Chapter 15. 6410 *Molinia meadows on calcareous, peaty or clayey-silt-laden soils* (S. Rūsiņa, A. Auniņš, V. Spuņģis)

15.1 Characteristics of the Habitat Type

15.1.1 Brief Description

Habitat type 6410 *Molinia meadows on calcareous, peaty or clayey-silt-laden soils* (referred as *Molinion grasslands* in the text) develop in moist areas poor in nutrients (nitrogen, phosphorus) in lake and river floodplains as well as outside of them in areas with fluctuating groundwater tables.

The habitat occurs rarely in Latvia – it occupies 1,400 ha or 3% of all semi-natural grasslands (Fig. 15.1.1). The largest areas are situated in Western Latvia (Ķemeri National Park, around Lake Liepāja, Ugāle Plain), in some places in Central Latvia (Ropaži Plain) and only a few localities are known in South-East Latvia (Rūsiņa 2013h). Latvia has 3.3% of the total area of *Molinion* grasslands in the EU boreal region.

Periodically moist sites in Latvia are often drained using internal drainage or open ditches. In such locations grasslands have been ploughed or cultivated and not all of them meet the status of habitat of EU significance. To classify the grassland as an EU protected habitat:

- the grassland should contain plant communities characteristic of the habitat with typical dominant plant species;
- if the turf is very sparse and there are pronounced signs of former arable land or improved grassland, then the grassland should contain at least five semi-natural grassland indicator species (Annex 4) that occur across the entire grassland and not just in some of its parts (for more details *see Chapter 1.2*).

Vast *Molinion* grasslands occur in the Lake Liepāja floodplain – "Vītiņu Pļavas" Nature Reserve, "Diļļu Pļavas" Nature Reserve and Ķemeri National Park. In many protected areas and outside them, these habitats occur in small areas (Fig. 15.1.2 –15.1.5).

No published summaries on the restoration and management of this habitat are available, therefore the guidelines have been based on practical experience and scientific articles (Klimkowska et al. 2007; Rēriha, Rūsiņa 2009; Priede 2011; Medene 2012; Laiviņš et al. 2012 and others).

15.1.2 Vegetation, Plant and Animal Species

Vegetation. Regularly managed grasslands are characterised by high biodiversity (Fig. 15.1.6). Due to periodically dry conditions, these grasslands can have a relatively high proportion of dry grassland species, especially if the soil is calcareous. Such species are, for example, *Briza media*, *Filipendula vulgaris*, *Plantago media*, *Poa angustifolia, Campanula glomerata*. These grasslands frequently occur in a complex with the EU protected habitat type 7230 *Alkaline fens*, especially near diffuse spring discharges.

Birds. Species that develop a typical grassland bird community, such as *Motacilla flava*, *Anthus pratensis*, *Saxicola rubetra*, *Acrocephalus schoenobaenus*, *Locustella naevia*, *Emberiza schoeniclus*, often occur in *Molinion* grasslands. Furthermore, the grassland usually has a mosaic of low-density shrubs and shrub clusters that is suitable for certain passerine species (*Emberiza schoeniclus, Carpodacus erythrina, Lanius collurio*). *Porzana porzana* and *Rallus aquaticus* occur in wet depressions, if there are any. If the grassland area is sufficient, *Crex crex* and/or meadow waders may also nest there, such as *Tringa totanus*, *Gallinago gallinago*, *Vanellus vanellus*, on rarer occasions also *Limosa limosa* and *Philomachus pugnax*. Grassland is also used by *Tetrao tetrix* as a lekking site. If the meadow is located near a water body or water course with a developed vegetation mosaic, meadow breeding 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 nest 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. If grasslands become flooded in spring, they are used as resting and feeding grounds by a large number of various waterbird and wader species.

Every listed species has its own specific requirements for breeding or feeding habitat. Therefore, only a large *Molinion* grassland can be diverse enough to ensure the required ecological niches for all these species. In a smaller grassland, species assemblages will be incomplete – only the species for which the conditions are suitable will be present.

Invertebrates. *Molinion* grasslands are relatively well researched in terms of invertebrates. They have a high diversity of various insects. Characteristic species are *Euthystira brachyptera*, *Cicadella viridis*, *Coenonympha arcania*. In addition to the

rich range of insects, *Molinion* meadows also contain *Dolichopodidae* and *Chamaemyiidae*. Topsoil fauna contains approximately 150–200 different arthropod species. A great diversity and population density of millipedes *Diplopoda* is characteristic of these grasslands.

15.1.3 Important Processes and Structures

An important maintaining factor is seasonal variability of moisture regime. It is caused by pronounced fluctuations of the groundwater table, usually determined by surface runoff changes. Such habitats develop in floodplains, where the groundwater table fluctuates depending on the hydrological regime of the river or lake, and in sites where the temporary groundwater table (local, relatively shallow impermeable or low-permeable layer, such as clay) is present, or in groundwater discharge zones. Therefore, the habitat may occur in terrain depressions, as well as on hillsides and hilltops.

The annual amplitude of groundwater table fluctuations – average water table depth, as well as the maximum and minimum depth (De Becker et al. 1999) is a very important factor.

Usually groundwater table fluctuations are seasonal. It is higher in spring and autumn and lower in summer (Fig. 15.1.7). However, grassland can also be wet in summer following long or heavy rain. In such conditions, a specific plant community develops. Plant species of dry and moist areas can grow together. In especially dry summer periods, some plant species may wither, creating areas free from turf, where new species can establish by seed, thus maintaining diverse grassland vegetation structure and species richness. The vegetation in spring develops slightly slower than in grasslands with a normal moisture regime, therefore these grasslands are usually mown later – in mid- or late July, when the grass has grown sufficiently. Highly variable moisture conditions in different years determine the development of different vegetation structure, changing the role of species and species groups in plant communities and creating a different appearance of the grassland.

A very important factor is calcium. Soil reaction has to be neutral or alkaline to enable the formation of habitat. This is usually ensured by calcium-rich substrate (for example, snail shells in floodplains, supply of calcium-rich groundwater, dolomite layer close to topsoil). *Molinia* variant can also form in acidic peaty soils.

Gleying occurs due to moist conditions, humic and peaty medium-acidic to alkaline soils usually develop. They are poor in nutrients (phosphorus, potassium and nitrogen) because nitrogen is not available to plants due to the wet conditions, but phosphorus tends to be immobilised in iron compounds or its absorption by plants is prevented by high calcium concentration.

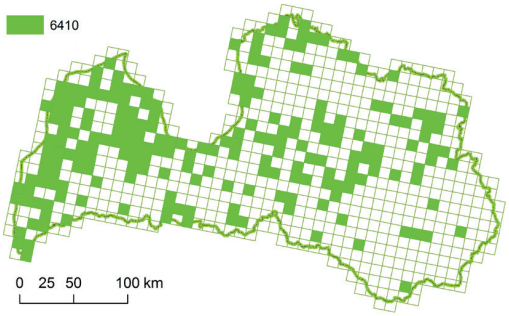

Fig. 15.1.1. Distribution of EU protected habitat type 6410 *Molinia meadows on calcareous, peaty or clayey-silt-laden soils* in Latvia (Anon. 2013a).

15.1.4 Succession

The habitat in Latvia has been developing both naturally and on former arable land. Naturally this could happen through grazing by wild herbivores in moist forests and in river and lake floodplains. Human influence caused its development through the grazing and mowing of fens and moist forests. In slightly drier areas where ploughing was possible, the habitat has mostly developed in former arable land, after the commencement of mowing or grazing (Fig. 15.1.8).

With extensive use, the grassland can remain almost unchanged for a long period of time (decades or centuries). Paludification (peat formation and establishment of species characteristic of fens) can take place in moister areas. In more acidic soils, habitat type 6230* *Species-rich Nardus grasslands, on siliceous substrates in mountain areas* or 4010 *Northern Atlantic wet heaths with Erica tetralix* may develop.

With reduced regularity or intensity of management, the cover of *Molinia caerulea* and *Sesleria caerulea* in plant communities increases temporarily and almost monodominant stands of these species develop. The cover of *Molinia caerulea* also increases after drainage. As abandoned *Molinion* meadows gradually become more wet, *Carex lasiocarpa* characteristic of fens and transitional mires get established. Ceased management in western Latvia has resulted in the development of almost mono-

Table 15.1.1. Variants of habitat type 6410 *Molinia meadows on calcareous, peaty or clayey-silt-laden soils.* Photo: S. Rūsiņa.

***Molinia caerulea* grasslands (6410_1, Molinia variant)**	***Sesleria caerulea* grasslands (6410_2, Sesleria variant)**
High vegetation (1 m and taller) consisting of tall grasses – *Molinia caerulea* and less frequently *Festuca arundinacea*. The most common sedges are *Carex flacca* and *C. panicea*. Various forb species – *Scorzonera humilis, Betonica officinalis, Trollius europaeus, Succisa pratensis.* Hay yield 1–1.5 (2) t ha^{-1}.	Grasslands with very low vegetation (15–20 cm). Dominated by *Sesleria caerulea*, low sedges: *Carex panicea, C. hostiana, C. flava.* The most common forbs are *Ophioglossum vulgatum, Scorzonera humilis, Potentilla erecta, Polygala* spp., *Selinum carvifolia.* Hay yield 0.5 t ha^{-1}.



Sedge grasslands (6410_3, sedge variant)	**Polydominant grasslands (6410_4, forb variant)**
Low vegetation mainly consisting of low sedges (*Carex panicea, C. hartmanii, C. hostiana, C. flacca*). Forb cover can be negligible, the same species as found in other variants of this habitat are typical. Hay yield 0.5–1.0 t ha^{-1}.	Vegetation is moderately tall (30-50 cm), more dominated by forbs, less grasses. There is no single dominant species, high species richness. Characteristic species are *Succisa pratensis, Inula salicina, Potentilla erecta, Ophioglossum vulgatum*, grasses: *Briza media* and *Helictotrichon pubescens*. Hay yield 0.5–1.0 t ha^{-1}.



Fig. 15.1.2. "Vītiņu Pļavas" Nature Reserve in Grobiņa Municipality has a rich locality of the protected species *Sanguisorba officinalis*. Photo: S. Rūsiņa.

Fig. 15.1.3. The northern part of "Diļļu Pļavas" Nature Reserve (Alsunga Municipality) is the only area where this habitat is currently managed within a nature reserve. Photo: S. Rūsiņa (December 2015).

Fig. 15.1.4. Several *Molinion* grasslands have been restored in Ķemeri National Park in 2014. *Sesleria caerulea* and *Polygala amarella* bloom abundantly in spring. Photo: S. Rūsiņa.

Fig. 15.1.5. In Slītere National Park, the *Molinion* grasslands occur in small glades. Photo: S. Rūsiņa.

Fig. 15.1.6. (**a**) Vegetation can be very small-leaved or narrow-leaved if it is dominated by sedges and rushes – *Carex panicea, C. hartmanii*, and *Juncus conglomeratus* creates the bluish shade of vegetation, or (**b**) markedly broad-leaved if dominated by forbs – *Cirsium heterophyllum, Trollius europaeus*, and *Filipendula ulmaria*. Photo: S. Rūsiņa.

dominant stands of *Carex hostiana* and *C. buxbaumii* in some places. When woody species get established, grassland mainly overgrows with *Salix* spp. (in coastal areas of western Latvia also with *Myrica gale*), later also with *Betula* spp. and *Alnus glutinosa*. Due to periodically wet conditions, especially in floodplains and groundwater discharge areas, overgrowth takes place relatively slowly and a sparse shrub layer can be maintained for a long time. The role of moss increases in areas with prolonged or more regular moist conditions and fen plant communities may develop.

Often, if mowing and grazing is ceased, the grassland first overgrows with expansive herb species – *Calamagrostis epigeios, Molinia caerulea, Brachypodium pinnatum, Festuca arundinacea* (Priede 2011). Such overgrown grasslands can persist for decades. Drained areas have a very marked proliferation of nitrophilous plants (*Urtica dioica, Anthriscus sylvestris*).

15.1.5 Pressures and Threats

The habitat is adversely affected by all factors listed and described in Chapter 3. Drainage has affected the biodiversity and the total area of *Molinion* grasslands most significantly. Arable land or improved grasslands have been created in many drained areas. Grasslands drained using only shallow ditches are an exception. They mostly preserve the species composition and structure characteristic of the habitat.

Another factor, which is still as relevant as before, is the cessation of management (Fig. 15.1.9–15.1.12). For example, the population density of *Euphydryas aurinia* has been reducing over several years in "Diļļu Pļavas" Nature Reserve due to overgrowth. Inappropriate management (mostly mulching and also abandonment) has resulted in the excessive growth of expansive plant species, for example, *Molinia caerulea, Filipendula ulmaria, Calamagrostis epigeios, Festuca arundinacea*, in Coastal Lowland also *Myrica gale* (Priede 2011) (Fig. 15.1.12). Overgrazing (Fig. 15.1.13) also has an adverse impact on some species, for example, the population density of all butterflies, including protected ones, has decreased in "Vītiņu Pļavas" Nature Reserve. Beaver impoundments may lead to paludification (Fig. 15.1.14).

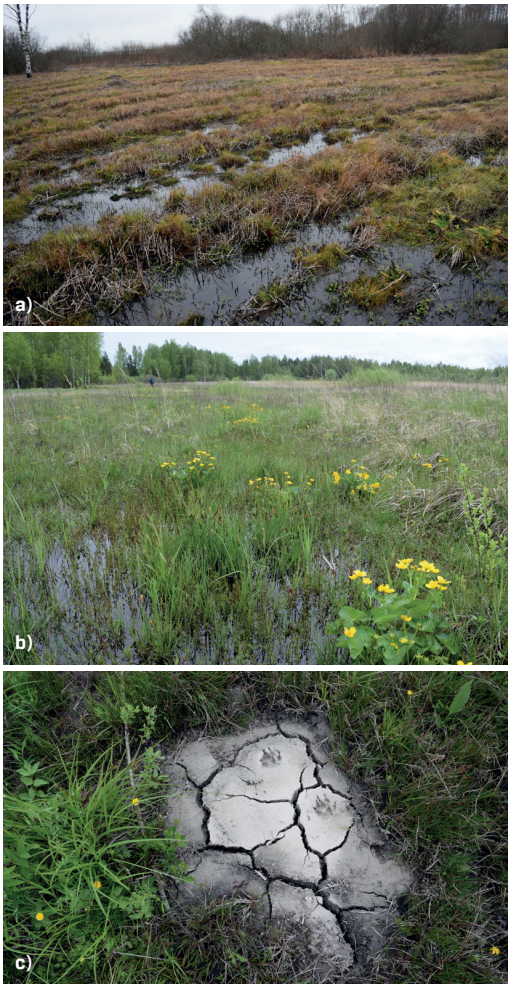

Fig. 15.1.7. The habitat is periodically water-logged, or dry. (**a**) *Sesleria* variant of *Molinion* grassland in "Diļļu Pļavas" Nature Reserve in December 2015, (**b**) Ķemeri National Park on 21 May 2015, (**c**) "Kuja" Nature Park on 25 May 2016. Photo: S. Rūsiņa.

15.2 Conservation and Management Objectives of *Molinion* Grasslands

- Ensure the landscape connectivity and ecological processes characteristic of *Molinion* grasslands (specific moisture regime with periods of drought and supply of calcium-rich groundwater, vegetation and micro-terrain structure diversity and nutrient cycling ensured by appropriate mowing or grazing), creating preconditions ensuring that the diversity and quality of the ecosystem services offered by this type of habitat do not decrease.
- Promote improvement in the number of localities and conservation status of typical, rare and declining species, by restoring suitable habitats for them in degraded sites.
- Restore and maintain the diversity of mosses and higher plant species and communities that have adapted to alternated moist and dry conditions and habitats suitable for them: *Molinion* grasslands are an important habitat for several protected plant species: *Primula farinosa, Sanguisorba officinalis, Iris sibirica, Serratula tinctoria, Dianthus superbus, Viola persicifolia, Gladiolus imbricatus, Crepis praemorsa, Gymnadenia conopsea*, as well as several species of *Dactylorhiza* spp. and *Orchis* spp.
- Restore and maintain the diversity of invertebrate species and communities and habitats

suitable for them: these are important habitats for many protected species and species included in Annex I to the Habitats Directive, for example, *Euphydryas aurinia, Lycaena dispar* and *Maculinea teleius, Vertigo angustior, V. geyeri* and the very rare *V. genesii* (grasslands in "Vitiņu Pļavas" Nature Reserve and "Diļļu Pļavas" Nature Reserve are important for the last three species). The habitat is inhabited by an ant species that is rare in Latvia: *Formica pressilabris*, the only species making their nest from dry grass.

- Restore the populations of meadow waders (protected species: *Tringa totanus, Philomachus pugnax, Limosa limosa*, etc.). Grassland management should be aimed at the preservation of breeding places of these species where they still exist, or appropriate management where they currently do not exist, but the configuration and moisture conditions of grassland are suitable for these species.
- Provide a sufficient living space for other protected species related to grasslands (for exam-

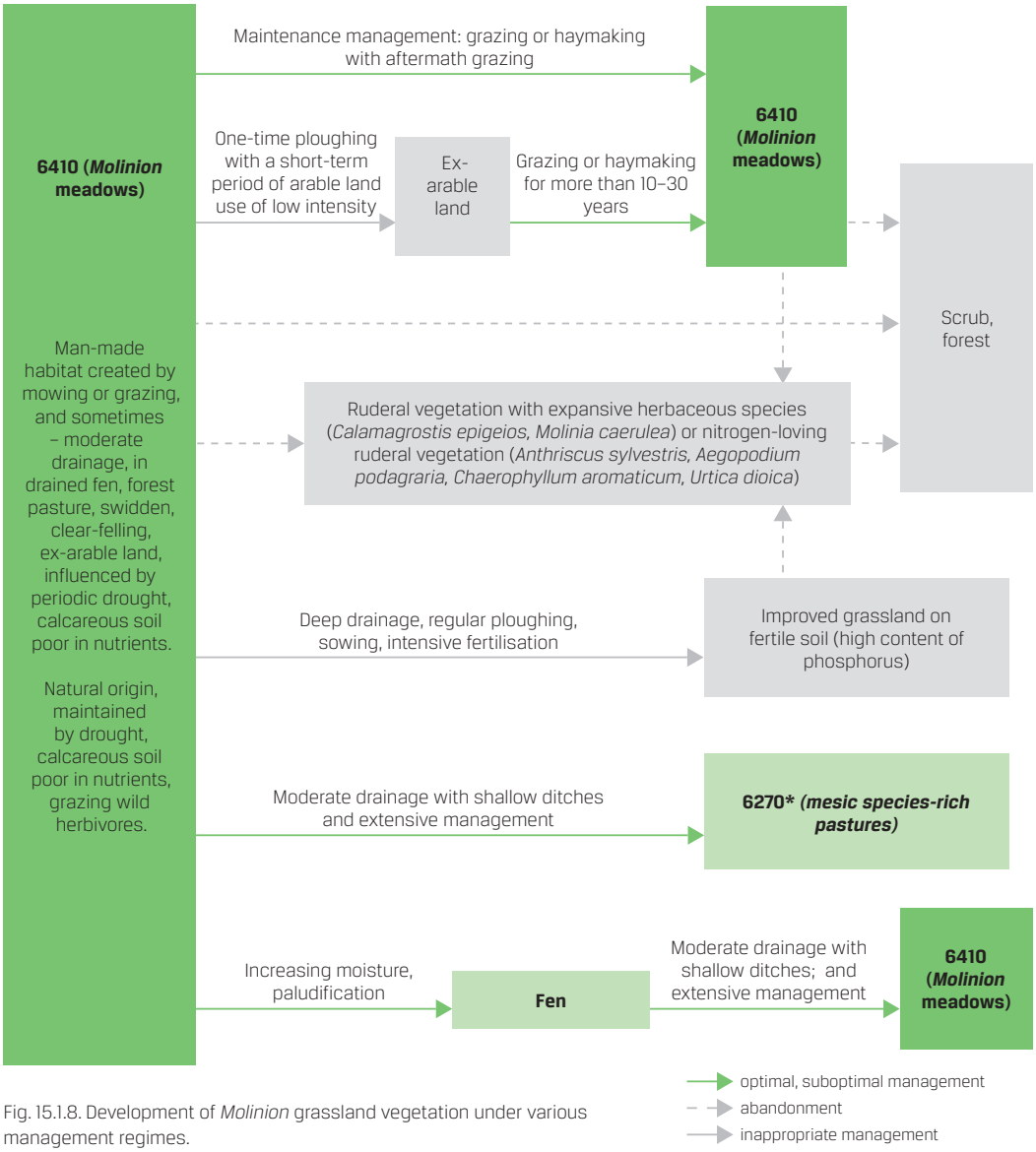

Fig. 15.1.8. Development of *Molinion* grassland vegetation under various management regimes.

Fig. 15.1.9. An abandoned *Molinion* grassland overgrowing with *Filipendula ulmaria*. Photo: S. Rūsiņa.

Fig. 15.1.10. An abandoned *Molinion* grassland overgrowing with *Salix* spp. Photo: S. Rūsiņa.

Fig. 15.1.11. Due to drainage, *Molinia caerulea* has become expansive and forms an almost monodominant stand. Photo: S. Rūsiņa.

Fig. 15.1.12. Expansion of *Myrica gale* in *Molinion* grassland in "Engures ezers" Nature Park, pasture on the east shore of Lake Engure (3 August 2011). Photo: S. Rūsiņa.

ple, *Crex crex*) and species, whose populations in Latvia have been reducing recently (*Motacilla flava, Carpodacus erythrinus* (Auniņš, 2016)).

15.3 Maintenance and Restoration of *Molinion* Grasslands

If the habitat is in a favourable condition, then restoration is not required and only maintenance management is necessary (*see Chapter 15.3.1*). If any habitat features indicate the opposite (*see Chapter 15.3.3*), then they first require restoration. Examination of the area is required to ascertain the present nature values before commencing habitat restoration or management and a management plan has to be developed (*see Chapter 7*), taking into account the habitat management legal framework (*see Chapter 7.2*). Special attention should be paid to evaluate the moisture conditions. Traditionally, shallow ditches has been created to improve the management possibilities. They must be preserved.

15.3.1 *Molinion* Grasslands Requiring Maintenance

Maintenance is necessary for all *Molinion* grasslands that are in a favourable condition. *Molinion* grassland is maintained in a favourable condition by mowing every year with hay harvesting or grazing. This prevents overgrowth with shrubs and prevents the formation of litter, leading to various plant communities, where the plant species diversity is high (both with low grass and taller). Pasture features low grass in wet depressions, where birds can feed, in some places and abundantly flowering herbs, where butterflies and other insects feed, in other places. Meadows have many orchids and other richly flowering forbs. The grassland has not been drained, no ditches have been dug or they are shallow and do not affect the duration of spring flood in floodplains substantially and do not reduce the periodically (temporarily) moist conditions (Fig. 15.3.1–15.3.4, Table 15.3.1).

Fig. 15.1.13. In terms of botanical and entomological diversity conservation, an overgrazed *Molinion* grassland in the "Engures ezers" Nature Park, pasture on the east shore of Lake Engure (3 August 2011). Photo: S. Rūsiņa.

Fig. 15.1.14. *Molinion* grassland paludified due to the influence of a long-term beaver impoundment as evidenced by the dominance of *Carex lasiocarpa* in the vegetation. Photo: S. Rūsiņa.

Favourable condition is indicated by the presence of umbrella species – plant species adapted to alternately moist conditions, for example, *Carex panicea, C. flacca, C. hartmanii, Sesleria caerulea, Molinia caerulea, Ophioglossum vulgatum, Polygala amarella* – and rare species such as *Primula farinosa, Gymnadenia conopsea, Orchis mascula* and bird and invertebrate communities, especially the presence of whorl snails *Vertigo* spp. (*see Chapter 15.1.2*).

15.3.2 Optimal, Suboptimal and Inappropriate Management

A summary of optimal, suboptimal and inappropriate management types is given in Table 1 and 7 of Annex 2.

Appropriate maintenance in order to maintain the diversity of all living organism groups is mowing with the harvesting of hay from mid- to late July. If mowing is performed in late June, then late mowing should be carried out, or unmown areas should be left in parts of the grassland to protect plant and animal species. Meadows can also be grazed in early spring until late May – mid-June, but then grasslands are mown in late summer (second half of August) when the seeds of most plants are ripe. In grasslands where whorl snails *Vertigo* spp. occur, mowing should be performed very carefully to avoid trampling of the habitats suitable for whorl snails and at least partially preserve tussocks.

Mowing time should be adapted to moisture conditions. Mowing should be done in the driest period of summer. In wetter sites, it is recommended to use “floating” machinery that is suitable for moist soils, for example, tracked tractor or wheeled tractor with wide wheels to provide a greater support surface (*see Chapter* 22.2.1).

Concerning birds, the objective of restoration is to prevent the overgrowth of grassland and ensure diverse vegetation that can provide ecological niches and create a diverse community of bird species. Depending on the target species, both grazing and mowing are suitable. If the grassland is large, grazing is preferable in its moister areas with depressions and pools to make the grassland more appropriate for meadow waders, and mowing (with removal of grass) is preferable in drier areas, which suit *Crex crex* better. In grasslands too small to be inhabited by waders, management should be organised to suit the requirements of vegetation or invertebrates. Shrubs and trees are permitted in small quantities in a mosaic form to increase the diversity of passerines, but trees and tall shrubs (taller than 1.5 m) are not desired near pools and moist depressions that may be suitable for meadow waders. Free and gently sloping access to the water edge, if any, should be ensured.

In Central Europe, *Molinion* grasslands are usually mown very late in the summer or in autumn (late September) every year or every two years to obtain litter for bedding because *Molinia caerulea* has broad leaves and it forms a thick layer of loose litter in autumn. In such places, special plant communities markedly dominated by *Molinia caerulea* develop. This has not been done in Latvia, therefore very late mowing is likely to be unsuitable, because the grassland gets constantly enriched with nitrogen and transformed into a homogeneous sward consisting of nitrophilous species.

Fig. 15.3.1. A habitat in a favourable condition in the floodplain of the River Taleja. There are many forb species, expansive species are absent. Photo: S. Rūsiņa.

Fig. 15.3.2. In the sedge variant of the habitat type (6410_3) in favourable condition, the species diversity is not as high as in other variants, determined by the relatively stronger and longer period of moist conditions, therefore there are few blooming forbs. Photo: S. Rūsiņa.

Fig. 15.3.3. A habitat in a favourable condition is a suitable habitat for rare and protected orchid species. (**a**) *Orchis militaris*, (**b**) *Gymnadenia conopsea* and *Epipactis palustris*. Photo: S. Rūsiņa (a), A. Priede (b).

15.3.3 *Molinion* Grasslands Requiring Ecological Restoration

Grassland requires restoration if it has one or more of the following features (Fig. 15.1.9 – 15.1.14):

- it has not been managed for several years;
- it has been mown by mulching, by leaving the grass for more than five years;
- it is very tussocky;
- overgrown with trees and shrubs;
- it has been drained using closed drainage or deep open ditches;
- vegetation is dominated by one or several expansive species, for example, *Calamagrostis epigeios, Molinia caerulea, Phragmites australis, Festuca arundinacea, Aegopodium podagraria, Anthriscus sylvestris, Elytrigia repens, Filipendula ulmaria, Myrica gale,* mosses *Aulacomnium palustre, Shpagnum* spp.;
- there are many invasive species, for example, *Impatiens glandulifera, Echinocystis lobata, Solidago canadensis, Helianthus tuberosus;*
- vegetation consists of sown grasses, for example, *Dactylis glomerata, Phleum pratense, Festuca pratensis.*

15.3.4 Restoration Potential

Nowadays *Molinion* grasslands mostly overgrow with shrubs and trees, therefore restoration mainly involves shrub felling, removal of litter, grinding of tussocks and shrub roots, control of expansive species, restorative mowing or grazing. If the grassland is isolated (there are no *Molinion* grasslands or alkaline fens (habitat type 7230 *Alkaline fens*) in its proximity), then the introduction of species characteristic of the habitat by sowing or spreading of seed-containing hay should also be considered.

Where these grasslands have been drained using

Table 15.3.1. Indications of a well-managed habitat type 6410 *Molinia meadows on calcareous, peaty or clayey-silt-laden soils*.

Parameter	Meadow	Pasture
Litter	Litter covers no less than 10% and no more than 30% of the ground.	
Hydrological conditions	Moist periods (spring, autumn, sometimes in more humid summers) alternating with dry periods when the soil can even dry out completely.	
Vegetation	Great species diversity, not just one or several dominant species; the vegetation consists of both grasses and sedges, as well as forbs.	
Indicator species of semi-natural grasslands	There are several semi-natural grassland indicator species, for example, *Cardamine pratensis, Carex panicea, Dactylorhiza* spp. in a large number, *Galium boreale, Geranium palustre, Lathyrus palustris, Parnassia palustris, Ranunculus auricomus, Scorzonera humilis, Succisa pratensis, Trollius europaeus*.	
Vegetation structure	A very colourful meadow in full bloom, proportion of forbs and grasses at least 1:1, except for sedge grasslands where there can be very few forbs.	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.
Bird species	*Crex crex* or at least one meadow wader breeding (only passerines will be present in a grassland smaller than 10 ha).	At least one meadow wader or *Crex crex* breeding (at least passerines in a grassland smaller than 10 ha).
Invertebrate species	Very diverse invertebrate fauna, including insects and snails, as well as soil fauna.	Very large diversity of invertebrate species, including insects and snails, as well as soil fauna. Rich community of species related to the excrement of grazing animals.
Tussocks	Tussocks of *Molinia caerulea* are preserved in some places because they are important for birds and whorl snails *Vertigo* spp.	
Expansive plant species	Not present or only up to 10% of the grassland area contains expansive species (*Anthriscus sylvestris, Filipendula ulmaria*). *Molinia caerulea* may dominate, but its cover is no larger than 50–60%.	Overgrazing indicators, for example *Trifolium repens, Plantago major, Polygonum arenastrum, Poa annua, Prunella vulgaris*, do not cover more than 30% of the area.
Drainage ditches	Shallow drainage ditches (~20 cm deep) are maintained, no deep ditches.	
Shrubs and trees	Large trees are preserved, small shrubs occupy at least 10% of the area, but no more than 30%.	

shallow ditches (approximately 20 cm deep), ditch filling is not usually necessary. Vegetation of *Molinion* grasslands can still persist in such sites (Fig. 15.3.5). There can also be situations, where the development of the habitat types 6270* *Fennoscandian lowland species-rich dry to mesic grasslands* 6230* *Species-rich Nardus grasslands, on siliceous substrates in mountain areas* starts, because drainage encourages the leaching of calcium and acidification of soil (Van der Hoek, Sykora 2006). However, if the grassland has been managed extensively for a prolonged period of time after drainage, preservation of the current nature values of the grassland should be preferred over the attempts to restore another habitat (*see Chapter 20.5.3*).

If the grassland has been drained using deep ditches, rewetting is usually necessary. Drainage causes peat mineralisation and an increase in the bioavailab-

Fig. 15.3.4. Favourable condition is indicated by vegetation structure – it has several layers, where many plant species are distributed evenly. Photo: S. Rūsiņa.

Fig. 15.3.5. A shallow ditch in a grassland in "Diļļu Pļavas" Nature Reserve (December 2015). Vegetation fully corresponds to *Molinion* grassland. If the ditch ceases to function, paludification is likely to occur, so a shallow drainage system should be maintained. Photo: S. Rūsiņa.

le nitrogen, which leads to reduced species diversity. Rewetting in the long term reduces the content of nitrogen, but releases phosphorus (Klimkowska et al. 2007). In such cases soil fertility should be reduced by grass mowing with removal at least twice per season in the first years. If the soil is very rich in phosphorus, then fertility reduction by deturfing or other methods is desirable before rewetting (*see Chapter 21.6*) (Tallowin, Smith 2001).

Hydro-ecological research and a comparison of *Molinion* grasslands pending restoration and those in favourable condition, should be carried out before rewetting. The hydrological system the grassland hydrological regime functions on several levels – the local hydrological system is connected to the subregional and regional systems.

Even the same habitat may be formed in many different hydrological systems. For example, the association *Cirsio–Molinietum* in the Netherlands forms in six hydrological systems have different functioning: floodplain; discharge of groundwater from shallow aquifers and from deep aquifers; isolated pools with discharge of base-rich groundwater; discharge of base-rich water from canals combined with surface water flooding etc. (Jansen et al. 2000). It is very important to ensure the supply of calcium-rich water to the grassland, or the restoration may fail (van Duren et al. 1998). The rewetting plan may be developed, when detailed research of drainage system and hydrogeological conditions on site and in a wider area has been carried out, determining the size of area where the moisture regime should be changed around the grassland under restoration, in order to achieve the desired result. Therefore, competent experts – hydroecologist, hydrogeologist, species and habitat experts – should be involved.

If it is expected that the management of the grassland will be impossible after restoration of the moisture regime due to excess moisture and it will overgrow or paludify again, then it is better to choose the creation of a wetland (restore the hydrological regime) or restoration of a grassland in the existing moisture conditions (Rīze et al. 2015).

15.3.5 Restoration Methods

The necessary restoration methods are presented in Table 20.1 of Chapter 20 and in Chapter 21.

When selecting restoration methods, special care is required with protected plant and animal species. If there are whorl snails in the grassland, then prescribed burning or soil grinding should be carried out extra carefully and over several years so that the whorl snails can move from the undisturbed areas of the grassland to the restored ones.

If the grassland contains many late-blooming plant species or feeding plants of *Maculinea* genus butterflies, such as *Gentiana pneumonanthe* and *Sanguisorba officinalis,* then late mowing starting from approximately mid-July with preservation of the tussock structure of the grassland preferable during restoration and maintenance.

15.4 Conflicting Management Priorities of *Molinion* Grasslands

Managers of *Molinion* grasslands can experience conflicting management situations both typical to all types of grasslands (*see Chapter 7.1.4*), as well as specific conflicts, which can arise if the impact of management on all nature values present in the grassland is not evaluated during management planning (Table 15.4.1).

15.5 Examples of Restoration of *Molinion* Grasslands in Latvia

In Latvia, *Molinion* meadow has been restored in three LIFE projects: "Restoration of Latvian floodplains for EU priority species and habitats" LIFE04 NAT/LV/000198, "Implementation of the management plan for Lake Engure Nature Park " LIFE00 NAT/LV/007134 and "Restoration of Biological Diversity in the Military Training Area and the "Ādaži" Natura 2000 Site " LIFE06 NAT/LV/000110 (Anon. 2015d). However, the experience has not been documented (Anon. 2009; Rūsiņa 2008).

In Ķemeri National Park, where habitat restoration took place in several grasslands on land possessed by the Nature Conservation Agency the restoration experience was documented (Priede 2011) (Fig. 15.5.1–15.5.5).

Table 15.4.1. Conflicting management priorities of habitat type 6410 *Molinia meadows on calcareous, peaty or clayey-silt-laden soils*

Question	Problem	Solution
Habitats		
Which habitat type should be preserved – 6410 *Molinia meadows on calcareous, peaty or clayey-silt-laden soils* or 7230 *Alkaline fens*	Both habitats often occur side by side. Extensive mowing and moderate drainage of shallow ditches creates a grassland habitat, while abandonment often encourages excessive humidity and paludification.	Extensive mowing is not harmful for fens. On the contrary, it prevents the overgrowth of fens with reed and shrubs. When restoring grasslands, care should be taken with ditch cleaning. If there is also a mire nearby, then grassland ditches may only be cleaned if they will not drain the mire. The creation of new drainage systems is undesirable because it can destroy fen habitat.
Plants		
Gladiolus imbricatus, Sanguisorba officinalis, Serratula tinctoria	These plant species flower late in late summer and intensive grazing or early mowing without letting the plants flower can eradicate these plant species from the grassland.	When mowing, flowering plant areas should be left unmown, grazing intensity should be reduced in pastures or some areas should be left ungrazed (for example, by using fences). Late mowing of the entire grassland may be performed every few years.
Myrica gale	*Myrica gale* is a protected plant species that only occurs in alkaline fens and *Molinion* grasslands of the Coastal Lowland in Latvia. Mowing restricts and eventually eliminates this species from the meadow, however some individuals remain on meadow edges or in damper depressions. The species usually persists well in pastures and even tends to spread because grazing animals do not like it.	Although this species is protected, it is not a typical meadow plant. As the species can become expansive (spread and suppress the herb layer), it should be controlled by mowing in meadows and pastures.
Invertebrates		
Whorl snails	Grazing, even if it is extensive, can compact the soil, harming whorl snails. Very low mowing can destroy whorl snail habitats.	Graze the pasture in parts every year, leaving one part ungrazed for one year to restore whorl snail populations. Leave unmown islets or mow high enough to preserve plant tussocks.
Butterflies	Butterfly larvae feed on plants which are mown or eaten if traditional mowing and grazing is used. Several species of *Maculinea genus* may occur. Larvae of *M. teleius* live on *Sanguisroba officinalis* and *M. alcon* on *Gentiana pneumonanthe*. The larvae spend one stage of development in ant-hills of Myrmica ants, which can only form if they are not smoothed each year.	Mow or graze grasslands sector by sector or leave unmown or ungrazed zones every year and alternate them on a yearly basis. To conserve the *Maculinea* spp. butterflies, mowing should only be performed by hand to spare ant-hills. Part of the grassland should be left unmown for 2-3 years in a row, later alternating the unmown sectors with other sites in the grassland, where the butterfly feeding plants are found.
Birds	Meadow waders and Corncrake have different ecological requirements and, consequently, different forms of appropriate management. Grazing is better suited for waders, and mowing for Corncrake. The choice of management type will adversely affect one of the target species.	In larger grasslands, both management types can be combined: the relatively drier areas can be mown and the wetter ones that are closer to the water can be grazed. If the grassland is not large enough for combined management, the suitable conditions (moisture regime, proximity of water edge, presence of vertical elements) for the particular species should be determined. If the grassland is suitable for meadow wader communities, they should be given priority because they are more endangered in Latvia.

Fig. 15.5.1. Vegetation structure (tussocks, a lot of litter) in a *Molinia* variant that has not been managed for a long period of time (approximately 40 years) in Čaukciems meadows in Ķemeri National Park. Clearing of shrubs, smoothing of tussocks and grinding of shrub roots to prevent regrowth was required to prepare the grassland for management. Photo: A. Priede.

Fig. 15.5.2. Grinding of grassland in Čaukciems meadows in Ķemeri National Park in January 2013. Shrubs and separate trees were cleared and removed before grinding, except for older tree clusters and some individual trees. In grinding, "islets" of vegetation around tree clusters were left. Grinding was done in the snow-free period when the ground was not frozen. Photo: A. Liepa.

Fig. 15.5.3. In moist areas, grinding can also be done when the soil is not frozen; use of a tracked tractor has an especially low impact. Photo: A. Liepa.

Fig. 15.5.4. In wet areas, grinding should be done when the soil is frozen, but the work schedule cannot always be adjusted to weather conditions. Grinding with a tracked tractor in no-frost conditions was gentle and did not leave deep tracks in the grassland. Photo: A. Liepa.

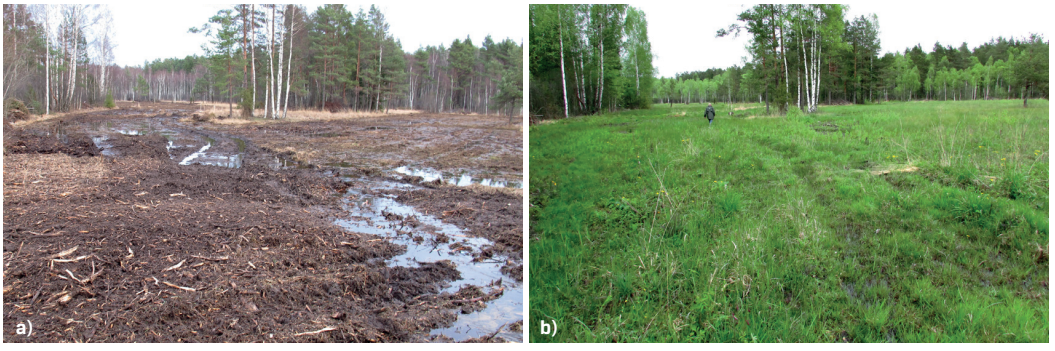

Fig. 15.5.5. The restored grassland in Čaukciems meadows in Ķemeri National Park. (**a**) Ground site a few days after the completion of work (January 2013). (**b**) In May 2015 the ground areas were covered by vegetation that only remained sparse in some places. Tussocks have been smoothed by grinding, there is almost no deciduous tree and shrub regrowth at all. Vegetation recovers successfully. Unfortunately, whorl snails were not studied before or after restoration, so there is no information about the impact of restoration on them. Photo: A. Liepa (a), A. Priede (b).