PÄRANDKOOSLUSTE
KAITSE ÜHING

Maintenance plan for floodplain meadows

Compiled by Jaak-Albert Metsoja
Tartu 2020

Table of contents

Foreword 3
I Floodplain meadows. Definition and classification 4
Definition 4
Classification of floodplain meadows in Europe 4
Classification of floodplain meadows in Estonia as Natura 2000 habitat types 7
Floodplain meadows in the classification of Estonian habitat types 7
II Formation of floodplain meadows and environmental conditions 12
Meadows have originated in floodplain forests as a result of human activity 12
Environmental conditions create a mosaicity of floodplains 12
Historical use of floodplain meadows 14
III Distribution and status of floodplain meadows, risk factors 16
Distribution and status of floodplain meadows in Europe 16
Distribution and status of floodplain meadows in Estonia 16
Risk factors 21
IV Values and biota of floodplain meadows, their protection 26
Landscape and typological diversity 26
Habitat and protected species 26
Ecosystem services 29
Ensuring the favorable condition of floodplain meadows based on conservation values 30
V Restoration of floodplain meadows 31
Selection criteria for the site to be restored 31
Open or with trees and shrubs? 31
Removal of woody vegetation from the area 31
Restoration of water regime; opening of oxbow lake estuaries. 35
Restoration of ditches 36
Closing of ditches 38
Other floodplain meadow water bodies 39
Accesses and crossings 39
Removal of sods 41
Other issues related to restoration 41
VI Maintenance of floodplain meadows 44
Purpose of maintenance, expected result 44
Floodplain meadow status indicators 45
Choice of maintenance method 47
Maintenance instructions and peculiarities on grazing 48
Maintenance instructions and peculiarities on mowing 54
Degradation of floodplain meadows / inadequate maintenance 55
Risks of over - management 56
Variety of maintenance 57
Special equipment suitable floodplain for meadows 57
Future prospects for maintenance 59
VII Summary 61
Used literature 62

Foreword

Floodplain meadows are unique semi-natural communities that, due to their dual nature (can be considered as grasslands as well as temporary wetlands), are, on the one hand, very important for many biota groups - from fish in rivers to birds of prey in the sky - and on the other hand they very difficult to maintain.

The local floodplain meadow maintenance plan is an overview of the values of meadows and their protection needs, as well as restoration and maintenance practices commissioned by the Environmental Board. The plan is intended to provide recommendations and background information to the caretakers of semi-natural communities and the authorities coordinating their activities. Compared to the previous maintenance plan prepared in 2011, the data on the distribution and status of floodplain meadows have been updated, and newer research works and practices in the restoration and maintenance of meadows have been included.

The plan is divided into the following parts:

Chapter I opens the concept of a floodplain meadow and defines floodplain meadows against the background of other types of meadows both in Estonia and in Europe, and opens the classification (typology) of floodplain meadows;

Chapter II describes the formation and environmental conditions of floodplain meadows and their historical use;

Chapter III provides an overview of the distribution, status, and risk factors of floodplain meadows;

Chapter IV opens up the values of a floodplain meadow as an ecosystem and habitat and introduces the protection of floodplain meadows, with special reference to protected species on meadows for conservation purposes;

Chapter V deals with the restoration of floodplain meadows;

Chapter VI deals with the maintenance of floodplain meadows;

Chapter VII provides a summary of the above.

I thank all the caretakers, officials and colleagues, and biota experts who contributed to this and the previous plan; I would like to single out Marju Erit and Ilona Lepik from the Environmental Board for their numerous meaningful comments and corrections, Meeli Mesipuu for collegial support and Viljar Ilves and Tõnno Olonen for valuable advice and ideas.

I Floodplain meadows. Definition and classification

Definition

Floodplain meadows or floodplain grasslands are flooded semi-natural communities (meadows or pastures) on the floodplains of rivers and larger streams, where flood water carries sediments. Floodplain meadows can also be found around lakes with shallow shores (e.g., Lake Võrtsjärv and Lake Peipsi). Floodplain meadows are widespread throughout Estonia, more on the floodplains of the headwaters of larger rivers - Emajõgi, Põltsamaa, Pedja, Kasari, Halliste, Raudna, Piusa, Koiva, Mustjõgi, Narva (Paal, 2007). Areas in lake floodplains can be considered floodplains meadows conditionally, as the nature of the floods and the sediments they produce are quite different from those located by floodplains by rivers (Laasimer, 1965; see also Chapter II).

Special mention may be made of floodplain wooded meadows, where there is a tree (and shrub) layer characteristic of a wooded meadow, in particular in the higher relief parts, especially broad-leaved species, particularly oaks. Such floodplain wooded meadows are listed in the Natura habitat databases as wooded meadows, which is justified both in the botanical (they are located in the higher, drier part of the relief, there is the tree and shrub layer, high shrubbery, high species richness in the grass layer) and in terms of maintenance practices (with higher support rates, as they require regular shaping or pruning of the shrub and tree layer, more machine maneuvering and, in some cases, manual work). However, all floodplain meadows have formed from former floodplain forests (see also Chapter II).

In the present work, the concept of floodplain meadows also includes grazed grasslands located on floodplains. It would be more terminologically correct but much more cumbersome to use the term floodplain grassland.

Classification of floodplain meadows in Europe

In Europe, according to the Habitats Directive, floodplain meadows belong to the type group of semi-natural wet high grassland habitats, which has five habitat types (Paal, 2007):

6410 Molinia meadows on calcareous, peaty, or clayey mud sediments;

6420 Mediterranean moist, high types of grass with Molinio-Holoschoenion communities;

6430 Hydrophilous tall herb fringe communities of plains and of the montane to alpine levels;

6440 Flooded meadows with Cnidion dubii communities in river valleys;

6450 Nordic floodplain meadows.

In the European context, the 6510 lowlands hay meadows with *Alopecurus pratensis* and *Sanguisorba officinalis* along the rivers can also be considered to partially overlap with the concept of floodplain meadows. Examples of European floodplain meadows are shown in Figure 1.

a)

b)

c)

d)

Figure 1. Examples of European floodplain meadows: a) the floodplain meadow along Nemunas River in Lithuania, botanically rich in species due to the drying of the soil in summer. (b) floodplain meadow with *Sanguisorba officinalis* in upstream of the Thames in England. (c) Fritillaria,

the flagship of the English floodplain, meadows among the Ranunculus and Filipendula ulmaria. (d) the floodplain meadow along the Morava River in Slovakia - *Clematis integrifolia* in the foreground.

Classification of floodplain meadows in Estonia as Natura 2000 habitat types

Within the meaning of the European Union's Habitats Directive and as a Natura 2000 habitat type, Estonian floodplain meadows can be considered primarily habitat type 6450 (Nordic floodplain meadows), which are grasslands on the banks of large rivers in quietly flowing sections that freeze every winter and are flooded in spring and summer (Paal, 2007). Nordic floodplain meadows are distinguished from other types of European floodplain meadows and the meadow types close to them by the effects of winter ice, often also wet soils (less drained, swampier) for a longer period of time.

Of the other habitats in the European Habitats Directive, Hydrophilous tall herb fringe communities (6430) are also considered to be floodplain meadows, in particular as (less valuable) buffer zones at the edges of the core areas of floodplain meadows (in practice, this type can also include some unmaintained floodplain meadows) of a poorer status and wooded meadows already mentioned above (*6530 Fennoscandian wooded meadows; 2007).

In nature, floodplain meadows also have transitions and overlap with fen meadows (7230) in addition to tall herb fringe communities (6430). Transitions and overlaps between the edge areas of floodplain meadows and fens are due to the fact that it is often not possible to clearly distinguish between the end of the flood impact area, i.e., the end of a floodplain meadow and the beginning of a fen meadow.

Floodplain meadows in the classification of Estonian habitat types

In the currently used classification in Estonia (Paal, 1997), floodplain meadows in meadow vegetation are classified in floodplain meadow class (2.2), floodplain meadow type group (2.2.1) and divided into fresh (2.2.1.1), and wet (2.2.1.2) habitat types with 7 and 19 plant communities, respectively. The classification excludes from floodplain meadows plant communities on higher relief elements located on a floodplain, which are not affected by flooding and which therefore belong to the class of grassland on mineral soil (2.1). In practice, such smaller meadow patches belonging to dry and fresh grasslands are also included in the surrounding floodplain meadows with a larger surface area, which is justified in view of the complex landscape and maintenance; however, it should be noted that strictly in terms of the classification of habitat types, the highest (and often the most species-rich) meadow patches may not be classified as floodplain meadows. As in the case of other meadow communities, wooded floodplain meadows are not a separate unit in the Estonian classification, only the presence of a tree and shrub layer is indicated for the type (i.e., for example - fresh wooded floodplain meadow = “2.2.1.1 p”).

In summary, the most important factors in the delimitation of floodplain meadows, as well as classification inside the groups, are sediments and water regimes. Thus, the criterion for distinguishing meadows from other meadow or bog types is the presence of alluvial sediments - sediments in floodplain meadow soils and peat in fen soils (Masing et al., 2000).

In the former large-scale vegetation mapping (Laasimer 1965), floodplain and fen communities have also been considered to partially overlap; many fens, which back then were considered meadows, deserved it because they used to be mowed/grazed, which they no longer are. Thus, Laasimer (1965) disagrees with Pork (Pork, 1959), who, as a group of floodplain meadows, describes plant communities on the slopes of a floodplain terrace where the effects of alluvial sediment and flooding are minimal, and the main shaping factor is calcareous groundwater.

Within the floodplain meadow type group, the main criteria for distinguishing between subdivisions are the moisture regime - the duration of floods and the amount of sediment, and the location of the meadow area on the floodplain in terms of both distance and height from the river. According to the above, Laasimer (1965) distinguishes four groups of associations of floodplain meadows. In the most

articulated classification (Krall et al., 1980), there are 8 subtypes, and 26 plant communities have been distinguished. (Table 1). The species richness of plant communities generally decreases as the community becomes wetter (Table 1 from top to bottom).

Table 1. Classification of floodplain meadows according to Krall et al. 1980 and the relationship with the systems of Laasimer (1965) and Paal (1997)

Grassland type and subtype (Krall et al. 1980)	Laasimer 1965	Paal 1997	Flood and wetness regime	Type of sediment	Characteristic plant species	Predominant soils	Location on the floodplain
Dry floodplain grasslands 1. rich in species	Floodplain meadows and short-term flooded floodplains	Fresh floodplain meadow	Short-term, irregular flooding, dry	No or little used to be calcareous	Molinia caerulea Festuca ovina	Floodplain soddy soils, floodplain clay soils	On higher floodplain elements
2. species-poor				Scant, low in nutrients	Festuca ovina Nardus Agrostis capillaris		
Grasslands 3. dry			Regular flooding, good drainage	Moderate	Agrostis gigantea Festuca rubra Alopecurus pratensis Deschampsia cespitosa	Clay floodplain soils	On the shore floodplain, less often on the central floodplain

4. wet	Floodplains with long-term floods	Wet floodplain meadow	Regular flooding, relatively good drainage	Mostly scant	Cirsium palustre Filipendula ulmaria Deschampsia cespitosa Calamagrostis stricta	Clay floodplain soils, floodplain clay soils	On shallow river and stream banks, at the central floodplain of larger rivers

5. (Wet) flooded grasslands of large grasses	Floodplains with long-term floods	Wet floodplain meadow	Regular flooding, poor drainage, to excessive wetness	Scant to abundant	Phalaris arundinacea Deschampsia cespitosa Calamagrostis stricta	Floodplain clay soils, clay floodplain soils	On a central or terrace floodplain, less often on a shallow shore floodplain
6. Great sedge floodplain grasslands			Regular flooding, constantly excessive wetness	With varying numbers and textures, more often scant and silty	Carex cespitosa Carex acuta Carex disticha	Floodplain clay soils, floodplain peaty soils	On the central and terrace side floodplain, in the lacustrine extensions of the river valley, on the delta floodplains

7. Floodplain fen grasslands	Floodplain fen meadows		Constantly too wet	Missing or insignificant amount	Carex nigra Carex elata Carex cespitosa Carex lasiocarpa Carex disticha	Floodplain fen oils	On low, constantly wet floodplain elements (characteristic of lacustrine extensions of a river valley, shallow wide river floodplains)
8. River and lake reed beds			Constantly flooded	Abundant	Reed Schoenoplectus lacustris	Underwater soils	On the waterfront of rivers and lakes

II Formation of floodplain meadows and environmental conditions

Meadows have originated in floodplain forests as a result of human activity

In Estonian areas, meadows are predominantly secondary vegetation types that have developed instead of the primary community (forest) due to human activities. More specifically, floodplain meadows have developed from oak and elm deciduous forests, alder carrs, willow groves, and gray alder forests (Pork, 1964; Leibak & Lutsar, 1996). To a very small extent, floodplain meadows can also be primary and have never been forested; this can be caused by soils unsuitable for tree growth (Paal 1997) but also by elk and other large herbivores (Pork, 1979; Pärtel et al., 2005) and even by beavers (Kukk et al., 2000), which reduce the growth of woody plants accordingly or create large flooded areas. Primary floodplain meadows can also be found in Western Estonia (Matsalu), where as the land rises from the sea, it has been gradually used as grassland and pasture and has never been forested. In most cases, however, man has played a role in the emergence and formation of floodplain meadows by removing trees and shrubs and later mowing (Pork 1964; Laasimer 1965).

The oldest settlements in Estonia are mostly located along with ancient water bodies. According to the data of Kriiska & Tvauri, 2002, the southern part of the Põltsamaa and Pedja river basins - the shore areas and islands of the former Võrtsjärv - was inhabited in the Mesolithic; the former floodplain forests along Emajõgi River began to appear as small wooded meadows in the Atlantic climate period already 8000–5000 years ago (Pork 1979). The floodplains became meadows more widely in the middle of the first millennium (Laasimer 1965), and humans began to influence the floodplain meadows and the entire Estonian meadow vegetation in particular with the introduction of the scythe in the middle of the first millennium BC. Thus, it can be said that the floodplains are among the oldest grasslands with human influence (Laasimer, 1965).

The initial formation of meadow vegetation in the floodplains began with deforestation in the area of settlements, later, with the expansion of livestock farming even further afield. There are still many species in the floodplain vegetation, which are also found in floodplain forests (e.g., *Phalaris arundinacea*, *Calamagrostis canescens*, *Caltha palustris*, *Geum rivale*, *Poa palustris*, *Agrostis gigantea*, *Carex cespitosa,* etc.). Many modern meadow species also come from floodplain oak forests (*Festuca rubra*, *F. pratensis*, *Dactylis glomerata*, *Briza media*, *Phleum pratense*, *Lathyrus pratensis*, *Trifolium pratense*)or from alder groves growing on shores and sediment-rich shore slopes (*Veronica longifolia*, *Lysimachia vulgaris*, *L. nummularia*, *Ranunculus repens*, *V. scutellata*, *Myosotis scorpioides*, *Symphytum officinale*, *Carex acuta*, *C. distica*, *Agrostis stolonifera*, *Poa trivialis*). The vegetation cover of floodplain meadows also includes species of fens and willow groves (*Comarum palustre*, *Viola epipsila*, *Menyanthes trifoliata*, *Calamagrostis stricta*, *Poa pratensis*, *Carex elata*, *C. vesicaria,* etc.). (Pork, 1964).

According to Pork (1964), floodplain meadows were significantly species-poorer in the past than they are today - although they are one of the oldest meadow communities, a very large proportion of meadow species have spread into them from drier meadows on the mineral soil in the watershed area.

Environmental conditions create a mosaicity of floodplains

Unlike, for example, wooded meadows on mineral soil, where the richest communities in Estonia are located on a scale of one square meter (76 vascular plant species per square meter of Laelatu wooded meadow), floodplain meadows are relatively poor in species, especially in the wetter part. True, Meeli Mesipuu has registered 41 species per square meter in the most species-rich square, and 40

species in two other squares during the Koiva-Mustjõgi flooded meadow surveys (Mesipuu, 2014). In total, at least 350 species of vascular plants, i.e., about a quarter of the Estonian flora (Pärtel et al., 2007), are associated with Estonian floodplain meadows. It can also be seen from the table presented in the previous chapter that the floodplains have many different plant communities, and typologically the floodplains are very diverse. This diversity is directly due to the varying moisture conditions of the floodplains, which in turn are related to the (micro) relief of the floodplain. The most characteristic feature of floodplain meadows is periodic flooding. Alluvial sediments are transferred to the floodplain by flooding, the different distribution of which in the meadow also causes the zonality and zonation of the soils (Pork 1959).

Three zones can be distinguished on Estonian floodplains (Pork 1959):
1. River bedside flooded meadow with the highest flow rate during seasonal floods and thick deposits of sandy sediments that form layered floodplain soils.
2. Central floodplain meadow where the flow of seasonal floods is at a low speed and dusty and loose sediment particles settle on the meadow in a thin layer up to a few mm thick, which results in the formation of very fertile granular floodplain soils.
3. The terrace edge floodplain meadow, where the finest particles settle, and the total amount of sediment is very small; at the same time, the terrace edge floodplain is constantly too wet due to the mineral-rich groundwater protruding through it.

These three zones can also be distinguished in the vegetation with no human impact, i.e., willow groves, floodplain forests, and carrs (Figure 2). Willow groves are common in the river basin side floodplain meadows, in which case the formation of longer-term communities is hindered here due to the continuous transformation of the meadow caused by the spreading of sediment. The central floodplain meadow corresponds to alluvial forests where the species richness of the vegetation is the highest due to better moisture conditions (the same is true later in the case of the floodplain meadow; however, such meadows may be the most difficult to restore due to being heavily overgrown or even forested). On the floodplain meadow along the terrace, there are carrs that are constantly too wet; in the case of floodplain meadows, sedge-rich floodplain fen meadows are common here, and in the case of calcareous groundwater, they can be quite rich in species.

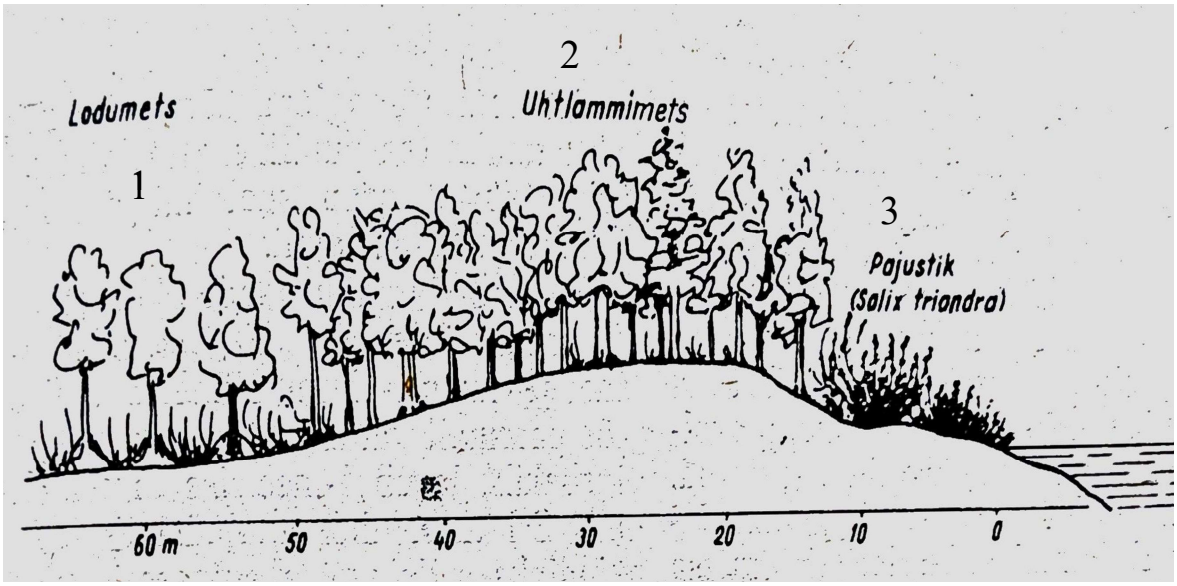

Figure 2. Distribution of shrubs and forest communities in different parts of the floodplain meadow and the relationship of the meadow profile with the three zones distinguished by Pork (1959) (adapted by Laasimer 1965).

Often the above-mentioned zones cannot be distinguished, and especially in the case of smaller meadows, the conditions may be everywhere uniformly those of a terrace side floodplain meadow (low sedge layer), and in the case of a thin layer of sediment, the zoning/mosaicity may be caused only by the wetness regime.
In floodplain grassland communities, the main determinant of vegetation structure is the flood regime (Pollock et al., 1998; Wassen et al., 2003): duration and depth of flooding. As these two are directly related to the rise of the ground away from the river, these two environmental factors can also be expressed within a specific area by a common factor - the altitude gradient. The distribution of the flood regime on the altitude gradient is expressed in the fact that the areas further from the river are covered for less time and with a thinner layer of water. Areas further away from the river also have a less fluctuating groundwater level: while groundwater in coastal areas is relatively low in summer, groundwater in the terraced meadow zone is also relatively close to the surface in summer. Wassen et al. (2003) show that the farther away from the river, the more species richness increases and terrestrial biomass decrease, but species richness is not unambiguously related to distance from the river; variability in the local flood pattern is also decisive - the more diverse the microrelief and, consequently, the flood characteristics, the more species-rich the community (Pollock et al. 1998).

The sediments accumulating in the floodplain meadow are highly variable not only due to the change in distance from the river but also due to the continuous and extensive transformation of floodplain meadows due to erosion and sedimentation processes - on the eroding bank of the river, the river is constantly digging the bank, and a layer of sediment up to 7 cm thick can be added to the point bar per year (Pork, 1964). It has also been found in the study of floodplain meadow soils that the layers located at different depths of sediment are not of the same nature - there are often peaty sediments under the current sandy ones, which leads to the conclusion in the context of the Emajõgi floodplain meadow that the sedge communities associated with peat richer and more paludified soils have previously spread over a much larger area than in the present (Pork, 1964).

The existence of oxbow lakes is also very characteristic of larger floodplain meadows. Old rivers or oxbow lakes floodplains (Ristkok, 1969) are floodplain water bodies formed by the slow displacement of a river bed due to the river eroding the bank on the eroding bank and accumulating sediment on the point bar, and occasionally breaking a new bed for itself over the floodplain meadow. Oxbow lakes can be connected to the main river at one or both ends or separated from the river over time. Oxbow lakes are especially important breeding grounds for fish but also for invertebrates in floodplain meadows.

Historical use of floodplain meadows

Grazing started in the floodplain meadows earlier than mowing, already about 3000 - 4000 years ago, but both because the floodplain meadows were far from home and because the floodplain meadows were assessed as forage areas with good yields, they have historically been used primarily as hayfields. The cattle were only taken to the mowed floodplain meadows closer to home to eat (Pork, 1964; Troska, 2004). In the case of mowing, people went to areas far from home with their families and often for a few weeks; in some places, temporary housing has been built, such as the huts made of willow branches (oral information by V. Metsoja). The hay was cut with a scythe, later in some places with a horse mower. The hay was gathered on platforms made of willow bushes, in some

places, a base of assembled stones has also been used; often, the hay was taken to the farms by winter road (Troska, 2004). It is also known from the Soviet period that the hay was carried out from floodplain meadow in winter, often with belt tractors and drag plates placed under the pile (oral information by U. Valge).

Historically, mowing of floodplain meadows started either on Midsummer Day (Troska, 2004), at the beginning of July (oral information by V. Metsoja) or, due to being away from home, also in late summer (Suurkask, 1999), grazing began in April (on April 1, when the cattle was usually released to the pastures, or St. George's Day on April 23; Troska 2004), the mowing was usually completed by St. Jacob’s day (July 25), sometimes by St.Bartholomew’s day (August 24), grazing lasted until late October, essentially until snowfall (Troska, 2004).

III Distribution and status of floodplain meadows, risk factors

Distribution and status of floodplain meadows in Europe

The assessment of the conservation status of species and habitats of European Union importance submitted to the European Commission periodically (https://nature-art17.eionet.europa.eu/article17/) presents an area assessment of the distribution of Nordic floodplain meadows (for the years 2013-2018) of 51,800 - 60,000 ha in Estonia, in Latvia, Lithuania, Finland, and Sweden in total, including 15,000 - 19,000 ha in Estonia. In all countries, the overall assessment of habitat status is "unfavorable," and future prospects are also assessed. Estonia and Lithuania specify an unfavorable assessment with the extension “deficient” (U1), other countries with the extension “bad” (U2). Only Lithuania assesses the level of achievement of the area objectives as “good,” based on the estimated area of floodplain meadows of approx. 14,800 ha. The main threats that are highlighted are the cessation of mowing and grazing, the violation of hydrology (incl. the absence of flooding), and, less often, the use of arable land.

Distribution and status of floodplain meadows in Estonia

The maximum area of Estonian floodplain meadows is around the turn of the 19th-20th century - nearly 150,000 hectares. By the middle of the last century, the area had shrunk to 83,000 hectares, and by the end of 1970, to approx. 26,000 hectares. (Laasimer 1965). In 1990, the area of floodplain meadows has been estimated at 20,000 hectares (Kukk & Sammul, 2006), after which it has increased somewhat due to national and European support but is not estimated to have significantly exceeded 20,000 hectares in 2006 (ibid.).

The University of Tartu has recently prepared an assessment of the ecological functioning of semi-natural communities (Helm & Toussaint, 2020), providing, inter alia, a consolidated database of semi-natural communities based on current best knowledge, which contains information from the database of Natura habitats, the database of semi-natural communities of the Environmental Register, the database of meadows of the Estonian Seminatural Community Conservation Association and the database of semi-natural communities located outside protected areas. A total of 5,712 floodplain meadows with a total area of 27,573 ha were identified. Most of these floodplain meadows have also been assessed for their conservation status, which is an overall assessment * of the structure of the plant community (whether these are species-specific to floodplain meadows and their abundance relationships, what is the situation of overgrowth), *from the perspective of preservation as the current land use of the moment of inventory continues, and * the complexity of restoration (sodding, access, etc.).

Table 2 shows the areas and conditions in the aggregated data layer for floodplain meadows (6450) and their edge meadows (6430), which belong to the type group of floodplain meadows (221) or floodplain willow shrublands (122) in terms of Estonian habitat type.

Table 2. Area and status of floodplain meadows and edge meadows in the aggregate layer of semi-natural communities (Helm & Toussaint, 2020)

6450 conservation status on the aggregate data layer	Number, pcs	Total area, ha	In protected areas, ha	Outside protected areas, ha
I (good)	643	4896	4503	393
II (average)	745	5328	4910	418
III (bad)	4189	17136	7811	9325
not specified	135	213	0	213
6430 Conservation status of meadows considered as floodplain meadows among in the aggregate data layer	Number, pcs	Total area, ha	In protected areas, ha	Outside protected areas, ha
I (good)	22	55	14	41
II (average)	20	75	59	16
III (bad)	219	1319	161	1158
not specified	4	0.7	0	0.7

As the table shows, the lion's share of our floodplain meadows is in poor status - about 62% of the total area of the aggregate layer, including about 45% in the case of protected meadows. It follows that the targeted protection of floodplain meadows in the designated areas is at least partially effective - there is 9413 ha of meadows in good or medium status in the protected areas. At the same time, it should be noted that there is a relatively same amount (7811 ha) of floodplain meadows in poor status - and only from a geobotanical point of view, which is reflected in the databases. It is feared that the status of floodplain meadows outside protected areas has also steadily deteriorated since the inventory data was collected, as conservation measures are not applied in such areas. It is also noticeable that areas in good and medium status are located in significantly larger arrays than areas in poor status. However, it is likely that there may be areas among the smaller areas that need more attention than before - it can be assumed that their poor status is often caused by overgrowing, which in turn is due to the fact that smaller batches of floodplain meadows are more logistically burdensome for maintainers. However, smaller pieces of floodplain meadows may be located along smaller rivers, where, unlike large and relatively uniform floodplain meadows along, e.g., the Emajõgi River, for example, there may be more communities of grassland on mineral soil due to the shorter duration of flooding, there may be areas of high botanical value.

There were a total of 270 edge meadows defined as floodplain meadows, with a total area of 1,450 ha. Some edge meadows along rivers or streams that were not marked with floodplain meadows or floodplain willow shrubs may be excluded from the selection. The total area of all edge meadows (according to Helm & Toussaint, 2020) is 6536 ha; however, it is not expected that there will be

significantly more than 1500 ha of areas considered floodplain meadows. For the most part, they are also in poor status, and moreover, they are also outside the protected areas.

The action plan for semi-natural communities for the period 2013-2020 set the target of 12,200 ha for the maintained floodplain meadows by 2020, i.e., an increase of 5,160 ha compared to the 7040 maintained meadow hectares in 2013. In reality, as of 2019 (EELIS data), among the maintained semi-natural communities, there was 7736 ha of floodplain meadows (meadows with the only or accompanying habitat code 6450; those with the determination of only 6450 were 7413 ha), i.e., the growth has been only about 700 ha instead of the planned more than 5,000 ha. In the period 2013 to 2020, more than 700 new floodplain meadows were added to maintenance, but on the other hand, some floodplain meadows have also fallen out of use (Holm et al., 2019).

Figure 3 gives an overview of the conservation and protection areas where there are floodplain meadows in good condition (good nature conservation status in Helm & Toussaint, 2020 aggregate data), and the location of floodplain meadows in different statuses in Estonia is given in Figure 3. It should be pointed out that, despite the constant updating of the data, even to the best of today's knowledge, there is no up-to-date inventory data even for floodplain meadows in good condition. Of all the meadows in good condition (643 meadows with a total area of 4896 ha), only 216 meadows (3011 ha) have a known inventory date, and 64 of these floodplain meadows have data from before 2005.

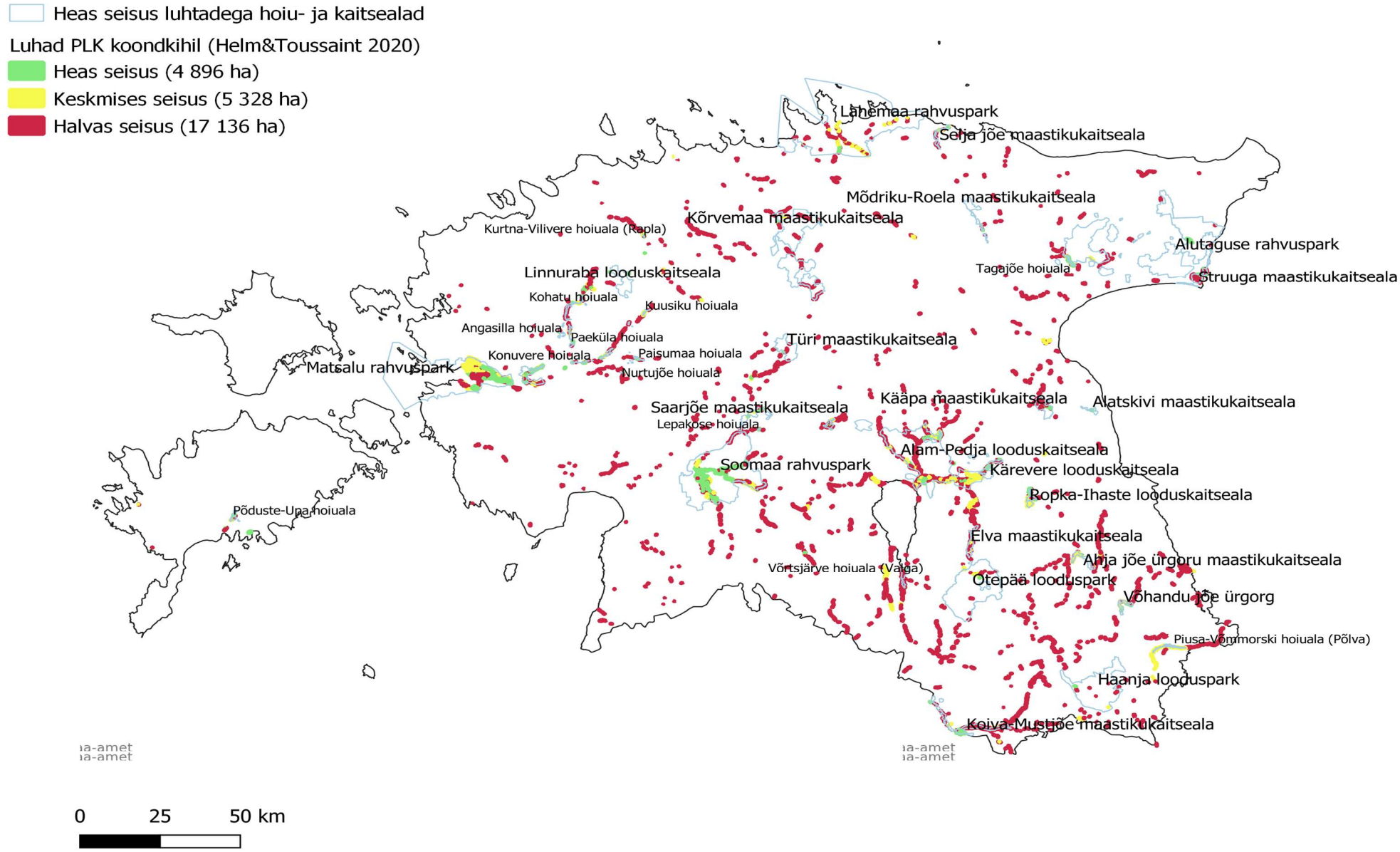

Figure 3. An overview of the location of protection and conservation areas in good condition and floodplain meadows in the different conditions in

Estonia.

Risk factors

As a rule, in Estonia (unlike in Western Europe), the restored floodplain grassland areas were rather extensively managed before the cessation of management, the local flora species fund is in a fairly good condition and the creation of open mowing conditions is usually sufficient to restore species richness (Sammul et al., 2000). The water regime in Estonian floodplain meadows has also been changed relatively less than in Western Europe, and it is often close to nature (for example, Kasari's once extensive dredging works or the dense network of ditches in the Kärevere lka floodplain meadow). **The biggest threat factor is the cessation of maintenance** (see also Holm et al., 2019) and, in connection with this, the growth of shrubs and the decline of species richness and the **area of meadows** (Sammul et al., 2000). In the case of more heavily overgrown small-scale floodplain meadows, the fragmentation of communities may also be important - if the species characteristic of the meadow has disappeared, then in the absence of connected areas, the spread of meadow plants from outside the area cannot be expected. Fragmentation is also a risk factor for more mobile groups of organisms - for example, the population of the Estonian great snipe is strongly affected by the fragmentation of suitable habitats.

Floodplain meadows that have fallen out of use may grow into reedbeds; often, Filipendula ulmaria, Carex cespitosa, Carex disticha begin to dominate. In the later phase, willow shrubs usually form on floodplain meadows, often composed of Salix cinerea, Salix pentandra, and/or Salix triandra (Wagner et al., 2003; Sammul & Jürgens, 2004). See Figures 4 and 5.

Inappropriate maintenance, and mulching (including *chopping* or *shredding* - mowing with a wasteland mower without removing the hay), which has been used more in the past, has a negative effect on both floodplain meadow birds and vegetation. Leaving old grass behind due to both inappropriate and completely lacking maintenance reduces species richness in the vegetation, worsening lighting conditions and preventing seed germination (Neuenkamp et al., 2013). In the case of short-beaked Charadriiformes (but also of Gallinago media with a relatively long beak), in addition to the old grass layer emerging on mulching, higher mowing heights can also hinder the acquisition of food (Lotman, 2005). The old grass residue created on shredding (or mowing) and which is not removed is also a direct source of organic pollution (Pork, 1984) and thus affects the aquatic life associated with floodplain meadows. Lack of oxygen in oxbow lakes and shallow water due to the accumulation and decomposition of organic matter primarily affects fish at a young age and during spawning.

In the example of semi-natural communities in Latvia (Rūsiņa, 2017), late mowing (which has been taking place continuously since the second half of July) has also been identified as an important risk factor, which has led to the rapid spread of a number of expansive species (in particular nitrogen-tolerant nettle, Anthriscus sylvestris, Filipendula ulmaria, Aegopodium podagraria, but also high-growing grasses such as Phalaris arundinacea and Elymus repens), which in turn reduces the species richness of the meadows. The presence of patches with tall species in a large area may, in turn, significantly reduce the suitability of floodplain meadows as habitats and mating display sites of Charadriiformes, including Gallinago media (Sviridova et al., 2018). The issue of expansive species is also addressed in the maintenance chapter. Areas with late mowing (from 1 August) are also unsuitable for feeding male Gallinago media (Korniluk et al., In press).

As a result of overgrowth, first, the Vanellus disappears from the floodplain meadows; later, as the bushes grow taller, for example, Motacilla flava, Anthus pratensis, Numenius arquata and crex disappear. It is gallinago that stays the longest in the strongly overgrown areas. In the intermediate

stage of overgrowth, for example, Acrocephalus schoenobaenus and Emberiza schoeniclus come to nest on the floodplain meadows. Carpodacus erythrinus, Turdus Iliacus, Phylloscopus trochilus, Sylvia communis, Sylvia nisoria, Sylvia borin, Cuculus canorus, and others take up nesting in the rather high and dense shrub layer. As the tree layer begins to form, bird species characteristic of forests will appear (Renno, 1985).

Alien species related to floodplain meadows

Floodplain meadows and riverbanks can be distribution corridors for alien species of Heracleum, and Impatiens glandulifera can be one of the invasive alien species (identified in the 800 m long section along the Keila River according to the data of the management plan) that could spread on unmaintained and overgrown floodplain meadows.

Figure 4. Floodplain meadow overgrown with willow shrubs by the Kõpu River. In the herbaceous vegetation, large sedge sods (Carex elata and Carex appropinquata) and Jacobaea paludosa, whose abundant, tall, flowering, or fruiting specimens are a sign of inadequate maintenance.

Figure 5. Degrading small size floodplain meadow by Kõpu River - onslaught of trees from the edge, the grass layer has signs of neglect and overgrowth: Filipendula ulmaria and Cirsium oleraceum.

IV Values and biota of floodplain meadows, their protection

Landscape and typological diversity

Floodplain meadows are valuable as both meadows and wetlands - on the one hand, they belong to semi-natural communities; on the other hand, they belong to (temporary) wetlands. Many European floodplain meadow communities have lost their wetland functions due to drainage and ditching, especially in the 20th century. Many rivers have been dredged, straightened, and channeled into canals, and the natural water regime has been changed by dams and dykes. This has been done both to facilitate shipping and to use floodplain meadows as agricultural land or for direct drainage. Many Estonian floodplain meadows have generally remained relatively intact compared to Western and Southern Europe; especially the floodplain meadows of Suur-Emajõgi River, together with its numerous oxbow lakes, can be considered a good example of a functioning wetland. The author of the plan has seen a very large-scale restoration project on the Morava River on the Austrian-Slovak border, where a straight river canal surrounded by concrete banks (built for navigation) was partially filled, and old natural river bends or meanders were opened with highly voluminous excavation work. As relatively more floodplain meadows with natural meanders and oxbow lakes have survived in Estonia than in Western Europe, no extensive restoration projects have been undertaken here. However, this has been done to a lesser extent (the low dam of Laeva canal and opening of the meanders of Koosa river; bridge regulator of the Kloostri and Rõude rivers).

Due to the varying (micro) topography, the floodplain meadows have varied humidity and flooding conditions, and this landscape diversity is directly reflected in the typological diversity of the vegetation in the floodplain meadow. In the floodplain meadow type group, according to the currently dominant classification, there are two subtypes, similar to all other type groups; however, a total of 26 most important plant communities have been identified within them (8 plant communities in the type group of alvar meadows, 6 plant communities in the type group of boreal heath meadows, 5 plant communities in the type group of boreal meadows, 13 plant communities in the type group of boreo-nemoral meadows, 22 plant communities in the type group of coastal meadows, 15 plant communities in the type group of paludified meadows; Paal 1997).

Both landscape and typological diversity make floodplain meadows an extremely diverse complex of places of growth and habitats.

Habitat and protected species

Vascular plants. A total of more than 350 species of vascular plants have been found in floodplain meadows (Pärtel et al., 2007), including at least the following species under nature conservation that are related to floodplain meadows or to a wider floodplain meadow complex (Table 3):

Table 3. Protected plant species associated with floodplain meadows and adjacent areas. The species that are occasionally abundant in the floodplain meadows are in bold type

Scientific name	Estonian name	Protection category	Notes
Ligularia sibirica		I	Grows in an overgrowing border area of floodplain meadows and fens
Swertia perennis		I	Smaller floodplain meadows with calcareous groundwater
Angelica palustris		II	In addition to coastal meadows, also in calcareous paludified and floodplain meadows around Tartu
Berula erecta		II	Widespread on the banks of streams, in coastal waters
Dactylorhiza russowii		II	On calcareous, fen type meadows
Gentiana pneumonanthe		II	At the edges of large lake floodplains (Lake Peipsi)
Saxifraga hirculus		II	On calcareous, fen type meadows
Trisetum sibiricum		II	In mixotrophic bog areas with mobile groundwater
Dactylorhiza baltica		III	
Dactylorhiza fuchsii		III	More prevalent in the edge areas
Dactylorhiza incarnata		III	May appear in large collections in some years, completely absent in others (typical of orchids)
Dactylorhiza maculata		III	
Gladiolus imbricatus		**III**	**Coastal meadows, floodplain meadows, dry and fresh grasslands, often in large populations**
Epipactis helleborine		III	Rather on higher relief parts with few trees
Epipactis palustris		III	In lower places with not very lush vegetation
Euonymus europaea		III	Mainly on the banks of rivers in southern Estonia
Iris sibirica		**III**	**Also, in overgrown areas in small conglomerations, on open areas often in large populations.**
Thalictrum lucidum		**III**	**Often only as an individual specimen**
Ulmus laevis		III	Tree species of floodplain forests

Viola uliginosa	III	Upon transition of a floodplain meadow into a fen or a minerotrophic mobile water swamp forest

Among the species with limited distribution and high dependence on floodplain meadows, Sanguisorba officinalis, e.g., in Matsalu floodplain meadows, as well as Galium uliginosum, Polemonium caeruleum, especially in southern Estonia floodplain meadows, Symphum officinale, rather common on floodplain meadows, can be pointed out.

Birds of floodplain meadows About 20-22, maximum of 30 bird species are typical of floodplain meadows (Kuresoo, 2004, oral information by E. Mägi 2011):

Characteristic birds are warblers (more specifically waders): *Vanellus vanellus*, *Gallinago gallinago*, Gallinago *media* (protection category II, bioindicator of floodplain meadows), *Numenius arquata* (III), *Tringa totanus* (III); gruifomes: *Crex crex* (III), *Porzana porzana* (III).

A characteristic but declining species is *Limosa limosa* (II), Philomachus pugnax (I) has been identified in recent years in the Kasari floodplain meadow only as lone nesters, and the *Calidris alpina schinzii* (5) has only been historically associated with the floodplain meadow.

Typical waterfowl are *Anas spp.,* up to 5 species); *Chlidonias niger* (III); *Hydrocoloeus minutus* (II).

The floodplain meadow is used as a feeding ground by all the circuses: *Circus aeruginosus*, *C. pygargus*, *C. cyaneus* (all III), *Ciconia ciconia* (III), *C. nigra* (I), *Aquila clanga* (I), *A. pomarina* (I), *Haliaeetus albicilla* (I) and the non-nesting and molting *Grus grus* (III).

During the migration, the floodplain meadows are very important stopping and feeding areas not only for swans and geese but also for a large number of waders - especially for Vanellus vanellus, Calidris pugnax, Tringa glareola, and other Tringas, Limosas and Gallinago gallinagos. Protected migrants include *Cygnus columbianus, C. cygnus,* and *Mergellus albellus* (all II)

Fish. There are about 40 fish species associated with oxbow lakes and floodplain meadows, of which the protected species are *Misgurnus fossilis* (III), *Cobitis taenia* (III), *Cottus gobio* (III), and *Aspius aspius* (II), the latter two being associated only with oxbow lakes. Oxbow lakes and floodplain meadows are important spawning grounds for fish. Therefore, from the point of view of fish stocks, it is necessary for meadows connected to oxbow lakes to be free of reeds and bushes. Oxbow lakes must also be connected to the river's headwaters to allow fish to migrate from the river to spawning grounds and back after spawning, as well as from oxbow rivers to the river in the event of a lack of oxygen, especially in winter and mid-summer. It is important for many fish species that rivers do not have obstacles to migration (dams). Rivers dug into the canal are not suitable habitats or spawning grounds for most fish species.

Invertebrates. A large part of the floodplain meadow insects are the imagos of aquatic species: Odonata, Ephemeroptera, Trichoptera, some Diptera, Heteroptera, and Coleoptera. The larvae of these invertebrates (larva of Odonata and Phryganea or the larva of Trichoptera that live in the water - in the grooves, in oxbow lakes - are food for waders. For invertebrates, floodplain meadow water bodies separated from the main riverbed by the river where the predation pressure of fish is lower are very important; it is also important that the banks of such isolated oxbow lakes do not end up overgrown.

The protected odonata species are *Aechna viridis* (III) and *Leucorrhinia pectoralis* (III); the protected butterflies are *Parnassius mnemosyne* (II), *Lopinga achine* (III), and *Euphydryas aurinia* (III).

Habitat and feeding preferences of the *Parnassius mnemosyne* have been studied in the floodplain meadows of the Ahja River (*Meier* et al., 2005), and it has been found that this butterfly species depends on alder-lined shore strips where the caterpillar food plant Corydalis solida grows; the floodplain meadow corridor is also used by adult species for migration and alder strips are used as refuges.

Osmoderma barnabita (II), who prefers old oaks in light-rich floodplain meadows, has been found in the wooded floodplain meadows of Koiva-Mustjõgi (Süda, 2018).

Ecosystem services

Floodplain meadows provide at least the following ecosystem services:

(a) flood management- rivers that are not dredged, straightened, or dammed flow in a natural bed serve as a hydrological buffer in the event of flooding and alleviate water level fluctuations in downstream areas;

b) regulation of matter and energy cycles - nutrients (N, P) entrained in flood waters are deposited in the floodplain meadow; thus, floodplain soils become rich in nutrients, and flow water becomes depleted of nutrients or becomes clean. Floodplain meadow vegetation can significantly affect sedimentation processes, and the most effective cleaning takes place if there is also a meadow vegetation cover at least in the bedside zone; floodplain meadows also play a role in carbon sequestration (fen peat formation) and renewable energy resources (use of hay and shrub as biofuel). Both minerals and carbon are removed from the floodplain meadow ecosystem in the composition of biomass - the mown grass is either removed or eaten by animals; therefore, the role of maintenance of floodplain meadows must also be seen in water treatment. The dense meadow turf created during maintenance also protects the soils from water erosion, which in turn prevents nutrients from entering the river.

(c) bioproductive function - the most important in terms of its history; the hay of floodplain meadows has been used as animal feed for centuries; alternative uses in bioenergy today.

(d) habitat for species of flora and fauna - feeding grounds for migratory birds and for birds living in and around the floodplain meadow, nesting sites for birds hatching in the floodplain meadows; breeding and feeding grounds for various aquatic and terrestrial invertebrates and vertebrates; important spawning grounds for fish.

(e) social functions - cultural-historical: material (barns, tools, etc.) and mental (local heritage, traditional practices, songs, etc.) heritage, aesthetic-recreational (walking, horseback riding and water trips, etc.) and scientific/educational (from bird watching and study trips all the way to scientific research).

The floodplain meadow is also a diverse habitat because it is located in the contact area of three biotopes - forest, meadow, and water body - and is used as a habitat and feeding ground not only for meadow species but also for many aquatic (beaver, otter) or forest species (elk, roe deer).

Ensuring the favorable condition of floodplain meadows based on conservation values

From a landscape and hydrological point of view, it is important that the floodplain meadow is not drained or leveled - that it has a natural water regime and varied terrain.

Specific management objectives may be set out in the management plans and species protection action plans for the following species: Clanga clanga and Clanga pomarina, Ligularia sibiricar, Gallinago media, Crepis mollis, Grus grus, Ciconia nigra, bat species, Pandion haliaetus, Anser erythropus, Calidris pugnax, Osmoderma eremita, Calidris alpina schinzii, Leuciscus aspius.

In floodplain meadows where the requirements of different species for conservation purposes are either contradictory or must be applied with the desired maintenance practices, case-by-case management plans should be established with monitoring of changes in long-term biota and other status indicators. Such case-by-case plans shall give priority to the conservation needs of more endangered and more strictly protected species (e.g., Gallinago media).

V Restoration of floodplain meadows

Selection criteria for the site to be restored

When restoring floodplain meadows, it is important to reasonably select the area to be restored. When doing it, there are several aspects to be considered.

Firstly, the cohesiveness of the meadow area with other nearby meadows is important - if the restored meadow is a continuation of nearby meadows or a link between different meadows, it can be hoped that both plant and animal species can use the restored meadow as a habitat or distribution corridor. It is also obvious that, if possible, better-preserved areas which are less overgrown-afforested or sodded and where there is meadow vegetation and grass turf characteristic of meadows should be preferred for restoration. Restoration of the site in a better condition is not only more economically sensible and reasonable from the point of view of the restoration effort, but the biota, especially the flora, which is more characteristic of open communities, has also been preserved in an area that is in a better condition. Restoration of an already forested area is many times more expensive due to the lack of grass turf and meadow species, the restoration takes a longer time, and the floodplain forest that is developing on the floodplain meadow is a value in itself. Restoration of such an area is primarily a matter of expanding an existing habitat or connecting otherwise isolated habitats.

From the point of view of both access to and further maintenance of the restored area, the question is whether and in what condition there is access to the restored floodplain meadow. Access must be such as to enable access to the area not only by means of restoration equipment (tractor, for example, with a shredder or a chain shredder) but also by subsequent access to the area with haymaking equipment or with a cart for transportation of cattle. In addition to the collection of hay and removal thereof from the floodplain meadow, a storage or loading area is also very important: is there a place in the vicinity where the hay can be stored until its transportation to the point of consumption? If the hay is transported so far that it is expedient to use a car with a longer trailer instead of a tractor, the need for its maneuvering must also be taken into account.

It is also critical to consider at an early stage of restoration whether there is an application for the hay of the floodplain meadow, whether as animal feed or as an alternative option.

Open or with trees and shrubs?

The issue of trees and shrubs: in case of the presence of shrubs, ground-nesting birds, as well as birds feeding and performing mating displays on the ground, are more likely to fall prey to predators and birds of prey. At the same time, some shrubs are sometimes suitable for Gallinago media and other bird species that nest in the floodplain meadow or on the edge of the floodplain meadow (e.g., ducks, crex.

As a general rule, the total shrub cover of the floodplain meadow should not exceed 30%, and a relatively large (up to a couple of dozens of hectares) open area may be important in the nesting and play areas of the snipe - this reduces the likelihood of predators and nest predators (e.g., foxes, crows) approaching unnoticed.

Some presence of trees and shrubs in the area may be due to both aesthetic considerations and the provision of more heterogeneous lighting and humidity conditions. It is also important for livestock to have shelter in the form of trees and shrubs. Shrubs should definitely not interfere with mowing.

Removal of woody vegetation from the area

The choice of restoration equipment is important when removing trees and shrubs. In the case of shrubs up to 1.5 m (in some cases up to 3 m in the case of fast-growing willows), shredding the shrub

with a chopper or chain shredder may be possible - in this way, the chopped shreds of the shrubs are left behind, but the experience of Alam-Pedja shows that there was no massive accumulation of wood chips and no subsequent inhibition of plant growth. However, if you want to use wood as wood chips, you must consider whether it is possible to remove/gather shrubs removed by guillotine or otherwise and not too damaging to the floodplain meadow. There is also an example of the restoration of the meadow between the Alam-Pedja River in Elva and Ilmatsalu River, where larger shrubs were removed from the area in the cold of the winter using a bulldozer and a plow. As the woodchip removal route would have been very long (up to 5 km along the floodplain meadow) and the so-called bottlenecks formed between the oxbow lake and the forest edge could have become jellied during such transport, the bush was burned on site.

Figure 6. Removal of the bush and sods in Alam-Pedja by plowing on the flooded meadow of Emajõgi River.

After removing trees and shrubs with a thicker stem (with a guillotine or a harvester), it is necessary to mill the remaining stumps. The surface treated with the milling machine allows the water and decomposing organisms to have better access to the stump, and further decomposition of the stump is easier. Especially when mowing, it is important for the stumps to be milled as low as possible so as not to damage the haymaking equipment. Practical experience shows that even relatively low-milled stumps can rise above the ground again in the first few years - therefore, it may be necessary to mill the stumps again with a stump milling machine after a few years of shredding of the area, and with the mowing technique it may even not be possible to access the area with stumps with meadow equipment before 3-4 years after restoration. In the case of an area densely filled with stumps, there is also a risk that livestock will injure their feet on sharp stumps. In the case of thinner bushes and young shrubs, a chain shredder helps, as it makes the surface of the stump particularly split into the so-called brush - such a stump is much less likely to injure the legs of animals.

Figure 7. The stumps must be milled as low as possible during restoration to prevent damage to the mowing equipment at a later date. A stump on the restored flooded meadow of Pikknurme River.

Especially in the few years following the removal of woody plants, but also later, fast-growing tree and shrub species (aspen, gray alder, ash, downy birch, willows, alder buckthorn; Sammul & Jürgens, 2004) can become a problem. Grazing with a heavier load can help to get rid of them, as cattle is a relatively effective shrub repellent. In this case, the cattle should be restricted to the shrub area using, e.g., a temporary fence. However, cattle are not always prone to eating shrubs, and there are reports (Ilona Lepik, oral information) that beef cattle are not useful in controlling gray alder. Crushing the bushes with a shredder or a chain shredder could also help, preferably in the second half of the summer (early to mid-August), before the strongest growth slows down and the storage of reserves in the underground parts of the plant begins. As the dense meadow vegetation cover and especially the grass turf is also an obstacle to the growth of shrubs, you can also try techniques that encourage the growth of meadow species - mowing the area several times during the summer and why not spreading hay removed from adjacent floodplain meadow area in good condition to the shrub area. In this case, the hay is removed when the seeds are ready, and it is recommended to spread the hay in a layer of 5-15 cm either across the entire area or in strips (Hölzel & Otte, 2003; Donath et al., 2007; Burmeier et al., 2011); according to one study, only a few centimeters of the original thick layer had remained by the next spring (Donath et al., 2007). Spreading of hay in such a way can also be helped by previous disturbance of the restored area, e.g., with a cultivator - grassland species settle in the area faster (although in the long run, such a single disturbance did not have an effect -- after 13-14

years, similar conditions prevailed in terms of vegetation both in areas treated with a cultivator and in the untreated areas; Harvolk-Schöning et al., 2020).

Figure 8. Alder buckthorn is one of those shrubs that need to be removed from the floodplain meadow, especially right after restoration but also later. Floodplain meadow of Laeva River in Alam-Pedja.

Figure 9. After removing the shrubs, the young growths must be vigorously removed. Pikknurme floodplain meadow.

Restoration of water regime; the opening of oxbow lake estuaries.

Just as the ditching of floodplain meadows and the dredging of rivers have been practiced on the floodplain meadows for decades, so the confluence of the river's headwaters and oxbow lakes - the oxbow lake estuaries - has been kept open. Ristkok (1969) mentions proposals to open the estuaries of the oxbow lakes of the Emajõgi in connection with articles published as early as the 1950s but states that it was not effective as manual work (some local fishermen had manually kept the old estuaries open). According to Ristkok's proposals from 1957, the opening of 28 oxbow lake estuaries in the upper reaches of the Suur-Emajõgi River with the dredger “Peipsi-2” which dug an 8 m wide and 2 m deep canal to connect the river and the oxbow lake (a total of about 50,000 cubic meters of sediment was moved) was carried out between 1959 and 1960. An interesting observation is that already between 1960 and 1964, some previously cleaned oxbow lake estuaries or the canals connecting them were covered with new sediments to such an extent that instead of the previous 2 m, there were only 1 m, 0.8 m, or even only 0.2 m of depth left (i.e., in four years, up to 1.8 m sediments were collected in the oxbow river estuary, Ristkok, 1969).

Oxbow lakes not connected to the main river bed are not suitable for fish but are very important for floodplain meadow invertebrates and birds feeding on them, so when restoring the connection, one should make sure that oxbow lakes and other floodplain meadow water bodies are separated from the main bed remain.

Despite the fact that Estonian rivers have been changed relatively little by means of hydrology, considerable work has been undertaken over the last decade to restore the water regime of floodplain meadows, and their rivers closer to nature - be it Kloostri and Rõude bridge dam regulators in Matsalu or the opening of the Alam-Pedja oxbow lake estuaries and the partial excavation of the Laeva oxbow lake and the placement of the bottom dam on the Laeva canal.

The water regime that has been restored to be more similar to the natural one can provide more suitable conditions for the floodplain meadow, both in terms of the vegetation and the birds characteristic of the floodplain meadow (feeding area of the Charadriiformes), but it is especially important for the fish connected to oxbow lakes - without opening the estuaries of oxbow lakes, he fish there, and their juveniles can become deficient in oxygen, especially when the water level drops. NGO Wildlife Estonia has the best experience of such activities obtained from several Life projects.

When opening the estuaries of oxbow lakes, a relatively large amount of sediment is placed in the meadow, which raises the question of how the activities could affect the floodplain meadow vegetation and the possible spread of unwanted plant species to the floodplain meadow. A study carried out by the author of this plan and Ott Luuk in the Alam-Pedja sediment areas (unpublished data) found that although the proportion of ruderals in the sediment areas increased sharply in the first year after spreading the sediment, opportunistic species disappeared from the community within the next few years. The vegetation of such areas became quite similar to the nearby floodplain meadows (although somewhat richer in species for at least the first few years), and in the development of vegetation, the decisive factor was the way in which human activities changed the competitive relationship - in areas where there was no subsequent mowing, a relatively dense and several meters high willow shrub developed within three to four years.

Restoration of ditches

The issue of ditches related to floodplain meadows is very multifaceted and often controversial. There have certainly been low, manually dug ditches in the floodplain meadows even before mowing with tractors - the reason being the desire to drain excess water so that mowing can take place in more favorable conditions and perhaps start earlier. However, the effect of such ditches has probably been very local, and the increase of the effect, i.e., manual dredging and compaction of the ditch network, has been hindered by the annual addition of sediments. Later, mainly during the Soviet period, the water regime of the floodplain meadows was much more extensively designed both by the construction of larger ditches on the floodplain meadows and by the dredging and straightening of rivers. However, the earliest large-scale works of that kind date back to the prewar period or even before that - the flowing water of Kasari delta has been strongly designed by digging straight canals already in 1927-1938 (Meriste & Kirsimäe, 2015) and Pork (1964) mentions the end of the 19th century as the beginning of more extensive land reclamation work on the floodplain meadows of the Põltsamaa and Pedja rivers; the dredging of Põltsamaa River began in 1930 and was completed during the Soviet period with the construction of a network of main ditches (Pork, 1964).

Despite the above (and similar activities elsewhere on Estonian rivers and floodplain meadows), Estonian floodplain meadows have often quite a natural water regime compared to the rest of Europe, and this is one of the great values of our floodplain meadows. Therefore, special care must be taken in the restoration or construction of ditches or ditch networks - the general principle could be that in addition to the authorities and maintainers, floodplain meadow biota experts will be involved in the planning of each such works and, more importantly, in subsequent monitoring. It should be clarified what the impact of the activity is on maintenance (whether there will be a change in the quality and yield of hay, access and transportation options, whether, eventually, dredging will bring economic benefits); on hydrology/flood characteristics (whether the time of flooding is shortened, whether the

amount and nature of sediments change); on floodplain meadow biota - whether the conditions for fish (use of spawning grounds), birds (places of feeding and mating display of Charadriiformes; location of food objects in the soil), whether the flora and vegetation cover change. Such monitoring requires *a minimum of* 5 years and a period of 15 years or more to obtain reliable results.

When planning the restoration of ditches, in addition to the above-mentioned monitoring, the precautionary principle should also be taken into account - ditches should be flat and low rather than deep and steep. The ditches with shallow banks could be suitable for Charadriiformes feeding on floodplain meadows - soft muddy places where earthworms can be found even during the drier period - and amphibians. Also, a flat ditch without a higher embankment does not create a locally wetter place on the floodplain meadow - at some point, the ditch embankment is an obstacle to the water moving on the floodplain meadow, and the author has seen such soft areas requiring maintenance caused by deep ditches and high embankments, e.g., in Jürikülа floodplain meadow in Alam-Pedja and near Palupõhja. If possible, such works should be combined with the cleaning of oxbow lake estuaries (carried out in Alam-Pedja, planned, for example, on Koiva-Mustjõgi River), and perhaps water should be discharged into the oxbow lake instead of into the river. Large cross surface ditching and the associated drainage are contraindicated in areas connected to Gallinago media-Alam-Pedja NPR FAQ highlights: “When constructing accesses to floodplain meadows, ditching shall be limited to the area between the culvert and the river; strict preference must be given to options that do not involve clearing the entire length of old ditches and draining water from floodplain meadow areas." The draft action plan for the protection of Gallinago media explicitly mentions as a necessary measure for the species: "a ban on the construction of new ditches and the maintenance of existing land improvement systems, except for headwaters, in protected areas in the habitats of Gallinago media."

Figure 10. Overgrowing drainage ditch in Kärevere floodplain meadow, by Emajõgi river. Scrub has been removed from the shore of the ditch, the shores are flat, and today the ditch is not very deep, but it still has a local draining effect.

Closing of ditches

Most of the floodplain meadows contain traces of the Soviet-era network of ditches - both ditches and (now dilapidated) culverts and other places of crossing or passage. Most of their effects are fading - the ditches are full of sediments, in some cases mainly identifiable only due to willow bushes growing on the shores. The former culverts have also fallen apart, and, in short, such a ditch network may not facilitate the maintenance of the meadow but rather complicate it - the shrub strips on the shore break the integrity of the floodplain meadow, and the narrow passages inside the shrub strips between the floodplain meadow parts have often become impenetrable swamps (or are becoming them during the maintenance of the meadow, removal of hay).

In the case of an old and non-functioning ditch network, one solution is to eliminate it altogether - to remove willow bushes from the shores and close the ditches. Shrubs taller than two meters should definitely be removed (or burned) after cutting, and the lower ones can be chopped. It is possible to use the ditch embankment to close the ditch. The resulting area should be planned to be as flat and

smooth as possible so that it can be mowed. Mowing is necessary both to prevent the re-emergence of shrubs and to encourage the formation of a meadow turf.

Other floodplain meadow water bodies

Shallow dells, ponds, or grooves that fill with water during high water in summer are usually filled with stagnant water or, in cases of drought, have a soft, muddy bottom, are very important as amphibian spawning grounds and feeding grounds for waders. Such places are difficult to mow and tend to develop higher vegetation. Cattle is the best to help against the accumulation of organic matter there, and the pond areas are better preserved in grazed areas. During the restoration phase, further maintenance of such sites needs to be considered - in addition to the oxbow lake banks; these areas may need regular additional activities that do not fit into normal maintenance.

Accesses and crossings

The construction of accesses to the floodplain meadow and the crossings of rivers, ditches, or oxbow lakes must take into account the relatively difficult equipment used to maintain the floodplain meadows. In the case of grazed areas, it is also necessary to ensure access by tractor; as a rule, the cattle are transported to the floodplain meadows from further away by cattle transportation carts. At present, the construction of accesses and crossings has taken place primarily on state lands, and roads and culverts have been built with RMK's funds. Fords can be a problem for the built infrastructure - strong erosion also carries away larger cobblestones, not to mention gravel and crushed stone. Fords built with concrete slabs are significantly more resistant to erosion. Fords are also not useful for the winter transportation of the grass of floodplain meadows - even if the rest of the floodplain meadow surface is frozen, the ice above the fords is thinned due to the flowing water, and the place becomes unpassable. The advantage of building a ford instead of a culvert is that it allows it to go through /pass very large amounts of water and does not clog. The clogging of the culvert, or simply very large amounts of spring water, involves vigorous erosion, which can carry material away from beside the culvert so that the culvert can no longer be used. The ecological justification of the ford is related to the fish - culverts can be an obstacle for fish on their way to the floodplain meadow or even to forest ditches.

The access roads to floodplain meadows could reach a somewhat into the floodplain meadow so that they could be approached by several alternative paths. One possibility is to design the end of the exit in the form of a semicircle or, for example, a letter T.

Figure 11. Gravel reinforced access to the floodplain meadow of Mustjõgi River.

Figure 12. T-shaped exit to Koosa floodplain meadow in Alam-Pedja nature reserve. The exit must allow the road to be approached by a hay load along several alternative paths in order to avoid the formation of a swamp immediately at the end of the exit. Another option is to design the exit in the form of a semicircle.

In addition to access by land, at least in the case of navigable rivers (e.g., the Suur-Emajõgi River), the transport of floodplain meadow hay, mowing equipment, and livestock by water could also be considered. This helps to avoid the construction of massive infrastructure in the floodplain meadow (mooring sites with strong banks are naturally present on the point bar of the river) and also evens out the transportation load - on land, access to a floodplain meadow of hundreds of hectares is often only possible from one place, whereas in case of a waterway, it is possible to use several mooring sites.

Removal of sods

In the case of heavily sodded areas, remove/level the sods before mowing. One way to do this is by chopping with a waste land mower (Mesipuu, 2008), but the plowing of sodded areas in winter when the ground is frozen (done in both Alam-Pedja and Koiva-Mustjõgi; Mesipuu, 2014) has also given good results. Neither method creates oversized non-vegetated spots in the floodplain meadow area; the advantage of plowing is a significantly lower price compared to milling. Based on the research of the floodplain meadow soil seed bank carried out in Alam-Pedja (Metsoja et al., 2014), it is also recommended to spread the plowed sods on the areas cleared of bushes during the same restoration - the soil seed bank of areas that have been out of use for less time may contain floodplain meadow species that have been lost in an area that has been abandoned for a long time. Just as the mosaicity of the habitat must be preserved when removing shrubs when removing sods, it is necessary to take into account that a varied microrelief is characteristic of the floodplain meadow, and some occurrence of sods is natural. In very shallow floodplain fen meadows, sods can be micro refuges for certain plant species and thus increase botanical species richness (Kotowski et al., 2013), and completely sod-free, over-maintained floodplain meadows are not suitable for the great snipe (draft great snipe protection action plan).

Other issues related to restoration

Habitats of protected species (patches of Gladiolus imbricatus, Iris Sibiricas) may need manual work as well as protection against overgrazing after restoration.

For fish associated with oxbow lakes, it is very important that the riverside reedbed is removed. As cattle are very happy to eat young reed, it may be sufficient to crush the reed during restoration and then graze the area relatively early and with greater intensity in the following years. Sedge and reed spots in the overgrown ponds of the oxbow lakes, which are constantly too wet and difficult to access with equipment, can be another problem. Such areas are also significantly more abundant in sedges than riverbanks (where there is an abundance of delicious reed canary grass and reeds for the cattle), which makes them less attractive to the cattle. In such areas, it may be necessary to confine the cattle there (e.g., with temporary fences) from time to time as early as possible (even during floods) so that the cattle would trample on and eat the young sedge (cattle can eat the young sedge even if it under water (Ilona Lepik's oral information 16.07.2020)2020)). Especially during the restoration phase, but also later, the intensity of grazing plays an important role - the result is better with higher than usual intensity. The cattle must not starve, of course, and they must also have access to drier areas to rest. As many types of sedges have the adaptability to grow even in the event of flooding, the sedges are some of the first plants to bud in the spring, and the earliest possible introduction of the cattle into the area is very important in several respects. A young sedge is a better feed for the cattle, and in the absence of anything else, they eat it relatively well. From a practical point of view, the absence of other vegetation may mean that no special fences need to be built.

Figure 13. Overgrowing river edge on the floodplain meadow of Koosa River. Such a wall is impermeable to fish and should be removed. With large mowing equipment, this may not be possible (beaver holes), and such activities could be remunerated separately.

The effects of various agricultural techniques on restoration, such as harrowing, disc harrowing, etc., have not been studied in Estonia. A German study (Harvolk-Schöning et al., 2020) on the restoration of floodplain meadows in species-poor floodplain meadow areas subject to intensive agricultural use found that disturbance of the restored area with a cultivator somewhat accelerated the germination of the propagule in the area, but in the long run (13-14 years) cultivated and uncultivated areas did not differ from each other. As there are usually no problems with the distribution of the propagule of local meadow plants in the restored area in Estonia, such disturbance does not seem very promising. A disturbance that removes sods or scrubs could be more beneficial (see above).

The practical criterion for assessing whether a floodplain meadow has been restored is whether the floodplain meadow can be maintained with hay equipment - whether there is access not only to the shredder but also to the baler, hay cart, cattle cart; whether it is possible to transport the desired amount of hay or silage by existing (restored) transportation road without destroying the floodplain meadow and the road. And, of course, whether routine maintenance can be performed with hay equipment/livestock. For example, a floodplain meadow area may be covered with willow of more than 2 m high after a maintenance break of a year or two and cannot be mowed with conventional hay equipment.

Figure 14. A floodplain meadow in poor condition near Pikknurme river. Jacobaea paludosa has joined the massive sedge fauna, which is an indication of overgrowth, and willows and birches have appeared in the bush and tree layer.

VI Maintenance of floodplain meadows

Purpose of maintenance - expected results

Mowing and grazing certainly have somewhat different effects on floodplain meadows, but there are still a number of similarities between the two in terms of the expected outcome of maintenance.

Landscape and vegetation cover structure. Floodplain meadows are, by nature, open meadow communities (wooded floodplain meadows being semi-open), so as a result of maintenance, the floodplain meadow must be either empty or with few trees and shrubs (the total coverage of trees and shrubs in the floodplain meadow complex does not exceed 30%). The species richness and variability of vegetation in the floodplain meadow are mainly related to the differences in humidity conditions due to the floodplain profile; the mosaicity created by the presence of shrubs under lighting conditions may not significantly increase the species richness of the vegetation; however, there may be species in the shrub-rich areas that are practically absent from the open floodplain meadow, e.g., Jacobaea paludosa, one of the indicators of overgrowing. However, in very rare exceptional cases, such rarities as the Ligularia, which tends not to grow in the completely open area, may be found in the overgrowing transition area of the floodplain meadow and the fen. As a rule, such individual cases are not an argument for leaving shrubs or trees in the floodplain meadow.

Figure 15. Species-rich floodplain meadow of Pikknurme River. Filipendula ulmaria on the foreground is low in growth and does not predominate. Even in September, it was possible to identify more than 20 species of vascular plants per square meter.

The good condition of the meadow vegetation cover is certainly shown by the fact that there are no large sedge sods in the area (from 20 cm) - in such areas, the meadow turf between the sods is incomplete, and species richness also suffers. It is also important that there is no heavy layer of old grass in the area - this prevents seed germination and again impoverishes the plant community. In

addition to preventing the germination of seeds, the plant community is also impoverished because, due to the old grass layer, tall species and other species shading the others (e.g., Filipendula ulmaria), displacing lower-growing plants (including valuable fodder plants) are being given a competitive advantage. Neuenkamp et al. (2013) have found that in the floodplain meadows along the Pedja River, the old grass layer - and not so much the nutrients available to the plants - removed from the community by mowing was the main factor favoring the species richness of the plants. It is true that in the same work, it was found that a certain amount of old grass (about 250 g/m^2) had a positive effect on species richness; the authors associated it with a more favorable microclimate, especially with providing higher humidity and higher temperature for germinating seeds. A similar positive effect of the old grass layer (in this case, more specifically: abandoned shredded hay) has been found in the case of the Gladiolus imbricatus (Jõgar & Moora, 2008), for the large seeds of which a certain old grass layer can provide a stable microclimate. It must be emphasized that the old grass, especially of the quantities involved in shredding the floodplain meadow, is, in any case, a very negative factor for a very large number of species groups. The above individual positive examples apply to the amount of old grass that inevitably remains on the floodplain meadows even in managed areas, and from 300 g/m^2 onwards, the old grass layer has a strong negative effect on the species richness of vegetation (Neuenkamp et al., 2013). The effect of shredded and unremoved hay has the greatest negative effect on the general species richness of the floodplain meadow, as it is also transferred from the meadow to water bodies, where it also causes problems for fish and invertebrates.

In the case of the most prominent Charadriiformes associated with floodplain meadows, the Gallinago media, it has been found that birds prefer a relatively large open area but still not completely without bushes (Kuresoo & Luigujõe, 2003). A study of Gallinago media habitat preferences conducted in Russia (Sviridova et al., 2018) found that the number of Gallinago media was highest in areas with relatively many vegetation patches, where grass growth was as low as possible (up to 10 cm) during the mating display (early May to mid-June) and at the same time there was variability in the overlap of vegetation in the area (areas with thinner grass alternated with denser spots). Such grassland certainly contains more sparsely vegetated muddy spots, which are very important for the feeding of the Charadriiformes. The author of the plan has seen traces of activity and mating places of Gallinago media in Pikknurme floodplain meadow, where there is fairly species-rich and relatively low-growing vegetation (max. 40-50, sometimes 15-20 cm), where there were also wetter muddy pits, and on the other hand about 4 m high willow bushes. A recent study by Polish ornithologists (Korniluk et al., in press) suggests that male Gallinago media may prefer medium areas of the height gradient of the floodplain meadow (neither too wet nor too dry) where the height of vegetation is between 30 and 60 cm high, and there is a very significant percentage (up to 60% coverage) patches of uncovered, exposed soil.

From the point of view of fish spawning in floodplain meadows, in addition to opening the estuaries of oxbow lakes, it is important to keep the riparian areas of rivers and old rivers free of reeds and bushes.

Floodplain meadow status indicators

The landscape and water system of the floodplain meadow is in good condition if they are affected as little as possible by human activities - the river is in its natural flow bed, and there are floodplain water bodies both connected to the main bed and separate from it, including shallow wet dells. There is no or very little ditching, the terrain of the floodplain meadow is natural, and there are no dams and other artificial structures.

The floodplain meadow as a structure is generally characteristic of an open plant community, but there is also variability - sometimes groups of trees or shrubs, single trees; banks of oxbow lakes and rivers are free of shrubs and reeds.

A mowed floodplain meadow in good status is free of higher sods (over 10 cm) and free of old grass; the grass layer is diverse, in addition to large-sized sedges (Carex acutar and Carex elata) and grasses (reeds, Phalaris arundinacea), there are also lesser-sized ones (Carex nigra, Carex panicea) and various grasses (Agrostis capillaris, Festuca rubra, Alopecurus pratensis, Elymus repens, Elymus caninus, etc.) as well as herbs (Lathyrus pratensis, Galium palustre, Silene flos-cuculi, Veronica longifolia, etc.). Due to the zonal plant communities, small-scale species-rich vegetation may not be present in every area of the floodplain meadow - it is normal for the near-shore Phalaris arundinacea or large sedge community to contain only 2-6 different vascular plant species per square meter. However, looking at the floodplain meadow complex as a whole, there are areas where the species richness reaches more than 20 plant species per square meter; in the drier parts of the floodplain meadow near the meadows on mineral soil, there are also more than 30 vascular plant species per square meter. There are no large collections (by hectares, so that the mosaicity disappears and expansive species predominate) of expansive species such as Filipendula ulmaria, Calamagrostis canescens, reed, etc.; smaller collections may even be suitable for the biota of floodplain meadows, including Gallinago media. The value of Luha is increased by the presence of protected plant species (e.g., Gladiolus imbricatus, Iris sibirica).

As for birds, a well-maintained floodplain meadow in good status is characterized by the presence of well-maintained species related to the open floodplain meadow, especially the Charadriiformes (e.g., Gallinago media, Gallinago gallinago), as well as Anatidae (Anas clypeata and Anas acuta); less susceptible to deterioration of marshland are Gruiformes (Porzana porzana, Crex crex). An important indicator of the good condition of the meadow is the presence of mating display places suitable for the Gallinago media and, of course, the presence of the Gallinago media itself on the floodplain meadow.

Polish researchers studying Gallinago media habitat preferences (Korniluk et al., In press) have found that areas close to the mating display places with a grass height of 30-60 cm and there is at least 20%, but in some places also more than 60% of areas free of grass turf, exposed and soft, moist soil areas are suitable for male, feeding Gallinago media.

The floodplain meadows that are in good condition are characterized by the species-rich fish stock associated with them and the regular spawning of fish in the floodplain meadow. The survival of juvenile fish is high; the free movement of fish between the river, the oxbow lake, and the spawning grounds are detectable.

It is important for invertebrates to have a natural structural mosaicity in the floodplain meadow due to the varied terrain, vegetation, and landscape elements (e.g., ponds), as well as variations in maintenance conditions (shorter and higher vegetation, more open and more overgrown areas), unmowed patches. Shallow floodplain water bodies are very important.

The presence of old oaks exposed to the sun suitable for hermit beetles is important in wooded floodplain meadows.

In addition to shrubs (especially willows, but also alder buckthorn, sometimes Rhamnus cathartica), large sedge sods (Carex cespitosa and Carex elata, also Carex appropinquata in fen and peated parts), which can reach a height of 50 cm and higher, indicate longer non-maintenance. Grazing will inevitably lead to some sodding; in this case, however, the estimated extent of heavily sodded areas on the flooded meadow complex should not exceed 15-20%. In unmaintained areas with unremoved hay, Filipendula ulmaria (under which practically no other species grows), Cirsium oleraceum, Aegopodium, and Senecio paludosus are sometimes overwhelmingly present. Early cultivation can

be indicated by massive Phalaris arundinacea fields and more commonly cultivated grasses - Alopecurus pratensis, Elymus repens, and Dactylis.

In case of emergence of a higher grass layer upon inadequate maintenance, first the Vanellus vanellus and the Alauda arvensis, and then also the Limosa limosa disappear from the floodplain meadows. In a floodplain meadow in poor status, overgrown and covered in the reed bed, the number and diversity of the Passeriformes increase, and the Locustella naevia, the Saxicola rubetra, and the Carpodacus erythrinus are added as pioneer species that do not occur in open floodplain meadows.

Choice of the maintenance methods

Floodplain meadows have historically been primarily hayfields (Troska, 2004), both because they were located away from farms and therefore grazing was more difficult, and also because floodplain meadows were the most valued haymaking places due to their high yields. Mowing is also preferred to grazing because the cattle tend to break the soft grass in the moist soil of the floodplain meadows, and the ground becomes soddy (Pork, 1964; Kukk, 2004); the soil surface also thickens during grazing, and grasses especially valuable as fodder disappear (Pork 1964). On the other hand, mowing, especially with modern large and heavy, and high-performance machines, makes the microrelief of the meadow more even, and as a result, mowing, for example, shallow water bodies or narrow ponds may not remain open. In modern land use and conservation practices, it is inconceivable that floodplain meadows should only be used as hayfields - despite the various potential alternative uses for the hay from floodplain meadows, the most significant use thereof is still as animal feed, and due to the specifics of the protected areas, as a rule, no dry pastures in the volume equal to floodplain meadows can be found in the vicinity. Therefore, it can be said that when maintaining floodplain meadows according to nature conservation principles, it is most sensible to use both types of maintenance - both mowing and grazing. As a general trend, the maintenance model has also moved in this direction, and there is more and more grazing in the floodplain meadows compared to 10-15 years ago.

Ideally, for the purposes of maintenance, mowing and grazing should alternate within one area. It would be best if both the start of maintenance and the species of grazed animals could be varied from year to year, but in practice, this is rather difficult to do. As grazing can be started earlier due to the current regulations (start time chosen by the maintainer vs. 10 July in the case of mowing) as well as natural conditions (cattle can also cope in a floodplain meadow where the flood has not yet completely subsided), then the obvious choice seems to be to select for grazing, in particular, the floodplain meadows/parts of floodplain meadows that will be released from the floodwater at the earliest. Such floodplain meadows are also drier in summer and, therefore, less vulnerable due to the aforementioned trampling. Also, as a rule, there is a longer flood period on floodplain meadows with flatter floodplains, where the terrain varies little - such flat and gentler floodplain meadows are more suitable for mowing, and floodplain meadows with more variable terrain are more suitable for grazing.

Figure 16. Cattle like to eat the Phalaris arundinacea that grow on the banks of the river and effectively keep the river edges open. Floodplain meadow of Emajõgi River.

For many groups of organisms, the mosaicity of the maintenance of floodplain meadows is very important, which can be provided by alternating grazing and mowing, and in addition, leaving up to 30% of the floodplain meadows unmaintained in some years. In the case of the Gallinago media, it has been found (Korniluk et al., In press) that relatively intensively maintained areas where mowing twice took place during the summer (early June and later in August), followed by grazing, are the most suitable feeding areas. Female Gallinago medias, on the other hand, need much less intensively managed or even unmaintained areas for nesting, places where there are shrubs for shelter (ibid). Thus, the habitat demand of one species may require very differently maintained sites; more precisely, such sites should be located close enough to each other in a complete floodplain meadow complex - the mating display and feeding grounds of male Gallinago media are no more than 500-600 apart (Korniluk et al., In press; Draft Gallinago media Protection Action Plan), females may be more than 1 km away from mating display sites (Draft Gallinago media Protection Action Plan).

Maintenance instructions and peculiarities on grazing

Start time

In semi-natural communities, grazing has been started in April; depending on the area and year, April 1 and St. George's Day (April 23) are considered the start time of grazing (Troska, 2004). As the peak of the flood falls around mid-April, animals cannot usually be taken to floodplain meadows before May. Experience has shown that if the cattle have access to higher and already dry terrain areas in the floodplain meadow, they will also move between feeding areas through relatively deep water and will not have to wait for the floodplain meadow to be completely dried of water.

Selection of animal species and breed

The most suitable animal species in floodplain meadows are cattle, especially the lighter and less demanding breeds of beef cattle, such as Scottish mountain cattle and Galloway. In the case of

floodplain meadows with a stronger surface, it is also possible to graze with heavier breeds (Hereford, Aberdeen Angus, Limousine, etc.). Horses are certainly also suitable for floodplain meadows, and sheep are suitable for drier floodplain meadows. It must be borne in mind that floods can sometimes come unexpectedly and that one must be prepared to rescue animals from floodwaters.

Infrastructure and logistics related to animals

If it is not just a matter of driving some cattle to a floodplain meadow close to home, then the notion that the access infrastructure of grazed meadows does not have to be as good as that of mowed ones does not apply. The animals must be transported to the area by means of an animal transportation cart and a tractor, and proper access and crossing to the area are certainly required. This may be particularly important in a situation where animals need to be rescued from a sudden flood. In addition to the place where the animals are loaded and unloaded, which may be located somewhere on higher ground by the floodplain meadow, it must also be borne in mind that the animals must be accessible by transport equipment within practically the entire grazing area - even if the transport of fence posts can be arranged, for example, by ATV, in the event of the death or emergency killing of an animal, access must still be provided for equipment which allows the transport of the animal. Forest areas on the edge of a floodplain meadow would certainly be suitable for rescuing from a flood and for shelter and recreation under normal conditions, especially if they are in a terrain part higher than the floodplain meadow. In terms of land ownership and land use, utilization of such areas can be problematic; good examples of the cooperation between the herder and RMK are, for example, the floodplain meadows of Koiva-Mustjõgi River.

Fences are the most important infrastructure for grazing. As a rule, 2-wire electric fences are used for cattle; like wolves, as a rule do not kill cattle, so there is no need for so-called wolf-proof fences with more wires (if sheep are grazed on the floodplain meadow, the wolf-proof nature of the fences can be a problem, a minimum of 3 wire fences, if possible, a mesh would be needed). The fences must be built to the waterline, leaving the river's edge open - so the animals will eat the edge of the river or oxbow lake clean from the vegetation and at the same time have access to drinking water. To ensure access to water, it is not always possible to build a ring-fence in the case of electric fences, and the current decreases further away from the generator, in which case it may be necessary to think about additional generators. Although the general guideline for the building of fences is about one livestock unit (1 adult bovine animal) per 1 ha, depending on the conditions of the area, it may be necessary to use fences to build paddocks, where the animals eat more intensively than usual (see control of unwanted species below). Lightweight plastic posts with metal ends may be suitable for the construction of short-term paddocks; however, impregnated wooden posts are more durable. Due to the flooding, as a rule, all corrals have to be removed for the winter. Grazed meadows should definitely have shrubs or tree groves where the animals can shelter from the sun.

Figure 17. Beef cattle by the Pedja River in the flooded meadow of Jüriküla. The floodplain meadow must also have tree or shrub groves for the cattle to find shelter in.

Winter ground

Keeping the animals in the floodplain meadow all year round is not possible due to the floods and the lack of available feed. (It is known that in Biebrza fen in Poland, a local horse breed, koniks, are kept in fen communities similar to floodplain meadows, where koniks feed on shrub growth during the winter and were, therefore, effective shrub repellents. The experience of keeping koniks in Estonia has not been so positive.) A good winter ground is very important for animals. The area must be as dry as possible, as the animals will, in any case, trample the ground into the mud, and it must be possible to keep bulls separate from the rest of the herd. Animals must have drinkers and a shelter; if calving takes place in a wintering area, there must also be enough space to separate. Manure handling must also be addressed in the vicinity of the winter ground. The location of both the winter ground and the manure handling site within the nature reserve (but also outside if there are rare or protected species) can be very problematic, as in some cases, there is no place with no Natura site within the protected area - all of which point to the need to reconcile nature conservation on the floodplain meadow with conventional farming.

Livestock and protected species of floodplain meadows

Trampling by cattle can be a serious problem for ground-nesting species and species performing their mating display in the floodplain meadow (see, for example, Pehlak & Luhamaa, 2018, Mägi, 2017, Leho Luigujõgi's oral report in the Soomaa NP section). Although naturally, the largest nest predators are the crow, the fox, and raccoon dog, then in the grazed coastal meadows of Pärnu, the bovine animals trampled up to 1/3 of all looted nests (Mägi 2017). As cattle can also choose areas of higher terrain on the floodplain meadow for night rest, where Gallinago medias can also perform their mating display, the conflict can be considerable. In the case of floodplain meadows important for waders, Latvian researchers have recommended starting grazing in the middle of June at the earliest (and grazing in autumn as long as possible so that the spring grass would be low - it also allows the animals to be moved to the area later). If animals are grazed in areas important for waders as early as April, they should be grazed there only during the day - grazing at night significantly increases the risk of trampling on nests (Rūsiņa, 2017). In practice, of course, this is very difficult to do. In fact, the scale and severity of the problem still need to be investigated in Estonia; as a precautionary measure, in well-identified conflict areas, mating displays of Gallinago media could be protected from grazing by fencing. The concentration of Gallinago media and livestock in similar locations could be somewhat mitigated by the use of areas bordering by floodplain meadows as a hinterland. However, cattle prefer to sleep in the open, so if the hinterland is a forest, the solution may not work. However, the beneficial effects of cattle - their presence may deter other predators - are not clear.

Some rare plant species (e.g., Gladiolus imbricatus) respond better to mowing than to grazing; it is especially sheep that are happy to eat the Gladiolus imbricatus (and especially its generative specimens) (Moora et al., 2007). In the case of a specific study, it is, of course, remarkable that as a result of livestock activities, the population of Gladiolus imbricatus did not decrease but became so-called younger - more young specimen emerged, and generative, flourishing-fruiting specimens disappeared. This may indicate a single maintenance recommendation: instead of keeping the animals away from the Gladiolus imbricatus population each year and releasing them to the area sometime after the seeds have matured (annual cost of setting up and removing fences), grazing should be attempted for a few years so that the animals also have access to the Gladiolus imbricatus plants, but this is followed by a break of a few years, where no animals are allowed to a specific population - allowing the young plants to grow and reproduce and restore the population structure.

A species that does not tolerate grazing is also a Angelica palustris, the maintenance of the habitats of which is particularly difficult due to its late flowering period, which is why late mowing is not suitable. The solution is to mow in a mosaic manner, so that part of the species' habitat is not mowed in any specific year.

Figure 18. Gallinago media

Grassland changes and control of problem species in grazing

With grazing, the floodplain meadows become more soddy, and the animals also tread through the delicate turf, and the abundance of meadow plants, including good fodder plants, decreases (Pork, 1964). Cattle also eat plants selectively, and plants that are not eaten by animals (e.g., Deschampsia cespitosa, high-growing sedges) may therefore start dominating the floodplain meadows; thistles, nettles, etc. may appear as a manifestation of overgrazing. In the event of such changes occurring severely, or rather in order to prevent them, areas that are generally grazed could also be mowed after some period for a few years. This approach may, of course, require separate control of sods before mowing (see the restoration chapter), but it may be the only way to control sedges. Certainly, the earliest possible directing of animals to the areas overgrowing with sedges will also help to control sedges - animals are much more willing to eat young shoots than those that have already become coarse; even though, to some extent, the animals may eat sedges also later, the sedges have diverted reserve substances to underground organs by the second half of the summer, giving them a competitive advantage over other plant species next year. However, it should be borne in mind that, due to the humidity and flooding regime, the floodplain meadows, despite all maintenance practices, will include areas where the predominant species are sedges -in heavily sedimented areas, Carex elata and Carex acuta, and in less flooded areas, Carex disticha, Carex panicea and Carex nigra. Due to the fact that the Carex disticha is sensitive to trampling, its share may decrease upon sufficient grazing load (it is also eaten when it is young). Adequate, sometimes higher-than-usual grazing load can be quite effective in controlling the problem species, but there are also higher costs associated with transporting more animals, and the costs will increase even more if batch grazing is used.

In addition to sedges, the onslaught of shrubs can also be a problem during grazing - e.g., alder buckthorn, aspen, gray alder, and black alder. Even in this case, grazing with a significantly more intensive load can be tried, but it is rather necessary to remove the shrubs with a wasteland mower or chain shredder. This should be done around the beginning of August when the bushes are most lush, but the underground storage of the reserve substances has not yet begun. In the case of alder, in particular, it has been found (oral information from Ilona Lepik) that cattle are unable to control shrubs and that there is no escape from its control with equipment: gray alder spreads to the floodplain meadows from the surrounding areas by way of seeds, and the animals provide the alder competition-free growth through selective eating.

Negative effects of supplementary feeding

It is forbidden to provide supplementary feed to animals in semi-natural communities, including animals must not graze alternately on semi-natural and intensive cultivated grassland, as the feed of the latter would reach the floodplain meadow as fertilizer; that kind of activity would also encourage the spread of alien plant species in the flooded meadows. Above the supplementary feeding, a very strongly trampled area is formed locally, the turf is broken, and thistles, nettles, and Filipendula ulmaria may begin to proliferate. A load of fertilizer in the form of manure at the place of supplementary feeding is also particularly strong, and some part of the feed is always wasted and trampled on, which makes it spread - this is also essentially fertilizer. Due to logistical reasons, the feeding grounds tend to be located in the higher parts of the flooded meadow, which are the most species-rich and botanically valuable due to environmental conditions; the damage is particularly great. Supplementary feeding may be indicated only exceptionally, for a short period (a few days) if the changed conditions (flood, snowfall) necessitate the removal of the animals from the area, and the animals must be provided with feed at a time when they have not yet been transported to the wintering area.

Figure 19. An eutrophic place in vegetation. If the supplementary feeding area of the animals is not trampled directly into the mud and is not completely covered with manure, the nutrients brought to the community via the supplementary feedingstuff promote the proliferation of nettle, Filipendula ulmaria, or, as shown in the picture, grasses (Dactylis, Alopecurus pratensis, etc.). The picture shows the base of a hay bale in a hayfield near Kärevere floodplain meadow.

Maintenance instructions and peculiarities on mowing

Start time

Unlike grazing, the start time of mowing in floodplain meadows is limited - as a rule, it is possible to start from July 10, and in agreement with the Environmental Board, even earlier. The start time set in this way is due to the protection of ground-nesting *Charadriiformes (Gallinago media* and others) and *gruifomes* (*Crex crex*, *Porzana porzana*) nesting in the floodplain meadows - as a rule, birds need about two months from the end of the flood to complete nesting and for the chicks be able to fly; however, flying skills may occur only in early August or in the case of a second brood even later (Renno, 2018). In the case of mowing with machines, either the nests are crushed together with the eggs or the chicks who are not yet able to fly and therefore cannot escape the machines die; in general, mowing starting in mid-July is a trade-off between the interests of maintainers and birds (Thorup, 2016), but late mowing alone may not be sufficient or appropriate in all cases (see below). In addition to the above *Crex crex* and *Gallinago media*, it is optimal to start mowing floodplain meadows living in the grass not before the beginning of July because of invertebrates living in the grass (Rūsiņa, 2017). However, the same work points out that from the point of view of floodplain meadow plants, it is bad to mow annually after mid-July. The consequences of such maintenance have been observed in Latvia due to the maintenance practice that lasted until about 2015, where semi-natural communities were mowed since August in order to protect birds. At present, the start time of mowing in Latvia is usually left to the discretion of the maintainers. Late mowing has led to the rapid spread of a number of expansive species (in particular nitrogen-tolerant nettle, Anthriscus sylvestris, Filipendula ulmaria, Aegopodium podagraria, but also high-growing grasses such as Phalaris arundinacea and Elymus repens), which in turn reduces the species richness of the meadows. (Rūsiņa, 2017). A similar negative effect of late mowing has been observed in floodplain meadows in England, where the authors (Rothero et al., 2016) emphasize that floodplain meadows need to be mowed at a time when hay is most lush and late mowing gives a strong advantage to plants such as nettle and Filipendula ulmaria. In floodplain meadows maintained in Poland, with the habitats of *Gallinago media*, it has been found that the *Gallinago media* do not use areas where mowing has taken place once since 1 August, mainly due to intensive biomass accumulation, and excessive vegetation cover (Korniluk et al., In press) and instead of areas mowed in August, 2.5 times more preference was given to grasslands where mowing was carried out twice - in early June and in August - and later grazing took place also on the mowed meadow.

Traditionally, meadows have been mowed, according to various data, since Midsummer's Day (Troska, 2004), the beginning of July (oral information by V. Metsoja), or late summer (Suurkask, 1999). The special feature of modern mowing compared to the past is, of course, the very high mowing speed, in extreme cases up to 20 km/h. It could be explored whether earlier mowing starting in early July or after Midsummer Day would be indicated for significantly slower mowing (see Maintenance outlook below). In addition to the high mowing speed, modern heavy equipment also destroys the microrelief of the floodplain meadow (Kotowski et al. 2013) and cannot successfully cope with lower relief parts, narrow ponds.

Mowing height

Different numbers have been suggested for the recommended mowing height: 5-7 cm (max 12; previous maintenance plan) or as low as possible, 3-7 cm depending on the vegetation (Rūsiņa, 2017). However, the same Latvian maintenance guide (Rūsiņa, 2017; Annex 2, Table 9) states that it is bad for nesting crex if the mowing height is less than 20 cm. In the latter case, it is believed that higher mowing would leave the brood/juveniles untouched. However, higher mowing hinders waders in particular because next spring, there will be a higher amount of old grass, which hinders the movement and food supply of birds. The general rule for mowing should be as low as possible. In this way, the stockpiling of fodder makes optimal use of the floodplain meadow resource, as well as encourages the most low-growing plant species, which are excluded from competition by high-growing ones; with the addition of lower-growing species to the community, it is also possible to achieve significantly lower grass cover in the spring period for Gallinago media. True, grazing after mowing can be more helpful here. It is very important to mow shallow pond areas and the edges of rivers and oxbow lakes open and as low as possible. The former primarily for the benefit of foraging Charadriiformes, the latter for the sake of fish spawning on the flooded meadow.

Uses of the hay of floodplain meadows

The most tried application for the hay of floodplain meadows is animal feed, for hay of inferior quality also bedding. Despite the fact that primarily beef cattle are kept in the floodplain meadows, at least in the example of Alam-Pedja, hay attained from floodplain meadows is also suitable as a feed for sheep and horses. To a lesser extent, hay has been used in bioenergy - e.g., the Lihula boiler house.

The bioenergetic potential of Estonian floodplain meadows has been assessed as higher than all other community types (Heinsoo et al., 2010). Later (Melts & Heinsoo, 2015), the possibility of using the hay from floodplain meadows in bioenergy has been studied in more detail - namely, the relationship between mowing time and biogas productivity. Biomass collected from floodplain meadows is highest in July; however, this sedge-rich biomass is also very high in fiber and is suitable for methane production when stockpiled both in July and August. If biomass is to be used for incineration, it should be stockpiled very late (e.g., in October) or pre-treated - leaching out unnecessary minerals (Melts & Heinsoo, 2015; Melts et al., 2019). Given that many floodplain meadows, especially the larger and flatter ones, are very rich in sedges, and the value of the hay from such areas as animal feed is low, the use of hay from floodplain meadows in bioenergy should be more strongly supported. Theoretical knowledge is rather available today, but there is a lack of practical large-scale experiments; among other things, the planned use of the hay from the floodplain meadow in Alam-Pedja at the Ilmatsalu biogas plant did not succeed.

In part, more efforts should be made to explore the possibility of composting the hay from floodplain meadows, both because low-value biomass is collected from large areas as feed and because more widespread grazing also requires solutions for manure handling.

Degradation of floodplain meadows / inadequate maintenance

Undergrazing is a problem today for many grazed floodplain meadows - the recommended one livestock unit per hectare is not achieved. Especially the higher sedge-covered areas, but in some places also, the reedbeds are only penetrated by the animal passages, and there is no actual feeding going on there. This is certainly exacerbated by the selective eating of the animals - preference is given to the areas with drier and more palatable vegetation (more grasses and herbs, fewer sedges)

located on higher grounds of the floodplain meadows. This means that even if, in general, there are enough animals for the entire complex, the sedge cover, reedbeds, and other areas where the animals preferably do not feed will remain undergrazed. To prevent this, the animals must be restrained in areas by paddocks that they would naturally avoid, and it is recommended that the grazing load be up to twice as high as usual, even more in the short term. In doing so, of course, the welfare of the animals must be carefully monitored so that they do not starve, and it must be borne in mind that the result can be achieved, in particular, by eating young plants. For example, in the case of reed control, it has been pointed out (Pehlak & Luhamaa, 2018) that animals must be directed to eat reeds early, when the height of the reed is still up to 30-40 cm, before the moment when the reed unfolds the leaf and turns green. Since the reed is still brownish-red at that time, it is not correct to estimate that the animals have nothing to eat yet if there is no green reed (ibid). Early direction to the area of non-preferred vegetation could be a general guideline - animals tend to eat young emerging shoots, and it may be much easier for them to keep such growth low than eating overgrown plants.

The formation of sods as a result of grazing is partly inevitable, and such areas should be mowed from time to time in addition to grazing if necessary. It would be best to graze in some years, in others to mow and remove the hay; if this is not possible, chopping the area after or before grazing is also a possible solution. Chopping before grazing allows the animals to feed on young plants. Such an approach is not possible in the nesting areas of protected endangered bird species.

Mowing also has its bottlenecks - especially when mowing, low, narrow grooves tend to be left unmown due to their softness when it is not possible to access the area at all, or they are mowed high if the groove is very narrow and the mower simply does not copy the terrain enough. Here again, it is helpful to change maintenance - grazing is more successful in making the vegetation of such areas low-growing than mowing.

In order to control Filipendula ulmaria, nettle, etc., it may also be necessary to graze their area with a heavier load or to mow more intensively (e.g., twice a year). Filipendula ulmaria, nettle, etc., may also start to dominate the floodplain meadow due to constant late mowing. As such areas are generally unsuitable for birds of floodplain meadow, they should definitely be mowed in the first half of July (and, if necessary, in August). Mowing twice a year (in June and in August) and grazing after mowing have proved to be a good way to preserve the feeding areas of Gallinago media (Korniluk et al., In press; but see their discussion regarding the fact that such maintenance is not suitable for nesting sites). Be sure to collect the hay when mowing, and bare chopping is not enough to control it.

Overgrowing of the edges of floodplain meadows is an inevitable phenomenon, especially on river and ditch edges or on the forest side edge. Such areas need to be cleared of scrub using similar methods as in restoration (see Restoration of floodplain meadows).

Risks of over-management

Floodplain meadows are generally very productive communities, and practice shows that the grass in the areas mowed in early summer is already high enough in the second half of the summer to be mowed again. One of the fundamental dangers, in this case, is probably the added pressure on early mowing - in order to make the second mowing in more favorable weather conditions, the first is to be done as early as possible. Mowing-tolerant grasses and rosette-creeping plant species may also benefit from this, but the proportion of those that require a longer fruiting season and are more dependent on seed multiplication may decrease. Also, at least superficial early mowing is not suitable for birds nesting on floodplain meadows, whose brood or younglings not yet able to fly are either killed directly under the mowing equipment or remain exposed for predation after mowing. Rather,

it would be advisable to graze in mowed meadow in the autumn - several different management methods are used and cattle create a greater mosaicity compared to mowing, among other things they offer niches with disturbance (trampling, tracks) also for those plants that need exposed soil for seed renewal.

Variety of maintenance

As has been mentioned many times before, the management of meadows should strive for a variety of maintenance methods. The main maintenance methods - mowing and grazing - could be alternated from year to year, or both maintenances could be combined in one year (grazing on mowed meadow). In the case of grazing, the use of a paddock system adds variability (and, unfortunately, additional work for the maintainer) - paddocks may be needed to control undesirable plant species (sedges, Filipendula ulmaria, etc.) as well as to direct animals to eat more intensively in some areas after restoration. If possible, the priority areas for mowing should be alternated from year to year. In order to encourage the seed dispersal of plants, intermediate or rest years should be applied in certain areas/parts of floodplain meadows; care must also be taken to ensure that these areas do not overlap from year to year and that non-management of technically and logistically more difficult areas should be avoided. If grazing in paddocks is focused on suppressing sedges or if animals are coaxed to feed on sedges, a method of maintenance could be beneficial where, for example, in half of the area, the animals are directed to eat as early as possible, and the other half of the area is mowed before the animals are moved there - so the animals can eat younger shoots.

The so-called rest areas can also be located in the floodplain meadow as strips or patches, in which case only the vegetation in the lower part of the floodplain meadow is left unmanaged - the strips could be located so that they cross through all the zones of the floodplain meadow from the river to the forest, encompassing both the large sedge fields located on lower areas as well as the parts more like dry and fresh grasslands located on higher knolls. The new measure for the maintenance of semi-natural habitats envisages leaving 10-30% of all such areas to be mowed that are not endangered by degradation (overgrowth-coverage in reedbed-sodding) unmowed.

Special equipment suitable floodplain for meadows

As a rule, conventional agricultural tractors and hitches, if necessary with double wheels, have been used to manage the floodplain meadows. A side-mounted mower or a mower placed at the end of the boom could be suitable for mowing the edges of oxbow lakes; of course, it is also difficult to collect hay in such areas (possible beaver holes, etc.). In Poland, in the fen meadows of Biebrza, crawler vehicles adapted from an alpine track tractor have been used, which allow the immediate collection of reed and sedge material also in a transport cart also placed on the crawlers.

Figure 20. A crawler tractor and a crawler cart were used in the Biebrza fen meadows.

Although such a vehicle has low specific pressure, it still has a significant effect on the floodplain meadow community. Kotowski et al. (2013) found that the use of crawler mowers reduced the diversity of the plant community, especially suffered the rarer species, which often found habitat in sedge sods under fen conditions, and the predominance was given to Menyanthes trifoliata, Comarum palustre, Equisetum fluviatile, Ranunculus lingua. The crawlers press the sedge sods flat and lose the variety of the microrelief. In addition to rarer plant species, it has also been found to be negative for Gallinago media, which can use sods as mating display places in very flat areas. Breaking the turf due to the metal lamellae on the crawlers is also a problem. The depressing of the sedge sods also lead to the problem of creation of peat - the sods added organic matter to the soil and the emergence of peat began in excessively wet conditions. In the process, the floodplain meadows (or fens) become even softer than they used to be, and mowing with no other equipment is possible. Based on the above, the widespread and long-term use of similar equipment in Estonian floodplain meadows is not recommended, or at least the use of such equipment should also be linked to monitoring the impact thereof on the communities of floodplain meadows.

Figure 21. Special equipment is used in the Struuga landscape protection area. Photo: Igor Gulov.

Future prospects for maintenance

Today, it is understood that the diversity of maintenance is very important for all semi-natural communities, including floodplain meadows. Mowing and grazing have also been alternating historically, and the start time of mowing has also varied. The uniform start of mowing, especially due to the protection of birds, has already caused visible negative changes in vegetation cover in the meadows of our southern neighbors, Latvians (Rūsiņa, 2017). In areas of endangered ground-nesting bird species, the choice of a start time for mowing cannot be unreasonably left open; however, it can be tried elsewhere. Even in habitats of endangered species, maintenance schemes can be made more flexible than they used to be. There is a clear need to identify exactly where the nesting grounds of endangered species (especially Gallinago media) are located, and on the contrary, feeding areas may need early mowing (Korniluk et al., in press). The drop-out of several floodplain meadows from maintenance and the non-fulfillment of spatial targets show that there is a shortage of maintainers, and according to the author of the plan, a drastic reduction in the area of maintained floodplain meadows has a greater impact than inappropriate management practices. Of course, changes in maintenance methods, including earlier mowing, in particular, must be very carefully considered and even more closely monitored. Technically, it is certainly possible to link earlier mowing, for example, to the obligation to mow at a slow speed - this can be monitored with a simple GPS device or even a telephone. The study of the impact of such maintenance must begin, in particular, outside the nesting areas of the Gallinago media. Monitoring of the maintenance method and other applied research must be planned for at least five years, and experts from all biota groups involved in the floodplain meadows must be involved.

Although grazing has gained popularity in floodplain meadows, there are enough areas that are not suitable for grazing and where the biomass collected is not a valuable animal feed - more resources should be devoted to the development of bioenergy solutions as the theoretical basis thereof is good enough today.

One of the solutions to the access and removal infrastructure that has not been tested on floodplain meadows in today's nature conservation practice, but has been used before, is the use of rafts for transporting both hay and machinery on suitable water bodies (e.g., Suur-Emajõgi River).

Certainly, one area that needs strong attention is the involvement of floodplain meadow maintainers as partners, not as enforcers of precepts and subject to sanctions. One specific option would be area-based or maintainer-based maintenance plans. At the meeting of maintainers organized in Matsalu within the framework of the preparation of this plan, it was pointed out that the state partner (Environmental Board) should be more of a facilitator than an inspector-punisher. There is also confusion among maintainers due to the fragmented organization of maintenance and the fact that in the current support scheme, different boundaries in the landscape must be taken into account for single area support and semi-natural habitat support areas. Training for maintainers could be more practical and, among other things, provide knowledge on how to recognize nature and pay attention to the protected species, the landscape and vegetation structure that shows good status, and so on. Unfortunately, it seems that until this day, the very important potential of civic science in the form of maintainers has been wasted - after all, maintainers stay in the floodplain meadows much longer and more often than any scientist can do it, and after some counseling, they could certainly provide important information about protected species, etc. in the area.

The maintainers themselves have mentioned very important trends: (excerpts from the “Analysis of ensuring the sustainable management of semi-natural communities” (Holm et al., 2019):
* Practical training in the management of SNC, conducted directly in nature and based on real experience, in addition to the existing classroom training, must be established.

* More than half of the respondents consider it important that the state should provide on-site area-based counseling, which is not available today and would make maintenance requirements simpler and more lenient. The review of management requirements should be more regular and advisory rather than punitive.

VII Summary

Floodplain meadows are flooded semi-natural grasslands that have replaced the former floodplain forests. Floodplain meadows and wet high grasses similar to floodplain meadows are found elsewhere in Europe, but the Nordic floodplain meadows (Natura type 6450) are unique to Estonia, Latvia, Lithuania, Finland, and Sweden. In all these countries, the current area of floodplain meadows has fallen sharply compared to history and is now in an unfavorable status.

The uniqueness of the floodplain meadows is due to the varied landscape on the one hand - the river floodplain alternates with the inland water bodies, the meanders of the river relocate over time due to the heaping and consuming activities, oxbow lakes and stagnant floodplain water bodies are formed; in floodplain meadows, one can distinguish the lower areas where the riverbed used to be, and on an otherwise uniform floodplain meadow, one can notice the higher parts that used to be the embankments of the river. On the other hand, the flooding and its uneven distribution in the floodplain meadow create very different humidity conditions and, as a result, the meadows have very mosaic plant communities, ranging from fen type conditions to fry and fresh grassland type conditions. In terms of vegetation, the driest areas are the most species-rich.

In addition to the varied plant communities, the flooded meadow is also inhabited by fish spawning in the flooded meadow and various birds of prey, as well as Charadriiformes, the most important of which is the Gallinago media that performs its mating displays and nests in Estonian floodplain meadows.

The largest area of floodplain meadows widespread in Estonia around the turn of the 19th/20th century was almost 150,000 hectares; today, there are at best about 27,500 ha of floodplain meadows, of which only about 7,700 hectares are maintained. Considering that the historically identified meadows were constantly managed as extensive meadows, only almost five percent of the former area is now inactive maintenance! Both the loss of surface area and, in some cases, inappropriate maintenance techniques (especially shredding) have also endangered the biota of floodplain meadows.

The conservation values of meadows are very diverse, and often the demands of conservation species can be conflicting (a floodplain meadow that provides ambush trees for protected birds of prey is not suitable for floodplain meadow Charadriiformes; the botanically rich in species would be a drained floodplain meadow, but this is not suitable for fish, etc.). Maintenance practices and related requirements developed to date may also be conflicting. For example, the latest possible start of mowing is suitable for the Gallinago media and the crex, but it can cause undesirable changes in vegetation - the proliferation of large grasses and Filipendula ulmaria and the impoverishment of the community over a long period of time.

Only local maintainers - mowers and herders - can preserve the floodplain meadows as semi-natural communities. In addition to the demands of the biota of the floodplain meadow, the maintainers have to deal also with administrative requirements and possible sanctions. It is very commendable that greater flexibility is being achieved, at least in part, in the principles of maintenance of floodplain meadows, both in terms of the non-maintenance of certain areas and, in some cases, the freer choice

of the starting time for mowing. Two important aspects should definitely be taken into account for any changes in maintenance: changes in maintenance practices must go hand in hand with their long-term monitoring and other applied research, and it must be taken very seriously into account that every effort must be made at the organizational level to motivate maintainers of floodplain meadows to significantly increase the area of floodplain meadows to be maintained, and not to give up the maintenance of areas that are already being maintained.

Used literature

Burmeier, S., Eckstein, R. L., Otte, A., & Donath, T. W. (2011). Spatially-restricted plant material application creates colonization initials for flood-meadow restoration. *Biological Conservation*, *144*(1), 212–219. https://doi.org/10.1016/j.biocon.2010.08.018

Donath, T. W., Bissels, S., Hölzel, N., & Otte, A. (2007). Large scale application of diaspore transfer with plant material in restoration practice - Impact of seed and microsite limitation. *Biological Conservation*, *138*(1), 224–234. https://doi.org/10.1016/j.biocon.2007.04.020

Harvolk-Schöning, S., Michalska-Hejduk, D., Harnisch, M., Otte, A., & Donath, T. W. (2020). Floodplain meadow restoration revisited: Long-term success of large scale application of diaspore transfer with plant material in restoration practice. *Biological Conservation*, *241*, 108322. https://doi.org/10.1016/j.biocon.2019.108322

Heinsoo, K., Melts, I., Sammul, M., & Holm, B. (2010). The potential of Estonian semi-natural grasslands for bioenergy production. *Agriculture, Ecosystems & Environment*, *137*(1), 86–92. https://doi.org/10.1016/j.agee.2010.01.003

Helm, A., & Toussaint, A. (2020). *Poolllooduslike koosluste ökoloogilise toimimise hinnang*. Tartu Ülikool, Ökoloogia ja Maateaduste Instituut.

Holm, B., Aavik, T., Kasari, L., Luuk, O., Holm, A., Väli, K., Sandre, S.-L., & Kallaste, E. (2019). *Poolllooduslike koosluste jätkusuutliku majandamise tagamise analüüs*. Pärandkoosluste kaitse ühing & Eesti Rakendusuuringute Keskus CentAR OÜ.

Hölzel, N., & Otte, A. (2003). Restoration of a species-rich flood meadow by topsoil removal and diaspore transfer with plant material. *Applied Vegetation Science*, *6*(2), 131–140.

Jõgar, Ü., & Moora, M. (2008). Reintroduction of a Rare Plant (Gladiolus imbricatus) Population to a River Floodplain — How Important is Meadow Management? *Restoration Ecology*, *16*(3), 382–385. https://doi.org/10.1111/j.1526-100X.2008.00435.x

Korniluk, M., Białomyzy, P., Grygoruk, G., Kozub, Ł., Sielezniew, M., Świętochowski, P., Tumiel, T., Wereszczuk, M., & Chylarecki, P. (sa). Habitat selection of foraging male Great Snipes on floodplain meadows: Importance of proximity to the lek, vegetation cover and bare ground. *Ibis*, *n/a*(n/a). https://doi.org/10.1111/ibi.12898

Kotowski, W., Jabłońska, E., & Bartoszuk, H. (2013). Conservation management in fens: Do large tracked mowers impact functional plant diversity? *Biological Conservation*, *167*, 292–297. https://doi.org/10.1016/j.biocon.2013.08.021

Krall, H., Pork, K., Aug, H., Püss, Õ., Rooma, I., & Teras, T. (1980). *Eesti NSV looduslike rohumaade tüübid ja tähtsamad taimekooslused.* Eesti NSV Põllumajandusministeeriumi Informatsiooni ja Juurutamise Valitsus.

Kriiska, A., & Tvauri, A. (2002). *Eesti muinasaeg*. Avita.

Kukk, T. (2004). Lamminiidud ehk luhad. *Pärandkooslused. Õpik-käsiraamat* (lk 191–203). Pärandkoosluste Kaitse Ühing.

Kukk, T., Lõugas, L., & Veski, S. (2000). Eesti elustiku mitmekesisuse muutustest pärast jääaega. *Loodusteaduslikud ülevaated Eesti Maa päeval: Eesti VIII ökoloogiakonverentsi lühiartiklid: Tartu, 26.-27. Aprill 2000. Kaasaegse ökoloogia probleemid.* (Kd 8, lk 90–109).

Kukk, T., & Sammul, M. (2006). Loodusdirektiivi poollooduslikud kooslused ja nende pindala Eestis. *Eesti Looduseuurijate Seltsi aastaraamat*, *84*, 114−158.

Kuresoo, A. (2004). Lamminiitude linnustik. *Pärandkooslused. Õpik-käsiraamat* (lk 163–167). Pärandkoosluste Kaitse Ühing.

Kuresoo, A., & Luigujõe, L. (2003). *Rohunepi Gallinago media asurkonna seisund Eestis: Arvukuse ja sigimisedukuse seire ning elupaigamustri selgitamine. Looduskaitseprogrammi projekti nr. 14/2003 aruanne. Käsikiri Zooloogia ja botaanika instituudis.*

Laasimer, L. (1965). *Eesti NSV taimkate*. Valgus.

Leibak, E., & Lutsar, L. (Toim). (1996). *Eesti ranna- ja luhaniidud =: Estonian coastal and floodplain meadows*. Kirjameeste Kirjastus.

Lotman, A. (2005). Poollooduslike märgalakoosluste taastamise probleemidest Kasari alamjooksu luha näitel. *Eesti Loodusuurijate Seltsi aastaraamat*, *83*, 167–191.

Masing, V., Paal, J., & Kuresoo, A. (2000). Biodiversity of Estonian wetlands. *Biodiversity in wetlands: Assessment, function and conservation, volume 1.* (lk 259–279). Backhuys Publishers.

Meier, K., Kuusemets, V., Luig, J., & Mander, Ü. (2005). Riparian buffer zones as elements of ecological networks: Case study on Parnassius mnemosyne distribution in Estonia. *Ecological Engineering*, *24*(5), 531–537. https://doi.org/10.1016/j.ecoleng.2005.01.017

Melts, I., & Heinsoo, K. (2015). Seasonal dynamics of bioenergy characteristics in grassland functional groups. *Grass and Forage Science*, *70*(4), 571–581. https://doi.org/10.1111/gfs.12155

Melts, Indrek, Ivask, M., Geetha, M., Takeuchi, K., & Heinsoo, K. (2019). Combining bioenergy and nature conservation: An example in wetlands. *Renewable and Sustainable Energy Reviews*, *111*, 293–302. https://doi.org/10.1016/j.rser.2019.05.028

Meriste, M., & Kirsimäe, K. (2015). Development of the reed bed in Matsalu wetland, Estonia: Responses to neotectonic land uplift, sea-level changes and human influences. *Estonian Journal of Earth Sciences*, *64*(2), 159. https://doi.org/10.3176/earth.2015.24

Mesipuu, M. (2008). *Botaaniline hinnang freesitud aladele Soomaa rahvuspargis. Töövõtulepingu nr 5.6-7.1/62 aruanne.* Pärandkoosluste Kaitse Ühing.

Mesipuu, M. (2014). *Taastamisvõtete sobivuse hindamine ning hoolduskava koostamise alusuuringud Koiva-Mustjõe maastikukaitseala luhaniitudel*. http://www.pky.ee/siselinkide_materjalid/Projekti3039_aruanne_luhad_Koiva_Mustj6e.pdf

Metsoja, J.-A., Neuenkamp, L., & Zobel, M. (2014). Seed bank and its restoration potential in Estonian flooded meadows. *Applied Vegetation Science*, *17*(2), 262–273. https://doi.org/10.1111/avsc.12057

Moora, M., Kose, M., & Jõgar, Ü. (2007). Optimal management of the rare Gladiolus imbricatus in Estonian coastal meadows is indicated by its population structure. *Applied Vegetation Science*, *10*(2), 161–168. https://doi.org/10.1111/j.1654-109X.2007.tb00514.x

Mägi, M. (2017). Maaspesitsevate lindude pesarüüste taastatud Pärnu rannaniidul. *Hirundo*, *30 (1)*, 1–15.

Neuenkamp, L., Metsoja, J.-A., Zobel, M., & Hölzel, N. (2013). Impact of management on biodiversity-biomass relations in Estonian flooded meadows. *Plant Ecology*, *214*(6), 845–856. https://doi.org/10.1007/s11258-013-0213-y

Paal, J. (1997). *EESTI TAIMKATTE KASVUKOHATÜÜPIDE KLASSIFIKATSIOON*.

Paal, J. (2007). *Loodusdirektiivi elupaigatüüpide käsiraamat* (2., parand. ja täiend. tr). Andreseni Projekt.

Pehlak, H., & Luhamaa, H. (2018). *Niidurüdi (Calidris alpina chinzii) kaitse tegevuskava*. https://www.keskkonnaamet.ee/sites/default/files/liigikaitse/niidurudi_tegevuskava_avalik.pdf

Pollock, M. M., Naiman, R. J., & Hanley, T. A. (1998). Plant Species Richness in Riparian Wetlands—A Test of Biodiversity Theory. *Ecology*, *79*(1), 94–105. https://doi.org/10.1890/0012-9658(1998)079[0094:PSRIRW]2.0.CO;2

Pork, K. (1959). Kesk-Eesti jõgede luhaniitude keskkonnatingimustest. *Eesti Loodusuurijate Seltsi aastaraamat*, *52*, 51–70.

Pork, K. (1964). Taimkatte genees ja antropogeensed suktsessioonid luhtadel (andmeid Põltsamaa ja Pedja jõe luhtadelt). *Loodusuurijate Seltsi aastaraamat*, *56*, 97–112.

Pork, K. (1979). Niidutaimkatte kujunemine, nüüdisaegne seisund ja niitude kasutamise küsimusi Eesti NSV-s. *Eesti Loodusuurijate Seltsi aastaraamat*, *67*, 7–37.

Pork, K. (1984). Jõeluhtade looduslikus seisundis säilitamisest. *Looduskaitse ja põllumajandus.* (lk 58–70). Eesti Põllumajanduse Akadeemia.

Pärtel, M., Bruun, H., & Sammul, M. (2005). Biodiversity in temperate European grasslands: Origin and conservation. R. Lillak, R. Viiralt, A. Linke, & V. Geherman (Toim), *Integrating Efficient Grassland Farming and Biodiversity* (Kd 10, lk 1–14). ESTONIAN GRASSLAND SOC-EGS.

Pärtel, M., Helm, A., Roosaluste, E., & Zobel, M. (2007). Bioloogiline mitmekesisus Eesti pool-looduslikes ökosüsteemides. *Keskkonnauuringute nüüdisprobleeme.* (lk 223–302). allinna Ülikooli Ökoloogia Instituut.

Renno, O. (Toim). (1985). *Maastike muutumise mõju lindudele. Linnud ja inimtegevus*. Valgus.

Renno, O. (2018, juuli 5). *Kes on huigud?* Maa Elu. https://maaelu.postimees.ee/4534659/kes-on-huigud

Ristkok, J. (1969). Emajõe vanajõed. *Zooloogia-alaseid töid V (TRÜ Toimetised.*

Rothero, E., Lake, S., & Gowing, D. (2016). *Floodplain Meadows: Beauty and Utility - A Technical Handbook*. Open University. http://www.floodplainmeadows.org.uk/floodplain-meadow-technical-handbook

Rūsiņa, S. (Toim). (2017). *Protected Habitat Management Guidelines for Latvia. Volume 3. Semi-natural grasslands.* Nature Conservation Agency. https://www.daba.gov.lv/public/eng/publications1/

Sammul, M, Kull, K., & Kukk, T. (2000). Natural grasslands in Estonia: Evolution, environmental and economic roles. *Conventional and ecological grassland management: Comparative research and development: Proceedings of the international symposium: Tartu, July 4–6, 2000*. Estonian Agricultural University, Estonian Grassland Society.

Sammul, Marek, & Jürgens, K. (2004). *Bioloogilise mitmekesisuse seisukohast väärtuslike metsaga seotud pool-looduslike koosluste majandamisjuhiste väljatöötamine*. Pärandkoosluste Kaitse Ühing.

Suurkask, M. (1999). Soomaa luhaniidud. *Eesti Loodus*, *10*. http://vana.loodusajakiri.ee/eesti_loodus/EL/vanaweb/9910/luhad.html

Sviridova, T. V., Soloviev, M. Y., Bazhanova, A. A., & Soloviev, S. M. (2018). Influence of the Vegetation Structure on the Numbers of Great Snipes (Gallinago media) (Scolopacidae, Aves) at Leks. *Biology Bulletin*, *45*(10), 1308–1315. Scopus. https://doi.org/10.1134/S1062359018100266

Süda, I. (2018). *Eremiitpõrnika (Osmoderma barnabita) kaitse tegevuskava*. Keskkonnaamet. https://www.keskkonnaamet.ee/sites/default/files/liigikaitse/eremiitpornikas_tk_avalik.pdf

Thorup, O. (2016). Timing of breeding in ruff philomachus pugnax: A crucial parameter for management and use of wet grassland in western Europe. *Wader Study*, *123*(1), 49–58. Scopus. https://doi.org/10.18194/ws.00027

Troska, G. (2004). Külaelu ja pärandkoosluste majandamine Teise maailmasõjani. *Pärandkooslused. Õpik-käsiraamat* (lk 48–64). Pärandkoosluste Kaitse Ühing.

Wagner, M., Poschlod, P., & Setchfield, R. (2003). Soil seed bank in managed and abandoned semi-natural meadows in Soomaa National Park, Estonia. *Annales Botanici Fennici*, *40*(2), 87–100.

Wassen, M. J., Peeters, W. H. M., & Olde Venterink, H. (2003). Patterns in vegetation, hydrology, and nutrient availability in an undisturbed river floodplain in Poland. *Plant Ecology*, *165*(1), 27–43. Scopus. https://doi.org/10.1023/A:1021493327180