Chapter 11. 6120* *Xeric sand calcareous grasslands* (S. Rūsiņa, A. Auniņš, V. Spuņģis)

11.1 Characteristics of the Habitat Type

11.1.1 Brief Description

Habitat type 6120* *Xeric sand calcareous grasslands* (referred to as sandy grasslands in the text) includes dry grasslands with sparse vegetation in sandy, calcareous or slightly and moderately acid soils. In Latvia, sandy grasslands occur in a very small area – they occupy 900 ha or 1.9 % of all semi-natural grasslands (Fig. 11.1.1). It is 45% of the total area of this habitat in the EU boreal (northern) region. Such grasslands occur in the valleys of the Gauja, Daugava, Venta and Abava rivers, as well as sandy plains in the Coastal Lowland, inland dunes and elsewhere (Rūsiņa 2013d).

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

Almost no sandy grasslands in good condition remain in Latvia. Relatively large areas are still found in "Sventājas Ieleja" Nature Park, "Augšdaugava" Protected Landscape Area and Gauja National Park. Fragments of dry, calcareous grasslands

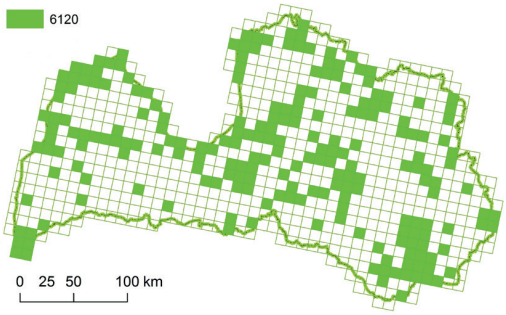

Fig. 11.1.1. Distribution of EU protected habitat type 6120* *Xeric sand calcareous grasslands* in Latvia (Anon. 2013a).

Fig. 11.1.2. Sandy grassland near Vičaki. Photo: S. Rūsiņa.

Fig. 11.1.3. Sandy grassland in "Ziemeļgauja" Protected Landscape Area. Photo: S. Rūsiņa.

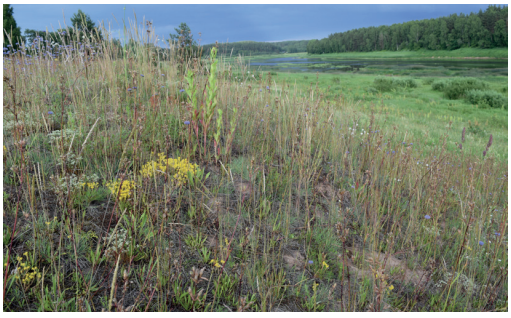

Fig. 11.1.4. Sandy grassland in the "Augšdaugava" Protected Landscape area. Photo: S. Rūsiņa.

Fig. 11.1.5. Sandy grassland in "Sventājas Ieleja" Nature Park. Photo: S. Rūsiņa.

Table 11.1.1. Variants of habitat type 6120* *Xeric sand calcareous grasslands*. Photo: S. Rūsiņa.

Typical variant, 6120*_1	Semi-dry variant, 6120*_2
Very dry grassland with open vegetation, many patches with lichens and mosses, very low vegetation (around 10–15 cm). Hay yield lower than 0.5 t ha^{-1}.	Dry grasslands, but the herb layer is almost closed, vegetation higher than 15 cm. Lichens are absent or rare, mosses do not form a continuous layer free of herbs. Hay yield lower than 0.5 t ha^{-1}.

Skeletal soil variant, 6120*_3
Dry grasslands on gravelly substrates. Species composition similar to the typical variant, but there are more calcareous species (*Plantago media, Fragaria viridis, Carex caryophyllea, Poa compressa*) occur frequently. Hay yield lower than 0.5 t ha^{-1}.

Fig. 11.1.6. Vegetation is polydominant. Open sand patches important for invertebrates are visible. *Jasione montana* with blue flowers, *Berteroa incana* with white flowers, *Viscaria vulgaris* after flowering. Photo: S. Rūsiņa.

Fig. 11.1.7. Annual plant species are tiny, only open soil patches are suitable for them. In the photo – *Arenaria serpyllifolia*. Photo: S. Rūsiņa.

Fig. 11.1.8. Sandy grasslands are characterised by open vegetation with bare sand areas. Flowers *Pilosella officinarum*. Photo: S. Rūsiņa.

also occur in other river valleys, for example, Abava, Aiviekste, Misa valley (Fig. 11.1.2–11.1.5).

11.1.2 Vegetation, Plant and Animal Species

Plants and vegetation. Moss layer (usually *Brachythecium albicans, Polytrichum juniperinum, P. formosum, Abietinella abietina, Syntrichia ruralis,* species of *Pottiaceae*) and lichen (*Cladonia* spp., *Cladina* spp.) is very typical, but it can also be absent (for example, if grassland has been burnt or has not been managed for a long period of time). Characteristic annual species are *Arenaria serpyllifolia, Veronica verna* and others. Dominated by grasses: *Koeleria glauca, Poa angustifolia, Festuca ovina, Phleum phleoides*, less frequently sedges: *Carex praecox* and *C. caryophyllea*. Often there are no dominant grasses and forbs cover the most part of the herb layer: *Veronica spicata, Sedum acre, Viscaria vulgaris, Galium verum* (Fig. 11.1.6–11.1.8, 11.3.1). Trees and shrubs usually occur rarely in sandy grasslands, but their presence in a small quantity is desirable because it increases the diversity of environmental conditions and provides a suitable habitat for different species.

Birds. Sandy grasslands are not rich in bird species, however, if their continuous area is sufficiently large (3–5 ha and more), they can be a suitable habitat for *Anthus campestris* and *Alauda arvensis*. Dry grasslands surrounded by forest are suitable for *Lullula arborea*. In southwest Latvia, if such grasslands are located in towns, they can also be used by *Galerida cristata*. The presence of shrubs and shrub clusters in the grassland makes it suitable for various passerines (for example, *Sylvia communis, Lanius collurio* or *Carpodacus erythrinus*). Dry grasslands are also suitable as feeding places for species feeding on larger insects, for example, *Upupa epops, Coracias garrulus* and *Lanius collurio*. They can also be used as feeding places for various species from habitats adjacent to the grassland.

Invertebrates. Fauna is very similar to that of habitat type 2130* *Fixed coastal dunes with herbaceous vegetation*. On the sea coast, these habitats are often located next to each other. Soil fauna in sandy grasslands is relatively poor, while in the herb layer the fauna is very rich (Spuņģis 2008b). The herb layer is dominated by saprophagous Diptera. Phytophages are mostly represented by scentless plant bugs *Rhopalidae*, capsid bugs *Miridae*, butterflies, leafhoppers *Cicadellidae*, weevils *Curculionidae*. During the

Fig. 11.1.9. Sand areas free of vegetation are important for solitary bees. Photo: G. Dolmanis.

Fig. 11.1.10. Sparse vegetation around a solitary bee nest. Photo: G. Dolmanis.

time of plant blooming, a high diversity of butterflies and other anthophilous insects – beetles, Hymenoptera, thunderflies Thysanoptera and Diptera, is observed. There are especially many grasshopper *Acrididae* and bush cricket *Tettigonidae* species. These Orthoptera need low vegetation to be able to leap. Characteristic of dry meadows are: *Myrmeleotettix maculatus, Decticus verrucivorus* and *Metrioptera brachyptera, Psophus stridulus*, protected *Oedipoda caerulescens* and *Omocestus* and *Chortippus* grasshoppers. If feeding plants (thyme) are present, then *Maculinea arion* may occur. Sandy grasslands are abundant in plant bug species (63 species known in Latvia), represented by high number of specimens (Spuris, Varzinska 1976). Meadows are rich with frit flies *Chloropidae* but their highest species diversity and number of specimens is characteristic in dry meadows (Karpa 1979). Mothes, for example, *Crambus perlella (Pyralidae)* and butterfly species are characteristic of meadows. Characteristic phytophages and phytosaprophages are *Aelia acuminata, Opatrum sabulosum* and milkweed bugs *Lygaeidae*.

Sandy grasslands feature a rich fauna of butterflies, bees and other anthophile insects (Fig. 11.1.9–11.1.10, 11.3.1). A characteristic feature of sandy grasslands are predatory invertebra-

Fig. 11.1.11. Grazed sandy grassland with open sand patches in Poland. The habitat would be suitable for *Anthus campestris* also if it had only many small sand patches (including smaller than 1 m^2). Photo: S. Rūsiņa.

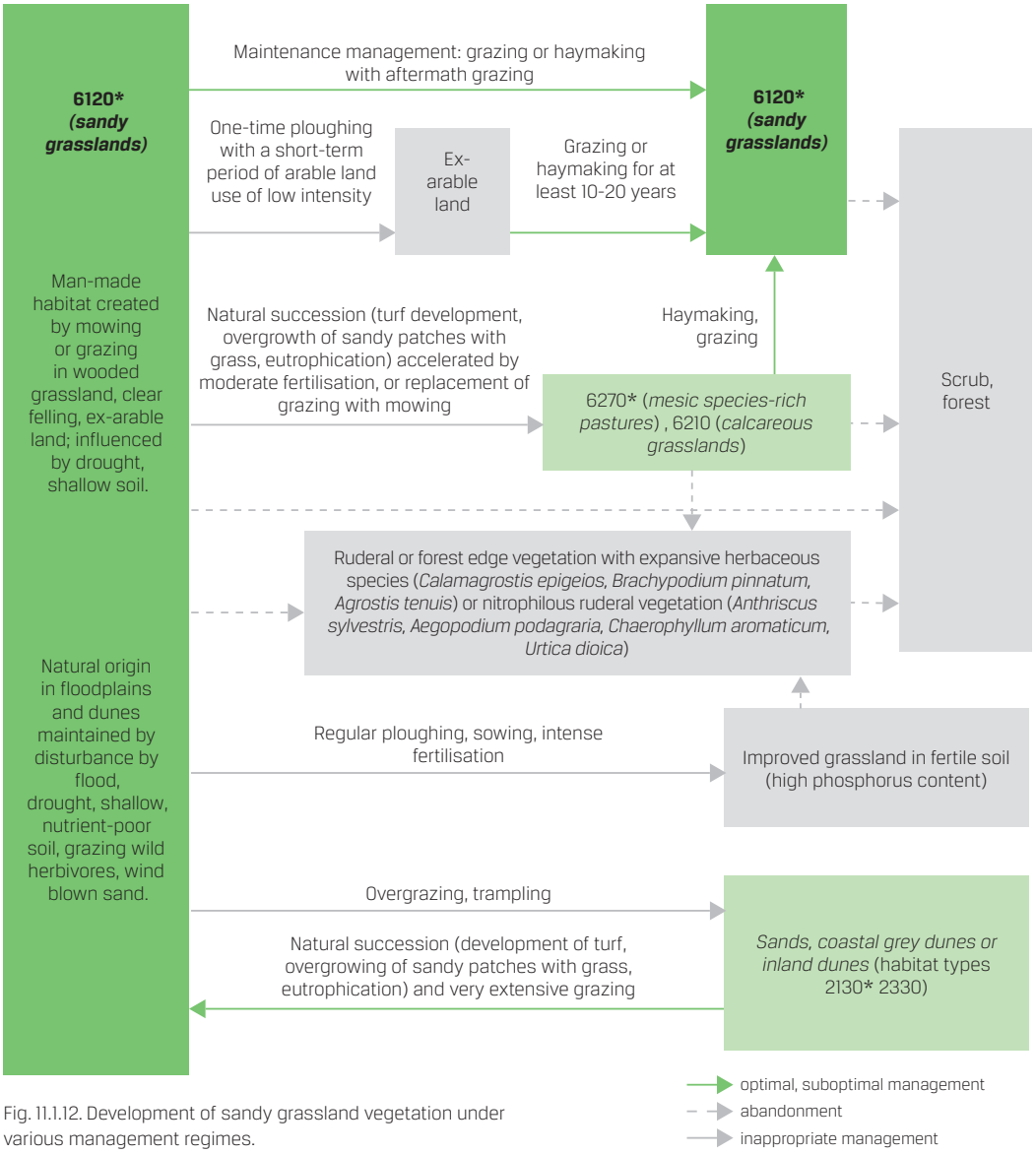

Fig. 11.1.12. Development of sandy grassland vegetation under various management regimes.

tes that are grassland habitat quality indicators, for example, spider wasps *Pompyliidae*, sand wasps *Sphecidae* (including the protected *Bembix rostrata*), *Agelena labyrinthica, Cicindela* spp. Colonies of mining bees *Andrenidae* and the parasitic violet oil beetle *Meloe violaceus* are often observed. In sandy grasslands, dominance of a single species is not characteristic. Overall, the grasslands are highly abundant in xerothermic species.

Reptiles. Sandy grasslands are suitable habitats for *Lacerta agilis* included in Annex IV of the Habitats Directive (Edgar, Bird 2006).

11.1.3 Important Processes and Structures

An important factor in the preservation of open sandy grasslands are drought and soils which are slightly acid to alkaline poor in nutrients, developed on sandy sediments. Many habitat characteristic plant species are found only in these conditions. In mesic places, where they could have sufficient moisture, they cannot outcompete larger and more competitive plant species. Due to sparse vegetation and sandy topsoil poor in humus, the ground-level air layer and topsoil get very hot on sunny summer days and rapidly cool down at night, creating

Fig. 11.1.13. In very dry soils, habitat type 6120* *Xeric sand calcareous grasslands* is not overgrown for a rather long time after abandonment. Photo: S. Rūsiņa.

Fig. 11.1.14. Ex-arable land after the abandonment of an arable field which was established in a sandy grassland habitat. *Senecio jacobaea* (yellow flowers) usually occurs in sandy grasslands, but only starts dominating under the influence of various disturbances. Photo: S. Rūsiņa.

Fig. 11.1.15. Abandoned eutrophicated sandy grassland overgrows with *Rubus caesius, Artemisia vulgaris, Calamagrostis epigeios* and shrubs. Photo: S. Rūsiņa.

Fig. 11.1.16. Due to excessive visitor load, sandy grassland vegetation has been trampled at the bench and further away in the grassland. Recreation area in a sandy grassland on the bank of the River Gauja near Gaujiena. Photo: S. Rūsiņa.

pronounced daily temperature fluctuations. Such conditions are suitable for subcontinental and continental species, whose main range of distribution is south of Latvia (Central Europe and Eastern European steppes).

Dry conditions are also provided by the wind. The stronger the wind, the faster the evaporation of water. Therefore it is very important to have a large grassland area without surrounding forests (Fig. 11.1.11). Dry grassland surrounded by forest does not experience as severe drought as an open place would experience, because the forest provides shade and wind cover.

Sand areas free of vegetation are very important for sandy grassland animals (breeding grounds, nest places for bees and wasps, warming areas) and also for plants (lower competition with other species, opportunity for annual plant growth). Open sand areas are maintained by grazing, which is the most suitable management for this habitat type (Fig. 11.3.1). Wind also helps to keep the sand open by establishing blowouts. It is important to maintain a balance between the formation of open sand patches and stable vegetation, which can be achieved by adjusting the grazing intensity.

Sandy grasslands can develop in the elevated parts of river floodplains. The influence of spring floods is very important for the existence of these grasslands. Floodwaters are rich in minerals, they decrease soil acidification processes and soil pH can stay close to neutral, which is necessary for many sandy grassland species.

The connectivity of habitats in the landscape is very important because plant species disperse poorly – they can only move a few dozens metres per year. If the grassland is surrounded by forests or arable fields, species die out gradually because they cannot move from one grassland to another and cannot sustain a healthy, genetically diverse population. Survival of such grasslands is better in landscapes with abundant dry pine forests because plant species characteristic of sandy grasslands can survive and disperse on edges, gaps and clearcuts of such forests.

11.1.4 Succession

Sandy grasslands can develop naturally in floodplains because the establishment of woody plant species is hindered by the mechanical effects of flooding and ice. The development of such grasslands can be observed in narrow bands on floodplain ridges of the largest rivers. Sandy grasslands form as a temporary succession stage between dunes and forest through the natural overgrowth of coastal or inland dunes. They can exist in such places for a long time if extensively grazed.

The longevity of sandy grasslands depends on grazing and less often on mowing because it is rarely used in the management of such grasslands (Fig. 11.1.12). Once the grassland is abandoned, its biodiversity decreases and one species starts dominating in the moss layer (usually *Rhytidiadelphus squarrosus,* but also several moss species characteristic for dry pine forests – *Pleurozium schreberii, Hylocomium splendens,* and *Dicranum polysetum)*, or moss and lichens disappear completely because the light is blocked by the thick herb cover.

Both after grassland abandonment and due to eutrophication (for example, runoff from agricultural land, mulching for several years, nitrogen pollution from air), nitrogen content in soil increases steadily (Ketner-Oostra et al. 2012), and the vegetation is increasingly dominated by expansive grasses such as *Calamagrostis epigeios* and *Deschampsia flexuosa*, as well as *Rubus caesius*, and only this type of grassland typically overgrows with *Equisetum hyemale*. Usually the next succession stage is pine forest, less frequently woodlands of *Populus tremula* and *Betula pendula*.

Due to extremely dry conditions, the characteristic vegetation structure can remain for a long period of time (even more than 20 years) after management cessation, but the biodiversity constantly decreases.

Table 11.3.1. Indications of a well-managed habitat type 6120* *Xeric sand calcareous grasslands*.

Parameter	Meadow	Pasture
Litter	Litter covers no more than 30% of the ground.	
Sand patches	Bare sand patches in some places, some of them 1 m^2 or larger, but they do not cover more than 30–50% of the area.	
Vegetation	Vegetation consists of habitat characteristic species, such as grasses *Koeleria glauca, Festuca ovina, Festuca trachyphylla, Poa angustifolia, Festuca rubra,* forbs: *Pimpinella saxifraga*, forbs *Fragaria viridis, Veronica spicata, Trifolium campestre, Hylotelephium triphyllum, Potentilla argentea.* In late April – early May, small spring ephemers *Erophila verna, Veronica verna, Myosotis micrantha* bloom.	
	High diversity of flowering plant species.	Abundantly blooming plants in at least 20% of the area from June to mid-August. At least 20% of the area has grass taller than 7 centimetres.
Indicator species of semi-natural grasslands	At least some semi-natural grassland indicator species occur: *Sedum acre, Dianthus deltoides, Viscaria vulgaris, Viola rupestris, Campanula rotundifolia.*	
Bird species	Ideally, *Anthus campestris.*	
Reptiles	*Lacerta agilis.*	
Invertebrate species	Many xerothermophyle, burrowing insects, great diversity of Orthoptera and pollinators.	
Moss and lichen species	Moss species characteristic of open areas (rather than forest) occur: *Syntrichia ruralis, Polytrichum piliferum, Cladina* spp. and *Cladonia* spp.	
Expansive herb and moss species	Absent or cover up to 10% of grassland area: *Calamagrostis epigeios, Rubus caesius, Equisetum hyemale*, mosses: *Rhytidiadelphys squarrosus, Hylocomium splendens, Pleurozium schreberii.*	Overgrazing indicators cover less than 30% of the sward – *Trifolium repens, Plantago major, Polygonum arenastrum, Poa annua, Prunella vulgaris*. There is no *Lolium* spp.
Shrubs and trees	Large trees are preserved, small shrubs in at least 10% of the area, but no more than 30%.	

11.1.5 Pressures and Threats

The habitat is adversely affected by all the factors listed and described in Chapter 3. Management cessation and change of land use type to building construction or forest land have been the most important pressures of recent years, because the productivity of sandy grasslands is low and their management is not profitable (Fig. 11.1.13). Sandy grassland structure recovers slowly after ploughing (Fig. 11.1.14).

The fastest manifestation of eutrophication effects occurs in habitats with nutrient-poor soils. Sand areas overgrow with moss and herbs, reducing the suitability of the habitat for invertebrates and the bird species of this habitat, *Anthus campestris* (Fig. 11.1.15). Elsewhere in Europe it has been found that eutrophication leads to soil acidification due to nitrogen pollution, causing the extinction of sandy grassland characteristic plant species. Even if the soil reaction decreases from pH 4.4 to pH 4.0, several lichen species already disappear (Ketner-Oostra et al. 2012). A critical amount of nitrogen that leads to initial negative changes in the habitat is 10–20 kg ha^{-1} y-1 (Bobbink et al. 2003).

Habitat-specific threats are:

- excessive load of visitors – these habitats are often located in higher parts of river floodplains, where recreation areas are often established. Excessive trampling causes the establishment of invasive and expansive plant species, the biodiversity decreases, ruderal vegetation may develop (Fig. 11.1.16);
- soil acidification caused by both natural factors (natural leaching or podsolisation due to a large volume of precipitation) and indirect human impact, such as acid rain, airborne nitrogen deposition. Biodiversity decreases because a soil reaction below pH 5 is not suitable for many habitat characteristic species (Olsson et al. 2009).

11.2 Conservation and Management Objectives of Sandy Grasslands

- Ensuring the landscape connectivity and ecological processes characteristic for sandy grasslands (development of open sand patches, diversity of vegetation structure, nutrient cycling promoted by appropriate mowing or grazing), creating preconditions so that the diversity and quality of the ecosystem services offered by sandy grasslands does not decrease.
- Promoting improvement in the number of localities and conservation status of typical species, as well as rare and declining species and their populations by restoring suitable habitats for them in degraded sandy grasslands.
- Restoring and maintaining suitable habitats for Anthus campestris.
- Restoring and maintaining the diversity of invertebrate, lichen, moss and vascular plant species and communities and habitats suitable for them. Sandy grasslands are the most important habitat for several rare plant species – *Armeria vulgaris, A. maritima, Botrychium matricariifolium, Jovibarba globifera,* and invertebrate species *Oedipoda caerulescens, Psophus stridulus, Bembix rostrata, Bombus schrencki.*

11.3 Maintenance and Restoration of Sandy Grasslands

If the habitat is in a favourable condition, its restoration is not necessary and only maintenance management is sufficient (*Chapter 11.3.1*). If there are any indications of the opposite (*see Chapter 11.3.3*), 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*).

11.3.1 Sandy Grasslands Requiring Maintenance

Management is necessary for all sandy grasslands in a favourable condition (Insertion 1, Table 11.3.1). Sandy grassland in a favourable condition is managed – annually mown (with hay removal) or grazed, therefore it is not overgrown with shrubs and a dense litter layer (old grass) is absent. Botanical and invertebrate diversity is high. There are patches of bare sand (soil) used by invertebrates (such as mining bees *Andrenidae*, ants *Formicidae*, sand wasps *Sphecidae*, blister beetles *Meloidae*). Herb vegetation is low (20–50 cm), there are patches dominated by mosses and lichens, but there is no continuous moss cover (Insertion 1). If the continuous area of grassland is sufficiently large (at least 3–5 ha) and located in a mainly open landscape, *Anthus campestris* breeds there. A favourable condition is indicated by the presence of sandy grassland umbrella species *Bembix rostrata, Psophus stridulus, Lacerta agilis, Cladonia* and Cladina lichens, moss *Syntrichia ruralis* and *Polytrichum piliferum* and typical species of sandy grasslands, for example, *Koeleria glauca, Dianthus*

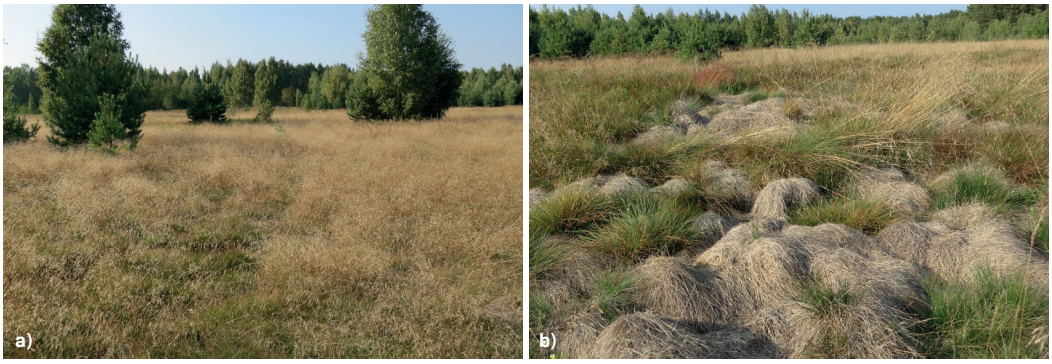

Fig. 11.3.1. Sandy grassland that is difficult to restore (**a**) and overgrown with *Deschampsia flexuosa* (**b**). To enable the establishment of sandy grassland typical species, deturfing or prescribed burning is necessary. In this case, grassland can also be restored by mowing or grazing, but restoration will take longer. Photo: S. Rūsiņa.

Fig. 11.3.2. Sandy grassland that is difficult to restore, overgrown with *Calamagrostis epigeios* and *Betula pendula*. Typical plant species are only represented by a few specimens. Grinding of roots and topsoil removal is necessary after the clearing of shrubs. Photo: S. Rūsiņa.

Fig. 11.3.3. Sandy grassland planted with birches that is relatively easy to restore. It is necessary to cut birches, cut their shoots until they do not regrow, carefully smooth the furrows created for tree planting to preserve turf as much as possible because it holds the majority of sandy grassland characteristic species. *Armeria vulgaris*, protected species, is visible in the foreground. Photo: S. Rūsiņa.

Sandy grassland restoration success

In Germany, sandy grassland was restored in an arable field that had been intensively used and fertilised for several decades (Gilhaus et al. 2015). Before restoration, the phosphorus content in soil was P_2O_5 100 mg kg^{-1} (Perking Elmer Lambda spectrophotometer 578 nm), nitrogen 0.1% and potassium K 20–25 mg kg^{-1} (flame photometry). To reduce soil fertility, 20–30 cm of turf was removed and year-round cattle grazing commenced with the grazing pressure of up to 0.5 LU ha^{-1}. In some areas 50–60 cm of topsoil was removed creating growth conditions suitable for wet heathlands because the groundwater table was close to the topsoil. Restoration of species composition occurred naturally from the existing seed bank and by species entering from the nearby areas. Supplementary sowing or spreading of hay containing seeds was not performed. After the restoration, phosphorus content was 35 mg kg^{-1}, nitrogen 0.01% and potassium 15 mg kg^{-1} (the same levels were also characteristic for an extensively managed sandy grassland).

Eight years after restoration, vegetation covered only 45–60% of the ground (in a sandy long-term extensively managed grassland it covered 96% on average), there were more annual plant species and more rare and threatened species than in the long-term sandy grassland. The possible reasons of these differences were more free ecological niches and higher soil pH (pH 5.0 in comparison with pH 3.97 in the long-term grassland) in restored grassland.

arenarius, Helichrysum arenarium, Thymus serpyllum, Viola rupestris, Veronica spicata.

11.3.2 Optimal, Suboptimal and Inappropriate Management

Optimal, suboptimal and inappropriate management types are summarised in Table 1 and 4 of Annex 2.

Ideally, sandy grassland should be grazed. Sheep are particularly suitable for grazing. Mowing is almost impossible due to the very low and sparse vegetation. If mowing is nevertheless performed, it should be done once per season in late June – mid-July with the harvesting of hay after it has been dried and stacked in the field.

The most appropriate management for the preservation of plants, invertebrates and birds is extensive grazing that results in low and sparse vegetation with bare sand patches. Grazing is recommended once per year or extensively during the entire season (approximately 0.1 LU ha^{-1}). Moderate overgrazing in only part of the grassland and the creation of bare sand patches is desirable. In grasslands that have been abandoned for a long time or mulched or that are overgrown with expansive species, mowing is equal to grazing, however, grazing is preferable for the long-term maintenance of a grassland.

Although mosaic-type shrubs and trees in small numbers are even desirable, it is important to prevent the increase of their area. Shrubs and trees can be left in bands or groups to create favourable microclimate areas for insects. Various disturbances (e.g., vehicle use) also help maintain and create new bare sand patches if they occur outside the bird breeding season and are not too intense.

11.3.3 Sandy Grasslands Requiring Ecological Restoration

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

- not managed for several years and a thick layer of litter has accumulated;
- mown with mulching or leaving the grass for more than five years;
- overgrown with trees and shrubs;
- vegetation is dominated by one or several expansive species, for example, *Equisetum hyemale, Deschampsia flexuosa, Rubus caesius, Pteridium aquilinum, Agrostis tenuis, Festuca rubra, Elytrigia repens*;
- there are many invasive species, such as *Solidago canadensis, Saponaria officinalis, Helianthus tuberosus, Rumex confertus, Lupinus polyphyl-*

Fig. 11.3.4. Sandy grassland created in ex-arable land by starting to mow. However, it is still not in a favourable condition, because there are many species not characteristic of the habitat, for example, *Leontodon autumnalis*. The vegetation shows that deturfing is not necessary and the species composition is already partially restored, so supplementary sowing is not necessary. Regular mowing or grazing is needed. Photo: S. Rūsiņa.

Fig. 11.3.5. A sandy grassland in ex-arable land that is relatively easy to restore. Felling of trees, smoothing of grassland surface, followed by regular mowing or grazing is necessary. Photo: S. Rūsiņa.

Fig. 1.3.6. Sand areas in pastures created by horses. Photo: S. Rūsiņa.

lus, Bunias orientalis, Oenothera spp., *Euphorbia cyparissias, Rosa rugosa, Amelanchier spicata, Gypsophila paniculata*;
- lichens do not occur, dominant mosses are *Rhytidiadelphus squarrosus* or forest mosses: *Hylocomium splendens, Pleurozium schreberii, Dicranum polysetum*;
- acid soil, continuous layer of litter and pine litterfall.

11.3.4 Restoration Potential

Restoration potential depends on how much the soil has been enriched and vegetation changed. Compared to more fertile semi-natural grassland habitats, sandy grasslands can be restored in less time and with less investment. Grasslands, where the herb layer has not significantly changed, even if they are heavily overgrown with pines, are the easiest to restore. In grassland that is easy to restore, vegetation resembles semi-natural grassland – there are various plant species, including both grasses and forbs (Fig. 11.3.1–11.3.5).

Sandy grassland is more difficult to restore after a period of improved grasslands or intensively used arable land because soil has become enriched with nutrients, especially nitrogen and phosphorus. To create sandy grassland in a previously fertilised arable land, nutrient removal is recommended first (for example, deturfing, deep ploughing), soil acidification should be prevented, the introduction of habitat-typical species should be ensured (by letting them enter naturally, if there are donor sites nearby, or by targeted sowing or transfer of material rich in seeds), and, finally, management with appropriate methods should be ensured (Gilhaus et al. 2015).

In dry sandy soils, plant nutrients brought in during arable field management or grassland cultivation leached out from the soil relatively quickly. However, if phosphorus content in soil exceeds 50 mg kg^{-1} (according to the Olsen method), turf removal is most likely necessary. Soil chemical properties in sandy grasslands of Latvia show that the total nitrogen in grasslands not significantly affected by eutrophication may vary from 0.08% to 0.26 %, phosphorus from 5 and 60 and even 137 and 175 mg kg^{-1} (according to the Egner-Riehm method), potassium from 20 to 132 mg kg^{-1} (Jermacāne, Laiviņš 2002; Jermacāne 2003; Rotkovska 2015; Rūsiņa, *unpublished data; see also Chapter 11.5*). Restoration success can also depend on the ratio of potassium, phosphorus and nitrogen. For example, in the sandy grassland where the highest content of phosphorus was recorded (175 mg kg^{-1}), there was only 37 mg kg^{-1} of potassium and 0.18% of nitrogen (Rūsiņa, unpublished data). This means that the current knowledge is not yet sufficient to determine the threshold content of phosphorous and potassium, when nutrient removal is necessary to restore grassland (*see Chapter 21.6*). Before restoration, it is recommended to measure soil chemical properties both in a renewable grassland and in grassland in favourable condition.

If the soil is acidic (pH below approximately 4.5), liming can be carried out.

Sandy grasslands are suitable for *Anthus campestris*. Presence of other grassland birds is possible, but not necessarily encouraged. In order to make the grassland appropriate for *Anthus campestris*, the following should be restored:

- low and sparse vegetation, interspersed with bare sand patches;
- sufficient area of continuous open grassland (at least 1 ha, preferably larger) and the highest possible proportion of such habitats in the nearest vicinity.

Fig. 11.5.1. Sandy grassland (**a**) before and (**b**) after removal of pines. Photo: S. Rūsiņa.

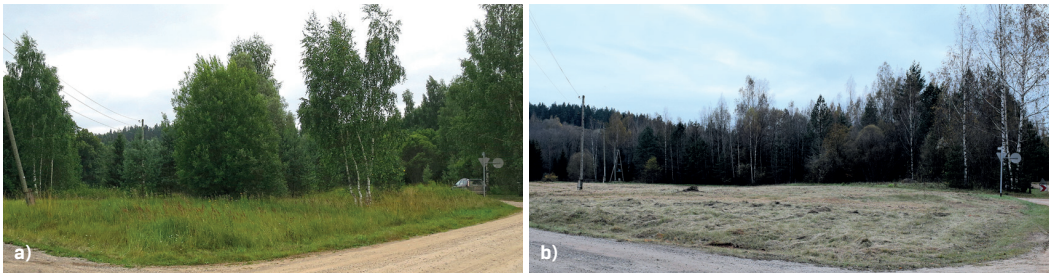

Fig. 11.5.2. Sandy grassland in Gauja National Park (**a**) before and (**b**) after shrub clearing. Photo: S. Rūsiņa.

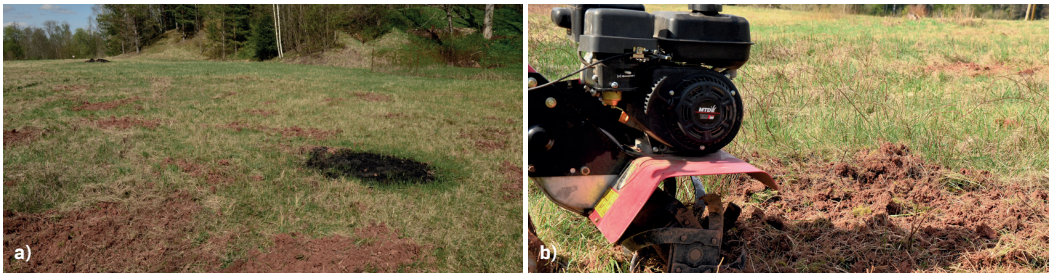

Fig. 11.5.3. Grassland (**a**) after smoothing of anthills which was performed using a small hand-pushed tiller (**b**). Photo: G. Jubelis.

Fig. 11.5.4. Sandy grassland overgrowing with *Calamagrostis epigeios* in Gauja valley in Cēsis. (**a**) The dense litter still delays the establishment of plants, only *Calamagrostis epigeios* can grow. (**b**) First-time mowing does not completely eliminate the litter layer because *Calamagrostis epigeios* has flattened, it cannot be mown to the ground and some litter remains. Prescribed burning would be a better solution before mowing because even after raking some litter remains (**c**). Photo: S. Rūsiņa.

Fig. 11.5.5. Overgrown sandy grassland in Gauja valley in Līgatne near the river crossing. If expansive species (in this case *Equisetum hyemale* and *Rubus caesius*) enter the sandy grassland along with pines, cutting of pines alone is not sufficient to restore the habitat. (**a**) Grassland before pine felling in 2009; (**в**) two years after pine felling in 2014 – herb vegetation is very dense, dominated by expansive species *Equisetum hyemale* and *Rubus caesius*. In this grassland, restoration by mowing at least twice per year followed by grass removal is necessary. Photo: S. Rūsiņa.

When restoring such grasslands, activities that could enrich soil (such as grass mulching), thus promoting unwanted vegetation changes, increasing sward density and overgrowth of open sand patches, should be avoided.

11.3.5 Restoration Methods

The management plan has to be developed prior to restoration or management (*see Chapter 7*). Restoration methods are summarised in Table 20.1 of Chapter 20 and Chapter 21, except for the creation of bare sand patches, which is a specific method for habitat type 6120* X*eric sand calcareous grasslands* and is described in this chapter. In rare cases, the creation of sand patches may also be carried out in the habitat types 6210 *Semi-natural dry grasslands and scrubland facies on calcareous substrates* and 6230* *Species-rich Nardus grasslands, on siliceous substrates in mountain areas*, if they have developed in sandy soils.

Open sand patches are an important habitat for annual plant species, invertebrates and lizards. Sparse vegetation and the presence of bare sand in the grassland are the main preconditions for the presence of *Anthus campestris*.

Sand patches develop naturally through grazing, as animals trample the turf and remove vegetation from sand (Fig. 11.3.6). In larger trampled areas, wind helps to blow out the sand. Open sand patches in meadows can only develop in very dry places, where all the vegetation burns out periodically due to drought. Therefore, grazing is more suitable habitat management.

If the grassland has been abandoned or fully overgrown with a thick herb layer due to eutrophication, the development of sand areas should be encouraged during restoration or they should be created artificially by various methods: topsoil removal, ploughing, harrowing or disc tilling, short-term intensive grazing. Sand patches should be at least 1 m^2 of size and cover up to 20–30% of the total grassland area. After the creation of patches, mowing or grazing must be commenced in the entire grassland (Schnoor et al. 2015).

Creation of micro-habitats – stone heaps – or leaving of tall tree stumps is recommended in order to ensure the diversity of the grasshoppers and katydids, as they use such elevations in their mating period.

If shrub cover must be removed and there are thin layers grass litter and litterfall with pine needles, and forest mosses are present, then prescribed burning is recommended, as it reduces the amount of nutrients that enter the soil after litter and moss decomposition. If there are only a few such problematic locations, felled trees can be placed in small ridges, left to dry out and later burnt. Then moss raking or turf removal will not be necessary.

11.4 Conflicting Management Priorities of Sandy Grasslands

Managers of sandy grasslands can experience conflicting management situations that can be observed in all grasslands (*see Chapter 7.2.4*). There are no specific conflicting situations related to sandy grasslands because all species of this habitat require similar habitat structure and management. Moderate disturbances are necessary for annual species to maintain open sand patches, while not being too intensive to completely destroy the turf and thus prevent the germination of annual species.

Open sand patches are necessary both for *Anthus campestris* and invertebrates characteristic to this habitat. Grasslands inhabited by *Anthus campestris* are usually not suited for other grassland bird species of nature conservation interest, so no conflicts are expected. Sandy grasslands are usually not inhabited by species whose chicks are precocious and might hide in grass, therefore there is no need for a bird-safe mowing direction, but the mowing time is important. *Anthus campestris* chicks remain in the nest until they are able to fly, so early mowing is not permissible. In coastal and inland dunes, a contradiction may arise in deciding which habitat type should be restored if open areas are overgrown with forest. Such areas may have previously been habitat types 6120* *Xeric sand calcareous grasslands*, 2130* *Fixed coastal dunes with herbaceous vegetation (grey dunes)* or 2330 *Inland dunes with open Corynephorus and Agrostis grasslands*. In such cases, the management objectives should be defined in accordance with the principles described in Chapters 6.3 and 6.4.

11.5 Examples of sandy grassland restoration in Latvia

In Latvia, habitat type 6120* *Xeric sand calcareous grasslands* has only been restored in few areas, although its condition is one of the worst if compared to other grassland habitats.

Impact of pine felling and moss raking on vegetation of long-abandoned sandy grassland has been studied in Daugava valley, Slutišķi Village within the LIFE project "National Conservation and Management Programme for Natura 2000 Sites in Latvia"

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).