Chapter 17. 6450 *Northern boreal alluvial meadows* (S. Rūsiņa, A. Auniņš, V. Spuņģis)

17.1 Characteristics of the Habitat Type

17.1.1 Brief Description

Habitat type 6450 *Northern boreal alluvial meadows* (referred to as *floodplain grasslands* in the text) includes moist and wet semi-natural grasslands in river and lake floodplains that become inundated in spring floods. This is the second most common type of EU protected grassland habitat in Latvia – its area is 15,600 ha and it accounts for 34% of all semi-natural grasslands (Fig. 17.1.1). Latvia has 32% of the total area of floodplain grasslands in the EU boreal region (Rūsiņa 2013j).

Floodplains may contain very different grasslands: including very dry, moist or permanently wet ones, which leads to high vegetation diversity, including both low and sparse and tall and dense. However, in terms of EU protected habitats, only wet and moist grasslands are included in the habitat type 6450 *Northern boreal alluvial meadows* in Latvia. Dry and mesic grasslands and grasslands in alternately dry soils (*Molinion* grasslands) are included in other types of EU protected habitat. Management and restoration of such grasslands has been described in chapters about the respective habitat types (*see Chapters 9–16, 18 and 19*).

Three variants can be distinguished by vegetation composition and its determining environmental conditions (Auniņš (ed.) 2013) (Table 17.1.1).

Floodplains can also contain improved grasslands without particular biodiversity importance, therefore not all moist and wet grasslands in floodplains should be considered EU protected habitats. In order to be recognised as an EU protected habitat type 6450 *Northern boreal alluvial meadows*, the grassland has to meet all of the below criteria:

- the grassland has to be subject to inundation;
- it has to contain typical floodplain grassland vegetation with typical plant species dominating in floodplains: *Alopecurus pratensis, Carex* spp.*, Phalaroides arundinacea, Poa palustris, P. trivialis, Deschampsia cespitosa*;
- the grassland has to contain at least three species typical of floodplain grasslands with high frequency (occurring in at least 4 out of 10 points selected with 20 m intervals): *Caltha palustris*, *Cardamine* spp., *Carex acuta*, *C. cespitosa*, *C. disticha, C. nigra*, *Calamagrostis canescens*, *Cnidium dubium*, *Filipendula ulmaria*, *Galium palustre*, *G. uliginosum*, *Geum rivale*, *Lathyrus palustris*, *Lythrum salicaria*, *Peucedanum palustre*, *Thalictrum flavum*, *T. lucidum*, *Valeriana officinalis*, *Veronica longifolia*, *Viola persicifolia*. If there are no typical species, then the grassland should

Table 16.3.1. Indications of a well-managed habitat type 6430 *Hydrophilous tall herb fringe communities of plains and of the montane to alpine levels.*

Parameter	Water banks or forest edges
Wave action	Stream and flooding drives river bank vegetation processes, the banks have not been transformed by humans or the impact of transformation on previously straightened river banks is no longer visible.
Plant species	A very colourful stand in full bloom, proportion of forbs and grasses at least 1:1 (the amount of grasses is not higher than that of forbs). Great diversity of forb species.
Invertebrate species	Great diversity of invertebrate species, dominated by Diptera, Hymenoptera and beetles, there is no single dominant species. Rich pollinator fauna, including those that only feed in this habitat, but do not live in it.
Expansive and invasive plant species	Not present or only up to 10% of the stand area on the water shore contains *Phragmites australis*, *Urtica dioca*, *Elytrigia repens*, *Aegopodium podagraria*, on forest edges: *Pteridium aquilinium*, no invasive plant species (*Echinocystis lobata, Impatiens glandulifera, Helianthus tuberosus, Reynoutria* spp.).
Indications of flooding activity	Sediments brought by river flow and spring floods are found in some places.
Birds	*Acrocephalus schoenobaenus, A. palustris*, and *Locustella naevia* nest there.

Fig. 16.3.1. Hydrophilous tall herb fringe on the right bank of a straightened and deepened river has deteriorated due to intensive grazing. The left bank in the section visible on the photo is too steep, so the hydrophilous tall herb fringe there is poor and fragmented. Photo: A. Priede.

contain a mosaic of several floodplain grass and sedge species (domination alternates in patches);

- at the same time, improved grassland species *Dactylis glomerata*, *Phleum pratense*, *Trifolium hybridum*, *T. pratense*, invasive species *Ehinocystis lobata*, *Impatiens glandulifera*, nitrophilous species *Aegopodium podagraria*, *Chaerophyllum aromaticum*, *Anthriscus sylvestris*, *Elytrigia repens*, *Taraxacum officinale*, *Urtica dioica* or invasive species should cover less than 60% of the area.

Great biodiversity and an untouched floodplain terrain and landscape has been preserved in the floodplain grasslands of Stende, Rinda, Pededze and Sita, and the upstream of the Gauja between Strenči and Gaujiena. Dviete floodplain is severely drained, however, thanks to a number of projects, it has been largely restored and its biodiversity is recovering well (Fig. 17.1.2–17.1.7).

The most important sources of literature on the preparation of management and restoration guidelines for this type of habitat are the Estonian floodplain grassland management guidelines (Metsoja 2011), floodplain grassland management guidelines published by the European Commission (Eriksson 2008a), floodplain grassland management manuals of Great Britain (Crofts, Jefferson (eds) 1999; Rothero et al. 2016), as well as scientific publications, for example, Joyce, Wade (Eds.) (1998) and Šeffer et al. (2008).

17.1.2 Bird and Invertebrate species

Species that form the typical grassland bird communities, such as *Motacilla flava*, *Anthus pratensis*, *Saxicola rubetra*, *Acrocephalus schoenobaenus*, *Locustella naevia*, *Emberiza schoeniclus*, often occur in floodplain grasslands. *Alauda arvensis* does not occur or only occurs rarely in drier places. The grassland also usually has a mosaic of low-density shrubs and shrub clusters that is suitable for certain passerine species (*Emberiza schoeniclus*, *Carpodacus erythrinus*, *Lanius collurio*). *Porzana porzana* and *Rallus aquaticus* occur in wet depressions and oxbow lakes. If the grassland area is sufficient, *Crex crex* and/or meadow waders, such as *Tringa totanus*, *Gallinago gallinago*, *Vanellus vanellus*, on rarer occasions also *Limosa limosa*, *Philomachus pugnax* and *Tringa stagnatilis*, may also nest there. *Gallinago media* and *Asio flammeus* may also occur in especially large and high-quality floodplain grasslands. Floodplain meadows are also used by *Tetrao tetrix* for lekking. If the meadow is adjacent to a water body or a water course with developed vegetation mosaic, meadow ducks – *Anas querquedula*, *A. clypeata*, *A. strepera* nest there. The occurrence of other species depends on the configuration of surrounding habitats – the feeding resources of floodplain grasslands attract species that usually breed near farmsteads, such as *Sturnus vulgaris*, *Ciconia ciconia*, as well as species feeding on flying insects – *Hirundo rustica*, *Delichon urbicum* and *Apus apus*, or in forests – raptors (for example, *Aquila pomarina*) and owls. During passage migration they are used as resting and feeding grounds by a large number of waterbird species, especially waders.

Every listed species has its own specific requirements for breeding or feeding habitat, therefore an ideal floodplain grassland is diverse and provides the required ecological niches for all these species.

Floodplain grasslands are the only sustainable habitat for *Gallinago media* (Auniņš, 2001) and *Acrocephalus paludicola* (both listed in Annex I of the Birds Directive; global species extinction threat level respectively "near threatened" and "vulnerable" according to IUCN criteria). The permanent breeding range of the *Acrocephalus paludicola* is located slightly south of Latvia, however, the species sometimes nests in floodplains in the south of the country and, taking into account the estimated shift of range due to climate change (Huntley et al. 2007), Latvian floodplain grasslands may become an important refuge for this species. It is a very important habitat for *Crex crex* (a species of Annex I of the Birds Directive) – the highest density of its population occurs in floodplain grasslands, therefore they are important as donor areas for other habitats (Keišs 1997). Species included in Annex I of the EU Birds Directive, such as *Porzana porzana, Philomachus pugnax*, *Asio flammeus, Lanius collurio, Tetrao tetrix* and the globally endangered *Limosa limosa* ("near threatened" according to IUCN criteria) nest in floodplain grasslands. Floodplains serve as a feeding habitat for *Ciconia ciconia* and *Aquila pomarina*.

Invertebrates. There is little data on invertebrates of these grasslands. There is a high diversity of arthropod species. These habitats are inhabited by *Conocephalus dorsalis* and *Pholidoptera griseoaptera*, as well as *Euthystira brachyptera*. Weevils of *Lixus* genus, *Eurygaster testudinaria*, ground bugs of *Cymus* genus are typical. Soil fauna is rich. *Dolomedes plantarius* is typical for floodplain grasslands. Larvae of *Lycaena dispar* develop on *Rumex* spp. in these habitats. The diversity of hygrophile insect species is rich.

Moist grasslands affected by flooding are inhabited by species that can successfully survive inundation, for example, ants and larvae of *Lycaena dispar* (Kajzer-Bonk et al. 2013).

Fish. At least 40 fish species are linked to floodplains. Some of them live in oxbow lakes. Spawning takes place in oxbow lakes and grasslands during spring floods (Metsoja 2011).

17.1.3 Important Processes and Structures

Flooding is the most important ecological process. It can be annual or less frequent. Flooding and the development of oxbow lakes in floodplains create moisture and fertility conditions that are very diverse and alternate rapidly in small areas. Flooding and ice are important for the maintenance of open grassland. During floods, ice even clears large shrubs. This only happens if the floodplain has not been drained and the flooding is strong – pieces of ice flow in a wide stream. At the same time, flooding enables the survival of individual shrubs and trees, providing structural diversity and the diversity of ecological niches (Fig. 17.1.11).

Meandering (natural change of the riverbed), which occurs by the constant displacement and deposition of sand and other substrates, causes the formation of oxbow lakes. Oxbow lakes are very important for floodplain ecosystem diversity. They are particularly important for fish, invertebrates and grassland birds. Spring flooding and the diverse micro-terrain created by it are critical to ensure grassland suitability for *Gallinago media* – flooding provides very fertile, loose and humus-rich mineral soil with high density of earthworms. The varied micro-terrain creates good feeding conditions for *Gallinago media* and other waders – sites that are moist "in the drying stage", not yet depleted of food sources and the location of which changes with the weather (precipitation, temperature). Micro-terrain is also important to maintain the presence of *Rallus aquaticus* and *Porzana porzana* in the grassland: these species mainly live in oxbow lakes and other wet depressions. *Crex crex* also uses these structures in spring while the grassland vegetation has not yet reached the height suitable for the species. Last year's vegetation helps to camouflage *Crex crex* in oxbow lakes and other depressions because they are not usually mown to the ground.

Floodplain grassland plant species are well adapted to long-term flooding. With a shallow root system and root and stem aerenchyma (spongy tissues to deliver air to the plant), they are also adapted to constant moisture. In drained floodplains, species that do not tolerate flooding get well established and this can indicate the impact of drainage (*Dactylis glomerata, Arrhenatherum elatius*, *Trifolium pratense*) (Tērauds 1972).

In drier years, tuft grasses become abundant, in years with longer floods – creeping grasses (*Agrostis gigantea*, *Alopecurus pratensis*). Under the activity of flooding, the grassland remains in the bunchgrass phase for a long time; the compact tussock stage does not occur or is temporary and is returned to the bunchgrass stage if larger or longer floods occur.

In the moist fertile variant of *Alopecurus pratensis* a well-aerated root zone during the vegetation period and a sufficient (but not excessive) amount of water for the growing of plants in early summer are important. Excessive quantity of water during this period is more dangerous than a short drought. Spring flooding in these grasslands occurs not every year (Wheeler et al. 2004).

Soils are usually wet, there are both mineral soils and peaty soils. Alluvial soils most frequently develop in floodplains; they are characterised by a layered structure – darker strata alternate with lighter ones. They develop during floods as mud or sand deposits. Mud settles where floodwater remains the longest. These places are more fertile and the grass is lusher and taller. In some places where the stream is faster, only sand deposits are created: these places are drier and poorer in summer. However, the deposits of particles carried by flooding are very uneven and it is not always the case that more nutrients get deposited in lower places, where water runs slower and lasts longer. Research of nutrients carried by flooding of the Rhine (Germany) showed that the phosphorus carried by floodwater principally deposited within a 300 m area from the river, and further away its concentration was lower. It is related to the fact that the phosphorus in floodwater is bound to solids that settle first (nitrogen is diluted in water and enters the soil in a different manner to phosphorus) (Klaus et al. 2011).

Traditionally, floodplain grasslands were used mainly for mowing and aftermath grazing, river banks were grazed up to the water's edge (Fig. 17.1.8, 17.1.9).

Traditionally, floodplain grasslands were not fertilised because nutrients carried by floods ensured the natural restoration of soil fertility. Natural rivers that do not contain human-created agricultural pollution do not have much flood-borne nutrients. They only compensate for the loss of nutrients removed with hay. For example, studies carried out in the 1950s-1960s revealed that the floodwater in the floodplains of Melnupe and Misa carried 2,000 kg of deposits per 1 ha, containing 5.2–9.4 kg of K_2O and 3.3–4.2 kg of P_2O_5. The Lielupe floods carried 10.0–36.4 kg of K_2O deposits per 1 ha (Tērauds 1972).

The limiting factor in grassland vegetation development is phosphorus and nitrogen. If it is excessive, then the species diversity decreases and grassland yield increases (Fig. 17.1.10). The optimal amount of bioavailable phosphorus in soil of moist fertile *Alopecurus pratensis* variant with pH 6.0 is 5–15 mg kg^{-1} (according to the Olsen method), an unacceptable amount is above 50 mg kg^{-1} (Wheeler et al. 2004; Duranel et al. 2007; Venterlink et al. 2009). Nitrogen mineralisation must be no higher than 80 kg ha^{-1} per year either, because it is naturally lower than 40 kg ha^{-1} per year. For example, nitrogen mineralisation in natural non-drained floodplain grasslands of the River Biebrza in Poland was 0–30 kg ha^{-1} per year, while in drained grasslands it exceeded 120 kg ha^{-1} per year (Venterlink et al. 2009).

Regular management with the prevention of overgrowth and uniform scrub development is very important for floodplain grassland birds. Continuous open area is a major habitat suitability criterion for meadow waders. These species avoid vertical elements, because they serve as observation points for raptor birds and other nest predators (corvids). Solitary trees, shrubs or shrub clusters are also very important from the point of view of landscape diversity because they increase the amount of available ecological niches in the grassland, thus increasing the diversity of bird species.

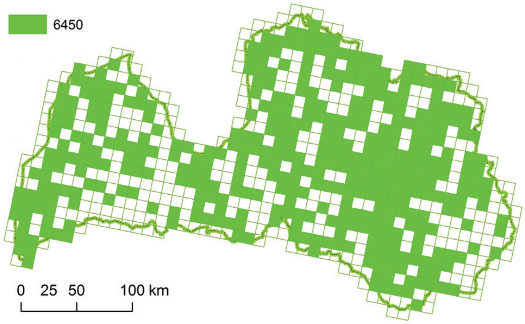


Fig. 17.1.1. Distribution of EU protected habitat type 6450* *Northern boreal alluvial meadows* in Latvia (Anon. 2013a).

There are situations, where these two major components – continuous open area and structural diversity created by shrubs and trees – contradict. In natural, large floodplains both of these components should be in equilibrium – large open grassland areas should alternate with structurally diverse areas. In small grasslands open areas should be prioritised, as long as the grassland is at least 10 ha large and the presence of trees and shrubs in it is not determined by any natural conditions, for example, terrain or the impossibility of continuous management.

Vegetation structure diversity and the height of sward itself are important in terms of ecological niche diversity, especially at the beginning of the breeding season. The presence of places with low vegetation (they will be suitable for meadow waders), as well as places with last year's vegetation, including stalks, is preferable. Such areas provide breeding opportunities for *Acrocephalus* spp., *Saxicola rubetra* and camouflage for *Crex crex* at the beginning of the vegetation season.

17.1.4 Succession

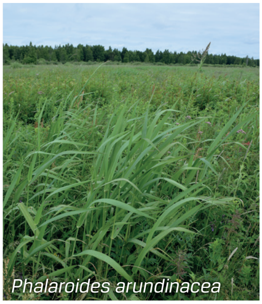
Grasslands can develop naturally in floodplains because the introduction of woody plant species is hindered by the mechanical effects of flooding and ice. Before human influences, floodplain grasslands were probably kept open by wild herbivores (aurochs, tarpans (horses)) (Vera 2000). Grasslands have developed without the forest stage near Lake Lubāns, Lake Burtnieks and elsewhere in Latvia on river banks and lake shores with long floods (Rubenis 1964; Bergmanis 2008). For example, adjustment of Lake Lubāns level (1950s) freed up more than 1,500 ha of land, which was immediately used for mowing.

There are no wild grazers in Latvia today (*Cap-*

Table 17.1.1. Variants of habitat type 6450 *Northern boreal alluvial meadows*. Photo: S. Rūsiņa.

Tall sedge and *Phalaroides arundinacea* floodplain grasslands (6450_1, tall-sedge variant)	**Moist fertile *Alopecurus pratensis* and *Poa* spp. floodplain grasslands (6450_2, *Alopecurus* variant)**
Vegetation in wet places consists of tall sedges and grasses. The most common sedges are *Carex acuta* and *C. elata*. The most common grass is *Phalaroides arundinacea*, in some places also *Calamagrostis canescens*. Hay yield is 1.5–4 t ha^{-1}.	Dominated by tall grasses: *Alopecurus pratensis* along with slightly shorter grasses: *Poa palustris* and *P. trivialis*. *Filipendula ulmaria* spreads in abandoned grasslands. Hay yield is 1.5–4 t ha^{-1}.

Carex acuta



Phalaroides arundinacea

Alopecurus pratensis

Veronica longifolia

Moist moderately fertile floodplain grasslands (6450_3, forb variant)

In moist areas the vegetation is lower. It consists of medium-tall and short grasses: *Helictotrichon pubescens*, *Hierochloe odorata*, *Deschampsia caespitosa*) and sedges (*Carex cespitosa*, *C. disticha*, *C. panicea*). Forbs, such as *Geum rivale* and *Filipendula ulmaria* are common. Hay yield is 1.3–1.5 t ha^{-1}.

Geum rivale

Deschampsia cespitosa

Fig. 17.1.2. Pededze floodplain during spring floods. The unchanged floodplain terrain is well visible. Photo: A. Auniņš.

Fig. 17.1.3. The moist moderately fertile variant in the floodplain of the River Venta near Piltene. Photo: S. Rūsiņa.

Fig. 17.1.4. The moist fertile *Alopecurus pratensis* variant in the floodplain of the River Ošupe in "Lubāna Mitrājs" Nature Reserve ("Lake Lubāns Wetland"). Photo: S. Rūsiņa.

Fig. 17.1.5. Tall sedge variant in the floodplain of the River Gauja in "Ziemeļgauja" Protected Landscape Area. Photo: S. Rūsiņa.

Fig. 17.1.6. Tall sedge variant in the floodplain of the River Sita in "Sitas un Pededzes paliene" ("Sita and Pededze Floodplain") Nature Reserve. Photo: S. Rūsiņa.

Fig. 17.1.7. Floodplain grasslands in Dviete floodplain in "Dvietes paliene" ("Dviete Floodplain") Nature Park (April 2016). Photo: S. Rūsiņa.

reolus capreolus, *Cervus elaphus* and *Alces alces* are browsers) and the river flooding activity is restricted – even the largest rivers do not reach natural flooding volume. For example, the floods in Dviete floodplain are the largest in the whole of Latvia (Škute et al. 2008). Nevertheless, unmanaged floodplain grasslands overgrow with *Salix* spp. there.

Climate change has also affected the frequency and duration of flooding. River runoff in spring in Latvia has decreased (less pronounced flooding period) and increased in winter (Apsīte et al. 2011; Latkovska et al. 2012).2012). For example, the floods lasted for 2-3 months in the floodplains of Lake Lubāna before drainage, while after it the duration of floods decreased by 30 days (Šķiņķis 1992). Consequently, the only maintenance factor nowadays is human economic activity – mowing and grazing (including the continuous grazing of semi-feral herbivores in fenced areas) (Fig. 17.1.12).

If mowing and grazing is interrupted, the grassland first overgrows with expansive (aggressive) herb species, such as *Phalaroides arundinacea, Carex acuta, C. acutiformis, Aegopodium podagraria, Urtica dioica, Filipendula ulmaria*, because they are able to absorb nutrients faster and better, thus outcompeting lower plants. Such overgrown grasslands can persist for decades because the thick herb cover prevents the development of woody plant seedlings. Shrubs and trees establish with time, helped by rodents that create areas free of herbs. In moister places they are *Salix* spp. and *Alnus incana*, in drier places *Betula pendula* and *Populus tremula*. Expansive species tend to enter fertile soils of floodplain grasslands much more frequently than outside floodplains. Wet soils and the action of water and ice during flooding slows down the overgrowth with shrubs. Even floodplain grasslands that have not been managed for several decades are often not overgrown with shrubs. In some places tall sedge tussocks develop due to wet conditions, which makes the management of such grasslands complicated.

Drained areas are characterised by a marked spread of nitrophyte plants (*Urtica dioica, Anthriscus sylvestris*). Most of the drained floodplains have not preserved the diversity of original grasslands because drainage induces peat decomposition, which can be efficiently used by plants, leading to the excessive growth of fertile soil species that outcompete the diversity of former floodplain plants. Restoration of such grasslands is very complicated and often impossible.

17.1.5 Pressures and Threats

The habitat is adversely affected by all of the factors listed and described in Chapter 3. **Drainage** has significantly reduced the floodplain grassland biodiversity and its total area. Arable land or improved grasslands have been created in many drained floodplains. Nowadays, river regulation and restoration and the digging of ditches threatens both the places that have so far been protected from drainage, and places where the previously cultivated grasslands have naturalised in recent decades to the extent that the biodiversity has at least partially returned.

Alongside drainage, **smoothing of floodplain terrain** took place, which reduced the diversity of floodplain terrain, and the grassland diversity in smoothed floodplains decreased dramatically. **Cessation of management** also had a serious impact,

Fig. 17.1.8. Banks of the Venta near the Latvia-Lithuania border in Ezere Rural Territory, 1930s. River banks are mown or grazed up to the water's edge. This is suitable for waders because the water's edge is not restricted by trees and shrubs and banks are suitable feeding places for waders. Photo: Digital library collection Lost Latvia (Zudusī Latvija) of the National Library of Latvia. An image from the collection of the Baltic Central Library of Lettonica and the Baltic Centre of the National Library of Latvia.

Fig. 17.1.9. Pasture in Saikava, Prauliena Rural Territory, 1930s. Cattle grazed the water's edge creating muddy shallow banks that were suitable feeding sites for meadow waders in spring. Photo: Digital library collection Lost Latvia (Zudusī Latvija) of the National Library of Latvia. An image from the collection of the Baltic Central Library of Lettonica and the Baltic Centre of the National Library of Latvia.

resulting in the development of resistant scrub with very low biodiversity.

Eutrophication can introduce a very high amount of nutrients with floodwater. For example, the load of nutrients with floodwater in the floodplain of the River Biebrza in Poland was 31 kg of nitrogen, 7 kg of phosphorus and 2 kg of potassium per hectare annually, in the Rhine floodplains – 42–240 kg of nitrogen and 15–102 kg of phosphorus per hectare per year (Venterlink et al. 2009).

One of the symptoms of **climate change** is periodic drought which can encourage the spread of invasive species in peaty soils. Typical species of wet sites may also be unable to survive the drought conditions and the vegetation structure may change.

If spring floods were to start earlier, the synchronisation of natural processes would be lost. The time of *Gallinago media* return was previously aligned with the maximum flooding level and, as the water level decreased, feeding conditions suitable for a large population of breeding or migrating Great Snipes became available. If the floods start earlier and the return time of Great Snipe remains the same or only becomes slightly earlier, the return of the species coincides with the late flooding stage when there are fewer places with suitable feeding conditions, this furthermore leads to the depletion of feeding places that would be required by the species later in the summer. More frequent flooding after the normal spring flooding season is also forecast due to prolonged rain. If it occurs in the nesting period of Great Snipe, when the eggs have already been laid but not yet hatched, there is a high risk that the nests may drown and nesting success of the species is reduced. Meanwhile, prolonged periods of drought bring the risk of feeding difficulties due to dry soil. It is expected that the migration of earthworms deeper into the soil, which now happens in early July, may take place sooner due to climate change, thus reducing the amount of food available to Great Snipe.

In the last decade, an adverse impact has been caused by inappropriate management – **grass mul-**

Fig. 17.1.10. Natural floodplain grassland near the River Bārta. It becomes completely ruderal (overgrown with weeds such as *Artemisia vulgaris*, *Cirsium arvense*) after abandonment and under the influence of nutrient-rich flood water. Photo: S. Rūsiņa.

ching or leaving in swathes or spread out. Great Snipe feed almost exclusively on earthworms obtained by probing the earth (Løfaldli et al. 1992), therefore free access to soil is very important for it. With prolonged mulching, the mulched grass layer blocks access to soil and can potentially form peat in which earthworms do not live due to its acidity. To reach food, Great Snipe then has to try to reach mineral soil, which can become impossible within a few years, taking into account the length of its beak. Mulching is not only harmful in the floodplain grassland itself, but also in grasslands higher up because mulched grass can be carried with floods from other places.

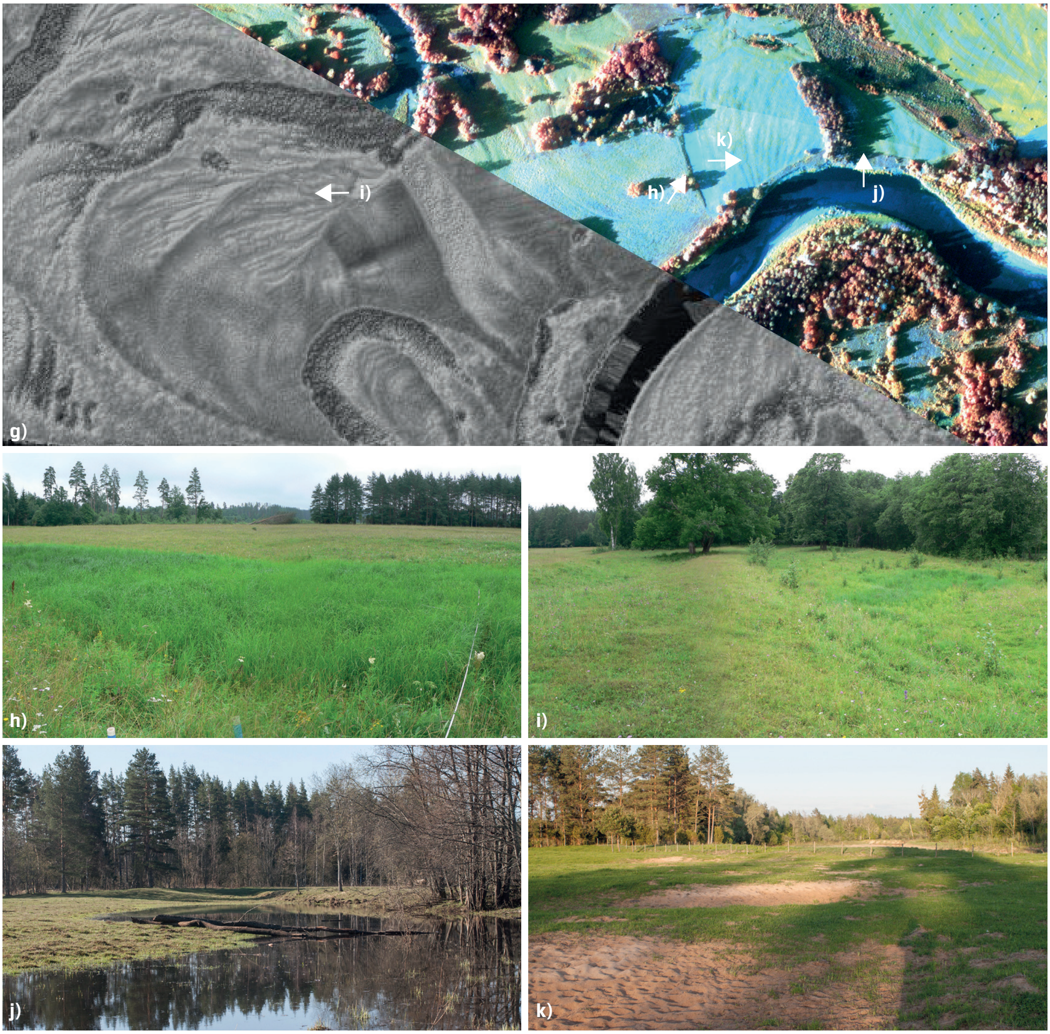
Mowing that is performed too early threatens protected bird species that nest later in floodplain grasslands, especially Corncrake and, to a lesser extent, Great Snipe. Mowing before 1 July destroys

Fig. 17.1.11. Changes in environmental conditions and semi-natural grassland diversity in Gauja floodplain ("Ziemeļgauja" Protected Landscape Region). (**a**) Orthophoto shows a very complex configuration of open grassland areas; (**b**) semi-natural grasslands during spring flooding are fully inundated; (**c**) in the middle of summer, the different shades differentiate the dry and moist grasslands well; (**d**) floodplain grasslands during flooding (mid-summer image on the right (**h**); (**e**) in the middle of summer grass grows so quickly that animals cannot consume all the grass by extensive grazing and plant species have time to bloom and shed seeds; (**f**) cattle keeps the water's edge open by consuming sedges in spring (when they are still soft and appealing to animals); this may not be seen in the second half of summer because the sedges have regrown and animals do not find them palatable any more. (**g**) Laser-scanned image shows the very undulated terrain where the relative height difference reaches up to 1.7 m (Rūsiņa et al. 2013), hyperspectral image (the coloured part of the image) shows vegetation structure differences – each colour corresponds to a certain plant community with its own unique species composition (grassland vegetation in blue and green, trees in dark red and black); (**h**) image shows two types of grassland

a large part of the nests of these species, whereas mowing after 15 July inflicts much less damage and affects only a part of repeated Corncrake broods.

17.2 Conservation and Management Objectives of Floodplain Grasslands

- Ensure landscape connectivity and the continuity and ecological functioning of river floodplains, maintaining the required conditions for natural processes.
- Ensure the preservation of large river floodplain grassland landscapes, preventing their overgrowth with woody species and the establishment of invasive species.
- Ensure the ecological processes characteristic for floodplain grasslands (flooding activity, diverse vegetation and structural



– wet tall sedge grassland in dark green (EU habitat type 6450 *Northern boreal alluvial meadows*), dry grasslands in lighter shade (EU habitat type 6210 *Semi-natural dry grasslands and scrubland facies on calcareous substrates*), the same place in spring under floodwater is seen in image (**d**); (**i**) orthophoto shows the fan-shaped structure of terrain, which enables the close existence of two different grassland habitats (in lower areas 6270* *Fennoscandian lowland species-rich dry to mesic grasslands*, in elevations 6210 *Semi-natural dry grasslands and scrubland facies on calcareous substrates*); (**j**) floodwater even brings large tree trunks and branches in the meadow, the removal of which requires additional management resources. Floodwater remains in depressions for longer, their edges are grazed low in autumn, therefore in spring they are very suitable as feeding places for waders; (**k**) sand brought in by floodwater provides new growth niches for plants and insects, thus promoting diversity in floodplain grasslands. Images produced by the Institute for Environmental Solutions, layout and photo: V. Lārmanis.

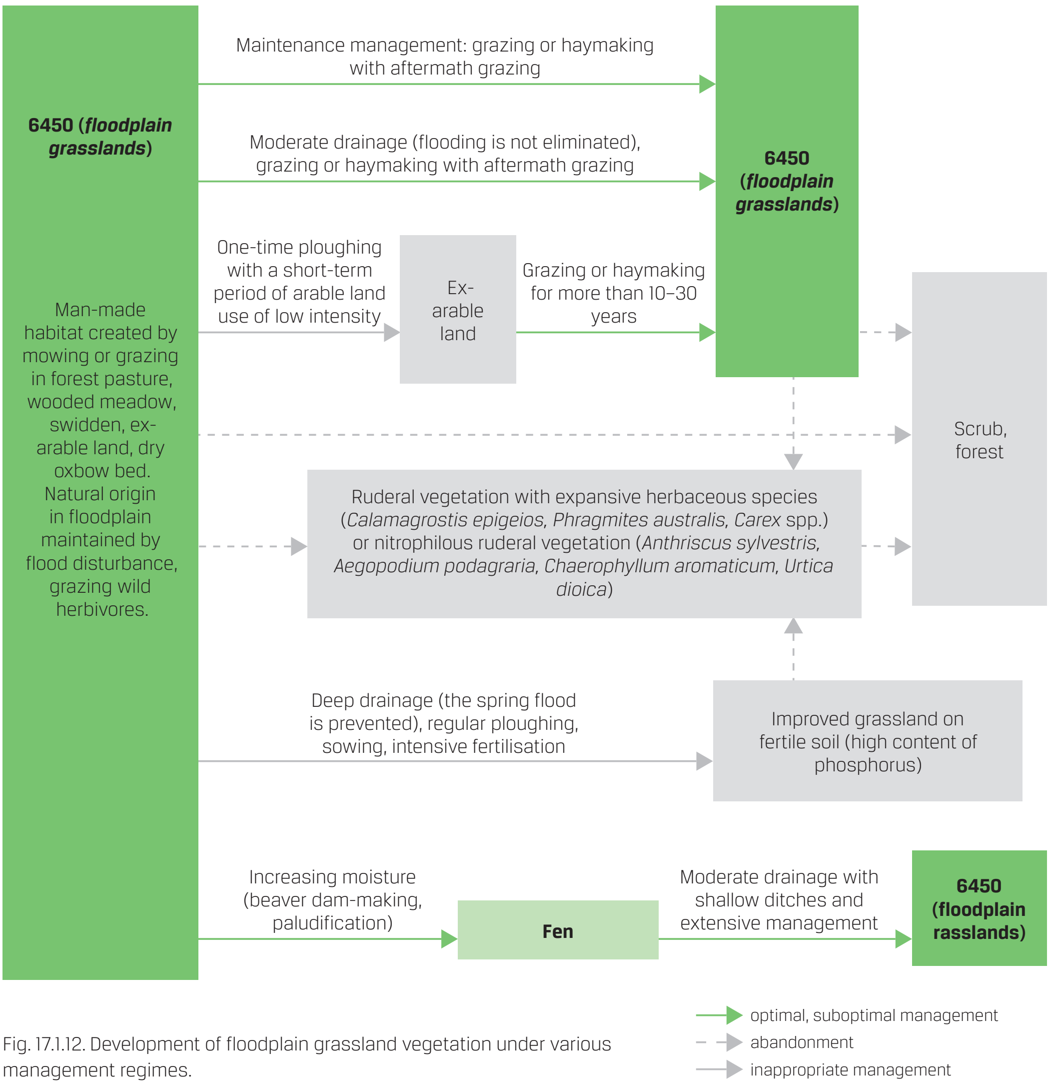


Fig. 17.1.12. Development of floodplain grassland vegetation under various management regimes.

micro-terrain diversity and the nutrient cycling provided by floodplain natural development, flooding activity and appropriate mowing or grazing), creating preconditions that do not decrease the diversity and quality of the ecosystem services offered by floodplain grasslands.

- Promote improvement in the number of localities and conservation status of typical floodplain grassland species, as well as rare and declining species and their populations by restoring suitable habitats for them in degraded floodplain grasslands.
- Restore and maintain the diversity of moss and vascular plant species and communities and habitats suitable for them. Floodplain grasslands are the most important habitat for several protected and rare plant species: *Gladiolus imbricatus*, *Polemonium caeruleum*, *Iris sibirica*, *Cnidium dubium*, *Viola persicifolia*. Plant species richness in floodplains is several times higher than in grasslands outside floodplains.
- Restoration of declining bird populations: the population of *Gallinago media* over the last century has decreased both in Latvia (Auniņš 2001) and elsewhere in the world (Hagemeijer, Blair (Eds.) 1997), therefore the species has not only been included in Annex I of the Birds Directive, but has also been assigned the global threat category “near threatened” according to IUCN crite-

ria. The current population of Great Snipe in Latvia is estimated at 200–300 couples (Auniņš 2001). Management and conservation should be aimed, firstly, at the preservation of the existing population and breeding places and, secondly, at the restoration of currently degraded large floodplain grasslands that are in a bad condition to increase the population of Great Snipe.

- Creating preconditions for the protection of globally threatened bird species in the context of climate change. Although *Acrocephalus paludicola* (Annex I of the Birds Directive, globally "vulnerable" according to IUCN criteria) is currently not a species that breeds in Latvia on a regular basis and its permanent breeding range is south of Latvia, Lithuania, Belarus, Poland, Ukraine and Russia, it is estimated that under the influence of climate change the range of the species will move north-east and include Latvia (Huntley et al. 2007). Thus the capacity of Latvia, together with other countries in the "new" range will be important in compensating the losses of climatic niche in the southern part of the current range by providing high-quality habitats suitable for the species (Huntley et al. 2008).
- Providing a sufficient living space for other grassland related protected species (for example, meadow waders and *Crex crex*) and species with declining populations in Latvia (*Motacilla flava, Carpodacus erythrinus* (Auniņš, 2016)).
- Restoring and maintaining the diversity of invertebrate species and communities and habitats suitable for them: some of the EU protected species are *Lycaena dispar* and *Vertigo angustior*.

17.3 Maintenance and Restoration of Floodplain Grasslands

If the habitat is in a favourable condition, then restoration is not required and only maintenance management is sufficient (*see Chapter 16.3.1*). If any habitat features indicate the opposite (*see Chapter 16.3.3*), than restoration is needed first. Before starting habitat restoration or management, research of the area is required to ascertain the present nature values followed by the development of a management plan (*see Chapter 7*), taking into account the habitat management legal framework (*see Chapter 7.2*).

The impact of grassland restoration work on the diversity of the river should also be assessed (Urtāns (ed.) 2017, *Chapter 17*).

17.3.1 Floodplain Grasslands Requiring Maintenance

All floodplain grasslands that are in a favourable condition require management. Floodplain grassland in a favourable condition is managed by mowing once or twice every year with haymaking and aftermath grazing, thus it is not overgrown with shrubs and is free of litter. The grassland is not drained or only has shallow ditches that do not reduce the duration of flooding substantially. Floodplain terrain is very diverse (it is not smoothed or bulldozed), mesic places or dry elevations alternate with wet depressions. The diversity of plant species is high, there are various plant communities. In some places there are low grass and wet depressions where birds can feed. In other places there are richly flowering herbs for insects to feed on, elsewhere there are tussocks, where birds can nest or hide (Insertion 3, Table 17.3.1).

Meadow birds nest, and their number and diversity corresponds to the grassland parameters (including grassland size and landscape context) – there is a full community of usual grassland species (*Anthus pratensis, Saxicola rubetra, Motacilla flava, Locustella naevia, Acrocephalus schoenobaenus, Carpodacus erythrina, Lanius collurio*), as well as a few couples of *Crex crex* or a meadow wader community. The presence of *Gallinago media* also indicates good quality, however it is only possible in very large floodplains.

17.3.2 Optimal, Suboptimal and Inappropriate Management

A summary of optimal, suboptimal and inappropriate management types is given in Table 1 and 9 of Annex 2.

Traditionally, floodplain grasslands were mown to obtain high-quality fodder for winter, and only the aftermath was grazed. Only grazing is common nowadays. It should be noted that the number of plant species in grazed floodplain grasslands decreases and that grazed grasslands are poorly suited to *Crex crex* (Eriksson 2008a). Grazing is suitable for meadow waders.

Mowing time should be adapted to moisture conditions. Mowing should be carried out in the driest period of summer. In wetter sites, it is recom-

Table 17.3.1. Indications of a well-managed habitat type 6450 *Northern boreal alluvial meadows*.

Parameter	Meadow	Pasture
Litter	Litter covers no less than 10% and no more than 30% of the ground.	
Flooding and moisture regime	Flooding activity is full or at least partial (not completely limited by drainage), high groundwater table remains until at least early and mid-June.	
Vegetation structure	A very colourful meadow in full bloom, proportion of forbs and grasses at least 1:1.	At least 20% of the area with grass shorter than 7 cm and at least 20% of the area with grass taller than 30 cm; flowering plants in at least 25% of the area.
Indicator species of semi-natural grasslands	There are several indicator species of semi-natural grasslands in the grassland, for example, *Cardamine pratensis, Carex panicea, Dactylorhiza* spp. in a great number, *Galium boreale*, *Geranium palustre, Lathyrus palustris, Parnassia palustris, Ranunculus auricomus, Scorzonera humilis, Succisa pratensis, Trollius europaeus*.	
Bird species	*Crex crex* nests in meadows; meadows and pastures feature a community of grassland-specific passerines (in a grassland that is smaller than 10 ha *Crex crex* can be absent and the passerine community can be incomplete). In oxbow lakes and pools – *Porzana porzana* and/or *Rallus aquaticus*. Many different waterbirds (ducks, geese, swans) are present in flooded areas during passage migration, migratory waders occur in shallow sites and along the water edge.	
Invertebrate species	Great diversity of hygrophilous ground beetles, Diptera, as well as anthophilous and coprophilous (in pastures) insects.	
Tussocks	Large sedge tussocks are preserved in some areas, which are important for birds.	
Expansive plant species	Expansive species are not present or cover only up to 10% of the grassland area: for example, *Urtica dioca, Anthriscus sylvestris, Elytrigia repens, Aegopodium podagraria, Filipendula ulmaria*.	Overgrazing indicators do not cover more than 30% of the vegetation area, for example *Trifolium repens, Plantago major, Polygonum arenastrum, Poa annua, Prunella vulgaris*. There is no *Lolium* spp. in the vegetation.
Traces of flooding activity	Flood deposits have mostly been removed from the grassland, mole hills smoothed out.	
Shrubs and trees	Large trees are preserved, small shrubs present in at least 10% of the area, but no more than 30%, not higher than 1.5 m (in grasslands important for birds, shrub cover should be below 10%, but large trees should be preserved due to their biodiversity value, although birds will avoid nesting near them).	

mended to use “floating” machinery that is suitable for wet soils, for example, a tracked tractor or wheeled tractor with wide wheels to provide a larger support surface (*see Chapter* 22.2.1).

Plants and vegetation. The most appropriate management includes mowing with haymaking in mid-June – early July (leaving unmown areas for blooming and seed ripening) and one-time aftermath grazing. Grazing can also be performed in early spring until late May – mid-June, but then mowing is only permissible in late summer when most of the plants have flowered. Annual mowing later than mid-July or mowing with leaving of the grass severely harms floodplain vegetation because in both cases the floodplain constantly becomes enriched with nitrogen, which transforms the sward into homogeneous vegetation consisting of nutrient-demanding species. Although it is an effective method for the preservation of birds, other methods should be chosen instead of late mowing.

In the case of several consecutive wet summers, tall sedges, for example, *Carex acuta* and *C. elata*, can start dominating the sward. Studies in Great Britain have shown that mowing and the removal of grass twice per season (in the first half of June and August) for a few years reduces the amount of sedges, but only if the summers are not constantly wet (Rothero et al. 2016).

Birds. Grazing is the most appropriate management type for meadow waders and its intensity should ensure low vegetation at the beginning of the breeding season. Mowing in floodplains should be coordinated with flooding – mow not earlier than two months after floodwater recedes (when meadow bird chicks have matured), furthermore, mowing should be performed in a manner that is safe for birds and other animals – from the centre to the edges or from one edge to the other so that animals have a chance to escape.

Invertebrates. Floodplain grasslands subjected to periodic flooding often have a rather heterogeneous structure and they are maintained by extensive grazing and mowing. Herds can be mixed: cattle, sheep, horses. Adaptive (New 1995; Kirby 2001) mowing – mowing in bands, leaving an unmown band/bands in the entire length of the grassland can be performed for the maintenance of floodplain grassland invertebrates. The unmown band can occupy up to 10% of the meadow area. If vegetation is high, such bands serve as sources of a suitable microclimate. In subsequent years the bands are changed to another location. Bands are not required if other microclimate-forming structures are present – forest edges, shrub and tree bands, or if the managed area is smaller than 1 hectare.

To protect **fish,** oxbow lakes should be connected to the river to ensure access to it after spawning and avoid a lack of oxygen in the low-water period or in winter. In the past, when fishing with nets for personal consumption used to take place in oxbow lakes, they did not overgrow.

17.3.3 Floodplain Grasslands Requiring Ecological Restoration

When planning the restoration of floodplain grasslands, its feasibility and necessity in drained grasslands, the restoration objectives and their achievement potential should be defined in the particular situation.

The decisions on whether to start rewetting and what methods to use must be made depending on the area pending restoration and the total grassland area in the landscape, the existing and preferable groundwater table and flood regime, as well as the existing and preferable soil fertility (*see Chapter 21.6* and *Table 21.6.1*).

Grassland requires restoration if it has one or more of the following features:

- it has not been managed for several years;
- it has been mown by mulching or leaving the grass for more than five years;
- it is very tussocky;
- overgrown with trees and shrubs;
- it has been drained and the flooding action is absent or is significantly lower than before drainage;
- vegetation is dominated by one or several expansive species, for example, *Urtica dioica, Aegopodium podagraria, Anthriscus sylvestris, Elytrigia repens, Filipendula ulmaria, Phragmites australis*;
- there are many invasive species, for example, *Impatiens glandulifera, Echinocystis lobata, Solidago canadensis, Helianthus tuberosus*;
- vegetation consists of sown grasses: *Dactylis glomerata, Phleum pratense, Festuca pratensis*;
- there are signs that bird species diversity and the number of rare species is decreasing or that it will happen soon, for example, the number of *Gallinago media* breeding in the grassland, the number of couples of other nesting waders, the number of *Crex crex* calling during the nesting season decreases for several consecutive years, or passerine species that have always been present start disappearing.

17.3.4 Restoration Potential

Floodplain grasslands in Latvia disappear due to overgrowth, drainage and cultivation. One of today's most important objectives in the context of biodiversity is to restore the floodplain flood regime disrupted due to large-scale floodplain drainage of previous decades. However, it is not always a successful and sufficient measure to achieve the restoration of species composition characteristic of floodplain grassland.

Depending on the character of the drained river, it has to be decided, whether the creation of the grassland is possible and sustainable. If the river gradient is very low, it flows through a plain, the soil is dense and not water-permeable or high activity of beavers is expected with the following paludification, it is more practicable either to create a wetland (by raising water levels), or to restore the grassland without raising the water level (maintaining the hydrological regime that enables the management of grassland) (Rīze et al. 2015).

Restoration options depend on the degree of drainage impact on the floodplain, the flood regime and nutrient composition in the floodwater, as well as soil fertility and vegetation. Two levels of restoration complexity can be distinguished based on these parameters.

17.3.4.1 Floodplain grasslands that are relatively easy to restore

Vegetation that perfectly matches natural moist or wet grassland vegetation with various plant species including grasses and forbs indicates that the drainage has not had a substantial impact on the grass-

Fig. 17.31. Floodplain grassland overgrown with shrubs that is easy to restore. All species characteristic of semi-natural grassland still occur. Drainage ditches are present, but they do not significantly affect vegetation, so no rewetting is necessary and mowing or grazing should be resumed. Photo: S. Rūsiņa.

Fig. 17.3.2. Floodplain grassland overgrown with *Filipendula ulmaria* that is relatively easy to restore. Restoration of moisture conditions and mowing with hay removal or grazing is required. Photo: S. Rūsiņa.

Fig. 17.3.3. Floodplain grassland that is difficult to restore overgrown with *Anthriscus sylvestris*. Only some of the semi-natural floodplain grassland characteristic species remain. Photo: S. Rūsiņa.

Fig. 17.3.4. Intensively drained and improved floodplain grassland that is difficult to restore in polder near Lake Liepāja. There are almost no plant species characteristic of semi-natural floodplain grassland. Photo: S. Rūsiņa.

land and rewetting is not required (Fig. 17.3.1).

In sites where drainage has had a partial impact, the vegetation usually resembles mesic grassland, and moist depressions are preserved in some places and the grassland is moist or wet only in spring and autumn. Long-abandoned grasslands can be dominated by *Filipendula ulmaria* or shrubs (mostly various *Salix* species). For the restoration of such grasslands, only a slight increase in moisture or the resumption of mowing and grazing after shrubs are cleared is sufficient (Fig. 17.3.2).

In some cases, semi-natural mesic grassland may develop under the new moisture conditions in well-drained floodplains with mineral soil as a result of extensive management. Usually this occurs 30-50-100 years after drainage, if the soil has not been substantially improved afterwards, but only mowing and/or grazing has been continued. Semi-natural grasslands develop more easily in places, where the moisture conditions are naturally slightly moist rather than permanently wet and the drainage is only slight – shallow ditches up to 40 cm in depth that only remove excess surface water, while the groundwater table remains sufficiently high for species requiring moist sites. In such situations, restoring the moisture regime is not necessary, but rather the existing nature values should be maintained.

17.3.4.2 Floodplain grasslands that are difficult to restore

Intensively drained floodplains in peaty soils, where the peat has mineralised and the grassland is mesic or moist only in spring and temporarily wet in autumn, are difficult to restore. Vegetation is dominated by nitrophilous species, *Anthriscus sylvestris, Aegopodium podagraria, Urtica dioica, Elytrigia repens*. Shrubs often fail to enter the area even in long-abandoned grasslands; if the establishment of woody species occurs, then they are usually *Alnus incana*.

Intensively drained floodplains in mineral soils, where the grassland is only mesic or moist and temporarily wet in spring and autumn due to drainage, can be difficult to restore. Vegetation may not contain nitrophilous species, however, nutrient-demanding species are characteristic: *Dactylis glomerata, Alopecurus pratensis, Phleum pratense*. Woody species do not enter the area for a long time or *Alnus incana*, and on rarer occasions *Salix* spp., get established (Fig. 17.3.3, 17.3.4).

Since the creation of meadows and pastures in wetlands has been traditionally linked to drainage, the necessity and extent of rewetting should also be carefully considered in restoration. It should not be simply assumed that complete elimination of a drainage system, for example, by filling all ditches, will restore the moisture conditions suitable for floodplain grassland. It was a common practice in Latvia to implement a shallow drainage in floodplain wetlands to create semi-natural meadows (*see Chapters 1.5 and 21.6.3*). Such sites were mostly deep drained during the Soviet Period and semi-natural grasslands was destroyed. After deep drainage, the signs of previous drainage systems (such as shallow ditches) are usually not visible in nature. To restore a floodplain grassland in such a site, overly excessive rewetting should be avoided.

Therefore, the optimal hydrological regime for the plant and animal community pending restoration should be determined first and the rewetting plan should be based on this. No data about annual groundwater table fluctuations optimal for habitat types and their variants in Latvian floodplain grasslands is available, but it is necessary for habitat restoration planning. For reference, spring and summer groundwater tables for floodplain grasslands in Great Britain are provided in Table 17.3.2.

The grassland can exist in the range between the optimal values and non-permissible values, but not for a long period of time. If optimal values are exceeded for several consecutive years (even without exceeding the non-permissible values), the grassland begins to transform.

As studies in Central Europe have shown, restoration of spring flooding and extensive mowing or grazing alone can fail to reach the desired results (Bissels et al. 2004). This can occur for a variety of reasons. Rewetting decreases the levels of bioavailable nitrogen, but may contribute to increased availability of phosphorus, which can cause eutrophication and prevent an increase in biodiversity.

If the grassland is located in a floodplain, entered by floodwater very rich in organic matter, the restoration of grassland or improvement of its conservation status by only restoring flooding is virtually impossible. Following the restoration of flooding activity within five years in a previously drained floodplain in Belgium, the vegetation diversity decreased (Vercoutere et al. 2007).

Experience in other countries shows that for the restoration of biodiversity and species communities, soil fertility reduction is necessary if the phosphorus level is above 50 mg kg^{-1} (according to the Olsen method) and nitrogen mineralisation is greater than 80 kg ha^{-1} per year (Wheeler et al. 2004; Duranel et al. 2007; Venterlink et al. 2009).

This could also apply to Latvian floodplain grasslands, however so far the data on chemical soil properties in floodplain grasslands is very sparse. For example, in the Dviete river floodplain grasslands that have been drained, but still have a marked and long spring flooding period and vegetation characteristic of floodplain grasslands, the topsoil nitrogen content was 9–18%, phosphorus – 12–25 (40) mg kg^{-1} (0.2 M HCl extraction), potassium – 150–274 mg kg^{-1} (1.0 n CH_3COONH_4 extraction) (unpublished data of the LIFE NAT-PROGRAMME project).

In very heavily drained floodplains, which have previously been fens, vegetation may not be very tall and productive, but biodiversity is also very low and difficult to restore because the soil nutrient balance is disrupted. These soils can contain high levels of nitrogen available to plants, but very little phosphorus or potassium. It is almost impossible to restore the previous biodiversity in such places, since restoration of the biochemical soil processes is very complicated. Bioavailable potassium can leach out very quickly after drainage because its reserves are lower than those of nitrogen, which is biologically immobilised in peat and is released gradually. Mowing encourages much faster removal of potassium from the soil (with plant parts containing potassium) than the removal of phosphorus or nitrogen, therefore long-term mowing with hay-

Table 17.3.1. Hydrological regime parameters in floodplain grasslands in Great Britain (according to Wheeler et al. 2014).

Hydrological regime parameters	Grassland types			
	Moist fertile Alopecurus pratensis variant		Moist moderately fertile variant (Geum rivale)	
	Optimal values	Non-permissible values	Optimal values	Non-permissible values
SPRING (March-May)				
Average maximum groundwater table depth, cm	45	>80	20	>45
Average minimum groundwater table depth, cm	45	20	20	<2
Cumulative duration of flooding per season, days	0	>30	9	>45
SUMMER (June-August)				
Average maximum groundwater table depth, cm	70	-	30	>65
Average minimum groundwater table depth, cm	70	<35	30	<15
Cumulative duration of flooding per season, days	0	>14	5	>60

making often does not increase the biodiversity, since species that tolerate a low amount of potassium and high amount of nitrogen remain in the vegetation for a long time (Klimkowska et al. 2007).

Another limitation of floodplain grassland restoration is the lack of persistent seed bank. If the period of improved grassland has been long, then species diversity does not recover upon the recommencement of management because no species resources are present in the area. Fragmentation prevents the introduction of species from other grasslands in the region, because most species have poor dispersal capacity. Therefore the supplementary sowing of seeds or transfer of a seed-containing material from species-rich grassland sites has great significance in the restoration of floodplain grasslands.

The restoration of severely degraded floodplain grasslands is more successful in terms of **bird habitat** restoration than the restoration of plant communities. Introduction of mowing or grazing in abandoned grasslands even without restoration of the moisture regime, will create suitable conditions for *Crex crex* and meadow passerines. To make grassland suitable for meadow waders, restoration with rewetting is necessary. Higher soil fertility ensures better feeding conditions for birds (fertile soils contain more earthworms, which are the main food source of *Gallinago media*), therefore rewetting usually gives good results.

The “flag species” of floodplain grasslands is the very rare and globally threatened bird species *Gallinago media*. Therefore restoration of floodplain grasslands should be primarily aimed at their suitability for *Gallinago media*. Other species characteristic of floodplain grasslands (for example, *Crex crex*, *Porzana porzana*, meadow ducks, various passerines) will also benefit from restoration measures that are beneficial for *Gallinago media*. To ensure that the grassland is suitable for *Gallinago media*, the following should be restored:

- the hydrological regime of floodplain grassland – annual spring floods should occur to the extent and intensity depending on the conditions of the previous winter;
- high groundwater table in spring and early summer, ensuring wet and loose soil required for the species;
- free access to mineral soil, getting rid of litter accumulated as a result of inappropriate management (leaving or mulching) or long-term abandonment;
- large continuous open area: the desired continuous grassland area is 100 ha and larger. However, there are situations where it may be smaller, especially if there is a large total proportion of suitable habitat in the landscape.

Invertebrates depend on plant diversity, so their diversity is affected by the same factors as vegetation diversity.

Availability of nitrogen to plants in the floodplain grasslands of the River Biebrza
Nitrogen mineralisation in drained peaty floodplains of the River Biebrza (Poland) was >100 kg ha^{-1} per year. This means that the amount of nitrogen that plants could obtain from soil per year was equal to the amount available to plants in grassland fertilised with 100 kg ha^{-1} of nitrogen fertiliser per year. In drained floodplain grasslands, more phosphorus and potassium than nitrogen is removed from hay every year. For example, in drained floodplains of Poland a reduction of potassium was already observed after nine years, while a reduction in nitrogen occurred only 26-45 years later. Therefore plants gradually start lacking potassium and phosphorus, and vegetation can be low and sparse even in nitrogen-rich soil. However, a great diversity of plant species cannot exist in such conditions anyway, because such soils do not occur in natural conditions and plant species are not adapted to them (Venterlink et al. 2009).

17.3.5 Restoration Methods

The necessary restoration methods are summarised in Table 20.1 of Chapter 20 and in Chapter 21. Creation of a riverbed profile that corresponds to a natural river is possible, if water flow rate requirements are followed (described in Part 9 of Regulation of the Cabinet of Ministers No. 631 "Construction standard LBN 224-05 "Amelioration systems and hydrotechnical structures""[1].

When restoring floodplain grasslands, several restoration aspects should be taken into account.

Grassland surface smoothing: grassland surface is often changed by severe spring floods which bring sediments, reed debris and turf and sand onto the grassland, therefore grassland surface smoothing may even be necessary every year. However, some debris may be left in the grassland to increase its structural diversity.

Rewetting: In many cases drainage has led to nearly irreversible changes in soil and vegetation, so the evaluation of this aspect is a very important stage of grassland restoration. In many cases, rewetting without other important biotechnical measures will make the grassland suitable for a few grassland bird species only and will not encourage the restoration of vegetation.

After the rewetting of previously heavily drained grasslands, the level of nitrogen in the soil usually decreases, but it is still much higher than it should be. Unlike nitrogen, the amount of phosphorus increases (it transforms from inactive forms to active forms available to plants), possibly even reaching 7 kg ha^{-1} per year, and species diversity may continue to decrease rather than increase (Klimkowska et al. 2007).

It is important to assess, whether the surface water and groundwater entering the grassland after rewetting will have a chemical composition that is suitable for the vegetation. If they contribute to acidification or eutrophication, restoration will not be successful (Klimkowska et al. 2015).

Targeted sowing of plant species: required if no floodplain grasslands in good condition are adjacent to the restored area or if no flooding activity occurs due to drainage. In other cases, maintenance grazing or mowing is sufficient because plant species will enter the area from adjacent grasslands, helped by spring floods.

Restoration grazing: floodplain grasslands are subjected to spring floods, as well as inundation during heavy rain in summer and autumn, therefore a sufficient area of safe refuge should be provided for cases of sudden inundation. In wet floodplain grasslands mowing should be preferred to grazing. Temporary very intense grazing (till black soil) can be used to control shrubs.

Creation of suitable conditions for floodplain grassland birds: the most important target species in floodplain grasslands are *Gallinago media* and other meadow waders. Regular flooding and a high groundwater table that maintain moist and loose soil are more important for *Gallinago media*, whereas vegetation parameters are less important. Meadow waders in spring require very low-grazed vegetation, therefore the grazing pressure in floodplain grasslands important for these birds should be higher than in other grasslands. Increasing the grazing pressure after the end of the bird breeding season is preferable.

17.4 Conflicting Management Priorities of Floodplain Grasslands

Managers of floodplain grasslands can experience conflicting management situations applicable to all other grasslands (*see Chapter 7.1.4*). Special attention should be paid to the occurrence of early- and late-flowering plant species in the grassland, the status of rare plant species populations (for example, *Iris sibirica, Gladiolus imbricatus, Cnidium dubium*, orchids) and requirements of bird species (*see Chapter 7.1.4*). The primary target species of large, regularly flooded floodplain grasslands is *Gallinago media* – management of grasslands should be organised in a manner that is favourable for this species. In floodplain grasslands that are not suitable for *Gallinago media*, the management model should be selected either for the benefit of *Crex crex* or meadow wader species. In small grasslands that are too small for these species, grassland value can be increased by attracting passerine species.

17.5 Examples of Floodplain Grassland Restoration in Latvia

Floodplain grassland habitats in Latvia have been restored in several LIFE projects. The most important areas have been restored in the projects "Management of the Lubāna Wetland Complex" LIFE03 NAT/LV/000083, "Restoration of Latvian floodplains for EU priority species and habitats" LIFE04 NAT/LV/000198, "Protection and management of the Northern Gauja Valley" LIFE03 NAT/LV/000082.

Rewetting (blocking of ditches, cleaning of ditches, restoration of natural river flow)

- LIFE project "Management of the Lubāna Wetland Complex" (2003–2007) included blocking of ditches, clearing of shrubs and mowing of meadows. An initial increase in *Gallinago media* population and an increase in moisture in adjacent meadows was achieved. The meadows are becoming increasingly difficult to access and mow, and the construction of access roads is required. In recent years, the population of *Gallinago media* has decreased, possibly due to mulching and repeated overgrowth of some restored meadows (Bergmanis 2008);
- LIFE project "Restoration of Corncrake habitats in the Dviete floodplain Natura 2000 site" LIFE09 NAT/LV/000237 (2010–2015) included the re-creation of meanders of the previously straightened River Dviete in 2015 and restoration of the spring flooding regime (Gruberts 2015);
- LIFE project "Conservation of Wetlands in Ķemeri National Park" LIFE02 NAT/LV/008496 (2002–2006) included the re-creation of meanders of the River Slampe in 2005 and the creation of wild herbivore pastures. Improvement of the hydrological regime has been achieved – floods occur again for the first time since the 1970s; the site is used as a rest and feeding area by migratory birds, grassland vegetation is becoming more natural (Ķuze et al. 2008; Priede 2013; Priede et al. 2015) (Fig. 17.5.1–17.5.2, *see also examples in Chapter 21.5*).

Fig. 17.5.1. Flooding no longer occurred after straightening the River Slampe (the ditch in the image). Photo: A. Priede.

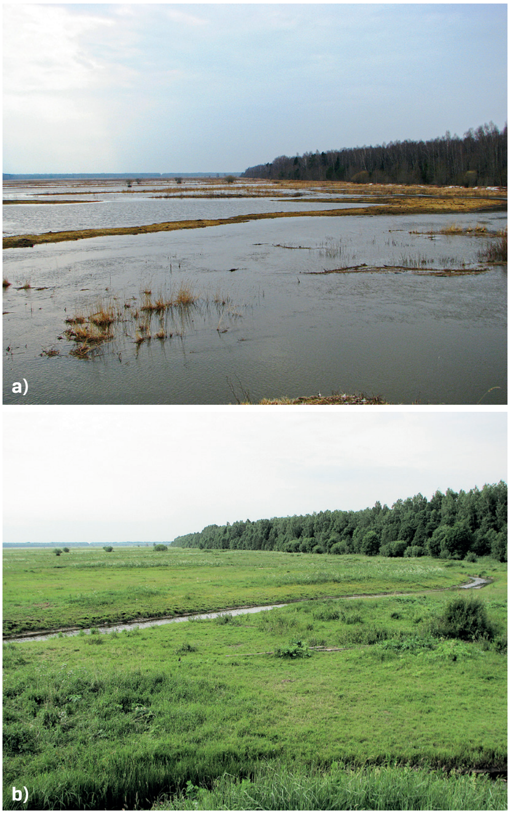


Fig. 17.5.2. Following the re-creation of meanders of the River Slampe, spring flooding returned. (**a**) River meander fragment dug in 2005; in summer the grasslands are mesic, (**b**) spring floods in 2013. Photo: A. Priede.

Felling of trees and shrubs: the method has been used in most floodplain grassland restoration projects. Benefits: stopping the overgrowth of grassland with scrub or forest and grazing or mowing has been commenced in most grasslands restored by this method. Where mowing and/or grazing have not been introduced after the clearing of shrubs, the effect is temporary and later even encourages the overgrowth of grassland, because shrub shoots regrow more densely and very quickly.

Shrub root grinding: used efficiently in several projects to reduce shrub regrowth. In larger areas this has been done within the LIFE project "Restoration of Latvian floodplains for EU priority species and habitats" LIFE04 NAT/LV/000198 (2004–2008) and "Restoration of Corncrake habitats in Dviete floodplain Natura 2000 site" (2010–2015), it has also been widely used in grassland restoration in Ķemeri National Park. Already in the next year after restoration, the grassland could be mown with a mowing technique, which is not possible if the shrubs have only been felled. Vegetation recovers quickly – shrub vegetation is replaced by grassland vegetation, species characteristic of semi-natural grasslands get established (Kalvīte 2015) (*see also examples in Chapter 21.4*).

Establishment of pastures: used in most LIFE floodplain grassland restoration projects. It is one of the most effective ways to restore grasslands, since it is possible in sites, which cannot be mown (no good access roads, too moist for mowing or too dry to mow efficiently).

With sufficient grassland grazing pressure, all documented restoration cases demonstrated very good results – tree and shrub cover decreased substantially or disappeared, the vegetation recovered, the area of open landscape suitable for birds increased. Higher grazing pressure had decreased the *Crex crex* population due to less successful nesting (Ozols 2008; Mednis 2008; Rūsiņa 2008a; Gruberts, Štrausa 2011). In floodplain grasslands of the left bank of the River Lielupe (downstream of Kalnciems bridge), grazing was commenced in 2003. Twelve years of grazing in one large enclosure all year round has resulted in markedly mosaic-type vegetation (Caune, Priede 2015). This study also revealed the adverse impact of beaver activity on the grassland sward – in just 2-3 years the grassland has become paludified with the formation of sedge and swamp vegetation of shallow water. More than 10 years of observations in Dundurpļavas in Slampes floodplain show that grazing is a more efficient grassland restoration method than mowing (Priede et al. 2015).