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Comparative vegetation ecological study reveals drying trends in the floodplain habitats of the Donau-Auen National Park (Austria)

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Figure 1 – Own image taken during fieldwork in 2023 on the study site.

Abstract

The Donau-Auen National Park in eastern Austria protects the largest contiguous floodplain forest in Central Europe along one of the last free-flowing sections of the Danube. The straightening of the river course and the lack of bedload, due to the damming by hydropower plants, have led to an incision of the riverbed and a lowering of the groundwater level. Over the past 35 years, the average groundwater level in the studied site has dropped by 50 to 60 cm. In the past, the distance to the groundwater table was a decisive factor in the determination of the vegetation. This raises the question of how the described changes affect the protected floodplain ecosystems. The thesis repeated 90 vegetation surveys in three habitat types (aquatic, open land, woodland) 35 years after their first observation (1987/1988 and 2023). In addition to comparative vegetation analysis, the elevation of the plots and thus the distance to the groundwater table was taken into account as a key variable. Overall, the species composition has shifted towards species that are adapted to drier, shadier and warmer conditions. All habitat types show a significant change over time, however aquatic habitats are the most affected, followed by open land and woodland habitats. Furthermore, low-lying plots located at a short distance from the groundwater level have changed significantly, while higher-lying plots show little or no change. The distance to the groundwater table is not a decisive factor for the determination of the vegetation any more. In order to preserve these protected floodplain habitats, the incision of the Danube needs to be addressed to counteract falling (ground)water levels.

Keywords: Donau-Auen National Park; floodplain vegetation; river bed incision; groundwater lowering; drying trends; habitat loss; vegetation survey; comparative analysis; indicator values

Zusammenfassung

Der Nationalpark Donau-Auen im Osten Österreichs schützt den größten, zusammenhängenden Auwald Mitteleuropas an einer der letzten freien Fließstrecken der Donau. Die Begradigung des Flusslaufes und das Fehlen von Geschiebe aufgrund der Staustufen führen zu einer Eintiefung des Flussbetts und sinkenden Grundwasserständen. In den letzten 35 Jahren ist der mittlere Grundwasserspiegel in dem Untersuchungsgebiet um 50 bis 60 cm gefallen. In der Vergangenheit war der Flurabstand ein entscheidender Faktor für die Ausprägung der Zeigerwerte. Das wirft die Frage auf, wie sich die beschriebenen Veränderungen auf das unter Naturschutz stehende Au-Ökosystem auswirken. Die vorliegende Arbeit hat 90 Vegetationsaufnahmen in drei Lebensräumen (Gewässer, Offenland, Wald) nach 35 Jahren zum ersten Mal wiederholt (1987/1988 und 2023). Neben den vegetationsökologischen Vergleichen ist der Flurabstand als Schlüsselvariable in die Analyse mit eingeflossen. Insgesamt hat sich die Artenzusammensetzung in Richtung von Arten verschoben, die an trockenere, schattigere und wärmere Bedingungen angepasst sind. Alle Lebensräume zeigen eine deutliche Veränderung über die Zeit, wobei Gewässer-Lebensräume am stärksten betroffen sind, gefolgt von Offenland- und Wald-Lebensräumen. Weiters haben sich tief liegende Aufnahmeflächen, die sich in geringer Entfernung zum mittleren Grundwasserspiegel befinden, deutlich verändert, während höher gelegene Aufnahmeflächen kaum oder gar keine Veränderungen aufweisen. Der Flurabstand ist für die Ausprägung der Zeigerwerte kein entscheidender Faktor mehr. Um den langfristigen Erhalt dieser geschützten Lebensräume zu gewährleisten, muss der Eintiefung der Donau und den damit verbundenen fallenden Wasserstände Einhalt geboten werden.

Schlagworte: Nationalpark Donau-Auen; Auen Vegetation; Flussbetteintiefung; Grundwasserabfall; Austrocknungstrend; Lebensraumverlust; Vegetationsaufnahmen; Vergleichende Vegetationsanalyse; Zeigerwerte

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1. Introduction

Floodplains have always been an area of tension for mankind (Starmühlner et al., 1972). Fruitful soils, an abundance of fish and game and fast-growing trees whose wood could be used for heating and constructing (Starmühlner et al., 1972). In contrast, flood events and especially ice jams destroyed settlements, infrastructure and harvests (Starmühlner et al., 1972). Early on, man tried to influence the course of the river and tame its power (Starmühlner et al., 1972). The first and second Danube regulations are of great importance for the Danube region east of Vienna (Brunner & Schneider, 2005). In this process, the meandering and anabranching river was forced into a single, straightened riverbed, and today's dike system was built (Brunner & Schneider, 2005). The untamed power of the river was harnessed, but the effects on the alluvial system were severe (Starmühlner et al., 1972). Many changes take place in time dimensions that exceed a human lifetime. However, the subjective feeling that the floodplain is running out of water is not only described by people who have known the area for a long time (Starmühlner et al., 1972). Measurements clearly show falling water levels of the river itself and the groundwater in the surrounding area (Klasz, 2024). This can be explained by the incision of the Danube (Klasz, 2024). Which is a result of forcing the river into a single straightened riverbed and a lack of sediment load due to the damming of the river by hydropower plants (Klasz, 2024). The big question arising from that is: “Does the accompanying floodplain habitats change over time?”

1.1. Floodplains

Floodplains are the point of intersection between aquatic and terrestrial habitats (Lazowski, 1997). From an ecological point of view, fluctuating, rather high groundwater levels and regular (seasonal) floodings are the factors that are decisive for their formation and persistence (Lazowski, 1997; Starmühlner et al., 1972; Wendelberger-Zelinka, 1952). Nutrient input through floods and the exchange of organisms between the river and the floodplain are typical (Dister, 1985). The river’s dynamic is the main force forming the landscape and habitats of a floodplain (Lazowski, 1997; Schnitzler, 1997; Wendelberger-Zelinka, 1952). A floodplain is therefore an azonal vegetation type, as the river’s dynamic is more important in its development than the surrounding climate conditions (Frey & Lösch, 2010). Thus, floodplains occur along seasonally fluctuating rivers throughout multiple zonal vegetation types around the world and are often integrated with other wetland types such as bogs, fens, swamps, wet meadows, marshes and aquatic ecosystems (Frey & Lösch, 2010; Keddy, 2024). Furthermore, floodplain forests are important ecological corridors that support the migration of animals and the spread of plant species (Malanson, 1993).

1.1.1. River dynamic

The ecology of a river is determined by its drainage basin (Lazowski, 1997). A drainage basin, or catchment, is a single fluvial system consisting of potentially multiple subcatchments (Fryirs & Brierley, 2013). Geology and climate determine the topography and valley width of a (sub)catchment and are therefore influencing the sediment and discharge regime of the river (Fryirs & Brierley, 2013). Varying water levels can be caused by precipitation events or the melting of snow and ice in the catchment area (Fryirs & Brierley, 2013). Therefore, the season in which a river is typically bearing low or high water levels is dependent on its catchment (Fryirs & Brierley, 2013; Wendelberger-Zelinka, 1952).

In the riverbed, erosion takes place when the kinetic energy is greater than the transported load, conversely, sedimentation takes place when the kinetic energy is lower than the transported load (Jelem, 1974). Floodplains establish in areas where river deposits accumulate, lateral as well as vertical accretion processes are therefore the primary processes influencing the formation of a floodplain (Fryirs & Brierley, 2013; Schnitzler, 1997). Along the course of a river, floodplains can occur as isolated pockets, as discontinuous pockets, or as continuous features along both sides of a river (Fryirs & Brierley, 2013).

Disturbance events can be natural or man-made, one can distinguish between ramp, press and pulse disturbance events (Fryirs & Brierley, 2013). For a ramp event the disturbance strength increases over time and space (Fryirs & Brierley, 2013) an example would be increased erosion of a channel bed due to the lack of bedload downstream of a hydropower plant. A press event results from a permanent shift in controlling variables (Fryirs & Brierley, 2013), flow regulation following the construction of a dam would be a typical example. Pulse disturbances are episodic events of low frequency, high magnitude and limited duration a typical example is a seasonal flood (Fryirs & Brierley, 2013).

Flood events are natural disturbance events in a river system (Fryirs & Brierley, 2013). Their magnitude, frequency and duration have varying consequences affecting, for instance, the erosivity of a reach (Fryirs & Brierley, 2013). The development of vegetation is influenced by the season, duration and height of flooding, as most plants can only survive if at least some leaves remain above the water (Dister, 1985). Lower morphological surfaces, such as the main channel, are experiencing sediment mobility more frequently, while higher morphological surfaces are largely inactive, experiencing partial mobility during higher magnitude flood events (Fryirs & Brierley, 2013). Reworking processes in floodplains include lateral migration, formation of cut-offs and avulsions, as well as floodplain stripping and flood channel scouring (Fryirs & Brierley, 2013). These processes

influence the morphology of a floodplain, leading to a mosaic of depositional and erosional forms (Fryirs & Brierley, 2013). Due to regular disturbance, old habitats are set back, and new ones are formed, the progress of succession is constantly happening in a natural floodplain system.

1.1.2. Succession

Succession is the replacement of one plant community by another (Schaefer, 2012). A distinction can be made between primary succession and secondary succession (Glavac & Hakes, 1996). Primary succession takes place on raw soils, for example, on newly sedimented gravel- or sandbanks (Glavac & Hakes, 1996). Secondary succession is the transformation of a plant community with a lower form of organisation into a plant community with a higher form of organisation (Glavac & Hakes, 1996). Succession can happen due to the exchange of species or due to a change in dominance of species (Braun-Blanquet, 1951). The primarily climatically determined final plant community is called 'climax' (Braun-Blanquet, 1951). Accordingly, floodplains are a mosaic of successional stages, representing different habitats (Malanson, 1993). Close to the main stream, disturbance happens frequently, hence early successional stages are found more frequently (Malanson, 1993). Further apart from the main stream areas are less disturbed and older, more stable successional stages dominate (Malanson, 1993).

1.1.3. Building process

Besides the restorative effects of floods within a floodplain ecosystem, the vertical accretion is the primary floodplain building process (Fryirs & Brierley, 2013). At higher water levels, the water overflows its banks and floods the surrounding, most likely vegetated, area (Schönborn & Risse-Buhl, 2013). The vegetation slows down the water flow, causing the suspended matter to settle out, the closer to the main stream, the larger the deposited sediment particles (Schönborn & Risse-Buhl, 2013). Additionally, the succession from pioneer vegetation to floodplain forest results in increased hydraulic resistance and sediment trapping (Fryirs & Brierley, 2013). Aside from that, vegetation also increases the bank strength, and roots bind sediments (Fryirs & Brierley, 2013). As a result, vegetation reduces erosion and channel migration (Fryirs & Brierley, 2013). In addition to the sedimentation effects, the water overflowing the banks also penetrates into the soil and groundwater (Schönborn & Risse-Buhl, 2013). An intact floodplain therefore is an effective retention system (Schönborn & Risse-Buhl, 2013).

1.1.4. Soil

Soils in floodplains distinguish them from all others by the alternation of sedimentation and erosion as well as the constantly fluctuating groundwater level and flooding (Stahr et al., 2020). Several

types of alluvial soils can be distinguished, such as rambla, paternia, vega, alluvial gley and alluvial fen (Stahr et al., 2020). The soil close to the river tend to be composed of coarse sediments, while more distant sites tend to be made out of finer sediments (Dister, 1988). Depending on the parent material, the water-holding capacity as well as the capillary rise can be very different, therefore, the available water for plant growth varies widely (Stahr et al., 2020). Fluctuating groundwater levels create an air pump effect, often leading to well-aerated topsoil (Stahr et al., 2020). Nutrients are delivered with flood events (Stahr et al., 2020), therefore, very fertile soils with high biotic activity can be found (Jelem, 1974).

1.1.5. Biodiversity

In floodplains a high total biodiversity can be found due to many different habitats on a relatively small scale and recurring disturbance events (Lazowski, 1997; Schnitzler, 1997). The alternation between wet and dry phases over the course of the seasons (Brunner & Schneider, 2005) as well as the natural coexistence of permanently wet habitats and natural dry habitats contributes to the high diversity (Lazowski, 1997). Furthermore, the landscape represents a continuum from flooding-prone sites to particularly protected ones, which act as a refugium and seed sources when the conditions change (Schnitzler, 1997).

Aquatic habitats of a floodplain differ in their formation, age and stadium of silting as well as their degree of isolation (Lazowski, 1997). This results in water bodies of varying size and depth, which are perennial or intermittent, differing in terms of their canopy cover and eutrophication, accordingly, very different abiotic parameters can be measured, and a variety of macrophyte communities can be found (Lazowski, 1997). In dynamic areas with rearrangement processes, herbaceous pioneer vegetation inhabits the riverbank (Lazowski, 1997). Along with the frequency of disturbance and the influence of fluctuating groundwater levels, different woodland habitats take over (Lazowski, 1997; Schönborn & Risse-Buhl, 2013). The nutrition-rich soil and good water availability lead to a vigorous forest, where light and air are the limiting factors (Wendelberger-Zelinka, 1952). Numerous tree species occur (Jelem, 1974) and often a clear stratification is formed with many vine species being present (Wendelberger-Zelinka, 1952). Open land habitats can be anthropogenic or of natural origin, a special type for floodplains is the so-called ‘hotland’ (German “Heißlände”) (Lazowski, 1997). Hotlands are established in areas where gravel has been piled up well above the mean groundwater level, due to the low water-holding capacity, these areas are very dry and are mainly colonised by drought-bearing shrubs and species-rich grasslands (Lazowski, 1997).

1.2. Nature conservation efforts

Riversides are and have always been preferred location for human settlements, as the river could be used as a freshwater supply, for navigation and waste disposal, as a source of food and for the irrigation of farmland (Finlayson et al., 2018). Therefore, rivers and their surrounding landscapes have been altered heavily by mankind (Finlayson et al., 2018). Dams are the most widespread and significant threat for river systems, followed by water withdrawal, overexploitation, the introduction of invasive species, and pollution not to forget the effects of climate change (Finlayson et al., 2018).

Many terrestrial protected areas, which include aquatic ecosystems, are not designed and managed to protect those habitats and species (Finlayson et al., 2018). Important issues such as the longitudinal and lateral connectivity (connection along the length of a river, connection between the main river channel and its adjacent habitats) as well as key hydrological processes (high water levels) are not considered (Finlayson et al., 2018). Additionally, aquatic ecosystems are especially vulnerable to pressures occurring outside the protected area, and rivers are of course also heavily dependent on their upper reach (Finlayson et al., 2018). The traditional approach of nature conservation to demarcate and protect an area is therefore less effective on freshwater habitats and species (Finlayson et al., 2018). Furthermore, protected areas are difficult to implement for a long, linear structure such as a river, which flows through different areas and therefore meets a wide variety of interests (Finlayson et al., 2018). Unsurprisingly, rivers, and particularly their middle reaches and floodplains, are underrepresented in protected areas around the world (Finlayson et al., 2018). In Europe and North America, up to 90% of the floodplains are cultivated and therefore functionally extinct (Tockner & Stanford, 2002). As for floodplain forests, it was thought for a long time that the high groundwater level was decisive for their preservation (Brunner & Schneider, 2005). However, around 1990 it became more and more clear that it is rather the interplay of changing groundwater levels and, above all, regular flood events that it takes for a floodplain to develop and persist (Brunner & Schneider, 2005). Worldwide efforts are being made to strengthen nature conservation and to protect and restore ecosystems. On an international scale the IUCN and the Convention on Wetlands are important players, the Natura 2000 network is an EU initiative.

1.2.1. IUCN – International Union for Conservation of Nature

The IUCN is the world's foremost membership union of government and civil society organisations aiming to protect the integrity and diversity of nature (Chape et al., 2003). A well-known tool are "red lists", which can be found for different regions, flora, fauna, and habitats, which are based on the threatened species categories introduced by IUCN (Chape et al., 2003; IUCN Species Survival Commission, 1994). Another important aspect in which the IUCN sets international standards is the definition of protected areas, management categories, and governance types (IUCN Commission on

National Parks and Protected Areas with the assistance of the Worlds Conservation Monitoring Centre, 1994). According to IUCN, a protected area is "A clearly defined geographical space, recognised, dedicated and managed, through legal or other effective means, to achieve the long-term conservation of nature with associated ecosystem services and cultural values." (Dudley, 2008). It can be distinguished between six management categories:

1a. Strict nature reserve,

1b. Wilderness area,

2. National park,

3. Natural monument or feature,

4. Habitat/species management area,

5. Protected landscape or seascape,

6. Protected areas with sustainable use of natural resources (Dudley, 2008).

A national park is a large natural or near-natural area where, on one hand, ecological processes, species and ecosystems are protected, and on the other hand, visitors have the opportunity to gain cultural, spiritual, scientific, educational and recreational experiences (Dudley, 2008). In Austria, 29.63% of the land area is protected and around 2% of the protected land area is in the IUCN management category 1 or 2 (UNEP-WCMC and IUCN, 2025).

1.2.2. Convention on Wetlands

On an international scale the Convention on Wetlands provides a framework for international cooperation and national action for the conservation and wise use of wetlands (Secretariat of the Convention on Wetlands, 2024b). More than 90% of the UN member states have joined the Convention on Wetlands and have therefore agreed on taking considerations in wetland conservation, establishing a national wetland committee, and developing a national wetland inventory (Secretariat of the Convention on Wetlands, 2024b, 2024a). Furthermore, a member state must designate at least one Wetland of International Importance, a so-called "Ramsar Site", and should promote training in research, management and wardening, as well as the exchange on a national and international level (Secretariat of the Convention on Wetlands, 2024a). In Austria, 26 Ramsar Sites can be found (*Austria | The Convention on Wetlands*, 2026).

1.2.3. Nature conservation in the European Union

On the level of the European Union, efforts have been made to develop a joint strategy for conservation of biodiversity (Ellmauer, 2005). In 1979 the council's directive on the conservation of wild birds was adopted, which covers the protection, management and regulation of all native wild bird species, their eggs, nests and habitats (Council Directiv 79/409/EEC on the Conservation of

Wild Birds, 1979). In 1992 the council directive 92/43/EEC, on conservation of natural habitats and wild fauna and flora (today well known as Natura 2000 directive) was published (Council Directive 92/43/EEC on the Conservation of Natural Habitats and of Wild Fauna and Flora, 1992). According to this directive, the "Natura 2000" network was established with the intent to ensure the continued existence or restoration of natural habitat types listed in Annex 1 and habitats of the species listed in Annex 2 (Ellmauer, 2005). Every six years the Member States shall draw up a report on the conservation status of its natural habitat types of Annex 1 and the species listed in Annex 2 (Council Directive 92/43/EEC on the Conservation of Natural Habitats and of Wild Fauna and Flora, 1992). Currently, 303 areas are part of the Natura 2000 network in Austria (Ellmauer et al., 2020).

1.3. Danube Floodplains

1.3.1. The Danube in Austria

The Danube in Austria flows 350 kilometres from Passau to the Czech border. It is classified as a headwater region with an average gradient of 90 cm/ km, after the "Wiener Pforte", the gradient decreases to 40 – 45 cm/ km (Haubenberger & Weidinger, 1990; Klimo & Hager, 2001). The hydrology and the sedimentation characteristics are highly determined by its alpine tributaries (Klimo & Hager, 2001). The water level fluctuates significantly over the course of the season (Jelem, 1974; Starmühlner et al., 1972), typical are low flows in late autumn and winter and high flows in late spring and early summer (Klimo & Hager, 2001). Thawing of snow and ice in the mountains, as well as more rainfall in spring and summer, causing the water level to rise (Jelem, 1974; Starmühlner et al., 1972). However, abnormal weather conditions can cause flood events at any time of the year (Jelem, 1974; Starmühlner et al., 1972). The difference between the two water level extremes is 7 – 8 m (Haubenberger & Weidinger, 1990). The Danube in Austria can furthermore be described as a mountain river which formerly transported, deposited and eroded high quantities of bed load, resulting in naturally wide floodplain ecosystems (Lazowski, 1997).

For the region east of Vienna, it is unclear how the river would behave under natural conditions. According to some criteria, a braided or anastomosing channel pattern would be expected (Klimo & Hager, 2001) according to other criteria, an unbranched, meandering type is seen as the most likely channel pattern (Klasz, 2011). However, it is assumed that the region was very changeable and dynamic with a great distribution of floodplains (Klimo & Hager, 2001), a wide area of shallow water bodies and a pronounced side-arm system (Hohensinner & Jungwirth, 2016). As a consequence succession patterns and dynamic behaviour of the alluvial forests have adapted to the rivers' changeability (Klimo & Hager, 2001). Nowadays, the floodplains downstream of Vienna only describes a fraction of the former river landscape, nevertheless, it is the largest contiguous alluvial forest in Central Europe (Brunner & Schneider, 2005).

1.3.2. History the Danube region downstream of Vienna

For a long time, the Danube in the area of Vienna was both a source of livelihood and a threat to the people of the region (Brunner & Schneider, 2005). The floodplains were used as a pasture and for the production of firewood, Danube fish were a common and valued food source, and shipping contributed significantly to the supply of goods, however, hunting was reserved for the imperial leader (Brunner & Schneider, 2005). Floods and ice jams were feared, and the changing course of the river repeatedly made access to the city of Vienna difficult (Brunner & Schneider, 2005). The map in Figure 23 shows the area between Vienna and Hainburg mapped from 1773 till 1781 during the Josephine land survey (German: "Josephinische Landesaufnahme") (Stein, 1773). It shows a river with multiple side branches and a wide floodplain accompanying it.

Danube regulation

The first attempts to regulate the Danube date back to the 15th century (Brunner & Schneider, 2005). At this time, the main river had shifted eastwards, away from the city of Vienna, which made navigation and the supply of the city difficult, therefore, attempts were made to force water into the bed of today's Danube Canal (German: "Donaukanal") (Brunner & Schneider, 2005). During the 18th century, flood protection became more and more important, and the major flood events of 1830 and 1862 were among the triggers for the formation of the Danube Regulation Commission (German: "Donauregulierungskommission") (Brunner & Schneider, 2005). In 1870, the constructions for the 'Great Danube Regulation' (German: "Große Donauregulierung") started, whereby all branches of the Danube were merged into a single, straightened channel with a fixed shipping route and riprap constructions eliminating bank erosion (Brunner & Schneider, 2005; Klimo & Hager, 2001). Next to the new bed, a wide inundation area was kept, which developed into a near-natural landscape that was used as a recreational area (Brunner & Schneider, 2005). In 1902 the dike along the left side of the Danube, starting at Langenzersdorf until the Czech border, was finished, protecting the areas in the east from floods (Klimo & Hager, 2001; Waldheim, 1904). In the 20 th century, more and more utilisation interests, such as agricultural and recreational usage, had an impact, however, also the idea of placing the area under nature protection became popular (Nationalpark Donau-Auen GmbH, 2019). Over time, it became clear that the 'Great Danube Regulation' had not yet solved all the problems, additional flood protection and low water regulation to keep up river navigation during low water seasons was needed (Brunner & Schneider, 2005; Haidvogl, 2009). In 1972, construction work began on the relief channel of today's New Danube (German: "Neue Donau") and the Danube Island (German: "Donauinsel") (Brunner & Schneider, 2005). Today the Danube is the only river in Austria used for shipping (Haidvogl, 2009).

Nature conservation efforts and hydropower plants

In 1973 the Austrian Institute for Spatial Planning (German: "österreichisches Insitut für Raumplanug") developed the first concept for the Danube-March-Thaya-floodplain national park (German: "Nationalpark Donau-March-Thaya-Auen") (Brunner & Schneider, 2005). In 1977, the Lower Lobau was declared a biosphere reserve, in 1978, the entire Lobau was declared a protected area (Brunner & Schneider, 2005). At the beginning of the 1980s, the discussions about a hydropower plant "Hainburg" gained momentum (Pauli, 1983; Rauscher, 1984). Leading to the famous occupation of the floodplain next to the village of Stopfenreuth (G. Schobesberger, personal communication, 13 November 1984) and demonstrations in Vienna (APA 295-ID, 1984). The protests ended with the "Christmas peace" and an "11-point plan", including the promise to look for alternatives (Lieckfeld, 1985). In the following years, various ideas and concepts for the region were analysed and discussed. Just to mention a few approaches: there was a study about the national park worthiness of the region (Wösendorfer, 1989), a feasibility study for the establishment of two hydropower plants in the area (Österreichische Donaukraft AG, 1989), a legal concept for the national park (Reindl, 1990), a concept on regional development perspective (Mang, 1988) and so on. Irrespective of the protests in Hainburg, the hydropower plant "Freudenau" was planned upstream of the discussed region, in a referendum in May 1991, a majority of the Viennese citizens voted in favour of the construction (Presse-Service, 1991; VERBUND Hydro Power AG, 2013). The hydropower plant "Freudenau" was built between 1992 and 1998 using a wet construction method (VERBUND Hydro Power AG, 2013). Today there are 10 hydropower plants on the Austrian Danube and one on the Danube Canal (VERBUND Hydro Power AG, 2013).

Donau-Auen National Park

In 1996 the Donau-Auen National Park was established (Budesgesetzblatt Für Die Republik Österreich - Jahrgang 1996 Ausgegeben Am 28. Jänner 1997 Teil 1, 1996), preserving one of the last two free-flowing sections of the Danube in Austria and its accompanying floodplains (Zauner et al., 2016). Since 1997, the Donau-Auen National Park has been protected according to IUCN's international protected area category II (Nationalpark Donau-Auen GmbH, 2019). The national park is located on both sides of the Danube, starting at the "Obere Lobau" in Vienna extending to the Austrian-Slovakian border (Nationalpark Donau-Auen GmbH, 2019). Furthermore, the area is part of the two Ramsar sites, namely "Untere Lobau" and "Donau-March-Thaya-Auen" (see Figure 24 in the appendix; (Land Niederösterreich, 2010; Nationalpark Donau-Auen GmbH et al., 2023; Stadt Wien, 2002)). The national park area is covered by the Natura 2000 area "Donau-Auen östlich von Wien" and accompanied by the other two riverine Natura 2000 areas namely "March-Thaya-Auen" and "Feuchte Ebene – Leithaauen" (see Figure 25 in the appendix; (NÖ-GIS, Land Niederösterreich, 2008)). The two alluvial forest types "91E0 Alluvial forests with *Alnus glutinosa* and *Fraxinus excelsior*" and "91F0 Riparian mixed forests of *Quercus robur, Ulmus laevis* and *Ulmus minor,*

Fraxinus excelsior or *Fraxinus angustifolia*, along the great rivers (Ulmenion minoris)" are the main protective goods (see Figure 26 in the appendix).

Since the establishment of the national park, the management has been orientated towards the visionary model of the Danube floodplains before the first major regulations (Bachinger, 2022). Taking into account flood protection, unhindered navigation and the preservation of the groundwater body for drinking water supply, attempts are made to approach this vision with revitalisation projects such as riverbank restoration and side branch reconnection (Bachinger, 2022). The Donau-Auen National Park has committed itself to the following general guidelines for natural area management:

- preserving the free-flowing section of the Danube – free development for river morphological processes with periodical floodings and changing groundwater levels
- protection of natural processes – no use of forestry and hunting
- all wild animals are equal – natural behaviour and full life cycle
- special responsibility for endangered species and their habitats (Nationalpark Donau-Auen GmbH, 2019).

1.3.3. Incision of the Danube River

Consequences of the Danube regulation

The Danube regulations have fully achieved their desired purposes (Starmühlner et al., 1972). The riverbed stopped relocating, transportation on water and land improved, the danger of flooding was eliminated, many square kilometres of dry land were created, and the city of Vienna could expand next to the river (Starmühlner et al., 1972). However, the results for the natural landscape are severe (Starmühlner et al., 1972). Aside from the loss of natural banks (Haubenberger & Weidinger, 1990), numerous side branches were cut off, and the course of the Danube was shortened, increasing the gradient and flow velocity, resulting in a deepening of the riverbed and a lowering of the groundwater level (Klasz, 2011; Starmühlner et al., 1972).

The regulation-induced changes primarily manifested in:

- strong reduction of aquatic habitats
- reduction of the hydrological connectivity between the river and the floodplain
- stabilization of former dynamic habitat (Hohensinner & Jungwirth, 2009).

The deepening of the Danube for the first half of the 20th century (1893/97 to 1942) is indicated with 20 cm to 30 cm for the eastern area of the national park (Klasz, 2011). More detailed data is available for the period from 1949 to 1970, with the level in Orth/ Donau dropping by 0.4 cm/a and in Wildungsmauer by 1.1 cm/a (Klasz, 2011). From 1979 to 1996, the average rate of deepening increased, and the water level dropped in Orth/ Donau by 1.7 cm/a and in Wildungsmauer by 2.0 cm/a (Klasz, 2011).

Furthermore, a reinforcing feedback effect can be observed, leading to an increase of corridor distance and hence drier site conditions for the surrounding floodplain (Klasz, 2011). The deepening of the main channel combined with rapid sediment deposits and vegetation development in the foreland and side branches forces the discharge in phases of higher water level to further concentrate in the main river channel, which fuels the deepening further (Hohensinner & Jungwirth, 2009; Klasz, 2011).

Another negative effect is that side branches that were fed by inflowing Danube water before the regulation are now more often only replenished by rising groundwater (Starmühlner et al., 1972). The rising groundwater hardly brings in any nutrients compared to the sediment-rich Danube water (Starmühlner et al., 1972). When the groundwater level drops, it leads to a release of minerals, which depletes the nutrient supply further (Starmühlner et al., 1972).

Consequences of hydropower plants

Due to the damming of the river by hydropower plants, the bedload transport is drastically reduced (Klasz, 2011). Remaining bedload settles in the reservoir before the hydropower plant, strong erosion occurs afterwards, unless the downstream section itself is dammed up again (Klasz, 2011). In the past, the expansion of uninterrupted barrage chains was therefore intended (Klasz, 2011). The formally free flowing river becomes a chain of impoundments (Wendelberger, 1975).

When building a hydropower plant, the groundwater body is separated from the river by the surrounding dams and sealing walls (Wendelberger, 1975). Due to the elevation of the water level, water backs up into the surrounding floodplain upstream, and low-lying sites are permanently flooded (Wendelberger, 1975). The water level within the barrages usually has to be kept very constant so that they can hardly hold any excess water, as the neighbouring alluvial forest is missing as a retention area, the situation during flood events often worsens (Weber, 1973).

For the Danube east of Vienna, the long-term average bedload transport capacity is considered to be between 300 000 and 400 000 m^3/a (Klasz, 2011). With the construction of the hydropower plant Freudenau, underwater protection was prescribed by water law in the form of normal bedload addition (Klasz, 2002). The mandatory volume of added bedload is 180 000 m^3/a, which compensates missing beadload due to the barrage but not the deepening itself (Klasz, 2002).

Since the partial start-up of the hydropower plant Freudenau in 1996 until 2020, a morphologically induced lowering of the mean water level of 40 to 50 cm has been determined for the middle section of the national park (Fischamend to Wildungsmauer) (Klasz, 2026). The rate of change for the mean water level in the same section and over the same period of time is a decrease of 1.7 cm/a (Klasz, 2026). For the entire section from Vienna to Stopfenreuth, the annual groundwater averages decreased by 2.5 to 3.5 cm/a for the period in question (Klasz, 2026).

In the years 2010 to 2020, riverbed erosion could be slowed down, but the effect is still difficult to estimate at present (Klasz, 2024). The gravel body under the riverbed is only a few meters thick, underneath it are fine-grained, mostly less erosion-protected fine clastic like sands and silt (Klasz, 2024). If the erosion of the riverbed progresses, a breakthrough of the riverbed is to be expected, which would have devastating consequences for navigation, drinking water supply, the ecology of the region and the areas further downstream due to increased sedimentation (Klasz, 2024).

Three major challenges that interfere with each other can therefore be seen for the region:

- The Danube as an international waterway must have a guaranteed minimum depth at regulation low water level
- Riverbed erosion due to a lack of bed load and the straightening of the riverbed must be terminated
- The unfolding of natural processes within the Donau-Auen National Park must be guaranteed (Klasz et al., 2009).

1.3.4. Damming of the floodplain

Another part of the Danube regulation programmes was the building of a dike system, which additionally and in other ways affected the region (Starmühlner et al., 1972). The dike was constructed as an earth core with excavated gravel on top to create the necessary watertightness (Waldheim, 1904). The flood protection dam on the left side of the Danube divides the floodplain into three areas: a dammed, a backwater and a flooded or open one (Haubenberger & Weidinger,

1990; Jelem, 1974). The dammed floodplain is disconnected from the dynamics of the river, the backwater area is slowly flooded at high water levels by water backing up (Haubenberger & Weidinger, 1990). The open floodplain is occasionally flooded, and the groundwater aquifer is directly connected to the water level of the river (Haubenberger & Weidinger, 1990).

In 1990 a study was published comparing the alluvial forest of the Lobau, which had been dammed almost 100 years earlier, with that of the Poigen Au, which is more closely connected to the dynamics of the river (Haubenberger & Weidinger, 1990). The results of the study lead to a rethink in alluvial forest ecology, as it became more and more clear that it is not high groundwater levels but rather the interplay of changing groundwater levels and, above all, regular flood events that it takes for the persistence of a floodplain (Brunner & Schneider, 2005). Hence, the damming deprives the floodplain of its decisive factors (Wendelberger, 1961). Furthermore, it restricts erosion and sedimentation processes into the area between the dams and reduces the connectivity between the river and its side branches (Haubenberger & Weidinger, 1990). By enclosing the river with dams, retention areas are lost, which can worsen the situation at high water levels due to an increase in runoff volume and velocity, as well as the peak height of the flood (Dister, 1983).

Consequences for the groundwater

The damming of the floodplain reduces groundwater fluctuations both in terms of height and time (Haubenberger & Weidinger, 1990). In the flooded parts, the soil dries out considerably more during low water (Haubenberger & Weidinger, 1990). The groundwater level in large parts of the dammed floodplain forest is located in the gravel body of the soil, the water conditions there are either saturated or dry, and hardly any capillary forces prevail so that water cannot rise to higher layers (Haubenberger & Weidinger, 1990).

Consequences for the soil

The absence of flooding in the dammed areas led to a different development of the soil, which matures and browns more quickly, the development of the soil can therefore be considerably different from the tree stand (Jelem, 1974). The soil of the flooded area has significantly higher total carbon and nitrogen stocks, a higher clay content, and the litter conversion is better than in the dammed floodplain (Haubenberger & Weidinger, 1990).

The pronounced fluctuation of the groundwater level in the open floodplain leads to a constantly changing aeration of the soil (‘lung effect’) in the dammed floodplain, the effect is less distinct, and the soil is therefore less well aerated (Haubenberger & Weidinger, 1990).

Consequences for side branches

Due to the damming of the floodplain, the side branches “run out” to the level of the downstream ford and drag the groundwater level with them (Haubenberger & Weidinger, 1990). Furthermore, colmatation (sealing) of the side branches occurs due to the input of clay and silt and the lack of mechanical action of rapidly inflowing water masses (Haubenberger & Weidinger, 1990). This results in further disconnection of the side branches and the groundwater (Haubenberger & Weidinger, 1990).

Consequences for succession

In the dammed floodplain, more herbaceous plants develop, which suppress the germination of willows and poplar trees (Haubenberger & Weidinger, 1990). The next step in succession is the development of a shrub-rich undergrowth, which does not occur in the open floodplain due to its sensitivity to flooding (Haubenberger & Weidinger, 1990). Once these shrubby stands reach their natural age of 40 – 60 years and break down, hardwood alluvial forest tree species such as ash and oak germinate (Haubenberger & Weidinger, 1990).

1.3.5. Natural habitats

The following paragraphs describe typical floodplain habitats, which form the transition of the main river to the adjacent habitats that are no longer influenced by it, for the floodplains east of Vienna. Water bodies in floodplains include all standing waters created by the dynamic of the river as well as all water bodies caused by groundwater and precipitation (Gepp et al., 1985). The water bodies within the floodplain usually change significantly over time (Dister, 1985). At low water levels, side branches are only partly flown through, and water bodies further apart from the main stream act as isolated ecosystems (Dister, 1985). As water levels rises, the conditions change, and more and more side branches, oxbow lakes and ditches are flown through, creating a connected water body system (Dister, 1985). This results in a large variance of abiotic factors that allow a high diversity of aquatic habitats and organisms (Dister, 1985). The duration, season and frequency of flooding are decisive for the development of plant communities in the floodplain (Dister, 1985; Starmühlner et al., 1972). An important boundary is between the mineralised riverbed (no vegetation) and the lowest permanently vegetated area (Starmühlner et al., 1972). The boundary lies about 30 cm above the mean water level, the area below is on average submerged for 140 days a year (Starmühlner et al., 1972). The natural vegetation was categorised in multiple ways Starmühlner et al., (1972) differentiates initial, successional and final communities (see Figure 2) while Jelem, (1974) divides the habitats into hardwood and softwood forests as well as hotlands.

The softwood forest describes the area of the alluvial forest in which more or less exclusively softwood tree species occur (Jelem, 1974). The area is close to the main stream and is frequently flooded over longer periods of time (Jelem, 1974; Schönborn & Risse-Buhl, 2013), therefore, a herb layer might be sparse (Dister, 1988). The water velocity through this part of the floodplain is rather strong (Schönborn & Risse-Buhl, 2013) and the soils are young and immature (Jelem, 1974). The seeds of *Salix sp.* and *Populus sp.*, which are typical softwood tree species, have good flight abilities and can only germinate for a relatively short period of time (Haubenberger & Weidinger, 1990). They require open, less mature soils to germinate and are therefore optimally adapted to natural alluvial systems (raw soil germinators) (Haubenberger & Weidinger, 1990). Most of the below-described initial and successional communities are a type of softwood forest.

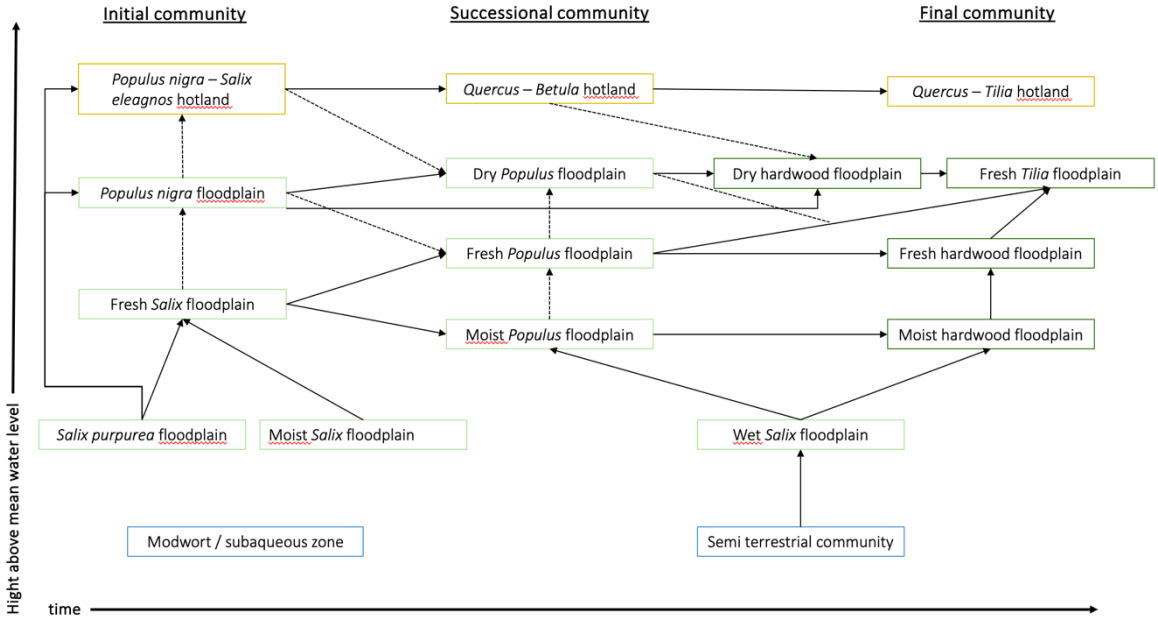


Figure 2 – Floodplain vegetation classification schema according to Starmühlner et al., (1972) (freely translated). The colour of the frame indicates the community assignment: light green – softwood, dark green – hardwood, yellow – hotland, blue – aquatic and semiaquatic communities.

The initial communities are located next to flowing water on dynamic riverbanks, newly created sites and islands (Lazowski, 1997). A prerequisite for colonisation is that the area is not covered by water for a longer period of time, for which a pronounced low-water period may be sufficient (Lazowski, 1997). Woody plants only become established when the site is above the mean water line for a large part of the vegetation period (Lazowski, 1997). Depending on the substrate, different plant communities develop, which are often dominated by one or a few species (Lazowski, 1997). Typical herbaceous species are *Phalaris arundinacea* and *Agrostis stolonifera* (Lazowski, 1997).

The primary stages (*Salix purpurea* floodplain and Moist *Salix* floodplain) establish directly on riverbanks (Jelem, 1974). *Salix purpurea* can root through coarse gravel and act as a sediment trap, preparing the site for *Salix alba* (Lazowski, 1997). The fresh *Salix* floodplain establishes on sandy banks in areas protected from the current (Jelem, 1974). The immature soil is very fresh and well supplied with nutrients (Jelem, 1974). In addition to *Salix alba*, other light-loving raw soil seedlings germinate (Jelem, 1974). The *Populus nigra* floodplain establishes on dry sites close to the current (Jelem, 1974). These can be found on high embankments made of gravel or sand, which *Populus nigra* can root through to satisfy its water requirements via the groundwater (Lazowski, 1997). These initial communities are at most as old as their main trees (approximately 100 years) (Lazowski, 1997).

The successional communities are located further apart from the main channel, flooding usually occurs as a result of backwatering along the side branches so that sedimentation progresses slowly (Lazowski, 1997). The fluctuation of the groundwater lags behind those of the stream in height and time (Lazowski, 1997). These communities require 500 to 1000 years to become a hardwood forest (Lazowski, 1997).

The wet *Salix* floodplain often inhabits the transitional areas between relict channels and the neighbouring alluvial forest (Lazowski, 1997). In the siltation zone, there are sparse stands of *Salix alba* between reed belts or large sedge reeds (Lazowski, 1997). As the siltation of the watercourse progresses, the moist *Populus* floodplain comes into play (Jelem, 1974). *Populus alba* colonises the silted-up watercourses through root sprouts, a sparse shrub layer of *Cornus sanguinea* can be established (Jelem, 1974). The soil is loamy and poor in air with a high groundwater level (Jelem, 1974). According to theory, the moist *Populus* floodplain is flooded for more than 8 days within every 2 years, while the fresh *Populus* floodplain is flooded for less than 8 days every 2 years (Starmühlner et al., 1972). Furthermore, the fresh *Populus* floodplain establishes on aggradations that have repeatedly been covered by sediments, therefore, the soil is fresh and well aerated (Jelem, 1974). In addition to *Populus alba* and *Populus nigra, Ulmus laevis, Prunus padus, Fraxinus excelsior* and *Alnus incana* can be found (Jelem, 1974). The dry *Populus* floodplain develops on thick sand deposits (more than 40 cm), on embankments that are well above the mean water level (> 3 m) or on gravel-underlain sites (Jelem, 1974). A sparse forest develops with *Populus nigra* as the main tree species, in the shrub layer, *Crataegus monogyna* achieves high cover values, light-loving grasses can be found in the undergrowth, but also trees of later successional stages, such as *Quercus robur, Ulmus minor* and *Tilia cordata*, can occur (Jelem, 1974).

In the hardwood forest many hardwood tree species can be found (Jelem, 1974). The area is located further away from the stream and is therefore flooded less frequently and with lower flow velocities

(Jelem, 1974; Schönborn & Risse-Buhl, 2013). On average, the areas are flooded every few years, but due to the basin location, the water often remains for a long time (Lazowski, 1997). The influence of groundwater is relevant for the existence of a hardwood floodplain forest, if the influence decreases and climatic influences become more important, the edge of the floodplain is reached (Lazowski, 1997). The soils are mature, and few hydromorphological dynamics can be observed (Jelem, 1974). A highly productive, multi-layered, species-rich deciduous forest develops (Dister, 1988).

The moist hardwood floodplain is considered a further developmental stage of siltation and accordingly colonises depressions and ditches (Jelem, 1974). The soil is moist, compact and poor in air (Jelem, 1974). In addition to *Populus alba, Ulmus minor* is occupying the site. The fresh hardwood floodplain lies higher than the moist hardwood floodplain (Jelem, 1974). *Quercus robur, Fraxinus excelsior* as well as *Ulmus sp.* establish themselves on the deep soil (Jelem, 1974) while *Populus sp.* and *Salix sp.* species are absent (Lazowski, 1997). Multiple shrubs and herbaceous species can be found, and geophytes such as *Allium ursinum* and *Galanthus nivalis* are present (Lazowski, 1997). The dry hardwood floodplain is found on gravel-bedded or coarse sandy soils (Jelem, 1974). The areas are high, far from the river and often close to hotlands (Jelem, 1974). Typical tree species are *Ulmus minor, Quercus robur* and *Fraxinus excelsior* (Jelem, 1974). This plant community is rare in the Danube floodplains east of Vienna (Jelem, 1974). The fresh *Tilia* – floodplain colonises the highest parts of the alluvial forest, such as former embankments (Jelem, 1974). The soils are light to loamy sands, the groundwater is beyond the reach of the tree roots (Jelem, 1974). The areas are flooded for 5 days every 5 to 10 years (Starmühlner et al., 1972), creating the transition to the habitats outside the floodplain forest (Jelem, 1974).

Hotlands are natural dry habitats within the floodplain ecosystem (Starmühlner et al., 1972). They occur when elevated gravel deposits are only slightly sanded over, resulting in a shallow upper soil layer (Jelem, 1974). Due to the low water-holding capacity of the shallow soil, a closed forest cannot evolve (Lazowski, 1997). Hotlands encompass a wide spectrum of habitats from the border of the floodplain forest to dry scrub- and grassland (Starmühlner et al., 1972). Next to the floodplain forest sites with relatively deep soils are dominated by a dense shrub layer and single overgrown trees (*Quercus robur, Populus nigra, Populus alba*) (Starmühlner et al., 1972). As the soil becomes more shallow, the prevalence of shrubs and trees is decreasing, and steppe grasses and herbs become more dominant (Starmühlner et al., 1972). On the extreme sites, a sparse, dry grassland or even a pioneer vegetation out of mosses and lichens can be found (Starmühlner et al., 1972). Aside from the soil depths and the according vegetation, a distinction can be made between primary and secondary hotlands (Wendelberger, 1975). While primary hotlands can be found on natural

elevated gravel deposits, secondary hotlands (also known as potential/ latent or concealed hotlands) are created by human activity due to falling groundwater levels (Wendelberger, 1975).

1.4. Plant sociology

1.4.1. Plant sociology and syntaxonomy

Biotic communities in nature represent a continuum, nevertheless, boundaries can often be drawn between different vegetation units (Kadereit, 2014). Plant sociology is the study of plant communities (Braun-Blanquet, 1951), which are abstract vegetation units, like a 'type' (Willner & Grabherr, 2007). Syntaxonomy is the science of describing, comparing and classifying plant communities (Willner & Grabherr, 2007). Braun-Blanquet's syntaxonomy (Braun-Blanquet, 1951) is not based on a general theory of vegetation but merely describes what can be found in nature (Willner & Grabherr, 2007).

The standard method for describing a vegetation stand is the vegetation survey (relevé, phytosociological record, record), which is a random sample enabling statistical comparisons (Willner & Grabherr, 2007). A vegetation survey is carried out as all plants of a predefined area are identified and noted down (Schaefer, 2012). The form and size of the vegetation survey depend on the habitat and the specific question raised, 100 m² for example, would be a typical size if the change in species composition is to be documented (Traxler, 1997). Most of the time four main vegetation layers are distinguished: tree, shrub, herb and moss layer (Braun-Blanquet, 1951). The species of a vegetation survey can be described by their frequency (number of occurrence) or cover values (proportion of ground area covered in vertical projection) (Willner & Grabherr, 2007). Abundance (German: "Artmächtigkeit") is a combination of frequency and cover values which is usually given in the ordinal scale developed by Braun-Blanquet ("abundance-dominance scale", see Table 5) (Willner & Grabherr, 2007). The result of a vegetation survey is therefore a tabular list of species displaying their stratification and abundance in a specific area (Schaefer, 2012).

In syntaxonomy, vegetation surveys are compared and classified according to their similarity, those unities are used as a basis for the establishment of plant communities (Adler & Fischer, 1994). The association (German: "Assoziation") is a floristically, ecologically and geographically individualised vegetation unit, comparable to a species in phylogenetics (Braun-Blanquet, 1951). Similar associations are grouped to form an alliance (German: "Verband"), similar alliances are grouped to form an order (German: "Ordnung") and similar orders are grouped as a class (German: "Klasse") (Braun-Blanquet, 1951). The naming of a syntaxon (plural: "syntaxa", abstract vegetation unit of any

rank) follows complex rules, important for the general understanding is that the endings of the name indicate the respective rank (Barkman et al., 1976).

Individual associations are determined by their overall species composition and their character species (German: “Charakterarten”), which have their main distribution range within the particular syntaxon (Braun-Blanquet, 1951). Differential species (German: “Differenzialarten”) do not have their main distribution range within the particular syntaxon, however, they make it possible to distinguish between two or more closely related associations (Braun-Blanquet, 1951). Another important parameter is the consistency (German: “Stetigkeit”) describing how often a species occurs in the individual records of an association (Braun-Blanquet, 1951). The social fidelity (German: “Treue”) is a measure of how closely a species is bound to an association or, in other words, how limited its occurrence is to the association (Braun-Blanquet, 1951).

1.4.2. Indicator values

In 1950, Heinz Ellenberg first proposed a nine-level numerical scale that describes the conditions under which a species occurs in nature (Karrer, 2024). The realised niche of a species is described on the basis of seven so-called indicator values, which are displayed in Table 1 (Karrer, 2024).

Table 1 – Overview of the seven indicator values as described by Karrer, (2024) (freely translated)

INDICATOR VALUE FOR …	PLANT IS INDICATING …		PLANT IS INDICATING …
LIGHT	deep shade tolerance	1 – 9	full light tolerance
TEMPERATURE	cold tolerance	1 – 9	extreme heath tolerance
CONTINENTALITY	euoceanic conditions	1 – 9	eucontinental conditions
MOISTURE	strong drought tolerance	1 – 9	wet tolerance 1)
REACTIVITY	strong acid tolerance	1 – 9	alkaline and lime tolerance
NUTRIENTS	extreme lean tolerance	1 – 9	extreme nutrient tolerance
SALINITY	non-saline tolerance	0 – 9	euhaline till hypersaline tolerance

1) additionally: 10 = indicator plant for alternating water (plants can survive a short period with the ground not being covered by water), 11 = aquatic plant that forms roots underwater, leaves are at least occasionally above the water surface or plant that leaves float on the water surface, 12 = fully submerged plant

Indicator values allow conducting statements about long-term environmental conditions and especially conditions of critical periods for plant persistence (Diekmann, 2003). They refer to the ecological optimum (site conditions under the competitive conditions prevailing under natural vegetation) and reflect the effects of a complex of parameters (Böcker et al., 1983). A common approach using indicator values is to calculate weighted averages of all plants present in a or multiple vegetation surveys and to compare them with another dataset (such as historic vegetation surveys) (Diekmann, 2003). Selected plots should be as homogeneous as possible, and it should be

kept in mind that human influence may distort the competitive relationship between species (Diekmann, 2003). Indicator values were criticised because they were mainly derived from field experiments and not from systematic measurements, furthermore the response of a species might shift over its lifetime or geographical range (Diekmann, 2003). Despite the points of criticism, the use of indicator values for the ecological characterisation of an area, is undisputed and enables a high degree of reliability, especially when it comes to monitoring environmental changes (Böcker et al., 1983; Diekmann, 2003; Englisch & Karrer, 2001).

1.5. Research Question

As a data basis for the present work the diploma thesis "Vegetation und Bestandesaufbau einer Versuchsfläche in den Donau-Auen bei Eckartsau" by Fraissl (1993) was used. The thesis deals with describing the stand structure and the floral composition of a ~1 km² big area located in the Donau-Auen National Park between Orth/Donau and Eckartsau. The floral composition was depicted by 90 vegetation surveys carried out in 1987 and 1988. The present work has repeated the vegetation surveys 35 years later, in 2023 to be able to carry out a comparison.

With the described data basis, this thesis aims to contribute to the general question posed at the beginning: "Does the floodplain habitats change over time?". This question resulted in the following research questions:

1) Has the vegetation and therefore the habitats of the floodplain changed in the study site between 1987/1988 and 2023?
    a. Did the overall indicator values and therefore the conditions change?
    b. Did the overall species composition change?
    c. Did changes in species composition and indicator values differ between the three habitat types (aquatic, open land, woodland)?
2) Records show that the average groundwater level has fallen in the area of the study site by around 50 to 60 cm between 1987/1988 and 2023. Can vegetation changes be linked to the decline in groundwater level?
    a. Do current indicator values and their change during the last 35 years depend on the elevation of the plots and therefore the distance to the groundwater level?

If a change in the species composition can be detected, the indicator values might help to identify the reasons for this change. Any of the indicator values might have shifted, however, especially moisture would be conceivable if the declining groundwater level is causally involved. Furthermore, if the falling groundwater level is the main reason for the observed change, the elevation of the plots and therefore the distance to the groundwater level should be correlated with changes. Overall it would be conceivable that lower-lying habitats, which probably include aquatic habitats, ditches and low-lying woodland plots, would be affected more strongly than higher-lying habitats. If the species composition changes, the indicator value for moisture decreases, and the intensity of the change correlates with the elevation of the plots, it can be assumed that the declining groundwater level plays a decisive role.

If the vegetation of the observed habitats did not change, one can assume that the falling groundwater level is not affecting it. This could be interpreted in the way that the connection to the groundwater is still sufficient and that the species composition is not (yet) altered by it. Furthermore, this observation would lead to the conclusion that no other forces have been causing a change in the species composition.

2. Methods

2.1. Study site

In 1987 and 1988 Christian Fraissl carried out 90 vegetation surveys and 11 stock structure analyses which he published in his diploma thesis “Vegetation und Bestandesaufbau einer Versuchsfläche in den Donau-Auen bei Eckartsau” (Fraissl, 1993). The study site is roughly 1 km² and located in the Donau-Auen National Park between Orth/Donau and Eckartsau (see Figure 3 for an overview of the region (basemap.at, 2026)). Forestry and fishery were abandoned in 1973, long before the national park was established, as the area was used for scientific purposes (Fraissl, 1993). A former meadow was abandoned to observe natural succession (“Dirdlwiese”) and attempts have been made to reintroduce the beaver (Fraissl, 1993). The area is limited by agricultural land in the north and by the Danube with fixed banks and a towpath in the south. Floodplain forest borders the area to the east and west. From east to west, the Marchfeldschutzdamm, as a big dike is dividing the area. Therefore, the northern part is not flooded, while the southern part is flooded at higher water levels. The forestry areas are part of the “nature zone”, while the meadows are part of the “nature zone with management”.



Figure 3 – Location of the study site in the Donau-Auen National Park between Orth/ Donau and Eckartsau, indicated with a red square. Base layer: (basemap.at, 2026) map created by Valerie Christ, May 2026.

According to the EU Habitats Directive, the majority of the forest within the study site is considered type 91F0 (Riparian mixed forests of *Quercus robur, Ulmus laevis* and *Ulmus minor, Fraxinus excelsior* or *Fraxinus angustifolia*, along the great rivers (Ulmenion minoris)) while some smaller areas south of the dike next to the old side branch of the Danube river and next to the main channel are considered type 91E0* (Alluvial forests with *Alnus glutinosa* and *Fraxinus excelsior* (Alno-Padion, Alnion incanae, Salicion albae). The meadows are either considered type 6510 (Lowland hay meadows (*Alopecurus pratensis, Sanguisorba officinalis*)) or type 6210 (Semi-natural dry grasslands

and scrubland facies on calcareous substrates (Festuco-Brometalia) (*important orchid sites)). The Fadenbach an old side branch, which was formerly permanently water-bearing, is nowadays only temporarily water-bearing (Schwarz, 1989). The according habitats are considered type 3150 (Natural eutrophic lakes with Magnopotamion or Hydrocharition-type vegetation). Figure 26 in the appendix gives an overview of the Natura 2000 habitat types in the observed region.

Christian Fraissl selected the locations of vegetation surveys according to the following aspects:

- representative for the habitat,
- representative for the succession stage,
- homogeneous in terms of location, morphology and floristic aspects,
- covering a certain minimum size (Fraissl, 1993).

He conducted 90 vegetation surveys describing eight aquatic, 14 open land (ditches with reeds, sedges, tall herbaceous vegetation and meadows) and 68 woodland plots (Fraissl, 1993). Figure 30 displays the map published by Christian Fraissl, Figure 31 displays an aerial image of the same area (basemap.at, 2026). Figure 32 shows a relative elevation model in relation to the mean water level of the Danube in 2010 (Land Niederösterreich & Nationalpark Donau-Auen GmbH, 2015).

2.1.1. Groundwater

Groundwater measurements for the region taken from (Bundesministerium für Land- und Forstwirtschaft, Klima- und Umweltschutz, Region und Wasserwirtschaft, 2025) show a clear trend of falling groundwater levels. Figure 4 displays the monthly groundwater averages for six groundwater observation wells, while Figure 5 displays the location of the wells on a map. The wells are located upstream and downstream of the study site as well as in the north and in the south of the dike separating the study site. Measurements date back until 1939, in the 1980s the network of groundwater observation wells became denser.



Figure 5 – Overview of the groundwater observation wells (symbols and coloured identification numbers) and water bodies (blue lines) around the study site (red square). Screenshot taken from https://ehyd.gv.at (Dezember, 2025) additional information (red square and identification numbers) added by Valerie Christ, Dezember 2025.

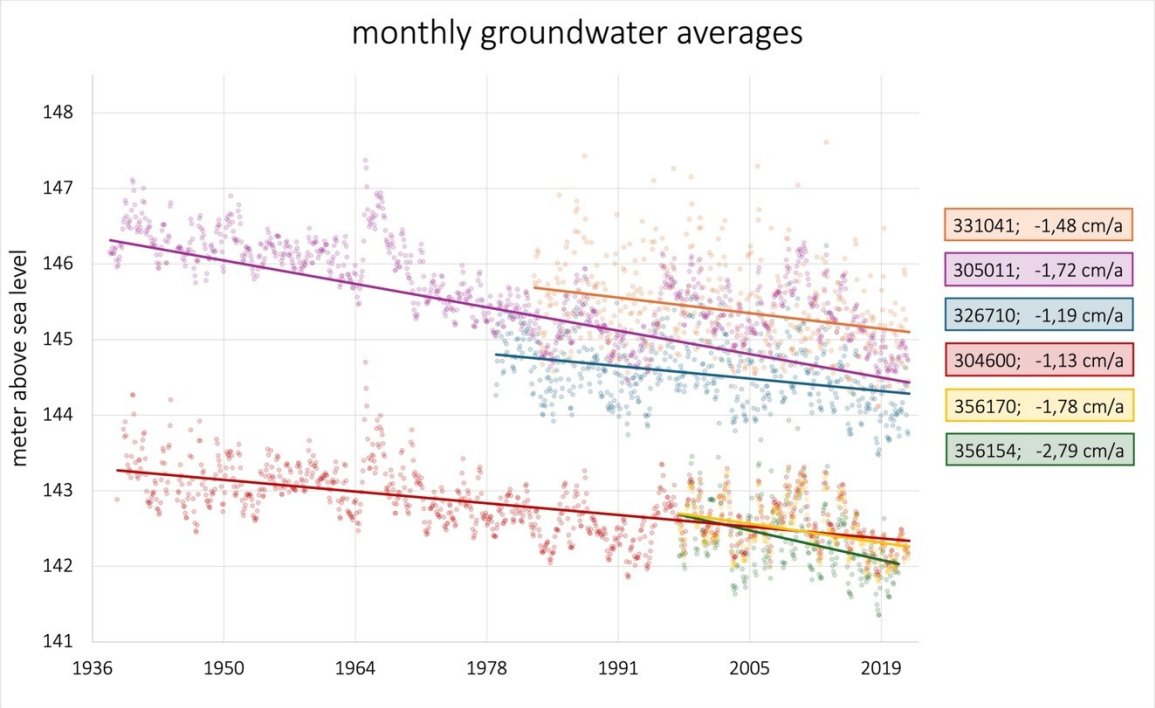


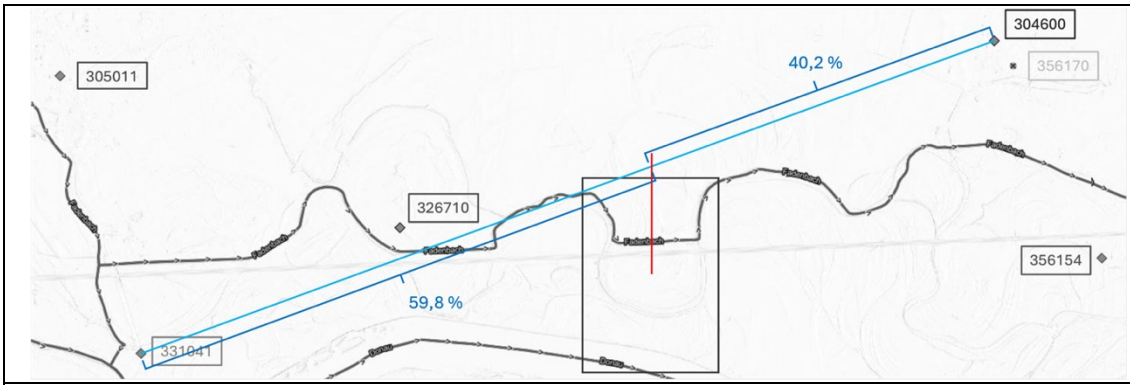
Figure 4 – Every dot is representing a monthly average groundwater level of a groundwater observation well (data taken from https://ehyd.gv.at). Linear trend lines were created. In the legend the number of the groundwater wells and the according slope values can be found.

According to Klasz, (2011, 2024) a reduction of the average groundwater level of 1.7 to 1.85 cm/a can be assumed from 1987 up to 1996 (partial start-up of the hydropower plant Freudenau) and an additional loss of 1.5 cm/a up to 2020. This results in an approximated overall drop of the groundwater level by 51.1 to 59.0 cm (1987 – 1996: 8 x 1.7 cm – 10 x 1.85 cm = 13.6 – 18.5 cm; 1996 – 2023: 25 x 1.5 cm – 27 x 1.5 cm = 37.5 – 40.5 cm) for the study site.

The groundwater level in the study site can be approximated by calculations (see Table 2). Therefore, one well upstream and one well downstream of the study site are graphically linked by

a line. Then a line is drawn from the centre of the study site north until it intersects with the line connecting the two wells. Now the distance between the groundwater observation wells and the study site can be measured, and a ratio can be calculated. As a next step the mean of the monthly averages of a year is calculated for the two groundwater observation wells. The means from the upstream and downstream wells are subtracted to obtain the difference. Based on the calculated ratio and the calculated difference, it is possible to calculate how far the groundwater level drops between the upstream well and the study site[1]. In a last step the calculated difference between the upstream well and the study site can be subtracted from the mean groundwater level of the upstream well resulting in the approximated mean groundwater level of the study site. The calculations are carried out for the years 1987/1988 and for the year 2021[2].

Table 2 – Calculation of the average groundwater level in the study site using the data from the groundwater observation wells 331041 and 304600. Including a sketch measuring the distance between the two wells and calculating the ratio of the distance between the wells and the study site.



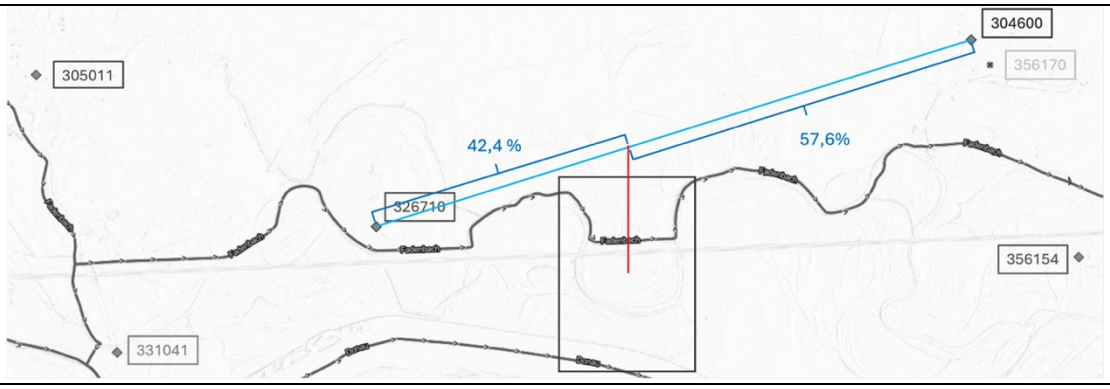
1987/1988		
Mean of the monthly groundwater averages	well 331041	145.94 m a.s.l.
	well 304600	142.72 m a.s.l.
Difference between the two wells		3.22 m
Difference between the upstream well and the study site		1.93 m
Calculated mean groundwater level in the study site		144.01 m a.s.l.
2021		
Mean of the monthly groundwater averages	well 331041	144.99 m a.s.l.
	well 304600	142.31 m a.s.l.
Difference between the two groundwater observation wells		2.68 m
Difference between the upstream measuring well and the study site		1.60 m
calculated mean groundwater level in the study site		143.39 m a.s.l.

[1] According to a groundwater layer plan it can be assumed that the groundwater level decreases evenly in the observed area.

[2] When this thesis was written, data from groundwater observation wells were only available up to 2021.

To verify the calculations, they are performed once more for two other wells (see Table 3). (The data from the wells 356170 and 356154 could not be used as they do not date back sufficiently far into the past.)

Table 3 – Calculation of the average groundwater level in the study site using the data from the groundwater observation wells 326710 and 304600. Including a sketch measuring the distance between the two wells and calculating the ratio of the distance between the wells and the study site.



1987/1988		
Mean of the monthly groundwater averages	well 326710	144.84 m a.s.l.
	well 304600	142.72 m a.s.l.
Difference between the two groundwater observation wells		2.12 m
Difference between the upstream measuring well and the		0.90 m
calculated mean groundwater level in the study site		143.94 m a.s.l.
2021		
Mean of the monthly groundwater averages	well 326710	144.11 m a.s.l.
	well 304600	142.31 m a.s.l.
Difference between the two groundwater observation wells		1.80 m
Difference between the upstream measuring well and the		0.76 m
calculated mean groundwater level in the study site		143.35 m a.s.l.

It appears that the groundwater in the study site was around 144 m a.s.l. in 1987/1988 and around 143.4 m a.s.l. in 2021. This results in a decrease of around 60 cm, which fits well with the above-described calculations by (Klasz, 2011, 2024). These are, however approximations, and the groundwater level also varies within the study site.

Furthermore, three of the groundwater observation wells offer yearly minimum and maximum values. The difference between the yearly minimum and maximum value is the yearly amplitude (see Table 4). The groundwater observation well 331041 is relatively close to the main stream of the Danube with a comparable high yearly amplitude while, the wells 326710 and 356154 are

further away from the main stream with lower amplitudes. Furthermore, the difference between the yearly minimum/ maximum value and the yearly groundwater average can be considered. The means of these differences are the amplitude strokes (Table 4). It is apparent that the amplitude does not fluctuate equally upwards and downwards, instead, there are higher highs. The average upward amplitude stroke is therefore 1.46 m while the average downward amplitude stroke is -0.63 m.

Table 4 – Average groundwater amplitude and stroke for three groundwater observation wells.

Groundwater observation well	331041		326710		356154	
Average yearly amplitude	3.2 m		1.3 m		1.9 m	
Average amplitudes stroke	-0.85m	2.35m	-0.53m	0.77m	-0.52m	1.27m

Schöpfer, (2016) modelled in her thesis the effects of the river incision on the potential natural vegetation in the same study site. While in 1985 around 90% of the study site south of the dam was flooded during a 2-year flood event only 20% of the study site south of the dam was flooded during a 2-year flood in 2010 (Schöpfer, 2016). Additionally, in 1985 around 9.45% of area of the study site were covered by water or had a maximum of 1.5 m depth to the groundwater, in 2010 this decreased to 5.46% (Schöpfer, 2016). The areas with a depth to groundwater from 1.5 to 3.5 m decreased from 64% in 1985 to 54% in 2010 (Schöpfer, 2016). Furthermore, the areas with a depth to groundwater from 3.5 to 5 m increased from 26% to 40% of the area of the study site (Schöpfer, 2016). It can also be pointed out that special sites which are submerged made up for 0.05% of the whole area in 1985 and were completely lost in 2010 (Schöpfer, 2016).

For the sake of completeness, it should be noted that the annual precipitation has remained largely unchanged or increased slightly during the period in question (see Figure 27 in the appendix).

2.2. Data collection

Since the aim of this thesis is to compare two data sets, particular attention was paid to repeat the approached as described in “Vegetation und Bestandesaufbau einer Versuchsfläche in den Donau-Auen bei Eckartsau” by Fraissl, (1993) as accurately as possible.

2.2.1. Relocation of the plots

As a first step, the original locations of the vegetation surveys were relocated as accurate as possible. Two approaches were followed. During the fieldwork in 1987, Christian Fraissl marked the location of the plots on a map using his own steps as a measuring unit. He used intersections or other prominent features as starting points and counted his steps along a path or at a right angle to a path straight into the woodland (see Figure 28 and Figure 29 in the appendix). Together with Christian, an attempt was made to relocate the plots using this original map. In the field, it quickly became clear that many of the former paths have been abandoned and are barely recognisable today. In various cases it was impossible to determine the actual starting point. Additionally, walking on a straight line in the woodland turned out to be more difficult than expected due to fallen trees, dense shrubs and other obstacles. Another approach was needed. In the thesis an official map is included which was compiled after the fieldwork, summing up all available information and preparing a clean copy (see Figure 30 in the appendix). This map was imported as a JPG file to ArcGIS Pro, and the tool Georeference was used. After moving, scaling and rotating the picture towards the right place, additional control points were set. A Spline as well as a Projective Transformation was carried out. The locations of the plots were indicated by dots in the official map. The centre of these dots was marked manually by point features for both projected maps (see Figure 6). The points were named after the number given to the plot by Christian and according to the transformation used. The point features based on the different transformations were mostly a few meters (2 – 4 m) apart but sometimes also up to 18 – 19 meters. An ArcGIS Field Maps project was set up, including the two point feature classes as well as the two projected maps. Therefore, it was possible to use the ArcGIS Field Maps project on the phone for orientation outside in the fields. During the fieldwork the points were searched for. If the points were some distance apart, it was attempted to find the centre in between them, sometimes the surface was also taken into account. Most of the time the GPS signal was rather good, and it was possible to decide on the centre of the plot with less than 5 m of inaccuracy.

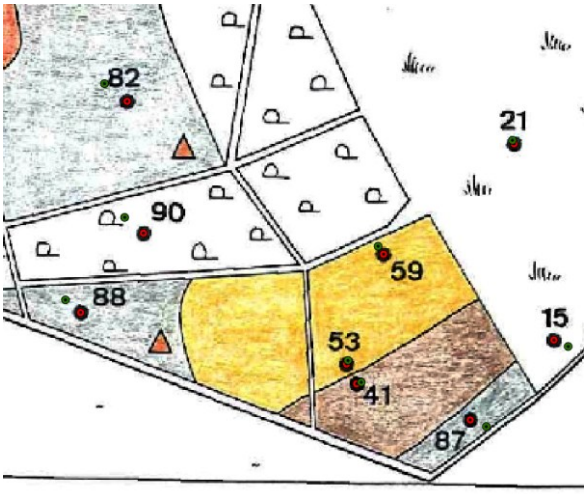


Figure 6 – Snippet of the published map (Fraissl, 1993) in a projective transformation. The red points indicate the centre of the plots in the projective transformation, while the green points indicating the centre of the same plots in the spline transformation.

2.2.2. Vegetation surveys

The recording procedure was reconstructed as accurately as possible, with the methodical information of the thesis as well as original notes and statements from Christian Fraissl. The points on the original map represented the centre of a circular area in which the vegetation surveys were carried out. The recorded area was therefore a circle. The area specification given in Christian's work refers to the hypothetical square that surrounded the circular area. A plot of 400 m^2 was therefore a circular area with a radius of 10 m (see Figure 7).

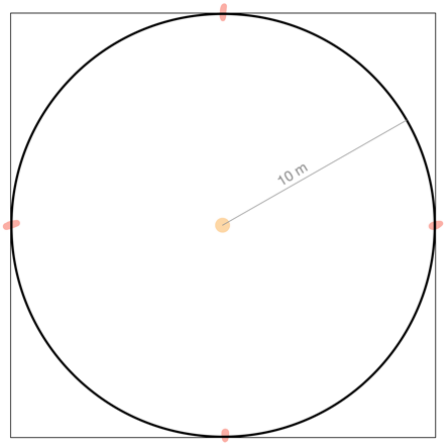


Figure 7 – Sketch of a plot: the orange dot represents the marking of the center, the red dots represent the marking of the edges. The vegetation surveys were carried out within the circular area (own image).

In the header data of the original vegetation tables found in Fraissl, (1993) the size of the plots is only given for plots outside the woodland. According to Christian Fraissl, within the woodland, a plot size of 400 m^2 was used. Further details such as “15 x 20 m” or “elongated” were found on the original recording sheets. These shapes were used, for example, to characterise ditches. All available information was collected and digitised. During fieldwork it was decided on site how to deal with additional information on plot size and shape. Most of the time when “elongated” or a specific expansion was noted, the morphology of the area made it clear where the vegetation survey was carried out and how big the original plot was. In case of doubt, a minimum and a maximum survey were carried out at the same location (see Figure 8). Figure 9 shows a plot located on a slope next to an old side branch. A minimum survey was carried out, taking the flat area at the foot of the slope into account, additionally, a maximum survey including the slope was carried out. In the appendix a table can be found listing the collected information on the location, size and shape of every plot (Table 6).

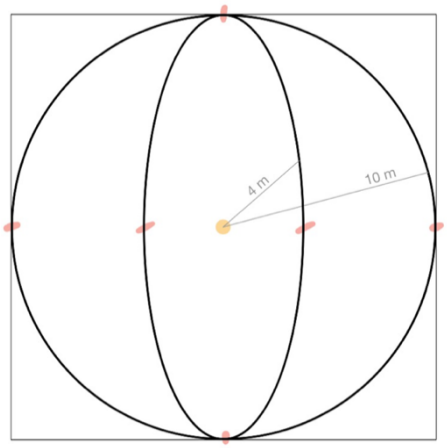


Figure 8 – Sketch of a minimum and a maximum plot. The minimum vegetation surveys were carried out within the oval area the maximum vegetation surveys were carried out within the circular area (own image).



Figure 9 – Minimum and maximum plot at a hill slope. The center of the area is marked in orange, the two outer boundaries of the minimum and maximum areas are marked in red. (own image, 13.04.2023, plot 48)

In April, plots in the woodland were visited for the first time to take record of the spring geophytes. After the plot was located, the centre was marked with spray colour on a tree or shrub if possible or a coloured stick that had been stuck into the ground. From the centre 10 m were measured with a roll-up tape into four directions to mark the outer edges of the circle. Those points were marked with red crepe tape on branches or sticks that were stuck into the ground (see Figure 10). The markings were left in place. During the second half of May, plots on meadows were observed. As the meadows are mown, sticks for marking as in Figure 10 could not remain, instead, one to two iron nails were buried in the centre of the plot. During June and July, the plots in the woodland were visited for the second time, and full vegetation surveys were carried out (all layers, all plants). For most plots the retrieval of the markings left in spring worked out well, which ensured that the same area was observed twice. Additionally, plots in or close to water bodies were visited for the first time during those two summer months.

Out of the 90 plots described in 1987/1988 89 plots could be relocated in 2023. Plot number 6 was originally described as a pond lens community on a 10 m² big plot with 45 cm of water depth. According to the map (see Figure 30) plot number 6 was located within plot number 24. In the field a wide ditch was found whose morphology did not allow any further differentiation (e.g., by means of a distinct depression). Since this ditch gets flooded when the water level is high, it seems likely

that the former depression, where the plot number 6 was located, has been silted up. Therefore, only plot number 24 was described by a vegetation survey.



Figure 10 – Left: marking of the centre of a plot on a stick; right: marking of the edge of a plot at a branch (own images taken during fieldwork in 2023)

During late autumn 2023 a RTK-GPS (see Figure 11) with an accuracy of a few centimetres was used to take accurate measurements of the plots' centres. The retrieval of the plots in the woodland worked well, and the marks were removed after the measures were taken. On the meadows a metal detector was used to retrieve the iron nails used for marking the centre. Some marks of plots located within a ditch or water body had vanished as the water level once rose significantly in the meantime. For those points that could not be accurately retrieved with the RTK-GPS, the centre point between the georeferenced points was calculated in ArcGIS Pro. The Table 6 displays the coordinates of the plot's centre as well as additional information on their accuracy.



Figure 11 – RTK-GPS with a tablet displaying the ArcGIS Field Maps project where measures were added (own image taken during fieldwork 19.12.2023.)

When a plot was located and marked, the area was walked (at least two concentric circles, one at the very outside and one between the centre and the outer edge), and all plants were noted down. The species found were identified using identification literature (Adler & Fischer, 1994; Eggenberg & Möhl, 2020; Holzner & Adler, 2013). All herbaceous plants and woody plants under 1 m in height were described in the herb layer. The shrub layer comprised all woody plants between 1 and 5 m in height, and the tree layer comprised all woody plants over 5 m in height. The total coverages of the three layers (tree, shrub, herb layer) were estimated in percentage while standing in the centre of

the plot. In order to display the species abundance, the same scale was used as by Christian Fraissl (see Table 5) (originally from (Braun-Blanquet, 1951)). Pictures of the plot were taken once round while being in the centre.

Table 5 – Abundance-dominance scale by Braun-Blanquet and the conversion used for the statistical analysis.

COVER ABUNDANCE VALUES	DESCRIPTION	CONVERSION
5	covering more than ¾ of the area, no matter how many individuals (> 75%)	87.5
4	covering ½ to ¾ of the area, no matter how many individuals (50 – 75%)	62.5
3	covering ¼ to ½ of the area, no matter how many individuals (25 – 50%)	37.5
2	covering 1/20 to ¼ of the area or plenty individuals (5 – 25%)	15.0
1	many individuals but covering less than 1/20 of the area or few individuals with high coverage (1 – 5%)	2.5
+	sparse with very low coverage (< 1%)	0.5
R	rare (1-2 individuals)	0.1

2.3. Data analysis

2.3.1. Preparation of the raw data

During the fieldwork a physical and digital herbarium (pictures) were created. The herbarium specimens were carefully identified and, in case of uncertainty, discussed with experts (Mag. Dr. Karl Hülber; Dr. Luise Schratt-Ehrendorfer; Mag. Dr. Wolfgang Willner).

The program Turboveg (Hennekens & Schaminée, 2001) with the species list for Austria was used to digitise the vegetation data provided in the thesis “Vegetation und Bestandesaufbau einer Versuchsfläche in den Donau-Auen bei Eckartsau” by Fraissl, (1993) as well as the new data collected in 2023. The data sets were exported as CSV files to serve as a data basis for further analysis.

Furthermore, the elevation was calculated for the centre points of the plots which were measured with the RTK GPS, in the program ArcGIS Pro. This was based on the relative elevation model of the Donau-Auen National Park (see Figure 32) (Land Niederösterreich & Nationalpark Donau-Auen GmbH, 2015). The elevation values are based on the mean water level referring to KWD 2010 (German: “Kennzeichnende Mittlere Wasserstände der Donau” English: “Reference water level of

the Danube" (via donau - Österreichische Wasserstraßen-Gesellschaft mbH, 2012). Elevations were calculated with in the Calculate Field tool using a short code and can be found in the Table 6.

2.3.2. Statistical analysis of the data

Within the statistical program R (R Core Team, 2024), a script was written to analyse the data. In a first step, the script is combining the spring and summer recordings of 2023. This step was necessary, as Christian Fraissl's vegetation surveys were only available as a combined record. For this purpose, the two lists were added together, and if a species occurred in both recordings, its higher cover value was valid for the final combined data set. The Braun-Blanquet abundance-dominance scale was converted by calculating the mean values of the coverage value intervals. The conversion (see Table 5) therefore orients towards the values described by Tüxen & Ellenberg, (1929) and Dierschke, (1994). The vegetation tables can be found in the appendix, see Table 7, Table 8 and Table 9.

At the beginning of the descriptive analysis, all vegetation surveys (minimum and maximum plots, as well as alternative plots) were examined. The final analyses presented in this thesis were based solely on the most likely matching plots. If minimum and maximum plots were described in 2023, the data set describing the same plot size as in 1987/1988 was used for the present analysis. If this was not possible the data of the most probable plot size was selected to the best of the authors knowledge and judgement (see Table 6).

The analysis started with adding the red list status according to Schratt-Ehrendorfer et al., (2022) and the indicator values based on Karrer, (2024) to the species data. Furthermore, three classes were formed depending on their elevation level therefore the function classIntervals (Bivand, 2025) was used together with the style jenks. Based on this framework, the data was comprehensively analysed in a descriptive manner. The most relevant results were prepared graphically and will be presented in the results section. Multiple approaches were followed: NMDSs were used to display the dissimilarities in the species composition of the plots, boxplots and scattered charts comparing the indicator values were used to make the observed change tangible.

A MDS (multidimensional scaling) is geometrically displaying points (experimental results) so that the distance between the points corresponds to the experimental dissimilarities of the points (Kruskal, 1964a). NMDS stands for Non-metric multidimensional scaling, the numerical method behind it was described by Kruskal, (1964b). The function metaMDS out of the vegan package was used, which performs a NMDS and tries to find a stable solution using several random starts

(Oksanen et al., 2025). The output is a two-dimensional scattered chart, with each point representing one plot. The points representing the individual plots were then coloured or changed into other symbols based on their affiliation with the two recording periods and three habitat types. Furthermore, the indicator values were represented by arrows in the NMDS. With that help it becomes possible to recognise patterns and differences. The adonis2 function was used to analyse the variance between the two recording periods using distance matrices (Oksanen et al., 2025). The resulting p-value indicates wheatear the two recording periods differ significantly.

Boxplots were created using the package ggplot2 (Wickham, 2016) and the geom_boxplot function. The boxplots representing average indicator values and comparing the two recording periods. Depending on the raised question different subgroups of plots were used as a database (all plots, only plots of one habitat type, only plots of a certain elevation level). The function t.test was used to conduct a paired student's t-test. As a result the according p-value states whether the boxplots of the recording periods differ significantly.

Scattered charts were created using the ggplot2 and the geom_point function (Wickham, 2016). The result is a figure with the x-axis showing the elevation, y-axis showing an indicator value and points representing the plots. Furthermore, the geom_smooth function was used with the “lm” method which applies a linear regression model (Wickham, 2016; Zurr et al., 2009) where the indicator values is modelled as a function of the elevation. The according p-value was calculated using the anova function. It describes if the influence of the elevation on the indicator value differs depending on the recording period. Furthermore, the β-value as well as the corresponding p- and r^2-values were extracted using the functions tidy or glance (r package: broom, (Robinson et al., 2024)). The β-value describes the slope while the r^2-values describes the quality of the regression model (Fahrmeir et al., 2023). The quality is analysed by a residual analysis which is using the distance between the observed y-values and the straight line produced by the linear regression model (Fahrmeir et al., 2023). The r^2-values therefore describes how well the line of the linear regression describes the according points. Additionally, the according p-value describes if the indicator value correlates with the elevation.

3. Results

3.1. Capturing changes

The total number of species as well as measures for biodiversity did not change significantly over time when comparing all plots. In 1987/ 1988, a total number of 286 species were found, while 280 species were found in 2023. The average number of species per plot did not change significantly with 41.0 species in 1987/1988 and 39.7 in 2023 (paired t-test: p = 0.369). The distribution of the species across the red list categories was analysed, see therefore Figure 33 in the appendix (Fisher Test: p = 0.514). In 1987/1988 50 species were found in the four categories “critically endangered“, “endangered“, “vulnerable“ and “near threatened“, in 2023, 42 species were found. Furthermore, 13 “neophytes“ could be observed in 1987/1988, while in 2023, 18 “neophytes” were found. The Shannon-Wiener Index, as a measure for diversity, resulted in a mean of 2.27 for 1987/1988 and a mean of 2.31 for 2023 (see Figure 34 in the appendix) (paired t-test: p = 0.484).

To investigate whether conditions changed over the last 35 years, indicator values were used. Figure 12 is confronting boxplots of five indicator values for the two recording periods. The three indicator values of moisture, light and temperature changed significantly while the indicator value of reactivity and nutrients did not. The decrease of the medians of the moisture and light indicator

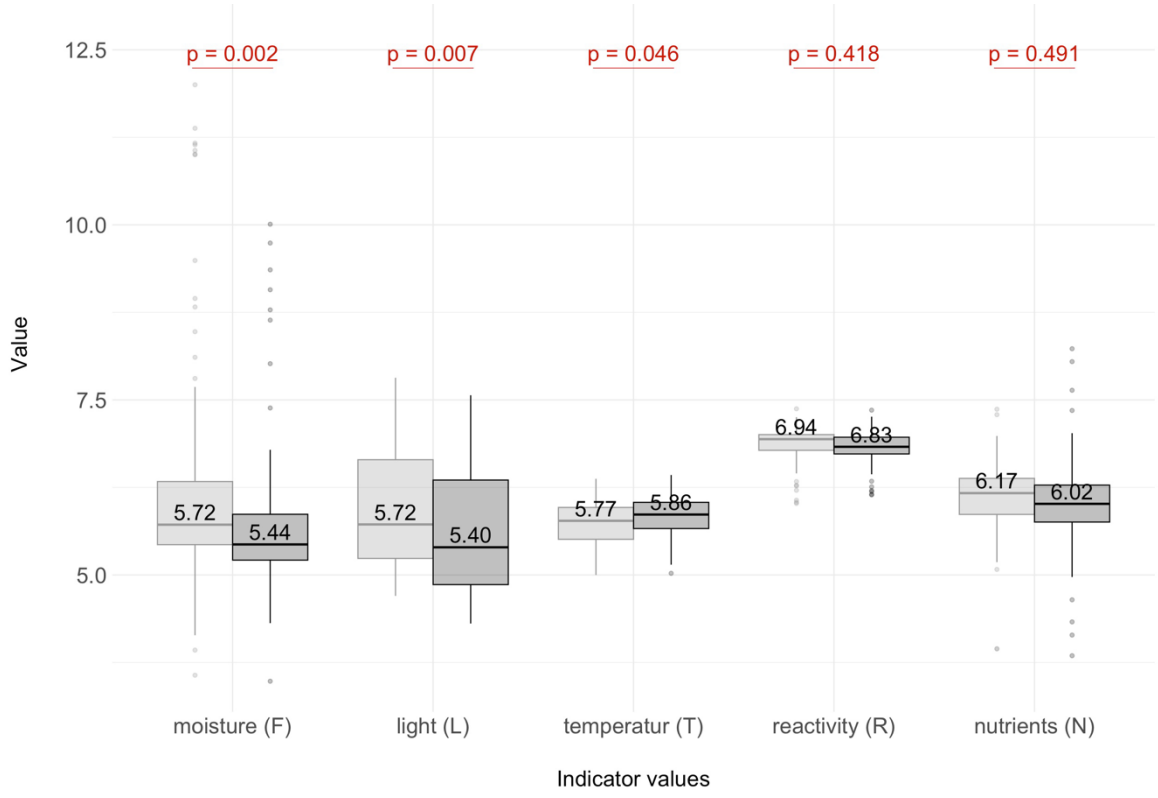


Figure 12 – Five indicator values comparing all plots between the recording periods (1987/1988 – light grey; 2023 – dark grey). Within the boxplots the median is labelled in black. The p-value in red results from a paired t-test.

value indicate that the conditions became dryer and darker. The medians of the indicator value for temperature increase stating that the conditions became warmer.

In order to further investigate whether the species composition of the plots changed over time, a Nonmetric Multidimensional Scaling (NMDS) was performed. Figure 13 displays all plots of all habitats over time. The overview panel shows that the species composition of former aquatic plots is very different from those of all other plots. The species composition of today's aquatic plots overlaps with those of open land and woodland habitats. On the first zoom-in a separation between open land and woodland plots can be seen. Furthermore, it becomes clear that the species composition of former open land plots is clearly separated from woodland plots, but those of today's open land plots is not. The second zoom-in shows that former and today's woodland plots form two hardly overlapping clusters.

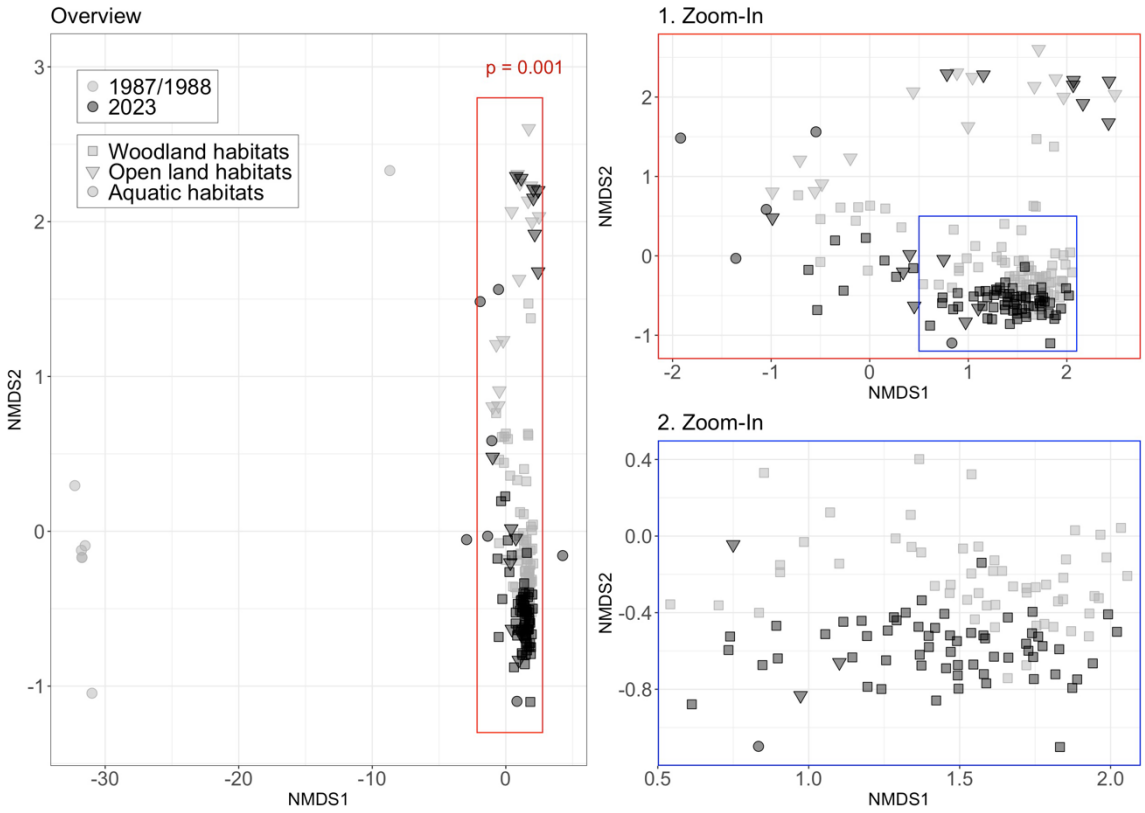


Figure 13 – NMDS for all plots (aquatic, open land and woodland habitats) for both recording periods (1987/1988 – light grey; 2023 – dark grey). On the left an overview plot, on the right two zoom-ins can be found. Permanova: p = 0.001

In order to further examine the described changes and follow the observations made within the NMDS the same procedure was conducted for the individual three habitat types: aquatic, open land, woodland.

3.1.1. Aquatic habitats

In 1987/1988 eight aquatic plots were described, seven of them could be relocated in 2023. In total 9 species were found on all aquatic plots in 1987/1988 while 57 species were found in 2023. An overview of all species assigned to the red list categories can be found in the appendix (see Figure 36; Fisher Test: p = 0. 485). In 1987/1988 on average 2.4 species were found per plot while in 2023 an average 10.7 species were found per plot, which is a significant change (wilcoxon test: p = 0.036).

Figure 14 gives the NMDS of aquatic habitat plots. Within the overview figure a graphical zoom-in (red square) can be found. The species composition of the two recent plots 1 and 4 differ strongly from all other aquatic plots (see points in the overview). In the graphical zoom-in the remaining plots are shown. The former plots tend to be located in the upper part of the zoom-in while the recent plots are located in the lower part of the zoom-in. The arrows representing the indicator values are not shown in the figure as they are located around the origin and can not be made visible without a further zoom-in.

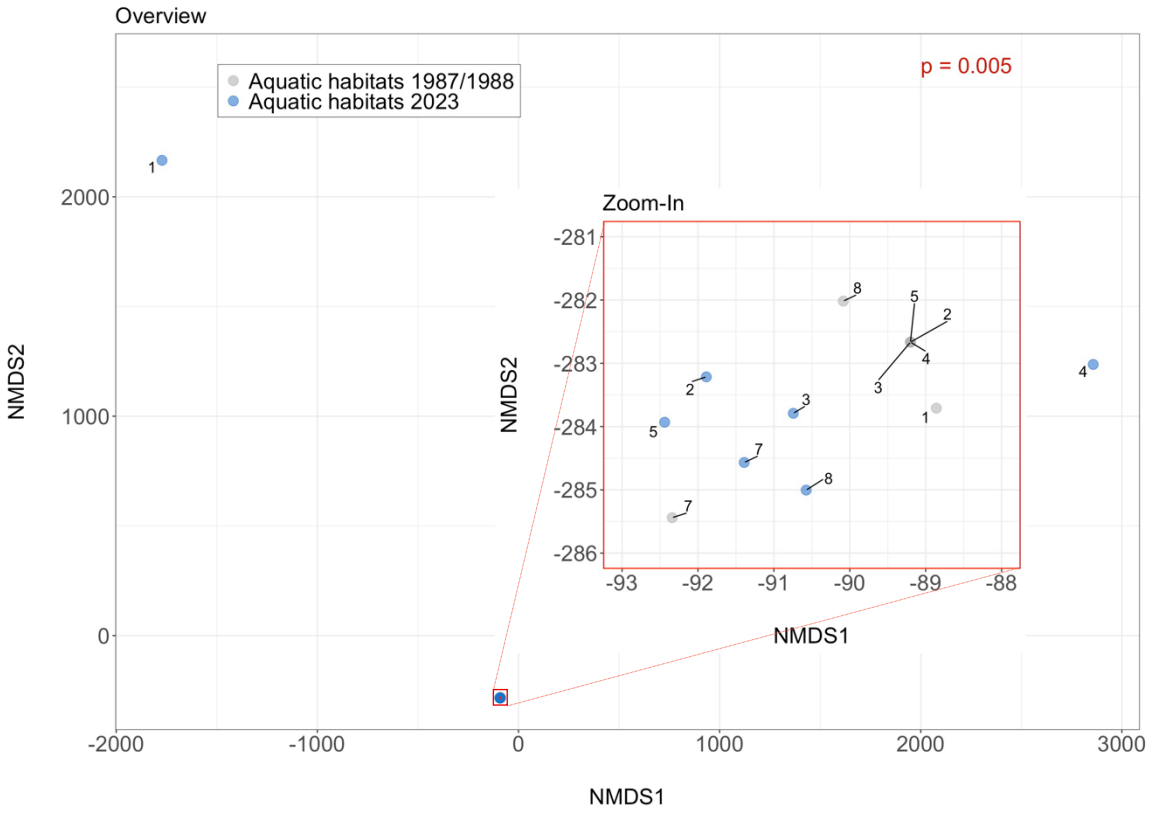


Figure 14 – NMDS of aquatic habitat plots for both recording periods (1987/1988 – grey; 2023 – blue). In the overview figure most plots overlap, the red square is a graphical zoom-in showing the overlapping plots in more detail. Plots are labelled with their according number. Permanova: p = 0.005

The boxplots in Figure 15 give an overview of the indicator values of all aquatic habitat plots comparing the two recording periods. Conditions in aquatic habitats became significantly drier, darker and warmer. The indicator value of reactivity and nutrients did not change significantly.

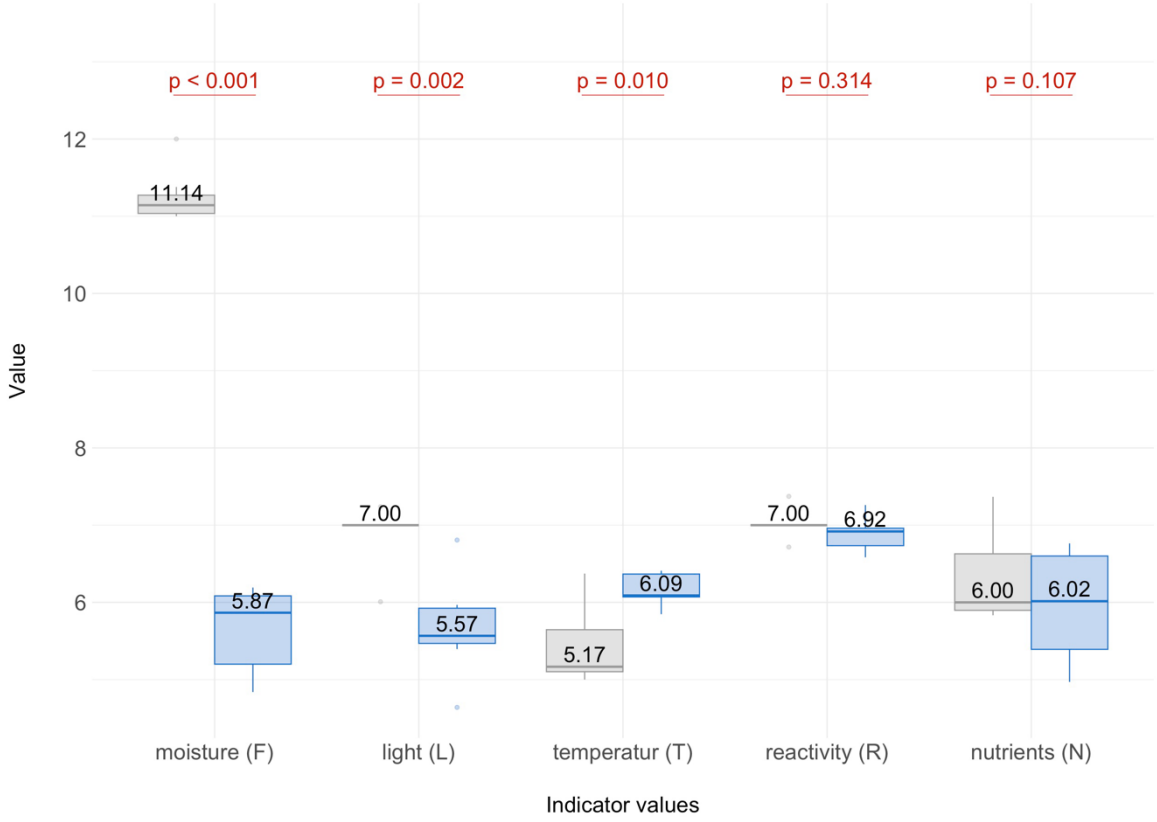


Figure 15 – Five indicator values comparing aquatic habitat plots between the recording periods (1987/1988 – light grey; 2023 – blue). Within the boxplots the median is labelled in black. The p-value in red results from a paired t-test.

3.1.2. Open land habitats

14 open land habitat plot, seven meadows and seven ditches with tall herbaceous vegetation and reeds were observed during both recording periods. In 1987/1988 142 species and in 2023 150 species were found on open land plots. The assignment of the species found on open land plots to the red list categories is displayed in Figure 35 in the appendix (Fisher Test: p = 0.426). Although the overall number of species increased, the number of threatened species decrease from 29 in 1987/1988 to 24 in 2023. Furthermore, the number of neophytes increased from 2 in 1987/1988 to 6 in 2023. The mean number of species per plot increased from on average 26.7 in 1987/1988 to 33.3 in 2023 (wilcoxon test: p = 0.055).

Figure 16 displays the NMDS for open land habitats. The meadows and the ditches form two groups. The indicator values show that ditches are more moist and nutrient richer than meadows. Furthermore, it is apparent that within the two groups, a clear differentiation between the two recording periods can be observed. Plots observed in 1987/1988 reached higher values for the indicator value of light than plots observed in 2023. A higher light value is indicating more light tolerant and less shadow tolerant species. The conditions in open land habitats are becoming darker to approximately the same extend in meadows and ditches.

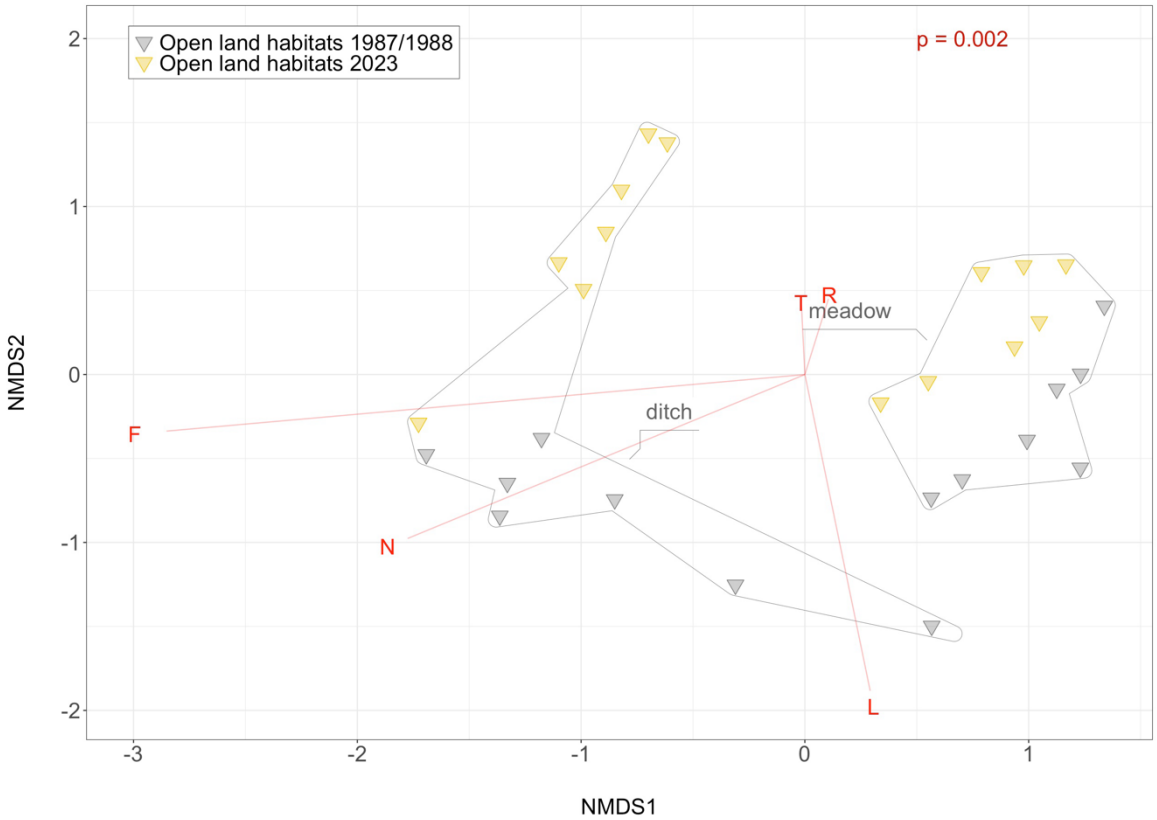


Figure 16 – NMDS of open land habitat plots for both recording periods (1987/1988 – grey; 2023 – yellow). Open land habitats include ditches and meadows which are marked by light grey hulls. Permanova: p = 0.002

The boxplots in Figure 17 are further supporting the observations described for the NMDS. Only the indicator value of light changed significantly. The open land habitats became significantly darker and more shadow tolerant species became present.

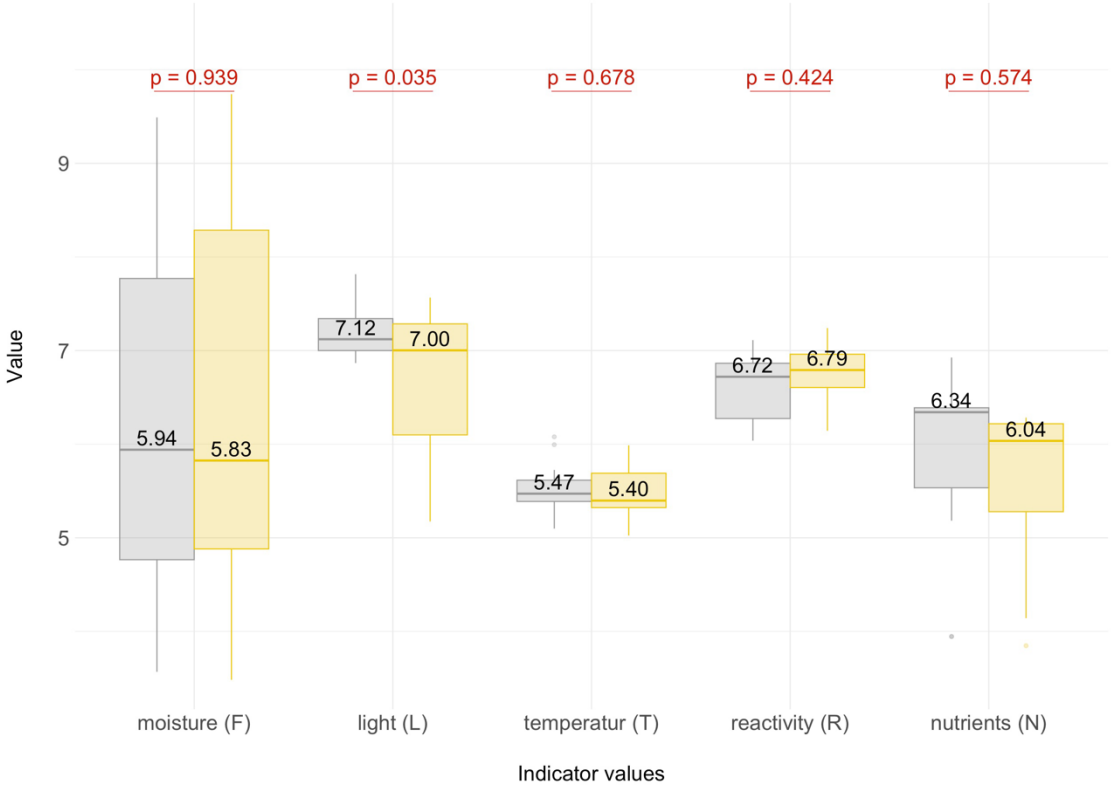


Figure 17 – Five indicator values comparing open land habitat plots between the recording periods (1987/1988 – light grey; 2023 – yellow). Within the boxplots the median is labelled in black. The p-value in red results from a paired t-test.

3.1.3. Woodland habitats

68 woodland habitat plots were described. In 1987/1988 a total of 206 different species were found on the plots while 184 different species were found in 2023. The assignment of the species to the red list categories is displayed in the Figure 37 in the appendix (Fisher Test: p = 0.260). The count of species which are threatened in any manner decreased from 25 species to 15 species. Additionally the total count of neophytes increased from 13 to 18. The mean number of species per plot decreased significantly from on average 47.9 in 1987/1988 to 44.0 species per plot in 2023 (paired t-test: p = 0.022).

Figure 18 displays the NMDS for woodland habitats. A highly significant separation between the species composition of the two recording periods can be recognised. The arrows representing the indicator values do not point in the direction of the observed change.

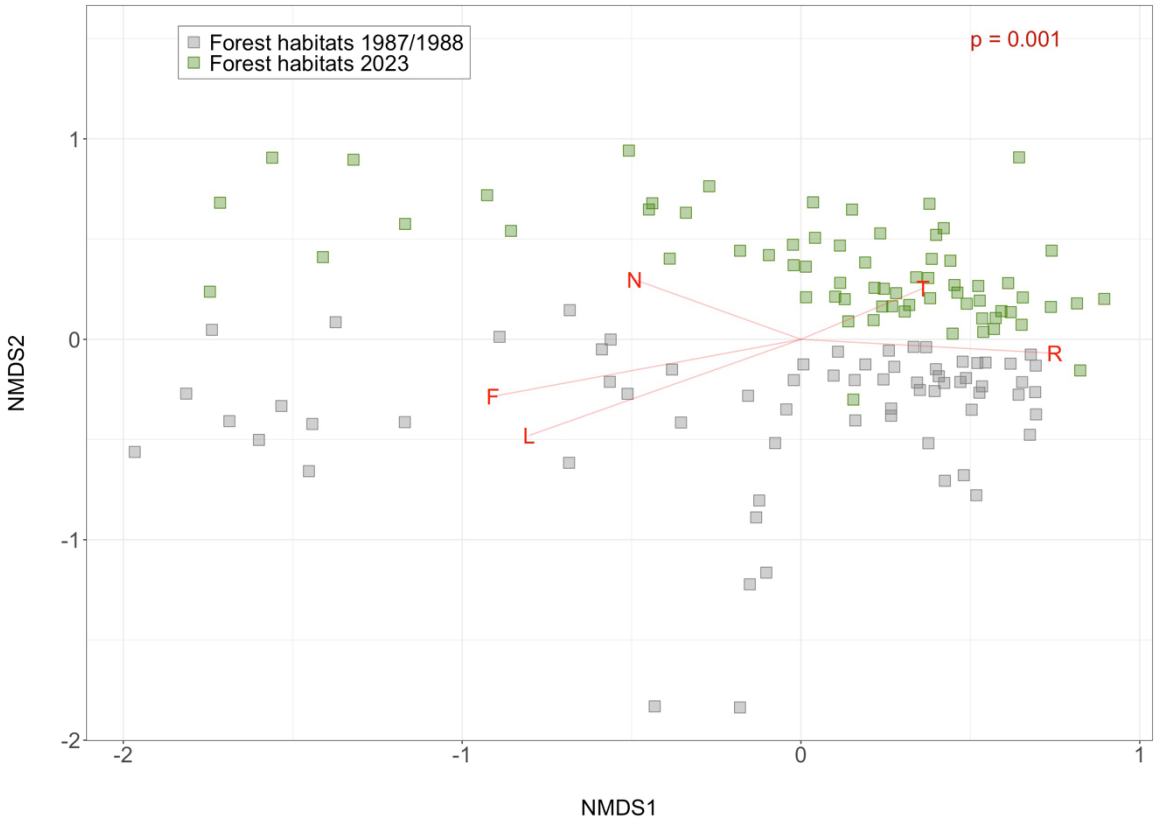


Figure 18 – NMDS of woodland habitat plots for both recording periods (1987/1988 – light grey; 2023 – green). Permanova: p = 0.001

The boxplots shown in Figure 19 show that none of the indicator values changed significantly.

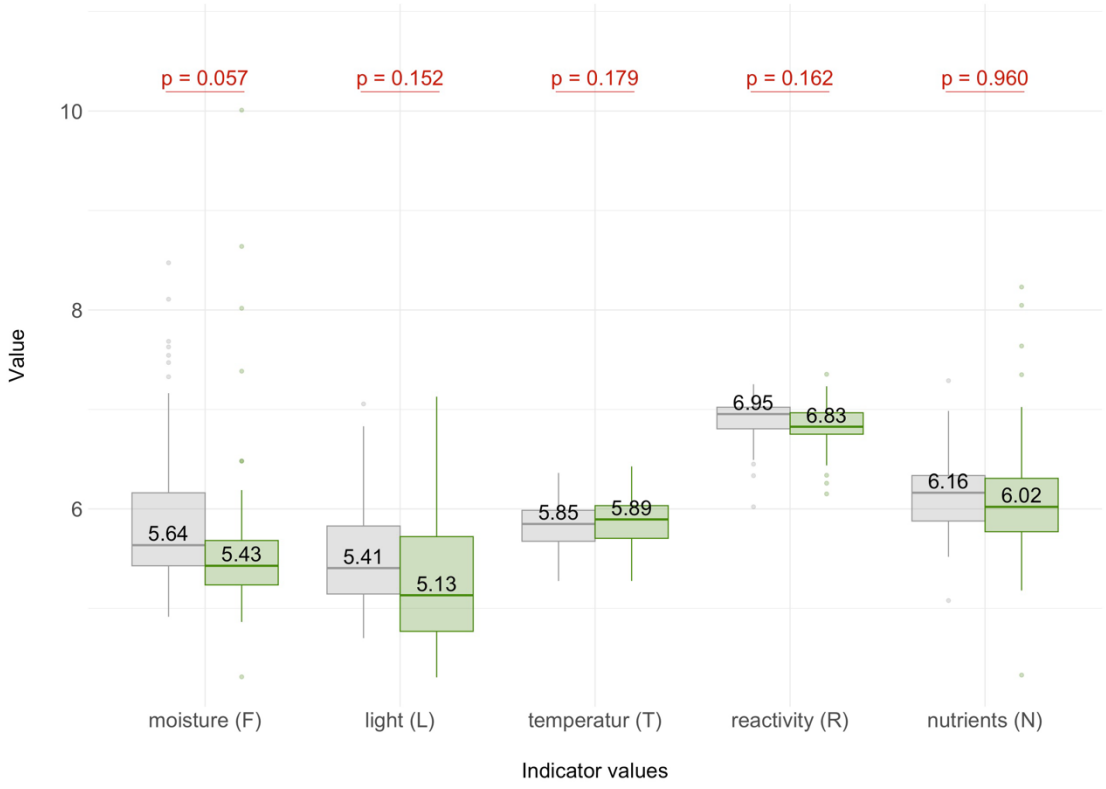


Figure 19 – Five indicator values comparing woodland habitat plots between the recording periods (1987/1988 – light grey; 2023 – green). With in the boxplots the median is labelled in black. The p-value in red results from a paired t-test.

Additionally, for woodland habitats the cover values per layer were compared (see Figure 38). While the average cover values of species found in the herb layer remained unchanged (paired t-test: p = 0.678), those of the shrub layer increased significantly (paired t-test: p = 0.039) from 51.3% to 56.2%. The average cover values of species found in the tree layer could not be compared, as in 1987/1988 tree layer 1 and 2 were described, while only one tree layer was described in 2023.

3.2. Linking the groundwater

The average indicator value per plot was set in relation to the elevation, which describes the distance above groundwater level (see Figure 20). The relation of the four indicator values moisture, light, temperature and nutrient to elevation differ significantly between recording periods. The linear regression model for the indicator value of moisture based on the elevation shows a clear gradient in 1987/1988 which flattened in 2023. The slope (β-value) of -1.08 for the data of 1987/1988 is highly significant with a p-value below 0.01, while the slope of -0.05 for 2023 is not significant. Furthermore, the residual standard error (r^2) was 0.48 in 1987/1988 while it was 0.0 in 2023. The linear regression model of the indicator value of light also showed a significant gradient in 1987/1988 (β = -0.38) which continued to be less pronounced and not significant any more in 2023 (β = -0.11). The residual standard error in 1987/1988 was 0.26 while in 2023 it was 0.02. For the linear regression model of the indicator value of temperature a slight but significant increase could be observed in 1987/1988 (β = 0.08) which changed to a slight but not significant decrease in 2023 (β =-0.02). The residual standard error decreased from 0.08 to 0.01. The opposite was the case for the linear regression model of the indicator value of nutrient where a slight but significant decrease was observed in 1987/1988 (β = -0.12) and a slight not significant increase was observed in 2023 (β = 0.10). The residual standard error decreased from 0.07 to 0.03.

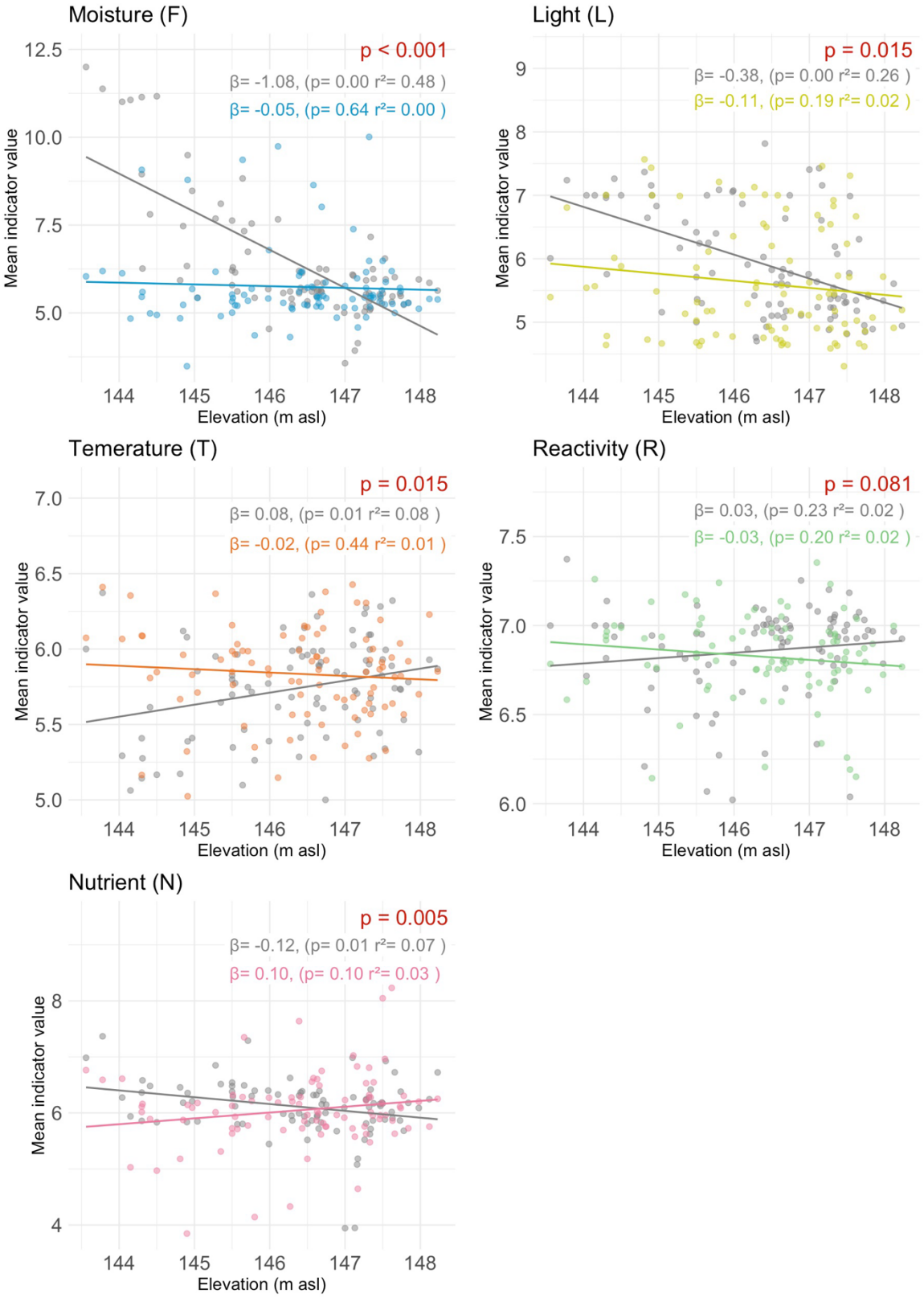


Figure 20 – Indicator values in relation to the elevation of the plots (1987/1988 – grey; 2023 – colored). The p-value (ANOVA) in the top right corner states whether the regression lines differ significantly between recording periods. Furthermore, a β (slope)-value as well as a corresponding p- and r²-value can be found. The slope value describes the change of the linear regression model per meter of elevation. The according p-value describes whether the indicator value correlates with the elevation while the r²-value (residual standard error) describes how well the line describes the distribution of the points.

Furthermore, all plots were grouped into three elevation classes namely L – low, M – medium and H – high (see Table 6 for the assignment of the plots to the elevation classes). For every class boxplots representing the according indicator values were made, see Figure 21. For the low elevation class four out of five indicator values, namely moisture, light, temperature and nutrient changed significantly. For the medium elevation classes non of the indicator values changed significantly. For the high elevation classes the indicator value of reactivity changed significantly.

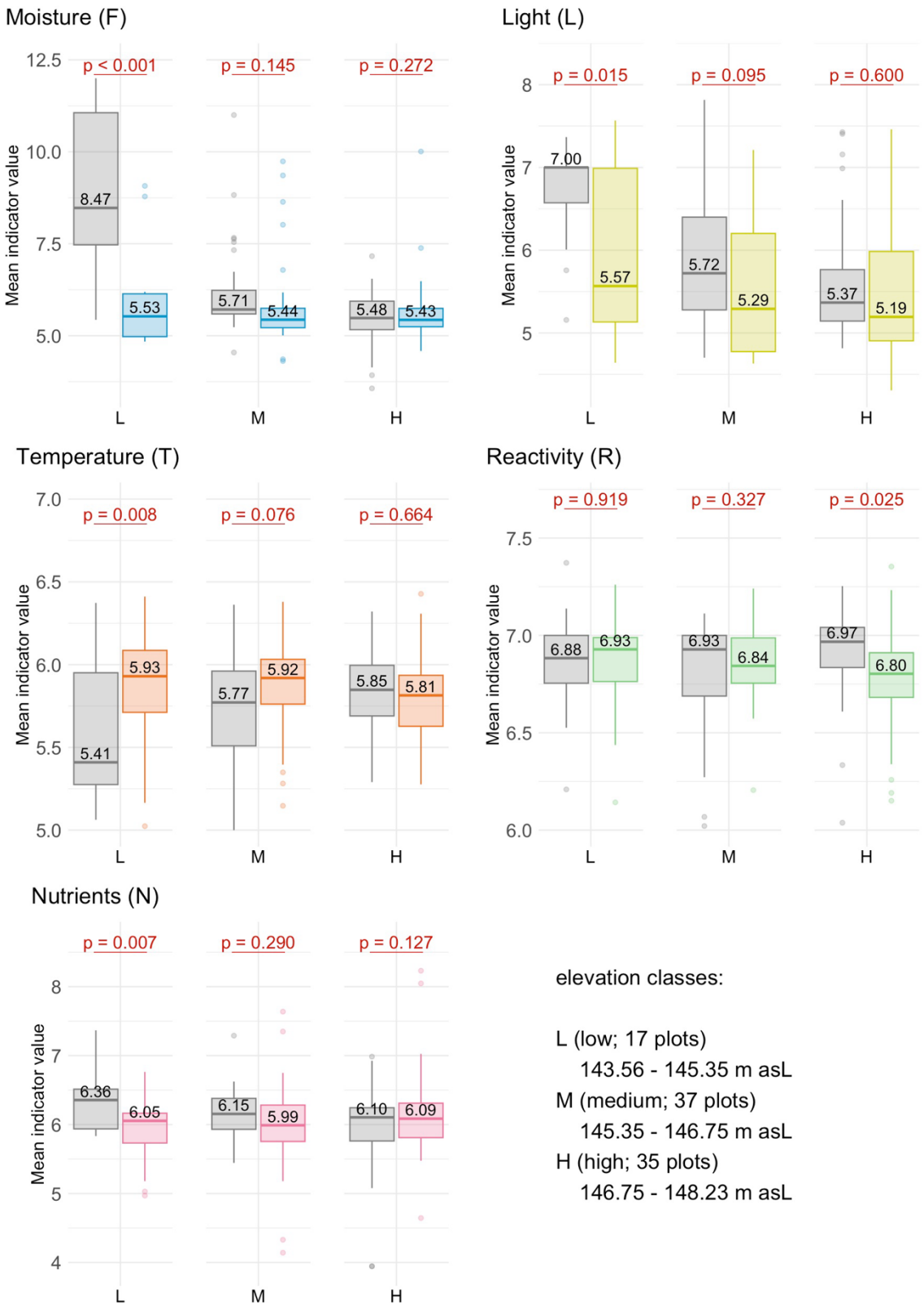


Figure 21 – Every figure of boxplots is representing one of the five indicator values. Within the figures three elevation classes (L – low, M – medium and H – high), produced with the classIntervals function are compared. Within every boxplot a value for the corresponding median can be found. The p-value in red results from a paired t-test.

4. Discussion

The results clearly indicate a change in the study site over time. The vegetation and therefore the habitats of the floodplain altered between 1987/1988 and 2023.

4.1. Capturing changes

The indicator values and therefore the overall conditions became drier, darker and warmer. The species set changed towards more drought tolerant and shadow-tolerant species which are adapted to higher temperatures. These results are in line with Sauberer & Pfundner, (2019), studying vegetation changes from 2011 to 2019 as well in the Donau-Auen National Park. They also found a clear decrease for the indicator value of moisture which was more pronounced for wet meadows than for mesic meadows and hotlands. Furthermore, the overall species composition changed significantly and shifts of plots from one habitat type to another can be observed. The three habitats types are affected to varying degrees.

4.1.1. Aquatic habitats

The above described results indicate that aquatic habitats as such are being lost. In the NMDS comparing all plots over time (Figure 13) it becomes immediately apparent that former aquatic plots (grey dots) differ in their species composition from all other plots while recent aquatic plots (black dots) are located closer to plots from open land and woodland habitats. It can therefore be derived that the species composition of aquatic habitats had changed and became similar to the species composition of open land and woodland habitats. Furthermore, the header data from the vegetation surveys (see Table 7 and Table 9 in appendix) reveals that in 1987/1988 all eight aquatic plots were completely covered by water (30 – 145 cm depth) while in 2023 only one plot was partly covered by water, the remaining plots were dried out.

Rare aquatic species are disappearing, while neighbouring terrestrial species migrate into the former aquatic habitats. In 2023 six times more species were found on aquatic plots than in 1987/1988. Plot number 3 was described as a 100 m^2 big *Lemna sp*. community in 1987/1988. In 2023 55% of the plot was covered by a shallow water body with some macrophytes and mainly sedges on the edges. Plots number 1 and number 4 were located in bomb craters which were formally water-bearing and a vital community of *Lemna sp*. species was described. In 2023 the bomb craters could be relocated as distinct depressions, however they were not filled with water and the described species were only woodland species (see Figure 14). On the four remaining plots (number 2, 5, 7, 8) mainly sedges and reeds were described which were not found in 1987/1988.

Their species composition became comparable to the former species composition of ditches (Figure 13; In the top left corner of the 1. zoom-in the four recent aquatic plots 2, 5, 7, and 8 can be found next to the former open land plots 9, 10, 11, 12 and 13). In 1987/1988 44% of the species were classified as threatened in any manner while in 2023 25% of the species were classified as such (see Figure 36). Four out of nine species described in 1987/1988 are considered threated. Two species were found again in 2023 (*Lemna trisulca, Myriophyllum verticillatum*) two other macrophyte species were lost (*Nuphar lutea, Ranunculus circinatus*). Fourteen species were described as threatened in 2023. Three threatened species are macrophytes two of them were also found in 1987/1988 one was gained (*Hydrocharis morsus-ranae*). The remaining species classified as endangered are typical of shorelines and wet depressions. Considering the overall context, their presence is therefore not a gain, but it is once again attributable to the shift in habitats. Rare shoreline and open land species are migrating into aquatic habitats, while rare aquatic species are being lost or becoming less frequent.

Aquatic habitats as special sites like islands of fresh water, coldness and direct sunlight change towards areas that are comparable to the surrounding habitats. The change in species composition is also reflected in the indicator values, the conditions became significantly drier, darker and warmer (see Figure 15). While the moisture indicator value had a median of 11.14 in 1987/1988, it decreased to a median of 5.87 in 2023. It should be noted that the moisture indicator value of 11 stands for: “aquatic plant that form roots underwater, leaves are at least occasionally above the water surface or plant that leaves float on the water surface” while the moisture indicator value of 12 stands for: “fully submerged plant” (see Table 1). In 2023 five species were found with a moisture indicator value of 11 or 12. All species were located in plot number 3 (*Hydrocharis morsus-ranae*: +, *Lemna minor*: +, *Lemna trisulca*: +, *Myriophyllum verticillatum*: 1, *Spirodela polyrhiza*: 2) which was partly covered with water and one single individual (*Myriophyllum verticillatum*: r) was located in plot number 7 which was partly covered by mud. The average of 5.87 is comparable to the average indicator value of moisture found on open land habitat plots (average 1987/1988 5.94, average 2023: 5.83). The average indicator value of light changed from 7.00 to 5.57 in aquatic habitats. The average indicator value found in former times can be compared to the indicator value of light found on open land plots (7.12 in 1987/1988 and 7.00 in 2023) it could be interpreted as a typical indicator value for open areas that are not overshadowed by trees and shrubs. However, the indicator value of 5.57 as describe for recent aquatic plots can almost be compared to typical indicator value found in woodland habitats (5.41 in 1987/1988). It must therefore be concluded that aquatic plots are strongly overshadowed differing in their exposure to sunlight barely from woodland plot. The average of the temperature indicator value changed from 5.17 to 6.09. Interestingly this change means a shift from what were formerly the coolest areas in the study site to what are now the warmest areas in the study site.

4.1.2. Open land habitats

Natural open land habitats, ditches, appear to be subject to greater change than artificial open habitats such as meadows. In ditches, as well as in aquatic habitats, it can be observed that woodland species appear to be migrating into. This is evident, on the one hand, in the fact that ditches are becoming increasingly similar to woodland habitats, on the other hand, in the fact that open land habitats are becoming darker and more shade-tolerant species are occurring. In the 2. zoom-in of Figure 13 six recently observed open land plots are found, which are comparable in their species composition to woodland plots, all six of them are located in ditches (plot number 9, 11, 12, 13, 14 and 15). The boxplots (Figure 17) further support the observations: the median of the light indicator value changed significantly. In addition, the boxplot became larger, meaning that there are more plants with different and, in particular, values indicating darker conditions. The actual vegetation data (Table 7 and Table 9) further underpins the observations. In 1987/1988, the total cover of the shrub and tree layer for open land plots was not recorded. Nevertheless, individual shrubs and trees with low cover values could still be found in the relevant plots. In 2023 6 out of 7 plots located in ditches had a pronounced shrub and tree layer. No shrubs and trees were found on the plots describing hay meadows.

4.1.3. Woodland habitats

The species composition of woodland habitats changed significantly, however none of the indicator values explains this shift (see Figure 20). The cover of the shrub layer changed significantly over time (see Figure 38) which could be a consequence of less frequent flood events which allows a denser shrub layer to develop. Alternatively an ongoing succession following the abandonment of cultivation could also have caused this change.

It can be summarized that aquatic habitats and ditches changed the most. They are being lost as special sites and are invaded by the surrounding more common (woodland) species. As stated at the beginning of the thesis, river bed incision is leading to falling groundwater levels in the study site which is assumed to be the main driver for the described change. The results can be compared to the findings from Bravard et al., (1997) who describes that river bed incision is leading to a progressive isolation of aquatic habitats which affects side arms and aquatic-terrestrial ecotones the most. The observations are further substantiated by Bornette et al., (1996) who observed territorialization trends in two cut-off channels located in the incised reach of the river. Moreover, Bravard et al., (1997) predicts that river bed incision leading to a decrease in the groundwater level would lead to a reduction in habitat heterogeneity and furthermore a decrease in biodiversity. Likewise, Ahlmer et al., (2018) described that a reduction in groundwater fluctuations causes a

decline in habitat diversity. Further analyses therefore focused on whether the observed change can be linked to the falling groundwater levels.

4.2. Linking the groundwater

In former times the elevation influenced the environmental conditions and therefore the average indicator values, in the recent recording period this effect was lost. The elevation and thus the distance to the groundwater is no longer affecting the environmental conditions. The effect can be observed in four of the five indicator values, although it is most pronounced for the indicator value of moisture. The linear regression model describing the indicator value of moisture showed a clear and significant decrease with the elevation level which flattened out and became insignificant over time (see Figure 20). While in 1987/1988 the slope and therefore the average indicator value decreased by - 1.08 for every meter of elevation in 2023 this effect was barely identifiable any more (β = - 0.05). In 1987/1988 lower-lying habitats had on average a higher moisture value than higher-lying habitats. The according residual standard error can be interpreted as the percentage of scatter of the points that can be explained by the linear regression model line. Hence, 48% of the observed scatter of points in 1987/1988 can be explained by the linear regression model line while 0% of the scatter of points can be explained in 2023. While in 1987/1988 the elevation was a good explanation for the indicator value of moisture the elevation was not explaining any scatter in 2023.

In a last step it was tried to answer the question if the indicator values and therefore the conditions change to a different extent depending on the elevation. Therefore, three classes were formed, differentiating the plots against their elevation level. For every class boxplots were prepared comparing the development of the indicator values over time. Figure 22 presents graphically the elevation of the three classes, the calculated average groundwater level within the study site (see Table 2 and Table 3) as well as the average amplitude (see Table 4). What can clearly be seen in Figure 22 is that formally the average groundwater level was within the low elevation class. Some of the plots within the low elevation class were therefore on average submerged. Considering the amplitude, it can be assumed that most plots of the low elevation class were flooded, or the soil was completely saturated with water at least once a year. Regarding the estimated average groundwater level in 2021 it becomes apparent that on average none of the plots was flooded. Considering the amplitude it can be assumed that the number of plots which were flooded or which's soil was occasionally saturated with water decreased. This observation is also clearly depicted in the boxplots. Four out of five indicator values changed significantly in the lowest elevation class, while no indicator value changed significantly for the medium elevation class and only one for the high elevation class. The low elevation plots became drier, darker, warmer and nutrient poorer. Interestingly this decrease in the nutrient indicator value was not found for the overall habitats nor for any of the habitat types individually. Dwyer et al., (2021) demonstrates that the water table depth had the strongest influence on the indicator value of moisture while Schaffers & Sýkora, (2000) came to the conclusion that the average lowest moisture contents in summer correlated best followed by the annual average groundwater level and the average spring level with the indicator value of moisture. Furthermore, Schaffers &

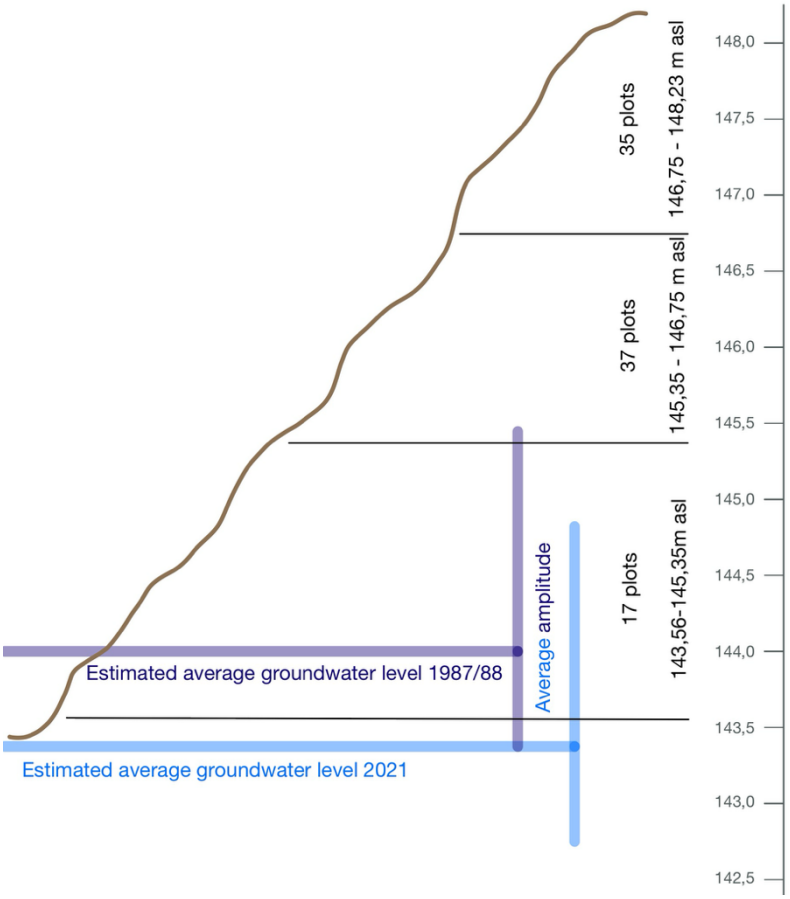


Figure 22 – Three elevation classes (low, medium, high) as well as the estimated average groundwater levels and amplitude.

Sýkora, (2000) found that the indicator value for nutrients correlated only weakly with soil parameters, including N-mineralization and available mineral N however a strong relation with biomass production could be found. That the indicator value for nutrients correlated better with the yield than with the applied nitrogen was also found for fertilized, regularly mown meadows (Hill & Carey, 1997). Schaffers & Sýkora, (2000) as well as Hill & Carey, (1997) suggest that the nutrient indicator value should be seen as 'productivity values'. With that in mind the decrease in the nutrient indicator value could more be interpreted as a decrease in biomass production.

Summing up all the described results it must be concluded that the habitats in the study site did change over time. Especially the indicator value of moisture was highly affected. The elevation of the plots and therefore the distance to the groundwater correlates with the change. Lower-lying habitats are more affected than higher-lying habitats. It therefore stands to reason that the falling groundwater level due to the river bed incision is causally involved in the observed striking changes.

The results presented must, of course, be considered in light of their limitations. An important point is that repeating the methodology involved the challenges described above (relocating the plots in the field, repeating the recording process and combining the spring and summer recordings into one). Nevertheless, the plots were very accurately located for the technical aids available at the time, and the methodology was precisely described and well supplemented by additional information from Christian Fraissl. Aside from that, it must also be acknowledged that the sample size for aquatic habitats is small (7/ 8 plots) and that open land habitats are also under-represented, especially when differentiated between meadows and ditches (7 + 7 plots). Nevertheless, the average trend of all plots is so clear that general conclusions can be drawn from it. It may also be noted that only two points in time are being compared. However, as these are vegetation surveys, the presence or absence of a plant always reflects the long-term impact of environmental factors. The long-term trend is therefore certainly accurately represented.

5. Conclusion

Especially low-lying habitats, which formally were closely connected to the groundwater level, changed dramatically over the past 35 years. This includes aquatic habitats, ditches with tall herbaceous vegetation and low-lying forests which are typical habitats of a vital floodplain ecosystem. The described habitats are either being lost, as it can be observed for the aquatic habitats or their species composition is shifting towards species that are more shadow and heath tolerant, as well as less adapted to wet and moist conditions. Therefore, it must be concluded that long-term preservation of these protected habitats is not given under the current circumstances. In order to preserve these habitats, the incision of the Danube needs to be addressed to counteract falling (ground)water levels. On the other hand, the approach of revitalisation projects which bring the river and its floodplain habitats closer together and allow natural processes to take effect once more should be followed.

6. References

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7. Appendix



Figure 23 – „Josephine land survey“ (German: “Josephinische Landesaufnahme”) displaying the area between Vienna and Hainburg mapped from 1773 till 1781 (Stein, 1773).

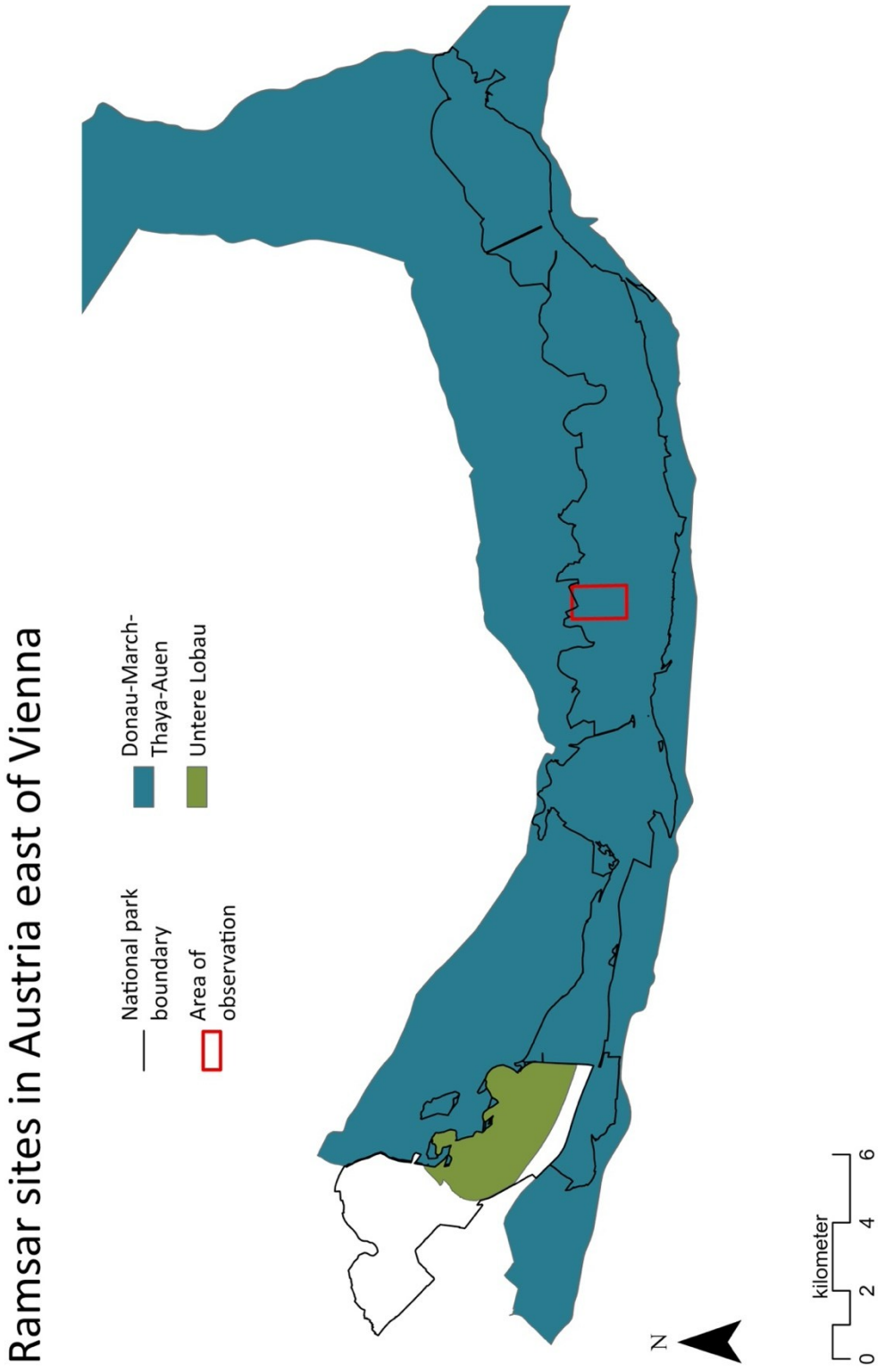


Figure 24 – Donau-Auen National Park boundary and its overlapping Ramsar sites “Donau-March-Thaya-Auen” as well as “Untere Lobau”. Data based on Land Niederösterreich, (2010); Nationalpark Donau-Auen GmbH et al., (2023); Stadt Wien, (2002) map created by Valerie Christ, January 2025.

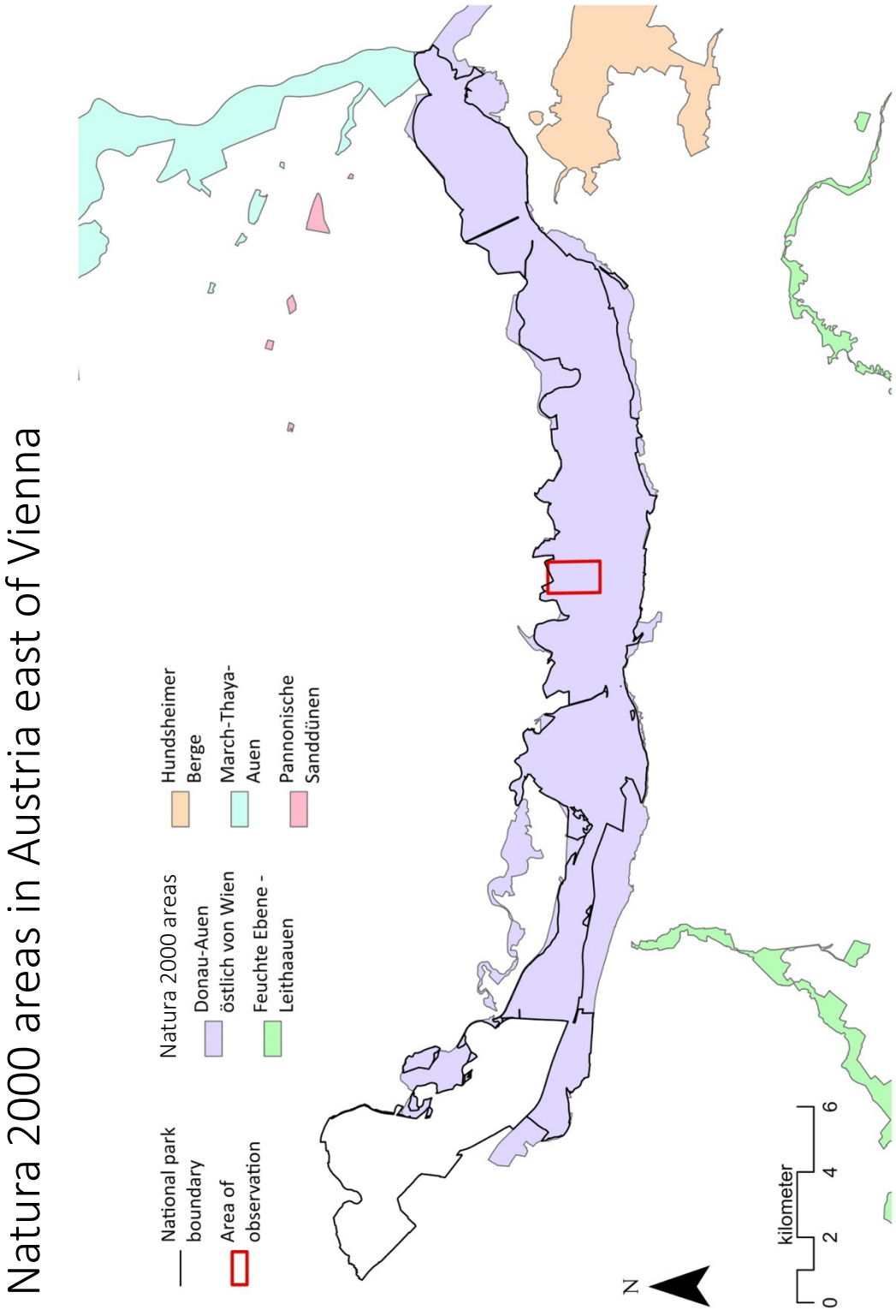


Figure 25 – Donau-Auen National Park boundary and its overlapping Natura 2000 areas in Lower Austria. Data based on Nationalpark Donau-Auen GmbH et al., (2023); NÖ GIS, Land Niederösterreich, (2008) map created by Valerie Christ, January 2025.

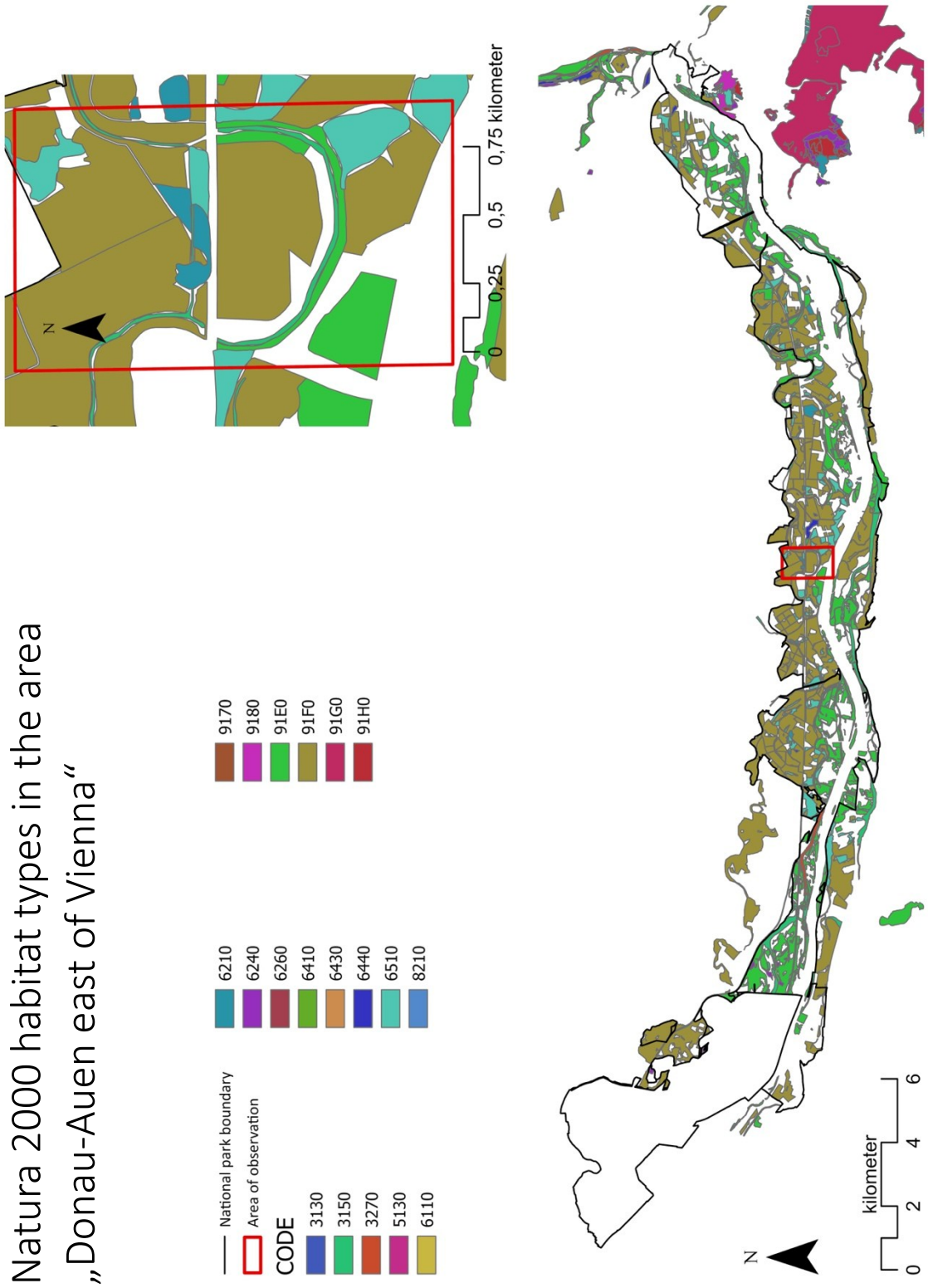


Figure 26 – Donau-Auen National Park boundary and its overlapping Natura 2000 habitat types in Lower Austria. Data based on Nationalpark Donau-Auen GmbH et al., (2023); NÖ GIS, Land Niederösterreich, (2008) map created by Valerie Christ, January 2025.

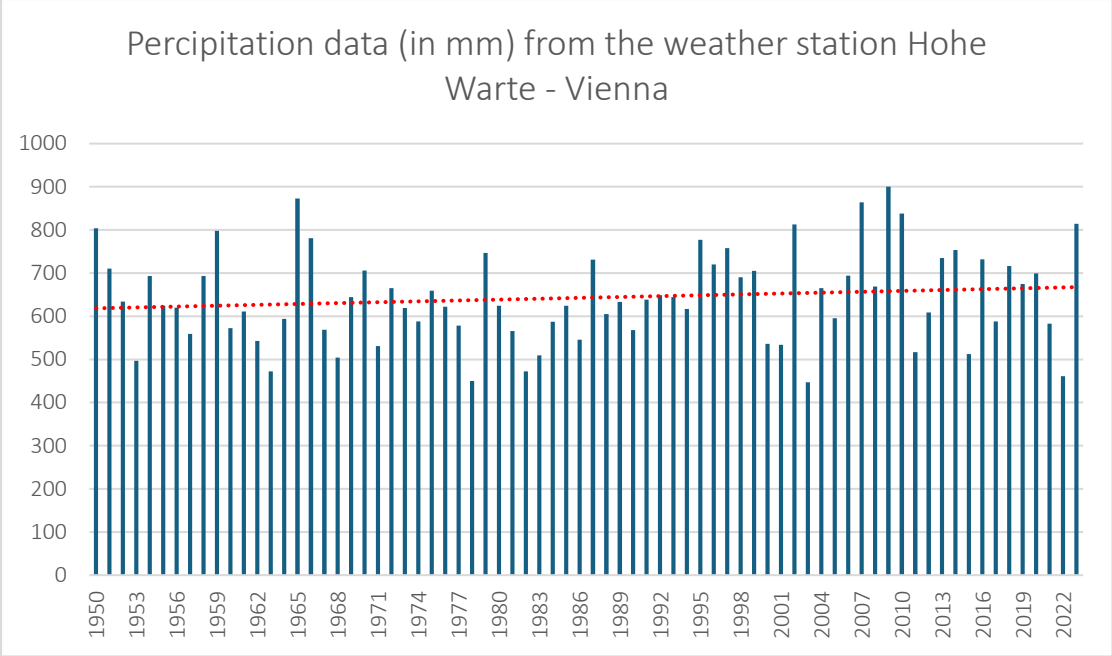


Figure 27 – Precipitation data (in mm) from the weather station Hohe Warte – Vienna with a linear trendline in red (data: Stadt Wien – data.wien.gv.at; 21.08.2025).

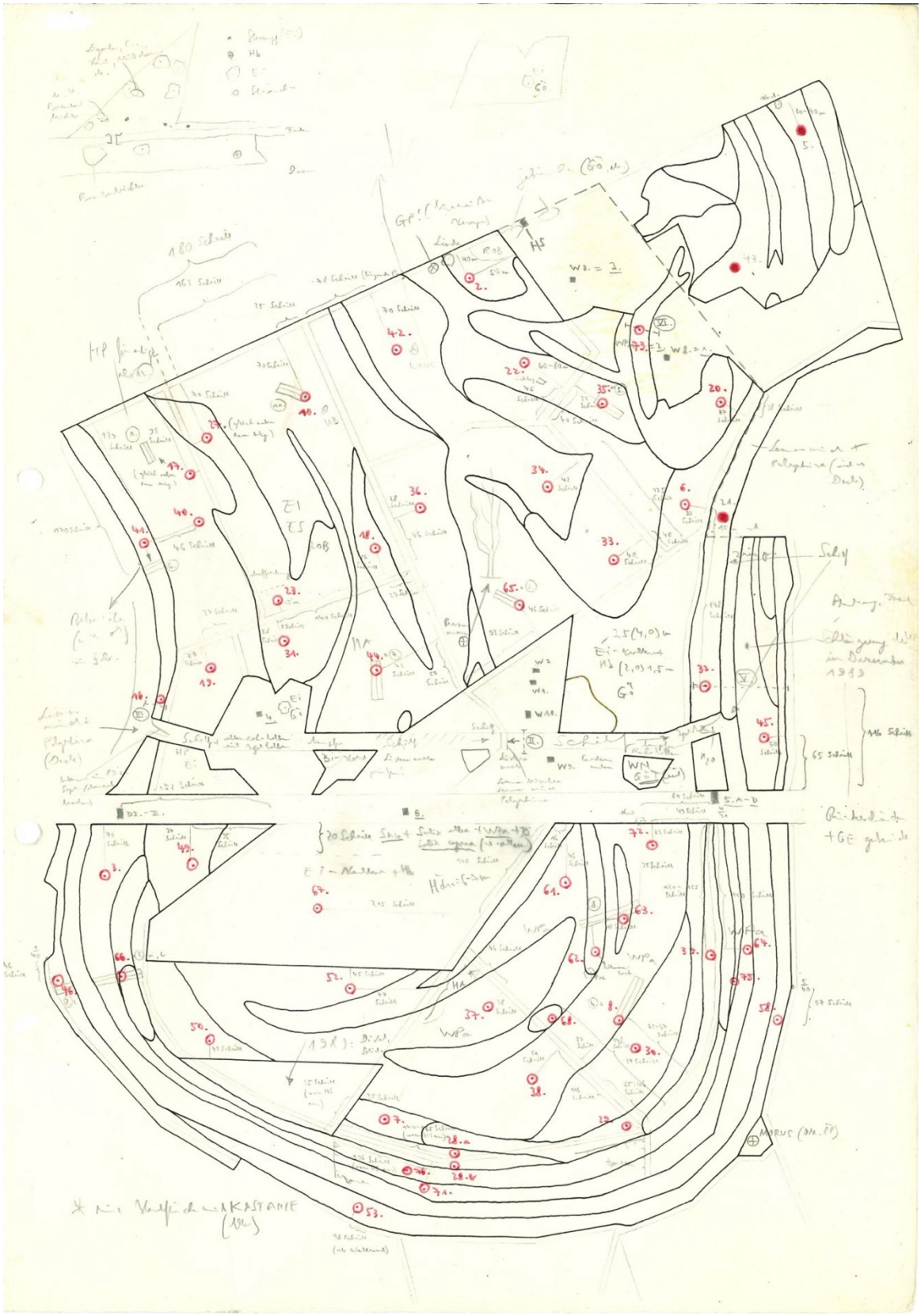


Figure 28 – Scan of Christian Fraissl's original map with foot steps used as a measuring unit (1/2).

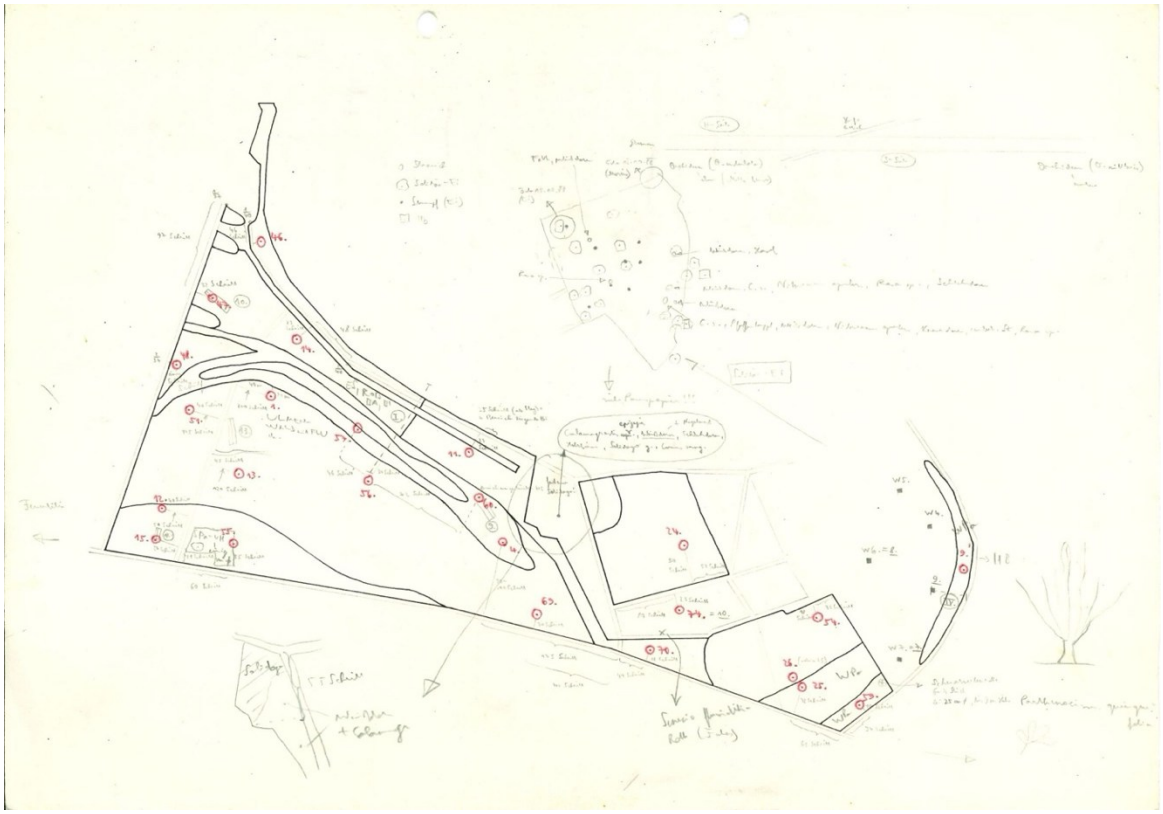


Figure 29 – Scan of Christian Fraissl's original map with foot steps used as a measuring unit (2/2).

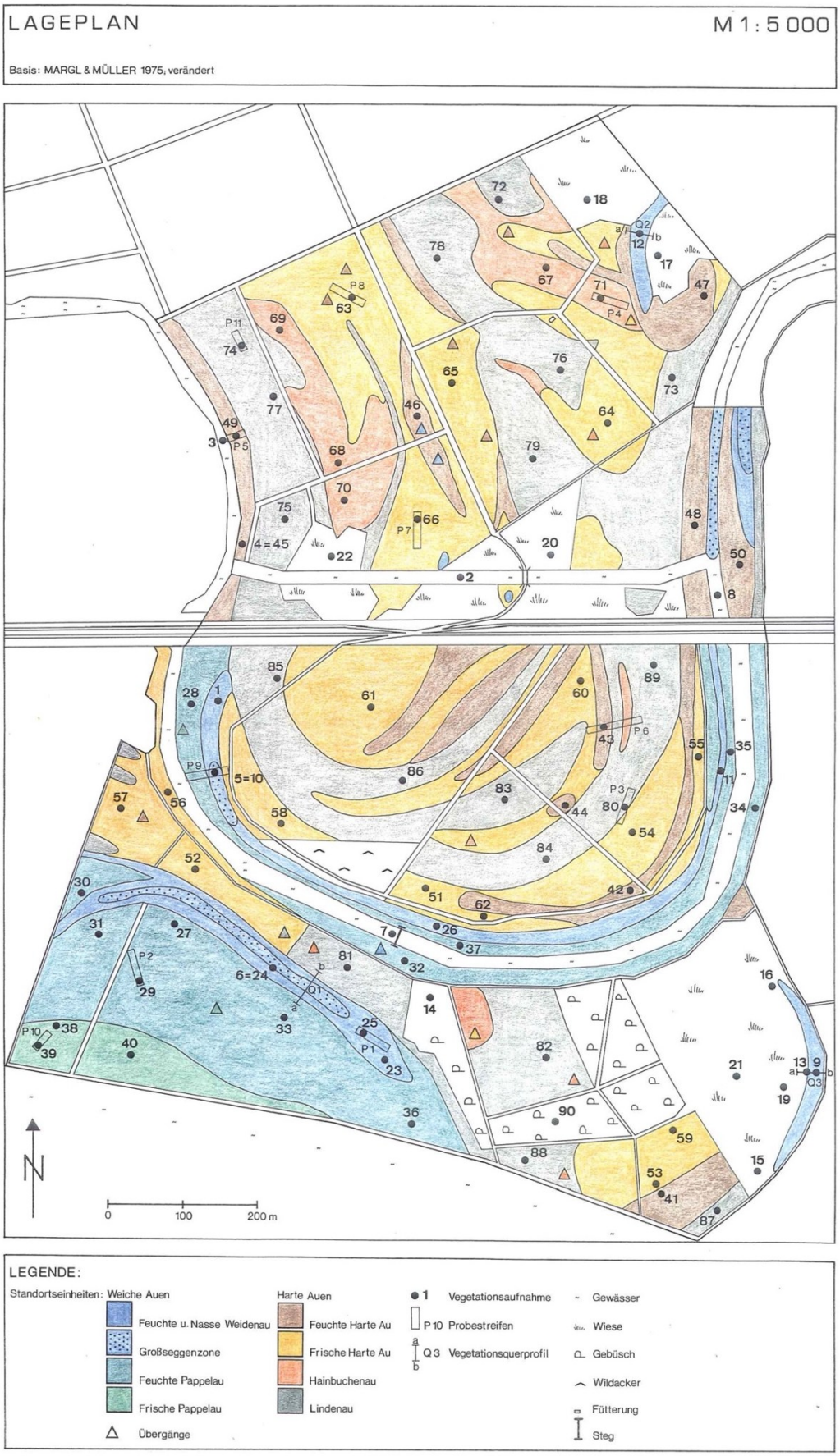


Figure 30 – Map displaying the vegetation survey plots as published by Christian Fraissl in his thesis (Fraissl, 1993).



Figure 31 – Aerial image of the study site with the vegetation survey plots indicated by their numbers. Map created by Valerie Christ, May 2026; base layer: (basemap.at,2026).

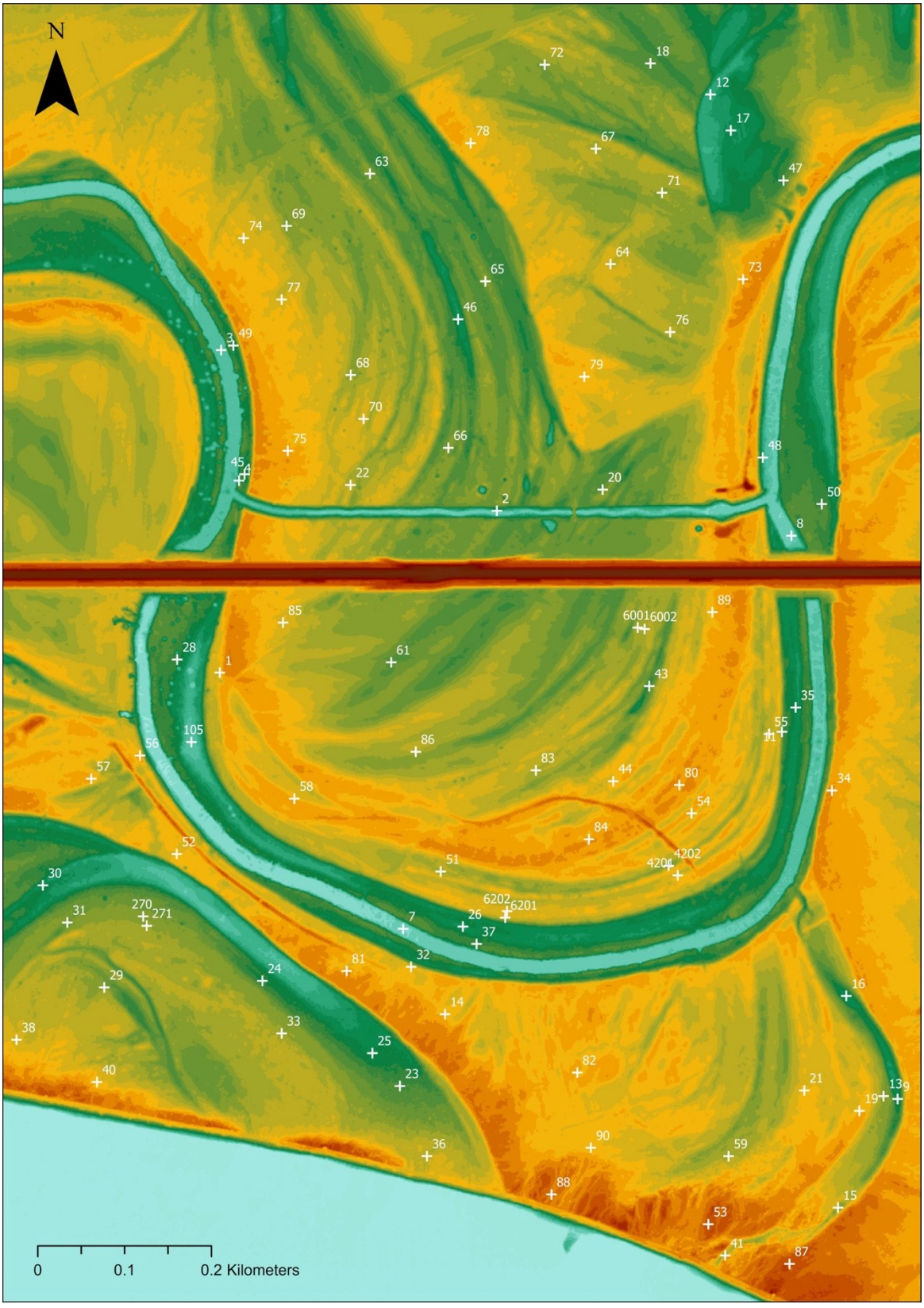


Figure 32 – Elevation model of the study site with the vegetation survey plots indicated by their numbers. Data base Land Niederösterreich & Nationalpark Donau-Auen GmbH, (2015) map created by Valerie Christ, May 2025.

Table 6 – Location of the vegetation survey plots. X- and y-values as well as the elevation were calculation in ArcGIS Pro. The assignment to elevation class as well as the accuracy categories are described in the methods section. The data on the area observed in 1987/1988 was collected from the original survey sheets. In 2023 minimum and maximum plots were observed as well as some alternative plots when the situation in the field was unclear. The plot size used for the statistical analysis is written in black.

Location of the vegetation survey plots									
			Elevation			area observed (in m²)			
Plot	x-Value	y-Value	(in m)	class	accuracy (= centroid ...)	1987/1988	2023	min	max
1	16,75599	48,13326	146,74	Medium	measured	9	25		
2	16,76029	48,13492	144,04	Low	calculated	12	12		
3	16,75603	48,13660	144,15	Low	calculated	100	100		
4	16,75630	48,13525	144,50	Low	measured	1	1		
5	16,75554	48,13254	144,30	Low	measured	9	9		
7	16,75880	48,13059	143,78	Low	calculated	60		60	100
8	16,76484	48,13464	143,56	Low	calculated	16		16	100
9	16,76644	48,12880	144,91	Low	measured	50		50	400
10	16,75554	48,13254	144,30	Low	measured	50		50	100
11	16,76468	48,13261	145,64	Medium	measured	60 (elongated)		60	120
12	16,76363	48,13922	144,41	Low	measured	80		80	100
13	16,76622	48,12883	146,11	Medium	measured	60		60	400
14	16,75944	48,12970	147,54	High	measured	unknown		100	400
15	16,76551	48,12768	146,41	Medium	measured	70		70	100
16	16,76565	48,12987	144,90	Low	measured	100	100		
17	16,76394	48,13885	144,81	Low	calculated	100	100		
18	16,76270	48,13955	145,80	Medium	measured	100	100		
19	16,76585	48,12868	147,17	High	calculated	unknown	100		
20	16,76193	48,13513	145,99	Medium	measured	unknown	100		
21	16,76500	48,12889	147,13	High	measured	100	100		
22	16,75803	48,13519	147,00	High	measured	60		60	100
23	16,75874	48,12896	145,71	Medium	measured	20 x 20 m		100	400
24	16,75662	48,13006	145,50	Medium	measured	unknown		100	400
25	16,75831	48,12930	145,28	Low	measured	400		100	400
26	16,75973	48,13061	144,97	Low	measured	200 (elongated)		200	400
28	16,75533	48,13339	145,66	Medium	measured	15 x 20 m	400		
29	16,75417	48,13000	146,63	Medium	measured	400	400		
30	16,75323	48,13106	145,35	Low	measured	unknown		100	400
31	16,75360	48,13068	146,39	Medium	measured	400	400		
32	16,75892	48,13020	147,34	High	measured	elongated	160		
33	16,75691	48,12951	146,65	Medium	measured	400	400		
34	16,76545	48,13200	147,53	High	measured	elongated		240	
35	16,76490	48,13286	144,85	Low	measured	elongated	400		
36	16,75915	48,12823	146,75	Medium	measured	elongated	400		
37	16,75994	48,13043	145,76	Medium	measured	elongated		100	400

38	16,75281	48,12946	147,38	High	measured	400	400		
39	16,75237	48,12925	147,98	High	measured	unknown	400		
40	16,75405	48,12902	147,46	High	measured	400	400		
41	16,76376	48,12719	147,10	High	measured	elongated		170	400
43	16,76263	48,13309	145,54	Medium	measured	elongated		180	400
44	16,76207	48,13211	147,28	High	measured	400	400		
45	16,75639	48,13531	145,57	Medium	measured	elongated	220		
46	16,75970	48,13691	145,04	Low	measured	elongated 400		160	330
47	16,76475	48,13833	145,50	Medium	measured	400	400		
48	16,76441	48,13545	144,31	Low	measured	elongated		70	220
49	16,75622	48,13665	145,51	Medium	measured	elongated		220	360
50	16,76532	48,13497	145,50	Medium	measured	400	400		
51	16,75939	48,13118	146,62	Medium	measured	15 x 15 m	225	160	400
52	16,75530	48,13138	147,49	High	measured	longer than wide	400		
53	16,76350	48,12751	148,23	High	measured	400	400		
54	16,76327	48,13177	147,28	High	measured	400	400		
55	16,76448	48,13259	146,71	Medium	measured	elongated			400
56	16,75474	48,13240	147,73	High	measured	elongated		130	380
57	16,75399	48,13217	147,74	High	calculated	400	400		
58	16,75713	48,13195	147,66	High	measured	400	400		
59	16,76382	48,12822	146,50	Medium	measured	400	400		
61	16,75864	48,13335	145,98	Medium	measured	400	400		
63	16,75835	48,13842	146,29	Medium	measured	400	400		
64	16,76207	48,13747	146,89	High	measured	400	400		
65	16,76013	48,13730	146,18	Medium	calculated	unknown	400		
66	16,75954	48,13557	146,30	Medium	measured	400	400		
67	16,76185	48,13866	146,58	Medium	measured	400	400		
68	16,75804	48,13633	146,50	Medium	measured	400	400		
69	16,75706	48,13788	146,43	Medium	measured	400	400		
70	16,75823	48,13588	147,33	High	measured	400	400		
71	16,76287	48,13821	146,39	Medium	measured	400	400		
72	16,76107	48,13954	146,27	Medium	measured	15 x 20 m	400		
73	16,76412	48,13730	147,50	High	measured	20 x 20 m	400		
74	16,75639	48,13776	147,28	High	measured	400	400		
75	16,75706	48,13555	147,62	High	measured	400	400		
76	16,76299	48,13676	146,69	Medium	measured	400	400		
77	16,75697	48,13712	147,11	High	measured	400	400		
78	16,75991	48,13873	147,34	High	measured	400	400		
79	16,76165	48,13630	147,32	High	measured	400	400		
80	16,76309	48,13207	147,47	High	measured	15 x 20 m	400		
81	16,75792	48,13016	147,84	High	measured	400	400		
82	16,76149	48,12909	147,37	High	calculated	400	400		
83	16,76087	48,13223	146,56	Medium	measured	400	400		
84	16,76169	48,13151	147,63	High	calculated	400	400		
85	16,75697	48,13377	147,26	High	measured	elongated	400		
86	16,75901	48,13243	146,68	Medium	measured	400	400		

87	16,76475	48,12710	148,12	High	measured	elongated	400		
88	16,76108	48,12783	147,78	High	measured	400	400		
89	16,76362	48,13386	147,32	High	measured	400	400		
90	16,76169	48,12831	147,16	High	measured	400	400		
2701	16,75478	48,13073	146,63	Medium	measured	15 x 20 m	400		
2702	16,75483	48,13064	146,69	Medium	measured	15 x 20 m	400		
4201	16,76306	48,13113	147,04	Medium	measured	elongated			220
4202	16,76292	48,13123	146,22	Medium	measured	elongated		150	
6001	16,76246	48,13370	146,45	Medium	measured	400	400		
6002	16,76257	48,13368	146,46	Medium	measured	400	400		
6201	16,76038	48,13070	146,86	High	measured	2 x elongated		200	400
6202	16,76041	48,13077	147,11	High	measured	2 x elongated		160	

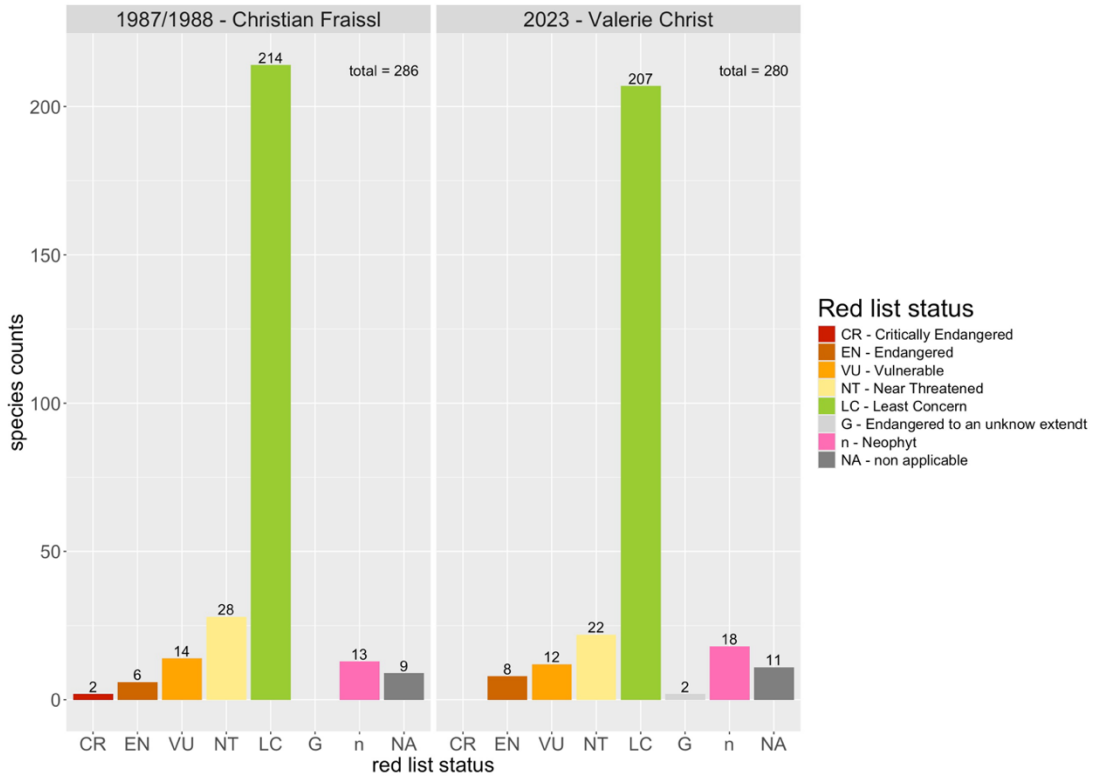


Figure 33 – Species found on all plots assigned to the red list categories. Fisher Test: p = 0.514

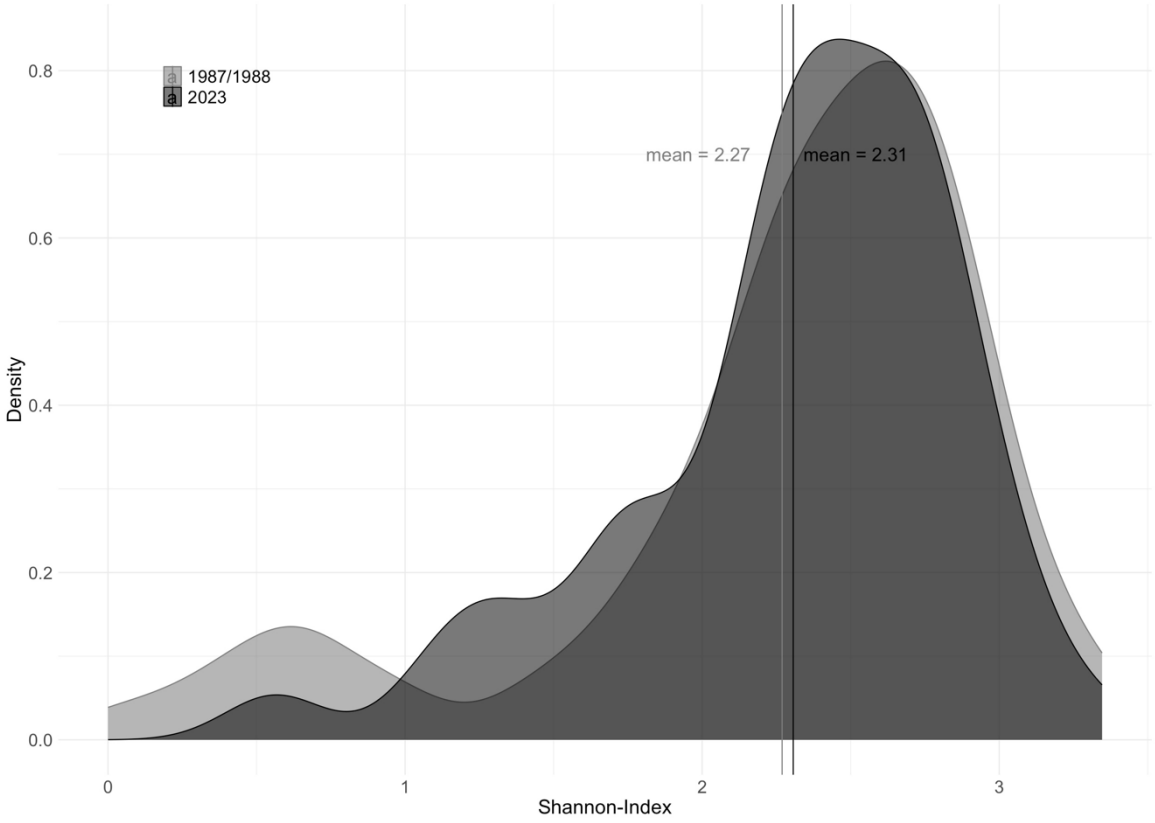


Figure 34 – Shannon Index as an indicator for diversity for all plots.

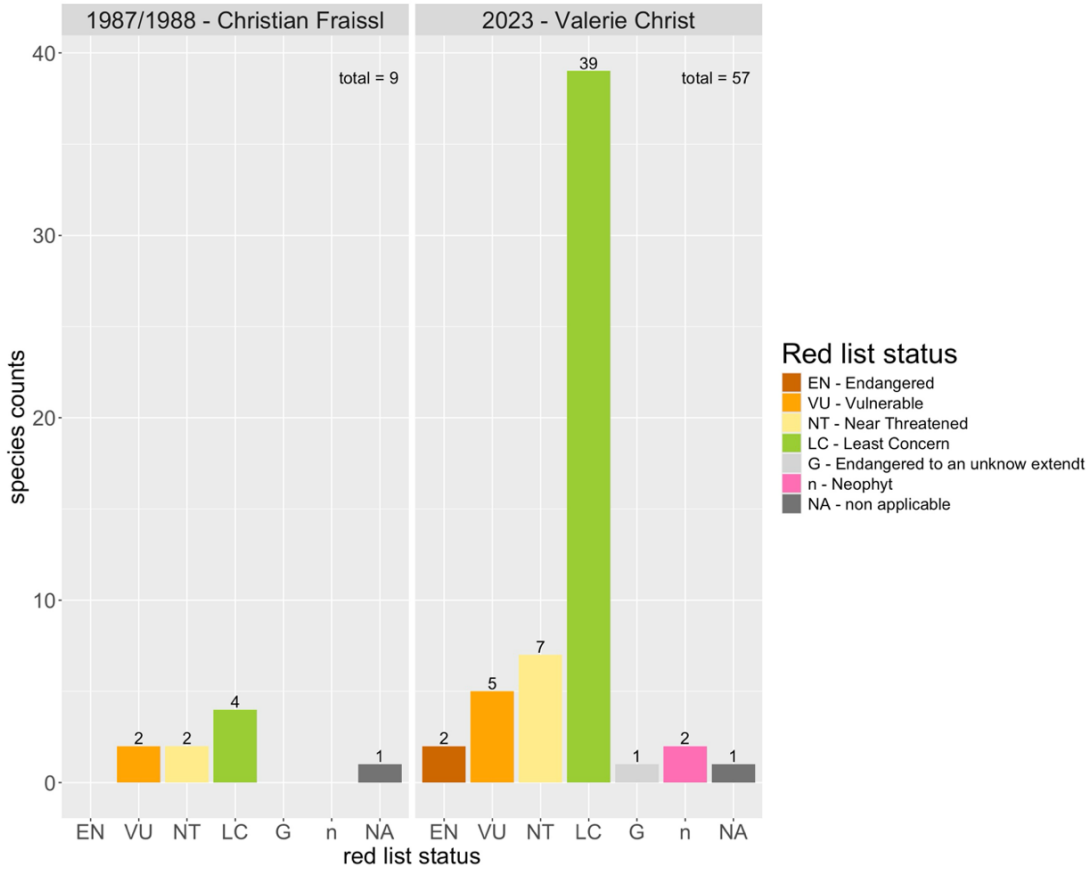


Figure 36 – Species found on aquatic habitat plots assigned to the red list categories. Fisher Test: p = 0.485

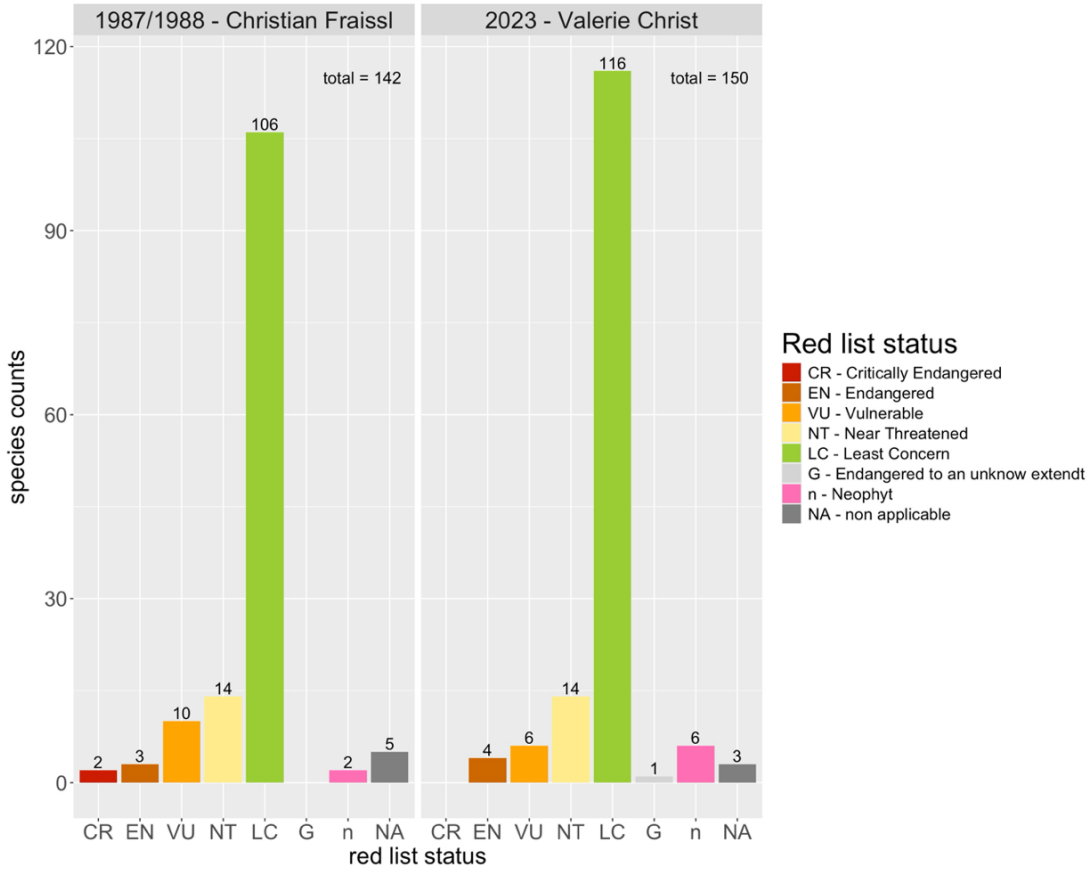


Figure 35 – Species found on open land habitat plots assigned to the red list categories. Fisher Test: p = 0.426

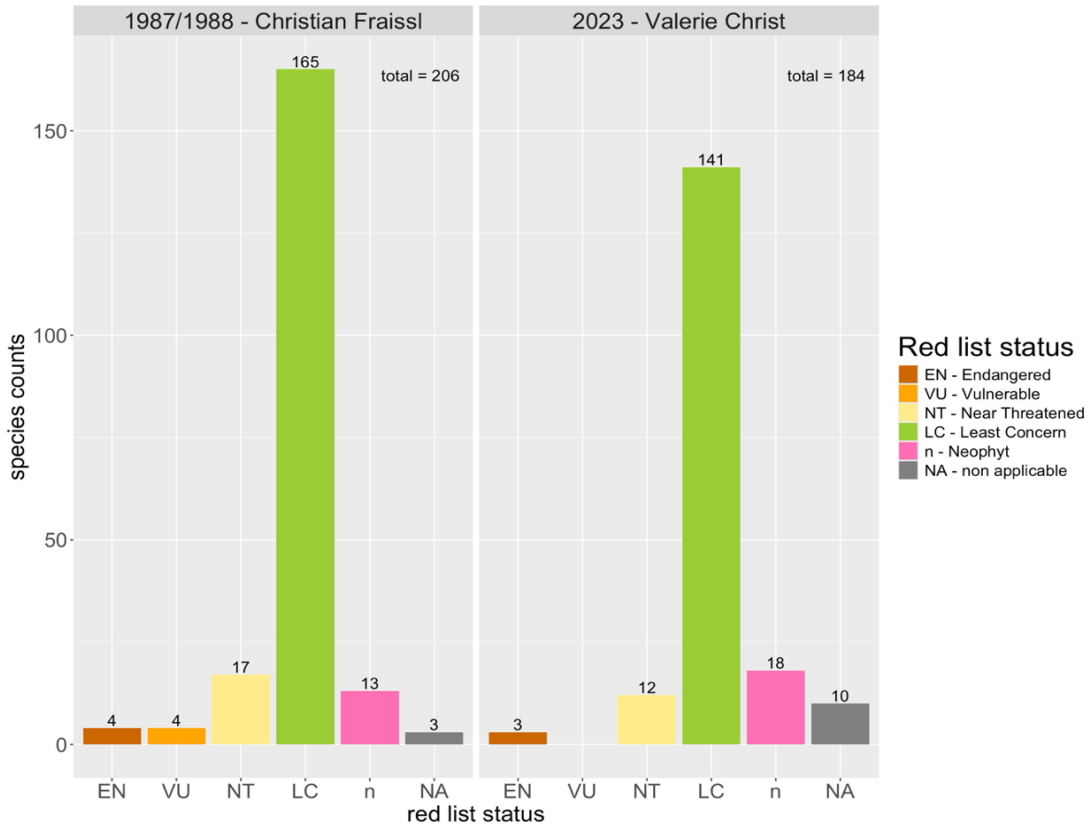


Figure 37 – Species found on woodland habitat plots assigned to the red list categories. Fisher Test: p = 0.260

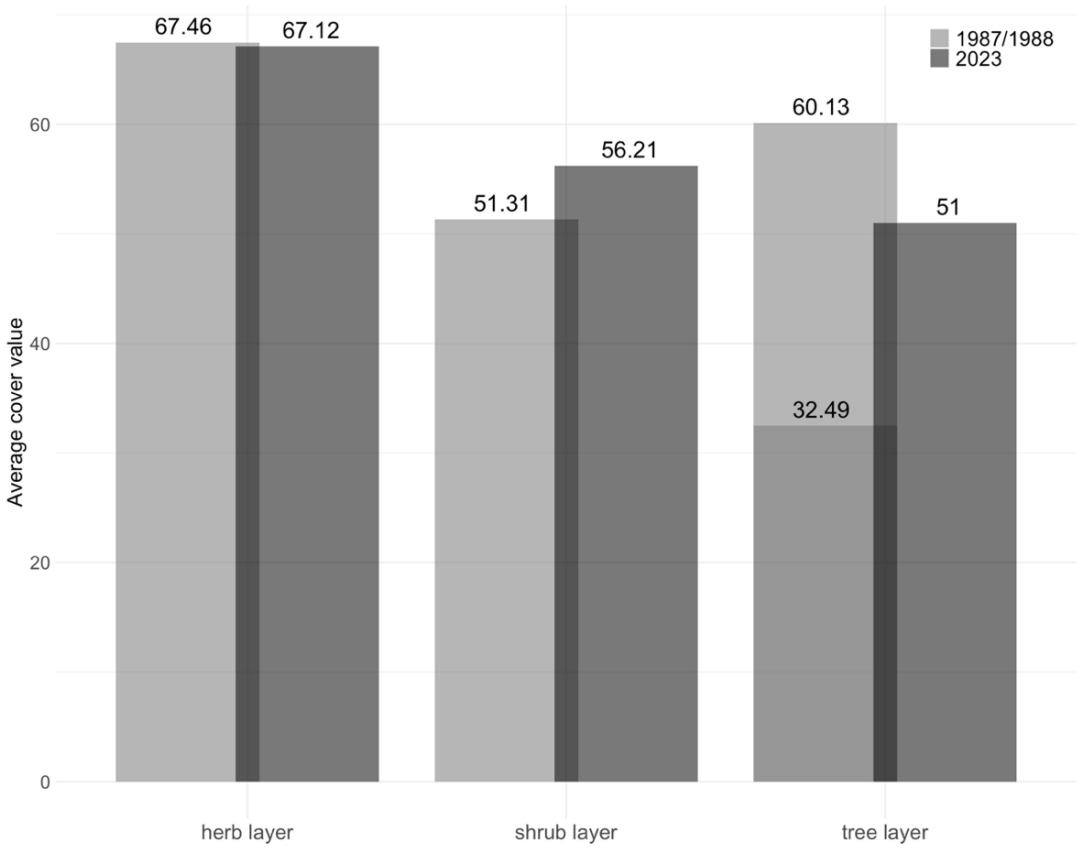


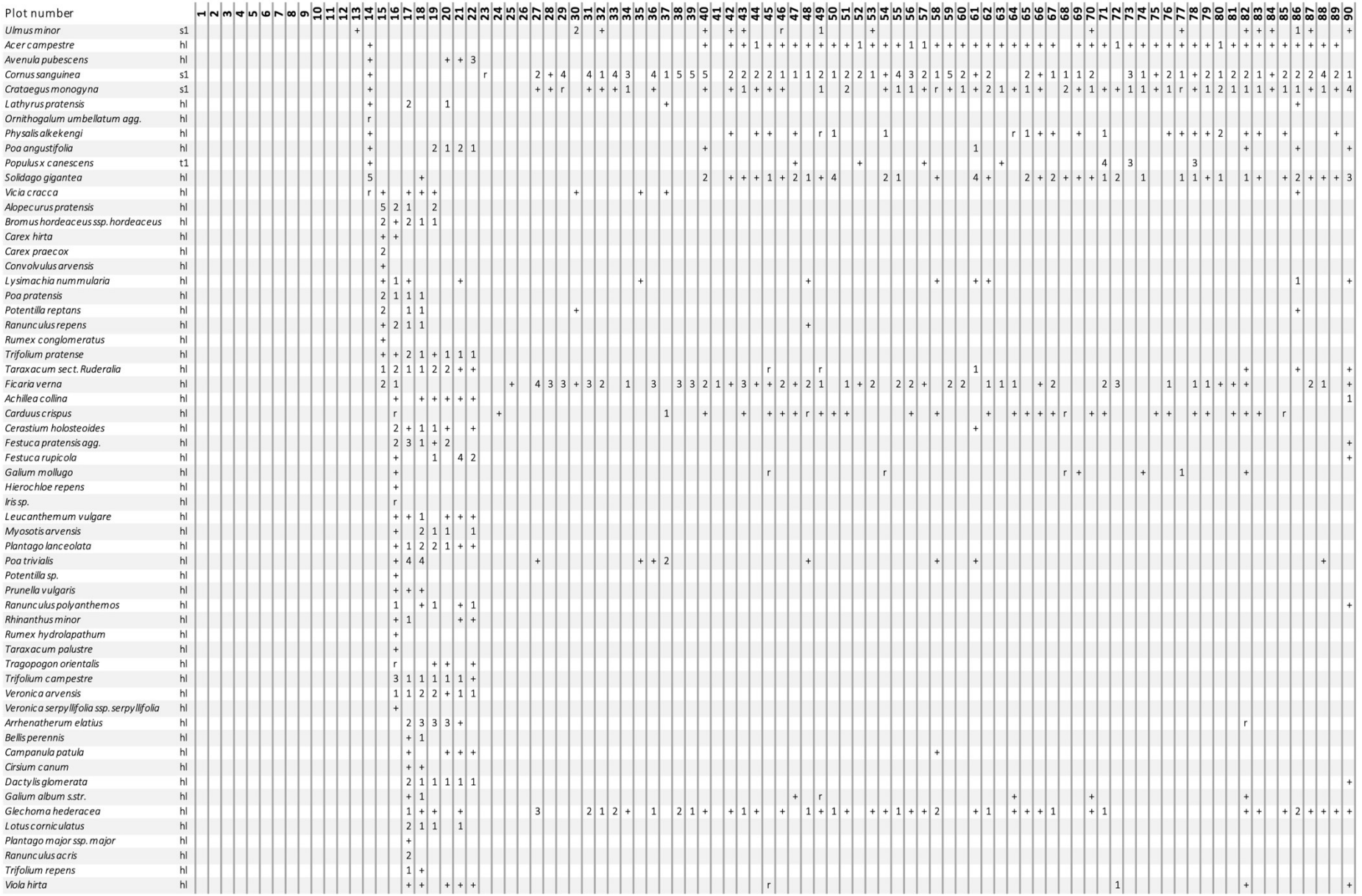
Figure 38 – Comparing the average cover values per layer in woodland habitat plots.

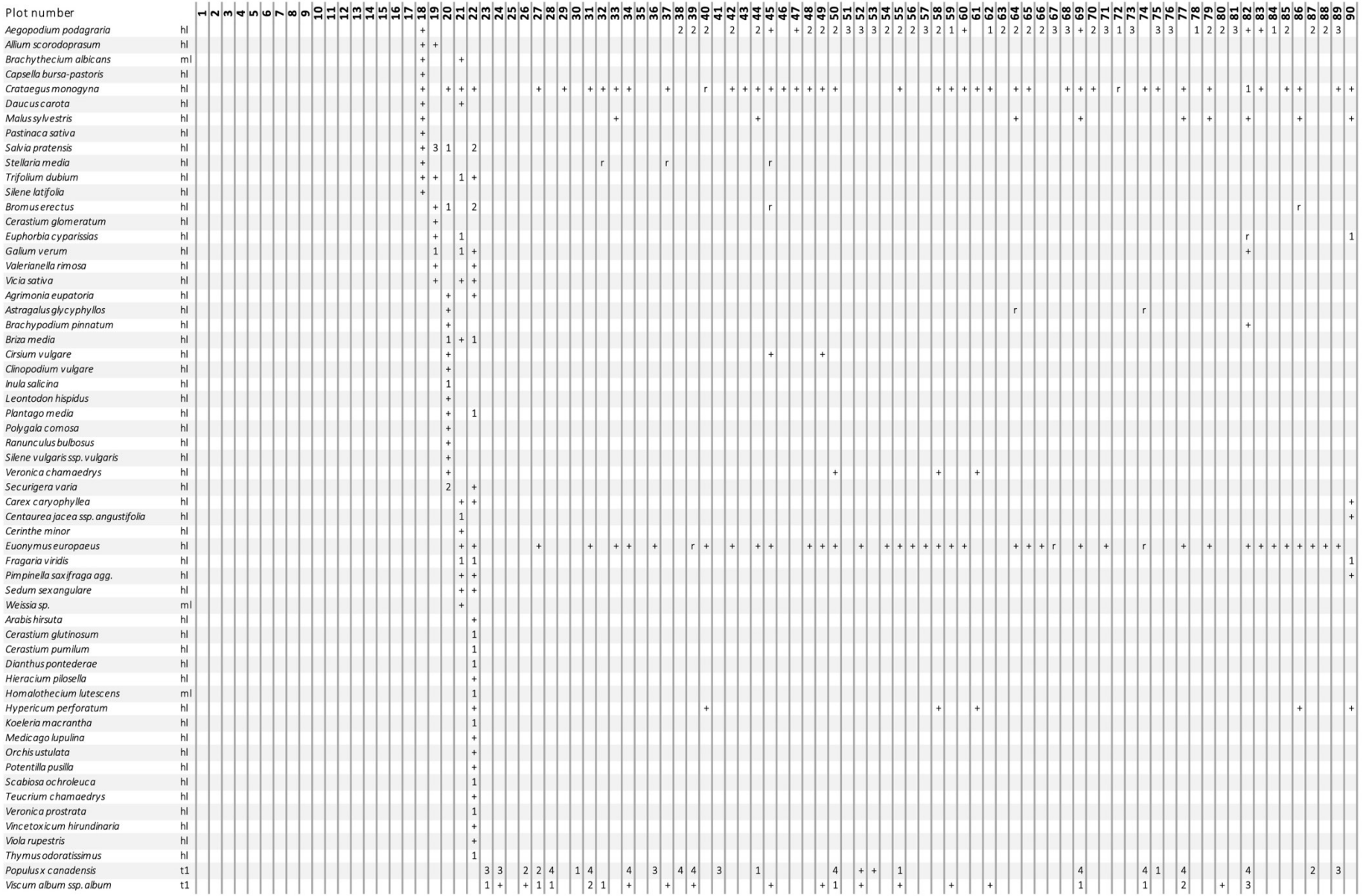
Table 7 – Vegetation data 1987/1988

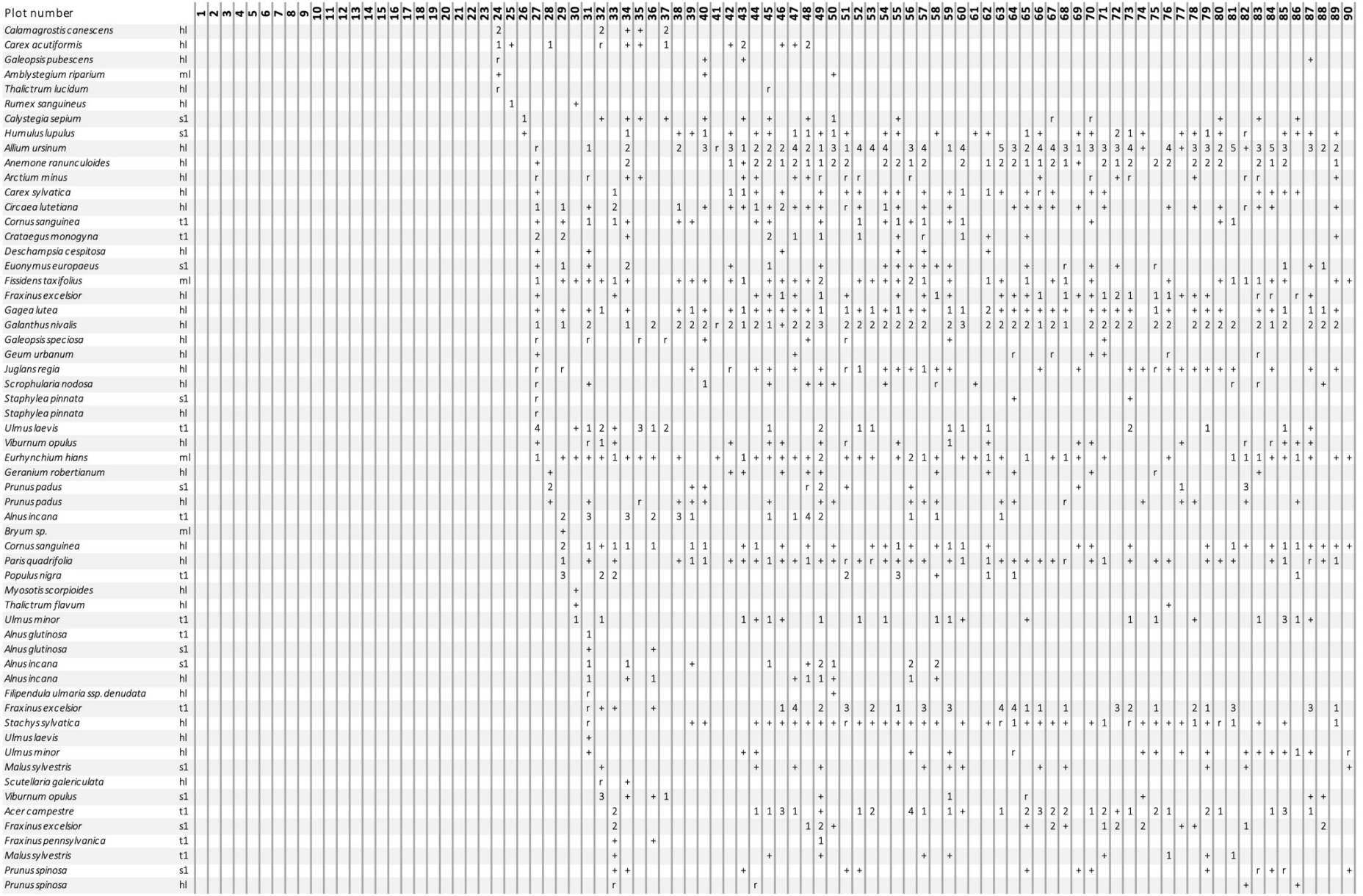
Plot number		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
Plot size (m^2)		9	12	100	1	9	10	60	16	50	50	60	80	60	-	70	100	100	100	-	-	100	60	400	-	400	200	-	-	400	-
Habitat typ		A	A	A	A	A	A	A	A	O	O	O	O	O	O	O	O	O	O	O	O	O	O	W	W	W	W	W	W	W	W
Cover total (%)		75	50	100	25	35	45	70	100	95	95	80	90	90	100	95	90	100	90	80	90	70	70	0	0	0	0	0	0	0	0
Cover tree layer 1 (%)		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	85	60	95	0	75	75	85	70
Cover tree layer 2 (%)		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	20	15	0	40	5
Cover shrub layer (%)		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	25	20	60	15
Cover herb layer (%)		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	100	95	30	100	80	100	80	100
Waterdepth		40	30	100	30	45	50	145	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Number of species		1	3	3	3	3	4	5	3	8	16	11	19	16	16	17	37	39	40	31	39	37	52	12	26	16	11	31	20	20	27
Lemna minor	hl	4	3	3	1	2	2																								
Lemna trisulca	hl		+	1	+	1	+		+																						
Spirodela polyrhiza	hl		2																												
Riccia fluitans	ml			4	2																										
Ricciocarpos natans	ml					2	2																								
Calliergonella cuspidata	ml						1	2										+													
Ceratophyllum demersum s.lat.	hl							3																							
Myriophyllum verticillatum	hl							+																							
Nuphar lutea	hl							4																							
Ranunculus circinatus	hl							r																							
Chara sp.	hl								3																						
Potamogeton pusillus agg.	hl								4																						
Carex riparia	hl									3	3													r	2	+			+		+
Iris pseudacorus	hl									+	1	1	1	1										+	1	+	+		1		+
Lysimachia vulgaris	hl									+	1	1	+	2			+	+							+		+		r		r
Phalaris arundinacea	hl									+	2	1	4	3				+						2	2	1	2	+	4		3
Phragmites australis	hl									4	4	1	2	+				1							3	+	5		3		4
Populus alba	s1									+				1																	
Rubus caesius	hl									1	2	1	1	2										3	3	2	3		4	2	3
Carex acuta	hl									1	1	3		1											+	+					
Carex vesicaria	hl										1	2													+						
Equisetum arvense	hl										+	+	+	+			+	+			+								+		+
Galium aparine	hl										+		+		1									3	+	1		2	2	1	1
Galium palustre	hl										+	+													+	+					
Impatiens noli-tangere	hl										+			1										3	1	+		1	3	2	1
Impatiens parviflora	hl										+													2	2	+		3	+	3	1
Poa palustris	hl										+						2								+						+
Salix alba	t1										1													4	2	5	2		3		4
Symphytum officinale	hl										1	+	1	2		1	2	1							1	+	+		1		+
Lythrum salicaria	hl											+	+	+											+						r
Calamagrostis epigejos	hl												2								+	2									
Calystegia sepium	hl												+		+																
Cirsium arvense	hl												+		1			+		+					1						
Colchicum autumnale	hl												+		+	1	2	+		+	+	2	1								
Euphorbia palustris	hl												3																		
Humulus lupulus	hl												+																		
Populus alba	t1												1																	4	1
Urtica dioica	hl												+	+	+									5	2	+		+		+	1
Veronica sp.	hl												+																		
Vicia sepium	hl												+								2										
Euphorbia lucida	hl													2		+	4														
Persicaria amphibia	hl													+																	
Populus alba	hl													+																+	+
Ulmus laevis	s1													1																	

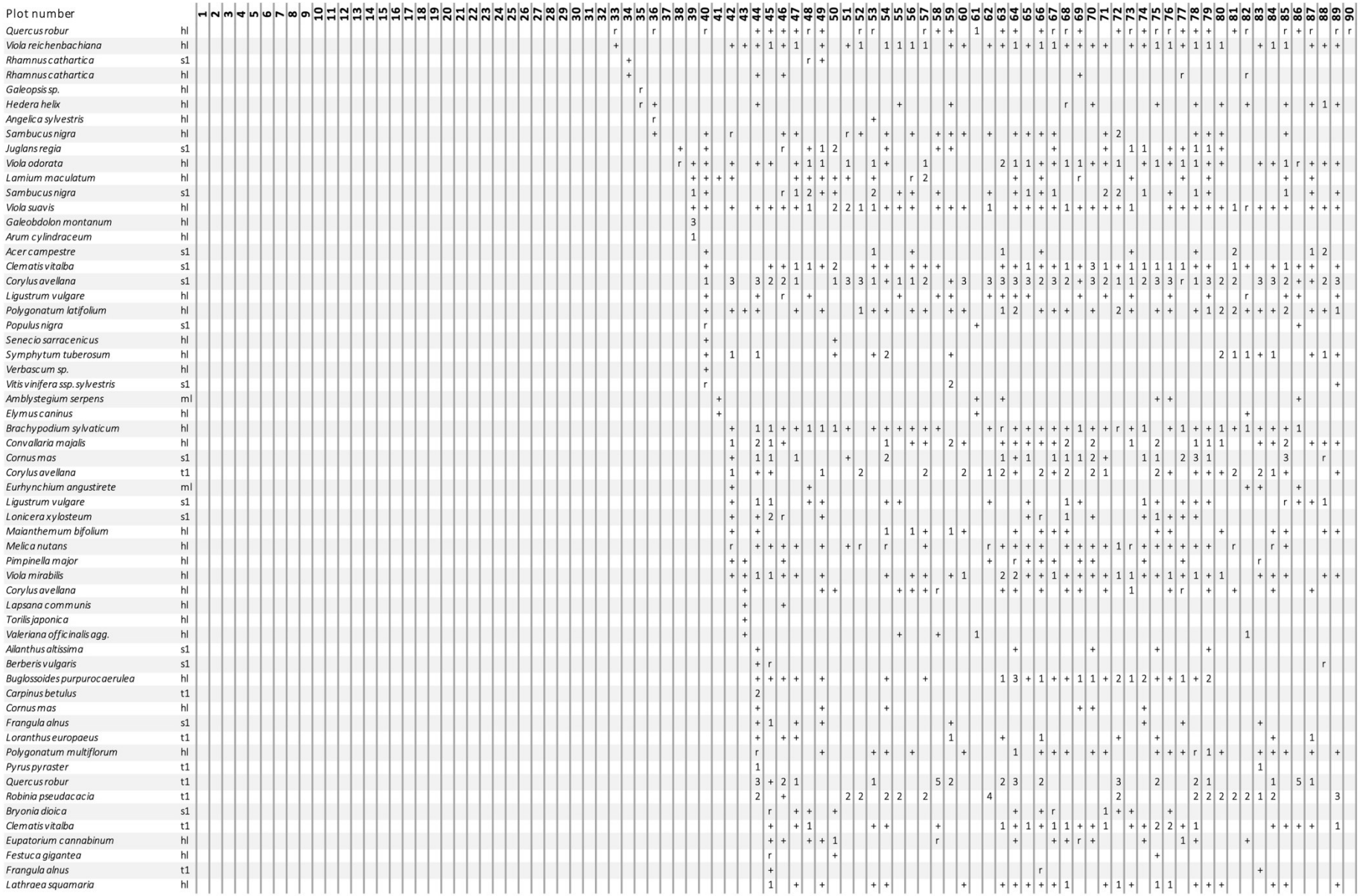
Plot number		31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60
Plot size (m^2)		400	-	400	-	-	-	-	400	-	400	-	-	-	400	-	-	400	-	-	400	-	-	400	400	-	-	400	400	400	400
Habitat typ		W	W	W	W	W	W	W	W	W	W	W	W	W	W	W	W	W	W	W	W	W	W	W	W	W	W	W	W	W	W
Cover total (%)		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cover tree layer 1 (%)		70	70	75	70	70	85	50	70	70	0	70	85	0	80	70	75	70	0	65	55	65	75	40	85	70	75	80	5	60	80
Cover tree layer 2 (%)		60	25	50	55	40	30	20	35	5	0	0	4	50	20	35	15	55	75	50	0	0	35	70	40	20	40	35	90	35	30
Cover shrub layer (%)		80	40	75	70	0	75	8	80	95	85	0	65	25	70	65	30	20	55	75	35	50	60	45	40	75	65	45	30	100	65
Cover herb layer (%)		60	95	65	60	80	45	95	85	65	75	95	55	90	70	65	65	80	70	70	100	65	50	50	65	75	65	70	70	40	20
Waterdepth		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Number of species		34	32	25	40	28	25	30	22	27	50	18	47	41	56	71	58	55	62	75	57	43	38	41	52	46	41	48	51	40	32
Lemna minor	hl																														
Lemna trisulca	hl																														
Spirodela polyrhiza	hl																														
Riccia fluitans	ml																														
Ricciocarpos natans	ml																														
Calliergonella cuspidata	ml							2																							
Ceratophyllum demersum s.lat.	hl																														
Myriophyllum verticillatum	hl																														
Nuphar lutea	hl																														
Ranunculus circinatus	hl																														
Chara sp.	hl																														
Potamogeton pusillus agg.	hl																														
Carex riparia	hl				1	+		1																							
Iris pseudacorus	hl		+		+	2		+						1		+	+	+	+	r	+										
Lysimachia vulgaris	hl		1		+	2		1						1		r	+														
Phalaris arundinacea	hl	+	3		+	1	+	2			+	+							+		3										
Phragmites australis	hl		2		2	2		3				+		1		r			1												
Populus alba	s1										+				r	+															
Rubus caesius	hl	2	4	1	2	3	1	4	1	2	2	2	1	3	+	2	2	2	2	1	2	1	1	+	+	2	1	+	+	+	+
Carex acuta	hl				+	3		1																							
Carex vesicaria	hl					1		1																		+					
Equisetum arvense	hl		+		+	1		+				r	+				r	r	+		1				+	+			+		r
Galium aparine	hl	+	1	+	+		2	1	2	2	1	2				1			+	+	1	r		2					2		
Galium palustre	hl		+		+	+																									
Impatiens noli-tangere	hl	+	1	+	1	+		+	2	2		2	+	1				1	+	+		2		+	+	+	1	+	+		
Impatiens parviflora	hl	1	2	2	+	+	2	2	3	1	1	3	1	2	1	2	1	+	1	+	+	2	1	+	1	+	1	2	1	+	
Poa palustris	hl				+							+																			
Salix alba	t1		4		1	1	3	3								2				1											
Symphytum officinale	hl	r	+		1	1		1			+			1		+			+		1					+			+		
Lythrum salicaria	hl		+		+									+					+												
Calamagrostis epigejos	hl										+																		r		
Calystegia sepium	hl																														
Cirsium arvense	hl							1			+										1										
Colchicum autumnale	hl													1			1	r	1							1					
Euphorbia palustris	hl																														
Humulus lupulus	hl																														
Populus alba	t1			4		4						3	5	3	2	3								+	5	2		2	+	2	5
Urtica dioica	hl	1		+	+		1		2	1	2	4	+		+			+	+		+	r		+	1	+	+		1		
Veronica sp.	hl																														
Vicia sepium	hl																				+										
Euphorbia lucida	hl																														
Persicaria amphibia	hl																														
Populus alba	hl			+		+							+	+	+	+	r								+			+		+	+
Ulmus laevis	s1																							+							

Plot number		61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90
Plot size (m^2)		400	-	400	400	-	400	400	400	400	400	400	-	400	400	400	400	400	400	400	-	400	400	400	400	-	400	-	400	400	400
Habitat typ		W	W	W	W	W	W	W	W	W	W	W	W	W	W	W	W	W	W	W	W	W	W	W	W	W	W	W	W	W	W
Cover total (%)		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cover tree layer 1 (%)		0	70	80	75	70	60	75	4	70	15	75	70	75	65	60	75	70	75	70	85	80	55	90	90	30	20	50	0	80	0
Cover tree layer 2 (%)		0	5	40	25	35	70	25	75	80	25	30	10	10	80	30	10	80	15	50	10	35	45	30	8	65	90	80	0	20	0
Cover shrub layer (%)		60	80	50	50	70	30	65	50	20	80	40	35	50	40	60	70	40	60	70	40	50	85	60	50	80	60	30	100	50	70
Cover herb layer (%)		95	65	65	80	70	70	80	60	45	55	75	85	70	60	70	65	60	70	70	65	60	45	25	30	65	60	40	40	70	70
Waterdepth		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Number of species		33	43	43	64	53	60	58	56	50	58	54	40	47	45	50	57	49	55	57	43	35	56	49	42	51	43	50	38	51	39
Lemna minor	hl																														
Lemna trisulca	hl																														
Spirodela polyrhiza	hl																														
Riccia fluitans	ml																														
Ricciocarpos natans	ml																														
Calliergonella cuspidata	ml																														
Ceratophyllum demersum s.lat.	hl																														
Myriophyllum verticillatum	hl																														
Nuphar lutea	hl																														
Ranunculus circinatus	hl																														
Chara sp.	hl																														
Potamogeton pusillus agg.	hl																														
Carex riparia	hl																														
Iris pseudacorus	hl						r					r												+							
Lysimachia vulgaris	hl																														
Phalaris arundinacea	hl																												+		
Phragmites australis	hl																														
Populus alba	s1	+																											1		+
Rubus caesius	hl	+	2	1	+	2	1	+	+		+	1		+	1	1	+	+		1	+	1	+	1	+	+	+	+	1	1	+
Carex acuta	hl																														
Carex vesicaria	hl																														
Equisetum arvense	hl		+	r						+		+			+			+												+	
Galium aparine	hl	r	2		+		1	+				1	2	+							r	+						1	+		+
Galium palustre	hl																														
Impatiens noli-tangere	hl		+					1				+					+		+		+	+						+		1	
Impatiens parviflora	hl		1		+	1	+	1	+	1	1	1	2	2	1	1	+		+	1	2	1		r	1	1		+		2	
Poa palustris	hl																											r			
Salix alba	t1																										1				
Symphytum officinale	hl		+				r	r						+									+	+			+				
Lythrum salicaria	hl																														
Calamagrostis epigejos	hl	3																r					+								3
Calystegia sepium	hl																														
Cirsium arvense	hl	+																	+				+								+
Colchicum autumnale	hl					1		+	+		+	+	1						2	1			2							+	2
Euphorbia palustris	hl																														
Humulus lupulus	hl																														
Populus alba	t1		1	+		4	+	4	3		2						4			3	4			5	5			4		3	
Urtica dioica	hl				+	+	+	+		+	+	+	1	+	r	+	+		1	+	1			+		+	+	+	+	+	
Veronica sp.	hl																														
Vicia sepium	hl																														
Euphorbia lucida	hl																														
Persicaria amphibia	hl																														
Populus alba	hl							r	r		+						+				+			+	+						
Ulmus laevis	s1																														


Plot number
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80 81 82 83 84 85 86 87 88 89 90
Ulmus minor s1
Acer campestre hl
Avenula pubescens hl
Cornus sanguinea s1
Crataegus monogyna s1
Lathyrus pratensis hl
Ornithogalum umbellatum agg. hl
Physalis alkekengi hl
Poa angustifolia hl
Populus x canescens t1
Solidago gigantea hl
Vicia cracca hl
Alopecurus pratensis hl
Bromus hordeaceus ssp. hordeaceus hl
Carex hirta hl
Carex praecox hl
Convolvulus arvensis hl
Lysimachia nummularia hl
Poa pratensis hl
Potentilla reptans hl
Ranunculus repens hl
Rumex conglomeratus hl
Trifolium pratense hl
Taraxacum sect. Ruderalia hl
Ficaria verna hl
Achillea collina hl
Carduus crispus hl
Cerastium holosteoides hl
Festuca pratensis agg. hl
Festuca rupicola hl
Galium mollugo hl
Hierochloe repens hl
Iris sp. hl
Leucanthemum vulgare hl
Myosotis arvensis hl
Plantago lanceolata hl
Poa trivialis hl
Potentilla sp. hl
Prunella vulgaris hl
Ranunculus polyanthemos hl
Rhinanthus minor hl
Rumex hydrolapathum hl
Taraxacum palustre hl
Tragopogon orientalis hl
Trifolium campestre hl
Veronica arvensis hl
Veronica serpyllifolia ssp. serpyllifolia hl
Arrhenatherum elatius hl
Bellis perennis hl
Campanula patula hl
Cirsium canum hl
Dactylis glomerata hl
Galium album s.str. hl
Glechoma hederacea hl
Lotus corniculatus hl
Plantago major ssp. major hl
Ranunculus acris hl
Trifolium repens hl
Viola hirta hl


Plot number
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80 81 82 83 84 85 86 87 88 89 90
Aegopodium podagraria hl
Allium scorodoprasum hl
Brachythecium albicans ml
Capsella bursa-pastoris hl
Crataegus monogyna hl
Daucus carota hl
Malus sylvestris hl
Pastinaca sativa hl
Salvia pratensis hl
Stellaria media hl
Trifolium dubium hl
Silene latifolia hl
Bromus erectus hl
Cerastium glomeratum hl
Euphorbia cyparissias hl
Galium verum hl
Valerianella rimosa hl
Vicia sativa hl
Agrimonia eupatoria hl
Astragalus glycyphyllos hl
Brachypodium pinnatum hl
Briza media hl
Cirsium vulgare hl
Clinopodium vulgare hl
Inula salicina hl
Leontodon hispidus hl
Plantago media hl
Polygala comosa hl
Ranunculus bulbosus hl
Silene vulgaris ssp. vulgaris hl
Veronica chamaedrys hl
Securigera varia hl
Carex caryophyllea hl
Centaurea jacea ssp. angustifolia hl
Cerinthe minor hl
Euonymus europaeus hl
Fragaria viridis hl
Pimpinella saxifraga agg. hl
Sedum sexangulare hl
Weissia sp. ml
Arabis hirsuta hl
Cerastium glutinosum hl
Cerastium pumilum hl
Dianthus pontederae hl
Hieracium pilosella hl
Homalothecium lutescens ml
Hypericum perforatum hl
Koeleria macrantha hl
Medicago lupulina hl
Orchis ustulata hl
Potentilla pusilla hl
Scabiosa ochroleuca hl
Teucrium chamaedrys hl
Veronica prostrata hl
Vincetoxicum hirundinaria hl
Viola rupestris hl
Thymus odoratissimus hl
Populus x canadensis t1
Viscum album ssp. album t1


Plot number
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80 81 82 83 84 85 86 87 88 89 90
Calamagrostis canescens hl
Carex acutiformis hl
Galeopsis pubescens hl
Amblystegium riparium ml
Thalictrum lucidum hl
Rumex sanguineus hl
Calystegia sepium s1
Humulus lupulus s1
Allium ursinum hl
Anemone ranunculoides hl
Arctium minus hl
Carex sylvatica hl
Circaea lutetiana hl
Cornus sanguinea t1
Crataegus monogyna t1
Deschampsia cespitosa hl
Euonymus europaeus s1
Fissidens taxifolius ml
Fraxinus excelsior hl
Gagea lutea hl
Galanthus nivalis hl
Galeopsis speciosa hl
Geum urbanum hl
Juglans regia hl
Scrophularia nodosa hl
Staphylea pinnata s1
Staphylea pinnata hl
Ulmus laevis t1
Viburnum opulus hl
Eurhynchium hians ml
Geranium robertianum hl
Prunus padus s1
Prunus padus hl
Alnus incana t1
Bryum sp. ml
Cornus sanguinea hl
Paris quadrifolia hl
Populus nigra t1
Myosotis scorpioides hl
Thalictrum flavum hl
Ulmus minor t1
Alnus glutinosa t1
Alnus glutinosa s1
Alnus incana s1
Alnus incana hl
Filipendula ulmaria ssp. denudata hl
Fraxinus excelsior t1
Stachys sylvatica hl
Ulmus laevis hl
Ulmus minor hl
Malus sylvestris s1
Scutellaria galericulata hl
Viburnum opulus s1
Acer campestre t1
Fraxinus excelsior s1
Fraxinus pennsylvanica t1
Malus sylvestris t1
Prunus spinosa s1
Prunus spinosa hl


Plot number
Quercus robur hl
Viola reichenbachiana hl
Rhamnus cathartica s1
Rhamnus cathartica hl
Galeopsis sp. hl
Hedera helix hl
Angelica sylvestris hl
Sambucus nigra hl
Juglans regia s1
Viola odorata hl
Lamium maculatum hl
Sambucus nigra s1
Viola suavis hl
Galeobdolon montanum hl
Arum cylindraceum hl
Acer campestre s1
Clematis vitalba s1
Corylus avellana s1
Ligustrum vulgare hl
Polygonatum latifolium hl
Populus nigra s1
Senecio sarracenicus hl
Symphytum tuberosum hl
Verbascum sp. hl
Vitis vinifera ssp. sylvestris s1
Amblystegium serpens ml
Elymus caninus hl
Brachypodium sylvaticum hl
Convallaria majalis hl
Cornus mas s1
Corylus avellana t1
Eurhynchium angustirete ml
Ligustrum vulgare s1
Lonicera xylosteum s1
Maianthemum bifolium hl
Melica nutans hl
Pimpinella major hl
Viola mirabilis hl
Corylus avellana hl
Lapsana communis hl
Torilis japonica hl
Valeriana officinalis agg. hl
Ailanthus altissima s1
Berberis vulgaris s1
Buglossoides purpurocaerulea hl
Carpinus betulus t1
Cornus mas hl
Frangula alnus s1
Loranthus europaeus t1
Polygonatum multiflorum hl
Pyrus pyraster t1
Quercus robur t1
Robinia pseudacacia t1
Bryonia dioica s1
Clematis vitalba t1
Eupatorium cannabinum hl
Festuca gigantea hl
Frangula alnus t1
Lathraea squamaria hl


Plot number
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80 81 82 83 84 85 86 87 88 89 90
Lonicera caprifolium s1
Parietaria officinalis hl
Prunus padus t1
Pulmonaria officinalis hl
Salvia glutinosa hl
Sanicula europaea hl
Acer pseudoplatanus hl
Galium odoratum hl
Pyrus pyraster s1
Senecio germanicus ssp. germanicus hl
Aristolochia clematitis hl
Juglans regia t1
Bryum pseudotriquetrum ml
Heracleum sphondylium hl
Lycopus europaeus hl
Solanum dulcamara hl
Acer pseudoplatanus s1
Campanula trachelium hl
Cardamine impatiens hl
Prunus cerasifera s1
Rosa canina s.lat. (= agg.) hl
Asarum europaeum ssp. europaeum hl
Chelidonium majus hl
Cruciata laevipes hl
Cucubalus baccifer hl
Dipsacus pilosus hl
Moehringia trinervia hl
Myosoton aquaticum hl
Vicia dumetorum hl
Aethusa cynapium hl
Carex tomentosa hl
Euphorbia stricta hl
Acer pseudoplatanus t1
Betula pendula s1
Populus x canescens hl
Senecio sp. hl
Alliaria petiolata hl
Allium carinatum hl
Juglans nigra t1
Juglans nigra s1
Veronica sublobata hl
Viola riviniana hl
Stachys palustris hl
Populus x canescens s1
Brachythecium rivulare ml
Carex muricata agg. hl
Lonicera caprifolium hl
Vitis vinifera ssp. sylvestris t1
Betula pendula t1
Erigeron annuus hl
Myosotis ramosissima hl
Quercus robur s1
Salix caprea s1
Salix cinerea s1
Salix purpurea s1
Tilia cordata t1
Pseudotaxiphyllum elegans ml
Hypericum hirsutum hl
Sisymbrium strictissimum hl

Plot number		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45
Berberis vulgaris	hl																																													
Epipactis helleborine	hl																																													
Colutea arborescens	hl																																													
Eurhynchium striatum	ml																																													
Lonicera xylosteum	hl																																													
Plagiomnium undulatum	ml																																													
Viburnum lantana	s1																																													
Viburnum lantana	hl																																													
Fraxinus pennsylvanica	hl																																													
Pyrus pyraster	hl																																													
Rosa canina s.lat. (= agg.)	s1																																													
Tilia cordata	s1																																													
Ailanthus altissima	t1																																													
Ailanthus altissima	hl																																													
Funaria hygrometrica	ml																																													
Fraxinus pennsylvanica	s1																																													
Bromus benekenii	hl																																													
Campanula rapunculoides	hl																																													
Robinia pseudacacia	hl																																													
Frangula alnus	hl																																													
Prunus domestica	s1																																													
Cornus mas	t1																																													
Acer negundo	s1																																													
Juglans nigra	hl																																													
Ribes rubrum agg.	hl																																													
Sambucus nigra	t1																																													
Carex flacca	hl																																													
Galium glaucum	hl																																													
Potentilla neumanniana	hl																																													
Weissia controversa	ml																																													

Plot number		46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90
Berberis vulgaris	hl																				+					r																				
Epipactis helleborine	hl																					r		r	+					+			+									+				
Colutea arborescens	hl																							r	r							r							r							
Eurhynchium striatum	ml																							+																						
Lonicera xylosteum	hl																							+					r																	
Plagiomnium undulatum	ml																							+																						
Viburnum lantana	s1																							+																				+		
Viburnum lantana	hl																							+	+						r															
Fraxinus pennsylvanica	hl																								+								+													
Pyrus pyraster	hl																								r													r				+				
Rosa canina s.lat. (= agg.)	s1																									r				r																
Tilia cordata	s1																											+						+												
Ailanthus altissima	t1																														1				+											
Ailanthus altissima	hl																														+				+											
Funaria hygrometrica	ml																															+														
Fraxinus pennsylvanica	s1																																+													
Bromus benekenii	hl																																		+											
Campanula rapunculoides	hl																																			r										
Robinia pseudacacia	hl																																				r									
Frangula alnus	hl																																					+				+				
Prunus domestica	s1																																					+								
Cornus mas	t1																																								+					
Acer negundo	s1																																									+				
Juglans nigra	hl																																										+			
Ribes rubrum agg.	hl																																										+			
Sambucus nigra	t1																																										+			
Carex flacca	hl																																													+
Galium glaucum	hl																																													1
Potentilla neumanniana	hl																																													+
Weissia controversa	ml																																													+

Table 8 – Vegetation data spring 2023

Plot number		27	29	31	32	34_max	34_min	36	38	39	40	41_1	41_2	42_1	42_2	43_max	43_min	44	45	46_max	46_min
Date		20230416	20230412	20230412	20230416	20230416	20230416	20230416	20230412	20230412	20230412	20230416	20230416	20230415	20230415	20230415	20230415	20230411	20230413	20230413	20230413
Plot size (m^2)		400	400	400	160	240	140	400	400	400	400	170	400	220	150	400	180	400	220	330	160
Habitat typ		W	W	W	W	W	W	W	W	W	W	W	W	W	W	W	W	W	W	W	W
Cover herb layer (%)		70	30	93	85	94	90	70	89	85	99	98	65	65	83	40	43	45	93	75	70
Cover litter layer (%)		20	62	0	10	2	5	8	0	0	1	0	4	43	17	52	50	54	5	15	17
Cover open ground (%)		10	1	0	5	1	0	14	1	12	0	1	22	0	0	3	0	1	2	10	13
Cover deathwood (%)		0	7	7	0	3	5	8	10	3	0	1	9	2	0	5	7	0	0	0	0
Number of species		13	8	10	11	19	17	8	13	13	10	14	13	7	8	13	8	8	13	10	5
Aegopodium podagraria	hl					+	1		+		+	+	+		+			+			
Allium ursinum	hl	+	+		3	2	2		3	+	4	2	2	3	5	3	3	2	4	4	3
Anemone ranunculoides	hl				+	3	3		+					2	1	2	2	1	2	+	+
Cardamine impatiens	hl																				
Convallaria majalis	hl													+		+	+	r	1		
Gagea lutea	hl				+	+	+									r		r	r	r	
Galanthus nivalis	hl	+	1	+	3	2	2	1	1	+		2	1	2	1	2	1	1	2	2	2
Galeopsis speciosa	hl																				
Galium sylvaticum	hl																			+	
Lathraea squamaria	hl		r								r					+	+	r	r	+	r
Paris quadrifolia	hl	+	+	1		+	+							+		+	+		+		
Polygonatum latifolium	hl				1	+										r					
Pulmonaria officinalis	hl																		+		
Ficaria verna	hl	3	2	2	2	+	+	3	2	1	+	2	2	2	+	2	2	+	+	1	+
Sanicula europaea	hl																				
Stachys sylvatica	hl																				
Viola mirabilis	hl																		+	+	
Viola odorata	hl					+	+														
Viola reichenbachiana	hl				+	+	+							+	r	+	+		+	+	
Galium aparine agg.	hl	3	1	2	1	r	r	2	2	2	3	2	2		+					r	
Glechoma hederacea agg.	hl	+		1					1	1		1	1								
Bromus ramosus agg.	hl																				
Geranium robertianum	hl																				
Melica nutans	hl																				
Parietaria officinalis	hl									+	+	+	+								
Stellaria media	hl	+		+				1	+	3		1	1								
Urtica dioica	hl	1	+	1	+			+	+	2	2	1	2								
Viola suavis	hl																				
Carex acutiformis	hl																				
Geum urbanum	hl	+		+								r									
Lamium maculatum	hl								1	2	+	2	2								
Maianthemum bifolium	hl																				
Scrophularia nodosa	hl																				
Viola sp.	hl				+	+	+								+	+					
Galium sp.	hl																		r		
Salvia glutinosa	hl																		+		
Solidago gigantea	hl					1	1					+									
Alliaria petiolata	hl	+		1	+	r	r	+		+	+										
Heracleum sphondylium	hl																				
Lamium purpureum	hl									+											
Cirsium oleraceum	hl																				
Carex otrubae	hl																				

Plot number		47	48_max	48_min	49_max	49_min	50	51_CF	51_min	52	53	54	55	56_max	56_min	57	58	59	60_1	60_2	61	62_1_max	62_1_min	62_2
Date		20230405	20230413	20230413	20230415	20230415	20230405	20230415	20230415	20230416	20230412	20230411	20230415	20230416	20230416	20230412	20230411	20230412	20230411	20230411	20230411	20230415	20230415	20230415
Plot size (m^2)		400	220	70	360	240	400	225	135	400	400	400	400	380	130	400	400	400	400	400	400	400	200	160
Habitat typ		W	W	W	W	W	W	W	W	W	W	W	W	W	W	W	W	W	W	W	W	W	W	W
Cover herb layer (%)		98	99	100	68	80	98	60	60	97	90	96	60	55	65	98	40	85	95	70	1	80	78	93
Cover litter layer (%)		1	1	0	22	20	1	39	39	1	3	1	40	45	35	2	57	5	2	28	96	20	22	1
Cover open ground (%)		1	0	0	10	0	0	1	1	1	7	1	0	0	0	0	1	10	0	1	3	0	0	3
Cover deathwood (%)		0	0	0	0	0	1	0	0	1	0	2	0	0	0	0	2	0	3	1	0	0	0	3
Number of species		17	20	14	12	11	12	12	11	11	20	11	9	15	15	13	16	12	9	8	8	18	13	16
Aegopodium podagraria	hl	1	1	1			+	+	+	1	+	1	+	r	+	+	+		+			1	+	1
Allium ursinum	hl	5	4	4	4	4	5	1	1	4	2	5	3	2	2	4	1	2	5	3	r	1	1	1
Anemone ranunculoides	hl	2	1	1	2	2	2	2	2			1	1	2	2	1	+		2	1		2	2	2
Cardamine impatiens	hl																							
Convallaria majalis	hl										+					+		+						
Gagea lutea	hl	+	r	r			+					r	r	+	+	+		r	+	+				
Galanthus nivalis	hl	2	2	2	2	2	2	2	2	2	1	1	1	2	2	3	r	1	2	2	r	2	2	2
Galeopsis speciosa	hl																							
Galium sylvaticum	hl																							
Lathraea squamaria	hl										+	r		+	+				+	+				
Paris quadrifolia	hl		+	r	+	+	+	+	+			+	+	r	r		r			r		+	+	+
Polygonatum latifolium	hl	r			+	+		r	r		+	+		r	r	+			+			+		
Pulmonaria officinalis	hl				1	1								+	+	+	+				r			
Ficaria verna	hl	+	2	2	2	2	1	2	2	2	1		+	+	1	1	3	2	1	1	r	2	2	2
Sanicula europaea	hl	1																				r		
Stachys sylvatica	hl																							
Viola mirabilis	hl	+			+	+	r							+	+	+								
Viola odorata	hl	+	+				+					r				r	r							
Viola reichenbachiana	hl	+	+		+	+		1	1	1	r	+	+	+	1	1	+	r	1	1	+	1	+	1
Galium aparine agg.	hl	r	+	r				+	+	1	+	r		+	+	+	+	+			r	2	3	2
Glechoma hederacea agg.	hl						+	+	+		+		+					1			r	+	+	1
Bromus ramosus agg.	hl																							
Geranium robertianum	hl										+													
Melica nutans	hl																							
Parietaria officinalis	hl	r	1	1						+	+						+					+		+
Stellaria media	hl										4						r	2						1
Urtica dioica	hl		+								+						1	1				+		+
Viola suavis	hl	+									+													
Carex acutiformis	hl	1																						
Geum urbanum	hl	r	r	r						+											+			+
Lamium maculatum	hl	+	+	+													+					+	+	1
Maianthemum bifolium	hl																							
Scrophularia nodosa	hl																							
Viola sp.	hl				+	+		1	1	1				+	+							+	+	+
Galium sp.	hl																							
Salvia glutinosa	hl		+	r																				
Solidago gigantea	hl				1	1																		
Alliaria petiolata	hl				r					+	+						+	+				+		
Heracleum sphondylium	hl		+	+			r																	
Lamium purpureum	hl						r																	
Cirsium oleraceum	hl		r	r																				
Carex otrubae	hl		+																					

Plot number		63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90
Date		20230404	20230405	20230413	20230404	20230405	20230404	20230404	20230404	20230405	20230413	20230405	20230404	20230403	20230405	20230404	20230405	20230405	20230415	20230416	20230412	20230411	20230411	20230415	20230411	20230416	20230412	20230411	20230412
Plot size (m^2)		400	400	400	400	400	400	400	400	400	400	400	400	400	400	400	400	400	400	400	400	400	400	400	400	400	400	400	400
Habitat typ		W	W	W	W	W	W	W	W	W	W	W	W	W	W	W	W	W	W	W	W	W	W	W	W	W	W	W	W
Cover herb layer (%)		98	92	97	92	97	95	94	99	97	100	92	85	98	100	40	98	97	96	93	99	98	90	98	75	96	78	94	95
Cover litter layer (%)		1	7	2	7	3	2	2	0	2	0	7	7	2	0	30	1	2	3	0	0	2	10	1	22	1	22	4	0
Cover open ground (%)		1	1	0	1	0	1	4	1	0	0	0	8	0	0	30	0	1	0	1	1	0	0	1	3	1	0	0	5
Cover deathwood (%)		0	0	1	0	0	2	0	0	1	0	1	0	0	0	0	1	0	1	1	0	0	0	0	0	2	0	2	0
Number of species		10	15	14	10	15	15	13	13	15	18	14	15	19	12	13	11	14	15	15	16	14	9	19	15	15	19	11	14
Aegopodium podagraria	hl	+	+	+	+	+	+	+	1	+	+	+		1	1	+	r	+	1	+	+	+	+	2		+	+	1	
Allium ursinum	hl	5	5	5	5	5	5	4	5	5	3	4	4	5	5	2	5	5	4	3	5	5	5	4	4	2	2	4	1
Anemone ranunculoides	hl	2	2	2	r	1	+	2	1	2	2	2	1	2	1	r	1	2	2	+		r	+	2	+		1	2	
Cardamine impatiens	hl													r															
Convallaria majalis	hl		+	1			+					+		+					+					1			2		
Gagea lutea	hl	+	+	r	r			r			+	+		+	r			r	r	+	r					+		1	
Galanthus nivalis	hl	1	2	2	2	2	2	+	2	2	2	2		2	1		2	2	2	2	+	1	2	2		2	1	2	1
Galeopsis speciosa	hl													r															
Galium sylvaticum	hl			+		+			+	+	+			r	+			+											
Lathraea squamaria	hl		r				r		+	r		+		r	r		r	+	+			r	r	+				+	
Paris quadrifolia	hl		r	+		r			r	r		+		r	r	r	+	r	+		+	+	+	r	+			r	
Polygonatum latifolium	hl		+	r		r	+					+	r	+			+	r	r	+	+			r	r	+	+	1	+
Pulmonaria officinalis	hl	+	r	r	+	+						+	+	+	+	r	+	r		+				1	+				
Ficaria verna	hl			1		+		1					2	+			1		1	2	2	+		+	1	2	1	1	4
Sanicula europaea	hl	r			r	r	r		+					r							r								
Stachys sylvatica	hl													r															
Viola mirabilis	hl	+	+		r	+	+			+	2	1	+	+	+	1	+	+											
Viola odorata	hl	r	+		+	1	+	+	+	+	+	+	1	+		1	+	+	+			+		+		+	r	+	
Viola reichenbachiana	hl	+	+	+	1	+	+	1	1	+		+	1	+	+	1		+	1	+	1	1	1	1	1		+	r	1
Galium aparine agg.	hl		r				r	r	r		+					r			r	1	+	1	r	+	1	+	+		1
Glechoma hederacea agg.	hl					r			+	+	2		+							1		+					+		+
Bromus ramosus agg.	hl							1					+																
Geranium robertianum	hl												+									r							
Melica nutans	hl												+																
Parietaria officinalis	hl							+		+	1	r	+			2								r					+
Stellaria media	hl						r	+			1		1			2					1			r	3	3			2
Urtica dioica	hl							+		r			+			+				+	+			r	1	+			1
Viola suavis	hl		+			+				+	+							+											
Carex acutiformis	hl																												
Geum urbanum	hl						r				r					r				r	+			+	+				
Lamium maculatum	hl																					+					+		1
Maianthemum bifolium	hl						r																+	+			+		
Scrophularia nodosa	hl			+																									
Viola sp.	hl			+																1									
Galium sp.	hl																												
Salvia glutinosa	hl										+																		
Solidago gigantea	hl																												
Alliaria petiolata	hl										+									+	+			r	+	+	+		+
Heracleum sphondylium	hl														r														
Lamium purpureum	hl																												+
Cirsium oleraceum	hl																							r					
Carex otrubae	hl																												

Plot number		27	29	31	32	34_max	34_min	36	38	39	40	41_1	41_2	42_1	42_2	43_max	43_min	44	45	46_max	46_min	47	48_max	48_min	49_max	49_min	50	51_CF	51_min	52	53
Iris pseudacorus	hl																						+								
Veronica sublobata	hl	2	+	1				2	1	3	1	2	2										+					+			2
Buglossoides purpurocaerulea	hl																														
Capsella bursa-pastoris	hl																														
Circaea lutetiana	hl															+														+	
Polygonatum multiflorum	hl																														
Lysimachia nummularia	hl																														
Colchicum autumnale	hl															r															
Campanula sp.	hl					+	+																								
Carex sp.	hl					+	+																								
Impatiens parviflora	hl					r	r	3				+	+																		
Veronica chamaedrys	hl					r	r																								
Symphytum officinale	hl					+																									
Chelidonium majus	hl												+																		+
Galeobdolon montanum	hl								1	+																					+
Symphytum tuberosum	hl																														+
Carex sylvatica	hl	+																													
Rumex sp.	hl	r																													
Arum cylindraceum	hl								r																						
Fallopia japonica	hl																														

Plot number		54	55	56_max	56_min	57	58	59	60_1	60_2	61	62_1_max	62_1_min	62_2	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90
Iris pseudacorus	hl																																									
Veronica sublobata	hl						2	2																										1	+			1	2	2		2
Buglossoides purpurocaerulea	hl																							1																		
Capsella bursa-pastoris	hl																							+																		
Circaea lutetiana	hl																															r										
Polygonatum multiflorum	hl			+	+																											r					1			r		
Lysimachia nummularia	hl																																					+				
Colchicum autumnale	hl																																	+								
Campanula sp.	hl																																									
Carex sp.	hl																																									
Impatiens parviflora	hl																																						+			
Veronica chamaedrys	hl																																									
Symphytum officinale	hl																																									
Chelidonium majus	hl																																							+		
Galeobdolon montanum	hl																																									
Symphytum tuberosum	hl											+	+	+																									+	r		
Carex sylvatica	hl											1	+																													
Rumex sp.	hl																																									
Arum cylindraceum	hl																																									
Fallopia japonica	hl																																						+			

Table 9 – Vegetation date summer 2023

Plot number		1	2	3	4	5	7_max	7_min	8_max	8_min	9_max	9_min	10_max	10_min	11_max	11_min	12_max	12_min	13_max	13_min	14_max	14_min	15_max	15_min	16	17	18	19	20	21	22_max	22_min	23_max	23_min	24_max	24_min	25_max	25_min	26_max	26_min	27	28	29	30_max	30_min	31	32	33	34_max	34_min	35	36	37_max	37_min	38	39	40	41_1	41_2	42_1	42_2	43_max	43_min	44	45	46_max	46_min	47	48_max	48_min	49_max
Date		2023 07 17	2023 06 20	2023 07 20	2023 06 19	2023 07 17	2023 07 19	2023 07 19	2023 06 23	2023 06 23	2023 07 12	2023 07 12	2023 07 17	2023 07 17	2023 07 19	2023 07 19	2023 06 12	2023 06 12	2023 07 12	2023 07 12	2023 07 20	2023 07 20	2023 06 07	2023 06 07	2023 05 28	2023 05 29	2023 05 23	2023 05 24	2023 05 22	2023 05 24	2023 05 23	2023 05 23	2023 07 18	2023 07 18	2023 07 18	2023 07 18	2023 07 18	2023 07 18	2023 07 19	2023 07 19	2023 07 11	2023 07 17	2023 07 11	2023 07 18	2023 07 18	2023 07 18	2023 07 20	2023 07 18	2023 07 10	2023 07 10	2023 07 19	2023 07 18	2023 07 19	2023 07 19	2023 07 11	2023 07 11	2023 07 11	2023 07 10	2023 07 12	2023 06 28	2023 06 28	2023 06 28	2023 06 28	2023 06 27	2023 06 19	2023 06 15	2023 06 15	2023 06 14	2023 06 23	2023 06 23	2023 06 19
Plot size (m^2)		25	12	100	1	9	100	60	100	16	400	50	100	50	120	60	100	80	400	60	400	100	100	70	100	100	100	100	100	100	100	60	400	100	400	100	400	100	400	200	400	400	400	400	100	400	160	400	240	140	400	400	400	100	400	400	400	170	400	220	150	400	180	400	220	330	160	400	220	70	360
Habitat typ		A	A	A	A	A	A	A	A	A	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	W	W	W	W	W	W	W	W	W	W	W	W	W	W	W	W	W	W	W	W	W	W	W	W	W	W	W	W	W	W	W	W	W	W	W	W	W	W	W
Cover tree layer (%)		95	0	0	95	0	0	0	0	0	45	30	0	0	45	45	65	65	97	97	70	70	25	22	0	0	0	0	0	0	0	0	40	50	0	85	17	17	40	30	85	40	22	30	35	30	91	80	22	15	65	93	18	15	15	25	10	70	15	65	45	65	80	70	40	66	70	65	37	40	35
Cover shrub layer (%)		90	0	0	99	0	0	0	4	0	25	15	0	0	95	98	5	60	12	12	85	85	18	12	0	0	0	0	0	0	0	0	0	0	7	5	7	7	3	3	55	45	82	2	0	95	83	85	65	65	2	80	18	22	70	95	85	60	95	45	70	85	85	60	70	25	15	57	25	17	85
Cover herb layer (%)		15	98	65	0	100	36	18	85	90	98	100	100	100	25	25	90	90	97	97	72	75	99	98	100	100	99	100	100	100	99	99	93	87	98	97	95	94	99	99	47	100	66	100	100	45	52	65	95	97	98	50	98	94	77	85	55	87	55	57	42	35	45	17	85	18	18	97	93	96	37
Cover litter layer (%)		10	2	5	60	0	2	1	8	3	1	0	0	0	43	43	5	5	1	1	19	16	0	0	0	0	1	0	0	0	1	1	3	5	0	0	2	1	0	0	27	0	2	0	0	23	23	5	3	1	1	15	0	0	6	8	25	1	23	10	20	30	44	75	5	35	35	1	2	2	37
Cover open water (%)		0	0	55	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cover open ground (%)		10	0	17	0	0	60	80	2	2	0	0	0	0	2	2	5	5	1	1	5	4	1	2	0	0	0	0	0	0	0	0	3	5	1	2	1	2	0	0	22	0	12	0	0	25	21	15	1	1	0	23	1	4	6	2	10	5	2	10	21	25	1	5	5	35	35	1	3	1	20
Cover deathwood (%)		65	0	23	40	0	2	1	5	5	1	0	0	0	30	30	0	0	1	1	4	5	0	0	0	0	0	0	0	0	0	0	1	3	1	1	2	3	1	1	4	0	15	0	0	7	4	15	1	1	1	12	1	2	11	5	10	7	20	23	17	10	10	3	5	12	12	1	2	1	6
Number of species		13	15	18	6	7	19	8	8	3	39	25	9	8	20	19	29	27	37	23	27	23	24	22	40	35	35	33	58	36	57	47	16	15	18	17	12	12	24	24	22	31	14	15	13	27	19	16	49	37	11	24	21	16	28	27	31	27	30	19	16	34	22	21	41	27	15	44	42	30	49
Acer campestre	t1										1						2	2			3	2																			2						3												1	2		2		2	1	3	3	1			
Acer campestre	hl	1									+	+			+	+	1	1	+	+	+	+	1	1				r	r		1	+			+	+					+	r	r			r	+	+	+	+	r	r			+	+	1	1	1	+	+	+	1	1	1	1	1	2	+	+	+
Acer pseudoplatanus	s1																																																																	2	2		2	2	2
Acer pseudoplatanus	hl	+																			1	1																									+		r			r						r			r	+	+		+	2	2	r	2	2	1
Aegopodium podagraria	hl														+	+																																	2	2					+		+	+	2	+	+			r				2	1	1	r
Alliaria petiolata	hl										+	+							+	+	+	+	+	+									+	+					r	r	r	+				+	+		+	+		1			+		+	+	+												r
Allium ursinum	hl																+	+					r	r																																				+	+	+	+	+	+	+	+	r	+	+	+
Bromus sterilis	hl																						+	+	+																																														
Campanula trachelium	hl																																																+	+																					
Cardamine impatiens	hl																																									r											r	r		r									+						r
Clematis vitalba	s1																1	1																															+	+					+		3		+						1				1		1
Clematis vitalba	hl										r								r				+	+			+				r		r	r															+	+		+				+	1	+				r			+	+	+	+	+		1
Convallaria majalis	hl										+																																																	1		+		+	2	+					
Cornus mas	s1																																																												3			3	1			+			1
Cornus mas	hl																														+																													r				+							
Corylus avellana	s1	5															1	r	+	+															r	r											4		+	+					+			3	1	3	2	3	1	3	1	2	2				2
Corylus avellana	hl	r									r				+	+					+	+	+	+													r	r			+	r				+	+		+	+					+		+	+		+	r			+	2	+	r	+	+	r	
Crataegus monogyna	hl	+									+	+			+	+	+	+	r	r	+	+	+	+			+			r	+	+							r	r		r	r			+	+		+	+		+	+	+	+	+	+		+			+	+	r	1	+	+		+	r	+
Euonymus europaeus	hl																				+	+									+	+																	+	+		+				r	r	+	r			r	r	1		+	r	+	+	r	+
Fraxinus excelsior	t1	2																																													3	1								+		2								2	2	4	2	2	2
Fraxinus excelsior	hl	+									r				r	r	+	+			+	+	1	1							+	+			+	r							+			+	+	+	+	+		1			+	+	+	r			r	1	1	+	1	2	2		+	+	+
Galeopsis speciosa	hl	r									+	r			+		+	+	+	+	+												1	1	1	1	+	+	+	+	+	1	+	+	+	1	1	+	r			1	+	+	+	r	r			+				r	+				+	+	r
Galium sylvaticum	hl																																																																	+		+			
Geranium robertianum	hl																																																																			1			
Hedera helix	hl														+	+					+	+											r	r							r		r				+		+	+		+				r	r	+	r	+	+	+	+	+	+	+	r				+
Heracleum sphondylium	hl																																																																				+	+	
Impatiens parviflora	hl	2									2	2			+	+	1	1	1	1	4	4	1	1									1	1	2	2	+	1	+	+	2	2	4	+	+	2	2	3	1	+	+	3	1	1	2	2	3	2	2	4	3	3	3	r	1	1	1	2	2	3	1
Juglans regia	t1				5																																												+	+						1			1						2			1	3	3	2
Juglans regia	s1										r																																						+	+					+	r	+	1	1			1			2			2	1		1
Juglans regia	hl																r	r	r		+	+																											+	+		r					+	+	+	r		+	+	+	1	r		1	+	+	+
Ligustrum vulgare	hl														+	+																																									+					r	r		2			+	+		
Lonicera xylosteum	s1																																																															2			1			
Parietaria officinalis	hl																1	+			+		1	+											+	+						r				+						r				2	1	+	+									3	4	4	r

Plot number		1	2	3	4	5	7_max	7_min	8_max	8_min	9_max	9_min	10_max	10_min	11_max	11_min	12_max	12_min	13_max	13_min	14_max	14_min	15_max	15_min	16	17	18	19	20	21	22_max	22_min	23_max	23_min	24_max	24_min	25_max	25_min	26_max	26_min	27	28	29	30_max	30_min	31	32	33	34_max	34_min	35	36	37_max	37_min	38	39	40	41_1	41_2	42_1	42_2	43_max	43_min	44	45	46_max	46_min	47	48_max	48_min	49_max
Paris quadrifolia	hl														+	+					r	r																			r					r			+	r							r			r		+	r		+	+		r	+	+	+
Polygonatum latifolium	hl										+																																				+																			r	r		+	r		r
Polygonatum multiflorum	hl																																																																				+			+
Populus alba	t1	4									2	2			3	3	3	3	5	5	3	3	+	+											5	5						3	2					4	1	1	4						2	1	1	4	3	2	2	+	1						
Populus alba	hl	1									1	1			r	r	1	1	+	+	1	1	2	2	+		+								1	1						1	+	r					+	+	+						+	r		+	+	1	+	2	+			r			
Prunus padus	hl	+									r																														r	r							r						r	r			r		+			r					+	r	r
Pulmonaria officinalis	hl																				1	+											r	r																															+			+			+
Quercus robur	t1										2	2																																																		2	4	3				1			2
Ribes rubrum	hl																																																										r												
Rubus caesius	hl		r	r		+			1	1	3	3	2	2	+	+	3	3	3	3	r		+	+									2	2	2	2	2	2	2	2	2	4	1	3	2	+	2	+	2	2	5	+	2	2	1	1	+		+	1		1	+		+	2	2	+	1	1	+
Salvia glutinosa	hl																														+																																		1			2	1	1	+
Sanicula europaea	hl																r	r																																															+			2			
Stachys sylvatica	hl										+																																												1	+			1			+			+	+		2	1		
Ulmus laevis	hl	r					r																												r	r					+					+			r	r						+					r	+	+		1						
Ulmus minor	hl										+												1	+																																								+							+
Ulmus sp.	s1																																				+	+	+	+													+																		
Viola mirabilis	hl																																																+																	+		+			r
Viola sp. 2achsig	hl																																																+	+										+	+			+				+	+		+
Viola sp. 3achsig	hl										+	+			1	1																																	+	+										+		+	+		+	+	+	+			r
Acer pseudoplatanus	t1																																																																						2
Ailanthus altissima	s1																																																1	1					1	+			+			r									
Brachypodium sylvaticum	hl										+				+	+	r				+	+																				r				r		+	2	2		+			+	1	+	1		+		+	+	+	1				1	1	1
Carex sylvatica	hl														+	+					+	+																			1					1			+	+										+		+	+			r	r		r	r	r
Cornus sanguinea	s1										1	+			5	5	2	2	1	1	5	5													2	1			1	1	3	1	5			5		5	3	3		4	2	2	3	2	2		3	1	2	3	4		2			r	2	2	3
Cornus sanguinea	hl										+				2	2	+	+			1	1	+	+																	2	r	1			1	+	2	2	2		1	1	1	1		1	+	2	+	+				2	+	+	+	1	1	3
Crataegus monogyna	s1								1		1	+			2	2	2	2	+	+	1		1	+																	1	1	2						1	1		2	2	1	1		2	1				2	2	1	+			3	1		1
Euonymus verrucosus	hl																																																																						
Galium aparine agg.	hl	+									+	+					1	1	2	2	+	+	2	2		r							1	1	+	+	2	1	+	+	+	1	+	1	1	1	+	+					+	+	+		+	+	1									+	+	+	
Geum urbanum	hl										r								r		r	r																			+					1									+			+										r	+	+	
Glechoma hederacea agg.	hl														r	r	+	+	2	2			1	1		1	+	+	1	+	+	+									+	r				1		3	+	+					3	3		2	+									+			
Humulus lupulus	s1																		r																														+						1		3											1			
Lonicera xylosteum	hl																																																																1	r					+
Melica nutans	hl																																																																1						
Prunus avium	hl																																																																+						
Sambucus nigra	hl																				+	+	1	1																						+		+				+			+	+	+	1	1							r		+	+		
Acer platanoides	t1																																																																						
Bromus benekenii	hl																																										r																									1			
Circaea lutetiana	hl										+	r							r																								1					1	+	+			+	+	r		r			1		+	+			r		+	+	+	
Clematis vitalba	t1				1												1	1																															+										+						1				1		1
Ligustrum vulgare	s1				3										+	+																																									+								2						2
Poa palustris	hl																								+	1																																													
Sambucus nigra	s1																						2	2																	r					+									2	5	2	2	3									+	1	+	
Ulmus laevis	s1										1	1							r																						2	1				+	+										+	1	1			+									
Ulmus minor	t1																						2	2																																								2							
Urtica dioica	hl					+					3	3	2	2					3	3			3	3									5	5	3	3	5	5	2	2	2	2	+	3	4	2	+	1				+	3	3	2	3	1	2	2										+	r	
Viscum album ssp. album	t1	+																															+	+			+	+	+	+		1		+	+		+					+	+	+		1			1												
Acer campestre	s1										1	1					2	2	1	1			1																			1					2		+	+						+		1				+							1		
Buglossoides purpurocaerulea	hl																														1	r																																	2			1			1
Fraxinus excelsior	s1																																		+	+					r		+			+																+				1	2				1
Malus sylvestris	s1																		1	1																																																			+
Ulmus laevis	t1	3																																							5					2		2				4			1			4				1			1						
Solidago gigantea	hl														r	r	2	2								4	1	1		+	2	1																	1	1								+							+			+			1
Staphylea pinnata	s1																																																																						
Staphylea pinnata	hl																																																																							
Carpinus betulus	t1																																																															3							
Arctium lappa	hl																+																				+	+	2	2		1		1	+	r			+	+			3	4		+		r	r						+			+	+	r	r

Plot number		1	2	3	4	5	7_max	7_min	8_max	8_min	9_max	9_min	10_max	10_min	11_max	11_min	12_max	12_min	13_max	13_min	14_max	14_min	15_max	15_min	16	17	18	19	20	21	22_max	22_min	23_max	23_min	24_max	24_min	25_max	25_min	26_max	26_min	27	28	29	30_max	30_min	31	32	33	34_max	34_min	35	36	37_max	37_min	38	39	40	41_1	41_2	42_1	42_2	43_max	43_min	44	45	46_max	46_min	47	48_max	48_min	49_max
Carex acutiformis	hl		4								1	1			1	1	3	3	1	1																	1	+	+	+									+		1																	2			
Humulus lupulus	hl																																																						+		1											r	r		
Physalis alkekengi	hl																																+	+															1	1																		r			
Vicia dumetorum	hl																		+																																											+						r			
Quercus robur	hl																				r	r																				r							r	r		r					r		r			r	r		+						r
Acer platanoides	hl																																																																						
Maianthemum bifolium	hl																																																																						
Stachys recta	hl																																																																						
Colchicum autumnale	hl																								1	1	+	1	1	1	2	2																														r				+	+				
Aesculus hippocastanum	t1																																																																	1					
Aesculus hippocastanum	hl																																																																	r					
Rhamnus cathartica	hl																																																															r		r					
Epipactis helleborine	hl																				r	r																				r																			r	r									
Ulmus minor	s1										1	1											1	+																																															1
Prunus padus	t1																																																																						
Berberis vulgaris	s1																																																																2						
Berberis vulgaris	hl																																																																+						
Eupatorium cannabinum	hl																r	r											r																				r																+						r
Frangula alnus	t1																																																																1						
Frangula alnus	s1				2																																																												2						+
Lonicera caprifolium	s1				1																																																												1						
Lonicera caprifolium	hl																																																																+						+
Populus alba	s1										2	2					+	+	1	1			1	1											+	+	+	+				+		+						+	1						+								1						
Prunus spinosa	s1																																																																+						
Viburnum lantana	s1																																																																2						
Viburnum lantana	hl																																																																1						
Viburnum opulus	s1				3						r	r			+				+																												+																		2				1		1
Viburnum opulus	hl														1	1					+	+																									r		+													+			1				+		
Anemone ranunculoides	hl																																																																						r
Dactylis polygama	hl																																																																						r
Lapsana communis	hl																																																																						r
Malus sylvestris	hl																		r	r										r																																									r
Stellaria media	hl										+																																			+																							r		+
Viola sp.	hl	+																			1	1																									+																								+
Viscum album ssp. album	s1																																				+	+				+											+	+					r			r									+
Viola reichenbachiana	hl																																																																						r
Festuca gigantea	hl												+						+																+	+			+	+		+				+							+	+																	
Poa trivialis	hl					1	+				+	+	+	+					+	r			1	1									1	1					+	+	r	+											+																+	r	
Ailanthus altissima	t1																																																1	1					2																
Ailanthus altissima	hl																																																+	+									+												
Allium scorodoprasum	hl																									+				r	r																		r	r																			r		
Lysimachia nummularia	hl			3			r																		r		r			r	r		+	+															r	r																					
Viola hirta	hl																									+	+		+		+	+																																							
Asarum europaeum	hl																																																																						
Carex muricata agg.	hl																																																																						
Corylus avellana	t1																																																																						
Filipendula ulmaria	hl																																																																						
Lamium maculatum	hl																						1	1																									+	+						2	+	2													
Listera ovata	hl																																																																						
Prunus padus	s1	1																																								3														r	r														
Equisetum arvense ssp. arvense	hl								+								+	+	r	r					+	1	r																								r																				
Carex acuta	hl			+					5	5																																																													
Phalaris arundinacea	hl					+			2	2	+	+	2	2					+				1	2									+	+					1	1		+		1	1	1					+								+												
Carex pseudocyperus	hl			1					+																																																														
Lysimachia vulgaris	hl		1						r		+	r					r	r	+	r					1	2																									+																				
Scutellaria galericulata	hl		+				+		r																																												+																		

Plot number		1	2	3	4	5	7_max	7_min	8_max	8_min	9_max	9_min	10_max	10_min	11_max	11_min	12_max	12_min	13_max	13_min	14_max	14_min	15_max	15_min	16	17	18	19	20	21	22_max	22_min	23_max	23_min	24_max	24_min
Euonymus europaeus	s1																																			
Impatiens noli-tangere	hl																																		1	1
Iris pseudacorus	hl		r	+			1										+	+	r	r					+											
Lamium purpureum	hl																																			
Alnus incana	s1																																			
Alnus incana	hl																																			
Carex otrubae	hl			+																																
Phragmites australis	hl		2			5	3	2			1	+	4	4			1	1	2	2					+	+							r		2	2
Carex riparia	hl		2			2	1				+	+	2	2																						
Convolvulus arvensis	hl		+																																	
Equisetum fluviatile	hl		+																																	
Equisetum palustre	hl		+																									+								
Galium palustre	hl		+				r																													
Lathyrus pratensis	hl		+																						1	1		+	+	1						
Rumex conglomeratus	hl		+				r				+	r	+	+																					r	r
Symphytum officinale	hl		r								r								+	+					1	r		r								
Valeriana officinalis	hl		+																																	
Calamagrostis pseudophragmites	hl																r	r																		
Calystegia sepium	hl																+	+	+																	
Cornus sanguinea	t1																1	1																		
Euphorbia palustris	hl																1	1								r										
Prunus spinosa	hl																r	r																		
Mycelis muralis	hl																																			
Rosa canina s.lat. (= agg.)	hl										r																				r	r				
Aristolochia clematitis	hl																																			
Carduus crispus	hl																												r							
Chaerophyllum temulum	hl																						1	+												
Conyza canadensis	hl																																			
Cruciata laevipes	hl																												+		+	+				
Dactylis glomerata ssp. glomerata	hl																								1	1	+	+	2	+	+	+				
Galium mollugo agg.	hl																									1	+		+							
Melica uniflora	hl																																			
Robinia pseudacacia	t1																																			
Robinia pseudacacia	s1																																			
Ulmus sp.	hl																																			
Vitis vinifera ssp. sylvestris	hl										r																									
Carpinus betulus	hl																		r	r																
Hedera helix	t1																																			
Hedera helix	s1																																			
Carpinus betulus	s1																																			
Crataegus monogyna	t1																						1													
Frangula alnus	hl																																			
Pyrus pyraster	t1																																			
Pyrus pyraster	s1																																			
Pyrus pyraster	hl																													r						
Erigeron annuus	hl																								3			r		r						
Hypericum perforatum	hl																										r		+		+	+				
Populus nigra	t1																																			
Deschampsia cespitosa	hl																		+	+																
Loranthus europaeus	t1																																			
Robinia pseudacacia	hl																																			
Scrophularia nodosa	hl																																			
Clinopodium vulgare	hl																										+			+	+	+				
Alnus incana	t1																																			
Cirsium vulgare	hl																																			
Carex remota	hl																																			

Plot number		25_max	25_min	26_max	26_min	27	28	29	30_max	30_min	31	32	33	34_max	34_min	35	36	37_max	37_min	38	39	40	41_1	41_2	42_1	42_2	43_max	43_min	44	45	46_max	46_min	47	48_max	48_min	49_max
Euonymus europaeus	s1													+	+					+		+												r	r	
Impatiens noli-tangere	hl			+	+	r		1			+		1							+		+			1									2	2	
Iris pseudacorus	hl			+	+											1																		1	1	
Lamium purpureum	hl																																	r	r	
Alnus incana	s1													1	1																			1		
Alnus incana	hl																			+														+		
Carex otrubae	hl																																	r		
Phragmites australis	hl			3	4		3		3	2	+					1		3	2															r		
Carex riparia	hl																																			
Convolvulus arvensis	hl			+	+																															
Equisetum fluviatile	hl																																			
Equisetum palustre	hl																																			
Galium palustre	hl																																			
Lathyrus pratensis	hl																																			
Rumex conglomeratus	hl			r	r	r	r				+											+														
Symphytum officinale	hl			+	+					r				+				r	r																	
Valeriana officinalis	hl																																			
Calamagrostis pseudophragmites	hl																																			
Calystegia sepium	hl																																			
Cornus sanguinea	t1					1																														
Euphorbia palustris	hl																																			
Prunus spinosa	hl																	r																		
Mycelis muralis	hl																																			
Rosa canina s.lat. (= agg.)	hl																																			
Aristolochia clematitis	hl																																			
Carduus crispus	hl			1	+									+				+																		
Chaerophyllum temulum	hl													r	r						r															
Conyza canadensis	hl																																			
Cruciata laevipes	hl																																			
Dactylis glomerata ssp. glomerata	hl																																			
Galium mollugo agg.	hl																																			
Melica uniflora	hl																																			
Robinia pseudacacia	t1													2	2																					
Robinia pseudacacia	s1													2	2																					
Ulmus sp.	hl																																			
Vitis vinifera ssp. sylvestris	hl																										r									
Carpinus betulus	hl													r	r														r							
Hedera helix	t1																																			
Hedera helix	s1																				r															
Carpinus betulus	s1																																			
Crataegus monogyna	t1					1												1																		
Frangula alnus	hl																																			
Pyrus pyraster	t1																																			
Pyrus pyraster	s1																																			
Pyrus pyraster	hl																																			
Erigeron annuus	hl													+																						
Hypericum perforatum	hl																																			
Populus nigra	t1																																			
Deschampsia cespitosa	hl																																			
Loranthus europaeus	t1																										r	+								
Robinia pseudacacia	hl													+	+												+									
Scrophularia nodosa	hl													r	r												r									
Clinopodium vulgare	hl													r	r																					
Alnus incana	t1													2						+																
Cirsium vulgare	hl													r																						
Carex remota	hl																																			

Plot number		1	2	3	4	5	7_max	7_min	8_max	8_min	9_max	9_min	10_max	10_min	11_max	11_min	12_max	12_min	13_max	13_min	14_max	14_min	15_max	15_min	16	17	18	19	20	21	22_max	22_min	23_max	23_min	24_max	24_min	25_max	25_min	26_max	26_min	27	28	29	30_max	30_min	31	32	33	34_max	34_min	35	36	37_max	37_min	38	39	40	41_1	41_2	42_1	42_2	43_max	43_min	44	45	46_max	46_min	47	48_max	48_min	49_max
Hesperis matronalis ssp. matronalis	hl																																																																						
Artemisia vulgaris agg.	hl																						r																																																
Chelidonium majus	hl																																																									+	r												
Elymus caninus	hl																																																																					
Galeobdolon montanum	hl																																																						1	1															
Scirpus sylvaticus	hl						+																																																															
Malus sylvestris	t1																																																		3																			
Silene vulgaris	hl																																																																					
Tilia platyphyllos	hl																																																																					
Morus alba	s1																																																								+													
Betula pendula	t1																																																																					
Dryopteris filix-mas	hl																																																							r														
Populus x canadensis	t1																																								1										1				2			2												
Arrhenatherum elatius	hl																		r	r						+	1	2	+	1	+	+			1	+																																			
Calamagrostis epigejos	hl																		r							+			r										+	+		+																													
Cirsium arvense	hl																		+						r	+			r																																											
Elymus repens	hl																		+						+																																														
Acer negundo	s1										r	r																																	+															1												
Carex vesicaria	hl										+	+																																							+																				
Vitis vinifera ssp. sylvestris	t1										+																																																											
Fallopia japonica	hl																																																																					
Rumex obtusifolius	hl																																																																					
Acer negundo	hl																																																									r												
Lactuca serriola	hl																																																																					
Prunus sp.	hl																																														r	r				r																			
Vitis vinifera ssp. sylvestris	s1																																																																					
Dipsacus pilosus	hl																																																																					
Aster lanceolatus	hl																																																																					
Euphorbia platyphyllos	hl																												+																																										
Carex sp.	hl																																								1																													
Rosa canina s.lat. (= agg.)	s1																																								+																													
Salix alba	t1																																3	3	1		2	2	3	3		2		3	3								2	2																	
Myosoton aquaticum	hl					r							r	r																																																									
Alnus glutinosa	t1																						1																							2																									
Impatiens glandulifera	hl																																											1	+																										
Rumex sp.	hl																																											+	+																										
Symphytum officinale agg.	hl																																											r																											
Fraxinus americana agg	t1																																																		2																			
Salix alba	s1																																				1	1															1	1																	
Juglans nigra	hl																																																																					
Cardamine pratensis agg.	hl																																																																					
Prunus domestica ssp. insititia	s1																																																			1	1																	
Alopecurus aequalis	hl						+	+																																																															
Glyceria fluitans	hl						1	1																																																															
Lythrum salicaria	hl						1	+																																																															
Myriophyllum verticillatum	hl			2			r	r																																																															
Persicaria dubia	hl			+			1	+																	+																																														
Potamogeto pectinatus ssp. pectinatus	hl			2			1	1																																																															
Veronica anagallis-aquatica	hl			+			+	+																																																															
Alisma lanceolatum	hl						+																																																																
Lycopus europaeus	hl						+																																																																
Betula pendula	hl																																																																					
Juglans nigra	s1																				+																																																		
Prunus sp.	s1																																																																					
Hydrocharis morsus-ranae	hl			+																																																																			
Leersia oryzoides	hl			1																																																																			

Plot number		1	2	3	4	5	7_max	7_min	8_max	8_min	9_max	9_min	10_max	10_min	11_max	11_min	12_max	12_min	13_max	13_min	14_max	14_min	15_max	15_min	16	17	18	19	20	21	22_max	22_min	23_max	23_min	24_max	24_min	25_max	25_min	26_max	26_min	27	28	29	30_max	30_min	31	32	33	34_max	34_min	35	36	37_max	37_min	38	39	40	41_1	41_2	42_1	42_2	43_max	43_min	44	45	46_max	46_min	47	48_max	48_min	49_max
Lemna minor	hl			+																																																																			
Lemna trisulca	hl			+																																																																			
Oenanthe aquatica	hl			+																																																																			
Sagittaria sagittifolia	hl			1																																																																			
Sparganium erectum	hl			1																																																																			
Spirodela polyrhiza	hl			1																																																																			
Achillea millefolium agg.	hl																								r		+	+	1	+	+	+																																							
Agrimonia eupatoria	hl																										+		r		+	+																																							
Alopecurus pratensis	hl																								3	1			+																																											
Arabidopsis thaliana	hl																												+																																											
Astragalus glycyphyllos	hl																												+		+	+																																							
Avenula pubescens	hl																									+	1		3		2	2																																							
Brachypodium pinnatum	hl																												r		+	+																																							
Briza media	hl																										r		+		+	+																																							
Bromus erectus	hl																									+	3		3		2	2																																							
Bromus inermis	hl																								+	1		4	1	3	2	2																																							
Carex caryophyllea	hl																												+		r	r																																							
Carex flacca	hl																												+																																										
Carex tomentosa	hl																									1			1		+	+																																							
Dianthus carthusianorum agg.	hl																												1																																										
Euphorbia cyparissias	hl																												+	2	+																																								
Festuca rubra agg.	hl																											1	1	2	1	1																																							
Fragaria viridis	hl																									+		r	1	1	1	1																																							
Galium verum agg.	hl																								r	+		1	+	1	1	1																																							
Inula salicina	hl																												3	+	1	1																																							
Knautia arvensis	hl																												r		+	+																																							
Koeleria macrantha	hl																												+		1	1																																							
Leucanthemum vulgare	hl																								r		r	+	+	r	+																																								
Linum catharticum	hl																												r																																										
Medicago lupulina	hl																								+		+	+	r	+	+	+																																							
Myosotis arvensis	hl																											+	+	+	+	+																																							
Plantago lanceolata	hl																								1		+	+	+	+	+	+																																							
Plantago media	hl																												+		1	2																																							
Poa pratensis agg.	hl																								1	1	2	2	3	3	2	2																																							
Potentilla reptans	hl																								+	+	+		+																																									
Ranunculus polyanthemos	hl																								+	1	+	+	1	+	1	1																																							
Rhinanthus minor	hl																											r	+	+	1	1																																							
Rumex acetosa	hl																										+		r		+	+																																							
Salvia pratensis	hl																										2	+	2		2	2																																							
Securigera varia	hl																								r				+																																										
Tragopogon orientalis	hl																								r			+	+	+	+	+																																							
Trifolium pratense	hl																								+	+	+	+	r	1	1	1																																							
Veronica arvensis	hl																								+			+	r	r																																								
Veronica chamaedrys agg.	hl																									r			+		+	+																																							
Vicia angustifolia	hl																										1		r		+	+																																							
Vicia cracca agg.	hl																												r																																										
Vicia sativa agg.	hl																									1	r	+	+	1																																									
Viola pumila	hl																									+			+																																										
Polygala vulgaris	hl																														r	r																																							
Teucrium chamaedrys	hl																														+	+																																							
Veronica teucrium	hl																														r	r																																							
Anthericum ramosum	hl																														r																																								
Ornithogalum umbellatum agg.	hl																														r																																								
Selinum carvifolia	hl																														r																																								
Astragalus cicer	hl																										1	r																																										
Cerastium holosteoides	hl																								+		+																																											

Plot number		1	2	3	4	5	7_max	7_min	8_max	8_min	9_max	9_min	10_max	10_min	11_max	11_min	12_max	12_min	13_max	13_min	14_max	14_min	15_max	15_min	16	17	18	19	20	21	22_max	22_min	23_max	23_min	24_max	24_min	25_max	25_min	26_max	26_min	27	28	29	30_max	30_min	31	32	33	34_max	34_min	35	36	37_max	37_min	38	39	40	41_1	41_2	42_1	42_2	43_max	43_min	44	45	46_max	46_min	47	48_max	48_min	49_max
Cirsium canum	hl																									r	+																																														
Euphorbia esula	hl																										r																																														
Valerianella locusta	hl																										r																																														
Bromus hordeaceus	hl																								1			r		+																																									
Lotus corniculatus	hl																									1		+		+																																									
Pimpinella saxifraga agg.	hl																											+		+																																											
Trifolium campestre	hl																											+		+																																											
Vicia hirsuta	hl																								1			+		+																																									
Daucus carota	hl																											r																																													
Arabis glabra	hl																								r																																																
Carex melanostachya	hl																								r																																																
Euphorbia lucida	hl																								2																																															
Lotus corniculatus agg.	hl																								r																																																
Rumex crispus	hl																								r																																																
Vicia sepium	hl																								+																																																
Taraxacum sect. Ruderalia	hl																								+																																																
Carex hirta	hl																									1																																														
Alnus glutinosa	s1																						+																																																		
Alnus glutinosa	hl																						+																																																		

Plot number		2023.07.17	49_min	50	51_CF	51_max	51_min	52	53	54	55	56_max	56_min	57	58	59	60_1	60_2	61	62_1ma	62_1mi	62_2	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90
Date		2023 06 19	2023 06 20	2023 07 13	2023 07 13	2023 07 13	2023 07 11	2023 07 11	2023 07 10	2023 06 27	2023 06 27	2023 07 11	2023 07 11	2023 07 11	2023 07 13	2023 07 10	2023 06 27	2023 06 28	2023 06 28	2023 07 19	2023 07 19	2023 07 19	2023 06 15	2023 06 14	2023 06 15	2023 06 15	2023 06 26	2023 06 15	2023 06 19	2023 06 13	2023 06 26	2023 06 14	2023 06 13	2023 06 13	2023 06 26	2023 06 19	2023 06 15	2023 06 14	2023 06 27	2023 07 20	2023 07 20	2023 06 28	2023 06 28	2023 07 13	2023 06 28	2023 07 12	2023 07 10	2023 06 27	2023 07 10
Plot size (m^2)		W 240	W 400	W 225	W 400	W 160	W 400	W 400	W 400	W 400	W 400	W 380	W 130	W 400	W 400	W 400	W 400	W 400	W 400	W 400	W 200	W 160	W 400	W 400	W 400	W 400	W 400	W 400	W 400	W 400	W 400	W 400	W 400	W 400	W 400	W 400	W 400	W 400	W 400	W 400	W 400	W 400	W 400	W 400	W 400	W 400	W 400	W 400	W 400
Habitat typ																																																	
Cover tree layer (%)		35	55	65	65	65	65	10	70	95	50	92	15	95	65	80	77	75	90	90	80	15	40	45	55	40	25	75	45	10	60	57	80	65	65	60	75	11	60	27	10	56	65	15	92	75	65	67	10
Cover shrub layer (%)		85	55	94	93	92	85	85	50	65	70	15	7	34	37	45	67	80	40	95	95	95	54	90	35	40	82	60	50	90	30	25	27	80	60	55	60	60	70	65	80	25	55	65	85	15	62	55	45	65	95
Cover herb layer (%)		40	57	70	70	80	91	86	75	88	70	62	62	93	96	87	38	27	27	83	87	65	21	11	40	32	75	84	82	78	62	99	84	82	78	62	55	65	90	11	80	27	70	92	60	65	97	92	72	65	95
Cover litter layer (%)		0	26	25	25	15	80	2	9	8	4	36	35	4	2	4	47	50	68	7	4	11	49	83	30	66	15	21	4	65	5	0	13	8	21	37	5	65	70	5	1	97	7	22	72	68	2	5	10	26	1
Cover open water (%)		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cover open ground (%)		10	2	3	3	3	3	3	10	9	1	2	3	3	1	2	7	10	1	1	0	1	19	5	20	0	1	2	0	30	20	1	8	0	4	0	3	1	3	15	0	1	0	1	0	0	1	0	0	0	14
Cover deathwood (%)		2	15	2	2	2	2	2	2	7	3	0	2	1	1	2	13	13	4	9	8	14	11	1	10	2	2	4	2	5	10	2	1	2	1	5	2	1	2	9	2	1	2	5	1	0	2	1	11	10	3
Number of species		48	39	35	38	28	29	39	29	30	29	28	26	33	33	28	26	30	45	36	37	26	32	29	28	39	35	32	41	32	46	26	36	43	38	36	23	32	27	32	34	32	23	58	42	38	40	26	30
Acer campestre	t1		1					2	1	2			5	5	2	2	2	2	2				2			3	1	2			2		2		1	1			1	2		2			1		2	2	2	2
Acer campestre	hl	+	+	+	+	+	+	1	+	+	1	2	2	1	+	+	2	2	2	+	+	+	1	+	+	1	1	1	+	+	2	+	+	1	+	r	+	1	+	1	2	+	+	1	+	+	1	1	+
Acer pseudoplatanus	s1	2	1					1						1									1	+	1			1							r				+		+									
Acer pseudoplatanus	hl	1	+	r	r	r	2		r	+	2	2	2	+		r	+	r	r	r			1	+	1	r	r	2	1	1	+	+	+	1	+	r	r		+	r	2	+	+	+	r	+				r	r
Aegopodium podagraria	hl	r	1	+	+	+	1	+	1	r	+	+	+	+		1	+		r	1	1	1	1	+	+	1	+	1	2	+	1	+	2		3	2	+	+	1	+	1		+	1	2		+	1		
Alliaria petiolata	hl	r					r	+						r	+	r							r	+	r	1	r			+	r	1							+		+	+	1		+			
Allium ursinum	hl	+	+							r							1	1					1	+	+	1	r	+	+	2	+	r	+	+	2	+	+	+	1				r	r			r		+		
Bromus sterilis	hl																																	r																
Campanula trachelium	hl																								r						+			+															
Cardamine impatiens	hl	r		r	r	r																r				r								1															r
Clematis vitalba	s1	1	1						+							+							+	1	+	2	+		3		2		2		1				2	1			1			2	2	r
Clematis vitalba	hl	1	+	r	r			+	+	+	+	+	+			+			r	r	+		+	r	1	+	1	1	2	1	r	1	r		+	+	1	2	r	r			r	1	+	2	+	+	+
Convallaria majalis	hl								+						1		1		r						2			1				1		3				+						1				1	1	
Cornus mas	s1	1	1	1	1	1										2							2	1				2	1	3	2			2	2	2			4	2				2				1	2	
Cornus mas	hl				r	r																				+		+	+		r			+	1							1					+	
Corylus avellana	s1	2	3	4	3	4	4	2	3	2	1	1	3			3	4		2	2	+	2	2	2	3	2	3	3	3	3	2	3	4	3	3	3	2	4	3	4	3	4		3	4	2		2	2	2	
Corylus avellana	hl		+	+	+	+	+	+	+	+	+	+	+	+	+	r	+	+					+	+	+	+	+				+	1		+	+	+	+	+	+	+	+			+	+	+			+	+	
Crataegus monogyna	hl	+	+	1	1	1	r	+	+	+	+	+	+		+	+	+			+	+	+		r	r				r		r		+	r			r	+	+	+	r			+	+	+	+	+	+	
Euonymus europaeus	hl	+	+	r	r			r			+	r	r			+	r	r		r		+	+	r	+	+				r			+	+	r				+	r				+	+	r	+	+		+
Fraxinus excelsior	t1	2	3	3	3	3		3						3	2	3							3		1	2	2	2	2		+	3		1	2	1	1	3				2	2			3	3	2	
Fraxinus excelsior	hl	+	1	+	+	+	+	+		+	+	2	2		+	+	+	+	+	+	+	r		r	1	2	1	2	r	1	+	1	1	+	1	1	1	1	1	+		1	+	1	+	r					+
Galeopsis speciosa	hl	r	+					+		+		+	+	+	1	+	+	r	+	1	1	+				r	r				r	r	r	+	+					+	+			+	+	+	+				+	
Galium sylvaticum	hl																								1		1					r	+				+	1													
Geranium robertianum	hl							1							1				r												+	r		+	1								+							
Hedera helix	hl	+	+	+	+	+	+	r	r	+	1				+	+	+	r	+	+	+	+	+			+	+	+	1	+			+	1	1	1	+	+	+	+	+	+	+	+	+		2	+	1
Heracleum sphondylium	hl		+																												+			r	+													
Impatiens parviflora	hl	1	2	+	+		3	3	4	3	2	2	3	3	3	2	1		2	2	2	1	r			+	2	1	2	+	1	1	3	3	+	3	3	+		3	3	3	3	4	2	3	4	3	2	2
Juglans regia	t1	2	1								2	2													1				1		2		1	1	1			2	1				1						1	
Juglans regia	s1	1	2					r	1	+				2	+									+	2	2			1	+	2	2	+		+	1			1	1	1		+	1			+		1	+
Juglans regia	hl	+	+	+	+	+	+	1	1	+				1		+	+	+	r				+	r		2	+	r		r	1	+	1	+	1	1	1		+	+	+		+	+			+	+	+	
Ligustrum vulgare	hl			+	+	1				1					+			r	+	+				r	+				+					r		+		r							+	+				+	
Lonicera xylosteum	s1																								1									+	1												1			
Parietaria officinalis	hl	r	1					+	2	1	r				2							1		+		+	2			2	+	3	2	+	3	1	1	3		+	1	1	+		1	1	+			1

Plot number		49_min	50	51_CF	51_max	51_min	52	53	54	55	56_max	56_min	57	58	59	60_1	60_2	61	62_1ma	62_1mi	62_2	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90
Paris quadrifolia	hl	+	+	+	+	+		r	+		+	+				+	r	+	r	r		+	+	+	r	+	r		+	+		r	+	+	r	+	+	+			r	+	+			+	
Polygonatum latifolium	hl	r					+	1			+	+	+		+	+			+	+		+	+	+	+	+	+	r	r	+		+	2	+		1	+	+	+				+		1	+	+
Polygonatum multiflorum	hl	+					+	r			+	+			r								+				1	+				+	+		r		r	r				+		+			
Populus alba	t1							3	4				3	2		4	4						3	3		2	2		2	3		3		2	4			2	3			4	4	2		2	1	4	
Populus alba	hl							r	+	+				+	+	+	1	+		+	+		+	+	+	r	+	+		+	+	r	r		r	+		+	+	+	+		+	+	1		1		1	r
Prunus padus	hl	r	1				+				+	+	r		r	r	+	+														r	r		+							+	r			r	r		
Pulmonaria officinalis	hl	+					+				+	+	+	+				r				1	r	+	+	r	r	+	r	+			+	+	+		+		+				+	+					
Quercus robur	t1	2												4	4			4												2			2										4					
Ribes rubrum	hl							r																									+															
Rubus caesius	hl	+	1	1	1	2		+	+	1	1	+	+	+	+				1	1	2		+	1		+			r	1	1			+	+		+	+	+	1	1	1		+	r	+		+	
Salvia glutinosa	hl	+	1						1	+	r	r	+				+					2	r	1	2	2	+	1	+	2	2	1	1	1	3	1	+	1	2				1	+				
Sanicula europaea	hl																	r				+	+		+	1	+		r					+	r	r	r	+						+	r				
Stachys sylvatica	hl		+	1	1	1	+	1	1	2	+	+	3	1					2	2	+	1	r			3		1	+	3	2	1	2	1	3	2		1	2	2	+	2	1	2	1	+	+	+	
Ulmus laevis	hl		+				r	+			r	r	r		+		+		r		+		r										+				+	+	+									
Ulmus minor	hl	+												+	1			+						1		r			+					+									+	+	1			r
Ulmus sp.	s1																																r															
Viola mirabilis	hl	r									1	1										+	+		+	+	+			+	+	r	+	+	+	+	r											
Viola sp. 2achsig	hl	+	2	2	2	1	+	+	1		+	+	1			+						1	+	+	+	1	2	1	+	1	+	+	1	1	+	1		+	1			1	+	1	+	+	1	+	+
Viola sp. 3achsig	hl	r		2	2	1	1		1	1	+	+	+	+		1	1	1				1		+	+	1	+	+	+	1	+	r	+	+	1	+	+	+	1			1			1	1	+		1	+
Acer pseudoplatanus	t1	2											2									1		1	+			3	+					1	3	2			2									
Ailanthus altissima	s1							+																				+	+					r				r									
Brachypodium sylvaticum	hl	1	2	2	2	2	1	2	+	+	1	1	+	1			r		2	2	2			+		1		2	+	+	1		2		1	2		+	1	1	2	+		2	1	+	r		+
Carex sylvatica	hl	r	+	1	1	2	+			1	+	+				+		r	1	1	+	1		r		r			r							r								r	r				
Cornus sanguinea	s1	3	2	2	2	2	2	+	3	3	2	1	1	2	3	2	2	3	3	3	3		1				1	2	1			1				2				1	2	3	2		3	3	2	2	3	3
Cornus sanguinea	hl	3	1	1	1	1	1	+	1	1	1	1	+	1	2	+	+	2	2	2	2	+	1	+			+	2	1			+				1				1	+	3	+		1	3	+	+	1	1
Crataegus monogyna	s1	1	+	1	2	+				2	2			1		2	2	1	2	2	3								1					1			1	1		+	1	2	1	2	2	1	2	4
Euonymus verrucosus	hl																												r																		
Galium aparine agg.	hl														+				+	+	+						+	+	+		+			r	+				+	+	1			+	+		r
Geum urbanum	hl		1				+	+					r	+	r			+	+	+	1					r	+	+	r		+		1			1				+	+			+	1			+
Glechoma hederacea agg.	hl		1	+	+	+		1		r				r	+	+		r	1	1	1							+	1	3			+									+			r		r	1	
Humulus lupulus	s1																				+							+																				
Lonicera xylosteum	hl	+																										r						r								+						
Melica nutans	hl			+	+																			+	+			r				+							+									
Prunus avium	hl						r										r								r			r																				
Sambucus nigra	hl		+				+	+	+			+	r	1	+				r	r		+		r	r	+	r	+	r	+	+	r	+		+		r	+	+			+	1	r	1	+	r	1
Acer platanoides	t1																															3															
Bromus benekenii	hl																	r				+		+		+				1		+															
Circaea lutetiana	hl		1	+	+		2		2	2			1	2	+	+		1	+	+	+					1		1				+					+	2	+	+	+	+	r	2				
Clematis vitalba	t1	1																				1		1		2						2		3	1			+	1		1			+			
Ligustrum vulgare	s1	2		+	+	+													+	+			+	1								1						1							+		
Poa palustris	hl																															+															
Sambucus nigra	s1						+	3						2										1				1			2		1		2					+			2				+	
Ulmus laevis	s1		+																+	+												1							+									
Ulmus minor	t1														2																	1												1				
Urtica dioica	hl		r					1						2	2	r	r	r	+	+	1					+		+		r		2			1				+	+	+		2	1			3
Viscum album ssp. album	t1			+	+	+		+			+									1								1				1			1						+	+		+			
Acer campestre	s1		+					+		+	+	1						1				1	+				+				1						r	1	1	1				2	1			
Buglossoides purpurocaerulea	hl	1																					1		+	1	+		+	2							+											
Fraxinus excelsior	s1	1																						1			1	+		1				1			r								1			
Malus sylvestris	s1	+																																			1											
Ulmus laevis	t1		1				1										2						1														2	2	2		2								
Solidago gigantea	hl	1	+	+	+					r					+				1	1	1		+			+		+		r	2												r	+					
Staphylea pinnata	s1		1																				4								+																	
Staphylea pinnata	hl																						2								+												r					
Carpinus betulus	t1																	2													2														2			
Arctium lappa	hl	r		r	r		r		r	r	r	r		+					r		+					+			r	+				r								+	+				

Plot number		49_min	50	51_CF	51_max	51_min	52	53	54	55	56_max	56_min	57	58	59	60_1	60_2	61	62_1ma	62_1mi	62_2	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90
Carex acutiformis	hl																																													
Humulus lupulus	hl																		+	r										1														+		
Physalis alkekengi	hl														+				+		+								1	1				1						+			+				
Vicia dumetorum	hl																																													
Quercus robur	hl	r		r	r	r									r			r							r	r								r								+	r	+	r	
Acer platanoides	hl				r													+									r													+	+		+				
Maianthemum bifolium	hl																										+															+			+		
Stachys recta	hl																										+																			
Colchicum autumnale	hl																																													
Aesculus hippocastanum	t1																																													
Aesculus hippocastanum	hl																																													
Rhamnus cathartica	hl															r	r									+																r				+
Epipactis helleborine	hl									r						r	r	1						r											r											
Ulmus minor	s1	1													+									1																							
Prunus padus	t1																																			1										
Berberis vulgaris	s1																																													
Berberis vulgaris	hl																																													
Eupatorium cannabinum	hl	r																																												
Frangula alnus	t1																																													
Frangula alnus	s1	+																																												
Lonicera caprifolium	s1																																													
Lonicera caprifolium	hl	+																																												
Populus alba	s1							r					r																											+			+				
Prunus spinosa	s1																																													
Viburnum lantana	s1																																													
Viburnum lantana	hl																																													
Viburnum opulus	s1	1																																												
Viburnum opulus	hl			+	+	1				1	+	+						+	r		+																					r	+				
Anemone ranunculoides	hl	r																																												
Dactylis polygama	hl	r																																												
Lapsana communis	hl	r						r							r																										+			r				
Malus sylvestris	hl	r																																												
Stellaria media	hl	+																																										+		
Viola sp.	hl	+																	1	1	+																		2	+							
Viscum album ssp. album	s1	+		+	+	+				+						+																											+				
Viola reichenbachiana	hl																																													
Festuca gigantea	hl				+		r												+	+	1							+								+					+			r				+
Poa trivialis	hl							r							r													1								+								r			+		
Ailanthus altissima	t1							2																												+												
Ailanthus altissima	hl																																			r								r				
Allium scorodoprasum	hl																																			+												
Lysimachia nummularia	hl																																			+									1			
Viola hirta	hl																																			r												
Asarum europaeum	hl		+																																											
Carex muricata agg.	hl		+																																											
Corylus avellana	t1		1																																				1								
Filipendula ulmaria	hl		+																																											
Lamium maculatum	hl		+											+					1	1	1									+										+	1						1
Listera ovata	hl		+																																											
Prunus padus	s1		2																																											
Equisetum arvense ssp. arvense	hl		r																																											
Carex acuta	hl																																													
Phalaris arundinacea	hl																																												1		
Carex pseudocyperus	hl																																													
Lysimachia vulgaris	hl																																													
Scutellaria galericulata	hl																																													

Plot number		49_min	50	51_CF	51_max	51_min	52	53	54	55	56_max	56_min	57	58	59	60_1	60_2	61	62_1ma	62_1mi	62_2	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90
Euonymus europaeus	s1																				+																								1		
Impatiens noli-tangere	hl						+		1	r				1					r	r																							+				
Iris pseudacorus	hl																																							+							
Lamium purpureum	hl																																														
Alnus incana	s1																		+	+	1																										
Alnus incana	hl																		r	r	+																										
Carex otrubae	hl																																														
Phragmites australis	hl										+										+																										
Carex riparia	hl																																														
Convolvulus arvensis	hl																																												+		r
Equisetum fluviatile	hl																																														
Equisetum palustre	hl																																														
Galium palustre	hl																																														
Lathyrus pratensis	hl																																														
Rumex conglomeratus	hl														+						r																										
Symphytum officinale	hl																																														
Valeriana officinalis	hl				r	r												r																												
Calamagrostis pseudophragmites	hl																																														
Calystegia sepium	hl							1																																				+		
Cornus sanguinea	t1																	1																													
Euphorbia palustris	hl																																														
Prunus spinosa	hl												+																																r		
Mycelis muralis	hl																									r																				+
Rosa canina s.lat. (= agg.)	hl																	+								r																				
Aristolochia clematitis	hl																													+																
Carduus crispus	hl																		r											+													+		r	r	
Chaerophyllum temulum	hl			r	r																r									+													r	1	1			+
Conyza canadensis	hl																													r													r		r	+		
Cruciata laevipes	hl																													+																	
Dactylis glomerata ssp. glomerata	hl																													r																	
Galium mollugo agg.	hl																													+																	
Melica uniflora	hl																													1																	
Robinia pseudacacia	t1						2												4	4	2									2										1		2					
Robinia pseudacacia	s1								2										2	2	2									+																	
Ulmus sp.	hl															+																															
Vitis vinifera ssp. sylvestris	hl																+																												+	r	+		
Carpinus betulus	hl																	r																												+		+	r	
Hedera helix	t1								1	1									r																				+								r	
Hedera helix	s1								+	1									r																												+	
Carpinus betulus	s1																	1																													2	
Crataegus monogyna	t1																	1																														
Frangula alnus	hl																	+																												+	r			
Pyrus pyraster	t1																	1																														
Pyrus pyraster	s1																	1																														
Pyrus pyraster	hl																	r																														
Erigeron annuus	hl							+																																				+		+	r			
Hypericum perforatum	hl																																													r	+			
Populus nigra	t1																		2																												+			
Deschampsia cespitosa	hl																		+	+																							+						
Loranthus europaeus	t1																																															
Robinia pseudacacia	hl																																															
Scrophularia nodosa	hl																																															
Clinopodium vulgare	hl																																													r		
Alnus incana	t1																		2	2	2																											
Cirsium vulgare	hl																																															
Carex remota	hl														r																																	

Plot number		49_min	50	51_CF	51_max	51_min	52	53	54	55	56_max	56_min	57	58	59	60_1	60_2	61	62_1ma	62_1mi	62_2	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90
Hesperis matronalis ssp. matronalis	hl														+																															
Artemisia vulgaris agg.	hl							+																																					
Chelidonium majus	hl							1																																			r	+		
Elymus caninus	hl							r																																					
Galeobdolon montanum	hl							1																																					
Scirpus sylvaticus	hl							r																																					
Malus sylvestris	t1																																										1		
Silene vulgaris	hl																																										+		
Tilia platyphyllos	hl																																										r		
Morus alba	s1																																												
Betula pendula	t1						1																																1						
Dryopteris filix-mas	hl																																												
Populus x canadensis	t1			2	2	2																																							
Arrhenatherum elatius	hl																																												
Calamagrostis epigejos	hl																																												
Cirsium arvense	hl																																										r		
Elymus repens	hl																																												
Acer negundo	s1																																												
Carex vesicaria	hl																																												
Vitis vinifera ssp. sylvestris	t1																																												
Fallopia japonica	hl																																										+		
Rumex obtusifolius	hl																																										r		
Acer negundo	hl																																												
Lactuca serriola	hl																																											r		
Prunus sp.	hl			+	+	+								r					r																				+				+			
Vitis vinifera ssp. sylvestris	s1																																										2			
Dipsacus pilosus	hl													r																																
Aster lanceolatus	hl			1	1	1													+		+																								
Euphorbia platyphyllos	hl			r	r	r																																							
Carex sp.	hl																																												
Rosa canina s.lat. (= agg.)	s1																																							+					
Salix alba	t1																																												
Myosoton aquaticum	hl																																												
Alnus glutinosa	t1																																												
Impatiens glandulifera	hl																																												
Rumex sp.	hl																																												
Symphytum officinale agg.	hl																																												
Fraxinus americana agg	t1																																												
Salix alba	s1																																												
Juglans nigra	hl																		r																					+					
Cardamine pratensis agg.	hl																				r																								
Prunus domestica ssp. insititia	s1																																												
Alopecurus aequalis	hl																																												
Glyceria fluitans	hl																																												
Lythrum salicaria	hl																																												
Myriophyllum verticillatum	hl																																												
Persicaria dubia	hl																																												
Potamogeto pectinatus ssp. pectinatus	hl																																												
Veronica anagallis-aquatica	hl																																												
Alisma lanceolatum	hl																																												
Lycopus europaeus	hl																																												
Betula pendula	hl																																							r					
Juglans nigra	s1																																								1				
Prunus sp.	s1																																								+				
Hydrocharis morsus-ranae	hl																																												
Leersia oryzoides	hl																																												

Plot number		49_min	50	51_CF	51_max	51_min	52	53	54	55	56_max	56_min	57	58	59	60_1	60_2	61	62_1ma	62_1mi	62_2	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90
Lemna minor	hl																																														
Lemna trisulca	hl																																														
Oenanthe aquatica	hl																																													
Sagittaria sagittifolia	hl																																													
Sparganium erectum	hl																																													
Spirodela polyrhiza	hl																																													
Achillea millefolium agg.	hl																																													
Agrimonia eupatoria	hl																																													
Alopecurus pratensis	hl																																													
Arabidopsis thaliana	hl																																													
Astragalus glycyphyllos	hl																																													
Avenula pubescens	hl																																													
Brachypodium pinnatum	hl																																													
Briza media	hl																																													
Bromus erectus	hl																																													
Bromus inermis	hl																																													
Carex caryophyllea	hl																																													
Carex flacca	hl																																													
Carex tomentosa	hl																																													
Dianthus carthusianorum agg.	hl																																													
Euphorbia cyparissias	hl																																													
Festuca rubra agg.	hl																																													
Fragaria viridis	hl																																													
Galium verum agg.	hl																																													
Inula salicina	hl																																													
Knautia arvensis	hl																																													
Koeleria macrantha	hl																																													
Leucanthemum vulgare	hl																																													
Linum catharticum	hl																																													
Medicago lupulina	hl																																													
Myosotis arvensis	hl																																													
Plantago lanceolata	hl																																													
Plantago media	hl																																													
Poa pratensis agg.	hl																																													
Potentilla reptans	hl																																													
Ranunculus polyanthemos	hl																																													
Rhinanthus minor	hl																																													
Rumex acetosa	hl																																													
Salvia pratensis	hl																																													
Securigera varia	hl																																													
Tragopogon orientalis	hl																																													
Trifolium pratense	hl																																													
Veronica arvensis	hl																																													
Veronica chamaedrys agg.	hl																																													
Vicia angustifolia	hl																																													
Vicia cracca agg.	hl																																													
Vicia sativa agg.	hl																																													
Viola pumila	hl																																													
Polygala vulgaris	hl																																													
Teucrium chamaedrys	hl																																													
Veronica teucrium	hl																																													
Anthericum ramosum	hl																																													
Ornithogalum umbellatum agg.	hl																																													
Selinum carvifolia	hl																																													
Astragalus cicer	hl																																													
Cerastium holosteoides	hl																																													

Plot number		49_min	50	51_CF	51_max	51_min	52	53	54	55	56_max	56_min	57	58	59	60_1	60_2	61	62_1ma	62_1mi	62_2	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90
Cirsium canum	hl																																														
Euphorbia esula	hl																																														
Valerianella locusta	hl																																														
Bromus hordeaceus	hl																																														
Lotus corniculatus	hl																																														
Pimpinella saxifraga agg.	hl																																														
Trifolium campestre	hl																																														
Vicia hirsuta	hl																																														
Daucus carota	hl																																														
Arabis glabra	hl																																														
Carex melanostachya	hl																																														
Euphorbia lucida	hl																																														
Lotus corniculatus agg.	hl																																														
Rumex crispus	hl																																														
Vicia sepium	hl																																														
Taraxacum sect. Ruderalia	hl																																														
Carex hirta	hl																																														
Alnus glutinosa	s1																																														
Alnus glutinosa	hl																																														