22		6	8	7	83
Phyllobius pomaceus						8		14	15			3	37
Phyllopertha horticola	10	5	11	17	2	16	17	15				8	93
Phyllotreta atra	46	7	64		3			56	41	7	24	8	248
Phyllotreta cruciferae		7	7		2	16	10	53	61	7	41	9	204
Phyllotreta undulata	44		73		5			38	46	7	33	7	246
Platynus assimilis					8	17	8					3	33
Pleurophorus caesus	8	9	18	20	1	9	22	15	3	4	9	11	118
Poecilus cupreus cupreus	26	11	21	40	8	34	18	46	38	14	28	11	284
Poecilus senicus								22			12	2	34
Prosternom tessellatum		9	5	17	3	14	6	12				7	66
Pselaphus heisei heisei					3	2	2					3	7
Pseudoophonus griseus		13		19				7				3	39
Pseudovadonia livida						13	7					2	20
Psylliodes attenuatus						20			15			2	35
Psylliodes napi napi						15	13				43	3	71
Ptenidium formicetorum			3	18	2		7	5				5	35
Pterostichus cylindricus cylindricus									59			1	59
Pterostichus macer macer									22			1	22
Pterostichus melanarius melanarius	8		14		4	37	10	11	42	10	13	9	149
Pterostichus oblongopunctatus					5	25	15		13			4	58
Rhinocyllus conicus	17	7	9	16	2	8		27	10	9	7	10	112

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Saprinus semistriatus		3		3				3				3	9
Scopaeus laevigatus			5	8	5	5		8				5	31
Scymnus frontalis		11	7			3		9	5			5	35
Sibinia unicolor		15										1	15
Silpha carinata					2	3	1					3	6
Silpha obscura obscura		7	5	12	5	4	6	31	3	7	4	10	84
Sitona hispidulus				12		17	16	8				4	53
Sitona lineatus				16		14	11	12				4	53
Spermophagus sericeus								12				1	12
Sphenophorus piceus	13		12			7	10	10	11		11	7	74
Staphylinus ater		12		11	4	10	7	4	8	3	10	9	69
Staphylinus caesareus				9		11	3		7			4	30
Staphylinus compressus			1			7	2	5	9			5	24
Stenolophus skrimshiranus						13	18	11	14			4	56
Stenolophus teutonus	5	11	11	11		9	13	14				7	74
Stenopterus flavicornis			4									1	4
Stenurella bifasciata			7	6		16	6	7				5	42
Stenurella nigra			3	4		15	27	7				5	56
Stomodes gyrosicollis		9		11			3	8				4	31
Strophosoma melanogrammum		11		17				7				3	35
Subcoccinella vigintiquatuorpunctata		7	2		3	24		8				5	44
Syntomus foveatus	20	22	14	34	7	23	88	38	29	10	31	11	316
Syntomus pallipes					3		10					2	13
Trechus quadristriatus	11	39	20	55	13	58	38	57	17	11	19	11	338
Tribolium madens					6							1	6
Trichodes apiarius			5		4			3				3	12
Tropinota hirta		13	3	19	3		11	31	22		8	8	110
Trox sabulosus		10	5	5		3		7				5	30
Trypocopris vernalis				62	4	61	25	42				5	194
Tytthaspis sedecimpunctata	19	9	20	24	2	6	11	19	25		11	10	146
Valgus hemipterus					2	14		7				3	23
Zabrus spinipes							12		5			2	17

6.5 Plants and Vegetation (*Planta*)

6.5.1 Vegetation development indexing in D4EU SRWCs

The total data set for D4EU plant species / vegetation monitoring consist of 469 plant taxa, 334 filled data forms with species compositions, as well as 13,915 species records. They were collected during four vegetation seasons at 95 D4EU monitoring localities. We selected 79 monitoring localities, which have at least 3 seasonal records into final statistical analyses.

All plant taxa were classified into 3 contrasting plant species groups – PSG (Figure 23):

1. **Invasive species** according to Medvecká et. al. (2012) – 17 plant taxa with 1,206 records
2. **Ruderal species** according to Jarolímek et al. (1997) – 167 plant taxa with 7,211 records
3. **Natural species** – all others – 285 plant taxa with 5,498 records

Based on values estimating cover of identified species, we have calculated total cover per particular group (Figure 23). Ruderal and invasive species cover two thirds of monitoring sites.

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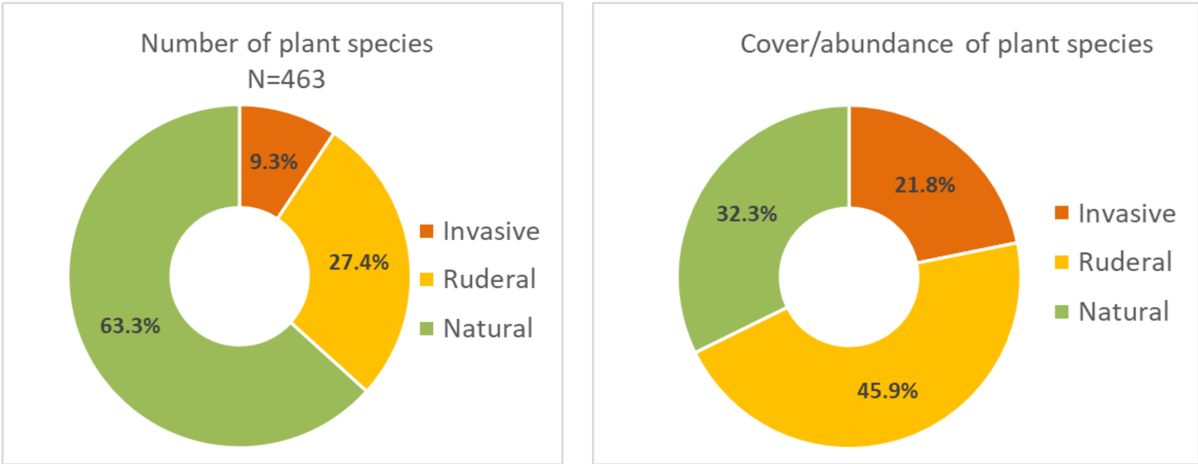

Figure 23: Proportion of species in particular groups and estimation of their cover.

The main idea behind our data processing was to evaluate the monitoring records according to number of present species of particular PSG (Table 12) for each record over the project years.

Table 12: Example of numbers of species per particular PSG (INV – invasive, RUD – ruderal, NAT – natural) for SRWC locality R2 (Rohožník).

Monitoring record	INV	RUD	NAT
R2_2018	1	10	9
R2_2019	5	20	24
R2_2020	6	22	26
R2_2021	6	34	29

Due to fact that each PSG has a different range, we applied a Min-Max normalization procedure (Suarez-Alvarez et al. 2012), which was calculated as follows:

$$v' = \frac{v - Min_A}{Max_A - Min_A}(new\_Max_A - new\_Min_A) + new\_Min_A$$

Where

- A is the attribute data,
- Min_A, Max_A are the minimum and maximum value of A respectively,
- v’ is the new value of each entry in data,
- v is the old value of each entry in data,
- the ‘new_ MaxA’ , ‘new_ MinA’ is the max and min value of the range (i.e. boundary value of the range required, respectively).

The new normalized range for each monitoring record per PSG was calculated as a relative value (ranging between 0-100, see example for the three PSGs at locality R2 in **Fehler! Ungültiger Eigenverweis auf Textmarke.**).

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Table 13: Example of normalized values per particular PSG (INV – invasive, RUD – ruderal, NAT – natural) for SRWC locality R2 (Rohožník).

Monitoring record	INV	RUD	NAT
R2_2018	14.29	17.86	18.92
R2_2019	71.43	35.71	59.46
R2_2020	85.71	39.29	64.86
R2_2021	85.71	60.71	72.97

We used these values as an assessment score in a 3D ordination space, which is defined by the following three axes that coeespond to the PSG defined above:

- x-axis: NAT – natural
- y-axis: INV – invasive
- z-axis: RUD – ruderal

Due to fact that range of all three axes is equal, we can show 3D space as a perfectly symmetric cube (Figure 24).

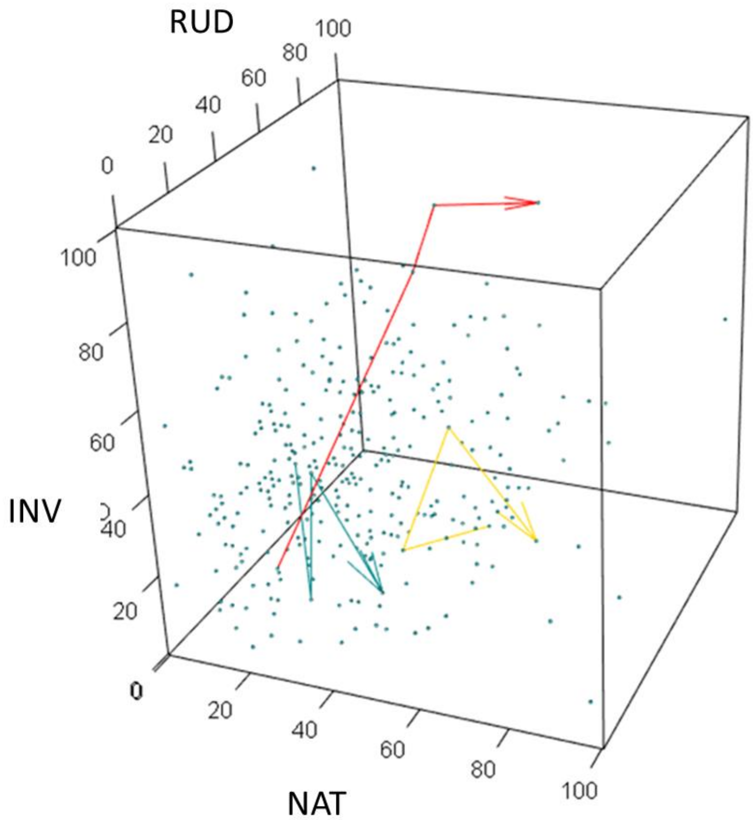

Figure 24: 3D data plot with data pointsdefined by: x-axis – NAT = normalized number of species of the natural plant species group (PSG) for the record/year, y-axis – invasive PSG, z-axis – ruderal PSG. Three of the investigated D4EU monitoring SRWC sites are shown by connection lines with arrows. Dots indicate all monitoring records per monitoring site.

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In order to find a synthetic biodiversity value, which will show the overall trend of monitored D4EU vegetation habitats, we decided to express this by Euclidean distance of position of particular dot from vertex with 100, 0, 0 coordinates. This vertex can be interpreted as a data point, which represents the best possible biodiversity value, which would result from the maximum possible normalized number (100) of natural species (NAT), as well as from 0 ruderal (RUD) and 0 invasive (INV) species. This theoretical vertex is termed 'optimal biodiversity vertex' (OBV). The maximum value of the OBV is linked to current data set.

For the calculation of the Euclidean distance between any data point and the OBV in the 3D plot, we used the followingEuclidian equation:

$D = \sqrt{[(x_2 - x_1)^2 + (y_2 - y_1)^2 + (z_2 - z_1)^2]}$

Figure 25 shows the succession of the habitat in the D4EU monitoring plot R2 (Rohožník) in the years 2018 to 2021, and the R2 data is expressed by the red arrow. The blue lines show Euclidean distances of each annual data point in particular vegetation season. The succession trend can be interpreted as relatively good start in 2018 with shortest distance from OBV. The year 2019 was characterized by an increase in the number and coverage of invasive and ruderal species, which caused a shift of the arrow along the y- and z-axes. This resulted in an increase of the distance from OBV and indicated a gradual deterioration. In text years, 2022 and 2021, the situation was more-less stable.

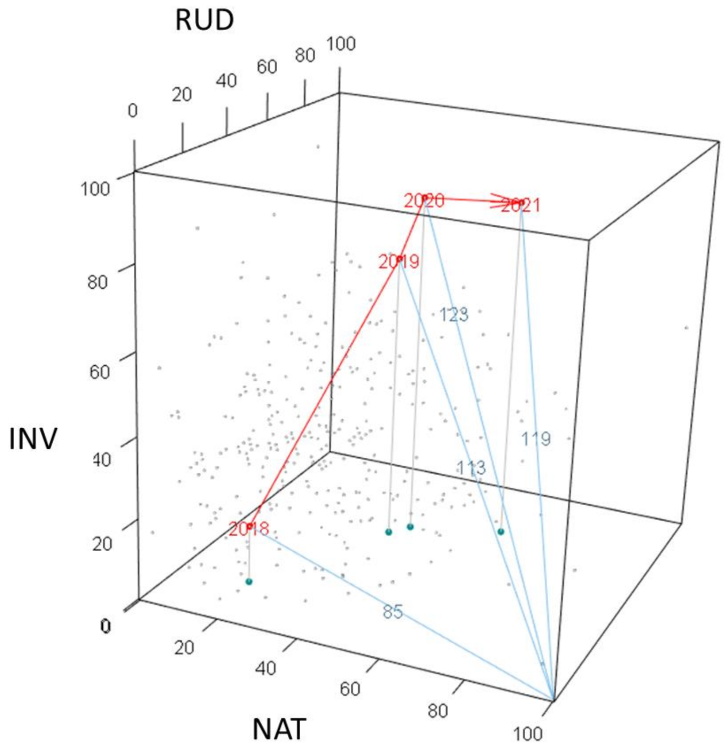

Figure 25: 3D data plot with data points defined by: x-axis – NAT = normalized number of species of the natural plant species group (PSG) for the record/year, y- axis – invasive PSG, z- axis – ruderal PSG. The succession of the habitat in the monitoring locality R2 (Rohožník) is expressed by the red arrow. Blue lines show the Euclidean distances of vegetation data points from the optimal biodiversity vertex OBV (NAT = 100, INV = 0, RUD = 0) in one of the monitoring seasons 2018-2021.

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6.5.2 Results plants and vegetation

We have analysed monitoring records from 79 sites - only those, which have at least 3 records during the period 2018-2021 (Table 14). The values of the distance of the data point from the OBV (the lower the value, the closer to the natural habitat character of biotopes) show a different picture between sites of bad and sites with good biodiversity values. More interestingly, the trend of succession on monitoring sites (Table 15). Trend has been calculated by means of linear regression. The regression result over all monitoring sites indicates, on average, a slight improvement of the biodiversity values of D4EU monitoring sites (Figure 26).

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Table 14: Biodiversity values (distances from OBV) - bad, or, erage, good.

locality	2018	2019	2020	2021	AVG	trend
M11b	127	134	110		**124**	**-8.5**
M14		124	107	121	**117**	**-1.5**
T15		123	105	118	**115**	**-2.3**
T14		107	120	113	**113**	**3.2**
S7	116	104	120	108	**112**	**-0.8**
T13	101	124	113	106	**111**	**0.2**
T6	128	98	113	105	**111**	**-5.2**
T11	106	112	116	109	**110**	**1.3**
R2	85	113	123	119	**110**	**11.2**
R13		100	117	111	**110**	**5.7**
R10	102	104	122	108	**109**	**3.5**
M2b1	103	119		104	**109**	**-0.8**
S3b	126	103	105	100	**108**	**-7.5**
M11bx	113	114	111	82	**105**	**-4.9**
M11a	105	103	104		**104**	**-0.4**
S14		94	107	110	**104**	**8.1**
S6	106	94	116	97	**103**	**-0.5**
T4	112	101	99	97	**102**	**-4.8**
MF3		106	100	98	**102**	**-3.7**
T6x	110	96	100	99	**101**	**-3.0**
M6	89	116	101	98	**101**	**1.3**
S3a2	97	96	106	104	**101**	**2.9**
M2b	88	111	104	99	**101**	**2.5**
S4	103	102	91	106	**100**	**-3.3**
S3d	105	105	100	92	**100**	**-4.2**
S3a1	105	98	107	90	**100**	**-3.8**
T3	105	100	98	96	**100**	**-2.8**
MF2		106	95	97	**99**	**-4.3**
R12a	108	91	96	101	**99**	**-1.5**
M2a	97	111	97	90	**99**	**-3.5**
T12b		111	94	91	**99**	**-9.7**
T1	101	103	99	88	**98**	**-4.1**
S3a3	97	96	96	101	**98**	**1.3**
S10	102	98	101	89	**97**	**-3.4**
R11a	102	96	94	97	**97**	**-1.7**
M1	99	101	86	103	**97**	**-0.3**
M4	97	96	100	94	**97**	**-0.5**
M5a	91	94	97	105	**97**	**4.3**
R12b	104	94	90	95	**96**	**-3.1**
R6	94	94	100	91	**95**	**-0.3**
R5	97	88	94	100	**95**	**1.6**
R9a	86	107	106	80	**95**	**-2.0**
S12a		95	101	88	**95**	**-3.5**
S5	100	100	87	91	**94**	**-9.9**
M8	89	109	92	86	**94**	**-0.5**
S13	91	82	97	104	**93**	**5.5**
M5b	91	94	98	91	**93**	**0.3**
T10a	93	89	95	95	**93**	**1.2**
S9b	89	96	97	88	**93**	**0.0**
T5	101	102	89	78	**93**	**-8.0**
T2	104	95	88	81	**92**	**-7.4**
M7	80	110	95	82	**92**	**-0.9**
S9a	86	93	97	92	**92**	**2.1**
S1	76	99	88	105	**92**	**7.6**
MF1		100	96	78	**92**	**-10.7**
R8b	92	102	90	80	**91**	**-5.1**
R9b	93	84	89	98	**91**	**1.9**
S8a	105	93	89	72	**90**	**-10.1**
T7a	101	86	95	76	**89**	**-6.4**
S3c	89	89	93	81	**88**	**-2.1**
T10b	86	89	96	73	**86**	**-3.1**
S2	89	90	78	84	**85**	**-2.5**
R4	90	96	78	71	**84**	**-7.6**
S11	96	76	72	91	**84**	**-2.1**
R11b	83	80	85	82	**83**	**-0.1**
R7a	78	104	90	58	**82**	**-7.3**
M9	56	107	84	82	**82**	**5.4**
R10a	96	97	66	67	**81**	**-11.8**
T7b	85	79	85	68	**79**	**-4.4**
R3	77	82	69	85	**78**	**0.9**
M12	91	92	69	61	**78**	**-11.3**
R8a	84	79	76	74	**78**	**-3.4**
S8b	84	76	68	77	**76**	**-3.1**
S12b		91	72	63	**75**	**-13.6**
M10	70	70	79	60	**70**	**-2.0**
M13x	97	65	61	44	**67**	**-16.2**
M13y	54	66	44	45	**52**	**-4.7**
M13z	75	60	30	36	**50**	**-14.8**
R1	64	52	42	15	**43**	**-15.6**

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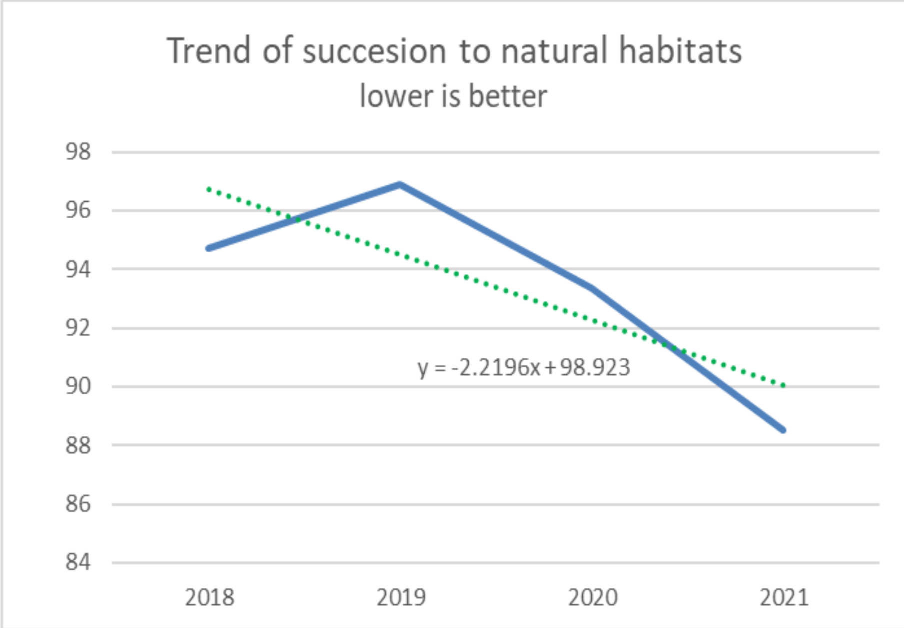

Figure 26: Trend of succession to natural habitats in all monitoring sites in period 2018-2021.

Another analysis shows proportion of localities with positive, stable and negative trends (Figure 27). It turned out that more than the half of sites follow a positive trend of vegetation succession, while roughly one third of the localities has stable and only 15 % of the sites show a decreasing biodiversity value over four vegetation periods (deterioration).

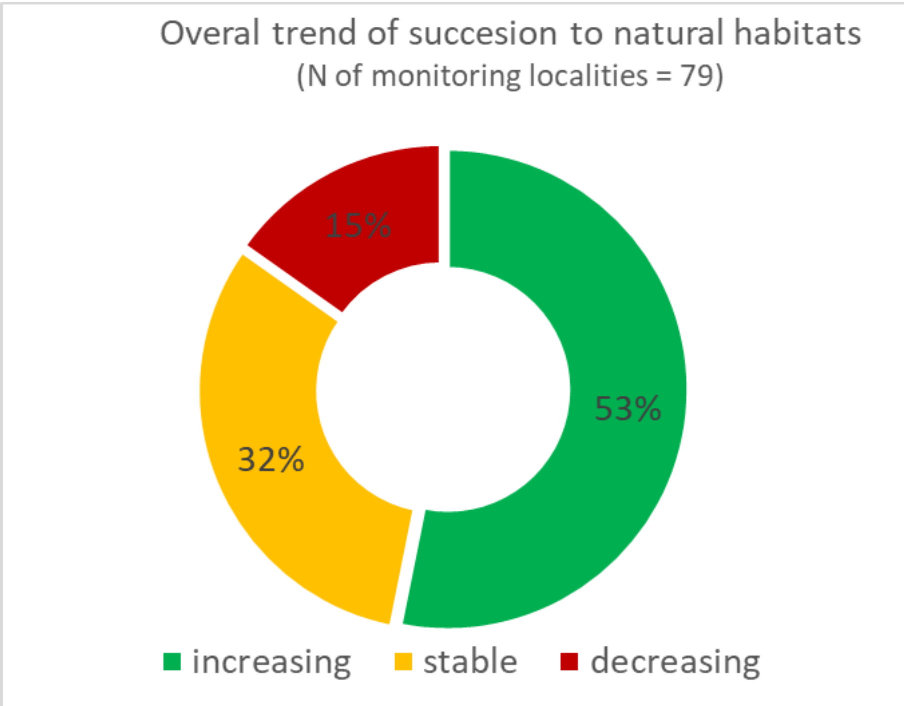

Figure 27: Trend of succession to natural habitats in particular localities.

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An important factor that influenced the biodiversity values and the succession trend at the monitoring localities was the basic situation on the site at the time of the SRWC establishment. The basic situation, or respectively the previous land use was classified into three categories:

1. Arable (classic farmland with annual crops)
2. Grass on arable land
3. Grassland

Single-factor ANOVAs wer applied to analyse differences among these three categories of monitoring sites with regard to their succession index towards more natural or more ruderal / invasive charcter.

The situation in year 2018 (Table 15) shows a good starting position in the SRWC localities established either on grassland or on 'grass on arable land'. As expected, sites on arable land have worse, that is less natural and less diverse, starting position.

Table 15: Single Factor ANOVA of monitoring sites in 2018. They are classified into three categories: 1. arable, 2. grass on arable, 3. grassland.

Anova: Single Factor	2018					
SUMMARY						
Groups	*Count*	*Sum*	*Average*	*Variance*		
arable	40	3977.233	99.43082	154.9416		
grass on arable	15	1284.481	85.6321	136.8226		
grassland	7	570.8911	81.55586	277.4453		
ANOVA						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	3313.731	2	1656.866	10.15858	0.000162	3.153123
Within Groups	9622.911	59	163.1002			
Total	12936.64	61				

In 2019, the biodiversity values in 'grass on arable land' decreased and it is practically on the same level as sites that were established on arable land (Table 16). Former grassland sites showed records with a slight shift downwards.

Table 16: Single Factor ANOVA of monitoring sites in 2019. They are classified into three categories: 1. arable, 2. grass on arable, 3. grassland

Anova: Single Factor		2019				
SUMMARY						
Groups	*Count*	*Sum*	*Average*	*Variance*		
arable	41	4020.358	98.0575	153.8047		
grass on a	16	1490.582	93.16137	257.8503		
grassland	7	585.4577	83.63682	372.4492		
ANOVA						
ce of Varic	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between (	1337.022	2	668.5111	3.327653	0.042497	3.147791
Within Gr	12254.64	61	200.8957			
Total	13591.66	63				

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The year 2020 shows significant increases of biodiversity values in sites that were established on grassland. In SRWC established on the other two categories of previous use, we observed a slight, but significant increase in biodiversity values (Table 17).

Table 17: Single Factor ANOVA of monitoring sites in 2020. They are classified into three categories: 1. arable, 2. grass on arable, 3. grassland.

Anova: Single Factor		2020				
SUMMARY						
Groups	*Count*	*Sum*	*Average*	*Variance*		
arable	43	4148.423	96.47496	188.8937		
grass on a	16	1448.396	90.52475	299.0694		
grassland	7	513.7853	73.39791	812.6607		
ANOVA						
ce of Varic	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between (	3295.592	2	1647.796	6.002191	0.004111	3.142809
Within Gr(	17295.54	63	274.5324			
Total	20591.13	65				

The growing season of the last year of D4EU vegetation monitoring (Table 18) manifested the continual significant improvement at sites established on grasslands. Overall, this year was also characterised by good developments for the SRWC at sites with the other two categories of previous land use.

Table 18: Single Factor ANOVA of monitoring sites in 2021. They are classified into three categories: 1. arable, 2. grass on arable, 3. grassland.

Anova: Single Factor		2021				
SUMMARY						
Groups	*Count*	*Sum*	*Average*	*Variance*		
arable	42	3843.038	91.5009	142.2503		
grass on a	16	1356.038	84.75238	555.6841		
grassland	6	361.2133	60.20222	642.3568		
ANOVA						
ce of Varic	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between (	5239.466	2	2619.733	9.195058	0.000323	3.147791
Within Gr(	17379.31	61	284.9067			
Total	22618.77	63				

The overall situation of vegetation succession on D4EU monitoring sites is shown in Figure 28. It shows a development of sites in three categories. The values at SRWC sites established on former arable land remained similar between the years, and they were significantly different from the sites established on grassland.

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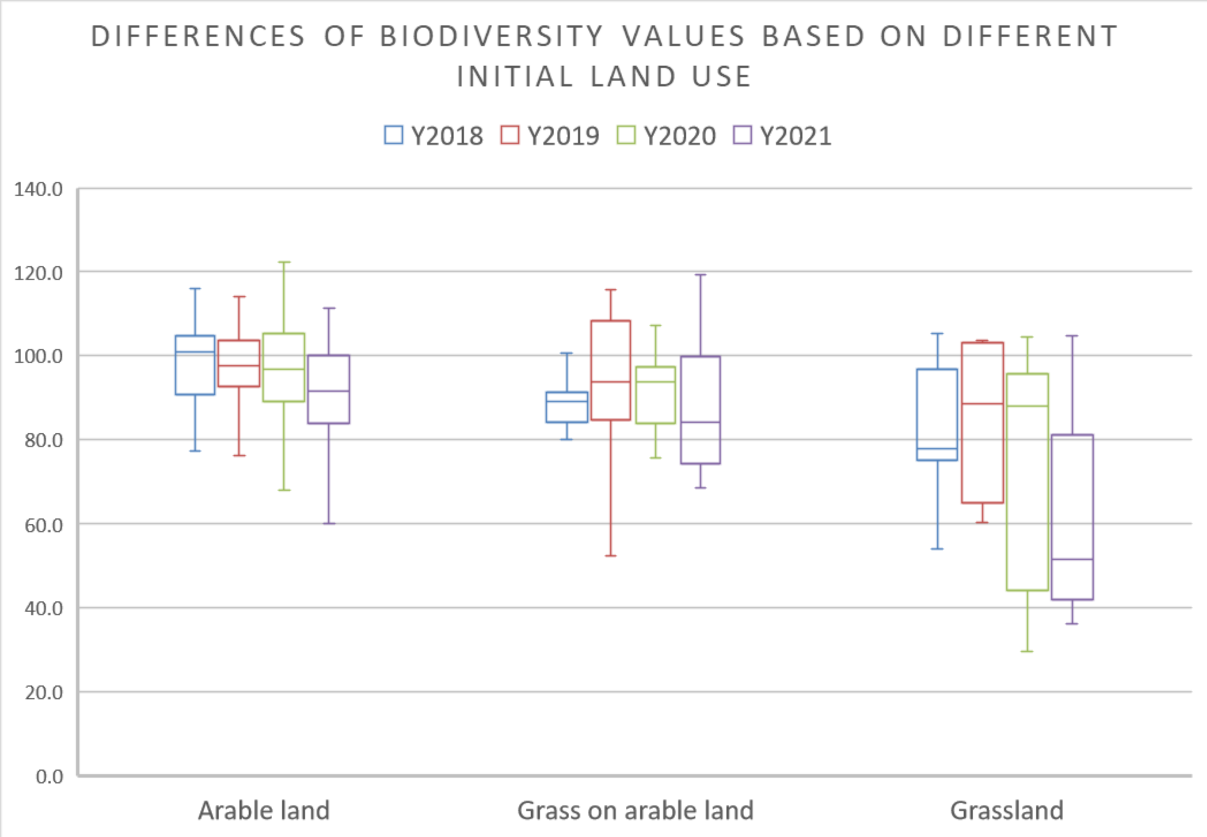

Figure 28: Comparison of three normalized vegetation categories of SRWC sites according to the original land use prior to SRWC establishment.

6.5.3 Conclusions plants and vegetation

All plant taxa were classified into three plant species groups of different "natural" character:

1. Invasive plant species
2. Ruderal plant species
3. Natural plant species

Regarding the total species pool of our monitoring results, the natural plant species group provide two thirds of all species, but they cover only one third of monitored area. The invasive and ruderal species provide, vice versa, only one third of the species, but two thrids of the land cover.

We have analysed the monitoring records of 79 sites - only those, which have at least three annual vegetation records during period 2018-2021. A trend of succession on monitoring sites has been calculated by linear regression. The regression equation over all the monitoring sites indicates a slight improvement of biodiversity values of the D4EU monitoring sites. It became evident that more than the half of monitoring sites had a positive trend of vegetation naturality, one third has a stable and 15% have a decreasing biodiversity values.

An important factor that influenced the biodiversity values and the succession trend is basic situation at the specific site at the time of the SRWC establishment. They are classified into three categories: 1. arable, 2. grass on arable land, 3. grassland. Last year of monitoring manifests continual significant improvement in particular at sites that were established on grassland. This year was also positive for

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the vegetation inside SRWCs that were established on the other two categories of previous land use (arable, grass on arable land).

The positive succession trend became evident in case of the D4EU sites established on grassland. But on the other hand, SRWC establishment in the grassland sites caused significant decrease of biodiversity. After four years of monitoring, we see also an improvement at sites established on arable land.

6.6 Other species groups

The overall number of 6,565 records of individuals of different animal species groups and of the group of fungi was observed in all SRWC localities in four seasons of monitoring. Figure 29 presents the percentage of occurrences derived from these records in D4EU SRWC localities and the distribution of the number of individuals per species group inside selected SRWC localities.

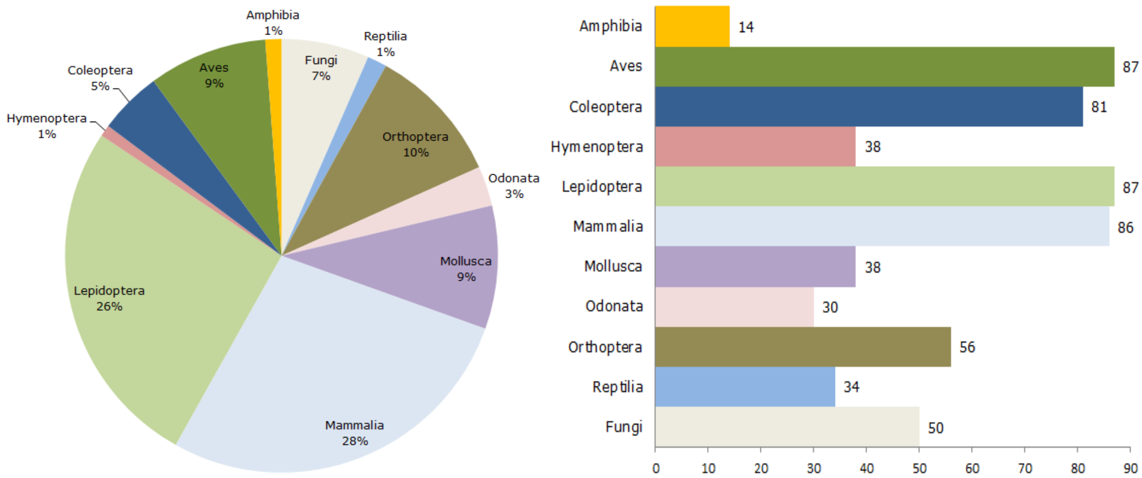

Figure 29: Percentage of occurrrence for different species groups in all SRWC localities (left) and number of SRWC localities with presence of specimens from specific species groups (right)

The most abundant species groups in SRWC localities are mammals, insects and birds which were recorded in more than 80 SRWC localities.

Mammals are represented mostly by deer species (*Capreolus capreolus, Cervus elaphus, Dama dama*), as well as by the wild boar (*Suus scrofa*), the European hare *Lepus europaeus* and the common vole (*Microtus arvalis*) Presence of deer species in selected SRWC localities was proven also by higher abundance of coprophagous beetle species (see 6.4 Beetles section). Activities of the European beaver (*Castor fiber*), a species of European importance, were recorded in 5 of D4EU's SRWC sites. Table 19 shows the presence of *Castor fiber* in all five localities during in all seasons.

Table 19: Presence of the Eurasian beaver (*Castor fiber*) in five D4EU localities during four monitoring seasons. (Coded locality names; M = Malacky, R = Rohožník.)

Castor fiber	M1	R1	R10a	R2	R13
2018	x				
2019	x			x	
2020	x		x	x	x
2021	x	x	x	x	x

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Lizards and snake species of the *Reptilia* group were recorded in 34 SRWC localities indicating that they benefit from these biotopes. They are represented by species of European importance such as the green lizard (*Lacerta agilis*), the European gree lizard (*Lacerta viridis*) and the smooth snake (*Coronella austriaca),* as well as one species of national importance, the grass snake (*Natrix natrix*). The number of specimens of snakes and lizards are summarized in the following Table 20.

Table 20: Numbers of individuals of snakes (*Serpentes*) and lizards (*Lacertidae*) recorded in D4EU monitoring localities. (Coded locality names; M = Malacky, R = Rohožník, S = Skalica, T = Trnava.)

Locality (coded)	*Coronella austriaca*	*Lacerta agilis*	*Lacerta viridis*	*Natrix natrix*
M1		4	2	1
M2b		2		2
M3		5		5
M5a		1		
M6	1			
M8	1			
M9		1		
R1				1
R10		1		
R10a		1		
R2		1		
R3				1
R4		3		
R5	1	4	5	1
R7b		1		
S1		8		
S12a		3		
S12b		1		3
S2		1		
S3a		1		
S3a1		4		
S3a2		8		
S3a3		3		
S3b		4		
S3c		2		
S3d		1		
S4		6		
S5		1		
S6		1		
S7		2		
S8a		3		
T89				1

The group of invertebrate species is represented mostly by *Coleoptera*, *Lepidoptera, Orthoptera* and *Mollusca* species. In SRWC localities with wetland character, the dragonfly species (*Odonata*) were recorded. In last monitoring season (2021) the presence of anthills in several SRWC localities were recorded: R9b (5 anthills), M6 (3 anthills), M4, M1, R8a, R2. All these localities were established in 2016 or 2017.

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Table 21: overall occurrences of specimens of different species groups in all D4EU SRWC localities, over all biodiversity monitoring seasons. (Coded locality names; M = Malacky, R = Rohožník, S = Skalica, T = Trnava.)

Locality (co-ceded)	*Chordata*				*Insecta*					*Mollusca*	*Fungi*
	Mammalia	*Aves*	*Reptilia*	*Amphibia*	*Coleoptera*	*Hymenoptera*	*Lepidoptera*	*Odonata*	*Orthoptera*		
M1	82	7	8		8		12		5	1	5
M10	1	7			2	1	101		6	6	8
M11a	7	5			11	1	18		7		1
M11b	25	8			4		19				
M11bx		4					8		2		
M12	5	8			3	1	20	5	3	8	
M13	10	21		2	5	2	91	3	5	6	
M14	9	5			4		17		1		1
M2a	2	5			16	1	20		1	1	
M2b	27	4	4	50	4		31			4	5
M2b1	2	1			1		20		2	8	1
M3	1	7	1	2	3		11	2		1	54
M3a	8	7	10		2	1	1		1		
M3b	5	2			1		2	1	2		
M4	9	4			5		38		3	1	51
M5a	1	3	1	1	3	1	13	1	1		16
M5b		4		1	12		16		3		13
M6	9	7	1		5	1	55		30		32
M7	5	7		2	2	3	58		9		10
M8	6	5	1		3		43		24		4
M9	9	4	1		3	5	5		2		
MF1	4	6		3	1		3	2			1
R1	66	15	1	7	6		9	2	2	23	5
R10	15	5	1		3	1	44		6	1	
R10a	5	14	1	1		2	23		1	20	
R11a	21				1						1
R11b	8	2			3		5				
R12a	28	4			6		3		3		
R12b					3		2	1		4	
R13	2	12		1	1		9		1		
R2	15	13	1	3	23		83	2	5	3	9
R3	2	11	1		1	1	24	4		7	1
R4	3	6	3		2		5				45
R5	5	7	11		9		20		2		1
R6	12	8			5	6	3				1
R7a	11	6			3	1	21	7	1	38	1
R7b		2	1		2	1					
R8a	1	8			3	1	6			5	
R8b		5			3	1	5				
R9a	3	11			5	1	41		4	1	2
R9b	3	5			2		35	1	2	3	4
S1	15	11	8		12		57		6	4	5
S10	23	3			2		5				11
S11	64	62			5	1	25	1			5
S12a	8	1	4		2		4	1			8
S12b		5	4	10	1		11	7		1	
S13	21	14			8		7		1		3

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S14	2	4			6	3	63		4		1
S2	14	6	1		12		63	3	4	5	23
S3a	33	5	1		2	1	1	2			
S3a1			4		2	1	10		3		5
S3a2	2	1	8		1		17				3
S3a3		5	3		1	1	39				2
S3b	17	5	4		8	1	19		2		35
S3c	8	3	2		2	1	7			1	
S3d	6		1		2	1	6				2
S4	26	18	6		8	3	46		3		7
S5	15	1	2		2		17				1
S6	4	15	1		6	2	18		2	2	46
S7	7	20	2		5	6	82	7	1	1	5
S8a	23	10	4		3		5	2	2	400	
S8a2	4	3			1		1				
S8b	19	3			2		12			2	4
S9a	1	9			2		4				
S9b	3	1			1		7				
T1	2	2			1				6		1
T10a	9	9			1	1	16	1	4		
T10b	10	4			2		19				
T11	51	1			6		13		2		
T12	6	8			5		6	15	11	1	
T12a	2	8			2		33	86	4	42	
T12b	1	2			2		11	30		2	
T13	522	9					54		2		
T14	4	16		1		1	39		119		1
T15	2	4			1		35	7	38	3	5
T17	3	2					4				
T18		1					1				
T2	7	22			1		9		2		1
T3	7	3			9	1	7		10		
T4	8	17			9	1	19		212		2
T5	9	4		1	2		30	8	5	4	
T6	54	13			6	1	36		80	20	10
T6x	1						3		1	15	5
T7a	1	13			2	1	10	2	4	1	
T7b	2	9			5	1	12	1	3	3	
T89	13	9	1		4	1	25	6	63	3	1

7 Risks, monitoring and evaluation

The main risk of the monitoring of different components of biodiversity (animal groups, plants and vegetation) on SRWC localities is harmonisation of methodologies for data gathering and proper selection of monitoring localities. We solved this typical problem by comprehensive information system, which includes GIS component. All gathered data were stored in common database, which was used for final evaluation.

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8 Deviations and next steps

There were no deviations comparing to the project's Grant Agreement.

9 Overall conclusions

Within the project, we managed to ensure extensive data collection. We obtained overall trends in vegetation succession and in the occurrence of indicator animal groups. The regular, annually recurring monitoring of selected indicator animal groups and of the vegetation was realised during four project years from 2018 to 2021.

The biodiversity data collected in the field at SRWC plantations and at reference sites is stored in the information system, which is a database that was created for this purpose. The major part of this data is published on the webpage http://daphne.sk/d4eu/index.html, to be available for project partners and interested expert stakeholders.

In total, 151 different bird species were recorded during all four seasons in 14 D4EU monitoring localities. 65 of them were recorded at SRWC localities, 112 at reference habitats and 137 species at the surrounding habitats.

In total, 10 different species of amphibians were recorded during all four seasons in 11 localities. Within the reference site such as areas in adjacent habitats with crops, respectively habitats that corresponded to the previous land use prior to SRWC establishment, seven species were identified.

In total, 45 different butterfly species were recorded during all four seasons. 39 of them were recorded at SRWC localities and 43 at reference habitats (7 in arable fields, 32 in shrub biotopes and 42 in grassland biotopes).

A total of 267 different beetle species was recorded during all four seasons in all 11 D4EU beetle monitoring localities. Thereof, 254 were recorded at SRWC localities and 247 at reference habitats (54 in arable fields and 247 in grassland). 20 beetle species were found only on SRWC localities.

The total vegetation data set consist of 469 plant species, 334 filled data forms with species composition records and 13,915 species records. They were collected during 4 vegetation seasons on 95 D4EU vegetation monitoring localities.

According to results of the D4EU biodiversity monitoring after four monitoring seasons and their evaluation, we can assess the impact of SRWC localities on biodiversity as follows.

- The present monitoring results have shown that amphibians can benefit from the ecological conditions in fast-growing tree crops. Compared to classical agricultural monocultures of annual cereal crops, not only the predominantly positive effect on amphibians was recorded during monitoring in SRWC.
- There were 30 different bird species recorded with nesting activities in SRWC localities and their reference habitats. 20 of these species occurred in SRWC localities and the surrounding reference habitats, and further 10 species were recorded solely inside the SRWC localities.

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- Comparing SRWC areas with that on intensively used arable land, an increase of the species diversity of daytime butterflies was observed in the SRWC. In case that the poplar SRWCs were planted on meadows, there was a significant decrease in the species diversity of daytime butterfly species after planting SRWC. The diversity of thes butterflies in SRWC areas is gradually decreasing due to the increasing canopy closure.
- As an overall conclusion regarding *Coleoptera*, we can confirnm that SRWC localities are suitable habitats for beetle species and in cases where the SRWCs were established on arable land, they result in an increase of the biodiversity of this species group.
- All plant taxa were classified into 3 plant species groups: 1) invasive; 2) ruderal; and 3) natural. From total species pool, the natural ones provide two thirds, but they cover only one third of the monitoring area. Invasive and ruderal species provide, vice versa, one third of the species but two thirds of the vegetation cover. An overall slightly positive trend of the vegetation succession on monitoring sites has been calculated towards more naturality by linear regression. Regression equation of all monitoring sites indicates slow improvement of biodiversity value of monitoring sites. We see that more than half of sites have positive trend, third has stable and 15% have decreasing biodiversity value.
- SRWCs established on previous classic arable fields become an important refugium for different species groups, and they can increase the biodiversity value of the respective part of the landscape. An overall assessment shows that the benefits provided by SRWCs results not only from thereduced or terminated use of agro-chemicals, but also from a structural difference that is the spatial structure of the habitat beyond that of classic agricultural cropland. Another advantage is the maintenance of free space between and below the tree rows - especially in comparison with denso cereal or oilseed crops, which provide only a minimum of space for wild flora or fauna.
- Micro-localities within SRWC tree rows, which were not disked, can provide suitable shelter for plant and animal species within the SRWC locality.
- Disking, which is an important non-chemical weeding measure, can have positive but also adverse effects, depending on the respective plant or animal species and on the timing of the disking within the growing season.
- SRWCs with one- or two-year old trees provide good conditions for most of the animal species groups. For bird species, the “memory of the site” was recorded. It is a phenomenon, according to which animals (especially birds) return to the known place even in cases when the site is already changed. In these situations, they do not have suitable conditions there anymore.
- Disking disturbances can be supportive for psamophytic and annual plant and beetle species. Some of them are rare and threatened such as the plant species *Aphanes arvensis*, *Ranunculus arvensis*, *Spergula morisonii*, *Teesdalia nudicaulis*, or the beetles *Sibinia unicolor* and *Maladera holoserica*.
- An overall increased structural diversity as well as the maintenance or creation of landscape elements such as tree solitaires or water ponds within SRWCs can contribute to landscape heterogeneity and help increasing biodiversity values.
- SRWC localities established on former grasslands, wetlands or other rather natural non-forest biotopes decrease original biodiversity value.

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Recommendations for the further management of SRWC sites

Providing spatial structures, respectively increasing the diversity of shelter options and reducing the degree of uniformity of the surfaces (e.g., free edges, strips) contribute to the improvement of biological functionality of SRWC stands. It is particularly advisable to leave heaps of wood on the edges. But also existing tree groups within and near the sites should be conserved. Small scale land depressions or ponds inside SRWC localities do not only attract individuals of amphibian species for seasonal use, but the suitability of the location and sufficiently long presence of water during the season are also ideal in terms of reproductive opportunities for amphibians. In some places, these biotopes can also be quite significant breeding sites, especially in the event of scarcity or extinction of suitable areas in the surrounding.

To support the diversity of butterfly species, it would be appropriate to keep meadow corridors (north-south direction) with a minimum width of 5 to 10 m between the poplar stands of a width of 50 m each. These corridors should be sown with a suitable meadow mixture of bee pasture species and should be mowed once in the growing season. At the same time, in the case of wetter habitats, it would be appropriate to create wetlands without poplar planting, which would also be mowed once per year until the end of the growing season.

The interventions with anticipated adverse effects are deep plowing, excessive and frequent disking, or disking and plowing of wetlands. Completely inappropriate would be too deep intervention into the soil cover, reaching a depth of several decimetres.

The elements or field operations in SRWC that could have a positive effect on biodiversity refer to higher structural diversity, such as diversified soil coverage (partly disturbed soil, partly herbaceous undergrowth), various sizes of woody plants and canopy closure, open areas, edge effects due to leaving parts of the SRWC open, and the local presence of surface water. Also, shallow discing, or mowing or mulching instead of deep ploughing, as well as lowering the load of pesticides, do create great benefit.

Establishing a mosaic of different tree age classes within one SRWC locality can increase its biodiversity and habitat values for several species of fauna and flora.

In many sites of SRWC plantations we can find small localities with unfavourable conditions for intensive poplar production. The reasons can be different hydrological conditions (too wet or too dry) or unsuitable soil conditions (sandy or rocky). They could be used for the creation of “biodiversity islands”, which will be managed for the benefit of wild flora and fauna. Under optimum conditions, such “biodiversity islands” should be protected by semi-natural grassland belts and would remain after finalisation of SRWC plantation as small biocentre in the agricultural landscape.

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