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Development of the riparian vegetation on muddy banks of the restored section of the river Traisen

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View of the river Traisen and its bank in August 2017 (Lucile Tillet)

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ABSTRACT

The river Traisen, in Low Austria, flows through the Natura 2000 area "Tullnerfeld Donau-Auen" before the delta in the Danube. The river has been channelized in the 19th century and in 1973 the river has been extended by 7.5 km in order to relocate the river mouth downstream of the hydroelectric power station Altenwörth. In 2009 it was decided to build a new meandering route of the extended part. The study focuses on the vegetation which grows on the new build slip-off slopes with a closer attention given to the habitat type 3270 "Rivers with muddy banks with *Chenopodion rubri p.p.* and *Bidention p.p.".* The following questions were addressed: Which vegetation dynamics and vegetation patterns can be recognized on the restored riparian banks of the Traisen? How is the plant succession at the river Traisen developing, regarding the dynamical characteristics of plant communities? The vegetation of thirty six 1m² plots have been surveyed four times in May, June, July and August 2017. The species richness, life forms and indicator values have been analyzed. Braun-Blanquet scale has been used and plant communities have been determined. The occurrence of invasive species and threatened species has also been considered.

Several plant communities characteristic for muddy banks were identified, notably Isoëto-Nanojuncetea and Bidentetea tripartiti. All plant communities identified are fragmented. Moreover several indicators of early stages of succession have been identified, specifically the occurrence of numerous phanerophytes. The comparison of the two sections of different ages did not show any major difference. Invasive species occur on 75 % of the plots. *Solidago gigantea* was the most frequent invasive species found. Some threatened species have been found which is encouraging.

Die Traisen, ein Fluss in Niederösterreich, fließt vor ihrem Donaudelta durch das Natura 2000 Gebiet „Tullnerfeld Donau-Auen". Der Fluss wurde im 19. Jahrhundert kanalisiert und 1973 wurde die Traisen um 7.5km verlängert, um flussabwärts des Kraftwerks Altenwörth zu münden. 2009 wurde entschieden eine neue Route mit Mäandern von der verlängerten Sektion zu bauen. Diese Arbeit fokussiert sich auf die Vegetation, die am neuen gebauten Schlammufer wächst und dabei wiederum besonders auf den Habitattyp 3270 "Flüsse mit Schlammbänken mit Vegetation des *Chenopodion rubri p.p.* und des *Bidention p.p.*". Die folgende Fragen werden beforscht: welche Vegetationsdynamiken und Vegetationsmuster können beobachten werden? Wie entwickelt sich die Pflanzensukzession an der Traisen bezüglich der charakteristischen Dynamik der Pflanzengemeinschaften? Die Vegetation von sechsunddreißig 1m² Flächen wurden vier Mal im Mai, Juni, Juli und August aufgenommen. Die Artenreichtum, Lebensformen und Zeigerwerte wurden analysiert. Dabei fand die Braun-Blanquet Skala Verwendung und die Pflanzengesellschaften wurden bestimmt. Das Vorkommen von Neophyten und bedroht Arten wurde berücksichtigt.

Mehrere charakteristische Pflanzengemeinschaften für Schlammbanken wurden erkannt wie z.B. Isoëto-Nanojuncetea und Bidentetea tripartiti. Alle erkannten Pflanzengemeinschaften waren fragmentiert. Außerdem wurden mehrere Zeichen von Sukzession ersichtlich, besonders das Vorkommen von vielen Phanerophyten. Der Vergleich zwischen den zwei Sektionen in unterschiedlichem Alter hat keine deutlichen Unterschiede hervorgebracht. Neophyten kommen auf 75 % der Aufnahmen vor. *Solidago gigantea* ist dabei die am häufigsten vorkommende invasive Art. Auch einige bedrohte Arten wurden gefunden, was ermutigend ist.

CONTENT

I. INTRODUCTION

In the past centuries, many rivers have been channelized and regulated for example in order to supply water, to supply power, to prevent floods, or to gain more land for farming (Harvey and Clifford 2009). Consequently floodplains are now one of the highest threatened ecosystems in the world (Tockner and Standord 2002).

The river Traisen, a tributary of the Danube in Lower Austria, was also channelized and regulated during the 19th century (Traisen.net 2014). A restoration project was implemented in order to intent to restore a channelized section of the river located in the Natura 2000 area "Tullnerfeld Donau-Auen" into a more natural section connected to the floodplain (Life+ Traisen 2017). The restoration work started in 2009 during which a new meandering route for the river was built.

Riparian banks are very complex ecosystems particularly because of their lateral connectivity with the surrounding landscapes, their longitudinal connectivity between upstream and downstream and their dependence to natural flow regimes. Because of that, restoration projects are challenging, and monitoring is essential to check to which extent the restoration succeed. Most of the time, restoration needs time and the results can often not be seen before several years (Falk et al. 2006).

The vegetation is a key component of the habitat and how it develops is one indicator and one requirement of the success of restoration.

The objective of this master thesis is to contribute to the monitoring of the riparian vegetation on the site of the restoration project of the Traisen and to better understand the vegetation dynamics and the succession process occurring there.
The thesis focuses on the following research questions:

- Which vegetation dynamics and vegetation patterns can be recognized on the restored riparian banks of the Traisen?

- How is the plant succession at the river Traisen developing, regarding the dynamical characteristics of plant communities?

Furthermore the study focuses on spatial difference between two sections, one finished in 2014 and the second finished in 2015, in order to see if there is already difference in the succession. The invasive species are studied as they can influence the evolution of the vegetation. Finally species under conservation or threaten are also considered as they good indicators of the conservation of the area.

II. BACKGROUND

A. Studied area

1. Description

The studied area lies on a section of the Traisen, a river of 80 km in Lower Austria formed from the rivers Türnitzer Traisen and Unrechttraisen (Traisen.net 2014a). The Traisen is flowing to the Danube next to the municipality of Zwentendorf. The river mouth is located in the protected area Natura 2000 "Tullnerfeld Donau-Auen" which lies between Krems and Vienna. The natural flow of the river has been modified during the building of the hydroelectric power station Altenwörth in 1973 on the Danube. The river has been extended by 7.5 km in order to relocate the river mouth downstream of the power station (Traisen.net 2014b). The extended part was homogeneous, straight and not connected to the surrounding landscape. In 2009 it has been decided to create a new natural section of the river mouth of the Traisen (Eberstaller et al. 2016). Furthermore the Traisen is highly regulated mostly because of regulations against floods implemented during the 19th and 20th centuries. There are many shore reinforcements, transverse structures, and hydropower stations (136) on the river which make the river morphology artificial (Traisen.net 2014c).

A study has been made by the WWF in 2011 with 15 alpine rivers in Germany, Switzerland and Austria (Hettrich et al. 2011). The river's water qualities, water accessibilities, water uses, typical species and habitat, outflow and sediment transport have been evaluated. The study found that 93% of the Traisen has severe impairments impacting considerably the diversity of species and structures which can go as far as the complete loss of the original function of the water system (Hettrich et al. 2011).

The studied area is located in the protected area Natura 2000 "Tullnerfeld Donau-Auen" which is part of the continental biogeographical region and is 17.990 ha (Amt der NÖ Landesregierung 2017a). It comprises the FFH site (17.530 ha) and the Bird site (17.760 ha) which partly overlap. Its altitude ranges between 203 m and 140 m. It comprises an important part of the floodplain between Krems and Vienna, mostly the northern part of it. The area is quite valuable because of its floodplain forest which is the biggest connected patch found in Austria. However the flow of the Danube is heavily regulated by the hydroelectric power plants Greifenstein and Altenwörth which have negative effects on some ecosystems. However on some places there are floodplains, wet meadows and dry meadows (Amt der NÖ Landesregierung 2017a). The site is particularly important for its "alluvial forests with *Alnus glutinosa* and *Fraxinus excelsior*" (91E0), "Riparian mixed forests of *Quercus robur*, *Ulmus laevisand, Ulmus minor*, *Fraxinus excelsioror Fraxinus angustifolia*, along the great rivers

(Ulmenion minoris)" (91F0). Furthermore there are seven different FFH types of water habitat like for example "Oligotrophic to mesotrophic standing waters with vegetation of the *Littorelletea uniflorae* and/or *Isoeto-Nanojuncetea*" (3130) or "Rivers with muddy banks with *Chenopodion rubri p.p.* and *Bidention p.p.* vegetation" (3270) (Amt der NÖ Landesregierung 2017a). In addition there are many fish species to find in the Tullnerfeld Donau-Auen site like the asp (*Leuciscus aspius*) or spined loach (*Cobitis taenia*), mammals like the beaver *(Castor fiber)*, birds like the Grey-headed woodpeakers (*Picus canus*) or amphibians like the Danube crested newt (*Triturus dobrogicus*) (Amt der NÖ Landesregierung 2017a).

The studied area lies in the Tulln basin also called Tullner Feld. The Tulln basin has a length of about 57 km and about 14 km wide between the Wachau and the Vienna gates (Haberreiter and Grinschgl 2003). It is bordered in the North from the Wagram and in the South from the beginning of the alpine region. In the area two important geological landscapes can be found: flysch and molasse. Both are covered by gravel from the Danube.

The soil has different gleizations depending on the elevation from the ground water. Furthermore there are differences between soils depending on their maturities. A young soil heavily influenced by the ground water has little humus, and fallow trees grow there. Soil which has more time to develop with more humus, and is less influenced from the ground water has more poplar forest. While an older soil with at least 20 cm of humus is "mature" and hard wood species can grow on it (Haberreiter and Grinschgl 2003).

The Tulln basin is in a climatic transition zone (Jelem 1974:93). Climatic factors are overlapping between west European climate, which has mild winters and chilly and wet summers and continual east European climate which has cold winters and warm and dry summers (Haberreiter and Grinschgl 2003).

2. Ecological restoration project

The last reach of the Traisen from the river mouth to the Danube has been newly built since 2009 within a project of ecological restoration (Life+ Traisen 2017). Ecological restoration attempts to initiate or accelerate the recovery of an ecosystem to get back "a natural range of ecosystem composition, structure and dynamics" mostly based on an historical state (Falk et al. 2006; SER 2002). Such restorations are necessary when an ecosystem has been destroyed, damaged or transformed by human activities (SER 2002). The case of the Traisen is particular because the old route of the river has been totally destroyed and it has been necessary to build a whole new route from the former one (Eberstaller et al. 2016)

On the next figure, the old route as well as the new route are represented.

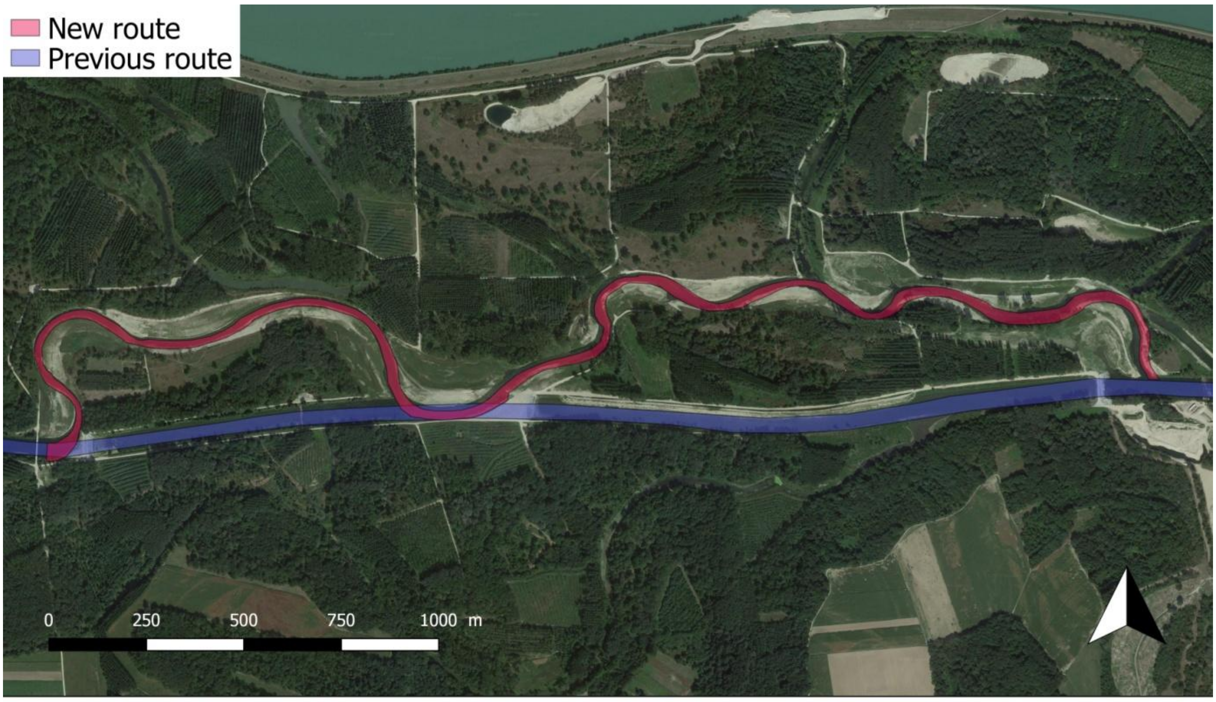

Figure 1: Map of the studied area with the new and old routes (Google Earth)

Rivers are quite complex ecosystems. The hydrology of a river has many characteristics, the characteristics which are particularly important for the floodplains are: the discharge, the lower water level, the middle water level, the highest water level, the elevation and duration of flooding, the frequency of flooding (Lazowski 1997). Moreover rivers have a longitudinal and a lateral connectivity (Darby and Sear 2008). The longitudinal connectivity is the relationships within a river between upstream and downstream. The conditions upstream are influencing the whole reach: water and sediment delivery whereas the lateral connectivity influences the conditions between the aquatic, riparian and floodplain ecosystems (Darby and Sear 2008).

There are then two possible strategies for river restoration: one at the catchment scale, the second at the reach scale. At the catchment scale, projects are working with the longitudinal connection but are rare because they are more complicated projects, with more stakeholders and more uncertainty about the outcome. However, the outcome at the catchment scale might be more successful and self-sustaining than restoration at the scale reach. At the scale of the reach, there are two mains approaches, one managing the physical process locally and the other managing the landforms in the floodplain. Both approaches have a rather local effect (Darby and Sear 2008).

The studied section was straight, regular and isolated from the surrounding. The section of the Traisen is a particular case of ecological restoration because the new route of the river does not follow the historical course because of the hydroelectric power station (Eberstaller et al. 2016). The new reach has been reconstructed with meanders, and has been inspired from near-natural rivers with similar abiotic conditions like the slope and flow which are a more natural morphology for a river (Eberstaller et al. 2016). The new course of the river creates new structures like riparian areas and new habitats as well as regularly flooded foreshores. The major aim is to reconnect the river with the surrounding landscape and others water bodies. This should particularly make the Traisen a better habitat for many fish species connecting better the different water bodies. (Life+ Traisen 2017) 9.4 km has been new build as well as 30 ha of typical river habitat and 60 ha of flood area (Eberstaller et al. 2016).

The next figure is a picture made in autumn 2017 from the project organization, where the old route (on the left) and the new route (on the right) can be seen.

Figure 2: New route and old route of the Traisen (Life+ Traisen 2017)

The restoration project was part of a LIFE project which is the EU's financial instrument for nature and environmental conservation with Verbund AG (energy company) as major sponsor as part of compensation measure. Others sponsors are the fishing federation of Lower Austria (niederösterreichischen Fischereiverband), Fund for landscapes in Low Austria (Landschaftsfonds Niederösterreich), Via donau, Bundesministerium für Land- und Forstwirtschaft, Umwelt und Wasserwirtschaft und Bundeswasserbauverwaltung NÖ (Life+ Traisen 2017).

B. Muddy bank vegetation

1. Description

This study focuses on the vegetation on slip-off slopes. On these banks, muddy bank vegetation is expected. A closer attention is given to the habitat type 3270 "Rivers with muddy banks with *Chenopodion rubri p.p.* and *Bidention p.p."* from the classification of the Habitat directive (European commission 2013). On these muddy river banks grows annual pioneer nitrophilous vegetation which are from the *Chenopodion rubric p.p*. and the *Bidention p.p.* alliances. The muddy banks are first without vegetation during the spring and the beginning of the summer and then the plants develops later in the year (European commission 2013). They can be found from plain to sub-mountain levels. This habitat can be found on muddy banks of natural and semi-natural rivers which are being regularly flooded (Ellmauer and Essl 2005). Several conditions favored this habitat:

- The situation of the bank: it should be situated on a regularly flooded bank between the mean lowest water stand and the high-water stand.
- The flow velocity: sedimentation of fine particles (argil, sand, silt and organic particles) is an important process on muddy banks, this is why the flow velocity has to be very slow (Ellmauer and Essl 2005).

These conditions contribute to the formation on very nutritive mud on the bank characteristic of the habitat (Ellmauer and Essl 2005). Furthermore the habitat requires a particular dynamic: it is necessary that the surface is regularly denuded due to floods or mud. If this dynamic is not present, perennial plants from other plant communities of other habitats types will establish (Ellmauer and Essl 2005). Indeed, riparian species are adapted and required variables flows for their life cycles and they are also time sensitive. These disturbances are necessary for structuring and maintaining the biodiversity. The plant succession is stopped by the disturbance and resets with pioneer species (Ellmauer and Essl 2005).

Succession can be defined as a directed change of the habitat, in the case of vegetation, a succession of plant communities (Frey and Lösch 2010:154). Primary succession occurs on new substrate which has never been populated while secondary succession occurs where the substrate has already been populated (Frey and Lösch 2010). So primary succession occurs on soils where there was no diaspore or soil building process (Frey and Lösch 2010). The case of the Traisen is unique because there has been a lot of earth-moving work to build the new bed. But as there has already been vegetation growing on the soil, and that seeds are still in it, we can talk about secondary succession (Lapin et al. 2016). Succession occurs because of differential site availability, due to disturbance, differential species availability due to dispersion or propagule pool and differential species performance because of competition or physiology for example (Pickett et al. 2013:107). The first vegetation to establish are called pioneer (Frey and Lösch 2010). Plants communities from the muddy banks are pioneer permanent communities (Ellmauer and Essl 2005). Theoretically communities develop from pioneers communities to a last stage: climax community, which is a steady state of the habitat. Humans interfere most of the time in this process and the climax is very rarely reached (Frey and Lösch 2010). On the river banks while a part of the vegetation stays as pioneers communities, others communities develops: softwood forests to the last step, alluvial hardwood forest (Drescher and Egger 2000).

Succession is intrinsically linked to restoration because restoration projects attempt to manipulate these dynamics in order to restore damaged ecosystems (Lawrence et al. 2007:1). Succession ecology uses most commonly a longer time scale, 10 to 200 years, to study the change whereas restoration ecology focuses on a shorter time scale, 1 to 20 years (Lawrence et al. 2007:6).

In the case of the restoration project of the Traisen the succession is mostly spontaneous. Only on some banks in 2015 cuttings of the species *Fraxinus excelsior, Populus nigra, Alnus incana, Populus alba* and *Salix alba* have been planted (Lapin et al. 2016). So most of the plant species which grow arrived naturally by dispersion, or the seeds were in the soil. An important dispersion factor for river banks is the water and the flooding, the wind and water birds (Ellenberg and Leuschner 2010).

2. Endangerment of riparian banks

Rivers and floodplains have always had a major role in the people life (Lazowski and Schwarz 2014). They are used for urban development, their resources, for agriculture… (Tockner and Stanford 2002). Since the middle of the 19^{th} century, rivers have been massively regulated and canalized to control the flow and floods. (Lazowski 2014) Added to this, increases in pollution, occurrence of invasive species make floodplains one of the most threatened ecosystems (Tockner and Stanford 2002).

Building of dams and hydroelectric power stations, canalization, monoculture forestry, agriculture with chemical and plowing in floodplains, construction of buildings, lowering of the ground water, and extraction of natural resource are the principal reasons for the loss of floodplains (Lazowski 1997).

Therefore, the conditions for muddy bank vegetation to establish cited in II.B.1. are in many cases not met. Moreover the riparian vegetation has an important role in the floodplain ecosystem: stabilization of river banks, flow regulation, nourishment for aquatic organisms, control of light and thermal regimes, buffer against pollutants and nutrients (Naiman and Décamps, 1997). So the loss of muddy banks or muddy banks in a bad state can have consequence on the whole floodplain ecosystem.

To attempt to protect these vulnerable and endangered ecosystems, conventions, networks, laws at international, European and national levels have been implemented.

3. Conservation status

The protected area Natura 2000 “Tullnerfeld Donau-Auen” is part of a network of more than 27.000 protected areas in Europe (European Commission 2017a). Natura 2000 Network is a very important disposition for nature conservation in the European Union. It aims to protect the species and habitats listed under the Bird directive of 1979 and the Habitat directive of 1992 in order to give them a favorable conservation status (Sundseth 2015). The Bird directive aims to protect all wild birds and their habitats while the Habitat directive includes in addition the protection of around 1000 rare, threatened or endemic species as well as the protection of 230 habitat types. The Habitat Fauna Flora Directive has five annexes (European Commission 2017b). Annex II lists the species which their core habitats should be a site of community importance. Annex IV lists the species which should be under strict protection in and out Natura 2000 area. And annex V lists species which should stay in favorable conservation status.

The EU states are required to design Natura 2000 sites. In addition they have to set up legislation for the protection of listed species inside and outside Natura 2000. There are two approaches in the Natura 2000 sites to ensure the conservation of the biodiversity: one is to avoid disturbance and activities which would damage the site and the second is to take positive measures to improve and restore the habitat (Sundseth 2008:58).

In Natura 2000 sites, human activities are not prohibited. Agriculture, fishing, hunting, forestry or tourisms for example are allowed. The activities should be sustainable and the idea is to have coexistence between humans and nature (Amt der NÖ Landesregierung 2009).

The European Water Framework Directive of 2000 is an important complement to the Habitat directive (Bilz et al. 2011). It aims to protect all the ground and surface waters and aims to improve its ecological and chemical status in terms of "quality of the biological community, the hydrological characteristics and the chemical characteristics" for the water surface (Umweltbundesamt 2017; Commission European 2016). The ecological restoration of the Traisen is part of the measures taken to respect the objectives of the Water directive implemented by Austria (Life+ Traisen 2017).

The Convention on biological diversity (CBD) from 1992 is also relevant, it has four principal objectives:

- The conservation of biological diversity
- The sustainable use of the components of biological diversity
- The fair and equitable sharing of the benefits arising out of the utilization of genetic resources

The CBD develops several strategies and programs. The "Global Strategy for Plant Conservation" is the most relevant for plants (Convention on biological diversity 2017; Bilz et al. 2011). Part of its objectives is to monitor the biological diversity, to conserve it and to use it in a sustainable way. The European Plant Conservation Strategy coordinates it at the regional level and has an influence on the measures taken in Europe and Austria (Convention on biological diversity 2017; Bilz et al. 2011).

The Bern convention and CITES can also be relevant for the conservation of the species growing on the riparian banks. The Bern convention (1979) is the first international binding agreement with the objective to protect wild fauna and flora and their habitats. A second objective is to promote cooperation between countries in the conservation domain, which is the basis for the habitat directive in Europe (Council of Europe 2017; Bilz et al. 2011).

CITES, Convention on International Trade in Endangered Species of Wild Fauna and Flora, is a legally binding agreement aiming to regulate the international trade in endangered species.

A last but not least relevant convention for floodplains and riparian banks is the Convention on Wetlands, also called the Ramsar convention (Ramsar Convention Secretariat 2014). It was adopted in 1971 in Ramsar, in Iran. Its mission is "the conservation and wise use of all wetlands through local and national actions and international cooperation, as a contribution towards achieving sustainable development throughout the world" (Ramsar Convention Secretariat 2014). Austria entered into the Ramsar Convention in 1983 (Bundesministerium für Nachhaltigkeit und Tourismus 2018). Since then Austria has implemented several measures and strategies, for example: national inventories, strategies to protect wetland, and nomination of Ramsar sites (Bundesministerium für Nachhaltigkeit und Tourismus 2018).

III. METHODS

A. Vegetation survey

In order to characterize the vegetation population of the riparian muddy banks, vegetation surveys have been performed from May 2017 to August 2017. Seven banks which lied on the first and second sections of the newly built river have been surveyed. They are named 1 to 7 from upstream to downstream. The restoration of 1, 2, 3 were finished in 2014, which means that their third vegetation period has been surveyed whereas 4, 5, 6, 7 were finished in 2015 and their second vegetation period has been surveyed.

Figure 3: Map of the studied areas with the seven surveyed banks (Google Earth)

On these riparian banks, plots of 1 m² have been chosen. This size has been chosen from the experience of a similar study in 2016 (Schidla 2017). The locations, numbers and distributions of the plots were not random but subjectively determined in order to have rather representative and homogeneous plots from ecological, physiognomical, structural and floristic perspectives (Tremp 2005). 36 plots distributed on seven banks have been surveyed in May and June. One plot has not been found again in July and August, so only 35 were surveyed. The number of plots resulted from the number of vegetation types found on each bank and was not predetermined.

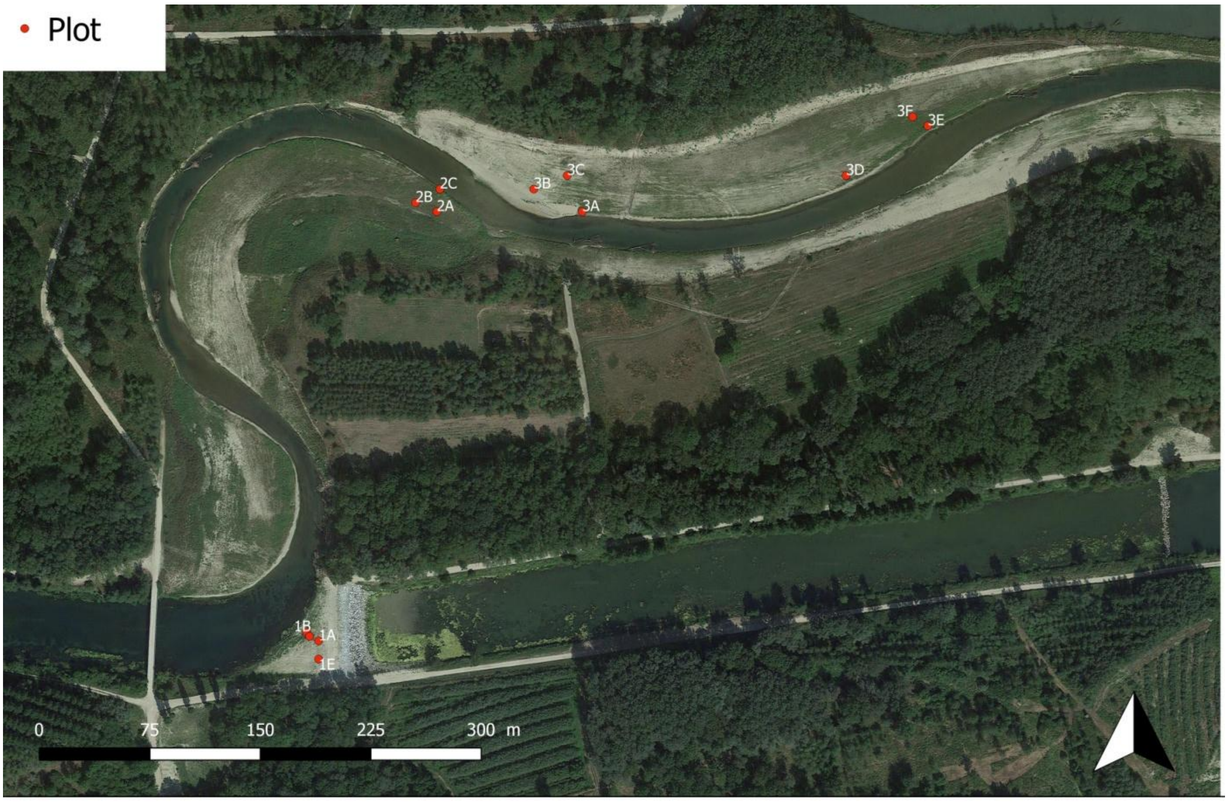

Figure 4: Map of the plots on the banks 1, 2 and 3. (Google Earth)

Figure 5: Map of the plots on the banks 4 and 5. (Google Earth)

Figure 6: Map of the plots on the bank 6 and 7. (Google Earth)

Phytosociological methods have been used to record the vegetation. For each plot, all the species were recorded following the Braun-Blanquet principles of vertical stratum from the tree layer to the bush layer to the herbs layer. The cardinality for each species was estimated with the index of abundance-dominance from Braun-Blanquet in Table 1.

Table 1 : Braun–Blanquet Scale (Dierschke 1994:160).

Grades	Species cardinality, Cover-abundance scale
r	minor, rare
+	<1 %, few individuals
1	>1≤5 % any number of individuals
2	>5≤25 %, any number of individuals
3	>25≤50 %, any number of individuals
4	>50≤75 %, any number of individuals
5	> 75 %, any number of individuals

On muddy banks pioneer species are expected. That type of species has a short life span and is influenced substantially by the floods, therefore each plot has been monitored four times between May and August. In addition, the humidity of the soil as well as the types of soil and the coordinates were reported during the recording.

The nomenclature used for the species is the one from the flora of Fischer et al. (2008).

B. Analysis

1. Vegetation composition

Firstly, several analyses have been realized to obtain a general impression of the composition of the vegetation.

- The composition and repartition of the families are analyzed.
- The species richness is the number of species in a defined area (Kent 2012:122). The species richness of each plot, both section and the whole area is calculated and then compared.

- The Jaccard coefficient is calculated. It gives the similarity in species composition between two samples (Kent 2012:116). It has been used in this study in order to compare section 1 and section 2. Its formula is the following:

$$Sj = \frac{a}{a+b+c}$$

a is the number of species common to both sections, b is the number of species in section 1 only, and c is the number of species in section 2 only.

- For each plot the plant cover has been taken. The evolution of the plant cover between May and August for the two sections is analyzed.

2. Plant communities

The Braun-Blanquet method is a widely spread method to classify vegetation. After the plant surveys using the method explained in chapter III.A, the tables are analyzed in order to define plant communities.

The basic unit of this classification system is the association (Kent 2012). The association is a plant community type, defined as a "floristic composition, presenting a uniform physiognomy, and growing in uniform habitat conditions" (Peet and Roberts 2013). This means that there are species composition patterns which can be found in different areas, and are the result of the environmental conditions. An association is characterized by a typical species composition including some species which are particular indicators for a community: character species and differential species.

Character species are characteristic for a specific community and can be used to identify the community (Tremp 2005). Differential species can have several definitions. Here the definition used is the one from "Die Pflanzengesellschaften Österreichs" (Mucina et al. 1993): the differential species differentiates syntaxon which are from the same syntaxa level and those which are from the same higher syntaxa.

The Braun-Blanquet system develops a classification system with the following nomenclature (Mucina et al. 1993):

Class *-etea*

Order *-etalia*

Alliance *-ion*

Association *–etum*

Some other differentiations can be found in addition: sub-association and variation (Dierssen 1990:12). To analyze the plant communities it is possible to use computer programs. Given that they are relative few plots, the analysis has been done with Excel Tables.

In order to characterize the association, several tables have been developed (Tremp 2005 ff:117):

- The raw table gathers all species from the inventories, where the rows show the species, and the columns show the Braun-Blanquet values.

- In the constancy table, a new column is added with the constancies. The data is classified as a function of these constancies. For this the absolute and relative constancies are calculated for each species.

- In the differentiated table the data is ordered to gather groups. The data is classified according to the life forms, diagnostic species, and ecological groups.

The floristic similarity in the table helps to determine the association (Tremp 2005:114). The diagnostic species help to determine the association. The differential species on the contrary helps to limit associations. Specific literature has to be used to identify the association, here the volumes of "Die Pflanzengesellschaften Österreichs" von Mucina et al. (1993) and Mucina and Grabherr (1993) are used.

3. Indicator values

The species indicator value is a concept developed by Ellenberg enabling to characterize the ecological and abiotic factors of an area (Ellenberg and Leuschner 2010). The indicator values use the principles of biological indication, which means that the plants species reflects the ecological and abiotic conditions of the area where they grow (Diekmann 2003). The specificity of Ellenberg is that ordinal numbers have been determined for each species for several factors (see table 2) which are supposed to represent their optima (Diekmann 2003).

For each factor (table 2), there are indicator values, mostly from 1 to 9. For example for the temperature value: 1 is a cold indicator for high mountains, the indicator goes then from 2 to 9 in a range of temperature and 9 is for very high temperature indicators (Ellenberg and Leuschner 2010:27.2).

Table 2: Different Factors of the indicator values with description (Dierschke 1994:226).

Factors	Description
Continental value (K)	Order according to geographic distribution in ocean or continental area
Temperature value (T)	Order according to thermal gradient
Light availability value (L)	Order according to shadow tolerance and relation to illumination
Soil acidity value (R)	Order according to soil acidity requirement
Soil humidity value (F)	Order according to soil humidity and water supply
Soil salinity value (S)	Order according to salt tolerance
Soil reaction value (N)	Order according to soil reaction

Each plant species has different indicator values and the one determined by Ellenberg, has been used for this analysis.

All the values for each species are then listed in tables. In order to search for differences in the abiotic and ecological conditions between the first and the second section, the weighted average was calculated for the species surveyed on the first section, the second section and both sections (Dierschke 1994:235).

Weighted average $= \frac{\sum I}{\sum N}$

I = Indicator value for a species

N = number of species

Then, the results can be compared and the ecological conditions from the values interpreted.

4. Life forms

Raunkiaer developed a system which differentiates five categories of life forms (Dierschke 1994:87). The distinction comes from the growth habit with a focus on the position of the renewal buds, which are there to survive the unfavorable time of the year (in Austria, Winter) (Fischer et al. 2008:108).

These life forms are:

- Phanerophytes: renewal buds high above the soil level
- Chamaephytes: renewal buds close to the ground
- Hemicryptophytes: renewal buds at the soil surface
- Geophytes: buds in the soil or in water
- Therophytes: annual plants which persist under seed form

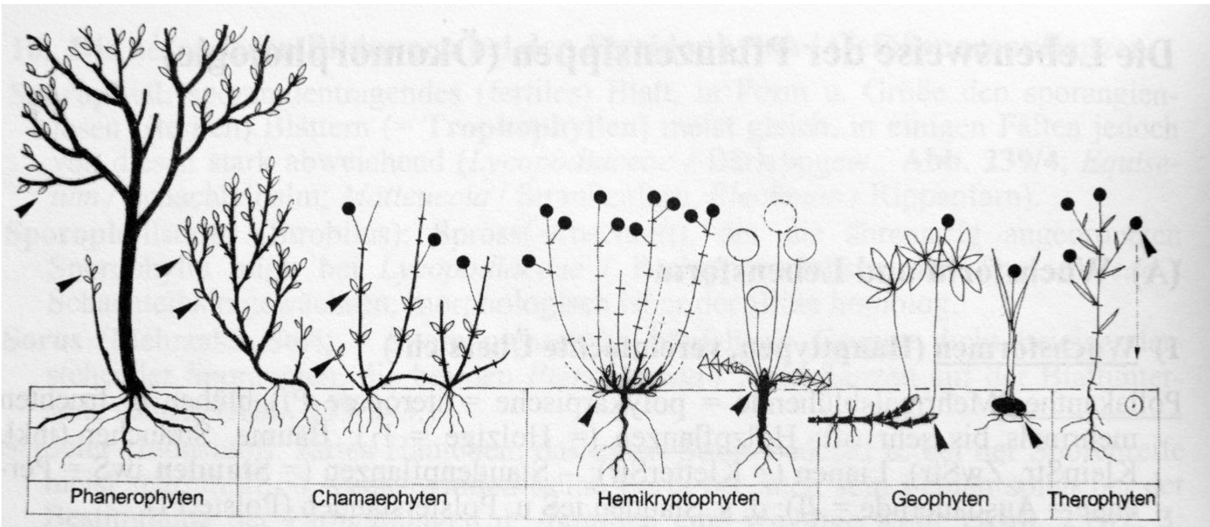

Figure 7: Illustration of the different life forms to find in Fischer et al. (2008:108)

These life forms correspond to different strategies to survive different ecological conditions. That is why, the life forms are a good indicator of the ecological conditions. Furthermore certain life forms are characteristically of a certain habitat type or a succession stage.

The life form is identified for each inventoried species with the help of the Flora from Fischer et al. (2008).

Furthermore, the hydrophytes have been taken into account. They are plants which can live in the water. For this purpose, they have morphological adaptations such as underwater leaves or swimming leaves. Raunkiaer classified this form under geophytes, hemicryptophytes and therophytes (Fischer et al. 2008:111).

The numbers of each life form per plot for the different sections and the whole area allows to see if the life forms correspond to the expectation of pioneer plant communities and if there are any differences between the banks.

5. Invasive species

Neophytes are plant species which are not native of a particular region and which arrived after 1492 with direct or indirect human assistance (Essel and Rabitsch 2002). But all neophytes do not threaten native species, around 1110 neophytes are listed in Austria, but only 17 are considered as invasive. These invasive species are a threat for conservation because they live in natural or semi-natural habitat competing and replacing native species (Essel and Rabitsch 2002:9).

These 17 species are "*Acer negundo, Ailanthus altissima, Aster lanceolatus, A. novi-belgii, Bidens frondosa, Elodea canadensis, Epilobium ciliatum, Fallopia japonica, Fraxinus pennsylvanica, Helianthus tuberosus, Impatiens glandulifera, I. parviflora, Populus x canadensis, Robinia pseudacacia, Rudbeckia laciniata, Solidago canadensis, S. gigantea*" (Essl and Rabitsch 2002:9).
Restoration projects can be seen as a kind of disturbance for the riparian banks. Disturbance plays an important role in the spreading of invasive species (Lapin et al. 2016). That is why, the studied area might be vulnerable to invasion. Several studies have already researched the establishment of invasive species in the same area (Lapin et al. 2016).
It is important to analyze the presence of neophytes because they could threaten the success of the restoration project. The presence of invasive species in the vegetation survey is analyzed for each plot and each section and the number and frequency are statistically analyzed.

6. Conservation assessment

In order to estimate the conservation status of the vegetation, the presence of surveyed species in different inventories of protected species has been controlled. The Austrian Red list has been used (Niklfeld 1999).

The Red list is an inventory which has been introduced by the IUCN (International Union for the Conservation of Nature) in order to evaluate the conservation status of many species. The species are classified into different categories: from “least concerned”, “near threatened”, “vulnerable”, “endangered”, “critically endangered”, “regionally extinct”, “extinct in the wild” to “extinct” (IUCN 2017). Not all species have been recorded, and there are in addition many publications of red lists which are only valid for a country, a region, certain habitats or a family. Red lists give a good overview of the status of endangered species and are really important to set up conservation measures.

The publications of the Austrian Red list by Niklfeld of 1999 are used in this study to determine which species are relevant for conservation (Niklfeld 1999).

7. Flooding and pluviometry

Flooding is the major process influencing the vegetation on riparian banks, which is why it is important to get the reading of the change in water level of the year. The Office of the Provincial Government of Lower Austria (Amt der NÖ Landesregierung) is doing the measurement (Amt der NÖ Landesregierung 2017b). From the reading, it is possible to interpret the possible influence that the water level had on the vegetation.

The Office of the Provincial Government of Lower Austria registers the pluviometry too (Amt der NÖ Landesregierung 2018). The pluviometry for Tulln (the closest station of the study area) is interpreted.

IV. RESULTS

A. Species composition

128 species have been identified on the 36 plots. 9 species have been additionally identified only to genus level.

These species are from 37 different families (See figure 8). Poaceae, Cyperaceae and Lamiaceae are the most represented families with respectively 20, 16 and 13 species.

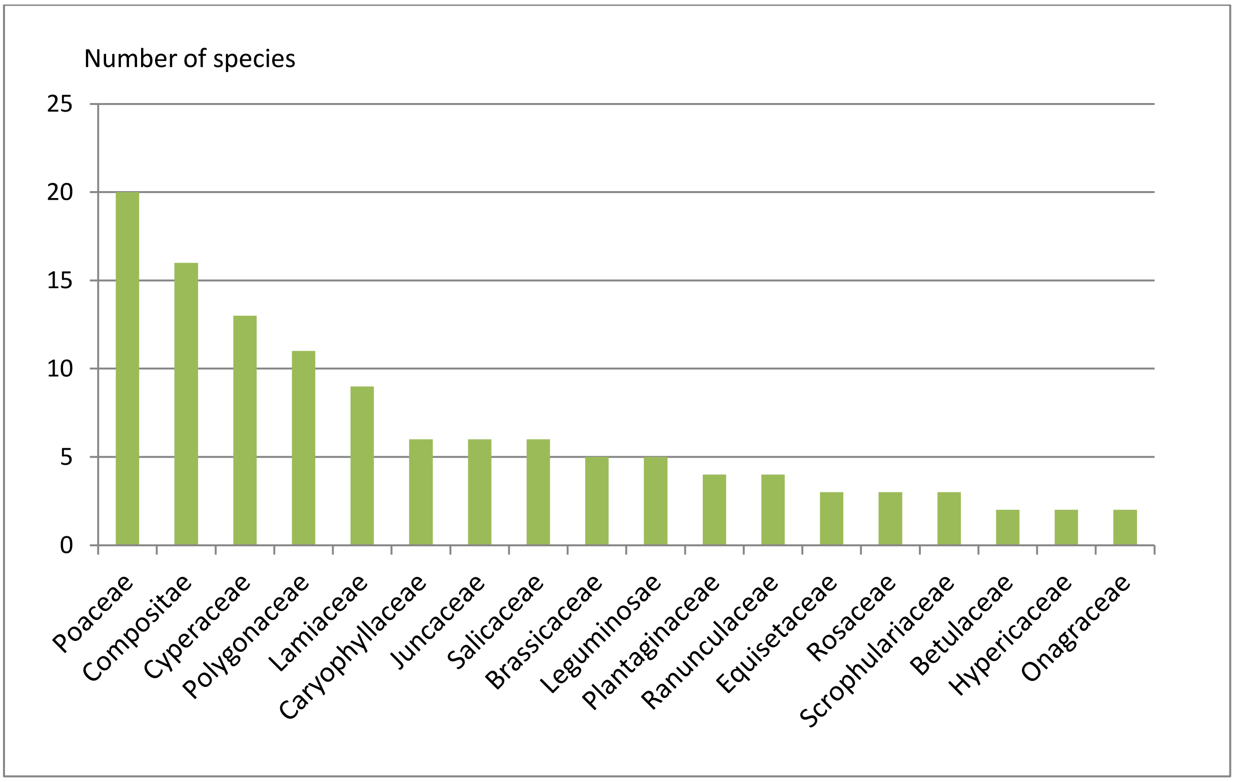

Figure 8: Numbers of species per families for the surveys of May, June, July and August 2017

The following families are represented by only one species: Alismataceae, Amaranthaceae, Balsaminaceae, Boraginaceae, Cannabaceae, Caprifoliaceae, Convolvulaceae, Euphorbiaceae, Gentianaceae, Geraniaceae, Iridaceae, Lytraceae, Oxalidaceae, Primulaceae, Rubiaceae, Sapindaceae, Simaroubaceae, Urticaceae, Verbenaceae.

- Frequent species

Table 3: Twelve most occurring species found during the surveys in May, June, July and August 2017

	Number of plots (n=36)	Frequency
Agrostis stolonifera	36	1.00
Salix purpurea	29	0.81
Calamagrostis epigejos	23	0.64
Solidago gigantea	22	0.61
Poa trivialis	20	0.56
Populus nigra	19	0.53
Lycopus europaeus	18	0.50
Populus alba	17	0.47
Mentha longifolia	16	0.44
Juncus articulatus	15	0.42
Phalaris arundinacea	15	0.42
Plantago major	15	0.42

- Species richness

The species richness has been summed up in the following box plots (figure 9).

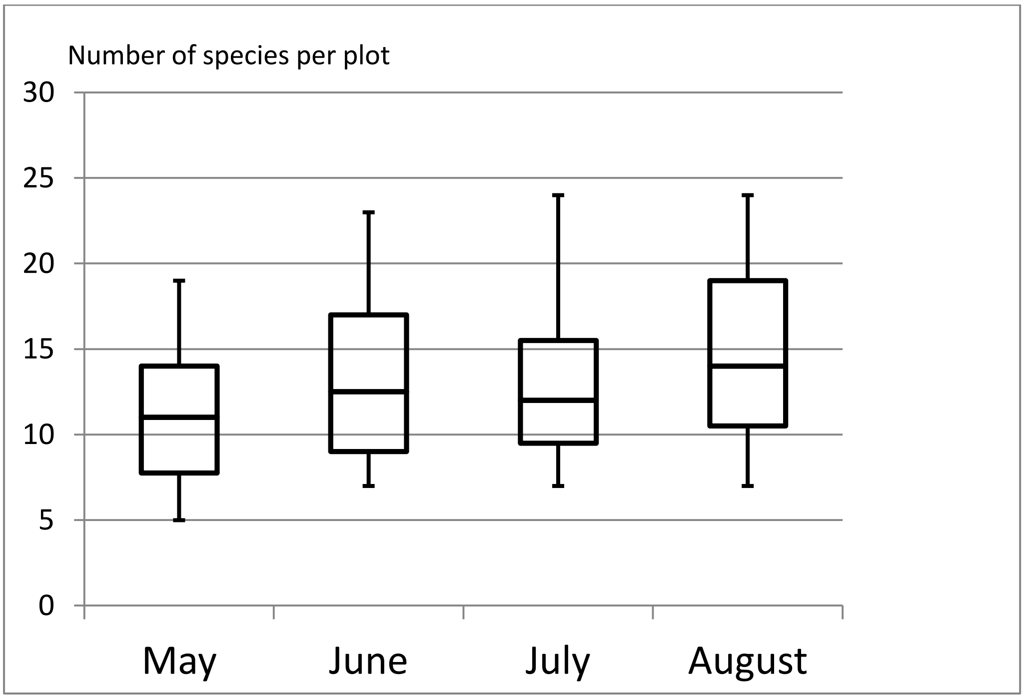

Figure 9: Box plots of the species richness per plot for in May, June (n=36) July in August (n=35) 2017

In figure 9 it can be observed that the numbers of species overall increased from May to August. The biggest difference can be seen between May and August.

The smallest number of species per plot is 5 in May, while it is 7 during the three others months. The biggest numbers of species per plot is 19 in May, 23 in June, and 24 in July and August. The median is hardly varying between the months. In August it is slightly bigger: 14 while it is 12 in July, 12.5 in June and 11 in May 11. The biggest difference between the months is the repartition of species richness between the plots.

In order to know if there is a difference in species richness between the two sections, the species richness per plot for each section is represented in the next box plot (figure 10).

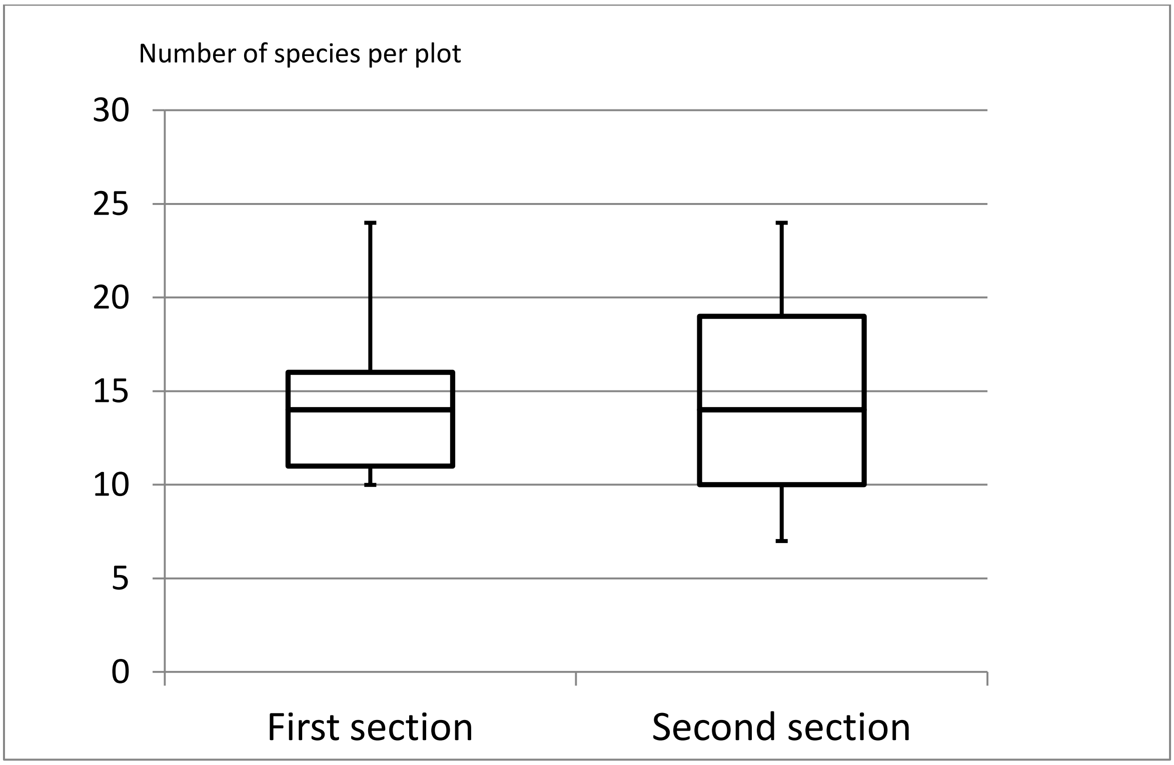

Figure 10: Box plots of the species richness per plot for the plots surveyed in the first section and the second section in August 2017 (n=35)

The box plots of the figure 10 show the difference of repartition of species richness per plot between the first section and the second section for the month of August. As August was the month with the highest number of species richness, this months data is be used to analyze the species richness repartition. The box plots show some similarities between the first and the second section: the median is the same as well as the highest species richness. The repartition of species richness per plot is quite different: in the first section 75 % of the plots have species richness between 10 and 16 while on the second section 75 % have species richness between 7 and 19. On the second section there are more plots with higher species richness: 25% between 14 and 19 and 25% between 19 and 24.

However a Whitney-Mann U test shows that there is no significant difference in species richness between the two sections ($p=0.95>0.05$).

- Jaccard coefficient

  The Jaccard coefficient found is 48 % similarity in species composition between the two sections. This means that almost half of the species are the same in both sections.

- The vegetation cover for each plot is in annex 5.

B. Plant communities

There are relatively few plots for a complete analysis of the area, however the results give a good idea of which communities are growing on the riparian banks. The plant communities have been only determined to the community levels. All the communities found are fragmented. The table regrouping all the plots and classified by classes can be found in the annex 5.

The plant communities found are:

- Isoëto-Nanojuncetea Br.-Bl. et R. Tx ex Westhoff et al. 1946
- Bidentetea tripartiti R. Tx. Et al. in R. Tx. 1950
- Phragmiti-Magnocaricietea Klika in Klika et Novák 1941
- Molinio-Arrhenatheretea R. Tx. 1937 em. R. Tx. 1970
- Stellarietea mediae R. Tx., Lohmeyer et Preising in R.Tx. 1950
- Galio-Urticetea Passarge ex Kopecký 1969

The plant communities as well as their developments are described following.

- Isoëto-Nanojuncetea

This class is composed of short lived and unstable communities, which grow on alternating wet ground (Traxler 1993:197ff). They can be found on sites like edges of ponds, open ground of ponds, riparian banks of rivers, dried old river arms, drainage channels, muddy puddles, wet lanes, rice fields or wet meadows (Traxler 1993). Their natural sites are riparian banks of rivers or lakes and old arms of rivers with natural water level variation. In order to develop, the site should have areas without vegetation or wounds of vegetation. The water supply is a very important determining factor; it influences the occurrence, species composition and the durability of the communities. Other factors are the variation of water levels, the duration of dryness, accumulation of plant materials.

Isoëto-Nanojuncetea can interlock with Bidentetea, Molinio-Arrhenatheretea or Polygono-Poetea annuae communities. If there is not enough disturbances, the Isoëto-Nanojuncetea will replace these other communities.

Two of the 26 character species have been found during the surveys *(Juncus articulatus and Cyperus fuscus).* These plant communities are on the plots 1 to 11. *Juncus articulatus* is the most frequent with a constancy of 13 and has cover abundances from + to 2 on the Braun-Blanquet scale.

Mentha aquatica is a differential species in this class. It has often a high cover abundance (4). Furthermore *Mentha aquatica* is an indicator species for azote.

- Bidentetea tripartiti

This class is one of the classes expected in the habitat 3270. The class of Bidentetea tripartiti can be anthropologic and natural communities with summer therophytes (Geisselbrecht-Taferner and Mucina 1993:90ff). They are short living and rather poor in species richness. They do not spread a lot. The sites can be under floods a longer time and be periodically dried in summer. The soil is rich in nutrients, humid, very eutrophic, rich in fine soil, muddy and sandy. It can be found on dried up effluent pools, riparian banks, soil rich in ammoniac near dung heaps, cesspits. They are nitrophilous communities. These plant communities are favored by human activities which eutrophy water bodies. They have the tendency to be fragmented. They grow mostly quickly after germination in spring and at the beginning of summer and have an optimal development between mid-August and mid-September.

4 species of the 7 character species were found during the surveys. However they have a low cover. Some species of the order Bidention tripartiti and the association Polygono lapathifolii-Bidentetum have been also found.

- Phragmiti-Magnocaricetea

The plant communities of Phragmiti-Magnocaricietea can be found on silting and inundation sites of rich in lime, oligo-mesotroph to eutrophic brackish standing waters and ripal and sub ripal of flowing waters (Balátová-Tuláčková et al. 1993:79ff). They are natural or near-natural communities. The helophyte is the dominant form; it has its renewable buds protected in water of mud layers and the leaves over the water.

Phragmiti-Magnocaricietea communities have an important role: they clean the water and protect the riparian banks against erosion and drift ice. Additionally they are a good habitat for birds.
Phalaris arundinacea and *Phragmites australis* are both character species, both have been found during the surveys.
Other species, which are character species for the order Phragmitetalia, have been found as well as character species for the alliance Caricenion gracilis. However the occurrence of the species is quite diffuse.

- Molinio-Arrhenatheretea

The Molinio-Arrhenatheretea are mostly herb populations. They grow on nutrient-rich, good water supplied ground and where forests could grow and shape by agriculture (Ellmauer and Mucina 1993). The soils are mostly brown soil, gley and pseudo gley. These communities are mostly on sites which are mowed.

They have many character species: 46 and 10 were found, their presences are diffuse with low covers.

- Stellarietea mediae

The communities of Stellarietea mediae are rich in therophytes. The ground is often disturbed and loose and has mostly a human origin (Mucina 1993a:112ff). Most of the species are annual and have a ruderal strategy.

The Stellarietea mediae communities have 46 character species defined by Mucina. Six of them occur but they are rather diffuse and have a low cover.

- Galio-Urticetea

They are nitrophilous saums, riparian shrubs and anthropogenic wood communities. (Mucina 1993b:205ff) They are sites which are often rich in basic nutrient. It is common that neophytes are linked to these communities.

Two of the four character species were found, as well as two of the invasive species which are weak character species for Galio-Urticetea. They have a low cover, except for *Solidago gigantea.*

In addition a dynamical stage has been identified with different tree species. They are young trees which are mostly less than 50 cm. Among them, *Salix purpurea* is the most frequent with a constancy of 26.

Calamagrostis epigejos is a fallow-land indicator. It grows on 23 plots and has cover-abundances from + to 3.

All the other species found have been classified as companion species.

C. Indicator values

The indicator values found for the studied area are in the following table:

Table 4: Indicator values for the studied area

L	T	K	F	R	N	S
7.0	5.7	4.0	6.7	6.6	5.9	0.2

The value for light (L) is 7 which corresponds to a half light plant, mostly in the sun but until 30 % in the shadow. (Ellenberg and Leuschner 2010:27.2) The value 4 (K) for continent corresponds to sub oceanic. The value 5.7 for the temperature (T) corresponds to planar to collin level. The value 6.7 for humidity (F) corresponds to an intermediary between fresh and humidity indicator. For the acidity

(R), 6.6 is for a rather weak acidity. 5.9 for the nitrogen shows that it is between moderate nitrogenous and rich in nitrogen. 0.2 for the saltiness shows that the soil is not salty.

The indicator values of the species on the first section and the second section are compared.

A Mann-Whitney U test is done to compare each indicator value of both sections. The table 5 shows the p-value found with Mann-Whitney U test.

Table 5: P-values obtained with the Mann-Whitney U test for the comparison of indicator values of both sections

	U	p-value	alpha
L	4311.500	0.762	0.05
T	2423	0.950	0.05
K	2713	0.840	0.05
N	3455.500	0.847	0.05
S	4198.500	0.515	0.05
R	1929	0.557	0.05
F	3279.500	0.646	0.05

The p-values found are for all indicator values clearly superior to 0.05 which means that there is no significant difference in the repartition of the indicator values between both sections.

D. Life forms

The life forms of the 137 listed species have been determined with the help of the Flora from Fischer et al. 2008. For seven species the life forms were not determinable because only identified to the genus level or hybrids.

Several species can have two life forms or even three like *Phragmites australis.* For these species the several life forms have been taken into account.

First the distribution of the different life forms per plot has been made for all the 36 studied plots. The result can be seen in figure 11.

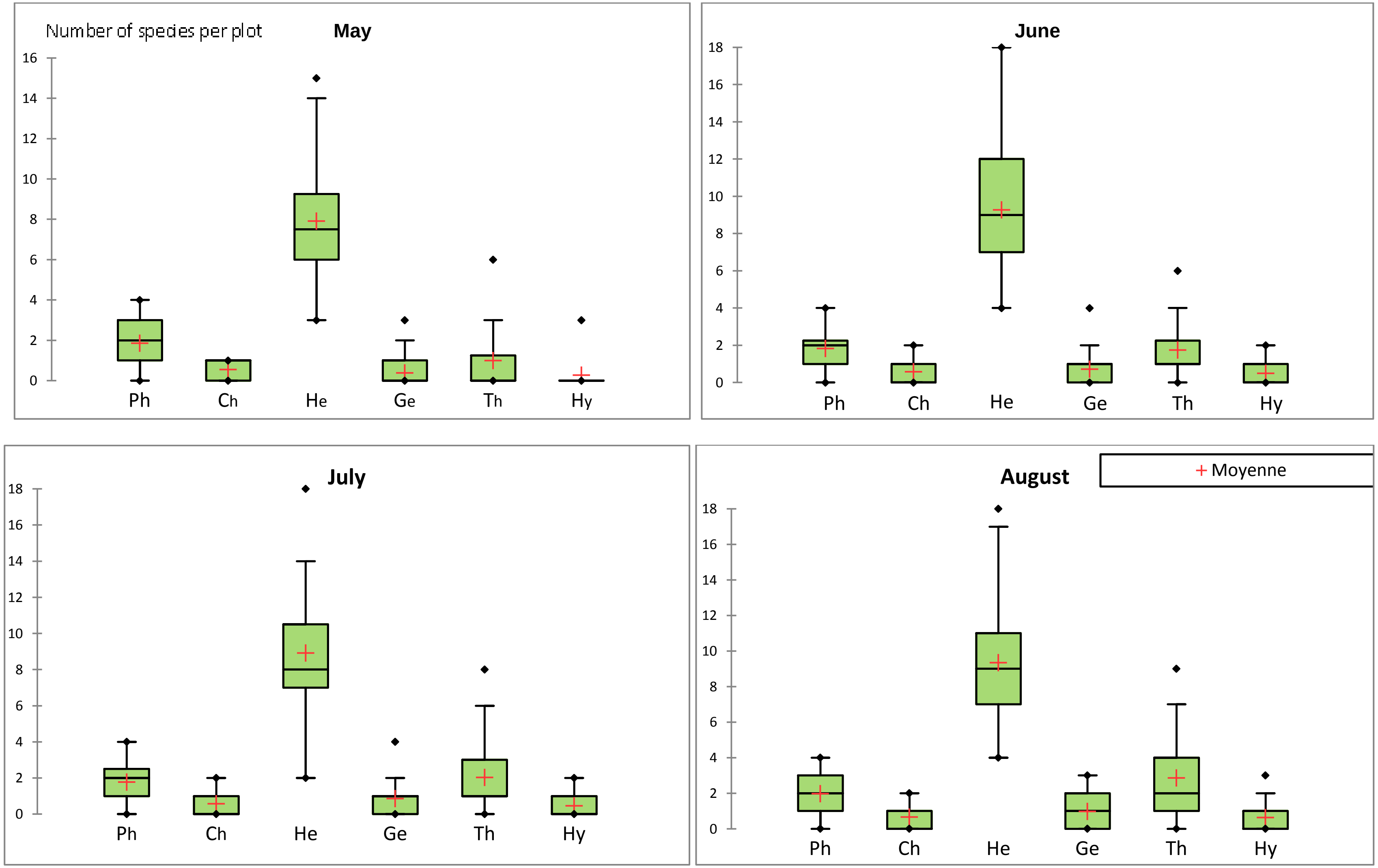

Figure 11: Box plots representing the number of species of each life form per plot for the surveys in May, June, (n=36) July and August (n=35) 2017 (He: Hemicryptophytes, Th: Therophytes, Ch: Chamaephytes, Ge: Geophytes, Hy: Hydrophytes, Ph: Phanerophytes)

The box plots of the figure 11 show that hemicryptophytes are clearly dominant during the four surveys. Therophytes and Phanerophytes are also frequent while chamaephytes, geophytes and hydrophytes are only represented by few species per plot.

Secondly, the life forms between the first and the second sections are compared in order to see if there are any differences of repartition of life forms.

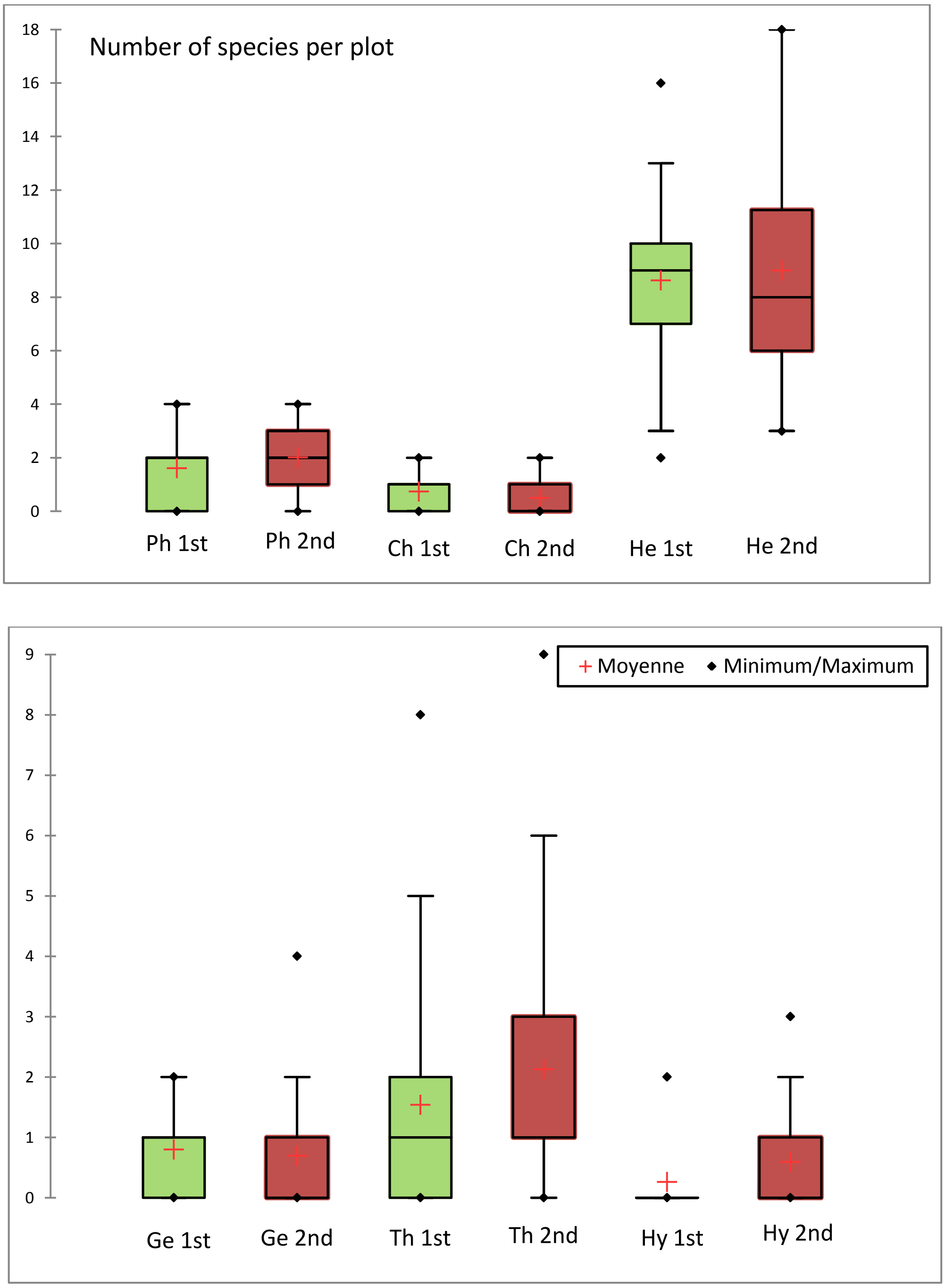

Figure 12: Box plots comparing the numbers of each life forms found per plot during the surveys in May, June, July and August 2017 (He: Hemicryptophytes, Th: Therophytes, Ch: Chamaephytes, Ge: Geophytes, Hy: Hydrophytes, Ph: Phanerophytes)

The box plots of figure 12 show the difference of distribution for each life form. In order to know if the differences are significant between the first and the second sections, a test Mann–Whitney U test is conducted with the numbers of each life form per plot for the four surveys of 2017. Excel is used to make the calculation.

Table 6: Results of the Mann–Whitney U test for each life form between the two sections

	U	p-value	alpha
Chamaephytes	2891.500	0.010	0.05
Phanerophytes	1821.500	0.032	0.05
Geophytes	2684	0.122	0.05
Therophytes	2004	0.134	0.05
Hemicryptophytes	2298.500	0.978	0.05
Hydrophytes	1767.500	0.005	0.05

The difference between the first and the second section is significant for the number of chamaephytes, phanerophytes and hydrophytes. This means that:

- There are more chamaephytes on the first section than on the second section,
- There are more phanerophytes on the second section than on the first section,
- There are more hydrophytes on the second section than on the first section.

E. Invasive species

Invasive species have been found on 27 plots out of 36, this corresponds to 75 % of the plots. Individuals of the species *Acer negundo, Ailanthus altissima, Impatiens glandulifera, Solidago canadensis, Solidago gigantea* have been found on the studied sites. The following graph (figure 13) represents their frequencies.

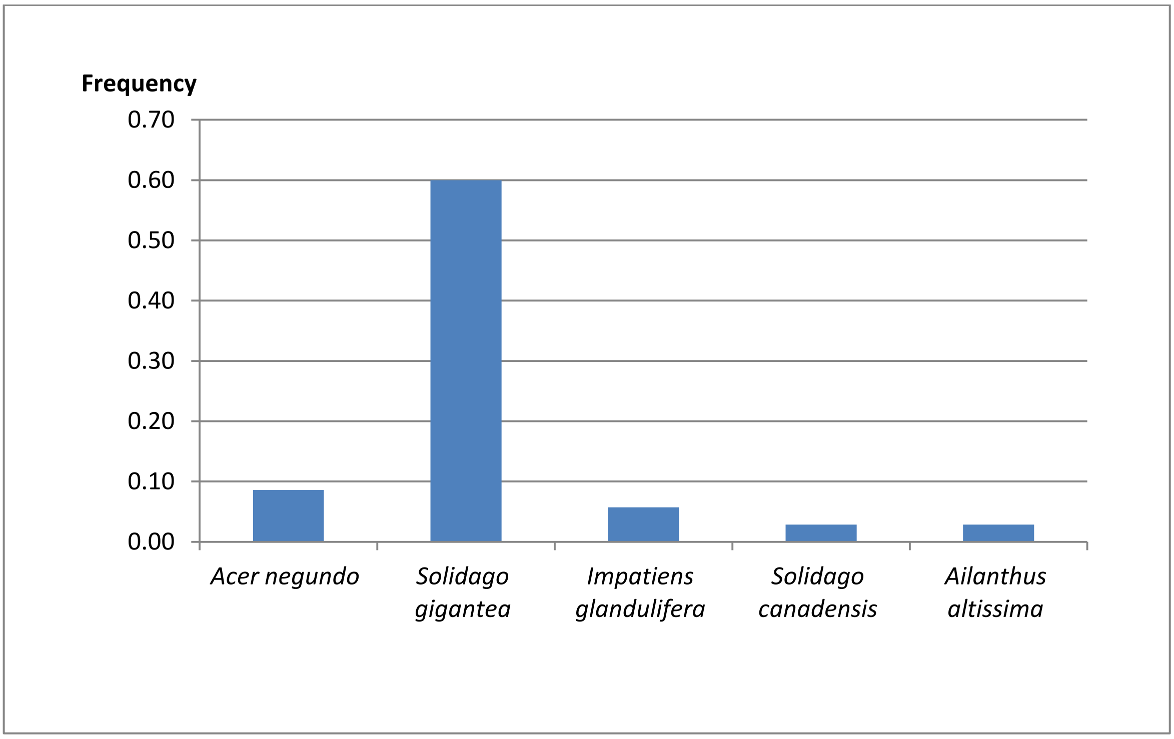

Figure 13: Frequency of the occurrence of the invasive species per plot during the surveys of May, June (n=36), July and August (n=35) 2017

Three individuals on three different plots have been found of *Acer negundo*, which correspond to a frequency of 0.09. Only one individual of *Ailanthus altissima* has been found on one plot, which corresponds to a frequency of 0.03. Two individuals only have been found of *Impatiens glandulifera* on two different plots. *Solidago canadensis* was on one plot with a cover abundance increasing from r to + on the Braun-Blanquet scale. *Solidago gigantea* is the most frequent species found (0.60), it was found on 21 plots with cover abundance from r to 5.

In order to compare the presence of invasive species between the two sections and to know if the differences are significant, Fisher’s exact test is used. The numbers of plot found with each invasive species is compared between the two sections

Table 7: Numbers of plots for each section found with invasive species and the p-values calculated with Fisher's exact test

	1st section	2nd section	p-values
Acer negundo	2	1	0.55
Ailanthus altissima	0	1	1.00
Impatiens glandulifera	1	1	1.00
Solidago canadensis	1	0	0.41
Solidago gigantea	6	15	0.03
Total of plots found with IS	6	16	0.09

The table sums up the p-values for each invasive species. The p-value is only inferior to 0.05 for *Solidago gigantea*. This means that the number of plots with *Solidago gigantea* is significantly higher in the second section than in the first section. This corresponds to 68 % for the second section and 43 % for the first section. The difference in numbers of invasive species for all the other species is not significant.

The numbers of plots with invasive species are also compared. 11 plots out of 14 have invasive species on the first section, and 16 out of 22 on the second section. This p-value found is 1.00, which is superior to 0.05. This means that there is no significant difference of numbers of plots with invasive species between the two sections.

The next figure (Figure 14) sums up the number of plots with each cover-abundance of the Braun-Blanquet scale for the invasive species found during the survey of August.

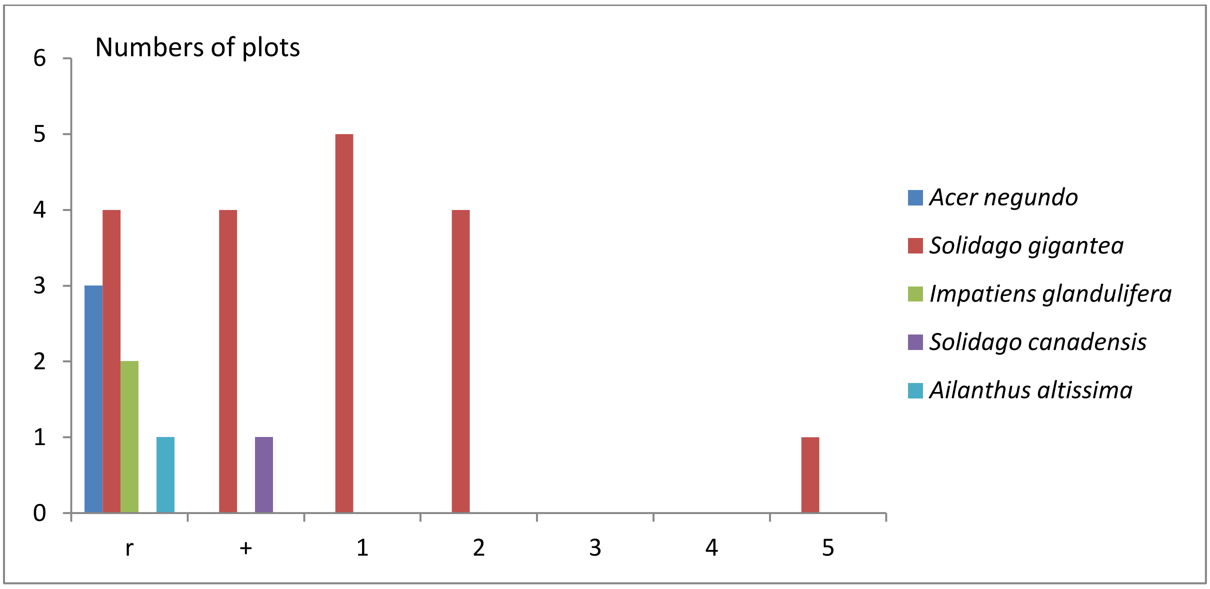

Figure 14: Numbers of plots for each invasive species per cover-abundance (Braun-Blanquet scale)

While isolated individuals of *Acer negundo, Impatiens glandulifera, Ailanthus altissima* were surveyed, some individuals on one plot of *Solidago canadensis* were surveyed. *Solidago gigantea* could be found as isolated individuals or several individuals. On one plot *Solidago gigantea* was clearly dominant covering more than 75% of the plot.

F. Conservation assessment

The next table (table 8) lists the surveyed species which are listed in the "Red list of threatened species of Austria" (Rote Listen gefährdeter Pflanzen Österreichs). 29 surveyed species are indexed in this red list.

Table 8: Surveyed species listed on the red list species in Austria, 0: Extinct, 1: Critically endangered, 2: Endangered, 3: Threatened, 4: Potentially threatened, r: Regionally endangered

Alisma plantago-aquatica	r
Alnus glutinosa	r
Bidens tripartiti	r
Carex acuta	r
Carex canescens	r
Carex echinata	r
Carex nigra	r
Carex pseudocyperus	2
Centaurium pulchellum	r
Cerastium glutinosum	r
Dipascus fullonum	r
Epilobium tetragonum subsp. Tetragonum	r
Equisetum hyemale	r
Iris pseudacorus	r
Juncus conglomeratus	r
Nepeta cataria	3
Persicaria dubia	r
Persicaria minor	r
Poa palustris	r
Populus alba	r
Populus nigra	3
Rumex acetosa	r
Rumex conglomeratus	r
Salix pentandra	2
Scirpus sylvaticus	r
Scophularia umbrosa	r
Scutellaria galericulata	r
Senecio sarracenicus	3

Carex pseudocyperus and *Salix pentandra* are endangered in Austria. *Populus nigra*, *Senecio sarracenicus* and *Nepeta cataria* are vulnerable while the other species listed in the table 8 are regionally endangered.

G. Floods and pluviometry

Water levels have been measured by the Land of Lower Austria. As Herzogenburg is the closest station to the studied area, its measures have been used.

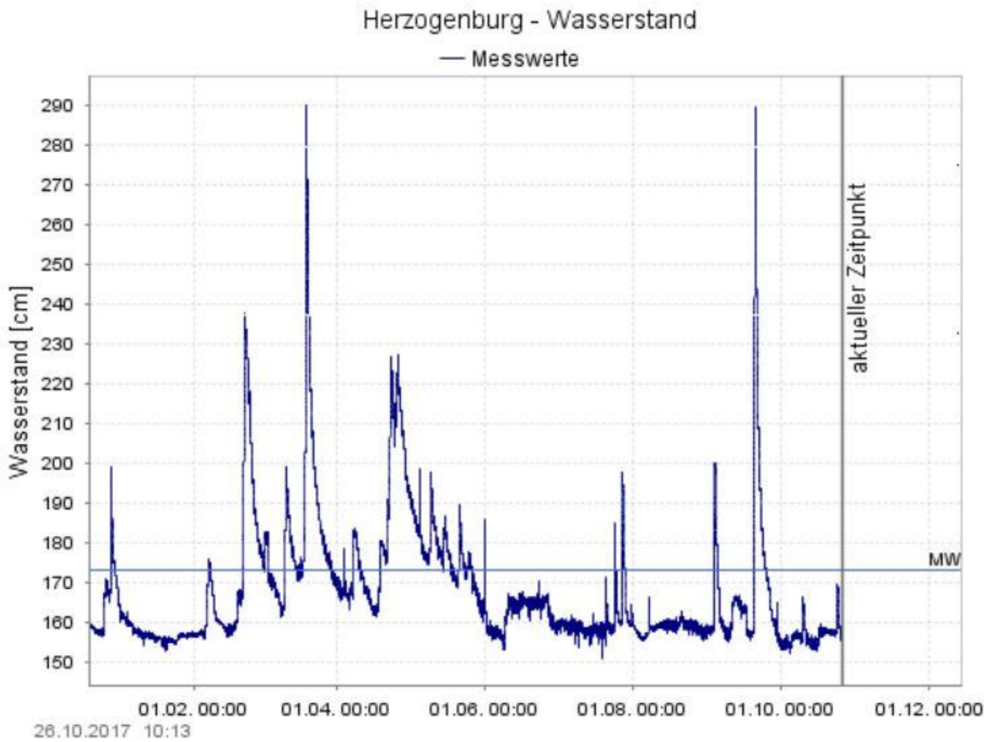

Figure 15: Water level of the Traisen at the station Herzogenburg between January 1st 2017 and October 26th 2017 (Amt der NÖ Landesregierung 2017b)

MW (Mittlere Wasserstand) is the average water level. The recording of the floods of the year 2017 shows that the water level was lower than the average level between May and August. When the first survey was done in the middle of May, the water level was higher than during the last survey in

August. After the first recording in May there were two small floods and then only two peaks are recorded at the end of July. These peaks represent an elevation of the water level of about 40 cm, which partly flooded the studied banks. In February and March there were several higher floods.

The pluviometry measured in Tulln (figure 16), which is the closest station to the studied area, shows that the summer was very dry. Indeed, all the months of 2017 were far from the average. In May 10 mm were recorded when the average is 62 mm. In June few millimeters were recorded when the average is 87 mm. In July no rain was recorded when the average is 85 mm. And in August 10 mm were recorded when the average is 82 mm.

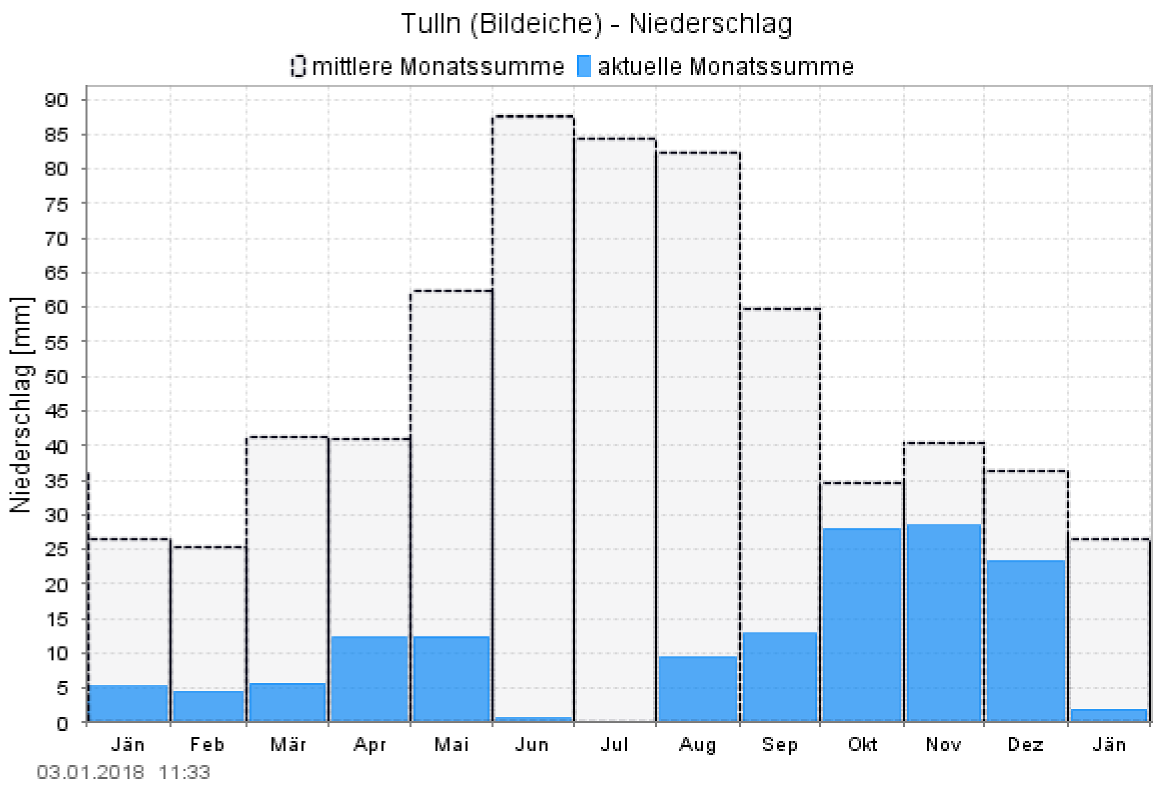

Figure 16: Pluviometry for each month of 2017 in Tulln (Amt der NÖ Landesregierung 2018)

V. DISCUSSION

A. Vegetation dynamic

As riparian banks can be very dynamic habitats, the vegetation dynamic (which is not the directional dynamic of succession) within the vegetation period is discussed. The vegetation dynamic on muddy banks are particular because it is not predictable and depends greatly on floods as well as how long the soil stays dry. There can be a succession of species during one season.

The recording of the flood from the office of the provincial government of Lower Austria shows that there were two small floods in May which probably impacted the plots close to the river. Some plots close to the river might have been impacted from the floods in July.

However, the species surveys show that the species were not significantly impacted, as there was no noticeable difference in the species composition between the month of May and the month of August.

The weather and particularly the pluviometry can also influence the development of the vegetation. The recording shows that the summer 2017 was a lot drier than the average. It might have influenced the growth of some plants.

The changes observed in the vegetation composition between the surveys concerned mostly the cover-abundance of the species due to difference of phenology. Many species increased overall their cover-abundance between May and August. Some species appeared later than others for example: *Cyperus fuscus* was recorded first in August. Others species bloomed early, and then died like *Ranonculus sceleratus* which was not found any more in August. Lastly, other species decreased their cover like *Rorripa austriaca* which was already blooming in May.

Furthermore, the vegetation cover increased from May to August for almost all plots.

It could have been interesting to know which plots exactly have been impacted from the floods, and the exact changes that it had produced. It was unfortunately not obtainable with the method used.

B. Vegetation succession

As already said, muddy banks are constantly in a pioneer state, flooding making impossible other plant communities to establish (Ellmauer and Essl 2005). However, as the studied area was restored and muddy banks developed on only small areas, it is interesting to know if muddy bank plant communities are developing at all and if there are some indications of succession. Several indicators have been researched.

The life forms by Raunkiaer gave a first indication. The hemicryptophytes are clearly the dominant life forms. Hemicryptophytes are perennial species with renewable buds at the soil surface. There is no difference in distribution of hemicryptophytes between the two sections.

Therophytes are the second most represented life form. Therophytes are annual species, occurring in pioneer vegetation, they spend the winter as seeds and they are the principal life form expected on muddy banks. The comparison of life forms distribution between the first and the second sections shows that there is no significant difference.

The chamaephytes are perennial and can be a bit woody, and are also a sign of succession. There are more chamaephytes on the first section than on the second section. Concerning the hydrophytes, they show that some species on the banks are very dependent on the water. They are more hydrophytes on the second section than on the first section.

The phanerophytes are woody species and their presence is a clear sign of succession. There are more phanerophytes on the banks of the second section than on the first section. On most of the plots only some species of phanerophytes have been surveyed but *Salix purpurea* is the second most frequent species found, and *Populus alba* and *Populus nigra* are among the twelve most frequent species found, so phanerophytes are wide distributed. But these plants were still young and they might not all survive. These woody species can develop into the habitat 91E0 "Alluvial forests with *Alnus glutinosa* and *Fraxinus excelsior"* which is an objective of the restoration project.

If so many species of others life forms than therophyte can develop, it means that the disturbances, which is in this case are the floods, are not frequent or strong enough (Ellenberg and Leuschner 2010:1062). Plant species from the life forms phanerophytes, hemicryptophytes and chamaephytes were able to survive in winter. Either the floods in winter are too infrequent or their amplitudes are too low. Some species can also be tolerant to floods (Kozlowski 1984).

Furthermore the comparison of both section does not clearly show that the older section is more engaged in succession that the younger section. Indeed, there are more phanerophytes on the younger section than on the older, but more chamaephytes on the older section than on the younger. A possible explanation is that a year of difference in the vegetation period is not enough to see clear pattern as succession is a very long process. However, the difference of life form distribution could be due to other factors as the presence of forest of *Populus* which might influence the dispersion of seeds.

So the analysis of life forms confirms that the riparian banks are in early succession stage on both sections even though there is no clear difference between the two sections. The plant communities found gave further indication of the state of the succession.

The plant community, Isoëto-Nanojuncetea is mostly composed of therophytes and needs a bare or very light populated soil to develop. If other life forms develop, it becomes difficult for Isoëto-Nanojuncetea to develop. Bidentetea tripartiti is also a community largely dominated by therophytes, which is present on the studied area. Isoëto-Nanojuncetea and Bidentetea tripartiti are both pioneer communities. However their occurrences are sparse. The presence of hemicryptophytes might disturb the development of Isoëto-Nanojuncetea.

Phragmiti-Magnocaricetea is a community of aquatic and semi-aquatic plants which shows that some part of the banks are more connected to the river.

Molinio-Arrhenatheretea is an anthropogenic grassland plant community while Stellarietea mediae and Galio-Urticetea are also anthropogenic vegetation which show that the riparian bank have partly characteristics of anthropogenic disturbances.

Furthermore, *Calamagrostis epigejos* is a follow-land indicator which confirms that succession takes place.

The indicator values by Ellenberg help to understand the abiotic conditions on the riparian banks. A notable value is the nitrogen because muddy banks are rich in nutrients, and nitrogen is an important nutrient. A part of nitrogen deposits with the sediments during floods (Piney et al. 2002). The calculated average of the indicator values corresponds to moderate nitrogenous to rich in nitrogen. Moreover on several plots, *Mentha aquatica* and *Juncus effusus* occur and they are azote indicators. This rich nitrogenous soil was mostly found on the riparian bank: 1, 4, 5, 6 and 7.

The average for humidity indicator shows that the soil is fresh to humid which corresponds to the muddy bank habitat.

The species richness has also been compared between the two sections. No difference in species richness was significant. A year of difference of vegetation period between the two sections did not make a difference in the species richness. Other factors can also play a role: the situation of the bank can influence the dispersal of the seeds. However a noticeable difference is the similarity coefficient of Jaccard which shows that only 48% of the species are the same between the two sections. A study of the seed bank would be interesting to get more detailed results and to know if this difference is rather due to difference in seed dispersion or establishment.

Vegetation fluctuations are short-period change on a period of one to two years (Dierschke 1994:477). It is difficult to delimit vegetation fluctuation with a long term process as succession. There can be strong fluctuations on riparian banks. Plant communities of Bidentetea for example develop when the water level sinks (Dierschke 1994:482). Therefore it is important to continue the monitoring work as succession is mostly clearly visible after several years.

C. Invasive species

Invasive species are not the main focus of this study but they are an important indicator of the evolution of the vegetation on the studied restored riparian banks. Muddy banks are very vulnerable to invasion: the soil is partly naked which allows the possibility for invasive species to establish. Furthermore, the flows of the river and the floods can easily disperse the seeds.

Invasive species were found on respectively 11 plots out of 14 for the first section and 16 out of 22 on the second section. So in all invasive species occur on 27 out 36 plots, or 75 % of the plots. This is a high frequency and shows clearly that invasive species are quite widespread on the restored banks of the Traisen.

The comparison of the numbers of plots with invasive species shows that there is no significant difference in the total numbers of invasive species found between both sections. This can show that a difference of one vegetation period is not enough to notice a difference in occurrence of invasive species. However, a target study of invasive species with a different method might have found different results. Nevertheless a difference is noticed for *Solidago gigantea:* they were found on more plots on the second section than on the first. Many factors play a role, which is why it is quite difficult without more data to exactly know why *Solidago gigantea* occurs more often on the second section. *Solidago gigantea* disperses its seeds with wind and a possibility is that seeds of *Solidago gigantea* would have more seeds dispersed on this part of the section than on the other because of proximity to other individuals of the same species.

On one plot, *Solidago gigantea* was largely dominant with a cover abundance of 5 on the Braun-Blanquet scale which means that on some areas, the vegetation of the riparian banks are already impacting the natural vegetation.

Solidago gigantea was already surveyed in 2016 on the first section (Schidla 2017). The method used was similar as in this case, but as both methods did not target to survey invasive species, it makes it difficult to compare the results.

Several studies have already been done in the last years on the same study area (Lapin et al. 2016, Schidla 2017). The study of Lapin et al., made in 2016, compares the cover abundance of invasive species before and after the restoration work. After the restoration work, the cover-abundance of invasive species was significantly lower than before (Lapin et al. 2016). However another study comparing several rivers in Switzerland on a longer period shows that the abundance of invasive species is higher on restored sections of rivers than no unrestored sections (Haag et al. 2013). As the occurrence of invasive species and its effects are still discussed and being researched, it would be important to do targeted monitoring of the invasive species the next years as well as starting to eradicate the invasive species before they spread even more. The planting of target tree species was seen as an effective measure to counteract the spread of invasive species in a study of Lapin et al. (2016).

D. Nature conservation assessment

Riparian banks are parts of floodplains and they are a very valuable ecosystem but unfortunately also very endangered. Therefore the restoration of a section of the Traisen supports the conservation of this ecosystem. However, such restoration cannot be a substitute for the ongoing protection of the remaining natural floodplains (Lazowski 1997).

Most of the species found on the European and Austrian red list are classified as "least concerned". But few species, as *Nepata cataria* or *Senecio sarracenicus* are vulnerable, or even threatened as

Carex pseudocyperus. The occurrence of vulnerable and threatened species in the restored area is encouraging and shows that the studied area has the potential to be a functioning riparian ecosystem.

Another important aspect for nature conservation is if the area is a good ecosystem and a good habitat for other species. Indeed, if the conditions are good, rare species should come over time and become establish. But the area can also be an interesting habitat for animal species like many birds species. Riparian banks are in addition an important ecological interface between land and water (Lazowski 1997).

E. Retrospect on the methods

During the surveys we could learn from our mistakes. The plots have not been marked during the first survey in May, but GPS coordinates and pictures had been taken for each plot. The precision of the GPS device was not sufficient enough to find the plots easily again. With the help of the pictures and GPS device we found again most of them exactly while some other were not exactly the same but very close and had the same vegetation. In June we marked all the plots with sticks and red adhesive tapes. In July and August the plots were found again except for one, where the marking did not stay. So we learned that good marking is fundamental when surveying vegetation permanently or multiple times.

A factor which might have influence this study is the experience in the choice of the studied plots. The choice of homogeneous and representative plots is very important for the success of the analysis of plant communities. Experience is important for the right choice of plots (Dierschke 1994:150). It was easier to choose for the last banks than for the first one.

Moreover, the plant communities found on the riparian banks are fragmented because they are pioneer communities and they had not a lot of time to develop since the end of the restoration work. The method with the tables to determine the communities was then quite difficult to process because the method is better adapted to whole developed communities.

F. Flow regime: a factor neglected?

Flow regime is an essential factor which should not be neglected in restoration projects (Poff et al. 1997). The magnitude, timing, duration, frequency and rate of change of hydrological conditions are characterizing the flow regime. Flow regime significantly influences the abiotic conditions on the banks and structures the plant communities.

But the architecture of a river is also a very important component for the functioning of the floodplain ecosystem. Therefore the project of restoration of the Traisen aimed to build a new meandering route. In this way, there can be a natural watercourse with convex banks and concave banks. During floods, more areas of the floodplain can be flooded than before the restoration. However, the flow regime is influenced by the numerous structures upstream, which might not allow enough of a natural dynamic regime.

In the case of cottonwoods restoration, it has already been proved that the best way to restore them is to have natural or simulated flood pulses mimicking historical hydrographs (Bhattacharjee et al. 2008). In the case where dams cannot be removed, it is advised to simulate periodic floods. Restoration of the natural flood pulse could significantly support the growth of natural vegetation communities on the banks and improve their competitiveness while it could reduce the number of invasive species (Levine and Stromberg 2001).

In the next years, it would be interesting to exactly record the flow regime and its impacts on the riparian bank to research its effects on the plant communities in order to know if the flow regime is natural enough for natural plant communities to establish.

VI. CONCLUSION

The plant communities on the restored banks of the Traisen are fragmented and not fully developed yet. Several plant communities characteristic for muddy banks occurred as Isoëto-Nanojuncetea and Bidentetea tripartiti. Moreover several indicators of early stages of succession have been identified as the occurrence of numerous phanerophytes. This succession is expected because alluvial forest should develop on the riparian banks.

The comparison of the two sections of different ages did not show any major difference. There might be fine differences but the methods used might not have been adapted to detect them.

Some indexed species in red lists have been found which is encouraging and shows that the restorated banks could support conservation of plant species.

Invasive species were found on 75 % of the plots which is concerning. *Solidago gigantea* was the most abundant invasive species found.

It is expected that plant communities of muddy banks continue to develop on some areas of the riparian bank while on some other areas alluvial woods develop. However for muddy bank plant communities to continue to develop, they need a natural flow regime with floods. More research on the flow regime of the Traisen and its impact on the riparian vegetation would be interesting to conduct.

To conclude the vegetation communities of the restored riparian banks of the Traisen still need time to develop but the succession is already in early stages. Regular monitoring is important to see if natural vegetation continues to develop or if invasive species take advantage.

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LIST OF TABLES AND FIGURES

Annex 1: Vegetation survey of 16.05-22.05.2017 of the restored banks of Traisen

16.05.-22.05.2017	1A	1B	1C	1D	1E	2A	2B	2C	3A	3B	3C	3D	3E	3F	4A	4B	4C	4D	4E	5A	5B	5C	5D	5E	6A	6B	6C	6D	6E	6F	6G	7A	7B	7C	7D	7E
Achillea millefolium																								r											+	
Agrostis stolonifera	1		2			3			2	1		1			1	+				1	+	1						2	+			1	3	+	+	3
Alisma plantago-aquatica																							r								r					
Alnus incana	r					r																														
Artemisia campestris							r																													
Barbarea vulgaris										1												r														
Calamagrostis epigejos			r			+		2					+					+	+		r				+				1	+	+			+		3
Calystegia sepium																																				r
Carduus sp.					r																														r	
Carex acuta						r																														
Carex canescens																				1																
Carex echinata																				1																
Carex flacca								+																												
Carex hirta																			1																	
Carex nigra															1																	2				+
Carex pseudocyperus																														2				1		
Carex sp.																+																				
Carex sylvatica																														2						
Cerastium glutinosum																			1																	
Cerastium sp.																																			1	r
Cirsium arvense										r									r															r	r	

Dactylis glomerata							+																													
Dipsacus fullonum																	r																			
Eleocharis palustris																												3								
Equisetum arvense								+					+		+			1									1							2		
Equisetum hyemale									+				+					+									+									
Equisetum sp.																				+																
Erigeron annuus	2						1			1				1			r							r					r					r	1	
Erodium cicutarium																			r																	
Erysimum cheiranthoides										r																										
Eupatorium cannabinum							+												r										2							
Euphorbia cyparissias							r																													
Festuca pratensis							r																													
Filipendula ulmaria			r																																	
Galium album																																	+			
Geum urbanum																													r							
Glechoma hederacea	1																2	+																		
Holcus mollis						r																														
Juncus articulatus															1			r		+		2		3	+			2			+		1			
Juncus conglomeratus																							2													
Juncus effusus									+			+									2				3		+			1		2				
Juncus inflexus									+			+	2	+		+				1							+	+								
Lolium perenne							+																													
Lycopus europaeus	1	1	1	+	r				2	1	r		+		r		+					+		+	r	1			r							
Lythrum salicaria						r						+				r	r																			r
Mentha aquatica			2	+											r	+	r		+	1		+	3		+						+			1		1
Mentha arvensis																								r												
Mentha longifolia	1	1	2			r			r				1	+			+	+	+					+											+	

Myosotis scorpioides		2																													2		+		
Oxalis stricta																																		r	
Persicaria dubia									r																										
Persicaria maculosa																														r					
Phalaris arundinacea			r			+		2				+						+		1						+						+				
Plantago lanceolata	1			r	r		r			r												+		r					r							
Plantago major	1			r	r					+						r	+	r	1			+		+					r		r			+	r	
Poa annua	+	2			r		+			1				+	1		1		+					+									1			
Poa palustris	2		+	+	r	2	+																													
Poa pratensis				+		2				1	1							1			1															+
Poa trivialis							+					1	+	2					+	1		1	3	+		1	2	2	+		+		1	1	+	
Populus alba	r										r					r	r	r	+			r		1		+			r				r	+	+	r
Populus nigra	+			r	1	r	r			1	1	r	+	r			r		r			r		+					1						r	
Ranunculus repens	2											1						2		+	3					+		r								1
Ranunculus sceleratus																															r		1			
Rorippa austriaca		3																												2						
Rorippa palustris																1															r		+			
Rorippa x anceps															r																					
Rubus caesius						r																												r		1
Rumex acetosa																												r								
Rumex conglomeratus		1						r																r							r					
Rumex crispus																r																				
Rumex obtusifolius			r					r	r																											
Rumex palustris																	r																			
Rumex sp.										r			r		r																					
Salix alba														+								r			+											r
Salix pentandra											+																									

Salix purpurea	r			r	r	r				+		+	r	+	+	+		r		r	r	+		1	+	+	+	1	+		r	1	1	+	+	r
Salix sp.														+																						
Saponaria officinalis								r																												
Scirpus sylvaticus													r												1		+									
Scrophularia nodosa						r				+									r																+	
Scutellaria galericulata		r																																		
Senecio sarracenicus																													1							
Senecio vulgaris																			r																	
Solidago gigantea	1				r						r						+		1		r	+		+		5	+		1		r		1	2	1	+
Tanacetum vulgare			r																																	
Taraxacum officinale agg.	r			r	r					+	+						+		1			r		+		+			r						r	
Trifolium dubium							+																												r	
Tripleurospermum inodorum																	+		r																	
Tussilago farfara																																			+	
Urtica dioica													r						+											r						
Veronica anagallis-aquatica													r																		r		+			
Veronica beccabunga					r												+	+					1													

Annex 2: Vegetation survey of 14.06-19.06.2017 of the restored banks of Traisen

14.06-19.06.2017	1A	1B	1C	1D	1E	2A	2B	2C	3A	3B	3C	3D	3E	3F	4A	4B	4C	4D	4E	5A	5B	5C	5D	5E	6A	6B	6C	6D	6E	6F	6G	7A	7B	7C	7D	7E
Achillea millefolium																						+		+											+	
Agrostis stolonifera	2		2	1		4				1	1	1		2	3	1	+		+	2	2	1		1		+		3	1	+	2	2	2	+	+	
Alisma plantago-aquatica																							r								r					
Alnus incana	r																																			
Artemisia campestris							+												r																	
Bidens tripartita	+				+																															
Calamagrostis epigejos	1	+	+			2		3		+			+	r				+	+		+	1	1	+	+		r		1	+	+			+		3
Calystegia sepium																																				r
Carduus sp.																																			r	
Carex acuta						+																1														
Carex canescens																				1																
Carex echinata																				1							+									
Carex flacca								+																+												
Carex hirta		+																	1																	r
Carex nigra															1												1					3				1
Carex pseudocyperus																														3				1		
Carex sp.																+																				
Carex sylvatica																														2						
Centaurium pulchellum																			r																1	
Cerastium sp.																																			r	

Cirsium arvense									+									r															+	r	
Dactylis glomerata							+																												
Dipsacus fullonum																r																			
Eleocharis palustris																											3								
Epilobium roseum	+																																		
Epilobium tetragonum					+																														
Equisetum arvense								+									2												r				3		
Equisetum hyemale									2				+				+									2									
Equisetum sp.																			+																
Erigeron annuus							1				1			1				r			+							r					+	1	
Erodium cicutarium																		r																	
Erysimum cheiranthoides																r		r																	
Eupatorium cannabinum						r				r								1			r		+					2							
Euphorbia cyparissias							r																												
Festuca pratensis							r																												
Galium album																																+			
Geum urbanum																												r							
Glechoma hederacea	+																2	+																	
Holcus mollis						+																													
Hypericum perforatum							r																												
Hypericum sp.														r																					
Impatiens glandulifera										r																									
Juncus articulatus												+	+		3			1		1	+	2		3	r	+	+	2			+		3	r		
Juncus bufonius																						1														
Juncus compressus														+																						
Juncus conglomeratus																							2													
Juncus effusus									2			+	+								2				4		1			+		2				

Juncus inflexus								+	1			2	1	+		+				2							1	1								
Lycopus europaeus	1	1	1	+	r				3	r			+		+		+		+			+		+		2			r							
Lysimachia nummularia															r																					
Lythrum salicaria									+								r														+					
Mentha aquatica			3	+		r									r	1	+			2		+	4		r						+			2		
Mentha arvensis																								+												
Mentha longifolia	r	r	3		+	1		+		2			+	+			1	1	+					1											+	
Myosotis scorpioides		+				+																										2	r			
Nepeta cataria	+																																			
Oxalis stricta																																		r	+	
Persicaria cf. dubia					+																													+		
Persicaria dubia			+	2													+											+	+			r	+			
Persicaria maculosa																											+				1					
Phalaris arundinacea			+			+		3	+	+		+	4					1		1				+			+					1		+		
Phragmites australis																																		+		
Plantago lanceolata				+	r																	+		+					r							
Plantago major	2			+	+											r	1	r	1			1		+					1				r	+	+	
Poa annua		2			+	+	+			1				+	1		1		+		1			1		+							1	+		
Poa palustris	2		+	+	1	1	+	+																												
Poa pratensis				+		3				2	2							2																		
Poa trivialis							+		3			+	+	2					+	2		1	3	1		+	+	1	+		+		1	1	+	+
Populus alba	r						r			r	+			r		r	+	r	+			r		1			+		+				r	+	+	r
Populus nigra	+			r	2	r	r			1	2		r	+			r		r			r		r		r			+					r	r	
Prunella vulgaris	+				r																															
Ranunculus repens	1											2						3		+	3							+					r			r
Ranunculus sceleratus																															+		1			
Rorippa austriaca		4																												2						

Rorippa palustris															2															+		+			
Rorippa x anceps														+																					
Rubus caesius																																	r		1
Rumex acetosa																											r								
Rumex conglomeratus		1						+															r							r					
Rumex crispus															r																				
Rumex obtusifolius			r					+	r																										
Rumex palustris																r																			
Rumex sp.										r					r																				
Salix alba														r								+			+										r
Salix pentandra											+																								
Salix purpurea	1			+		1			r				+		+	+		r		r	+	+	r	1	+	+	+	1	+	r	+	1	1	+	+	r
Schoenoplectus lacustris																											+							r		
Scirpus sylvaticus													r												1		r									
Scrophularia nodosa						1		2											+										r						+	
Scutellaria galericulata		1	+																																	
Senecio sarracenicus																													1							
Solidago canadensis					r																															
Solidago gigantea	r	r			+					1	+		r				+		1		+	1		1		5	2		1		r		1	2	1	+
Stellaria alsine																								r												
Tanacetum vulgare			r																																	
Taraxacum officinale agg.	+			r	r	r											+		r			r		+		r			r						+	
Trifolium dubium							r															r												r	r	
Trifolium pratense						r																														
Trifolium repens																								+												
Trifolium sp.					r																															
Tripleurospermum inodorum				r	r												+		+																	

Tussilago farfara	+			r	r																														1	
Urtica dioica			+													r														r						
Verbascum nigrum							r																													
Veronica anagallis-aquatica				2								+	r								1										+		+	+		
Veronica beccabunga															r		r	r					+													

Annex 3 : Vegetation survey of the restored banks of the Traisen (17.07-20.07.2017)

17.07-20.07.2017	1A	1B	1C	1D	1E	2A	2B	2C	3A	3B	3C	3D	3E	4A	4B	4C	4D	4E	5A	5B	5C	5D	5E	6A	6B	6C	6D	6E	6F	6G	7A	7B	7C	7D	7E
Achillea millefolium																							r											1	
Agrostis stolonifera	2	2	3	+						1		3		3	3				2	2	+	1	1	2			3	1	+	3	2	2	1		
Ailanthus altissima															r																				
Alisma plantago-aquatica																						r								r					
Artemisia campestris							+				r							r																	
Bidens tripartita	r				+					+						+	r						r					r							
Brachypodium pinnatum																																		1	
Calamagrostis epigejos	1	+	r			1		3	1	+			+				1		1	+	1	1	+			+		1	+				1		3
Calystegia sepium																																			+
Carduus sp.					r																													r	
Carex acuta						+															1														
Carex echinata																			1																
Carex flacca								+																											
Carex hirta		+																2																	1
Carex nigra														2												1					3				2
Carex pseudocyperus																													3				1		
Carex sp.													r		+																				
Carex sylvatica																													2						
Centaurium pulchellum					+																													1	
Cirsium arvense										+						r		1															+	r	

Dactylis glomerata							1			+																									
Dipsacus fullonum																r																			
Eleocharis palustris														+						+							2								
Epilobium roseum	+																																		
Epilobium tetragonum					r																		r												
Equisetum arvense								+						+			+							+					+				3		
Equisetum hyemale									1				+																						
Equisetum sp.																			+																
Erigeron annuus				r	+		1				+					r		r			+		+					r					r	2	
Erysimum cheiranthoides																+		+										r							
Eupatorium cannabinum						r				r						r		1					2					2							
Euphorbia cyparissias							r																												
Galium album																																r			
Geum urbanum																												r							
Glechoma hederacea	r															2	r							+	r										
Holcus mollis						+					+																								
Humulus lupulus										r																									
Impatiens glandulifera										r																									
Iris pseudacorus												r																							
Juncus articulatus												1	+	2			1		1	1	1	1	3	+			3			+		2	r		
Juncus effusus									+			+	+							3				2		4			1		2				
Juncus inflexus								+				3	1		1				2								1								
Lycopus europaeus	r	2	2	1	r				3					1		r		+			r		2		3			r							
Lythrum salicaria									+			1	1			+							r			+							1	r	
Matricaria discoidea																		1																	
Mentha aquatica			3	+										+	3	r			3		1	5								1			2		
Mentha arvensis																							+												

Mentha longifolia	r	r	3		r	+		1		3			r			2	1	1					1					r						+	
Myosotis scorpioides		+																													2	r			
Oxalis stricta																																	+	+	
Persicaria cf. dubia					+																														
Persicaria dubia			r	2					+	r			1			+			r					r			+	+	+		+	+	+		
Persicaria maculosa																										+				2					
Phalaris arundinacea			+	r		+		3	1	+		1	4				1		1				+			1					1		+		
Phragmites australis									2																								+		
Plantago lanceolata				+	+																r		+												
Plantago major	2			1	1										r	2		1			r		+					1				r	r		
Poa annua				+	+	1										2		+	+									+		1		2	+		
Poa palustris	1			1	+	3		+								1								3											
Poa pratensis										3	2						2			2															+
Poa trivialis									2			+	+					1	2		1	1	1		+	+	1	+	+			2	1	1	
Populus alba	r									1	+				r	+	r	+			r		1					+				r	r	1	r
Populus nigra	1			r	2	+	+			1	2		r			r		r			+		r		r			+		+			r	+	
Prunella vulgaris					+											1																			
Ranunculus repens	r											2					2		+	3			r				+					+	r		
Ranunculus sceleratus																														r					
Ranunculus sp.		r																																	
Rorippa austriaca		2																											1						
Rorippa palustris																														+					
Rorippa x anceps														+																					
Rubus caesius																																	r		1
Rumex acetosa																											r								
Rumex conglomeratus		2						1															r							r					
Rumex crispus															r																				

Rumex obtusifolius			r																																
Rumex sp.														r																					
Salix alba																								+											r
Salix pentandra											1							r																	
Salix purpurea	1			+		1					r		1	1	+		r		+	+		+	2	+	+	+	1	+	r	+	1	2	1	1	r
Saponaria officinalis							r																												
Schoenoplectus lacustris														+																			r		
Scirpus sylvaticus													+											2		1									
Scrophularia nodosa						+		+							r			1										r						+	
Scutellaria galericulata		2	+																																
Senecio sarracenicus																												1							
Setaria pumila					r																													+	
Solidago canadensis					+																														
Solidago gigantea	+	+			1					2			+			+	r	1		+	+		1		5			1		r		1	2	2	+
Tanacetum vulgare			r																																
Taraxacum officinale agg.	r			r	+	r										+		r					+		r			r						+	
Trifolium dubium	r				r																													1	
Trifolium pratense						r																													
Trifolium repens																							r												
Tripleurospermum inodorum				r	+											+		+																	
Tussilago farfara					+																													1	
Urtica dioica			+										+		1														1						
Verbascum nigrum							r																												
Verbena officinalis					r																														
Veronica anagallis-aquatica				1								r	r		r					1										1		+			
Veronica beccabunga														r								1													
Vicia cracca																																		r	

Annex 4: Phytosociological table for the survey of August (17.08 to 20.08.2017)

		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	
		1 C	4 B	6 G	1 D	6 D	4 A	5 D	5 C	5 A	5 E	7 C	6 C	3 A	2 A	3 E	4 D	2 C	3 B	3 D	1 A	7 E	6 E	5 B	7 A	6 A	6 F	4 E	4 C	1 E	7 B	6 B	7 D	1 B	3 C	2 B	Cons-tancies
KC1	Isoëto-Nanojuncetea																																				
	Juncus articulatus (d)			1		2	2	1	1	1	3	+				+	+			+				+							+						13
	Cyperus fuscus (d)			+			1																														2
D1/AI	*Mentha aquatica*	4	4	2	1		+	4	2	4		1																	+								10
KC2	Bidentetea tripartiti																																				
	Persicaria dubia	+	r		2	1	r					r		+		1							+	r	+	+	r	+	+	+	1			+			18
	Bidens tripartita	r									r					r	r		+		1		r					r	+	+	r						11
	Veronica anagallis-aquatica (d)			1																r				+							+						4
	Rorippa palustris			+																											+						2
	Persicaria minor																															+					1
KC3	Phragmiti Magnocaricietea																																				
D2	*Phalaris arundinacea*	+			r					2	1	+	1	1	1	4	2	3	1	2					+								+				15
	Phragmites australis											1	1	1																							3
	Lycopus europaeus	2	r		1		1		+		2			3		r					1		r					+	+	+		2		3			15
	Mentha longifolia (d)	2									1				+	+	2	1	2		r		r					1	2	r			+	+			14
	Poa trivialis					+		+	1	2				1		r				+			+								+	+	+				11
	Ranunculus repens (d)					1				r	r	r					4			1	1	1		2							+						10
	Lythrum salicaria											1	+	+	+	1				1											1		r				8
	Poa palustris				1										1			+			1					2			+	1							7
	Veronica beccabunga (d)						r	1																							r						3

	Alisma plantago-aquatica			r				r																													2
	Carex acuta								1						+																						2
	Eleocharis palustris					2	1																														2
	Iris pseudacorus																			r																	1
KC4	Molinio-Arrhenatheretea																																				
	Taraxacum officinale agg.			r	r				r		+										2		r					r	1	1			r			+	11
	Plantago lanceolata				+				+		+										r									1							5
	Prunella vulgaris								+												1							+	+	1							5
	Poa pratensis																1		2					2											+		4
	Achillea millefolium								r		+																						+				3
	Lysimachia nummularia	r					r																														2
	Dactylis glomerata																																			1	1
	Rumex acetosa					+																															1
	Trifolium repens										r																										1
	Vicia cracca																																r				1
KC5	Stellarietea mediae																																				
	Cirsium arvense								r			+							+				r					r	r				+				7
	Tripleurospermum inodorum				r																							+	+	r							4
	Polygonum aviculare agg.																												r								1
	Mentha arvensis										1																										1
	Erysimum cheiranthoides																											+									1
	Stellaria media agg.										r																										1
KC6	Galio-Urticetea																																				
IS	*Solidago gigantea*			r					+		1	2				1	+		2		+		1	1		r		1	r	+	r	5	2	2			18

IS	*Solidago canadensis*																													+							1
	Urtica dioica	+	1													+			r								1										5
	Rubus caesius											r										2															2
D3	Fallow land indicator																																				
	Calamagrostis epigejos	+						1	1	1	1	1	1	1	+	+	1	3	2		1	3	1	1			+							+			19
D4	Dynamical stage: Woody vegetation																																				
	Populus nigra			+	r		r		+		r	+			+	r			1		1		+					r		2		+	+		2	+	17
	Populus alba		r	r					r		1	r					r		1		r	r	+					+	1		r		1		+		15
	Salix purpurea		+	+	1	1	1	r	r	+	2	2	+		1	1				r	1	r	+	+	1	+	r			r	1	1	1		r		26
	Salix alba																					r				r											2
	Salix pentandra																											r							1		2
IS	*Acer negundo*															r													r	r							3
IS	*Ailanthus altissima*		r																																		1
	Alnus glutinosa																													r							1
	Remaining companion species																																				
IS	*Erigeron annuus*				+				+		r	r			+								r					r	r	+			2		1	2	12
IS	*Impatiens glandulifera*										r								r																		2
AI	*Juncus effusus*												3			+				+				3	2	1	1										7
	Agrostis stolonifera	4	3	3	3	4	4	3	3	3	3	+		3	1	2	1	1	3	4	2	1	2	3	3	3	2	1	1	+	4	+		2	3		32
	Plantago major			r	1				1		+						+				2		1					1	1	1			+				11
	Equisetum arvense						+					3		1		+	+	+								+	r		+								9
	Eupatorium cannabinum						+				2				1				r				3					2	1	r							8
	Juncus inflexus		1			1				1			+			1		r		3						1											8
	Poa annua			+	1					+													+					1	+						+	r	8
	Setaria pumila		+				r								+								+						+				+		1	+	8

	Echinochloa muricata		+	2	+		+		+															+				r								7
	Scrophularia nodosa		r												1			+					r					+					+			6
	Glechoma hederacea																+				+					+			2			r					5
	Carex hirta																					2						2			1			+			4
	Carex nigra						3						1									2			3												4
	Rumex conglomeratus			r							r							+																1			4
	Trifolium dubium																											r		+			1			r	4
	Carex pseudocyperus											1														1	3										3
	Euphorbia cyparissias														r															r						+	3
	Oxalis stricta			r								+																					+				3
	Scirpus sylvaticus												2			+										2											3
	Tussilago farfara																				1									1			2				3
	Verbena officinalis																						+							r			+				3
	Calystegia sepium																					+												r			2
	Carex flacca										+							+																			2
	Chenopodium polyspermum		r	+																																	2
	Epilobium tetragonum				r																									r							2
	Myosotis scorpioides																								2									1			2
	Rorippa austriaca																										1							2			2
	Scutellaria galericulata	+																																2			2

Only once present in this survey: *Epilobium roseum* 1A (+), *Verbascum nigrum* 2B (r), *Thalictrum minus* 4E (r),*Tanacetum vulgare* 1C (r), *Stachys palustris* 1B (+), *Senecio sarracenicus* 6E (1), *Saponaria officinalis* 2B (r), *Rumex sp.* 4A (r *), Rorripa x anceps* 4A (+), *Ranunculus sp*. 1B (r), *Poa compressa* 2B (+), *Persicaria maculosa* 6G (2), *Panicum capillare* 4B (+), *Matricaria discoidea* 4E (+), *Hypericum sp.* 6C (r), *Hypericum perforatum* 2B (r), *Humulus lupulus* 3B (r), *Holcus mollis* 2A (+), *Geum urbanum* 6E (r), *Galium album* 7B (r), *Festuca ovina agg.* 2A (1), *Equisetum sp*. 5A (+), *Equisetum hyemale* 3A (+), *Elymus repens* 2C (+), *Dipsacus fullonum* 4C (r), *Digitaria sanguinalis* 3C (+), *Cerastium sp.* 7D (+), *Centaurium pulchellum* 7D (1), *Carex sylvatica* 6F (3), *Carex sp.* 4B (+), *Carex echinata* 5A (1), *Carduus sp*. 7D (r),
Brachypodium pinnatum 7D (+), *Schoenoplectus lacustris* 4A (+)

Annex 5: Vegetation cover for each plot in % during the surveys of May, June, July and August 2017

	1A	**1B**	**1C**	**1D**	**1E**	**2A**	**2B**	**2C**	**3A**	**3B**	**3C**	**3D**	**3E**	**3F**	**4A**	**4B**	**4C**	**4D**	**4E**	**5A**	**5B**	**5C**	**5D**	**5E**	**6A**	**6B**	**6C**	**6D**	**6E**	**6F**	**6G**	**7A**	**7B**	**7C**	**7D**	**7E**
May	80	80	98	50	75	90	10	90	60	30	25	50	95	90	50	20	50	95	30	95	70	50	98	95	50	95	90	99	50	60	20	80	70	80	50	99
June	98	95	95	60	80	98	15	95	98	99	35	99	95	95	75	50	60	98	40	99	98	75	100	95	70	95	90	99	60	80	30	98	99	90	50	90
July	98	95	99	70	50	90	10	90	98	99	40	99	95		90	90	70	98	40	100	100	60	100	98	98	90	90	99	60	95	60	99	99	98	60	90
August	98	95	100	80	60	98	20	90	99	99	70	100	95		99	99	90	100	60	100	100	90	100	98	98	95	100	100	70	100	80	100	100	100	60	95

Annex 6: Coordinates of the plots

Plots	Coordinates	
1A	E 015°48'11.6''	N 48°22'08.5''
1B	E 015°48'11.2''	N 48°22'08.7''
1C	E 015°48'11.3''	N 48°22'08.6''
1D	E 015°48'11.3''	N 48°22'08.6''
1E	E 015°48'11.6''	N 48°22'08.1''
2A	E 015°48'15.5''	N 48°22'18.0''
2B	E 015°48'14.8''	N 48°22'18.2''
2C	E 015°48'15.6''	N 48°22'18.5''
3A	E 015°48'20.3''	N 48°22'18.0''
3B	E 015°48'18.7''	N 48°22'18.5''
3C	E 015°48'19.8''	N 48°22'18.8''
3D	E 015°48'29.0''	N 48°22'18.8''
3E	E 015°48'30.4''	N 48°22'15.5''
3F	E 015°48'31.2''	N 48°22'20.1''
4A	E 015°48'52.9''	N 48°22'13.0''
4B	E 015°48'55.2''	N 48°22'12.4''
4C	E 015°48'56.2''	N 48°22'12.7''
4D	E 015°48'56.9''	N 48°22'12.6''
4E	E 015°48'57.7''	N 48°22'13.0''
5A	E 015°49'29.8''	N 48°22'21.5''
5B	E 015°49'30.5''	N 48°22'21.3''
5C	E 015°49'31.0''	N 48°22'21.7''
5D	E 015°49'32.9''	N 48°22'21.5''
5E	E 015°49'35.9''	N 48°22'22.6''
6A	E 015°50'15.2''	N 48°22'21.4''
6B	E 015°50'13.5''	N 48°22'21.6''
6C	E 015°50'13.7''	N 48°22'21.4''
6D	E 015°50'05.5''	N 48°22'21.1''
6E	E 015°50'05.5''	N 48°22'21.5''
6F	E 015°50'09.2''	N 48°22'20.6''
6G	E 015°50'09.8''	N 48°22'20.6''
7A	E 015°50'18.9''	N 48°22'20.6''
7B	E 015°50'20.2''	N 48°22'20.5''
7C	E 015°50'21.6''	N 48°22'19.9''
7D	E 015°50'21.5''	N 48°22'19.7''
7E	E 015°50'22.8''	N 48°22'18.5''