ECOLOGICAL STATUS OF FLOODPLAINS AND THEIR POTENTIAL TO CARBON STORAGE: CASE STUDY FROM THREE WATERSHEDS IN THE SOUTH MORAVIAN REGION, CZECH REPUBLIC

KATEŘINA KRÁSNÁ[1,2*], LENKA ŠTĚRBOVÁ[1], MARCELA PROKOPOVÁ[1], JIŘÍ JAKUBÍNSKÝ[1], PAVEL VYVLEČKA[3], VILÉM PECHANEC[3]

[1]Global Change Research Institute of the Czech Academy of Sciences, Bělidla 986/4a, 603 00 Brno, Czech Republic
[2]Department of Geography, Faculty of Science, Masaryk University, Kotlářská 267/2, 611 37 Brno
[3]Department of Geoinformatics, Faculty of Science, Palacký University Olomouc, 17. listopadu 50, 771 46 Olomouc, Czech Republic
**Corresponding author e-mail: krasna.k@czechglobe.cz*

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ABSTRACT

Floodplains are important ecosystems that contribute to the ecological stability of the landscape. A number of ecosystem functions and services are significantly influenced by ecological aspects of floodplain habitats. This article focuses on the ecological quality and estimated amount of carbon stored in the biomass of habitats located in the studied watersheds, with an emphasis on floodplains. The habitats and their ecological quality were determined and assessed using the Biotope Valuation Method (BVM), an expert method for evaluating habitat (biotope) types based on eight ecological characteristics, mainly concerning various aspects of their biodiversity and vulnerability. The objective of this study is to compare the resulting assessments of habitats located in floodplains with assessments of habitats situated in the surrounding landscape. The study was carried out on three selected small stream watersheds in the South Moravian Region of the Czech Republic, which differ from each other in terms of the predominant land use and the overall level of anthropogenic pressure on the landscape. The results indicate that floodplains have a higher ecological value compared to the surrounding landscape, except for floodplains in areas with intensive agriculture. The ability of floodplains to store carbon in biomass turned out to be higher in the watershed with a higher percentage of tree stands, where woody plants store significantly more carbon in the biomass compared to other types of vegetation. It has been shown that human pressure on floodplains and land use significantly affects ecosystem functions and services. In addition to the intensity of agriculture, these were, in particular, pressures from an expansion of built-up areas and infrastructure developments, and forest management. In this study, forest stands in floodplain were more stable and had a more beneficial species composition than forests in the surrounding landscape.

Keywords: ecosystem services; biodiversity; carbon storage; floodplain; human pressure

INTRODUCTION

Floodplains are valuable ecosystems and are a key part of the river landscape. The positive characteristics and processes of floodplains worth highlighting are, among others, the ability to dissipate waves during flood events (Vári *et al*., 2022), air cooling through evapotranspiration (Čížková *et al*., 2013), biodiversity promotion (Maděra *et al*., 2011, 2013), habitat provision, and carbon sequestration (Schindler *et al*., 2013; Fischer *et al*., 2019; Shupe *et al*., 2021).

These properties and processes are a prerequisite for the performance of floodplain ecosystem functions and services, which have been studied by a number of authors (Funk *et al*., 2019; Meli *et al*., 2014; Opperman *et al.*, 2010; Schindler *et al*., 2014). CICES (The Common International Classification of Ecosystem Services) has become, to some extent, a standard for classification of ecosystem services (ESs). CICES defines ESs in three categories: regulatory services (e.g., nutrient regulation), provisioning services (such as fisheries and hydropower provision), and cultural services (recreational and educational values; Fish *et al*., 2016). Other ESs provided by floodplains include bolstering the supply of groundwater and contribution toward the fertility of soils for agriculture or forestry, which indirectly support numerous provisioning services (e.g., Fischer *et al*., 2019).

The ability of floodplains to provide ESs depends to a large extent on the hydrological regime. Inundation during floods is particularly significant. For example, Bernal & Mitsch (2008) found that floods have a positive effect on soil carbon storage in riverine wetlands. Moreover, the amount of carbon stored in riparian vegetation is related to the heterogeneity of riparian vegetation and soils, which is closely linked to water connectivity and influenced by valley geometry, channel pattern, and soil moisture gradients (Polvi *et al*., 2011; Tabacchi *et al*., 1998). Also, natural vegetation appears to be the most efficient at carbon storage in plant biomass (Fierke & Kauffman, 2005; Giese *et al*., 2003). However, it is necessary to emphasize the importance of soil, which is often able to store a larger amount of carbon than plants (e.g., Sutfin *et al*., 2016).

Frequent processes that disrupt river systems in the Czech Republic include the construction of buildings and levees in floodplains and anthropogenic modification of the riverbed (e.g., Báčová *et al*., 2013). These actions usually result in the degradation of floodplains and, in some cases, in the interruption of connectivity between the watercourse and the floodplain, which can lead to other negative phenomena such as wetland desiccation (Jakubínský, 2014; Křížek *et al*., 2006). The construction of levees that prevent floodplain inundation causes a fundamental problem in the preservation of floodplains, which have been disconnected from the river and can still provide several ESs but sometimes only if restored or rehabilitated.

Floodplains can be delineated as morphological floodplains, as described by Eder *et al.* (2022). These authors refer to floodplains inundated during a flood event with a return period of 100 years (Q100) as active floodplains and those that are not inundated as a result of human intervention (for example by channelization), but would have been otherwise, as former floodplains. The authors define morphological floodplains as the combination of the spatial extent of active and former floodplains.

One of the main factors on which analyses of ESs can be based is land use. Many studies have sought to establish relationships between different types of land use and the provision of ESs (e.g., Burkhard *et al*., 2012; Hermann *et al*., 2014; Koschke *et al*., 2012). In the Czech Republic, instead of using land cover categories, it is possible to map habitats based on the BVM methodology (Biotope Valuation Method) developed by Seják and Dejmal et al. (2003; latest version: Seják *et al*., 2018b). This methodology includes not only unnatural habitats but also natural and semi-natural habitats as defined by Chytrý *et al.* (2001, first version; 2010, latest version). This methodology defines the point value of a habitat per 1 m^2 of area, which expresses its relative ecological importance compared to other habitat types in the Czech Republic (Seják *et al*., 2018b). The resulting score is determined on the basis of eight ecological characteristics of habitats: (1) matureness, (2) naturalness, (3) diversity of plant species, (4) diversity of animal species, (5) rareness, (6) rareness of species, (7) vulnerability, and (8) endangerment. The point valuation can also be converted into a financial value, as shown, for example, by Machar *et al*. (2020), who focused on the monetary value of floodplain forests, and Pechanec *et al*. (2017). Consistent with previous research (Pechanec *et al*., 2021), ecological value, based on assessments of various aspects of habitat and species diversity, rarity and vulnerability, may not be entirely consistent with regulatory ecosystem services such as carbon storage capacity. However, the relationship between biodiversity and regulatory ecosystem functions has been described by different authors, though the relationship is often non-linear as biodiversity is more of a regulator of ecosystem processes that underpin ecosystem services (Cardinale *et al*., 2012; Mace *et al*., 2012). That is why we include ecological value, which includes biodiversity to a significant extent, as a complementary dimension to the assessment of carbon storage capacity.

The aim of this article is to assess the ecological value and ability of floodplain habitats to store carbon, and to compare these values with those of habitats in the surrounding landscape, defined here as the remaining area of a watershed.

MATERIALS AND METHODS

Study Area

The studied watersheds of the Okrouhlý Stream, the Ferdinandský Stream, and the Veverka Stream are part of the Danube basin and are located in the South Moravian Region of the Czech Republic (Fig. 1). These streams are small watercourses classified as streams of the third (Okrouhlý Stream and Veverka Stream) and fourth order (Ferdinandský Stream) according to Strahler's classification. The studied streams in the watersheds and their floodplains are in many cases strongly influenced by anthropogenic activities. The selected characteristics of the studied watersheds and streams are shown in Tab. 1.

Fig. 1: Location of the studied watersheds of the Okrouhlý Stream, the Ferdinandský Stream, and the Veverka Stream

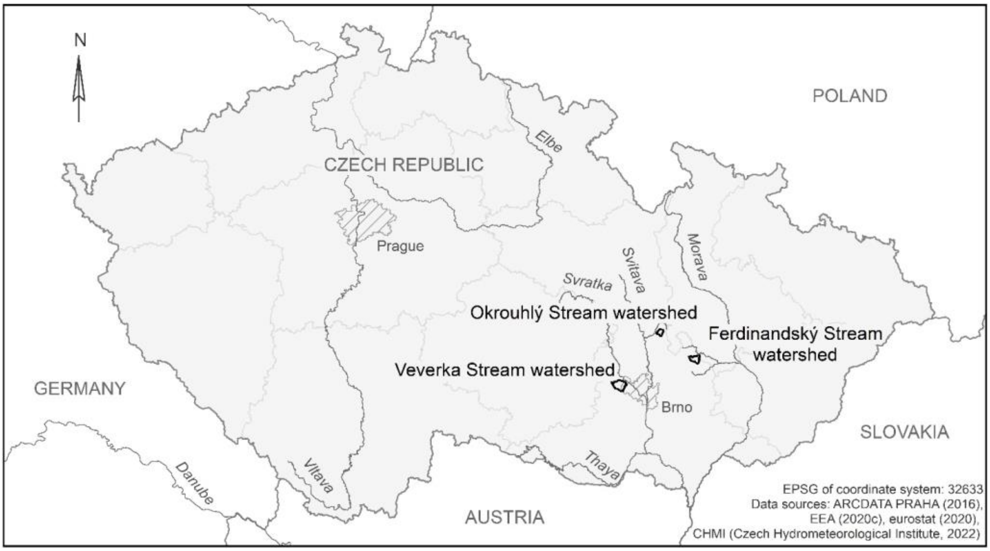


Table 1: Characteristics of the studied watersheds and streams

	Okrouhlý Stream	Ferdinandský Stream	Veverka Stream
Watershed area [km^2]	9.0	16.7	31.3
Elevation gain [m]	263.3	249.5	250.9
Average elevation of watershed [m a. s. l.]*	608.5	405.8	358.3
Average slope of watershed surface [°]*	7.3	8.2	8.0
Main watercourse length [km]	5.4	9.8	9.4
River network density [km.km^{-2}]**	1.4	1.6	1.2
Main watercourse slope [%]	4.6	1.9	2.0
Share of floodplains in watershed [%]	6.1	6.1	6.4
Average width of the main floodplain [m]***	66.6	51.5	62.1
Minimal width of the main floodplain [m]***	15.5	7.9	7.3
Maximal width of the main floodplain [m]***	172.9	128.4	180.0

Notes: *represent mean values of DEM rasters; **calculated as the ratio of the length of the streams in the watershed to the area of the watershed; ***calculated in GIS using the Fluvial Corridor tool (Roux et al., 2015) with a step of 1 m.

Land cover categories present in the watersheds in 2020 and 2021 are listed in Tab. 2. Forests predominate in all catchments, especially in the Ferdinandský Stream catchment, where the share of the forest is 81.7% and the share of fields is 10.3%. The second most forested watershed is the Okrouhlý Stream watershed, where forests make up 62.8 % and the other dominant surface type is meadows, pastures, and grasslands (29.9 %). The Veverka catchment is dominated by forest stands, accounting for 47.8 %, and arable land, representing 41.9 %. Our data from 2020 and 2021 show that clearings combined with standing dead trees covered between 10.0 % (Veverka Stream) and 17.5 % (Ferdinandský Stream) of the total area of forest stands in each of the watersheds, much of which was very likely the result of spruce and pine decline and dieback.

Table 2: Percentage of the main land cover categories in the studied watersheds in each of the catchments in 2020–2021

	Okrouhlý Stream	Ferdinandský Stream	Veverka Stream
Forests (including standing dead trees and clearing areas) [%]	62.8	81.7	47.8
Shrubs [%]	0.4	0.6	1.4
Meadows, pastures, and grasslands [%]	29.9	3.4	3.7
Arable land [%]	1.5	10.3	41.9
Settlements and artificial surfaces [%]	5.2	3.3	4.6

Note: Land cover is calculated from the habitat layer. Only habitats with an occurrence above 0.1% are included.

The Veverka Stream catchment was the most impacted by anthropogenic influences in the past. Historically, it developed with the purpose of the intensification of agriculture, with the share of arable land continuing to rise since the mid-19th century. Many meadows, which covered almost all floodplains in this basin in the mid-19th century, were often converted into arable land. Also, several streams in the catchment were straightened in the past (COSMC [Czech Office for Surveying, Mapping and Cadastre], 2023), and field research suggests that some watercourses were also deepened. Most of the Ferdinandský Stream watershed has been part of the Březina military district since the 1950s (VLS [Vojenské lesy a statky ČR], 2013). This type of land use means a long-term reduction in anthropogenic pressure on the landscape. Even still, the meandering stream surrounded by wetlands underwent substantial modifications in the past including straightening and channel relocation in some places. Some wetlands in the floodplain were converted into arable land, and they were converted to grasslands around 2010 (MA [Ministry of Agriculture], 2020). Around 2015, another three ponds were built on the upper course of the Ferdinandský Stream where there originally were valuable natural wetlands and wet meadows (NCA [Nature Conservation Agency of the Czech Republic], 2006). Historical development of the Okrouhlý Stream watershed was more typical for the territory of the Czech Republic for most of the second half of the 20th century, as a significant part of the land was converted into arable land. Today, this once arable land is covered by forests and meadows.

Data Processing

As a map base for this study, we used a habitat layer that was created by combining the following map sources: (1) LPIS register 2020 (Land Parcel Information System; MA, 2020) for the agricultural land, (2) Dominant Leaf Type 2018 (© EEA [European Environment Agency], 2020a) for the forest vegetation, (3) Imperviousness Density 2018 (© EEA, 2020b) for paved surfaces and sealed areas, (4) Habitat Mapping layer (© NCA ČR, 2022) for natural and close to nature habitats, (5) OpenStreetMap (© OpenStreetMap, 2022) for land use, roads, railways, traffic, and buildings, (6) ZABAGED (The Fundamental Base of Geographic Data of the Czech Republic; ® ZABAGED, 2023a) for watercourses and water bodies, and (7) a modified layer of forest growth stages 2015 (© FMI [The Forest Management Institute], 2015) to identify young forest plantations up to 10 years of age.

Habitats in the habitat layer were expressed in categories according to Seják *et al*. (2018b), which include 127 natural and semi-natural habitats (Chytrý *et al*., 2010) and 38 unnatural habitats. In the case of unnatural forest habitats, a more detailed categorization was used to distinguish coniferous forests, broadleaved forests, clearings, and young forest plantations. Ecological values of habitats were assessed using the BVM method (Seják *et al*., 2018b). This method assigns a point value to each habitat, representing its relative ecological value compared to other habitats in the Czech Republic. The point values were derived from eight ecological characteristics stated in the introduction. An example of the detailed delimitation of habitats of the Okrouhlý Stream watershed is given in Appendix (A.2) and is available in the electronic version of this article. Map layers were created and edited in GIS software using ArcMap 10.2.1 and ArcPro 2.9.5.

Due to the rapidly changing situation of forest stands caused by the current bark beetle calamity and drought, the resulting map was further updated by identifying recently logged wood and dead coniferous stands using satellite imagery and the normalized difference vegetation index (NDVI) raster. The multispectral satellite images from Sentinel-2 (© Modified Copernicus Sentinel data 2022/Sentinel Hub; ESA, 2022) of the type 2A product, containing bottom-of-atmosphere reflectance, were used. The NDVI was calculated in the ArcGIS environment using the Raster Calculator function as NDVI = (B8A−B4)/(B8A + B4), where B8A and B4 are the spectral bands of Sentinel-2. For more details, see Appendix A.1. Cleared and standing dead trees of spruce and pine forests were identified in areas with previous mature coniferous forests with a decline in NDVI values below 0.55. This limit was determined empirically for the study watersheds using 2020 orthophotos.

The amount of carbon stored in the biomass was determined based on the measured amount of dry matter for each habitat type in the habitat layer, which was then converted to net carbon using a coefficient of 0.46 or 0.5 for tree biomass (according to Cienciala et al., 2006). Carbon stocks were considered in three pools: above-ground biomass, below-ground biomass, and dead biomass. In this study, we used the total quantity of carbon obtained by combining the three pools mentioned above. For all studied habitats, the carbon stocks were assessed using available national data sources, a literature review, and our own experimental measurements (Stará *et al*., 2011). To calculate the total biomass on arable land, harvested area and per-hectare crop yield provided by the Czech Statistical Office (CSO [Czech Statistical Office], 2021) were used. The crop by-product biomass was estimated using coefficients according to the Czech University of Life Sciences (CZU [Czech University of Life Sciences Prague], 2001), and the biomass of post-harvest residues using mean values for each particular crop, as reported by Forchtsam and Prchal *et al*. (1961). The basic data on forest growing stock under bark for 2019 were taken from the report of the National Forest Inventory in the Czech Republic (Adolt *et al*., 2020).

Data on the total above-ground biomass, standing dead trees, stumps, lying deadwood, as well as the biomass of trees growing outside forest land has been completed from the results of the Czech Terra landscape inventory project for 2014/2015 (Cienciala *et al*., 2015; CzechTerra, 2015). The below-ground biomass of trees was obtained by multiplying the above-ground biomass by a coefficient of 0.2 (Cienciala *et al*., 2006). In addition, fine root biomass estimated according to Wang *et al*. (2018) was calculated. Herbaceous understory biomass, woody and herbaceous understory litterfall, dead below-ground biomass, and debris left after harvesting were estimated using data from Stará *et al*. (2011). Soil carbon was not included in this study due to a lack of adequately detailed data. Expert coefficients for individual habitat types were obtained using the abovementioned method, which is then connected to the mapped segments of individual habitats using the LUT (look-up table) method (Pechanec *et al*., 2022).

Floodplains Delineation

As stated in the introduction, this article focuses on morphological floodplains, as defined by Eder *et al*. (2022). The boundaries of these floodplains were determined using a geomorphological approach, according to which floodplains are plains formed by accumulated fluvial sediments along watercourses separated from other parts of the relief by edges with a more or less pronounced change in slope (Křížek *et al*., 2006). Therefore, when delineating borders of floodplains, which was done primarily using map sources, the following were mainly used: (1) a slope map created from a digital relief model of the fifth generation (© ZABAGED, 2023b), (2) a geological map 1:50,000 (© CGS [Czech Geological Survey], 2018), (3) Basic Map 1:10,000 (© COSMC, 2023), (4) an Orthophoto (© COSMC, 2023), (5) and a field survey.

RESULTS

Appendices A.3 and A.4 show tables with the names of habitats, their codes, BVM assessments, carbon stored in plant biomass, and their area in floodplains and surrounding landscapes in all three studied watersheds. For a more detailed analysis, the Intensively managed forests (XL1) category was further divided into Young managed forests plantations (XL1_a), Broadleaf forest stands of managed forests (XL1_b), and Coniferous forest stands of managed forests (XL1_c). Similarly, Dead trees and recent clearings (XL2_d) detected using satellite data were detached from the category Areas of deforestation (clear-cutting areas) (XL2). Detailed delineation of the areas of individual habitats in the floodplains of the main streams, tributaries, surrounding areas, and entire watersheds is given in Appendix A.5. Appendix A.6 summarizes areas of habitat types in the abovementioned environments.

Ecological Values of Habitats Based on BVM

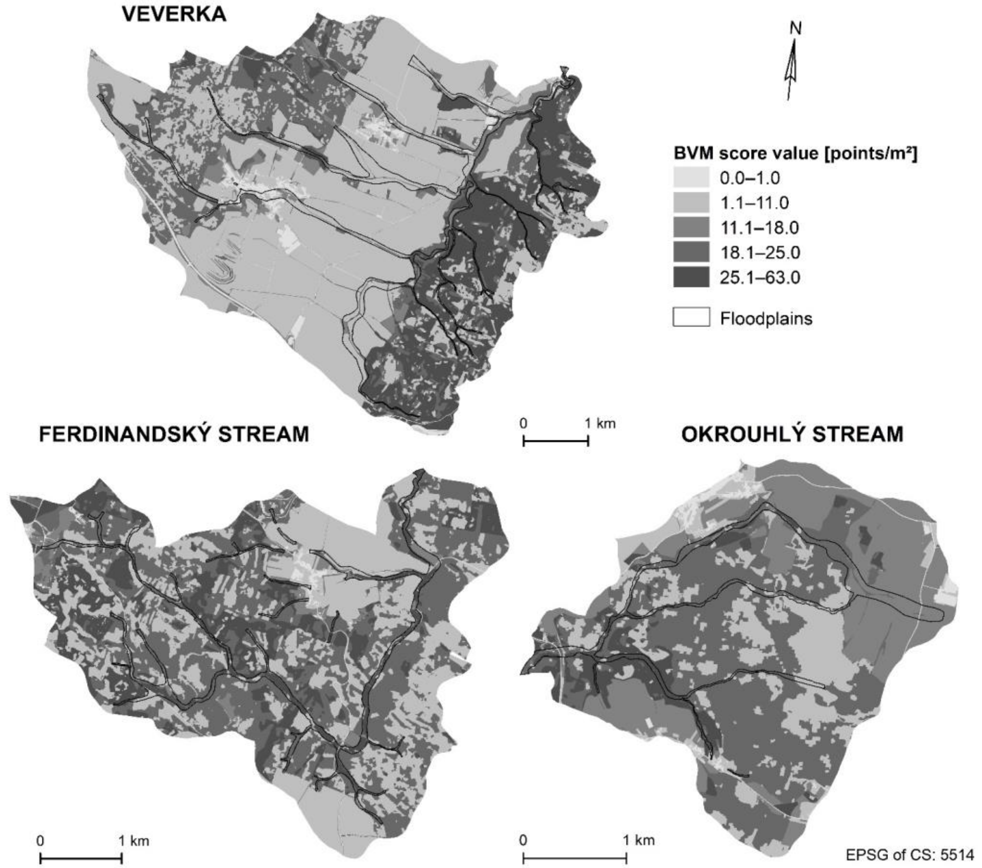
The map in Fig. 2 shows the ecological quality of habitats in the studied watersheds expressed in five categories. The least ecologically valuable habitats are in the category with points between 0.0 and 1.0 points/m^2, which consists of totally degraded habitats (as defined by Seják *et al*., 2018b). These are Continuous built-up area (XX3.1), Impermeable surfaces and permanently devegetated areas (XX3.2), and mosaics of these habitats with other unnatural habitats. The category of 1.1–11.0 points/m^2 consists mainly of Areas of deforestation (clear-cutting areas) (XL2), Young managed forests plantations (XL1_a), and significantly degraded habitats, in particular habitats on arable land (Weed vegetation of annual and biennial field crops, X4.1) and gardens and gardening colonies (X5.2). The third category (11.1–18.0 points/m^2) consists mainly of slightly degraded habitats, such as meadows (XT1, XT2), extensive orchards (XK4), water reservoirs (XV1), and watercourses (XV2). In the category of 18.1–25.0 points/m^2 are mainly significantly slightly habitats with woody vegetation, such as managed forests (XL1_b, XL1_c), non-forest tree stands (XL3, XK3), shrubs (XK1) as well as wetlands (XM) and dry meadows (XT3). Natural and semi-natural habitats (defined in Chytrý *et al.*, 2010) fall into the most valuable category of 25.1 to 66.0 points/m^2, with natural forests comprising the majority of habitats in the study area. Hercynian oak-hornbeam forests (L3.1) are the most abundant, followed by oak forests (L7.1, L6.5B), beech forests (L5.4, L5.1), and alder forests (L2.2). The most common non-forest habitats are Mesic *Arrhenatherum* meadows (T1.1), which have a relatively low ecological value compared to natural forests. The most valuable natural habitats in the study area are the Rock-outcrop vegetation with *Festuca pallens* (T3.1) in the surrounding landscape of the Okrouhlý Stream catchment floodplains and Intermittently wet *Molinia* meadows (T1.9), which are located only in two areas in the floodplain of one of the tributaries of the Ferdinandský Stream.

It is clear from the map in Fig. 2 that the eastern part of the Veverka Stream watershed is significantly more ecologically valuable than other parts of the watershed. There are valuable natural forest habitats in the east, especially Hercynian oak-hornbeam forests (L3.1) and Acidophilous thermophilous oak forests (L6.5). Most of the riparian area of the Veverka Stream is rated highly due to the occurrence of the Ash-alder alluvial forest habitat (L2.2). Similarly, it is clear from the map that more ecologically valuable habitats in the Okrouhlý Stream watershed are concentrated in lower positions and around watercourses. These habitats mainly include Ash-alder alluvial forests (L2.2), Herb-rich beech forests (L5.1), and Hercynian oak-hornbeam forests (L3.1).

The resulting assessment of ecological values of habitats according to the BVM in the floodplains of the main streams, in the floodplains of tributaries, and in the surrounding landscape of floodplains is presented in Tab. 3. The table shows the sums of the BVM score per 1 m^2 multiplied by the habitat areas divided by an area of the given environment (i.e., floodplains or surrounding landscapes). A comparison of BVM values shows that the most ecologically valuable habitats are in the Ferdinandský Stream watershed, where the average score for the watershed is 19.4 points/m^2. In contrast, the Okrouhlý Stream watershed has the least valuable habitats (their average value was 17.1 points/m^2). Habitats in floodplains of main streams were the most valuable on average (21.8 points/m^2) when considering all watersheds together. Meanwhile, the surrounding landscapes altogether are the least ecologically valuable (18.0 points/m^2). Floodplains turned out to be more ecologically valuable in the Okrouhlý Stream and Ferdinandský Stream watersheds (21.7 and 25.8 points/m^2, respectively) compared to the surrounding landscape (16.8 and 19.0 points/m^2, respectively).

Furthermore, the resulting assessments of environments were compared with average values for each watershed using percentages. The comparison showed that habitats in the floodplains of the Okrouhlý Stream are ecologically more valuable by 26.4 % and the floodplains of the Ferdinandský Stream by 33.1 % compared to the average assessment of each catchment. Habitats of the Veverka Stream floodplains are less valuable by 8.8 %. This is due to the low ecological values of habitats in the floodplains of tributaries. Although the floodplain of the main stream turned out to be slightly more ecologically valuable than the surrounding landscape, it is only 2.9 % more valuable than the average value for the catchment.

Fig. 2: Evaluation of habitats in the studied watersheds based on habitat layer in 2020–2021 assessed by the BVM method (Seják *et al.*, 2018b) expressing their ecological value



Tab. 3: The assessment of habitats in the studied watersheds in floodplains and surrounding landscapes according to BVM (Seják *et al.*, 2018b) in 2020–2021

	Okrouhlý Stream [points/m²]	Ferdinandský Stream [points/m²]	Veverka Stream [points/m²]	All watersheds [points/m²]
Main floodplain	19.2	28.0	18.3	21.8
Floodplains of tributaries	26.8	23.5	15.3	18.3
All floodplains	21.7	25.8	16.2	19.8
Surrounding landscape	16.8	19.0	17.9	18.0
Whole watershed [points/m²]	17.1	19.4	17.8	

Note: the values in the table are area-weighted averages, i.e., the results of the sum of the points of all habitats divided by the area of a given environment (floodplains or surrounding landscapes).

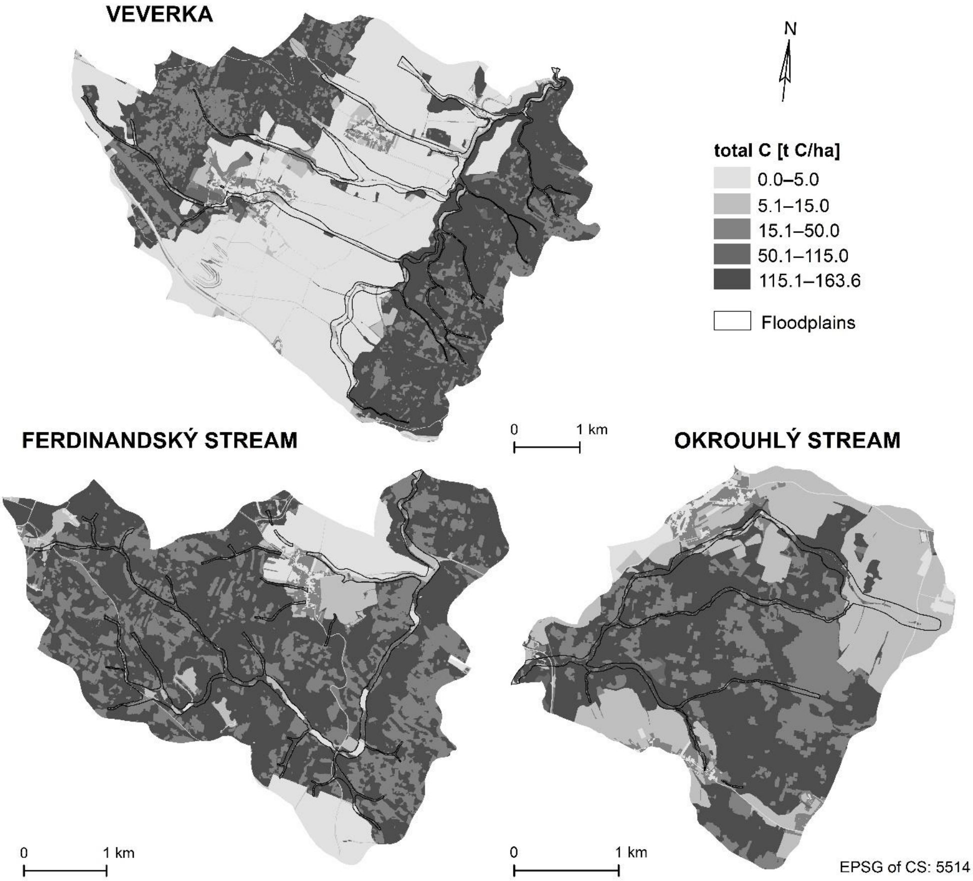
Carbon Storage Potential of Habitats

The map in Fig. 3 expresses the ability of habitats in the studied watersheds to store carbon in biomass. Totally degraded habitats, such as areas permanently without vegetation, continuous built-up areas and impervious areas, have zero capacity to store carbon in vegetation. The categories of habitats with potential carbon content up to 5 t/ha are also rocks, watercourses, and water reservoirs. Within the studied watersheds, vegetation on arable land stores most of the carbon in this category. When left fallow, carbon in arable land can easily reach values corresponding to the subsequent class (5.1–15.0 t C/ha). However, the carbon content decreases dramatically after harvest and is limited to only the carbon content in the dead biomass of post-harvest residues. The category of 5.1–15.0 t C/ha is comprised of mainly grasslands. One example is the Tall sedge beds habitat (M1.7) found in the Ferdinandský Stream catchment. The category of 15.1–50.0 t C/ha is characterized by the presence of scrub vegetation, young forest plantations, and forest clearings, where a significant part of carbon is stored in dead biomass (i.e., roots, stumps, and woody residues left after harvesting). This category also includes areas with standing dead trees. The 50.1–115.0 t C/ha category consists of habitats with non-forest tree cover. The highest carbon content, 115.1–163.6 t C/ha, is associated with forest habitats, where the most carbon is assumed to be stored in the biomass of mature coniferous production forests.

Habitats with tree stands can easily be distinguished from non-forest habitats in the map in Fig. 3. The habitats with tree stands are generally darker areas comprising all habitats with a value higher than 50 t C/ha while non-forest habitats are lighter areas with potentially stored carbon less than or equal to 50 t C/ha. It is clear that the more forested a watershed, the higher the amount of carbon it can store.

Tab. 4 compares the total carbon stored in floodplains and surrounding landscape habitats of the studied watersheds. The analysis showed that the Ferdinandský Stream catchment had the highest amount of stored carbon, with a watershed-wide average of 94.4 t C/ha. This catchment has the highest percentage of forest stands (81.7 %). In contrast, the smallest amount of stored carbon was in the Veverka Stream watershed, with 61.5 t C/ha. This catchment has large areas of arable land (41.9 %). However, floodplains in the Ferdinandský Stream catchment were evaluated as 9.7 % less valuable than the average value of the watershed, while floodplains in the Veverka Stream catchment were 25.6 % less valuable. In terms of carbon storage, only habitats in the Okrouhlý Stream watershed floodplains were evaluated as more valuable than the surrounding landscape at 17.7 % more valuable. In this case, the floodplain of the main stream reached almost the same value as the surrounding landscape, while floodplains of tributaries were rated 56.4 % better compared to the watershed. The reason for the higher rating is the widespread abundance of Intensively managed forests (XL1), Herb-rich beech forests (L5.1), and Ash-alder alluvial forests (L2.2) in the floodplains of tributaries. Meanwhile, the main stream floodplain is predominantly (37.1 %) Altered mesophilic meadows and pastures (XT1).

Fig. 3: Values of potential carbon storage in the biomass of studied watershed habitats based on the habitat layer for the period 2020–2021



Tab. 4: The assessed ability to store carbon in plant biomass in habitats of floodplains and surrounding landscapes of the studied watersheds in 2020–2021

	Okrouhlý Stream [t C/ha]	Ferdinandský Stream [t C/ha]	Veverka Stream [t C/ha]	All environments [t C/ha]
Main floodplain	77.8	72.8	54.7	66.6
Floodplains of tributaries	122.6	98.0	41.7	62.5
All floodplains	92.3	85.3	45.8	64.2
Surrounding landscape	77.6	95.0	62.5	74.4
Whole watershed [t C/ha]	78.5	94.4	61.4	

Note: Values in the table are area-weighted averages, i.e., they express the sum of tons of carbon stored in all plant biomass (above and belowground) of habitats divided by the area of a given environment (floodplains or surrounding landscapes).

The most extensive habitats and their influence on the results

Finally, the importance of the total area of natural habitats on the resulting ecological assessment and the key role of forest habitats in terms of the ability of the environment to store carbon is further illustrated in graph in Fig. 4. The graph shows the ten most extensive habitats in two environments, floodplains and the surrounding landscape, in each of the watersheds, and their BVM ratings in units of points/m^2 and the total stored carbon in t/ha. Totally degraded habitats were omitted from the graph, as their BVM scores and carbon storage values are 0. Their areas did not account for more than 5 % of any of the environments. All habitats categories (natural and semi-natural, slightly, significantly and totally degraded), their areas, ecological values and values of stored carbon in biomass in floodplains, surrounding landscapes and watersheds are shown in the Appendix in A.7.

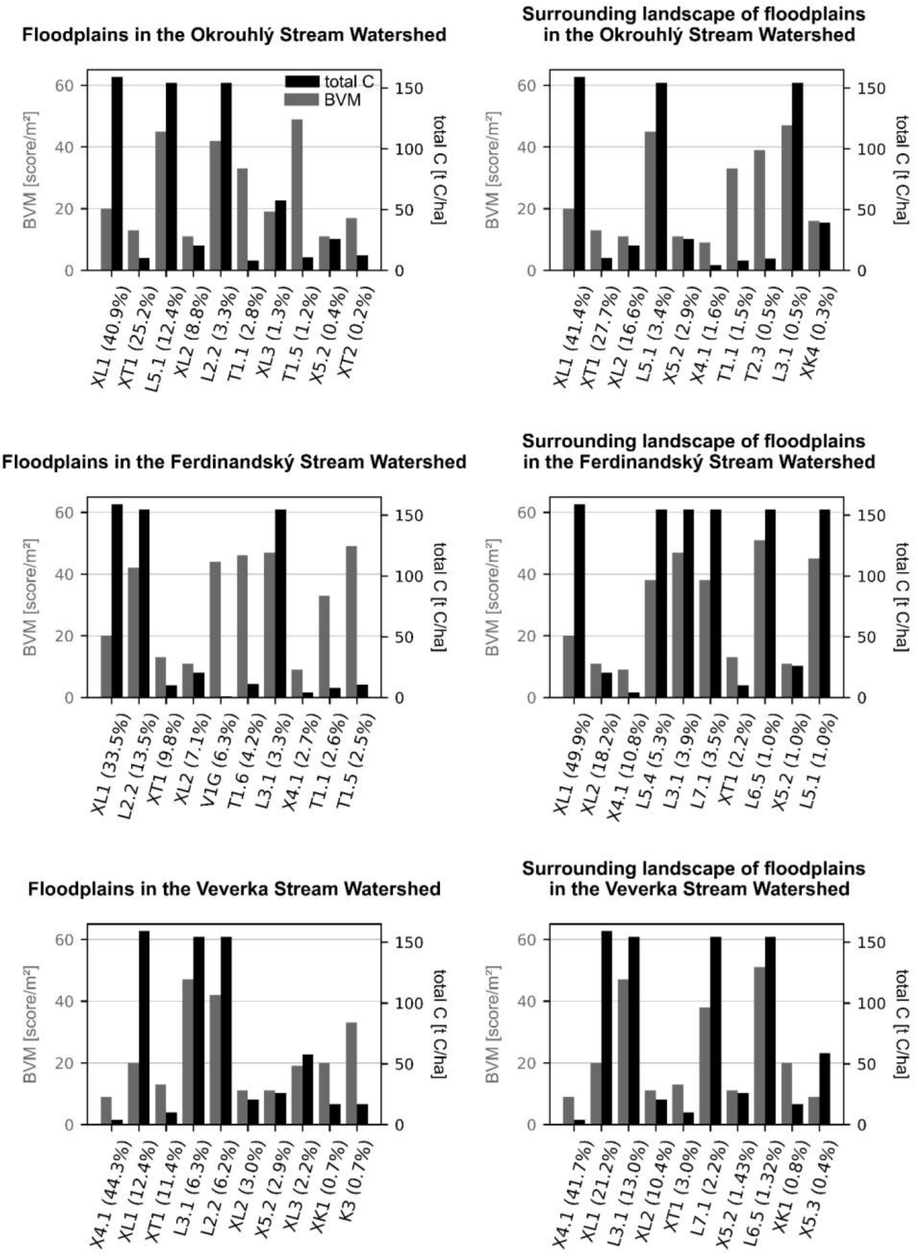
The total area of natural habitats was the fundamental difference between the floodplains and the surrounding landscapes that determined the resulting ecological assessment of the given environments. Floodplains in the Ferdinandský Stream watershed were 33.1 % more ecologically valuable than the catchment (based on its average value). In total, natural habitats covered 40.5 % of floodplains, whereas only covered 15.0 % of the surrounding landscape (see A.7). A similar difference was also found in the case of the Okrouhlý Stream catchment (20 % of the natural habitats in the floodplains and 15 % in the surrounding landscape). In case of Ferdinandský Stream and Okrouhlý Stream, a higher representation of natural habitats was recorded both in the floodplains of main streams (52.4 and 12.7 %, respectively) and floodplains of tributaries (28.3 and 35.3 %; see A.6). The high-value habitats occurring in these floodplains are mainly Ash-alder alluvial forests (L2.2), Hercynian oak-hornbeam forests (L3.1) and Herb-rich beech forests (L5.1), while their surrounding landscapes are predominately Intensively managed forests (XL1) and Areas of deforestation (clear-cutting areas) (XL2) including standing dead trees (Fig. 4).

In contrast, in the Veverka Stream watershed, there was a higher percentage of natural habitats in the surrounding landscape (17.7 %) than in the floodplains (14.8 %; see A.7). This explains why, only in the case of the Veverka Stream catchment, floodplains were assessed as ecologically less valuable than the surrounding landscape. The surrounding landscape was mainly covered by arable land (Weed vegetation of annual and biennial field crops, X4.1; 41.7 %), Intensively managed forests (XL1; 21.2 %), and Areas of deforestation (clear-cutting areas) (XL2; 10.4 %; see Fig. 4).

However, Hercynian oak-hornbeam forests habitat (L3.1) also covered a significant part of the surrounding landscape (12.6 %; see Fig. 4). These natural forest habitats, located mainly in the eastern part of the watershed, are the reason why the surrounding landscape was evaluated as ecologically more valuable than the floodplains. Still, the Veverka Stream watershed was assessed as the least ecologically valuable, given that the dominant habitat in the floodplains and the surrounding landscape was arable land (X4.1, see Fig. 4)

The amount of carbon stored in habitats depends strongly on the area covered by woody vegetation. The total stored carbon in the biomass of floodplains was only higher in the Okrouhlý Stream watershed due to a higher proportion of tree stands (57.9 %) compared to the surrounding landscape (46.0 %), where meadows and felling areas with standing dead trees were among the predominant habitats (30.0 % and 16.6 %, respectively). In the other two catchments, the amount of carbon stored in biomass in floodplains was lower than in the surrounding landscape. In the case of the watershed of the Ferdinandský Stream, forest habitats and habitats with tree stands dominated both in the floodplains (54.9 %) and the surrounding landscape (64.8 %), so the amount of biomass was relatively high in both environments. The dominance of arable land (X4.1) in the Veverka Stream watershed was the main reason for the reduced ability of watershed habitats to store carbon, both in the floodplains and throughout the watershed.

Fig. 4: Ten most extensive habitats in floodplains and surrounding landscapes in the Okrouhlý Stream, Ferdinandský Stream, and Veverka Stream watersheds, defined on the basis of habitat layers in 2020–2021



Key to habitat codes: K3 – Tall mesic and xeric scrub, L2.2 – Ash-alder alluvial forests, L3.1 – Hercynian oak-hornbeam forests, L5.1 – Herb-rich beech forests, L6.5 – Acidophilous thermophilous oak forests, L7.1 – Dry acidophilous oak forests, T1.1 – Mesic *Arrhenatherum* meadows, T1.5 – Wet *Cirsium* meadows, T1.6 – Wet *Filipendula* grasslands, T2.3 – Submontane and montane *Nardus* grasslands, V1G – Macrophyte vegetation of naturally eutrophic and mesotrophic still waters without macrophyte species valuable for nature conservation, X4.1 – Weed vegetation of annual and biennial field crops, X5.2 – Vegetable and ornamental gardens and gardening colonies, X5.3 – Intensively managed hop fields, vineyards, and orchards (in this research it is only orchards), XK1 – Altered mesophilic and riparian shrubs, XK4 – Extensively managed orchards, hop fields, and vineyards, XL1 – Intensively managed forests, XL2 – Areas of deforestation (clear-cutting areas), XL3 – Strips and groups of trees, XT1 – Altered mesophilic meadows and pastures, XT2 – Altered wet meadows, pastures, and fallows, XV1 – Altered ponds and water reservoirs.

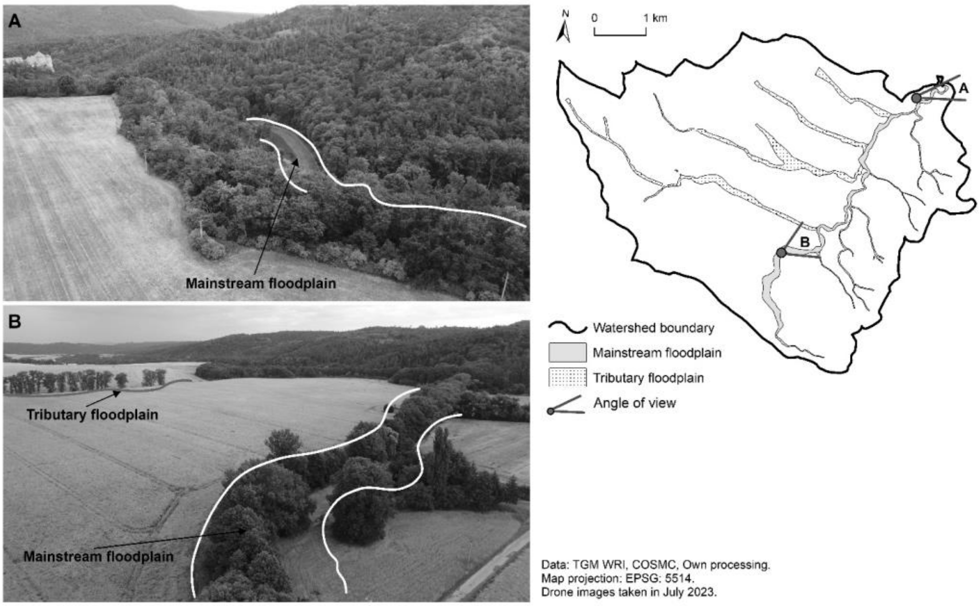
DISCUSSION

One of the uncertainties of this research is the accuracy of floodplain delineation. Although there are several different possible approaches to determining the floodplain of a watercourse (e.g., flood area of Q100, geological and pedological maps, or even the spatial distribution of indicator plant species), the geomorphological approach was deemed the most reliable due to the small size of the streams, the detailed scale, and the available data sources. As stated by Křížek *et al*. (2006), this approach, in many cases, enables a precise determination of the spatial delimitation of the floodplain. Still, the uncertainty of floodplain delineation can be seen from our results, as non-floodplain habitat types were also found in studied floodplains. On the other hand, anthropogenic influences in studied watersheds are prominent, and non-floodplain habitat types can, specifically in some of the narrow floodplains along small streams, occur as a consequence of the limited data resolution.

The ecological value of a particular area based on BVM methodology depends to a large extent on the share of habitats that are natural, semi-natural or slightly degraded, which have a higher BVM point values (Seják *et al.* 2018b) than significantly and totally degraded habitats. Although the Veverka Stream watershed had the largest share of natural habitats (17.5 %), the highest ecological value was found in the Ferdinandský Stream watershed (Table 3), with a slightly lower proportion of natural habitats (16.5 %). That is given by the forest landscape of the Ferdinandský Stream catchment, where forests make up almost 82 %. Production forests and woody vegetation have relatively high scores, as they are part of slightly degraded habitats (Seják *et al*. 2018b). Thus, the results show that the proportion of natural habitats is an important characteristic but may not be decisive in the final assessment of the ecological value of a given area.

Compared to the surrounding landscape, a higher proportion of natural habitats was found in all floodplains, except for the Veverka Stream tributaries (Appendix A.6). The reason for this pattern is that a significant part of these floodplains is located in settlements and especially in agricultural areas with arable land. Slightly degraded habitats are found here only in narrow strips along streams. In such an intensively used area, the occurrence of natural habitats is limited by the little space available for natural vegetation and by other damaging influences such as eutrophication, which often degrades the valuable habitats present. In addition, the floodplains in the local agricultural landscape are relatively broad and include a large percentage of agricultural land. The ecological valuation of the floodplain of the main stream Veverka was slightly higher than the average value of the watershed, even though some meandering reaches were straightened in the past and part of the floodplain is used as arable land. The reason for the different values of the main stream floodplain compared to the tributary floodplains was probably the ruggedness of the terrain. The Veverka Stream floodplain is confined in many places by steep slopes, which prevent the use of the floodplain as arable land and enables the occurrence of woody vegetation with high ecological values. The differences between the Veverka Stream floodplain and a floodplain of one of the Veverka Stream's tributaries can be seen in Fig. 5, where the boundaries of floodplains are delineated.

Fig. 5: Veverka Stream floodplain limited by steep slopes (A) and in an agricultural area with the floodplain of one of its tributaries (B) in July 2023



Our findings regarding the degradation of floodplains due to anthropogenic influences partially correspond to the conclusions of Demek *et al.* (2011). The authors studied land use and ESs in selected floodplains in southeastern Czech Republic (including the South Moravian Region) between 1836 and 2005 and described significant changes related to human activity. Their research documented considerable increases in arable land and built-up areas and a decline in permanent grassland. They stated that the strong anthropogenic pressure during these 250 years reduced floodplain aggradation, disrupted the connectivity between the stream and the floodplain, reduced the proportion of floodplain forests in the floodplain, and fundamentally affected the ESs of the floodplain.

In the area studied here, the floodplain of the main stream in the Ferdinandský Stream catchment was the most ecologically valuable. However, ponds situated in the floodplain, i.e., habitats categorized as Altered ponds and water reservoirs (XV1), reduced the ecological value of floodplains, as this is a frequent habitat in the Czech Republic characterized by low biodiversity. It is possible that in the future, with appropriate management of the reservoirs, their ecological value will increase and at least partially approach the value of the original valuable wetlands.

Large areas of clearings and standing dead trees had a significant impact on the results of our study. According to recent findings, they are an indirect consequence of anthropogenic influences. Most of the recent clearing in the Czech Republic was caused by the necessary harvesting of bark beetle-attacked spruce trees and accounted for the vast majority of salvage cutting (CSO, 2020). Salvage cutting in 2020 and 2021 (corresponding to the data used in this study) made up 95 % and 87 % of the overall cutting, respectively, based on the data published by the Ministry of Agriculture (MA, 2021, 2022). Within the individual catchments, higher levels of clearings and standing dead trees were recorded in the Ferdinandský Stream and the Okrouhlý Stream catchments (in each catchment around 17 % of the total area), which also have a high percentage of coniferous forests overall (Appendices A.3 and A.4). A significant finding is that the floodplains had fewer clearings and standing dead trees recorded overall, with about half to one-third the amount of the surrounding landscape. This appears to be related to a better water supply and to the different tree species composition in the floodplains, where the ratio of conifers to broadleaves is shifted considerably towards broadleaves compared to the surrounding landscape (Appendices A.3 and A.4). The studied catchments fall within the 1–5 forest altitudinal zones (FAZ) and the current tree species composition is not optimal especially due to the higher proportion of spruce. Spruce has suitable conditions only from about FAZ 6 onwards; at lower elevations it is already sensitive to stress factors, especially water deficit (Slodičák, 2014). The problematic over-representation of spruce and its inappropriate distribution due to climatic conditions have also been described by other authors (e.g., Čermák, 2014; Hruška & Cienciala, 2005).

In the Czech Republic, the decline and dieback of coniferous forests have been occurring for decades. In recent years, however, the withering of pines has also started to occur. This seems to be a synergistic effect of drought, increasing average temperature, and exposure to insect and fungal pathogens (Dudík *et al*., 2021; Špulák & Černý, 2023). Pine is also represented in all three catchments, but most of all in the Ferdinandský Stream catchment (about 16 % of the forest area), where it probably has a higher representation than spruce, according to the Forest Tree Species Map valid for 2017 (FMI, 2017). Although no data on logging were available, the Forest Tree Species Map, combined with our analysis of recent clearings and dead trees based on remote sensing methods, can provide an estimate of which stands were harvested most frequently between 2018 and 2020. Coniferous stands were overwhelmingly harvested in all three watersheds, and spruce stands predominantly in the Okrouhlý Stream watershed. In the Ferdinandský Stream and the Veverka Stream catchments, spruce and pine stands were harvested in around the same proportion. Broadleaf trees were also harvested in both of these catchments, accounting for about 20 % of the harvested stands.

The amount of carbon stored in biomass, that we calculated for each of the watershed, corresponds to the values published by Stará *et al*. (2011) from the upper catchment of the Stropnice River (located in southern Czech Republic). The Veverka Stream watershed in particular is comparable to this catchment, as both have a similar percentage of forest stands. The average carbon stock in the Veverka Stream watershed was 61 t C/ha, whereas in the other study it was calculated to be 54 t C/ha. Stará *et al*. (2011) also provided an estimate of carbon stocks in soils of the upper catchment of the Stropnice River, which amounted to 60 t c/ha. Therefore, more carbon was stored in soils compared to the biomass. It should be noted, that the carbon reserves in soil were estimated from gross summary data in the form of a nationwide soil carbon map, classified into only five categories of carbon content (Cienciala *et al*., 2011). Using the above-cited map, we tried to estimate the carbon stocks in the studied watersheds. We found that all watersheds show a similar carbon content in soil and vegetation. According to some authors, e.g., Opperman *et al*. (2017), floodplain habitats may hypothetically have significantly higher values of carbon stored in soil than in plant biomass. Such a trend was confirmed only in some floodplains we studied. However, the nationwide map of soil carbon stocks is too inaccurate for assessments at the local level. A more detailed study on this topic would be needed.

The carbon reservoirs in biomass that we determined refer to approximately the second half of 2020. A relatively high percentage of clearings that year lowered the amount of carbon stored in the vegetation. For example, the difference in carbon stock in a mature coniferous forest and a clearing is approximately 145 t C/ha. Currently, it is clear from the available orthophotos (COSMC, 2023) that the spruce dieback and salvage cuttings continued at a high rate even after 2020. This is particularly noticeable in the Okrouhlý Stream watershed, where spruce stands still clearly dominated around 2017. In this respect, floodplain habitats have the advantage of a more favourable forest tree species composition with a higher proportion of deciduous trees, which is confirmed by a reduced amount of salvage cuttings compared to the surrounding landscape. The function of forest stands in the floodplain is important not only as a more stable carbon reservoir in the landscape, but also as a "hot spot" supporting and increasing biodiversity and providing at least a partial refuge for plants and animals at a time when a substantial part of the surrounding forest was harvested within a short period of time.

This study showed that the ecological value of habitats can be contradictory to their ability to store biomass in some cases (as can be seen in Fig. 4). The amount of carbon potentially stored in vegetation depends primarily on the presence of woody vegetation in the habitat, whereas the ecological value is based on several ecological aspects, such as the naturalness of the habitat and species diversity. For example, the most ecologically valuable habitats in the study catchments can have a low carbon storage potential. The intermittently wet *Molinia* meadows (T1.9; 63 points/m^2) have a potential storage capacity of only 11.72 t C/ha due to a low amount of biomass and the habitats of Rock-outcrop vegetation with *Festuca pallens* (T3.3; 66 points/m^2) have a capacity of only 2.6 t C/ha. At the opposite end of the spectrum, intensively managed forests (XL1), which are ecologically less valuable (BVM 20 points/m^2), can play an important role in carbon sequestration. However, on the other hand, the lower ecological value of intensively managed forests, associated with lower species diversity, is also one of the reasons for their greater instability and lower resistance to pests and environmental change. This circumstance is pointed out, for example, by Mace *et al*. (2012).

CONCLUSIONS

All floodplains, except for floodplains of the Veverka tributaries, were found to be ecologically more valuable than surrounding landscapes. The lower ecological value of certain floodplain habitats may be the result of a strong anthropogenic pressure, such as development and intensive agriculture, which degraded floodplains in the Veverka Stream watershed. On the contrary, areas with lower anthropogenic pressure, such as floodplains in the Ferdinandský Stream watershed, were assessed as ecologically most valuable, especially thanks to the preservation of valuable natural wetland habitats and forest stands.

The ecological value of the study area is mainly influenced by the proportion of preserved natural habitats, as well as the proportion of some more valuable slightly degraded habitats, especially production forests. However, it is essential for production forests to have an appropriate species composition, in particular an adequate proportion of spruce and other tree species in relation to the given forest altitudinal zone. Given the habitat conditions, spruce is not a suitable species in the studied watersheds. The ecological value of some parts of the studied catchments was significantly reduced by salvage cutting caused by the decline and dieback of not only spruce, but also pine stands. In forest stands in floodplains, a higher proportion of broadleaved trees was found compared to the surrounding landscape. These forests were also found to be more stable in terms of the overall area of clearings, most likely due to a more suitable tree composition and better access to groundwater.

The proportion of forests in the landscape also had a strong influence on the carbon stored in the biomass. Here, too, the effect of the appropriate and inappropriate forest species composition and the extent of salvage cutting was evident, significantly reducing the originally high values of stored carbon, especially in production forests. Due to the current dieback and massive logging of coniferous forests, the protection and preservation of natural forests and forests with a more appropriate species composition, not only in floodplains, appears to be highly beneficial.

This study highlights the importance of forest stands in floodplains and the need for their protection and promotion. Unfortunately, due to human activities, many of these habitats have disappeared. That reduces the otherwise enormous potential of the riverine landscape, which is not only a significant water resource. If protected, forest stands in floodplains can combine the ability to store large amounts of carbon in biomass with high ecological values in the sense of, for example, habitats matureness, naturalness, and species diversity. Also, regularly flooded forest stands in floodplain forests provide other important ecosystem functions and services, such as flood wave transformation during floods or climate regulation through evapotranspiration. In combination with the conservation and protection of valuable wetland habitats, floodplain forests can be a good eco-stabilising element in a landscape currently exposed to the negative effects of climate change.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

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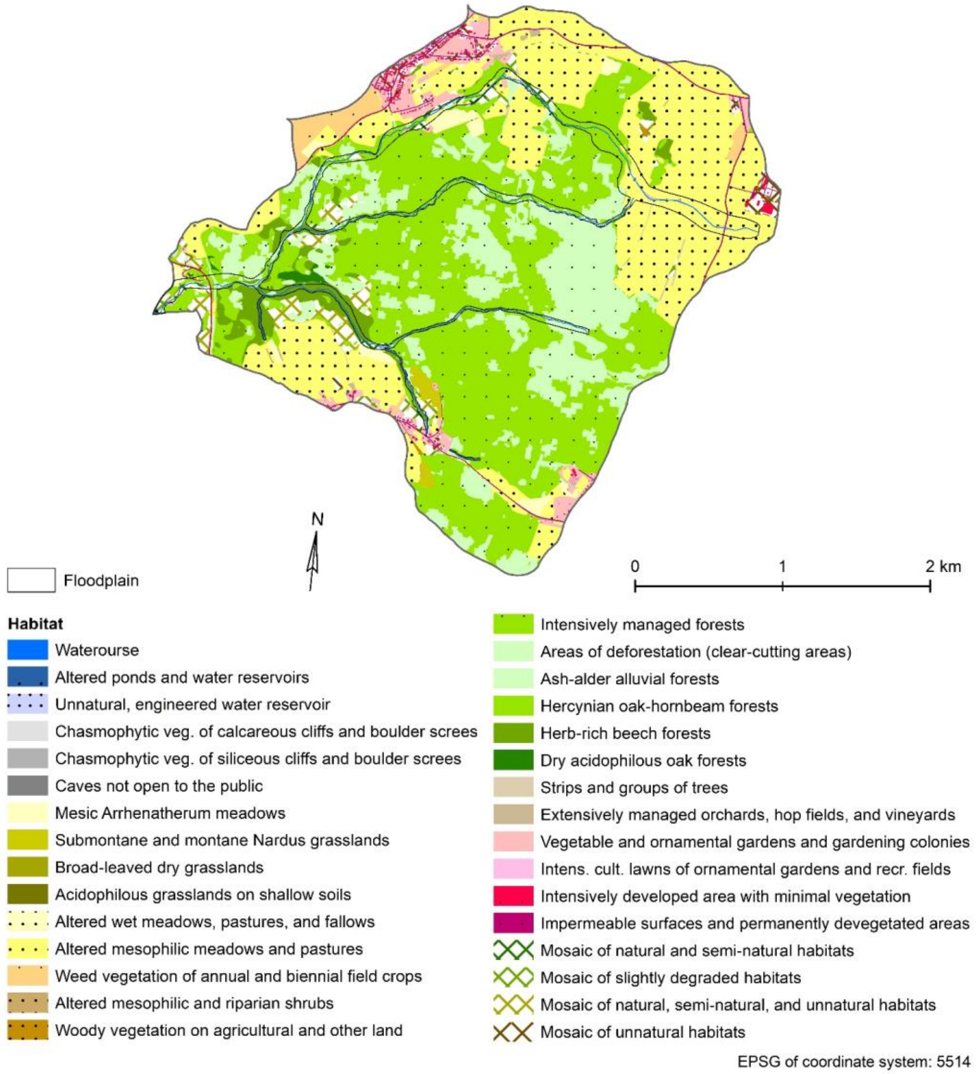
APPENDIX

A.1: List of satellite images used for the NDVI map layer of the whole Czech Republic. Only the relevant part of the NDVI map was applied in this study

Satellite Platform	Tile	Sensing period
S2B	33UUS	08.21.2020
S2A	33UVS	09.15.2020
S2A	33UWS	08.21.2020
S2B	33UWS	09.12.2020
S2A	33UUR	09.15.2020
S2A	33UVR	09.15.2020
S2B	33UWR	08.28.2020
S2A	33UXR	09.09.2020
S2B	33UXR	08.28.2020
S2A	33UYR	09.09.2020
S2A	33UUQ	09.15.2020
S2A	33UVQ	09.15.2020
S2B	33UWQ	08.28.2020
S2A	33UXQ	09.09.2020
S2A	33UYQ	09.09.2020
S2A	33UVP	09.15.2020
S2A	33UXP	09.09.2020
S2A	32UQA	09.15.2020

A.2: Habitats in the Okrouhlý Stream watershed in 2020–2021 defined on the basis of the habitat layer



A.3: Habitats present in the Okrouhlý Stream (O), Ferdinandský Stream (F), and Veverka Stream (V) watersheds with an indication of their overall BVM values (Seják *et al.*, 2018b) and area in percentages in the floodplains ($_F$) and the surrounding landscape of the floodplains ($_{SL}$) in 2020–2021, defined based on the habitat layer.
Habitats starting with a single letter except X indicate natural and semi-natural habitats (Chytrý *et al.*, 2010), with X and any letter except X indicate slightly degraded habitats (Seják *et al.*, 2018b), with X and a number indicate significantly habitats (Seják *et al.*, 2018b), and with XX indicate totally degraded habitats (Seják *et al.*, 2018b).

		Ecological value [BVM points]						Area [%]					
Habitat code	Habitat name	O_{SL}	O_F	F_{SL}	F_F	V_{SL}	V_F	O_{SL}	O_F	F_{SL}	F_F	V_{SL}	V_F
K2.1	Riverine willow scrub	0.0	0.0	0.0	0.0	343,411.7	53,752.3	0.0	0.0	0.0	0.0	<0.1	<0.1
K3	Tall mesic and xeric scrub	169,051.9	38,203.9	0.0	0.0	2,426,985.7	463,477.5	<0.1	0.1	0.0	0.0	0.3	0.7
L2.2	Ash-alder alluvial forests	1,112,700.1	5,731,353.4	338,810.1	767,688.0	2,529,758.5	5,191,863.7	0.2	13.5	<0.1	3.3	0.2	6.2
L3.1	Hercynian oak-hornbeam forests	28,712,698.9	1,556,168.8	1,901,456.0	3,727.5	179,671,908.5	5,861,484.7	3.9	3.3	0.5	<0.1	13.0	6.3
L3.3B	West Carpathian oak-hornbeam forests	59,694.4	9,055.8	0.0	0.0	390,114.4	62,787.2	<0.1	<0.1	0.0	0.0	<0.1	<0.1
L4	Ravine forests	0.0	0.0	382,348.3	0.0	729,550.6	102,335.4	0.0	0.0	0.1	0.0	<0.1	0.1
L5.1	Herb-rich beech forests	6,852,397.4	414,403.4	13,042,414.1	3,088,385.4	4,337,990.6	0.0	1.0	0.9	3.4	12.4	0.3	0.0
L5.4	Acidophilous beech forests	31,492,420.7	664,529.6	0.0	0.0	1,728,450.1	0.0	5.3	1.7	0.0	0.0	0.2	0.0
L6.5B	Acidophilous thermophilous oak forests	8,048,261.3	0.0	0.0	0.0	18,325,420.6	181,926.0	1.0	0.0	0.0	0.0	1.2	0.2
L7.1	Dry acidophilous oak forests	20,655,523.5	689,585.1	842,579.8	0.0	24,703,553.0	507,134.3	3.5	1.8	0.3	0.0	2.2	0.7
L8.1B	Boreo-continental pine forests	0.0	0.0	0.0	0.0	68,708.6	6,690.0	0.0	0.0	0.0	0.0	<0.1	<0.1
M1.1	Reed beds of eutrophic still waters	0.0	0.0	0.0	1,261.7	37,602.1	9,349.4	0.0	0.0	0.0	<0.1	<0.1	<0.1
M1.3	Eutrophic vegetation of muddy substrata	0.0	461,908.0	0.0	0.0	0.0	0.0	0.0	1.3	0.0	0.0	0.0	0.0
M1.7	Tall-sedge beds	34,191.5	343,398.7	0.0	0.0	0.0	0.0	<0.1	1.3	0.0	0.0	0.0	0.0
S1.1	Chasmophytic vegetation of calcareous cliffs and boulder screes	0.0	0.0	91,073.0	0.0	0.0	0.0	0.0	0.0	<0.1	0.0	0.0	0.0

		Ecological value [BVM points]						Area [%]					
Habitat code	**Habitat name**	**O_{SL}**	**O_F**	**F_{SL}**	**F_F**	**V_{SL}**	**V_F**	**O_{SL}**	**O_F**	**F_{SL}**	**F_F**	**V_{SL}**	**V_F**
S1.2	Chasmophytic vegetation of siliceous cliffs and boulder screes	22,065.9	0.0	73,784.8	3,363.4	964,277.1	149,706.9	<0.1	0.0	<0.1	<0.1	<0.1	0.2
T1.1	Mesic *Arrhenatherum* meadows	271,225.2	880,363.2	4,108,866.2	509,624.3	1,003,466.6	75,339.1	<0.1	2.6	1.5	2.8	0.1	0.1
T1.10	Vegetation of wet disturbed soils	0.0	5,879.0	0.0	0.0	0.0	0.0	0.0	<0.1	0.0	0.0	0.0	0.0
T1.3	Cynosurus pastures	0.0	0.0	432,821.1	24,988.4	0.0	0.0	0.0	0.0	0.1	0.1	0.0	0.0
T1.5	Wet *Cirsium* meadows	173,732.4	1,233,275.3	227,291.9	328,201.0	0.0	0.0	<0.1	2.5	<0.1	1.2	0.0	0.0
T1.6	Wet *Filipendula* grasslands	81,761.5	1,956,317.0	8,456.2	37,109.5	0.0	0.0	<0.1	4.2	<0.1	0.1	0.0	0.0
T1.9	Intermittently wet *Molinia* meadows	0.0	553,184.6	0.0	0.0	0.0	0.0	0.0	0.9	0.0	0.0	0.0	0.0
T2.3B	Submontane and montane *Nardus* grasslands	0.0	0.0	1,714,435.3	0.0	0.0	0.0	0.0	0.0	0.5	0.0	0.0	0.0
T3.1	Rock-outcrop vegetation with *Festuca pallens*	0.0	0.0	251,682.8	0.0	0.0	0.0	0.0	0.0	<0.1	0.0	0.0	0.0
T3.4D	Broad-leaved dry grasslands	0.0	0.0	273,089.1	0.0	317,170.1	68,409.4	0.0	0.0	<0.1	0.0	<0.1	<0.1
T3.5B	Acidophilous dry grasslands	0.0	0.0	0.0	0.0	193,774.0	3,100.4	0.0	0.0	0.0	0.0	<0.1	<0.1
T4.2	Mesic herbaceous fringes	0.0	0.0	0.0	0.0	17,660.8	0.0	0.0	0.0	0.0	0.0	<0.1	0.0
T5.5	Acidophilous grasslands on shallow soils	0.0	0.0	12,622.5	0.0	0.0	0.0	0.0	0.0	<0.1	0.0	0.0	0.0
V1F	Macrophyte vegetation of naturally eutrophic and mesotrophic still waters without species specific to V1A-V1E	0.0	0.0	0.0	7,930.6	0.0	168,568.8	0.0	0.0	0.0	<0.1	0.0	0.2
V1G	Macrophyte vegetation of naturally eutrophic and mesotrophic still waters without macrophyte species valuable for nature conser-vation	7,419.4	1,914,126.0	0.0	0.0	56.0	11,857.8	<0.1	6.3	0.0	0.0	<0.1	<0.1

Habitat code	Habitat name	Ecological value [BVM points]						Area [%]					
		O_{SL}	O_F	F_{SL}	F_F	V_{SL}	V_F	O_{SL}	O_F	F_{SL}	F_F	V_{SL}	V_F
X1.1	Unnatural, engineered water reservoir	2,245.5	0.0	0.0	5,821.9	0.0	13,916.3	<0.1	0.0	0.0	<0.1	0.0	<0.1
X3.3	Vegetated cracks in semi-permeable paved and gravel surfaces	2,154.2	16,803.0	0.0	0.0	1,604.5	17,142.5	<0.1	0.2	0.0	0.0	<0.1	<0.1
X4.1	Weed vegetation of annual and biennial field crops	15,198,890.1	244,970.9	1,209,936.6	0.0	110,229,031.6	7,960,138.9	10.8	2.7	1.6	0.0	41.7	44.3
X4.3	Tall, ruderal vegetation on permeable substrate	1,535,980.5	6,220.0	50,046.2	0.0	376,314.9	24,779.8	0.9	<0.1	<0.1	0.0	0.1	0.1
X4.4	Short, ruderal vegetation on compacted substrate	337,188.5	2,105.1	0.0	0.0	48,470.9	0.0	0.2	<0.1	0.0	0.0	<0.1	0.0
X5.1	Intensively cultivated lawns of ornamental gardens and recreational fields	49,508.8	613.6	88,622.0	0.0	464,155.6	28,574.4	<0.1	<0.1	0.1	0.0	0.2	0.2
X5.2	Vegetable and ornamental gardens and gardening colo-nies	1,729,998.7	54,496.0	2,700,278.8	24,482.6	4,278,411.5	639,773.9	1.0	0.5	2.9	0.4	1.3	2.9
X5.3	Intensively managed hop fields, vineyards, and or-chards	0.0	0.0	0.0	0.0	1,155,784.8	385.5	0.0	0.0	0.0	0.0	0.4	<0.1
X6.1	Parks and other urban green areas	27,290.6	0.0	0.0	0.0	139,463.9	30,189.6	<0.1	0.0	0.0	0.0	<0.1	0.1
XK1	Altered mesophilic and ri-parian shrubs	747,351.1	90,039.1	107,965.5	19,571.1	4,533,877.9	282,873.9	0.2	0.4	<0.1	0.2	0.8	0.7
XK3	Woody vegetation on agri-cultural and other land	394,611.5	146,992.2	155,236.4	0.0	529,369.4	92,383.9	0.1	0.7	<0.1	0.0	<0.1	0.2
XK4	Extensively managed or-chards, hop fields, and vine-yards	414,537.2	16,557.7	374,211.2	10,517.0	1,219,988.2	25,796.1	0.2	0.1	0.3	0.1	0.3	<0.1
XL1_a	Young managed forests plantations	16,486,535.9	429,047.6	2,578,996.3	107,080.5	7,218,433.7	19,401.3	9.6	3.9	2.8	1.8	2.2	<0.1
XL1_b	Broadleaf forest stands of managed forests	37,582,876.0	3,316,312.2	5,598,313.5	1,275,690.9	34,936,892.0	3,414,980.0	12.0	16.4	3.3	11.5	6.0	8.6
XL1_c	Coniferous forest stands of managed forests	88,417,836.4	2,665,404.8	60,085,211.6	3,064,876.5	75,973,045.0	1,480,789.1	28.3	13.2	35.4	27.7	12.9	3.7

Habitat code	Habitat name	Ecological value [BVM points]						Area [%]					
		O_{SL}	O_F	F_{SL}	F_F	V_{SL}	V_F	O_{SL}	O_F	F_{SL}	F_F	V_{SL}	V_F
XL2	Areas of deforestation (clear-cutting areas)	27,592,552.1	719,760.2	10,805,352.9	373,560.2	19,002,457.4	260,683.1	16.0	6.5	11.6	6.1	5.9	1.2
XL2_d	Dead trees and recent clearings	3,663,939.2	72,526.8	4,654,603.8	161,330.1	14,688,193.8	390,537.6	2.1	0.7	5.0	2.6	4.5	1.8
XL3	Strips and groups of trees	150,946.3	28,169.3	269,385.3	134,644.2	292,950.0	816,502.3	<0.1	0.2	0.2	1.3	<0.1	2.2
XM	Altered wetlands and peatlands	0.0	9,156.0	0.0	0.0	0.0	0.0	0.0	<0.1	0.0	0.0	0.0	0.0
XT1	Altered mesophilic meadows and pastures	4,561,286.9	1,296,867.2	30,549,196.6	1,812,928.9	11,327,478.3	2,959,443.0	2.2	9.8	27.7	25.2	3.0	11.4
XT2	Altered wet meadows, pastures, and fallows	5,856.9	13,192.6	1,111.2	16,808.4	20,872.7	127,073.6	<0.1	<0.1	<0.1	0.2	<0.1	0.4
XT3	Altered dry lawns, hedgerows, and heaths	3,826.9	0.0	0.0	0.0	111,922.8	1,943.1	<0.1	0.0	0.0	0.0	<0.1	<0.1
XV1	Altered ponds and water reservoirs	7,925.1	74,650.6	4,355.8	17,371.9	0.0	165,934.1	<0.1	0.5	<0.1	0.2	0.0	0.6
XV2	Altered watercourses	0.0	406,922.4	0.0	208,248.7	0.0	646,018.6	0.0	2.4	0.0	2.2	0.0	1.9
XX3.1	Intensively developed area with minimal vegetation	0.0	0.0	0.0	0.0	0.0	0.0	0.2	<0.1	0.6	<0.1	0.5	1.1
XX3.2	Impermeable surfaces and permanently devegetated areas	0.0	0.0	0.0	0.0	0.0	0.0	1.0	1.1	1.8	0.4	2.2	3.5

A.4: Habitats present in the Okrouhlý Stream (O), Ferdinandský Stream (F), and the Veverka Stream (V) watersheds with an indication of their carbon stored in biomass in total and area in percentages in the floodplains ($_F$) and the surrounding landscape of the floodplains ($_{SL}$) in 2020–2021, defined based on the habitat layer.
Habitats starting with a single letter except X indicate natural and semi-natural habitats (Chytrý *et al.*, 2010), with X and any letter except X indicate slightly degraded habitats (Seják *et al.*, 2018b), with X and a number indicate significantly habitats (Seják *et al.*, 2018b), and with XX indicate totally degraded habitats (Seják *et al.*, 2018b).

		Total Carbon stored [t C]						Area [%]					
Habitat code	**Habitat name**	O_{SL}	O_F	F_{SL}	F_F	V_{SL}	V_F	O_{SL}	O_F	F_{SL}	F_F	V_{SL}	V_F
K2.1	Riverine willow scrub	0.0	0.0	0.0	0.0	44.2	6.9	0.0	0.0	0.0	0.0	<0.1	<0.1
K3	Tall mesic and xeric scrub	8.5	1.9	0.0	0.0	122.2	23.3	<0.1	0.1	0.0	0.0	0.3	0.7
L2.2	Ash-alder alluvial forests	409.1	2,107.4	124.6	282.3	930.2	1,909.0	0.2	13.5	<0.1	3.3	0.2	6.2
L3.1	Hercynian oak-hornbeam forests	9,434.3	511.3	624.8	1.2	59,035.6	1,925.9	3.9	3.3	0.5	<0.1	13.0	6.3
L3.3B	West Carpathian oak-hornbeam forests	15.9	2.4	0.0	0.0	103.9	16.7	<0.1	<0.1	0.0	0.0	<0.1	<0.1
L4	Ravine forests	0.0	0.0	140.6	0.0	268.2	37.6	0.0	0.0	0.1	0.0	<0.1	0.1
L5.1	Herb-rich beech forests	2,351.6	142.2	4,475.9	1,059.9	1,488.7	0.0	1.0	0.9	3.4	12.4	0.3	0.0
L5.4	Acidophilous beech forests	12,798.4	270.1	0.0	0.0	702.4	0.0	5.3	1.7	0.0	0.0	0.2	0.0
L6.5B	Acidophilous thermophilous oak forests	2,437.0	0.0	0.0	0.0	5,549.0	55.1	1.0	0.0	0.0	0.0	1.2	0.2
L7.1	Dry acidophilous oak forests	8,394.3	280.2	342.4	0.0	10,039.4	206.1	3.5	1.8	0.3	0.0	2.2	0.7
L8.1B	Boreo-continental pine forests	0.0	0.0	0.0	0.0	28.1	2.7	0.0	0.0	0.0	0.0	<0.1	<0.1
M1.1	Reed beds of eutrophic still waters	0.0	0.0	0.0	<0.1	2.8	0.7	0.0	0.0	0.0	<0.1	<0.1	<0.1
M1.3	Eutrophic vegetation of muddy substrata	0.0	1.4	0.0	0.0	0.0	0.0	0.0	1.3	0.0	0.0	0.0	0.0
M1.7	Tall-sedge beds	1.2	12.5	0.0	0.0	0.0	0.0	<0.1	1.3	0.0	0.0	0.0	0.0
S1.1	Chasmophytic vegetation of calcareous cliffs and boulder screes	0.0	0.0	<0.1	0.0	0.0	0.0	0.0	0.0	<0.1	0.0	0.0	0.0
S1.2	Chasmophytic vegetation of siliceous cliffs and boulder screes	<0.1	0.0	<0.1	<0.1	<0.1	<0.1	<0.1	0.0	<0.1	<0.1	<0.1	0.2
T1.1	Mesic *Arrhenatherum* meadows	6.5	21.0	97.9	12.1	23.9	1.8	<0.1	2.6	1.5	2.8	0.1	0.1
T1.10	Vegetation of wet disturbed soils	0.0	0.2	0.0	0.0	0.0	0.0	0.0	<0.1	0.0	0.0	0.0	0.0
T1.3	Cynosurus pastures	0.0	0.0	11.0	0.6	0.0	0.0	0.0	0.0	0.1	0.1	0.0	0.0

Habitat code	Habitat name	Total Carbon stored [t C]						Area [%]					
		O_{SL}	O_F	F_{SL}	F_F	V_{SL}	V_F	O_{SL}	O_F	F_{SL}	F_F	V_{SL}	V_F
T1.5	Wet *Cirsium* meadows	3.7	26.5	4.9	7.0	0.0	0.0	<0.1	2.5	<0.1	1.2	0.0	0.0
T1.6	Wet *Filipendula* grasslands	1.9	46.4	0.2	0.9	0.0	0.0	<0.1	4.2	<0.1	0.1	0.0	0.0
T1.9	Intermittently wet *Molinia* meadows	0.0	10.3	0.0	0.0	0.0	0.0	0.0	0.9	0.0	0.0	0.0	0.0
T2.3B	Submontane and montane *Nardus* grasslands	0.0	0.0	41.7	0.0	0.0	0.0	0.0	0.0	0.5	0.0	0.0	0.0
T3.1	Rock-outcrop vegetation with *Festuca pallens*	0.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0	<0.1	0.0	0.0	0.0
T3.4D	Broad-leaved dry grasslands	0.0	0.0	3.0	0.0	3.5	0.7	0.0	0.0	<0.1	0.0	<0.1	<0.1
T3.5B	Acidophilous dry grasslands	0.0	0.0	0.0	0.0	2.4	<0.1	0.0	0.0	0.0	0.0	<0.1	<0.1
T4.2	Mesic herbaceous fringes	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.0	<0.1	0.0
T5.5	Acidophilous grasslands on shallow soils	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0	<0.1	0.0	0.0	0.0
V1F	Macrophyte vegetation of naturally eutrophic and mesotrophic still waters without species specific to V1A-V1E	0.0	0.0	0.0	<0.1	0.0	0.4	0.0	0.0	0.0	<0.1	0.0	0.2
V1G	Macrophyte vegetation of naturally eutrophic and mesotrophic still waters without macrophyte species valuable for nature conservation	<0.1	0.6	0.0	0.0	<0.1	<0.1	<0.1	6.3	0.0	0.0	<0.1	<0.1
X1.1	Unnatural, engineered water reservoir	0.0	0.0	0.0	0.0	0.0	0.0	<0.1	0.0	0.0	<0.1	0.0	<0.1
X3.3	Vegetated cracks in semi-permeable paved and gravel surfaces	<0.1	0.1	0.0	0.0	<0.1	0.1	<0.1	0.2	0.0	0.0	<0.1	<0.1
X4.1	Weed vegetation of annual and biennial field crops	694.1	11.2	55.3	0.0	5,033.8	363.5	10.8	2.7	1.6	0.0	41.7	44.3
X4.3	Tall, ruderal vegetation on permeable substrate	92.2	0.4	3.0	0.0	22.6	1.5	0.9	<0.1	<0.1	0.0	0.1	0.1
X4.4	Short, ruderal vegetation on compacted substrate	23.0	0.1	0.0	0.0	3.3	0.0	0.2	<0.1	0.0	0.0	<0.1	0.0
X5.1	Intensively cultivated lawns of ornamental gardens and recreational fields	3.5	<0.1	6.3	0.0	33.2	2.0	<0.1	<0.1	0.1	0.0	0.2	0.2
X5.2	Vegetable and ornamental gardens and gardening colonies	406.9	12.8	635.1	5.8	1,006.2	150.5	1.0	0.5	2.9	0.4	1.3	2.9
X5.3	Intensively managed hop fields, vineyards, and orchards	0.0	0.0	0.0	0.0	755.2	0.3	0.0	0.0	0.0	0.0	0.4	<0.1
X6.1	Parks and other urban green areas	14.3	0.0	0.0	0.0	73.0	15.8	<0.1	0.0	0.0	0.0	<0.1	0.1

Habitat code	Habitat name	Total Carbon stored [t C]						Area [%]					
		O_{SL}	O_F	F_{SL}	F_F	V_{SL}	V_F	O_{SL}	O_F	F_{SL}	F_F	V_{SL}	V_F
XK1	Altered mesophilic and riparian shrubs	62.1	7.5	9.0	1.6	376.8	23.5	0.2	0.4	<0.1	0.2	0.8	0.7
XK3	Woody vegetation on agricultural and other land	157.9	58.8	62.1	0.0	211.8	37.0	0.1	0.7	<0.1	0.0	<0.1	0.2
XK4	Extensively managed orchards, hop fields, and vineyards	101.9	4.1	92.0	2.6	300.0	6.3	0.2	0.1	0.3	0.1	0.3	<0.1
XL1_a	Young managed forests plantations	4,428.9	115.3	692.8	28.8	1,939.1	5.2	9.6	3.9	2.8	1.8	2.2	<0.1
XL1_b	Broadleaf forest stands of managed forests	28,667.9	2,545.4	4,196.1	933.2	26,349.5	2,528.4	12.0	16.4	3.3	11.5	6.0	8.6
XL1_c	Coniferous forest stands of managed forests	72,321.4	2,180.2	49,146.7	2,506.9	62,142.2	1,211.2	28.3	13.2	35.4	27.7	12.9	3.7
XL2	Areas of deforestation (clear-cutting areas)	4,679.5	123.0	1,825.2	63.8	3,205.1	43.7	16.0	6.5	11.6	6.1	5.9	1.2
XL2_d	Dead trees and recent clearings	626.2	12.4	795.5	27.6	2,510.3	66.7	2.1	0.7	5.0	2.6	4.5	1.8
XL3	Strips and groups of trees	44.5	4.7	80.3	40.8	85.9	246.8	<0.1	0.2	0.2	1.3	<0.1	2.2
XM	Altered wetlands and peatlands	0.0	0.6	0.0	0.0	0.0	0.0	0.0	<0.1	0.0	0.0	0.0	0.0
XT1	Altered mesophilic meadows and pastures	353.0	104.4	2,356.2	139.7	876.3	228.7	2.2	9.8	27.7	25.2	3.0	11.4
XT2	Altered wet meadows, pastures, and fallows	0.4	1.0	<0.1	1.2	1.5	9.2	<0.1	<0.1	<0.1	0.2	<0.1	0.4
XT3	Altered dry lawns, hedgerows, and heaths	<0.1	0.0	0.0	0.0	2.6	<0.1	<0.1	0.0	0.0	0.0	<0.1	<0.1
XV1	Altered ponds and water reservoirs	<0.1	0.5	<0.1	0.1	0.0	1.2	<0.1	0.5	<0.1	0.2	0.0	0.6
XV2	Altered watercourses	0.0	0.1	0.0	<0.1	0.0	0.2	0.0	2.4	0.0	2.2	0.0	1.9
XX3.1	Intensively developed area with minimal vegetation	0.0	0.0	0.0	0.0	0.0	0.0	0.2	<0.1	0.6	<0.1	0.5	1.1
XX3.2	Impermeable surfaces and permanently devegetated areas	0.0	0.0	0.0	0.0	0.0	0.0	1.0	1.1	1.8	0.4	2.2	3.5

A.5: Habitats present in the Okrouhlý Stream (O), Ferdinandský Stream (F), and the Veverka Stream (V) watersheds with an indication of their area in percentages in the surrounding landscape ($_{SL}$), floodplains of tributaries ($_{FT}$), main stream floodplain ($_{MF}$), all floodplains ($_{F}$), and watershed ($_{W}$) in 2020–2021, defined based on the habitat layer.
Habitats starting with a single letter except X indicate natural and semi-natural habitats (Chytrý *et al*., 2010), with X and any letter except X indicate slightly degraded habitats (Seják *et al*., 2018b), with X and a number indicate significantly habitats (Seják *et al*., 2018b), and with XX indicate totally degraded habitats (Seják *et al*., 2018b).

Habitat code	Habitat name	O_{SL}	O_{MF}	O_{FT}	O_{F}	O_{W}	F_{SL}	F_{MF}	F_{FT}	F_{F}	F_{W}	V_{SL}	V_{MF}	V_{FT}	V_{F}	V_{W}
K2.1	Riverine willow scrub	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.2	<0.1	<0.1	<0.1
K3	Tall mesic and xeric scrub	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.2	0.1	<0.1	0.3	0.5	0.8	0.7	0.3
L2.2	Ash-alder alluvial forests	<0.1	4.1	1.6	3.3	0.3	0.2	15.0	12.0	13.5	1.0	0.2	14.2	2.6	6.2	0.6
L3.1	Hercynian oak-hornbeam forests	0.5	<0.1	<0.1	<0.1	0.4	3.9	2.8	3.7	3.3	3.9	13.0	4.4	7.1	6.3	12.6
L3.3B	West Carpathian oak-hornbeam forests	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
L4	Ravine forests	0.1	<0.1	<0.1	<0.1	0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.3	<0.1	0.1	<0.1
L5.1	Herb-rich beech forests	3.4	2.5	33.1	12.4	4.0	1.0	<0.1	1.8	0.9	1.0	0.3	<0.1	<0.1	<0.1	0.3
L5.4	Acidophilous beech forests	<0.1	<0.1	<0.1	<0.1	<0.1	5.3	2.3	1.2	1.7	5.1	0.2	<0.1	<0.1	<0.1	0.1
L6.5B	Acidophilous thermophilous oak forests	<0.1	<0.1	<0.1	<0.1	<0.1	1.0	<0.1	<0.1	<0.1	0.9	1.2	0.3	0.1	0.2	1.2
L7.1	Dry acidophilous oak forests	0.3	<0.1	<0.1	<0.1	0.2	3.5	2.6	0.9	1.8	3.4	2.2	0.9	0.5	0.7	2.1
L8.1B	Boreo-continental pine forests	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
M1.1	Reed beds of eutrophic still waters	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
M1.3	Eutrophic vegetation of muddy substrata	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	2.5	<0.1	1.3	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
M1.7	Tall-sedge beds	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	1.6	1.0	1.3	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
S1.1	Chasmophytic vegetation of calcareous cliffs and boulder screes	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
S1.2	Chasmophytic vegetation of siliceous cliffs and boulder screes	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.2	0.2	0.2	<0.1
T1.1	Mesic *Arrhenatherum* meadows	1.5	4.0	0.2	2.8	1.5	<0.1	1.6	3.7	2.6	0.2	0.1	<0.1	0.2	0.1	0.1
T1.10	Vegetation of wet disturbed soils	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
T1.3	Cynosurus pastures	0.1	<0.1	0.4	0.1	0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1

Habitat code	Habitat name	O_{SL}	O_{MF}	O_{FT}	O_{F}	O_{W}	F_{SL}	F_{MF}	F_{FT}	F_{F}	F_{W}	V_{SL}	V_{MF}	V_{FT}	V_{F}	V_{W}
T1.5	Wet *Cirsium* meadows	<0.1	1.8	<0.1	1.2	0.1	<0.1	3.9	1.0	2.5	0.2	<0.1	<0.1	<0.1	<0.1	<0.1
T1.6	Wet *Filipendula* grasslands	<0.1	0.2	<0.1	0.1	<0.1	<0.1	8.4	<0.1	4.2	0.3	<0.1	<0.1	<0.1	<0.1	<0.1
T1.9	Intermittently wet *Molinia* meadows	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	1.8	0.9	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
T2.3B	Submontane and montane Nardus grasslands	0.5	<0.1	<0.1	<0.1	0.5	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
T3.1	Rock-outcrop vegetation with *Festuca pallens*	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
T3.4D	Broad-leaved dry grasslands	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.2	<0.1	<0.1	<0.1
T3.5B	Acidophilous dry grasslands	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
T4.2	Mesic herbaceous fringes	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
T5.5	Acidophilous grasslands on shallow soils	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
V1F	Macrophyte vegetation of naturally eutrophic and mesotrophic still waters without species specific to V1A-V1E	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.3	0.2	<0.1
V1G	Macrophyte vegetation of naturally eutrophic and mesotrophic still waters without macrophyte species valuable for nature conservation	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	11.7	0.8	6.3	0.4	<0.1	<0.1	<0.1	<0.1	<0.1
X1.1	Unnatural, engineered water reservoir	<0.1	0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
X3.3	Vegetated cracks in semi-permeable paved and gravel surfaces	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.3	<0.1	0.2	<0.1	<0.1	<0.1	0.1	<0.1	<0.1
X4.1	Weed vegetation of annual and biennial field crops	1.6	<0.1	<0.1	<0.1	1.5	10.8	0.4	5.0	2.7	10.3	41.7	39.6	46.4	44.3	41.9
X4.3	Tall, ruderal vegetation on permeable substrate	<0.1	<0.1	<0.1	<0.1	<0.1	0.9	<0.1	0.1	<0.1	0.8	0.1	0.3	<0.1	0.1	0.1
X4.4	Short, ruderal vegetation on compacted substrate	<0.1	<0.1	<0.1	<0.1	<0.1	0.2	<0.1	<0.1	<0.1	0.2	<0.1	<0.1	<0.1	<0.1	<0.1
X5.1	Intensively cultivated lawns of ornamental gardens and recreational fields	0.1	<0.1	<0.1	<0.1	0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.2	<0.1	0.2	0.2	0.2
X5.2	Vegetable and ornamental gardens and gardening colonies	2.9	0.4	0.4	0.4	2.7	1.0	<0.1	1.0	0.5	1.0	1.3	0.8	3.9	2.9	1.4
X5.3	Intensively managed hop fields, vineyards, and orchards	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.4	<0.1	<0.1	<0.1	0.4

Habitat code	Habitat name	O_{SL}	O_{MF}	O_{FT}	O_{F}	O_{W}	F_{SL}	F_{MF}	F_{FT}	F_{F}	F_{W}	V_{SL}	V_{MF}	V_{FT}	V_{F}	V_{W}
X6.1	Parks and other urban green areas	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.4	<0.1	0.1	<0.1
XK1	Altered mesophilic and riparian shrubs	<0.1	0.3	<0.1	0.2	<0.1	0.2	<0.1	0.8	0.4	0.3	0.8	0.9	0.6	0.7	0.8
XK3	Woody vegetation on agricultural and other land	<0.1	<0.1	<0.1	<0.1	<0.1	0.1	<0.1	1.4	0.7	0.2	<0.1	<0.1	0.3	0.2	<0.1
XK4	Extensively managed orchards, hop fields, and vineyards	0.3	0.2	<0.1	0.1	0.3	0.2	<0.1	0.2	0.1	0.2	0.3	<0.1	0.1	<0.1	0.2
XL1_a	Young managed forests plantations	2.8	1.7	1.9	1.8	2.7	9.6	5.4	2.3	3.9	9.2	2.2	0.1	<0.1	<0.1	2.1
XL1_b	Broadleaf forest stands of managed forests	3.3	15.7	2.7	11.5	3.8	12.0	15.3	17.5	16.4	12.3	6.0	11.1	7.4	8.6	6.2
XL1_c	Coniferous forest stands of managed forests	35.4	23.1	37.3	27.7	34.9	28.3	5.2	21.3	13.2	27.4	12.9	1.3	4.8	3.7	12.3
XL2	Areas of deforestation (clear-cutting areas)	11.6	3.5	11.6	6.1	11.2	16.0	5.4	7.6	6.5	15.5	5.9	<0.1	1.7	1.2	5.6
XL2_d	Dead trees and recent clearings	5.0	1.0	6.0	2.6	4.8	2.1	0.7	0.6	0.7	2.0	4.5	1.3	2.0	1.8	4.4
XL3	Strips and groups of trees	0.2	1.9	<0.1	1.3	0.2	<0.1	0.2	0.2	0.2	<0.1	<0.1	0.3	3.0	2.2	0.2
XM	Altered wetlands and peatlands	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
XT1	Altered mesophilic meadows and pastures	27.7	36.7	1.0	25.2	27.5	2.2	11.5	8.1	9.8	2.7	3.0	16.0	9.3	11.4	3.5
XT2	Altered wet meadows, pastures, and fallows	<0.1	0.3	<0.1	0.2	<0.1	<0.1	0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.5	0.4	<0.1
XT3	Altered dry lawns, hedgerows, and heaths	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
XV1	Altered ponds and water reservoirs	<0.1	0.3	<0.1	0.2	<0.1	<0.1	0.5	0.6	0.5	<0.1	<0.1	1.3	0.3	0.6	<0.1
XV2	Altered watercourses	<0.1	1.5	3.8	2.2	0.1	<0.1	1.8	2.9	2.4	0.1	<0.1	1.5	2.1	1.9	0.1
XX3.1	Intensively developed area with minimal vegetation	0.6	<0.1	<0.1	<0.1	0.6	0.2	<0.1	0.1	<0.1	0.2	0.5	0.2	1.5	1.1	0.5
XX3.2	Impermeable surfaces and permanently devegetated areas	1.8	0.6	<0.1	0.4	1.7	1.0	0.5	1.8	1.1	1.0	2.2	3.2	3.6	3.5	2.3

A.6: Habitat types present in the Okrouhlý Stream (O), Ferdinandský Stream (F), and Veverka Stream (V) watersheds with an indication of their area in percentages in the surrounding landscape ($_{SL}$), floodplains of tributaries ($_{FT}$), main stream floodplain ($_{MF}$), all floodplains ($_{F}$) and watershed ($_{W}$) in 2020–2021, defined based on the habitat layer.

Habitat type	O_{SL}	O_{MF}	O_{FT}	O_{F}	O_{W}	F_{SL}	F_{MF}	F_{FT}	F_{F}	F_{W}	V_{SL}	V_{MF}	V_{FT}	V_{F}	V_{W}
Natural and semi-natural habitats	6.7	12.7	35.3	20.0	**7.5**	15.0	52.4	28.3	40.5	**16.5**	17.7	21.3	11.9	14.8	**17.5**
Slightly and significantly degraded habitats	90.9	86.6	64.7	79.5	**90.2**	83.9	47.1	69.7	58.3	**82.3**	79.6	75.2	83.0	80.6	**79.7**
Totally degraded habitats	2.4	0.7	0.0	0.5	**2.3**	1.2	0.5	1.9	1.2	**1.2**	2.7	3.4	5.1	4.6	**2.8**

A.7: Habitat types present in the floodplains and surrounding landscapes of the studied watersheds in 2020–2021 with an indication of their area, ecological values, and carbon stored in plant biomass, defined based on the habitat layer.

	Natural and semi-natural habitats	Slightly and significantly degraded habitats	Totally degraded habitats
		Area [%]	
Okrouhlý Stream – surrounding landscape	6.7	90.9	2.4
Okrouhlý Stream – floodplains	20.0	79.5	0.5
Ferdinandský Stream – surrounding landscape	15.0	83.9	1.2
Ferdinandský Stream – floodplains	40.5	58.3	1.2
Veverka Stream – surrounding landscape	17.7	79.6	2
Veverka Stream – floodplains	14.8	80.6	4.6
		Ecological value [BVM points]	
Okrouhlý Stream – surrounding landscape	23,701,731.3	119,232,823.5	0.0
Okrouhlý Stream – floodplains	4,772,279.9	7,232,933.0	0.0
Ferdinandský Stream – surrounding landscape	97,693,144.1	198,913,338.4	0.0
Ferdinandský Stream – floodplains	16,451,752.0	9,610,807.2	0.0
Veverka Stream – surrounding landscape	237,789,859.0	286,546,427.4	0.0
Veverka Stream – floodplains	12,917,783.1	19,399,260.6	0.0
Okrouhlý Stream – surrounding landscape	23,701,731.3	119,232,823.5	0.0
Okrouhlý Stream – floodplains	4,772,279.9	7,232,933.0	0.0
Ferdinandský Stream – surrounding landscape	97,693,144.1	198,913,338.4	0.0
		Total carbon stored [t C]	
Okrouhlý Stream – surrounding landscape	5,868.1	59,980.1	0.0
Okrouhlý Stream – floodplains	1,364.2	3,752.2	0.0
Ferdinandský Stream – surrounding landscape	35,862.5	112,714.3	0.0
Ferdinandský Stream – floodplains	3,434.4	5,183.1	0.0
Veverka Stream – surrounding landscape	78,344.8	104,971.4	0.0
Veverka Stream – floodplains	4,187.1	4,942.9	0.0