Chapter 3. Pressures and Threats of Semi-natural Grassland Biodiversity (S. Rūsiņa, A. Auniņš, V. Spuņģis)

The pressures and threats are summarised in Table 3.1. Factors that are significant for a number of habitat types are described in the following chapters, while factors that significantly affect only one of the EU-protected grassland habitats have been described in more detail in the respective chapter dealing with the management and restoration of the particular habitat type.

3.1 Change of Land Use Type and Habitat Fragmentation

Changing the type of land use destroys the habitat. It has been a significant factor in the historic decline of semi-natural grassland areas, and in recent years it has become increasingly important. For instance, the proportion of arable land in the former pasture areas of Latgale Upland increased by 18% over the period from 2006 to 2012 (Lakovskis, Kruskops 2016). A significant threat near human settlements, especially in river valleys, is construction and landscaping with lawns, ponds, car parks, etc. In areas where agriculture is struggling, the semi-natural grasslands are often overgrown with forest, while in intensive agriculture areas they are ploughed or transformed into sown grasslands. These processes are driven by unbalanced overall Agricultural and Rural Policy support.

To date, there has neither been any research, nor unified records on the areas of destroyed EU protected grassland habitat types in Latvia. In the preparation of Article 17 of the Habitats Directive 2013 report, it was evaluated: since 2000 the change of land-use type has affected at least 10% of the total EU protected grassland habitat polygons (individual mapping units in grassland mapping and inventory) and at least 20% of the area of these habitats have been destroyed (Anon. 2014b). The monitoring of Latvian breeding birds show a substantial decline in the population of several common bird species re-

Table 3.1. Pressures and threats affecting semi-natural grassland habitats.
* Habitat types and their codes are listed in Chapter 1.3

Pressures and threats (sorted by their relative historical and current impact from the most significant adverse factors to the least significant).	**Pressures and threats affecting one or two habitat types** (sorted by habitat type in ascending order)*
– Change of land use type and habitat fragmentation • Building construction • Afforestation • Ploughing – Management cessation (abandonment) – Inappropriate management • Cultivation • Fertilisation • Frequent mowing • Overgrazing • Mulching and leaving the mown grass • Late mowing • Annual burning of litter • Use of inappropriate tractor machinery – Soil compaction – Drainage – Eutrophication • Intensive agricultural activity in areas adjacent to the habitat • River pollution • Airborne nitrogen deposition • Mulching and leaving the mown grass – Growing numbers of predators – Wild boar rooting – Beaver activity – Terrain modification – Mineral extraction – Introduction of invasive plant species – Introduction of expansive plant species – Climate changes	– Intervention in coastal geomorphological processes (1630)* – Rock climbing (6110*) – Frequent water level changes (6110*) – Soil acidification (6120*) – Excessive visitor load (6120*, 6210) – Logging (6530*) – Dead wood removal (6530*) – Destruction of wooded grasslands through agricultural land drainage (6530*) – Unsustainable age structure of wooded grassland trees (6530*) – Modification of the watercourses (6430) – Intensive river bank and forest edge management (6430)

lated to grasslands, for example, *Motacilla flava* and *Carpodacus erythrinus* (Auniņš, 2016). Reduction in grassland area and habitat quality are the most likely causes of population decline of these species.

Decreasing area of semi-natural grasslands causes grassland habitat fragmentation, which adversely affects conservation status and the restoration efforts of semi-natural habitats. We can already observe problems in semi-natural grassland restoration due to fragmentation. For example, floodplain habitat restoration of the River Slampe failed to reach the desired effect, because the grasslands are isolated and wild species cannot enter the area naturally (Priede et al. 2015). The semi-natural grasslands of Zemgale Lowland are severely fragmented and road verges are hardly suitable for the dispersal of semi-natural grassland species. This is proven by genetic analysis of *Galium verum* and *Galium boreale*. The samples of these species in the grasslands differed genetically from the ones growing on road verges, which proves that these species can no longer spread from one grassland to another (Gustiņa et al. 2016).

3.2 Management Cessation (Abandonment)

Along with cultivation and ploughing, the most important reason for reduction in area was and continues to be the abandonment of grasslands. This is evidenced by the increase in forested areas since the early 20th century in the regions that earlier had a large proportion of meadows and pastures in the total agricultural land area, for example, Nīca, Rucava, Mazsalaca, Rūjiena and Naukšēni municipalities (Penēze 2009).

The rate of grassland overgrowth depends on many factors – hydrological regime, availability of woody plant seeds, thickness of litter layer, disturbances facilitating the establishment of woody plants. Very dry and very wet meadows and pastures overgrow slower because the moisture conditions there are not suitable for tree seedlings. Mesic grasslands can also remain for a long time without being overgrown, if a thick layer of litter is accumulated and no disturbances (molehills, rodent activity, fires) that may create free spaces in the vegetation occur. However, although litter initially hinders the development of tree seedlings, microsites of open soil develop due to rodent activity or dieback of vegetation under the thick litter layer and woody plant species start growing. For example, wooded grasslands can transform into a closed canopy forest within 15 years (Mitlacher et al. 2002). A 700 ha alvar (calcareous grassland with juniper scrub) has almost completely overgrown within 40 years – only 30% of the area remained open (Pärtel et al. 1999).

After the mowing and grazing in semi-natural grasslands is ceased, litter accumulates very quickly. After seven years the biomass of litter can already reach 70% of the total above-ground biomass (Wells 1974). It has been observed that the amount of litter in wet, calcareous sedge meadows increases

Fig. 3.2.1. Accumulated thick layer of litter, under which the plants grow tall and thin or cannot produce shoots due to insufficient light. Photo: S. Rūsiņa.

more than tenfold after the mowing is terminated (Billeter et al. 2007), the number of species decreases significantly, the height of the sward increases by 50% (Diemer et al. 2001).

The layer of litter reduces the diversity of environmental conditions: the differences in microclimate, light intensity and moisture regime become less pronounced. Litter reduces the evaporation and soil becomes wetter. Litter hinders seed germination and reduces the diversity of plant species. The accumulation of litter also has a fertilising effect, as biomass is not removed from the meadow (Fig. 3.2.1). It accumulates and the content of soil organic matter increases (Willems 1985). More competitive grasses, such as *Calamagrostis epigeios, Brachypodium pinnatum, Dactylis glomerata, Elytrigia repens* suppress other lower species. The diversity of species declines rapidly. Annual and biennial species also disappear because the small open patches in the vegetation disappear.

Some bird species, for example, most of the waders, abandon grasslands within a few years after grassland management is ceased. Dense vegetation and high amount of litter in floodplain grasslands no longer suits their nesting and foraging needs. Other species abandon them over extended longer

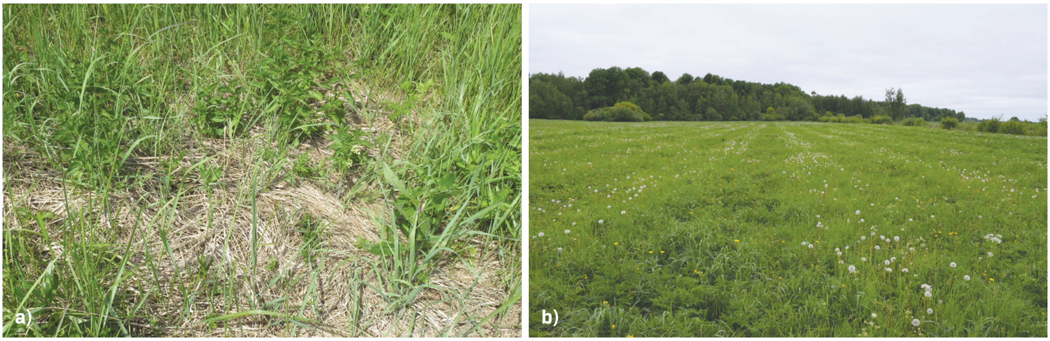

Fig. 3.3.1. The negative impact of mulching and leaving the mown grass in the meadow. (a) Meadow mulched in the previous year in the middle of June. In mulched areas, vegetation is undeveloped or only a few grass leaves have sprouted through the litter layer. (b) The litter left in swathes delays the development of vegetation. In the swathe bands the dandelion only begins to bloom, but between swathes it has already deflowered. Photo: S. Rūsiņa.

Short-term and long-term effects of mulching on the grassland

Short-term mulching (1–2 years of mulching, then 5–10 years of mowing for hay or grazing, then one year of mulching again) can have a beneficial impact on grassland biodiversity, especially in grasslands with very poor soil. As nutrients slowly return to the soil, new ecological niches appear and slightly more demanding plant species may get introduced.

Long-term mulching (grassland is mulched for more than five years without grazing or hay harvesting) has a highly negative impact on biodiversity, as it constantly increases the fertility and the tall grasses and nitrophilous forbs take over the meadow and the lower plant species disappear.

Researchers have found that mulching twice in summer (June and August) leads to the simplification of species composition and a drastic reduction in the number of low-growing species (Moog et al. 2002). By mowing the meadow and mulching the grass in June and early September for five years, the vegetation biomass increased from 6–7 t ha^{-1} to 11 t ha^{-1}, which is equal to the amount of biomass produced in an intensively improved and fertilised meadow.

By mulching a dry meadow once per year for over 25 years, a thick layer of litter developed. The species composition differed from the mown and harvested part of the meadow. Annual mulching created vegetation that was similar to the vegetation of abandoned meadows (Moog et al. 2002). Overall, mulching promotes the formation of vegetation not characteristic of semi-natural grasslands. The vegetation becomes higher and is dominated by various nitrophilous tall herb species that compete for light and cause the extinction of low-growing species. Thus, typical meadow vegetation and species composition disappears (Kornaš, Dubiel 1991; Gaisler et al. 2004). In a mesic *Cynosurion* meadow mulched every September in the Netherlands, tall herb vegetation formed within 15 years dominated by *Holcus lanatus, Agrostis tenuis, Elytrigia repens*, and *Heracleum spondylium* (Bakker et al. 2002).

Fig. 3.3.2. Grass left in the meadow last year has been caught in a shrub near a river during floods. This promotes the eutrophication of river banks. Photo: S. Rūsiņa.

Fig. 3.3.3. Moist grassland, which has been mown for a long time with grass mulching. The mulched grass has developed a dense litter layer which gets compacted and reduces the evaporation. Partial decomposition of litter promotes more intensive development of turf. *Gallinago media* cannot penetrate such layer with its beak to reach the mineral soil and feed on earthworms. Photo: S. Rūsiņa.

period of time. In the first years after the cessation of mowing and grazing, non-managed grasslands can become even better suitable for some bird species than before. For example, the nesting density of Corncrake at the end of the 20th century, when the mass abandonment of grasslands took place, was higher in non-managed grasslands than in managed ones (Keišs 1997), and a rapid increase in Corncrake population occurred in the 1990s (Keišs 2003). However, this period was not lasting. As the grassland overgrows with shrubs and the open area decreases, it becomes unsuitable for Corncrake. Some passerine species related to shrubs also benefit from grassland overgrowth. However, as the overgrowth of grassland continues, they are gradually replaced by forest and scrub.

The diversity of invertebrate species in the beginning of overgrowth increases as the vegetation structure changes and vegetation of varying height develops in the grassland – both higher herbs and shrubs. This is used by, for example, *Tettigonia cantans*. It requires higher plants, such as shrubs, for stridulation. Overgrowth with trees and shrubs creates individual patches with a favourable microclimate – low wind speed and sunny forest edges. The favourable effect of overgrowth only lasts for a few years. Later, the invertebrate fauna changes, together with the change in vegetation. Grassland plant communities are replaced by forest plant communities. As litter accumulates, the proportion

Examples of the influence of mowing frequency

In the Netherlands, it was observed that mowing in mesic meadow (*Arrhenatheretum*) two times per year was very beneficial for plant species diversity, especially for the low plant species. Late mowing once a year in September severely reduced the species diversity and low-growing species disappeared almost completely. Late mowing (in September) contributed to the increase in biomass in moist meadows as well, reducing the species diversity (Oomes et al. 1996). Studies in Switzerland have shown that mowing of dry calcareous meadows later than in July substantially reduces the plant species diversity – the meadow vegetation is starting to be dominated by some forbs, which are not typical for traditionally mown meadows (Ryser et al. 1995). Late mowing (late October and early November) carried out for 40 years in the Netherlands for the conservation of dry calcareous meadows resulted in a pronounced dominance of *Brachypodium pinnatum* and a substantial reduction of species diversity. The species diversity only recovered there after introducing early mowing (in June) or mowing twice per season (Bobbink, Willems 1991).

of saprophagous species increases. Replacement of species may take several decades, however, the complete replacement of invertebrate communities requires up to a century. The soil fauna are the last to change because earthworms and pot worms characteristic of grasslands can be found even in young forest.

3.3 Inappropriate Management

Inappropriate management as an influencing factor includes all types of grassland management that preserve the grassland as an ecosystem, but substantially alter the structure, species composition and functioning of this ecosystem. Only extensive management (*see Chapter 1.3*) is suitable for the maintenance of semi-natural grasslands and their biodiversity, while other types of management affect these grasslands adversely or even destroy them.

3.3.1 Improvement and Fertilisation

Grassland management which was mainly extensive lasted up to the early 20th century in Latvia. The agronomist J. Vārsbergs described the condition of meadows and pastures in 1923: "Even today, many farmers regard meadows as a natural gift that feeds their livestock on its own. Boulders, tussocks, shrubs, pits and other obstacles hinder the harvest; sometimes farmers "fish" for hay in their meadows, although the excess water could easily be drained, grazing cattle often need to be removed after being stuck in quagmires, or if wind kicks up the sand in the pastures. Most of our meadows are low-value

Fig. 3.3.4. Fresh deep tracks that have damaged the turf and hinder further management. Photo: A. Namatēva.

moist plain meadows and fens where the vegetation mainly consists of acidic grasses. Our meadows are characterised by well-known *Carex vulgaris, Carex flava* and *Nardus stricta* in drier places." (Vārsbergs 1923, p. 20).

However, in the second half of the 20th century agricultural intensification continued. Semi-natural grasslands were either abandoned or improved (ploughed and sown with a mixture of grasses) and, as a result, their area was reduced to 1% of the total land area of Latvia.

Volumes of land improvement can be judged by an increase in cultivated areas. In the 1960s, there were only 18% of agricultural lands with average or high phosphorus content (average P_2O_5 7–15 mg 100 g^{-1}, high 15–40 mg 100 g^{-1}), whereas in the 1990s there were already 60% of such soils (Skromanis et al. 1994). During the 1960s – 1980s, the use of mineral fertilisers increased fourfold and by 1985 each hectare of arable land received 276 kg of mineral fertilisers on average (Strods 1992).

The amount of phosphorus is very low in the soils of semi-natural grasslands (less than 15 mg kg^{-1} according to the Olsen method). To increase species diversity in previously improved grassland, the amount of phosphorus in the soil should not exceed 25 mg kg^{-1}. If the amount of phosphorus is 25–45 mg kg^{-1} than the measures that decrease soil fertility should be implemented (Kiehl, Jeschke 2005) (Table 21.7.2). Thus, the excessively high content of plant nutrients (especially phosphorus) in soil is one of the factors that limit biodiversity in most improved grasslands and ex-arable lands.

Fertilisation has no direct impact on birds, but it affects their occurrence through vegetation changes and is not desirable. In improved and fertilised grasslands, the vegetation becomes dense and develops faster, making them unsuitable for most bird species.

If grassland fertilisation reduces the diversity of plant species, the diversity of invertebrates also decreases, especially, weevils *Curculionidae*, frit flies *Chloropidae* and many butterfly species. However, conditions improve for many oligophagous and polyphagous plant-eating species, as the chemical composition of plants changes and their nutrient quality improves. Therefore an increase in the number of individuals of many species is possible. Improved grasslands are characterised by the dominance of certain species, for example, capsid bugs *Miridae*. The type and dose of fertilisers affect grassland invertebrates differently. Organic fertiliser (manure, compost, sewage sludge) significantly increases the number of soil and topsoil saprophаgous species. The diversity of soil mites, springtails and nematodes, and the number of saprophagous flies and beetles increases substantially. The effect of organic fertiliser lasts for a few years. Meanwhile mineral fertiliser initially affects the soil fauna by changing the proportion of springtails, mites, nematodes and pot worms. The density of rhizophagous nematodes usually increases and they can affect plant roots and damage them.

3.3.2 Frequent Mowing, Intensive Grazing and Overgrazing

Excessively intense mowing and grazing negatively affects semi-natural grassland habitats. Mowing more often than twice per year significantly reduces the plant species diversity because only a few ecologically very flexible species tolerate disturbance of such intensity. Relatively uniform vegetation usually develops in frequently mown and intensively grazed areas. It is poor in species and usually dominated by one or a few grasses, such as *Festuca rubra* and *Agrostis tenuis*. In overgrazed sites, they are accompanied by *Poa annua* and some forbs – *Prunella vulgaris, Plantago major, Polygonum arenastrum*. Overgrazing negatively affects turf formation and soil. Excessive trampling damages turf, tears plant roots and compacts soil. As a result, the oxygen supply to plant roots decreases and the diversity of soil fauna declines.

Mowing during the bird breeding season destroys almost all bird nests on the ground, while those that survive lose their camouflage and become an easy target for nest predators. After the destruction of a nest, birds usually try to breed again. If mowing occurs frequently (twice during a breeding season), the nesting success is close to zero, as the breeding (preparation of nest, laying eggs, hatching and flightless chicks) normally lasts for at least one and a half months. Thus, grasslands that are frequently mown become an ecological trap for species nesting on the ground. Intensive grazing with high cattle density substantially increases the nest trampling risk (Beintema, Muskens 1987).

3.3.3 Mulching and Leaving the Mown Grass

Annual mulching or mowing and leaving the cut grass on the field, which has been widely practised in Latvia in previous years, is not compatible with the conservation of biodiversity. Mulching is cutting of the grass, shredding and spreading it across the field (Moog et al. 2002). It creates a dual impact. Under favourable moisture conditions, the mulched plant parts decompose quickly and return into the nutrient circulation creating a fertilising effect (Schaffers et al. 1998; Bakker 2005) and increasing the biomass in the grassland (Oomes et al. 1996). In other cases, when the shredded or left grass decomposes slowly, it forms a thick and dense layer of litter. This creates a physical barrier for the germination of grassland plant species (Fig. 3.3.1) and also covers the soil, thus altering the light and moisture conditions. In floodplain grasslands, floods often carry the mown grass to other grasslands causing their eutrophication (Fig. 3.3.2). The grass brought into water courses by flooding promotes the eutrophication of water.

Mulching adversely affects wader foraging conditions. A layer of litter develops, and it prevents access to the soil, making the grassland unsuitable for waders, especially those feeding on earthworms in the soil (e.g., *Gallinago media*). With time, vegetation becomes denser, and grassland also becomes less suitable for Corncrake (Fig. 3.3.3).

3.3.4 Late Mowing

Late mowing is performed later than traditionally; mowing around mid-July or later is usually considered late. As a management method, it has been widely introduced in nature protection in Europe to protect grassland birds, especially Corncrake. For this purpose, it is very effective because Corncrake breeds relatively late and the traditional mowing in June, without the use of bird protection methods, substantially reduces its population (Green 1996).

However, most often the aim of semi-natural grassland protection is the overall biodiversity of the grassland, rather than one species, therefore it is important to understand the impact of late mowing on all semi-natural grassland ecosystem components.

As regards the vegetation, annual late mowing is not favourable. It allows the grasses to store nutrients in roots before mowing. In spring these plants are more competitive, but the new seedlings of other species have a lower chance of germinating and survival (Svensson, Carlsson, 2005). Nutrient reserves stored in roots, tillers and underground shoots are very important for grasses. After mowing or grazing, the regrowth is mostly ensured at the expense of nutrient reserves stored in the roots. If the grass is mown too late, all nutrients from surface parts will have been transferred to the underground parts, so significantly less nutrients are removed from the grassland than is characteristic of and necessary for a semi-natural grassland. Analysis and comparison of research in 24 places across Europe shows that late mowing (late summer, early autumn) reduces the diversity of plant and invertebrate species in comparison to early mowing (second half of June, July) (Humbert et al. 2012a). In Latvia, vegetation monitoring in Dundurpļavas of Slampe floodplain shows that late mowing with grass mulching increased the cover of *Anthriscus sylvestris* in the grassland (Priede et al. 2015).

3.3.5 Annual Burning of Litter

Annual burning is not suitable management for semi-natural meadows and pastures. Burning increases the productivity of a meadow in the short term (Ryser et al. 1995), but long-term annual burning adversely affects the soil fertility and reduces the organic matter content in it. Burning contributes to an increase in the proportion of grasses, especially *Brachypodium pinnatum, Calamagrostis epigeios*, and *Elytrigia repens*. They spread actively and reduce the diversity of species and, consequently, the botanical and scenic value of the meadow (Moog et al. 2002). Spread of *Aegopodium podagraria* and *Rubus idaeus* in grasslands burnt in spring has been observed in Sweden. In Sweden, annual burning created uniform vegetation with the domination of some species (*Trifolium medium, Dactylis glomerata, Hypericum maculatum, Aegopodium podagraria, Galium boreale*), which had little in common with a traditionally managed grassland (Wahlman, Milberg 2002). In this study the effect of burning started to appear within 7-13 years.

With time, the diversity of plant species decreases, plant composition changes and it becomes more similar to ruderal vegetation. In meadows burnt in the long term, the number of species is as low as in cultivated or long-abandoned grasslands. Annual (frequent) burning may contribute to the spread of invasive plant species (Priede 2008).

Long-term annual burning also has a negative impact on birds and invertebrates. Regular burning changes the soil fauna, i.e., the food base of birds. The larger the burnt area, the smaller the chance for specific grassland fauna to recover. The burnt area is attractive to predators and necrophagous species which feed on burnt animal bodies. Burning after the birds have started nesting is highly undesirable, because it destroys bird nests.

For wooded grassland landscapes, not only annual, but also one-off burning is destructive (see Chapter 19).

3.3.6 Use of Inappropriate Tractor Machinery

In moist and wet semi-natural grassland habitats (EU protected habitats and their subtypes: 6230_2, 6270_3, 6410, 6450, 6510_2) the use of unsuitable tractor equipment has a substantial adverse impact – it damages turf (Fig. 3.3.4), produces deep tyre tracks, which complicates further grassland management and creates conditions that are favourable for paludification.

3.4 Soil Compaction

Soil compaction adversely affects the soil fauna and plant growing conditions, reducing soil porosity and permeability, changing the hydrological regime (moisture increases as the infiltration capacity of the soil decreases) and oxygen access to the roots. Soil compaction is caused by the use of heavy tractor machinery and overgrazing (excessive number of grazing animals per unit of area). Soils of moist and wet grasslands are especially sensitive – the moist subtype of the habitat type 6270* *Fennoscandian lowland species-rich dry to mesic grasslands,* 6410 *Molinia meadows on calcareous, peaty or clayey-silt-laden soils* and 6450 *Northern boreal alluvial meadows*. Also in dry and mesic grasslands soil compaction is harmful for the diversity of semi-natural grassland species. Restoration of semi-natural grassland habitat in compacted soils is a complicated task that requires initial rehabilitation of the soil, which is a long process.

3.5 Drainage

Overall, 60% of agricultural land in Latvia is drained (both using ditches and internal drainage). Due to drainage of semi-natural grasslands, the occurrence of moist and wet meadow and pasture habitats decreased rapidly. Only 17% of meadows and 26% of pastures were drained in 1967, while in 1987 78% of meadows and 44% of pastures were already drained (Boruks 2003).

Control of the hydrological regime in meadows and pastures started as early as in the 19th century (mostly by shallow ditches). Yet, in the first half of the 20th century 65% of all semi-natural grasslands and pastures were still moist according to agronomists (Сабардина 1957) and moist and wet soil plant communities dominated them. Until the mid-20th century, shallow ditches dug mostly by hand were the dominating form of drainage, and grassland drainage was not followed by ploughing or the creation of an improved grassland. As traditional management was continued after grassland drainage, the composition of species changed from wet to moist or mesic plant communities, but the overall

Fig. 3.8.1. If wild boar rooting has not destroyed the entire vegetation, **(a)** vegetation of semi-natural grassland restores itself after smoothing; **(b)** if the entire grassland is "ploughed" for several years in a row , the restoration of semi-natural grassland is threatened. Photo: G. Dolmanis.

diversity of species persisted. In such areas, where semi-natural grasslands have survived until today, it is recommended to retain the shallow ditch drainage system.

Drainage affects not only the wet and moist grassland habitats, but also dry and mesic habitats in floodplains because the flood regime is changed or flooding no longer occurs. Dry and mesic sites become dryer, but most grasses have shallow roots and the moisture can only reach them through capillaries if the groundwater table is no deeper than 30-100 cm.

Both open drainage and internal drainage improves the availability of nutrients for plants, making the area more fertile and less biodiverse. After drainage, the plant species composition changes, wet grassland characteristic plant communities and species disappear. If peaty soil is drained, then the amount of nutrients available to plants increases as a result of decomposition or mineralisation to the extent that semi-natural grassland cannot develop. Drainage has been one of the factors that most adversely affected grassland bird communities in the 20th century. It has led to the complete disappearance of large floodplain grassland areas. Nowadays large floodplain grasslands not affected by drainage are almost no longer present. Drainage reduces the duration and extent of the flooding and promotes faster drying of grassland, which enables earlier management. Ditch systems contribute to the formation of shrub and tree belts, which fragment the grasslands and reduce their continuous open area. The most sensitive grassland bird species is *Gallinago media*, which almost exclusively occurs in areas flooded on a regular basis, where the groundwater table usually remains high until late June. Drained grasslands are usually too dry for other meadow wader species as well. All meadow wader species avoid shrub bands along ditches that fragment the landscape.

If wet soil, where the decomposition of plant remains was previously slow due to increased soil moisture, is drained, the activity of soil invertebrates decomposing plant remains increases, the decomposition of litter becomes more efficient. Changes in soil moisture are followed by changes in grassland plant species composition and invertebrate communities inhabiting them. For example, drainage in periodically flooded grasslands can adversely affect whorl snails.

3.6 Eutrophication

Eutrophication is the enrichment of soil with plant nutrients, resulting in a more fertile soil and denser and higher vegetation. The vegetation and fauna of habitat changes, species diversity decreases, expansive and invasive plant species get introduced. The causes of eutrophication can be various:

- intensive agriculture in areas adjacent to the habitat – intensive fertilisation of farmlands increases the inflow of nutrients in the semi-natural grassland. This is particularly characteristic of river valleys where semi-natural grasslands are located on terrace slopes and fertilised fields lay outside the valley. Fertiliser gradually enters the grassland with the water flowing downhill to the river and results in the same effect as if the grasslands were fertilised. Enrichment of wet grassland soil with nitrogen encourages the rapid spread of *Phragmites australis*;
- river pollution – nowadays the floodwater contains a higher amount of nutrients than in natural conditions because the surface runoff from forests and agricultural land is increased by drainage; intensive fertilisation contributes to nutrient runoff from farmlands; water very rich in nutrients fertilises the habitat and brings more nitrogen and phosphorus into it, thus reducing the diversity of species;
- nitrogen airborne deposition – the amount of nitrogen deposits in Latvia is approximately 5–7 kg ha^{-1} (Erisman et al. 2015). Significant changes in the plant species composition and ecosystem functioning of a semi-natural grassland start when nitrogen deposits reach 5–30 kg ha^{-1} (Bobbink et al. 2003);
- mulching and leaving the mown grass contributes to eutrophication because mowing promotes the regrowth of grass and increases the total grass biomass. Since all of this biomass remains in the grassland, it encourages the accumulation of nutrients and soil enrichment.

3.7 Growing Numbers of Predators

Grassland birds are increasingly threatened by nest predators. Significant nest predators are mammals (*Vulpes vulpes, Nyctereutes procyonoides, Neovison vison*), and birds (corvids, gulls and *Circus aeruginosus*). The extent of predator damage is increased both by disturbance when the birds are forced to temporarily leave the nest, making it easily accessible to predators, and the low nesting density of wader species. When birds nest in semi-colonies, the birds of species that are able to protect the nest territory (*Vanellus vanellus, Limosa limosa*) ensure the collective protection of their own nests and nests of other bird species (Elliot 1985).

3.8 Wild Boar Rooting

Rooting by wild boar *Sus scrofa* in a small area does not harm the biodiversity of the grassland, as they help create new niches for species that cannot compete with other species in a dense sward. However, intensive rooting that affects most part of the grassland has a negative effect on biodiversity. It creates vegetation that is similar to ex-arable land (similar to ploughing) and makes the management difficult (Fig. 3.8.1).

3.9 Beaver Activity

Activity of beavers *Castor fiber* mainly affects wet and moist habitats, but can also affect others. Beaver activity can be both positive (blocking drainage ditches and maintaining the optimal water table in moist and wet grassland, thereby reducing or eliminating the impact of drainage) and negative (blocking drainage ditches and creating constantly flooded areas, where reed stands develop due to extensive moisture and characteristic species of grasslands disappear). Activity of beavers has a negative effect on wooded grassland landscapes where they damage valuable wide-crowned trees (*see Chapter 19*).

3.10 Supplementary Feeding of Game Animals

Installation of game feeders in semi-natural grasslands is not desirable. Frequent presence of the animals near the feeders can cause degradation and disappearance of the grassland vegetation. The grass and bird nests on the ground are trampled. Wild boar root up the grassland turf excessively. The supplied feed and animal droppings cause eutrophication.

3.11 Terrain Modification

In some places grasslands were destroyed and are still threatened today by the smoothing of floodplain terrain. The adverse impact of terrain smoothing on biodiversity can last for decades (ex-arable land species occur in the grassland, the overall species diversity is reduced).

3.12 Mineral Extraction

Extraction of sand, gravel, clay, dolomite and limestone mostly affects dry and moderately humid grassland habitats. Mineral extraction destroys the habitat. Restoration is possible if appropriate substrate remains and moisture conditions are suitable. However, restoration requires large resources and time, because the habitat-specific species must be introduced anew, and turf and soil formation is a very slow process.

3.13 Introduction of Invasive Plant Species

Invasive species are non-native plant species that enter the territory outcompete the native plant species. So far, the highest impact of invasive species has been observed in habitat types 6450 *Northern boreal alluvial meadows* and 6430 *Hydrophilous tall herb fringe communities of plain and of the montane to alpine levels*. There, the most dangerous invasive plant species are *Impatiens glandulifera* and *Echinocystis lobata*.

In mesic and dry semi-natural grasslands, there is usually little invasion of foreign plant species, except when the grassland has been ploughed and its turf and species diversity have failed to recover enough to compete with invasive plant species. Common invasive plant species in mesic and dry semi-natural grasslands are *Solidago canadensis, Bunias orientalis, Rumex confertus, Oenothera* spp. They quickly occupy the free space and shade the habitat, thus outcompeting the species characteristic of the habitat.

To limit the invasive species, it is necessary to apply specific biotechnical measures, which often require a high financial and time investment. The control methods of major invasive plant species are presented in *Chapter 21.9* and *Annex 3*.

3.14 Introduction of Expansive Plant Species

Local wild species of plants that start dominating the vegetation and suppress habitat characteristic species, thus impairing the conservation status of the habitat, are called expansive species. Most often, the introduction and spread of expansive plant species is a result of other factors influencing semi-natural grasslands, such as eutrophication and abandonment. As soon as these species have spread, they significantly change the environment and interspecies competition conditions for grassland species.

In the last decade, the spread of expansive plant species in semi-natural grasslands has been a very significant problem. Most likely, it has been caused by the abandonment of semi-natural grasslands typical of the late 20th and early 21st century, as well as the influence of late mowing and permitted mulching as per the Agro-environmental sub-activity *Maintaining Biodiversity in Grasslands* of the Rural Development Programme of Latvia for 2007. The eradication methods of major expansive plant species are presented in *Chapter 21.9* and *Annex 3*.

3.15 Climate Change

European climatologists predict more flooding and longer droughts (ICCP 2007). It is estimated that in Latvia spring floods will occur earlier and their duration will decrease (Apsīte et al. 2011; Latkovska et al. 2012). The results of the simulation of the occurrence of several EU protected grassland habitat types in Europe until 2060 under the influence of climate change show that the overall occurrence of protected grassland habitats in Europe will decrease (Bittner et al. 2011). However, for certain types of habitats in Latvia, climate change could bring more favourable climatic conditions. For example, longer and more frequent droughts could increase the areas of dry grassland habitats (6120*, 6210).

It is expected that the range of most of the species will shift north-east due to climate change. The ranges of European birds will shift by 550 km on average and diminish by 20% on average (Huntley et al. 2008). Some of currently typical grassland species, including *Gallinago media*, might disappear from Latvia by the end of the 21st century (Huntley et al. 2007). Species with lower dispersal potential than that of birds (for instance, plants and invertebrates) will be even more affected by climate change. As the ranges of species change, species communities and interaction between species will change as well. This can cause unsaturated species communities with a high risk of the introduction and spread of invasive species (Auniņš 2009).