LIFE11 NAT/LV/000371 (2012–2017) (Fig. 11.5.1).

Before restoration, nitrogen content in topsoil was 1.65%, phosphorus – 52 mg kg^{-1} (0.2 M HCl extraction), potassium – 31 mg kg^{-1} (1.0 n CH3COONH4 extraction). In an area where mosses were raked the remaining nitrogen was only 0.85%, phosphorus content almost did not change – 48 mg kg^{-1} (0.2 M HCl extraction), the potassium level was half as much – 15 mg kg^{-1} (1.0 n CH3COONH4 extraction) (unpublished data of LIFE NAT-PROGRAMME project).

Within this project, restoration with shrub removal and mowing once per season was carried out in Gauja National Park in Cēsis, where sandy grassland was completely overgrown with *Calamagrostis epigeios* and *Rubus caesius*. Smoothing of anthills was also necessary there because part of the area was loamy and the old anthills interfered with mowing (Fig. 11.5.2–11.5.4). Before restoration, topsoil nitrogen was 2.82%, phosphorus – 29 mg kg^{-1}, potassium – 226 mg kg^{-1}.

Pine cover was removed in heavily overgrown sandy grassland in Gauja National Park near the river crossing in Līgatne (Fig. 11.5.5).

Chapter 12. 6210 *Semi-natural dry grasslands and scrubland facies on calcareous substrates* (S. Rūsiņa, A. Auniņš, V. Spuņģis)

12.1 Characteristics of the Habitat Type

12.1.1 Brief Description

Habitat type 6210 *Semi-natural dry grasslands and scrubland facies on calcareous substrates* (referred to as *calcareous grasslands* in the text) includes dry and almost dry grasslands in neutral and alkaline (less often weakly acid) soils poor in nutrients. In Latvia, calcareous grasslands occur in a very small area – they occupy 3000 ha or 6.4 % of all semi-natural grasslands (Fig. 12.1.1). It is 11.5% of the total area of this habitat in the EU boreal (northern) region (Rūsiņa 2013e).

In dry areas, there is also often ex-arable lands, so not all dry grasslands can be recognised as EU protected habitats. To classify the grassland as an EU protected habitat:

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

The highest biodiversity among dry calcareous grasslands has remained in Abava river valley. The largest areas are concentrated in "Ziemeļgauja" Protected Landscape Area, however the botanical diversity there is lower than in Abava valley, which is determined by geographical location. In Latvia, several plant species of dry calcareous soils are found in Kurzeme region only and do not occur eastwards due to the lack of suitable climate conditions. Therefore, the species composition in dry calcareous grasslands of Latgale region mostly found in "Augšdaugava" Protected Landscape Area is completely different (Fig. 12.1.2–12.1.6).

The key source of literature in the preparation of the guidelines were the guidelines for the management of calcareous grasslands published by the European Commission (Calaciura, Spinelli 2008). Restoration and management of this habitat has also been widely discussed in many scientific publications, for example, Poschlod et al. (1998); Tikka et al. (2001); Willems (2001).

12.1.2 Vegetation, Plant and Animal Species

Plants and vegetation. The habitat is characterised by relatively sparse and low vegetation and calcicole plant species. Turf is relatively well-developed, but in drier areas, where vegetation often burns out during prolonged drought or on very steep hillsides with pronounced erosion, the turf can be sparser. Herb layer is polydominant – it does not have one or several dominant species, and most species are evenly distributed in the sward. Plant species of South-East European steppes (Ukraine, south-west part of Russia) occur, for example: *Phleum phleoides, Filipendula vulgaris, Trifolium montanum, Veronica spicata, Helictotrichon pratense.*

Birds. No bird species are specifically associated with calcareous grasslands, but many of the species characteristic of grasslands may occur there. Most often, they will feature species from only two ecological groups – grassland-related passerines (most likely *Anthus pratensis, Emberiza citrinella, Carpodacus erythrina, Lanius collurio*) and birds that use grasslands for foraging (C*iconia ciconia, Buteo buteo, Aquila pomarina, Columba palumbus*). Other species may also breed here if the conditions are suitable for them. If the grassland is located near water, is larger than 10 ha (together with the surrounding grasslands) and is not too steep, meadow waders can nest there as well. If by June its vegetation is higher than 30 cm, *Crex crex* may also occur. Calcareous grasslands with sparser vegetation and open sand patches may be inhabited by *Anthus campestris.*

Invertebrates. Invertebrate species composition is similar to that of sandy grasslands – no dominance of certain species is observed. Since the vegetation is higher and denser, there are fewer Orthoptera, such as *Myrmeleotettix maculatus*, which needs areas with sparse vegetation. The diversity of soil fauna, however, is relatively high.

12.1.3 Important Processes and Structures

A major environmental factor is the drought and nutrient-poor soil which is rich in calcium. Many plants only occur in these conditions. In mesic places, where they could have enough moisture, they cannot outcompete larger and more competitive plant species. The most diverse plant communities develop in warmer places – south-facing steep hillsides and river valley terrace slopes that receive more sunlight. Species whose main distribution range is south of Latvia (Central Europe and Eastern European steppes) find suitable conditions there.

Plants have adapted to drought by smaller height and narrow, hairy leaves (Fig. 12.1.7, 12.1.8) which prevent water evapotranspiration, as well as a deep root system, for example the roots of *Medicago falcata* can reach several metres deep up to the groundwater. Depending on weather conditions, grass biomass may vary as much as four times in a year (Willems, Nieuwstadt 1996) (Fig. 12.1.9).

Dry conditions are also ensured by the wind. The stronger the wind the higher the evapotranspiration. Therefore it is very important to have large grassland area not surrounded by forests. Dry grassland surrounded by forest receives less severe droughts than grassland in an open place, because the forest provides shade and protection from the wind.

Calcareous grasslands can also develop in sandy soils, but mostly only in the higher parts of river floodplains. Floodwater plays an important role. Floodwaters are rich in minerals, they reduce soil acidification processes and soil pH can remain close to neutral.

The soil is usually skeletal (formed on dolomite bedrock or gravelly moraine sediments) or sandy

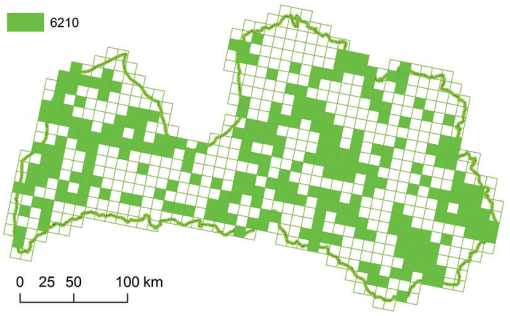

Fig. 12.1.1. Distribution of EU protected habitat type 6210 *Semi-natural dry grasslands and scrubland facies on calcareous substrates* in Latvia (Anon. 2013a).

Fig. 12.1.2. Calcareous grasslands in "Abavas Ieleja" Nature Park. Photo: S. Rūsiņa.

Table 12.1.1. Variants of habitat type 6210 *Semi-natural dry grasslands and scrubland facies on calcareous substrates.* Photo: S. Rūsiņa.

Dry calcareous grasslands of the western part of Latvia (6210_1, western variant)	**Dry calcareous grasslands of the eastern part of Latvia (6210_1, eastern variant)**
Grasslands in calcareous soils with dolomites close to soil surface or gravelly hillsides. Low, sparse or relatively dense sward. Vegetation consists of low and medium grasses: *Helictotrichon pratense, Poa angustifolia, Phleum phleoides.* Colourfulness is added by *Filipendula vulgaris, Trifolium montanum, Galium verum, Cirsium acaule.* Hay yield is 0.5 t ha^{-1} on average.	Grasslands on dry gravelly-loamy hillsides. Vegetation is very sparse, dominating grasses are *Poa angustifolia* and *Festuca rubra*, many colourfully blooming plants – *Pimpinella saxifraga, Centaurea scabiosa, Agrimonia eupatoria, Anthemis tinctoria, Thymus ovatus.* Hay yield is 0.5 t ha-1 on average.
	
 *Helictotrichon pratense*	 *Filipendula vulgaris*
 *Cirsium acaule*	 *Poa angustifolia*
 *Centaurea scabiosa*	 *Agrimonia eupatoria*

Dry grasslands in calcareous sandy soils (6210_3, sandy variant)	**Dry calcareous forest fringe grasslands (6210_4, forest fringe variant)**
Grasslands in slightly acidic soils, mostly in the higher parts of river floodplains. Fewer calcicole species than in other variants. Dominated by *Helictotrichon pubescens* and *Festuca rubra*; characteristic forbs are *Medicago falcata*, *Fragaria viridis*. Hay yield is 0.5–0.7 t ha^{-1} on average.	Grasslands in slightly shaded places, usually in complex with other variants of this habitat. Typically contains a large proportion of shade-tolerant forest edge species – *Melampyrum* spp., *Trifolium medium, Geranium sanguineum.*
	
 *Medicago falcata*	 *Helictotrichon pubescens*
 *Geranium sanguineum*	 *Trifolium medium*
 *Brachypodiu pinnatum*	

Fig. 12.1.3. Dry forest fringe grasslands in the Latgale Upland. Photo: S. Rūsiņa.

Fig. 12.1.4. Calcareous grasslands in "Ziemeļgauja" Protected Landscape Area. Photo: S. Rūsiņa.

Fig. 12.1.5. Calcareous grasslands in "Ances Purvi un Meži" Nature Reserve. Photo: S. Rūsiņa.

Fig. 12.1.6. Calcareous grasslands in "Augšdaugava" Protected Landscape Area. Photo: S. Rūsiņa.

(usually only in river floodplains where the acidification of soil characteristic for Latvia is reduced by floodwater which usually neutralises the leaching). Species diversity is higher if the nitrogen content in the soil is lower. Not more than 17–22 kg ha^{-1} of nitrogen is removed each year by mowing (Bobbink 2003).

The connectivity of habitats in the landscape is very important because plant species disperse poorly – they may travel only a few dozens of metres per year. If the grassland is surrounded by forests or arable fields, species become extinct because they cannot move from one grassland to another and cannot sustain a healthy, genetically diverse population.

12.1.4 Succession

Calcareous grasslands can develop naturally in floodplains because the establishment of woody plant species is hindered by the mechanical influence of spring flood and ice. The development of such grasslands can be observed in narrow bands on floodplain ridges of the largest rivers. However, in most cases in Latvia calcareous grasslands are developed by grazing and mowing. Habitat can also develop in ex-arable land, if mowing or grazing is resumed (Fig. 12.1.12).

If mowing or grazing is ceased, grassland can persist for a long time without being overgrown, because dry conditions delay the establishment of trees and shrubs – tree seedlings usually perish in drier years. However, the grassland gradually overgrows. The overgrowth is faster in small grasslands surrounded by forests because there is more shading and therefore less pronounced drought.

First, grassland overgrows with expansive (aggressive) herbaceous plant species – *Calamagrostis epigeios* and *Brachypodium pinnatum*, as well as *Rubus caesius*. In shaded areas with deeper soil, overgrowth with nitrophytes, such as *Aegopodium podagraria* or *Anthriscus sylvestris*, takes place, because they are able to uptake nutrients faster and better, thus outcompeting lower plants.

Such overgrown grasslands can persist for decades because the dense herb layer prevents the establishment of woody plant seedlings. However, shrubs and trees enter with time, helped by rodents that create vegetation-free areas, as well as by un-prescribed burning, unless followed by mowing or grazing. Burning creates areas free of litter, where trees can seed easily the next year. The most common tree species are *Pinus sylvestris, Betula pendula, Populus tremula*; the most common shrubs are *Crataegus* spp., *Rhamnus cathartica, Rosa* spp., *Euonymus europaea*. The

Fig. 12.1.7. During prolonged drought, all aboveground parts of plants or sometimes even roots dry out (image taken on 10 July). Photo: S. Rūsiņa.

Fig. 12.1.8. *Trifolium arvense* adapted to dry conditions. Leaves are hairy to reduce water evaporation from leaf surface. Photo: S. Rūsiņa.

Fig. 12.1.9. Calcareous grassland in "Ziemeļgauja" Protected Landscape Area. (**a**) 24 July 2006 (vegetation has dried up due to the drought). (**b**) 5 July 2011 (vegetation is green, moisture is sufficient).

Fig. 12.1.10. Calcareous grassland ploughed in 2015 and rapeseed sown in a very shallow soil developed over dolomite bedrock. Photo: S. Rūsiņa.

Fig. 12.1.11. Nutrients from a polluted river reach calcareous grassland during spring floods which results in the introduction of tall weed species that suppress the habitat characteristic species. Habitat conservation status is bad. Photo: S. Rūsiņa.

number of expansive species in steppe grasslands is lower than that in mesic grasslands because the very dry and poor soils are not suitable for them.

12.1.5 Pressures and Threats

The habitat is adversely affected by all factors listed and described in Chapter 3. The most important of these are management cessation and change of land use type. Since the habitat is very unproductive and its management is not profitable, arable land is rarely established in these grasslands nowadays. However, influenced by common agricultural policy in recent years, grasslands that have never been ploughed due to their excessively superficial soil are ploughed too, to claim agricultural support (Fig. 12.1.10). Inappropriate grassland management, especially improvement and fertilisation, has been historically important, for example, in Latgale Upland where steeper hillsides in gravelly, calcium-rich soils are especially suitable habitats for grasslands. In areas where calcareous grasslands gradually recovered in ex-arable land or improved grassland areas in the late 20th – early 21st century, ploughing has been recommenced recently. Contaminated floodwaters adversely affect river floodplains as well (Fig. 12.1.11, 12.1.12).

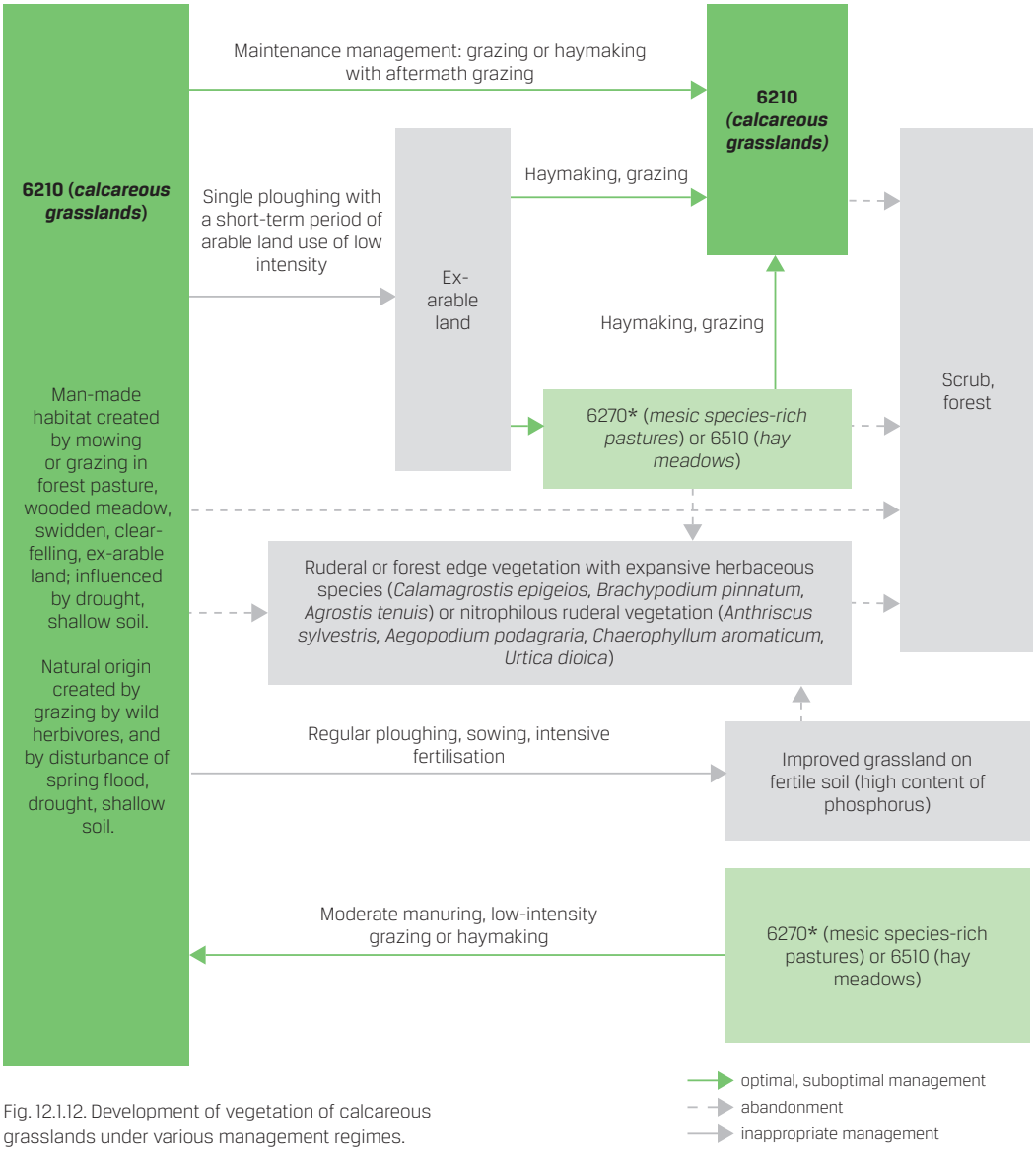

Fig. 12.1.12. Development of vegetation of calcareous grasslands under various management regimes.

Fig. 12.1.13. Calcareous grassland in the River Lielupe terrace has transformed into weed vegetation due to the fertiliser regularly leaching from the arable land (on the left in the image). Photo: S. Rūsiņa.

Habitat-specific threat is excessive load of visitors – these habitats are often located in river floodplains which are popular sites for recreation infrastructure establishment. Excessive trampling causes the introduction of invasive and expansive plant species, the biodiversity decreases and ruderal vegetation may develop.

12.2 Conservation and Management Objectives of Calcareous Grasslands

- Ensuring the landscape connectivity and ecological processes characteristic for calcareous grasslands (vegetation structure diversity and nutrient cycling), creating preconditions so that the diversity and quality of ecosystem services offered by this type of habitat do not decrease.
- Promoting improvement in the number of localities and conservation status of typical, rare and vulnerable species of calcareous grassland and their populations by restoring suitable habitats.
- Restoring and maintaining the diversity and suitable habitats for lichen, moss and higher plant species and communities. This is the most important habitat for several protected plant species – *Orchis* spp. (but not *Dactylorhiza* spp.), *Carex ornithopoda, Gymnadenia conopsea, Gentiana cruciata*. Calcareous grasslands are the most species-rich grassland habitats in Latvia. They can have even more than 50 plant species per square metre.
- Restoring and maintaining the diversity of invertebrates and their habitats. These grasslands are excellent feeding habitats for protected butterfly species included in the Habitats Directive, especially *Euphydryas aurinia* and *Lycaena dispar*. In relatively moister places *Vertigo angustior* (all species are protected in the EU) can be found.

12.3 Maintenance and Restoration of Calcareous Grasslands

If the habitat is in a favourable condition, its restoration is not necessary and only maintenance management is sufficient (*Chapter 12.3.1*). If any habitat features indicate the opposite (*see Chapter 12.3.3*), restoration is necessary.

Before habitat restoration, the territory must be surveyed, nature values clarified, management plan developed (*see Chapter 7*), considering the legal framework of habitat management (*see Chapter 7.3*).

12.3.1 Calcareous Grasslands Requiring Maintenance

Management is necessary for all calcareous grasslands in a favourable condition. Calcareous grasslands in favourable condition are managed by mowing every year with haymaking or grazing and therefore it is not overgrown with shrubs, there is no dense litter layer, there is high species diversity and various plant communities (both with low and tall plants) (Table 12.3.1).

Favourable condition is indicated by the presence of calcareous grassland umbrella species: *Bembix rostrata, Psophus stridulus, Lacerta agilis* and steppe grassland typical plant species *Acinos arvensis, Carex caryophyllea, Cirsium acaule, Filipendula vulgaris, Polygala comosa*.

12.3.2 Optimal, Suboptimal and Inappropriate Management

Optimal, suboptimal and inappropriate management types are summarised in Table 1 and 3 of Annex 2.

The most appropriate maintenance is extensive grazing by sheep or cattle. Grazing pressure should be based on grassland fertility, which can differ every year depending on moisture conditions. Respectively, no exact number of grazing animals can be recommended. Roughly, it would be 0.1–0.3 LU ha^{-1}.

Grazing is more suitable than mowing because historically these grasslands have primarily been managed by grazing, and plant and animal species have adapted to it, and because the yield of such grasslands is usually very low and most of the plant biomass is

Table 12.3.1 Indications of a well-managed habitat type 6210 *Semi-natural dry grasslands and scrubland facies on calcareous substrates.*

Parameter	Meadow	Pasture
Litter	Litter covers no more than 30% of the land	
Vegetation	Sward consists of habitat characteristic species such as grasses *Helictotrichon pratense, Festuca rubra or Poa angustifolia,* forbs *Filipendula vulgaris, Pimpinella saxifraga, Origanum vulgare, Polygala comosa, Trifolium montanum, Fragaria viridis.* There is a large diversity of plant species, not just one or a few dominant species.	
Vegetation structure	A very colourful meadow in full bloom, proportion of forbs and grasses at least 1:1	At least 20% of area with grass lower than 7 cm and at least 20% of area with grass taller than 20 cm; from June to mid-August. blooming plants in at least 25% of the area.
Indicator species of semi-natural grasslands	Many semi-natural grassland indicator species, for example, *Galium boreale, Polygala comosa, Fragaria viridis, Linum catharticum, Agrimonia eupatoria, Primula veris, Dianthus deltoides, Galium verum.*	
Invertebrate species	Many xerothermophyle insects – plant bugs, beetles, Orthoptera, Hymenoptera, rich fauna of anthophylous insects. Whorl snails can be present.	
Tussocks	Anthills are preserved in some places.	
Expansive plant species	Expansive species such as *Anthriscus sylvestris, Aegopodium podagraria, Trifolium medium, Brachypodium pinnatum, Calamagrostis epigeios* absent or present in up to 10% of grassland area.	Overgrazing indicators such as T*rifolium repens, Plantago major, Polygonum arenastrum, Poa annua, Prunella vulgaris* do not cover more than 30% of the area. L*olium perenne* is absent.
Signs of spring floods (only for grasslands in floodplains)	Varied terrain with elevations and depressions. Flooding deposits removed from the grassland, molehills smoothed.	
Shrubs and trees	Large trees are preserved, small shrubs cover up to 10% and no more than 30% of the area.	

concentrated 5–10 cm above the ground. Therefore mowing does not remove much of grass biomass. Eutrophication unfavourable for biodiversity occurs with time, as plant remains accumulate. However, in relatively moister soils or years without pronounced drought periods, when the grass grows better, mowing is a just as effective type of management as grazing. Mowing with the removal of grass is recommended from mid-June to mid-July or later, if the grassland is important for grass-dwelling invertebrates. In drier summers the grassland can already be dried out, therefore mowing may be commenced even earlier.

In relatively fertile soils, where aftermath regrows until autumn, grazing is preferable. Grassland can also be grazed in early spring until the end of May – mid-June, but then mowing is only done in late summer – late August, when the seeds of most plants have ripened.

Soil compaction due to grazing can negatively affect whorl snails and burrowing insects, therefore overgrazing must be avoided.

If tree or shrub cover develops, it should be cleared, while leaving some shrubs or trees in bands or groups (especially the flowering *Padus avium, Euonymus* spp.*, Rhamnus cathartica, Rosa* spp.*, Sorbus aucuparia*) to create a favourable microclimate for insects and increase the diversity of passerines. Ensuring low and sparse vegetation with open sand areas is recommended in sandy soils.

12.3.3 Calcareous Grasslands Requiring Ecological Restoration

Grassland restoration is necessary if it has one or more of the following indications:

- not managed for several years and a thick layer of litter has accumulated;
- it has been mown with mulching or leaving the grass for more than five years;
- it is very tussocky;
- overgrown with trees and shrubs;
- vegetation is dominated by one or several expansive species, for example, *Brachypodium pinnatum, Calamagrostis epigeios, Urtica dioica, Pteridium aquilinium, Aegopodium podagraria, Anthriscus sylvestris, Chaerophyllum aromaticum, Bromopsis inermis, Elytrigia repens*;

- there are many invasive species, such as *Solidago canadensis, Helianthus tuberosus, Rumex confertus, Lupinus polyphyllus, Bunias orientalis;*
- the sward consists of sown grasses: *Dactylis glomerata, Phleum pratense, Festuca pratensis;*
- *lichens Cladonia* spp., *Peltigera* spp., habitat-specific moss species are absent; only expansive species *Rhytidiadelphus squarrosus* and wood mosses *Dicranum polysetum, Pleurozium schreberii, Hylocomium splendens* can be found.

12.3.4 Restoration Potential

Many calcareous grasslands in Latvia are overgrown with forest or improved. Restoration potential depends on how much the soil has been enriched and vegetation changed.

Calcareous grassland is more difficult to restore after a long period of intensive cultivation because the soil is enriched with nitrogen and phosphorus. Sward is dominated by sown grasses or expansive species in such grasslands, the establishment of shrubs is slow because expansive herbaceous species compete with them (Fig. 12.3.1, 12.3.2).

So far, there has been no research on the success of restoration depending on soil chemical properties in Latvia. In the UK it was found that typical calcareous grassland species can establish if the soil nitrogen content does not exceed 0.2–1.2%, phosphorus – 15 mg kg^{-1} (Olsen method) and potassium – 120 mg kg^{-1} (Crofts, Jefferson 1999).

In Latvia, total nitrogen in grasslands which are not substantially affected by eutrophication can reach at least 0.51%, phosphorus 40 mg kg^{-1} (according to Egner-Riehm method), potassium up to 200 mg kg^{-1} (Jermacāne, Laiviņš 2002; Rusina, Kiehl

Fig. 12.3.1. Calcareous grassland that is difficult to restore, overgrown with *Aegopodium podagraria.* Photo: S. Rūsiņa.

Fig. 12.3.2. Calcareous grassland that is difficult to restore, overgrown with *Calamagrostis epigeios*. Only a few specimens of typical calcareous grassland species remain. The spread of *Calamagrostis epigeios* has been encouraged by the annual burning of litter. Photo: S. Rūsiņa.

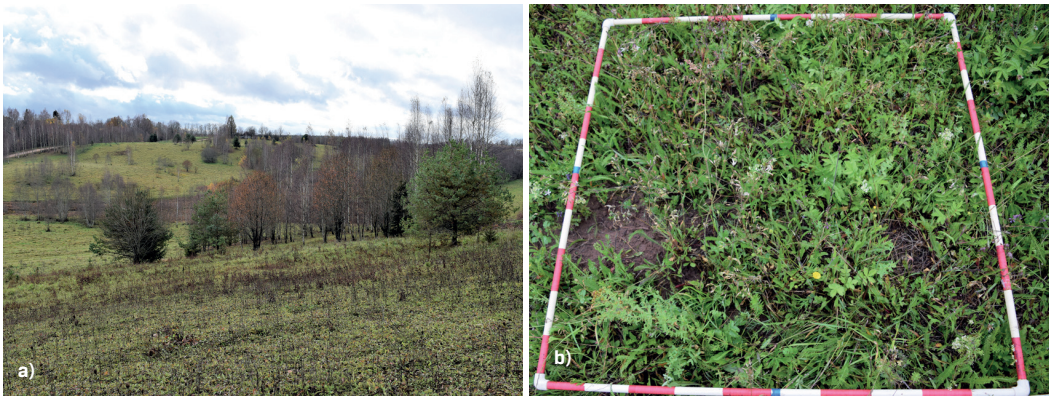

Fig. 12.3.3. (**a**) An ex-arable field in the site of previous calcareous grassland ("Augšdaugava" Protected Landscape Area). (**b**) Turf is not fully developed, although ploughing was terminated 20 years ago. Calcareous grassland species do occur, but in small numbers. Photo: S. Rūsiņa.

2010; Rotkovska 2015; Rūsiņa, unpublished data; *see also Chapter 12.5*). We can conclude that the current knowledge is not yet sufficient to determine the phosphorous and potassium threshold value after which nutrient removal is necessary (*see Chapter 21.6*). Determining chemical soil properties both in the restored grassland and in several grasslands in a favourable condition is recommended prior to restoration. If phosphorus and nitrogen content in the grassland under restoration exceeds the amount in grasslands in a favourable condition, nutrient removal should be performed. Monitoring of soil chemical properties should be carried out each time to make the necessary adjustments in the restoration plan.

The landscape ecological situation should also be taken into account. If there are no dry grassland species nearby, the restoration can be unsuccessful even with favourable soil conditions.

If soil properties are not substantially changed, vegetation resembles semi-natural grassland. Grasslands that have once been ploughed may lack turf and have many ex-arable land species – *Achillea millefolium, Veronica arvensis, Silene vulgaris, Agrostis tenuis, Convolvulus arvensis, Cirsium arvense* etc. (Fig. 12.3.3). Young pine woodland may occur in long-abandoned grasslands and the herb layer may have disappeared due to shading. However, in such cases restoration is relatively easy. Cutting of trees and shrubs, burning of litter and smoothing of tussocks are usually sufficient in an overgrowing grassland. Afterwards, it should be mown once per season with haymaking or intensively grazed. The results will manifest in the first year of restoration.

It is more difficult to restore grassland occupied by expansive species. For example, a grassland overgrown with *Calamagrostis epigeios* will be difficult to restore even if soil properties meet the requirements of calcareous grassland and a plant species pool is available in the nearby area (*see Chapter 12.5*). In such cases, it is necessary to select grassland restoration methods that limit the expansive species as much as possible.

12.3.5 Restoration Methods

Necessary restoration methods are summarised in Table 20.1 of Chapter 20 and in Chapter 21. Creation of bare sand patches is described in Chapter 11.3.5. When creating calcareous grassland in areas where it has not existed before or has been destroyed, the environmental conditions should be assessed first. Moisture and soil conditions must be suitable for the habitat characteristic species.

12.4 Conflicting Management Priorities of Calcareous Grasslands

Managers of calcareous grasslands can experience conflicting management situations typical to all types of grasslands (*see Chapter 7.1.4*). There are no specific conflicting situations related to this habitat type. All the species of this habitat require similar habitat structure and management. For annual species, moderate disturbances should be ensured to prevent excessive growth of vegetation and to maintain bare sand patches, while not being too intensive to completely destroy the turf and thus prevent the germination of these species.

Sparse vegetation and bare sand patches are necessary for *Anthus campestris*, habitat characteristic invertebrates and for *Lacerta agilis*. Grasslands inhabited by *Anthus campestris* are usually not suited for other grassland bird species of nature conservation importance, so no conflicts are expected.

Calcareous grasslands are usually not inhabited by species whose chicks are precocious and might hide in grass, therefore there is no need to observe a bird-safe mowing direction, but mowing time is important. *Anthus campestris* chicks stay in the nest until they are able to fly therefore early mowing up to early July is not permissible. If the habitat is located in a river floodplain in mosaic with moist and wet grasslands, the breeding of *Crex crex* is possible here, therefore a bird-safe mowing direction should be used.

12.5 Examples of Restoration of Calcareous Grasslands in Latvia

In Latvia the habitat has only been restored in a few places. The largest areas have been restored under the LIFE project "Protection and management of the Northern Gauja Valley" LIFE03 NAT/LV/000082 (2003–2007). Grazing of beef cattle for a few years there significantly reduced the amount of litter, overgrowth of grassland with pine (animals broke the small pines) and the amount of tussocks that had been caused by the spread of *Helictotrichon pratense* during the years of abandonment. Animals willingly ate species in spring, despite its hard leaves (Rūsiņa 2008a; Rūsiņa et al. 2013b).

Development of calcareous grassland vegetation in horse pastures, late-mown meadows and abandoned grasslands were studied in "Abavas Ieleja" Nature Park (Abava Valley) (Jermacāne et al. 2002; Rusina, Kiehl 2010; Kupča 2014; Kupča, Rūsiņa 2016). Abandoned grasslands quickly overgrew with *Aegopodium podagraria* and *Chaerophyllum aromaticum*. The overgrowth was especially fast (within a couple of years) on north-exposed slopes, where the drought was not so pronounced. In horse pastures grazed once per season (with tethered

horses), species diversity had a decreasing trend over a period of 12 years, which suggests that the grazing load was insufficient.

Impact of wild boar rooting on grassland vegetation was researched in Stende valley in "Ances Purvi un Meži" Nature Reserve within the LIFE project "National Conservation and Management Programme of Natura 2000 Sites in Latvia" LIFE11 NAT/LV/000371 (2012–2017). According to species composition and vegetation structure, the grassland had a favourable condition. Nitrogen content in topsoil was 0.23–0.51%, phosphorus – 6.6–12.4 mg kg^{-1} (0.2 M HCl extraction), potassium – 43–146 mg kg^{-1} (1.0 n CH3COONH4 extraction) (unpublished data of project LIFE NAT-PROGRAMME). Wild boar damaged turf was smoothed in March 2014 using a spring-tooth harrow 2–3 times. This is an effective method because it partially maintains the turf that helps the vegetation recover in the next years, but additional rolling is recommended. Wild boar uprooted turf must be smoothed to ensure effective future management of grassland. In river valleys, if there is no intensive farming in the surrounding area and no seed bank of weeds, harrowing does not cause the development of weed vegetation that would delay the restoration, therefore there is no risk that harrowing could destroy the habitat (*see figures in Chapter 21.3*).

In Latvia, soil chemical analyses have only been carried out in calcareous grasslands which have been abandoned for a long time (Fig. 12.5.1). In early stages of restoration in a grassland overgrown with pine and *Calamagrostis epigeios*, the content of soil nitrogen was 0.31%, phosphorus – 52 mg kg^{-1} (0.2 M HCl extraction), potassium – 211 mg kg^{-1} (1.0 n CH3COONH4 extraction) (unpublished data of the project LIFE NAT-PROG-

Fig. 12.5.1. Restoration of calcareous grassland by pine felling followed by mowing with grass removal once per season. "Augšdaugava" Protected Landscape Area, Slutišķi Village. (**a**) Grassland before restoration in July 2013; (**b**) after felling of pines in early July 2015; (**c**) *Calamagrostis epigeios* forms a dense stand before mowing in July 2013; (**d**) *Calamagrostis epigeios* stand after two years of mowing with grass removal is still dense, species diversity has not increased yet, but the thick litter layer has been removed by mowing. It promoted the slight increase of species number. However, the number of *Calamagrostis epigeios* shoots has also increased because favourable light conditions encouraged its vegetative reproduction. To restrict *Calamagrostis epigeios*, mowing should be done twice per season for at least eight years (Annex 4). Photo: S. Rūsiņa.

Fig. 12.5.2. Dry ex-arable land naturally developed into a calcareous grassland after abandonment. Protected Landscape Area "Augšdaugava", Slutišķi Village. (**a**) Development of semi-natural grassland vegetation continued in dry ex-arable land 20 years after abandonment, followed by rapid overgrowth with pines. If grassland habitat restoration had not been commenced in 2013, pine forest would have soon developed. (**b**) The transformation of ex-arable land into calcareous grassland successfully continues after pine felling and the recommencement of mowing. Photo: S. Rūsiņa.

RAMME). Restoration success by mowing and grass removal once per season over three years in grassland overgrown with *Calamagrostis epigeios* was negligible, which can likely be explained by competition rather than soil chemical properties. In dry ex-arable land, where the vegetation was still sparse, but almost all calcareous grassland characteristic species were already established (most likely from adjacent calcareous grassland) (Fig. 12.5.2), the content of nitrogen was 0.30%, phosphorus – 58 mg kg^{-1} (0.2 M HCl extraction), potassium – 186 mg kg^{-1} (1.0 n CH3COONH4 extraction) (unpublished data of the project LIFE NAT-PROGRAMME).