Chapter 22. Main Methods of Grassland Habitat Management

22.1 Non-intervention Management (S. Rūsiņa)

In the contemporary situation in Latvia only two of the habitat types reviewed in this book can exist entirely without human intervention, and they are maintained by natural processes. They are 6110* *Rupicolous calcareous or basophilic grasslands of the* Alysso–Sedion albi and 6430 *Hydrophilous tall herb fringe communities of plain and of the montane to alpine levels*. However, management is often required for these habitats due to human induced changes in environmental factors that are significant for these habitat types. All other EU protected habitats require management – regular maintenance.

22.2 Meadow Management for Biodiversity (S. Rūsiņa, A. Auniņš, V. Spuņģis)

22.2.1 Mowing

The following mowing conditions determine biodiversity in meadows:

- mowing equipment (suitability of the equipment to moist conditions and conservation of animals);
- mowing time (early, traditional, late);
- mowing frequency (one or several times per year);
- animal and plant friendly mowing (direction,

Table 22.2.1. Optimal and inappropriate meadow management for biodiversity.

Mowing parameter	Recommended (optimal) actions	Inappropriate actions
Mowing equipment	Select appropriate tractor equipment to avoid track formation, turf damage and soil compaction.	Avoid the use of equipment that is not suitable for moisture conditions.
Mowing time	Should be selected depending on biodiversity values and weather conditions. If the number of expansive species (*Anthriscus sylvestris*, *Aegopodium podagraria*) needs to be reduced, mowing must be performed prior to the maturation of seeds.	First mowing later than in mid-July (except for important bird areas) or earlier than mid-June every year is recommended.
Mowing frequency	Depending on habitat type 1–2 times per year; aftermath grazing is recommended.	Mowing frequency of more than two times per year and one time per two years is not recommended.
Mowing direction and type	Direction from the middle to the edges using animal repellents or from one edge to the other edge towards the animal refuge. In moist grasslands it is recommended to change the direction of mowing by 90 degrees every year to avoid track formation.	It is not recommended to mow from the edges to the centre, without the use of animal repellents, and the entire area at once.
Cutting height	3–5 cm in vegetation near watercourses and in sites suitable for waders; 20 cm in sites with Corncrake *Crex crex*.	Mowing lower than 3 cm and higher than 20 cm should be avoided.
Hay removal	Hay removal is mandatory. Grass mulching is permissible no more frequently than once every five years.	Mulching every year is not permissible. Making silage annually is not permissible (no sowing of seeds).
Aftermath grazing and spring grazing	Very desirable.	Permanent long-term overgrazing is not permissible.

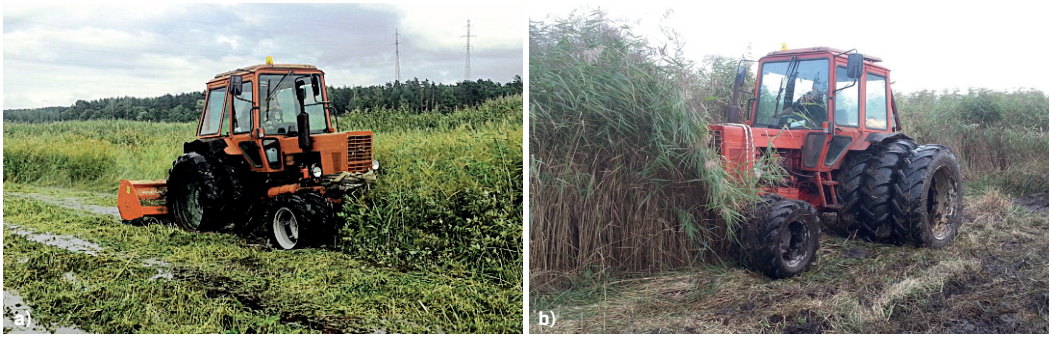

Fig. 22.2.1. The use of double wheel systems reduces the risk of soil compaction and track formation. Small wheeled tractors, which, depending on the moisture conditions, are used with (**a**) two or even (**b**) three pairs of wheels. Photo: A. Liepa.

speed, mowing in sectors);
- mowing height;
- drying and removal of mown grass or leaving (mulching).

A summary of the impact of mowing on the grassland is provided in Table 22.2.1, a detailed description – in the following chapters. Detailed explanations of the effect of mowing on particular grassland habitats are provided in chapters on particular habitats. For information on mowing as a restoration method, see Chapter 21.

22.2.1.1 Mowing Equipment

It is important to select appropriate tractor equipment in order to avoid track formation, turf damage or soil compaction (if it has happened, the grassland should be gently smoothed by grinding, harrowing, disc-harrowing, while preserving the turf and avoiding complete ploughing of the upper layer of topsoil). Wide tyres (Fig. 22.2.1) or tracked equipment, as well as avoiding to enter the grassland immediately after rain and waiting until the soil dries up is recommended. The preferable mowing width is up to 2.5 m, because a wider mower is unsuitable for grasslands with complicated configuration and increases the risk of killing birds and other wildlife.

22.2.1.2 Mowing Time

The traditional time for mowing semi-natural grasslands in Latvia was late June and early July (Draviņš 1937; Gustiņa 2016). The time of mowing changed every year, depending on weather conditions and the phenological phases of plants. Gradual mowing of meadows was common – some meadows were mown earlier, in order to enable the development of aftermath, which was also mown later; the other meadows were mown only once and later. If the grass was growing well and the year was beneficial for haymaking, then more remote and less accessible places were not mown, while, if the year was dry and the growth of grass was slow, then all, even the tiniest glades were mown.

In the second half of the 20th century, as agricultural tractor equipment evolved, enabling faster completion of spring and early summer works, the mowing of meadows could be commenced earlier. For instance, in Zemgale region mowing was completed and hay was stored in hay sheds by Midsummer Eve (June 24) during the last decades of the 20th century.

Annual changes of mowing time in the meadow are beneficial for the diversity of plant species (for instance, late June in the first year, in mid-July in the second year and August in the third year, with the recommencement of the cycle during the fourth year). This type of mowing conserves biodiversity, because it maintains the maximum richness of plant species, both – early and late flowering.

Late breeding bird species are most affected by mowing, especially Corncrake, as well as the repeated broods of other species or second and third broods in species that have them.

Waders have only one brood per year, but a second brood is possible, if the first one has been lost. Although no specific research has been conducted in Latvia, the known breeding phenology of wader species (time of migrations, nesting, etc.) allows one to assume that first broods of almost all these species have hatched and left the nest by mid-June. Thus, mowing can only affect some of the repeated broods (Fig. 22.2.2). After hatching minimum hazard is posed by mowing, since the chicks of these bird species are usually guided away from the nest to the water's edge immediately after hatching (if no water body is in the vicinity of the nest, the chicks are taken to a wet depression or low angle ditch edge, even

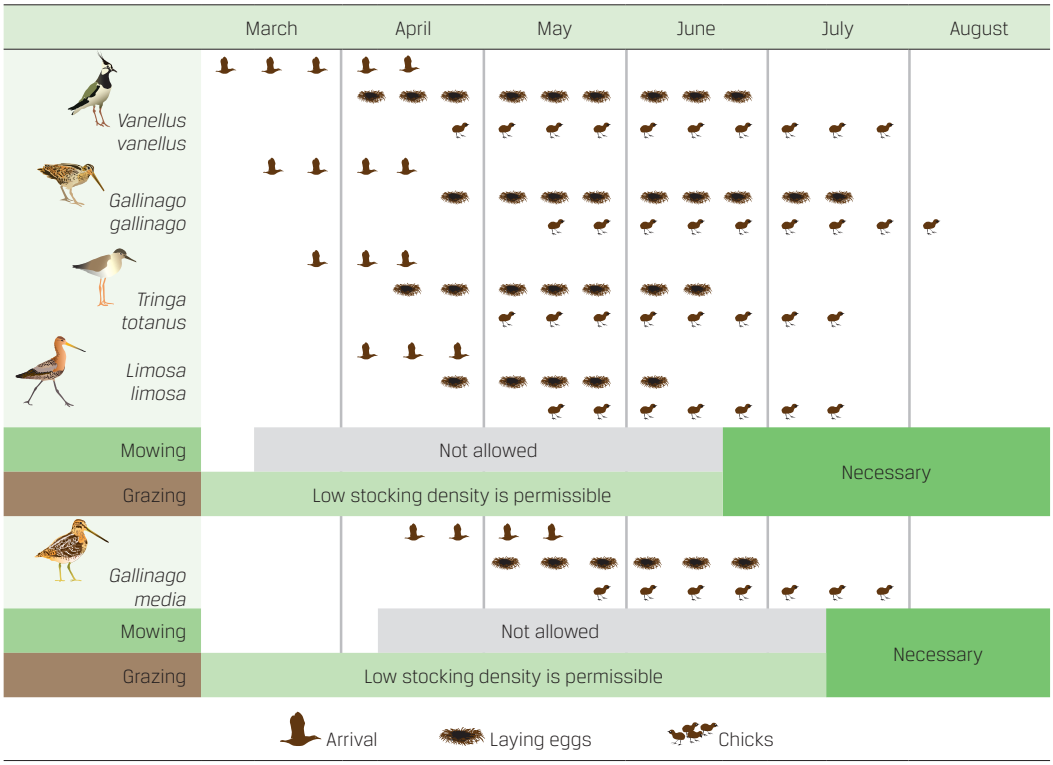

Fig. 22.2.2. Meadow wader breeding season and permissible time of mowing and grazing (according to Anon. *without date*, updated).

at a considerable distance from the nesting place). Grasslands aimed at conservation of waders should be mown no earlier than in mid-June. The second cut of these grasslands in late August or September is permissible and even preferable. This will ensure low vegetation that is suitable for waders in spring, when their breeding season starts.

Great Snipe *Gallinago media* on average breeds later than other waders, but earlier than Corncrake. The breeding season is extended, and the males continue lekking until late June, which means that up to that time there are females that only lay their eggs. Most probably these late broods are repeated broods, if the first brood has been lost. In July, however, the quantity of nests is very low, therefore, mowing in mid-July does not cause severe loss to the population of Great Snipe.

Corncrake *Crex crex* nests later and the chicks of the first brood hatch throughout the entire of June (Fig. 22.2.3). Furthermore, unlike meadow waders, Corncrake does not lead the chicks away from the meadow, therefore mowing poses hazard up to the moment when they learn to fly. Most of the first brood chicks learn to fly by mid-July. However, it is common for Corncrake to have second broods, which are significant for the maintenance of the population. The second broods are created, when the young of the first brood have matured. The chicks of the second brood learn to fly in August. The grasslands managed for the purpose of conserving the most significant populations of Corncrake may not be mown earlier than in mid-July and, preferably, even later. Corncrake already requires at least 30 cm tall vegetation in the last ten days of May to start nesting, therefore it is recommended to mow these grasslands only once per season. Since Corncrake prefers grasslands that have been abandoned for a short period of time (Keiss 2005; Keišs 2003),

The optimum frequency of mowing in the conservation of semi-natural grasslands is one or two times a year. Mowing once every two years is also permissible in dry and wet meadows with very poor soil and low productivity. Mowing three and more times during the season is impermissible.

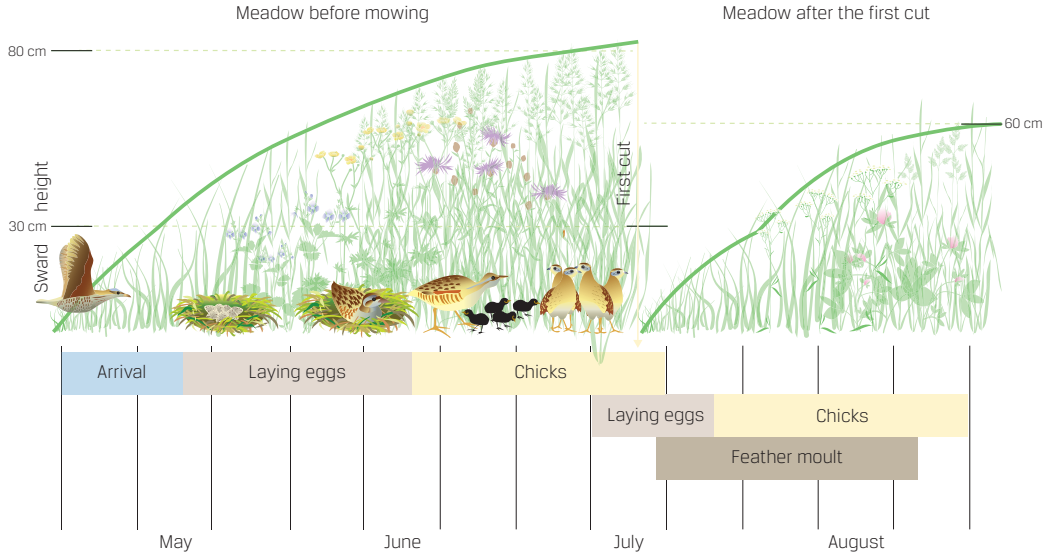

Fig. 22.2.3. Mowing after 10 July is a compromise that allows high-quality hay to be obtained, while causing the least damage to Corncrake (according to Anon. *without date*, updated).

annual mowing of such grasslands is not mandatory and it is sufficient to only mow these grasslands with the purpose of preventing the establishment of shrubs. However, less frequent mowing promotes the accumulation of litter and increases the density and height of vegetation, therefore, in the long run, less frequently mown grasslands may become less suitable for Corncrake.

If the first brood is lost, Corncrake can have a repeated brood. If it is raised successfully, Corncrake will not have a second brood.

Grasslands, where no song of Corncrake is heard (typically in the evenings and early mornings or, best, at nights), should be mown in early June. When the grass has regrown, the grasslands will be suitable for repeated and second broods.

22.2.1.3 Mowing Frequency

Traditionally the meadows in Latvia have been mown once per year followed by aftermath grazing. Mowing twice per season was used mainly if a summer was not beneficial for haymaking and the amount of hay harvested was insufficient. It was also used in the meadows where the aftermath was not grazed. Mowing of the meadow more frequently than twice per season is impermissible (it is only permissible during the restoration of the meadow). Frequent mowing converts grassland into a lawn and almost completely destroys biodiversity.

Mowing twice a year must only be performed if the aftermath grows too tall (>20–30 cm) in autumn and could create a thick litter layer in the following year.

Mowing once every two years is recommended, if the meadow is wet and tracks are easily created in it, which makes the meadow uneven and difficult to mow. The vegetation will gradually change in such meadow, it will become thicker and more homogeneous. In this case, annual mowing must be

The use of animal repelling devices and mowing from the centre towards the edges or from one edge to the other is mandatory in the grasslands where the main biodiversity value is birds. Unmown areas must be left in the grasslands that are significant for plants, to enable the maturation and dispersal of seeds. These areas can also serve as shelters for animals. The location of unmown areas must be changed every year.

The mown grass must be collected and removed from the meadow. Mulching is permissible no more than once every five years. Mulching is only permissible in grasslands that are significant for Corncrake, where no other biodiversity values are present. Mulching is not permissible in grasslands significant for meadow waders. In the grasslands that are significant for plants, mulching is permissible in meadows with very poor soil only and for a short period of time, while by no means in mesic and wet meadows that are moderately fertile.

resumed.

Grasslands mown less frequently than once every two years develop the vegetation structure resembling an unmanaged meadow and its biodiversity declines (Ryser et al. 1995; Wahlman, Milberg 2002). Therefore, it cannot be recommended, although, it is better than complete abandonment. In situations where mowing a particular grassland is difficult, or its main conservation value is Corncrake, mowing frequency that only prevents overgrowth with shrubs is permissible. Observations show that Corncrake prefer unmanaged grasslands during the first few years after they were abandoned (Keiss 2005; Keišs 1997, 2003).

22.2.1.4 Animal and Plant-friendly Mowing

The type of mower used affects the survival of invertebrates, as well as birds. The least number of animals is killed, when mowing is performed with a sickle bar mower, while most harm is inflicted with rotary disc mowers (Dicks et al. 2013).

To reduce the mortality of birds and other animal species caused by mowing, the meadow must be mown gradually or the correct mowing direction must be chosen – from the centre of the grassland to the edges or from one edge to the another (Fig. 22.2.4–22.2.7). When mowing from one edge to another, it is recommended to choose the direction where the last band of mown grass borders a natural habitat (for instance, a forest) or a ditch, the edges of which are not mown, instead of a field or another already mown grassland.

Mowing a part of water edge areas (slacks, ditches, oxbow lakes) is important, because these are bird feeding areas and birds require low vegetation in these places. Some of the water edge areas must be left unmown to provide hiding places for

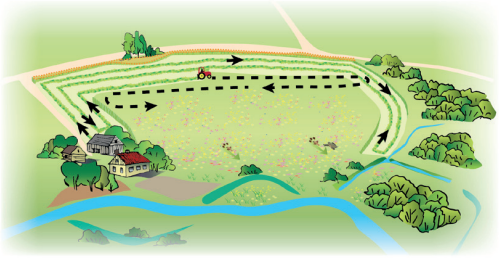

Fig. 22.2.4. Animal-friendly mowing direction from one edge to the other. First strips are mown at each side of the grassland to enable the manoeuvrability of the tractor. Then mowing in the direction from the road to the most appropriate bird refuge place, which, in this case, is the riverside, is commenced. Drawing by D. Segliņa.

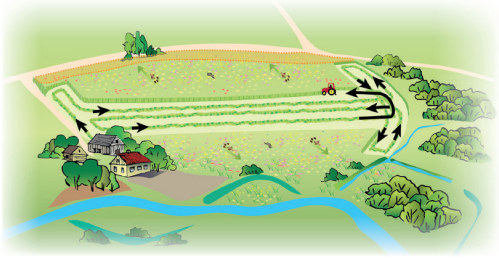

Fig. 22.2.5. Animal-friendly mowing direction from the centre to the edges. First strips are mown at each edge of the grassland to enable the manoeuvrability of the tractor. Then mowing from the centre to the edges is commenced. The most appropriate refuge for the birds is the riverside. If at least a 5 m wide unmown strip is left along the road, Corncrakes can find refuge there as well. Drawing by D. Segliņa.

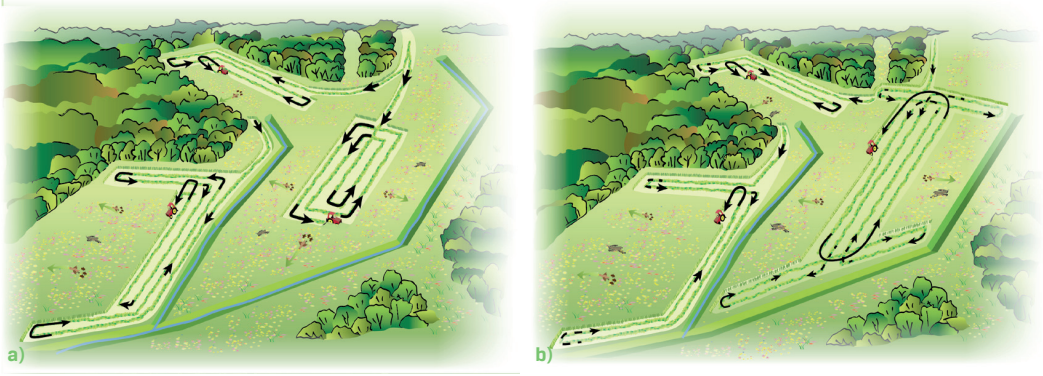

Fig. 22.2.6. The meadow is divided by ditches, therefore the largest meadow is mown (**a**) from the centre to the edges in the shape of a spiral or (**b**) from the middle to the edges, then, in the smaller meadows, a few strips are mown along the shorter side to enable manoeuvrability of the tractor and then mowing from one edge to the other is commenced. Corncrake will find refuge along the ditches and at the forest edge. Drawing by D. Segliņa.

Fig. 22.2.7. Mowing from one edge to the other. Photo: S. Rūsiņa.

Fig. 22.2.8. "Life islet" in mown grassland. The location of these areas will be changed in the following year. Photo: J. Kotāns.

Fig. 22.2.9. Cans filled with stones are fixed to a long pole. Cans are situated above the grass strip that will be mown next (next to the mower) (Kronītis 1982). Drawing by D. Segliņa.

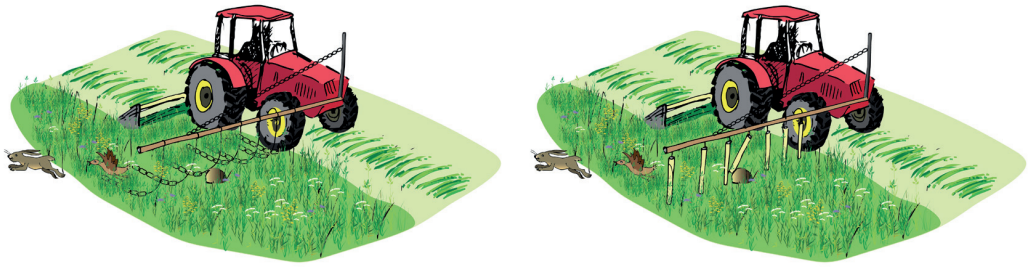

Fig. 22.2.10. Chains fixed (**a**) at the front of the tractor or (**b**) bars that move freely at the mounting point. Animals are startled and escape, or the tractor driver notices them and stops the tractor, allowing them to escape. This also helps to notice stones and protect the mower from damage (Kronītis 1982). Drawing by D. Segliņa.

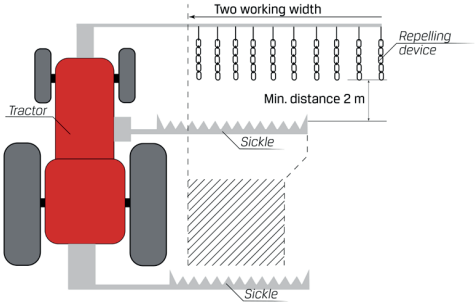

Fig. 22.2.11. Mounting of a section of chain (Kronītis 1982). Drawing by D. Segliņa.

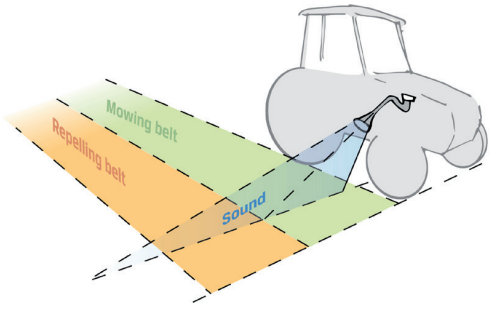

Fig. 22.2.12. Repelling by means of sound (Kronītis 1982). Drawing by D. Segliņa.

birds and their nests.

Both plants and animals are preserved, if strips or patches are left unmown. They can be cut the next day or better in a few weeks, or left until the next year. The location of unmown patches should be alternated every year (Fig. 22.2.8). Leaving of unmown patches until autumn is significant for plants, invertebrates and, especially, for Corncrake. If the only possibility is mowing from sides to the centre (this is very rarely the case), an unmown plot must be left in the centre (at least 20 × 100 m in size), which has to be mown no earlier than after one month.

The majority of semi-natural grassland plant species has only short-lived seed banks. Seeds lose germination ability in few years. Unmown plots are very important for the long-term conservation of such species in the grassland (Bossuyt, Honnay 2008).

When planning the proportion of unmown strips or patches, one at least 5 m wide and up to 0.1 ha large strip or "life islet" is left per one hectare of the grassland. The total unmown area should not exceed 10–15% of the total area of grassland, and such patches must be evenly distributed throughout the meadow, instead of concentrating them in one place. These shelters can save as much as 20% of the original (before mowing) populations of Orthoptera species (crickets, grasshoppers and katydids). Leaving such places of refuge is the only way to survive for insects that feed on nectar and seeds. However, mowing is not a disaster for invertebrates that could cause their extinction. A large proportion of the invertebrates that occur in the meadow are guests – they feed in the meadow, but do not live there permanently, therefore mowing of the meadow does not destroy the populations of these species. Many meadow invertebrate species are adapted to mowing – there are species that are only active in spring and autumn and spend summers in the dormant form of larvae. However, if the invertebrate species is monophagous (feeding on only one plant species), the sites rich in this plant species must be left unmown to conserve them. Invertebrate communities greatly depend on the management method that has been used for a long period of time, therefore in restoration it is important to know the former management and restart it in order to conserve these invertebrates.

Mower must be equipped with animal repellent devices (Fig. 22.2.9–22.2.12) even if the direction of mowing that preserves birds is chosen, because birds may be used to the noise of the tractor and not be afraid of it. The last strips of the meadow must be mown very slowly, to enable the birds that have hidden in the grassland escape; the birds escape the last hiding places slower and more reluctantly than at the beginning of mowing. If the grassland configuration does not permit mowing from the centre to the edges or from one edge to the other, then at least a 100 x 20 m large unmown patch must be left, and mown after one month.

Corncrake chicks run from the mower with a speed of 0.1 m min^{-1} to 5 m min^{-1}. The smallest chicks are the slowest. Corncrake start running from the mower, when it is already at a distance of 4–5 m (they do not run if the mower is at a larger distance). More than 55% of chicks get killed by the mower, if the grassland is mown from the edges towards the centre, while only 32% are killed, if the mowing direction is from the centre towards the edges (Tyler et al. 1998).

Mowing that saves animals is slightly more expensive (the consumption of fuel and the time of mowing is increased, and there will also be grass losses in the manoeuvring bands). A study was conducted in Germany to compare costs of various types of grassland mowing in rectangular areas sized 2–100 ha, where the ratio of field edge length to width was 2:1 (Porchnow, Meierhöfer 2003). It was concluded that using the same mower in grasslands with irregular shape and an area of up to 25 ha resulted in the highest cost increase of 5 EUR ha^{-1} on average. The average cost of mowing by using a mower with 7.7 and 4.9 m mowing width was two times lower (EUR 15–25 EUR ha^{-1}) than that of using the mower with a 2.7 m mowing width (40–45 EUR ha^{-1}). In the conditions of Latvia it must be consid-

The most appropriate time for the mowing of semi-natural grasslands with the purpose of conserving the biodiversity is late June and early July. Changing of the mowing time is recommended after a period of a few years. Late mowing every year can only be justified if the birds breeding in the grassland are the main nature conservation value and no other solutions are possible (for instance, mowing by sectors, leaving of patches, use of animal repellents, choosing an animal-friendly direction of mowing). A single late mowing once per several years of traditional mowing positively affects the diversity of plant species.

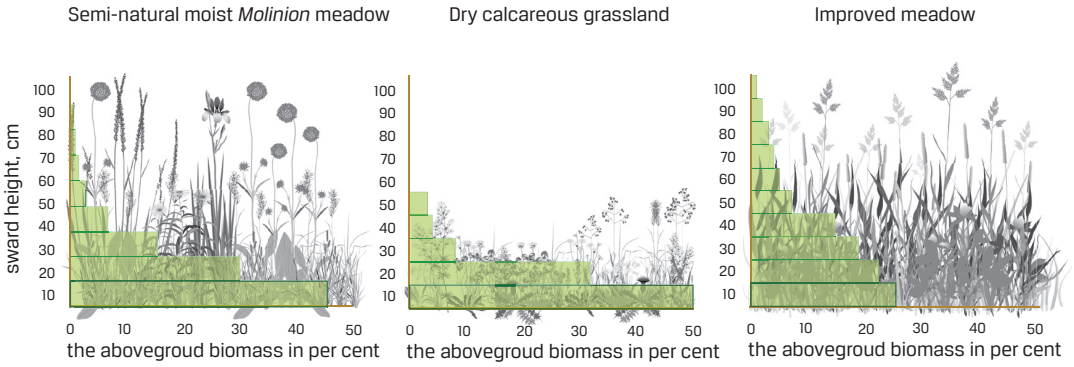

Fig. 22.2.13. Vertical distribution of above-ground biomass in grasslands (Sabardina et al. 1967; Fliervoet, Werger 1984). In semi-natural grasslands most of the biomass is concentrated in the first 10–20 cm above the ground, in cultivated grasslands it is evenly distributed up to the height of at least 50 cm from the ground. The photo shows the sward of the dry calcareous grassland. Only flower stalks would be mown if the mowing height was 10 cm. Drawing by D. Segliņa.

The possibilities of seed dispersal are drastically reduced.

22.2.14. Influence of various types of hay gathering on seed dispersal. Photo: S. Rūsiņa, A. Priede.

ered that most semi-natural grasslands are small and have complex configuration, which only allow narrow mowers to be used.

22.2.1.5 Mowing Height

Grass for haymaking is usually mown as low as possible, in order to enable the highest possible hay yield. The cutting height depends on the suitability of equipment and smoothness of grassland surface. The agronomists recommend mowing at the height of 5–6 cm, in order to preserve the buds of new shoots and ensure better regrowth of the grass both in the aftermath and the following years (Tērauds 1972). In semi-natural grasslands the largest amount of green mass (more than 50%) is concentrated at the height of the first 10–20 cm from the surface (Fig. 22.2.13), therefore they were traditionally mown as low as possible.

The latest studies conducted in Latvia have

Aftermath grazing increases the diversity of meadow plant and bird species. In the grasslands that are significant for Corncrake, aftermath grazing is only permissible if the meadow was mown late – after 20 July.

Fig. 22.2.15. Cows grazing in the aftermath. Many plant species have managed to blossom again (in the aftermath) and to sow seeds. Photo: S. Rūsiņa.

Fig. 22.2.16. The grassland is not suitable for waders within about 200 m radius around the group of trees, because corvids use trees to search for wader nests. Photo: S. Rūsiņa.

shown that up to 55% of the total aboveground biomass in dry grasslands is concentrated at the height of the first 10 cm from the surface, because dominating grass and forb species are low growing species, for instance *Festuca ovina, Phleum phleoides, Helictotrichon pratense, Potentilla arenaria, Pilosella officinarum*. Only in the moist and only in the most fertile floodplain grasslands and moderately moist meadows does 25–30% of biomass occur at this level (Strazdiņa et al. 2015).

To preserve plant species diversity, it is recommended to cut the grass no higher than 5 cm from the ground. Otherwise, too much green mass is left in the fertile areas, the soil is enriched and denser vegetation develops, which reduces the diversity of plant species and deteriorates the living conditions of soil organisms.

A mowing height of 10, preferably – 20 cm, is recommended in comparatively early mown grasslands inhabited by Corncrake to reduce the mortality of chicks. It is recommended to mow grasslands at water courses, especially grasslands inhabited by meadow waders (for instance, *Vanellus vanellus*, *Tringa totanus* and, especially, *Calidris alpina schinzii*), particularly low, especially when mowing the aftermath, because this will determine the vegetation height and structure in the beginning of the next year's breeding season.

22.2.1.6 Drying, Removal or Leaving of the Mown Grass

Removal of the mown grass is mandatory. Traditionally, the grass is used as animal feed, alternatively, it can be composted, used for the generation of bioenergy or burnt, while following the fire safety measures. For information on the negative effect of mulching and leaving of the mown grass *see Chapters 3.3.3 and 3.3.4*.

The most appropriate method that enables the retaining of biodiversity is drying the hay on the ground and then stacking it on haystacks. This enables the production of high quality animal feed, since complete drying of hay on the ground reduces its nutritional value. Stacking of hay on haystacks also stimulates the shedding of seeds (Fig. 22.2.14).

It is recommended to remove haystacks or bales from the meadow within a couple of weeks. If hay is left in the meadow, it starts to get mouldy and rotten. The grass perishes under the haystack or bale and expansive plant species may establish here in the following years. For practical reasons they may be stored in the meadow until winter, because it is often only possible to transport the hay from the meadow when the ground has frozen. The removal of hay from the meadow after the freezing of the ground preserves soil and vegetation in mesic and

The optimum frequency of mowing
in the conservation of semi-natural grasslands is one or two times a year. Mowing once every two years is permissible in dry and wet meadows with very poor soil and low productivity. Mowing three and more times during the season is impermissible.

Fig. 22.2.17. Optimum quantity and height of shrubs in terms of bird biodiversity. Photo: A. Auniņš.

Fig. 22.2.18. Low shoots of shrubs in old meadow, which is mown every year, affect neither the diversity of plants nor birds. Photo: S. Rūsiņa.

wet grasslands, therefore it should be preferred over the removal of hay from this type of grassland in summer and autumn. In the farms with too little space in hay sheds, the grass is frequently removed from meadows gradually. Storage of bales by stacking them in an uncovered stack causes higher losses of hay, because hay is damaged not only from below, but also at the contact surfaces with other bales.

22.2.2 Aftermath Grazing

The combination of mowing and grazing was a common practice in traditional agriculture throughout Europe. In recent decades mowing and grazing are increasingly separated, which adversely affects the diversity in semi-natural grasslands (Ellenberg 1996; Norderhaug et al. 2000; Wahlman, Milberg 2002; Jantunen 2003). In Latvia meadows were grazed in the aftermath (Fig. 22.2.15) or in spring. This is important for species diversity. Many annual plants only fail to sprout in spring because the aftermath of the previous year has grown after mowing and created a litter layer in spring. If the aftermath is grazed or animals trample the layer of old grass, the opportunities of such plants to sprout increase several times over. Very intensive grazing in aftermath reduces the biodiversity, because the number of forb species declines, but the abundance of some grazing resistant grasses increases. Spring grazing must be organised in a manner that leaves them ungrazed for a duration of at least eight weeks in the time period from June to mid-August and enables the development of a sward that can be mown.

22.2.3 Use of Fire in Meadow Management

Annual burning for longer than five consecutive years is not permissible for the management of semi-natural grasslands. Burning can only serve as a single measure for the restoration of the grassland, in order to get rid of litter that has accumulated over several years and prepare the grassland for mowing or grazing. For more information on the use of fire in the restoration and management of meadows see Chapter 21.2.

22.2.4 Management of Trees and Shrubs in Meadows

Importance of trees and shrubs for meadow plants. Small quantities of shrubs and trees in the meadow (up to 10% of the total area) increases both the total number of plant species, and herbaceous species because plants that cannot survive under full sun conditions can grow in the shade of shrubs.

In order to conserve the meadow-specific biodiversity, trees and shrubs are not desirable in small or narrow meadows, which are already shaded by a forest nearby. In meadows larger than 2 ha, the proportion of trees and shrubs of up to 10% of the grassland area increases the total biodiversity. In wide floodplain meadows and pastures, which are significant for the conservation of waders, trees and shrubs should be avoided in their wettest parts. For more information on tree and shrub layer in wood pastures and meadows, *see Chapter 19*.

Leaving of trees and shrubs must be avoided in a small meadow (up to 2 ha), if it borders with the forest on at least one side, or in a narrow meadow, where the shadows of trees affect the vegetation for most of the day even in the middle of summer. Too intensive shading and nutrients supplied by falling tree leaves reduce the diversity of plant species.

The importance of trees and shrubs for meadow birds. Shrubs and trees ensure the diversity of birds in the meadow. A small quantity of low (up to 1.5 m) shrubs occupying up to 10% of the total area of the meadow (if the meadow is larger than 20 ha) is favourable for the diversity of passerines of the grassland, because several species can nest in these shrubs. In the grasslands significant for waders, continuous bands of shrubs must be avoided, due to the fragmentation of the open landscape (Fig. 22.2.16, 22.2.17).

Big large trunk trees, especially hollow ones, significantly increase the diversity of birds, since birds that do not nest in open meadows and shrubs can nest in hollows. However, large shrubs and trees should be avoided in sites where meadow waders are the main conservation target. In these meadows trees and shrubs serve as hunting towers for predators on bird nests, resulting in less successful breeding of meadow waders.

For more detail on the quantity of trees and shrubs in grasslands that are important for birds *see Chapters 21.4 and 23*, on the tree and shrub layer in wood pastures – s*ee Chapter 19*.

The importance of trees and shrubs for meadow invertebrates. Trees and shrubs create a microclimate, thus increasing the overall diversity of invertebrates and ensuring an environment that is suitable for several species. Large trees not only create a microclimate for grassland invertebrate species, but also serve as a living environment for species that inhabit these trees. In small meadows (up to 2 ha) shrubs are not as important as in larger meadows. In large meadows (>5 ha) the preservation, or even creation of shrub belts is preferable, especially if they are created at right angles relative to the direction of prevailing winds in summer. In grasslands that are significant for birds, the belts of shrubs can only be created if they do not disturb the birds.

Cutting of trees and shrubs in a meadow. Trees and shrubs do not usually establish in meadows that are mown every year, except for cases where the shrubs are not controlled at the edges of the meadow or around clusters of shrubs that are present in the meadow. Trees and shrubs may interfere with mowing at meadow edges, as they grow and spread the canopy, or as the branches bend down and the operator of the mower usually chooses to drive around the bent branches. As these areas are not mown every year, they are gradually overtaken by shrubs, and thus, the area of the meadow may decline considerably. In regularly mown meadows, the regrowth of shrubs must be controlled at the edges and the clusters of shrubs in the meadow should not be permitted to expand.

Cutting of shrubs is most efficient in summer – June, July and August, because then the shoots of the shrubs contain the highest nutrient reserves. As they are removed, the shrub is weakened faster. However, for the purposes of bird conservation, the shrubs should only be cut after 1 August. If it is done earlier, nests are destroyed and works during the nesting season interfere with the life processes of birds. It is recommended to mow the shoots of the shrubs twice every summer during the next 2–3 years until resprouting stops. In meadows that have been mown for decades, especially meadows with a high moisture level, the shrubs may continue

Productivity of semi-natural grasslands

The productivity of semi-natural grasslands is low. In dry grasslands the yield of hay is less than 0.5 t ha^{-1}, in mesic grasslands it varies from 0.5 to 2 t ha^{-1}. Only in naturally fertile floodplain grasslands with *Phalaroides arundinacea* and *Alopecurus pratensis* can the yield of hay reach 4–5 t ha^{-1}, however, even there the average yield is 2–3 t ha^{-1} (Сабардина 1957. The yield does not significantly change over time, because plant species of semi-natural grasslands have adapted to nutrient limitation. A large proportion of plant biomass is allocated below-ground, so mowing removes only a small portion of the total plant biomass. For instance, the below-ground biomass of *Leontodon hispidus* constitutes 80%, while its above-ground biomass (leaves, stalks, flowers) accounts for only 20% (Mortimer 1992). Some of the biomass accumulated in roots is decomposed every year and the nutrients are returned back into the soil and will be used by the next year's vegetation.

Fertilisation promotes an increase in biomass and at the same time rapidly reduces the diversity of species. Under the influence of fertilisation many species disappear, because they are outcompeted by nutrient-demanding species (mainly grasses – *Dactylis glomerata, Festuca pratensis, Phleum pratense, Alopecurus pratensis* and others that can better absorb soil nutrients), while meadow productivity increases. The average productivity of improved grasslands is 6-8 t ha^{-1} (Adamovičs 1999; Adamovich, Kreismane 2000).

Fig. 22.2.19. Reed turf brought by a spring flood. It should be removed so as not to interfere with mowing. It can be left in the pastures. However, if there is a lot of such debris it may cause soil eutrophication and should be removed. (**a**) Floodplain grassland of the River Dviete in April 2014, (**b**) after two years (April 2016) the reed turf has not decomposed completely. Photo: S. Rūsiņa.

resprouting for several years and even decades. If these shrubs do not spread and take over the meadow, they are not perceived as a threat to biodiversity conservation (Fig. 22.2.18).

If a river flows through grassland, the amount of trees and shrubs along the river must be evaluated, considering not only the value of the meadow, but also the diversity of the river (Urtāns (ed.) 2017).

22.2.5 Harrowing in Meadows

Harrowing is a traditional method of reducing the amount of mosses. However, the expected effect is often not reached, because mosses predominantly grow in acidic soils. Harrowing does not alter soil pH and therefore mosses rapidly spread again. The best method of moss control is grazing. After harrowing, admixture sowing is recommended with seeds from similar semi-natural grassland habitats. Sowing of commercial grass varieties or fertilising is not permissible, since this will change species composition and the meadow will develop into improved grassland. Harrowing of floodplain meadows shreds and smooths the crust of litter brought by floods, which inhibits meadow plant growth. Harrowing in early spring, when the surface of the soil has melted, but deeper layers thereof are still solid, is preferable. It helps also to smooth anthills and molehills. Harrowing in autumn can negatively affect the wintering of meadow plants, because it tears roots and turf.

22.2.6 Meadow Fertilisation

If it is decided to maintain or increase the species diversity in a meadow, then regular fertilisation with such fertiliser doses which are used for the maintenance of conventional sown grasslands is not permissible.

Traditionally the grasslands (for instance floodplain grasslands), where the yield of hay was higher, have been used as meadows, therefore semi-natural meadows are usually slightly more fertile than semi-natural pastures. Unlike pastures, which were not fertilised at all, meadows were sometimes (once over several years) fertilised with small amounts of manure. Fertilisation reduces plant species diversity, because a denser sward with high grasses develops which inhibits both legumes and low growing forbs and grasses with weak competitive ability. In drier sites fertilisation also stimulates the replacement of xerophytic species with mesophytic plant species. This occurs, because denser vegetation overshadows the soil and evaporation from the soil surface is reduced. Thus, fertilisation causes the extinction of dry grassland habitats.

Manure may be applied to the meadow in amounts that are equivalent to that produced by pasture animals from hay of the particular meadow. Depending on the type of meadow habitat the permissible amount of nitrogen is 10–30 kg ha^{-1} (Bobbink et al. 2003). A tonne of naturally moist

Fertilisation is not recommended in semi-natural meadows, except for fertilisation with the amount of manure which is produced by animals while consuming hay mown in the particular meadow and the amount that is produced by pasture animals in aftermath grazing.

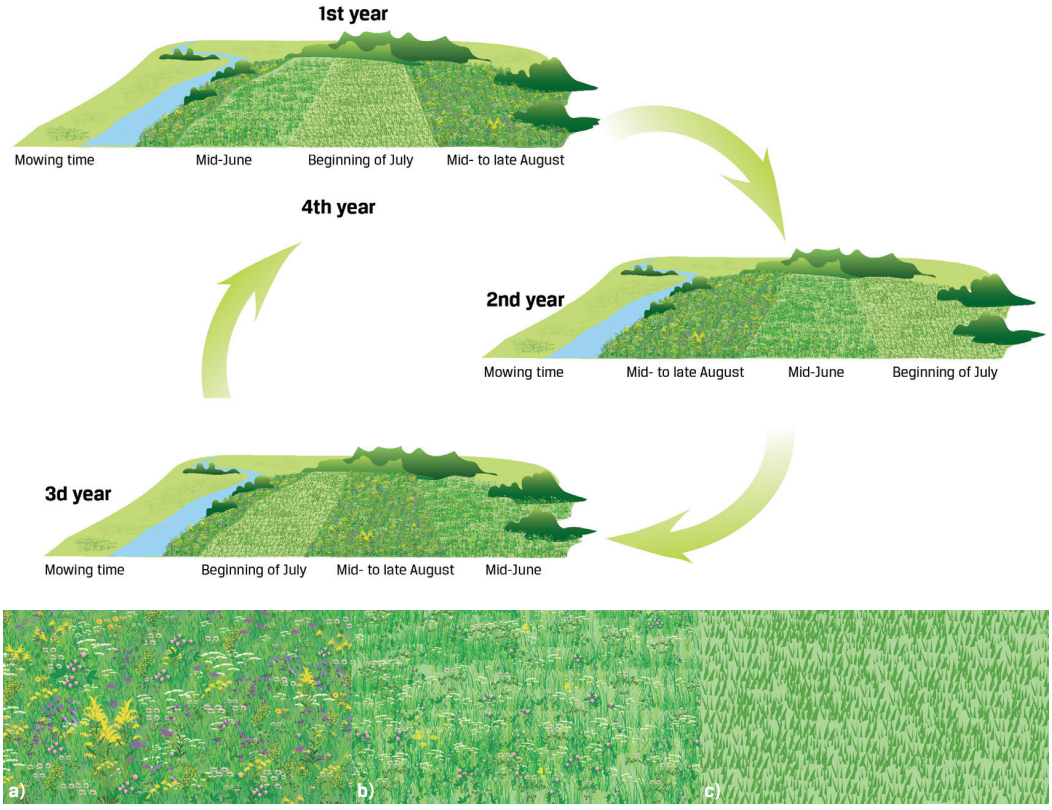

Fig. 22.2.20. Mowing of meadow for bee pasture. The image shows the flowering situation in the meadow in mid-July. (**a**) In July the bees use the part of the meadow that will only be mown in August. (**b**) In mid-July, legumes and other species start blooming in the aftermath and bees can start feeding there. (**c**) The section of the meadow mown in early July will not be suitable for bees for a few more weeks. In grasslands bordering water bodies it is recommended to only mow the strip of grass at the water's edge in mid-July or later, so that it is also suitable for grassland birds.

cattle solid manure, after storage contains 5–6 kg of nitrogen (N), 2.1–3.9 kg of phosphorus (P_2O_5), 5.8–11.1 kg of potassium (K_2O) (Timbare et al. 2010). Thus, no more than 2–5 tonnes of solid manure may be spread in one hectare of a meadow. Slurry and liquid manure may not be used because they get mineralised quickly and only participate little in the development of soil humus.

Mineral fertilisers and digestate may not be used on semi-natural grasslands. Digestate is produced from manure as a by-product of biogas production, and its influence is similar to that of liquid manure. No research on the effect of digestate on biodiversity is available, therefore its use must be evaluated with caution, and meadow vegetation must be monitored.

Fertilising does not have a direct impact on birds, however, it affects the occurrence of birds through changes in vegetation. In general, it should be avoided. In some cases mechanised fertilisation

Fig. 22.2.21. Many plant species of semi-natural grasslands bloom in the aftermath, which can be used by the honey bee. *Filipendula vulgaris, Hypericum perforatum* and *Knautia arvensis* are abundantly blooming in the aftermath in dry calcareous grassland in the valley of the River Abava near Kandava (photo taken on 28 July). Photo: S. Rūsiņa.

may destroy birds' nests, therefore fertilisation should be avoided during bird breeding seasons.

22.2.7 Other Meadow Maintenance Works

Maintenance works in springs is important for biodiversity conservation – raking of tree branches, leaves, pine cones, smoothing of mole and ant hills, removal of flood water litter, smoothing of tussocks and wild boar rootings. Tree leaf litter and branches supply additional nutrients to the grassland. Leaves mulch the soil and inhibit the germination of meadow plant seeds, therefore their removal positively affects biodiversity. Still, a diverse grassland structure promotes the diversity of species, therefore the grassland should not be cleared completely.

Anthills and tussocks can be smoothed by shredding. Tussocks should at least be left in a small area, because they serve as hiding places or nesting places during the breeding season of birds. Pasture animals do not step on tussocks, therefore bird nests are more secure on them. Furthermore, tussocks reduce the risk of flooding the nests situated on them.

In spring the molehills are usually smoothed creating free patches of bare ground, where seeds of plants can germinate. A toothless drag harrow can be used for smoothing the grassland 1–2 times (*see Chapter 21.3*).

If there are not many wild boar rootings (covering less than a third of the grassland area), they do not cause significant damage to the biodiversity. They must be smoothed immediately after the turf has been rooted up, because next summer it will be covered with vegetation and smoothing them using a toothless drag harrow, harrow or disc harrow will damage vegetation. If wild boar damage repeats every year and rootings cover more than one third of the grassland, the damage is significant and is comparable to harrowing. In these cases access of wild boar to the grassland must be prevented (hedges, repellents, control of population in cooperation with hunter teams), and the grassland must be restored (*see Chapter 21*).

In floodplain meadows, flood litter must be gathered in spring, for instance, reed turfs (Fig. 22.2.18). They can be burnt on site. Some of the debris can be left in the meadow, however, care should be taken to avoid shrubs introducing on debris, since the grass around them cannot be mown. It is recommended to roll the grassland in peaty soils. Winter and spring frosts loosen peat soils, the capillary system gets disrupted, the roots get torn and in some places the plants may perish.

22.2.8 Maintaining the Biodiversity of Bee Pasture Meadows

Meadows are frequently used as pastures for honey bees *Apis mellifera*. Plant species that are important for bees, bloom in meadows all summer long, therefore it is sometimes difficult to decide when to mow the meadow to enable the maximum length and efficiency of their use by bees.

To preserve the diversity of meadow plant species and abundant bloom, they must be mown in late June or early July, when some plant species are still blooming. The meadows of bee pastures are frequently mown late (in late August), when all plant species deflorate. This is not preferable in the long run, because tall grass species are gradually expanding in the meadow and outcompete richly blooming forbs.

It is recommended to mow a meadow in sections. One part of the meadow is mown early, another part in mid-summer and the third part in late summer or early autumn. The mowing time must be changed every year (Fig. 22.2.20). This will ensure food for bees and the correct circulation of nutrients in the meadow ecosystem. There are many plant species in the aftermath that bloom for the second time and are a good resource for bees (Fig. 22.2.21).

The honey bee can have a positive, as well as negative effect on the insect diversity of a semi-natural meadow. Therefore an assessment of whether bee pasturing will harm the diversity of species must be performed before using meadows as bee pastures.

Honey bees positively affect meadow plant species, because bees pollinate them, thus stimulating the increase in genetic diversity of wild plant species.

The honey bee can be a competitor of wild bees and bumblebees, because it has a constant hive temperature and it can fly out early in the morning. Wild bees usually fly out later because they need to wait for the air temperature to increase. While the wild bees are still in the nest, the honey bees have already "emptied" the flowers. Therefore, it should be determined whether the meadow is a habitat of a rare or protected wild bee or bumblebee species, which could be harmed by the presence of honey bees. The studies of wild bees and bumblebees in our country are scarce, therefore conclusions on the species that can be outcompeted by the honey bee can be drawn from the studies conducted in other countries.

Plant species that are necessary for some solitary bee species in Latvia include *Ranunculus acris, Lotus corniculatus, Medicago falcata, Lythrum salicaria, Echi-*

Fig. 22.3.3. Controlled stocking in the floodplain grasslands of the River Gauja at Lielkrūzes farm in Jaunpiebalga. The pasture is divided into paddocks to keep livestock in one enclosure as long as required to achieve optimum sward height. The beginning of grazing is also regulated, for instance, if Corncrake calls in a paddock, the grazing is only commenced after Corncrake brood has hatched. Photo: G. Dolmanis.

um vulgare, Campanula patula, Campanula rotundifolia, Knautia arvensis, Succisa pratensis (Muller et al. 2006).

Chelostoma florisomne requires ten flowers of *Ranunculus acris* to feed one larva. Bees of larger species, for instance *Anthidium manicatum*, require more than 1,000 flowers per one larva. *Andrena marginata*, which feeds on the pollen of *Succisa pratensis* need 1–5 flower heads. An average of up to 30 flowers are required to feed one wild bee larva, depending on the species of bee (if all pollen is available in the flower, but, if it is not, then even up to 60 flowers) or 0.1–17 individual plants (Muller et al. 2006). The bee flies a distance of approximately 150–600 m from the nest, so a large quantity of flowers is required in a very small area. The maximum distance a solitary bee can travel to the food source is 1.4 kilometres. Such distances can be travelled by a small portion of all individuals of one species. Foraging females feed mostly on host plant patches available in relatively close vicinity to their nesting site. (Zurbuchen et al. 2010).

22.3 Pasture Management for Biodiversity (S. Rūsiņa, A. Auniņš, V. Spuņģis)

In these guidelines, pasture maintenance is analysed from the perspective of biodiversity conservation. Grazing animal care and welfare issues, as well as the maintenance of grazing infrastructure (for instance, construction and repair of enclosures, installation of drinking bowls, etc.) are not discussed in this book (recommended references include Tērauds, 1972; Adamovičs, et al. 1998; SNOWBAL 2012; Džeimisone, Strazdiņa 2013). Only extensive grazing management (according to Allen et al. 2011) that uses relatively large pasture areas per animal is appropriate for the preservation of biodiversity.

22.3.1 Grazing System

Grazing systems are site-specific and integrate specific biotic and abiotic components and their environments, management objectives and social factors (Allen et al. 2011). The influence of grazing on the grassland is affected by the following factors:

- the grazing season (beginning of grazing, duration);
- stocking method (freely, tethered, enclosure grazing);
- type of pasture animals;
- grazing pressure (number of animals, duration of grazing, times of repeated grazing);
- 24-hour grazing;
- supplementary feeding during the grazing period;
- mowing of the pasture and spreading of manure.

A summary of the impact of grazing on the grassland is provided in Table 22.3.1, and a comprehensive explanation – in the following chapters.

22.3.1.1 Grazing Season

Two approaches to the grazing season are common in Latvia.

- Seasonal grazing – the animals only graze for a certain period during the year. Traditionally, the grazing season in Latvia is from mid-May to mid-October, while in winter the animals are kept in the barn. For biodiversity management purposes, the grazing season can be adapted to the needs of nature conservation.
- Year-round grazing – the animals are kept in the pasture all year. Depending on the severity of a winter or the status of a pasture (for instance, overgrazed, flooded) they may be provided with supplementary feed during winter. In these ca-

Year-round grazing facilitates biodiversity if the spreading of expansive species is avoided and a vegetation mosaic is created consisting of intensively and less intensively grazed patches enabling plants to mature and shed their seeds and invertebrates and birds to reproduce without disturbing them.

Table 22.3.1. Optimal and inappropriate management of pastures for biodiversity.

Grazing parameter	Recommended (optimal) actions	Inappropriate actions
Stocking method	Controlled stocking on the whole pasture or in enclosures, or with a shepherd.	Do not permit continuous stocking that deteriorates biodiversity (except for natural grazing areas).
24-hour grazing	No limitations for the vegetation. Grasslands that are important for waders must be grazed during the day.	Grazing at night is not permissible in the grasslands that are significant for waders.
The start and duration of grazing	There is no totally inappropriate grazing time, if other conditions are met. In the grasslands significant for waders grazing is started in early June and grazing must be performed during the day only. In autumn grazing should be continued long enough to leave a mosaic pattern of low grass patches (up to 5 cm) and patches of at least 30 cm high sward.	There is no totally inappropriate grazing time, if other conditions are met. Grazing in the grasslands that are important for waders may not be performed in spring until late May.
Grazing frequency	The sward is defoliated by grazing 1–3 times per season, depending on the type of habitat and species to be conserved.	The sward is defoliated less frequently than once or more frequently than 2–3 times resulting in homogeneous vegetation that resembles a lawn.
Grazing pressure, stocking density	Optimum grazing pressure as shown by diverse vegetation structure and varying height of sward, richly flowering plants in the middle of summer.	Continuous overgrazing (blooming plants are almost absent even in the middle of summer) and insufficient grazing (accumulation of litter) must be avoided.
Type of grazing animals	There is no decisive significance. Mixed herd will cause an effect that is similar to mowing – the grass will be of approximately the same length. Grazing with only one animal species creates a diversity of vegetation.	There is no decisive significance. Sheep should not be grazed in places that are highly significant for invertebrates, since they nibble the vegetation very low and the food base of insects and other invertebrates is decreased.
Supplementary feeding during the grazing period	No supplementary feeding is permissible in summer. If grazing occurs all year round, the supplementary feeding may be performed in the least biologically valuable places in autumn and winter.	No supplementary feeding is permissible in summer.
Mowing of the pasture and smoothing of manure	Mowing of the pasture is only necessary in undergrazed sites. Mown grass should be removed. Spreading or the removal of manure produced by grazing animals is needed in over-fertilised sites.	Do not mow after each time of grazing, thus maintaining a short, lawn-like sward. Do not leave the mown grass in the pasture.

Additional information about natural grazing and natural pasturing

The introduction and surveillance of semi-feral herbivores is a vast topic that falls beyond the scope of this book. Recommended sources of information on natural grazing include the book of F. Vera Grazing Ecology and Forest History (Vera 2000), the materials published by the society Rewilding Europe (https://www.rewildingeurope.com/publications/), for instance, Vermeulen (2015). In Latvia, the World Wildlife Fund has issued an overview of natural grazing (Pasaules Dabas fonds, 2004). The experience of grassland maintenance with semi-feral herbivores has been summarised in several articles (Mednis 2008; Ozols 2008; Gruberts, Štrausa 2011; van der Veen 2011). A bachelor's thesis was written on the use of semi-feral horses in Latvia (Luksa 2014).

Table 22.3.2. The influence of the start and end time of the grazing season on biodiversity (Crofts, Jefferson (Eds.) 1999, modified).

Grazing time	Impact on biodiversity
Year-round pasture: continuous stocking throughout the entire year	**Advantages:** perfectly suitable for the creation of mosaic-shaped landscape, as well as semi-natural grassland restoration and management. Grazing efficiently controls the amount of shrubs, because animals browse them mostly in autumn and winter, when fresh grass is not available. Spring grazing effectively controls the amount of litter, because then animals eat litter together with the fresh, newly sprouted grass. Therefore, early spring is the best time for starting grazing for restoration purposes. **Disadvantages:** the diversity of species in grasslands that are grazed all year long without adjustments of grazing pressure may decrease in comparison with summer grazing or mowing combined with aftermath grazing. If animals graze freely all year long, they create a mosaic of overgrazed areas where they return again and again, as well as insufficiently grazed areas where expansive species not favoured by animals spread, and shrubs and trees may establish (Mitlacher et al. 2002).
Early grazing: from mid-April	**Advantages:** early grazing is suitable, if the grassland is later used for mowing or if the pastures of the previous year are insufficiently grazed (litter has accumulated). Early grazing is efficient for the elimination of litter, because animals, together with fresh grass, eat the accumulated litter as well. It reduces the regrowth of shrubs, controls tall or coarse and "tasteless" herb species that are avoided by livestock when they are already mature – *Carex* spp., *Deschampsia cespitosa, Filipendula ulmaria etc.* **Disadvantages:** early grazing severely reduces the populations of *Orchis* spp. and *Dactylorhiza* spp., because livestock consume and trample the sprouts of these species. In spring *Rhinanthus* spp. are sensitive to trampling. They are annuals, which do not regenerate if they are trampled once. The animals trample eggs and larvae of invertebrates, bird eggs and chicks. Early grazing is only allowed in grasslands that are not significant for waders or Corncrake (or if there are grasslands around, which will only be grazed after 10–20 July and therefore may serve as alternative nesting places for Corncrake and waders).
Traditional grazing: from early May	**Advantages:** see early grazing. Active bacterial processes in the soil, which reduce nutrient accumulation from animal manure in soil. The most favourable moisture conditions – the lowest risk of trampling, overgrazing. **Disadvantages:** see early grazing. High grazing pressure reduces the quantity of flowering plants. As a result invertebrates and the visual value of landscapes at popular tourist sites suffer. Grazing for several years with high pressure eliminates annual and biennial plant species and reduces the diversity of invertebrate species (uniform, poor in species fauna of overgrazed pastures develops). Some butterflies (for instance, *Cupido minimus*) require seed heads of plants to complete their life cycle. A long period of drought can inhibit plant growth. Then the grazing pressure must be reduced, in order to prevent overgrazing. In grasslands suitable for nesting waders, the grazing season should start no earlier than in late May or, preferably, even June. This will prevent nest destruction due to trampling (Fig. 22.2.1).
Slightly delayed grazing: from the middle of June	**Advantages:** favourable for grassland waders because most broods have been hatched and chicks are taken to the water's edge or at least dispersed.
Late grazing: from mid-July	**Advantages:** favourable in pastures suitable for Corncrake, because most Corncrake broods have left their nests. Even if the chicks are not capable of flying, the threat to their survival is much lower, definitely lower than in the case of mowing. The best time of grazing to conserve the diversity of invertebrates. Facilitates the dispersal of seeds from biologically more valuable parts of the grassland to the least valuable, thus promoting diversity. **Disadvantages:** may increase the proportion of shrubs, because they are not browsed. The vegetation becomes thicker and higher as years pass, because animals do not eat all of it, furthermore, several plant species have already stored nutrient reserves in the soil. The nutrient removal from the grassland is not as efficient as during summer grazing, and eutrophication is induced. It may reduce the population size of late-flowering plant species. If specific insect species feed on them, they will also be negatively affected.

(continued)

Table 22.3.2 (continued)

Grazing time	Impact on biodiversity
Grazing in the autumn/winter period and in early spring	**Advantages:** the majority of plant species are not affected, because livestock graze the old grass. Highly beneficial for the conservation of invertebrates. Promotes the breaking up of the litter layer, which facilitates the germination of annual plants next spring. Usually promotes trampling, and is beneficial in grasslands that are important for waders. Very suitable feeding conditions can develop in trampled patches and muddy pools. **Disadvantages:** severe trampling may create poaching of the soil (especially in the frost-free period), because the lack of vegetation results in decreased soil protection, and, consequently, the expansion of annual weeds. Long-term grazing in winter only will result in increased uniformity and plant species diversity will decrease. Animals can lose weight due to low amounts of available nutrients. If the grazing pressure is high, severe consumption of litter can reduce the diversity of invertebrate species that use it for wintering. If grazing animals are additionally fed (hay is delivered), the grassland is enriched with additional nutrients.
End of the grazing season	The end of the grazing season should be carefully chosen. After the end of the bird breeding season (August, September) it is recommended to plan grazing based on considerations of how the grassland will look in spring, when the new bird breeding season begins. In grasslands that are important for Corncrake, the grazing should be ended early enough to enable the development of at least 30 cm high vegetation at the beginning of the next breeding season – in late May and early June. Too intensive grazing in autumn should be avoided (grazing should be stopped about 25 days before permanent frost; approximate sward height in October should be 15 cm). In grasslands that are important for waders, autumn grazing should be aimed at the development of mosaic of various vegetation patches in spring – from very low (5 cm and less) to relatively high (30 cm and more). This will ensure the diversity of bird feeding niches and nest hiding places according to the requirements of each bird species. *Vanellus* and *Haematopus ostralegus* prefer almost vegetation-free areas (less than 3 cm), the ideal vegetation for *Calidris alpina schinzii* (applies only to maritime grasslands) is 5–10 cm high, but it is also suitable for *Vanellus*. *Philomachus pugnax, Tringa totanus* and *Gallinago gallinago* prefer vegetation that is at least 20 cm high and Limosa limosa and ducks – even higher. Since all of these species develop breeding semi-colonies, vegetation that conforms to all these parameters should be situated in a mosaic pattern in one place. Special attention should be paid to the water's edge, where it is present, and wet slacks, trying to ensure as low vegetation there as possible. Depending on the situation this could be most conveniently achieved by the use of mobile enclosures, thus providing appropriate grazing intensity in specific locations.

Fig. 22.3.1. Indications of natural grazing in the floodplain pastures of the River Lielupe in Ķemeri National Park (13 July 2007). Grazing animals change the landscape by selectively choosing grazing sites, creating a mosaic-like vegetation of various height. Entirely natural grazing is not possible in this case, because supplementary feeding of animals is necessary in winter and therefore it is referred to as continuous stocking. Photo: A. Priede.

Fig. 22.3.2. Continuous stocking in one large enclosure, where animals stay throughout the year. Year-round pasture in Ķemeri National Park in Dundurpļavas meadows near the River Slampe on 24 January 2011. Photo: A. Priede.

Table 22.3.3. Stocking methods and their impact on biodiversity.

Stocking method	Impact on biodiversity
Natural grazing (not to be confused with continuous stocking – see description below). Wild or semi-feral species (bred-back breeds developed by selective breeding of domestic animals in an attempt to achieve an animal breed with a phenotype that resembles wildtype ancestor) herbivores. Grazing occurs entirely without human intervention (except for the maintenance of fences). It is difficult to implement this grazing type in Latvia, because the land is very fragmented, while large areas are necessary. In order to develop and preserve a healthy breed, the herd must contain an average of 150 animals. Depending on the productivity of the grasslands they need an area of 500 ha and more (Vermeulen 2015). Semi-feral herbivore pastures in Latvia are considered to be a type of continuous stocking instead of natural grazing.	Wild and semi-feral animal grazing and livestock grazing differ by their effect on both vegetation and wildlife, especially, bird populations. Natural grazing results in the formation of a mosaic-like landscape with a mixture of open, woodland and wood pasture habitats. Natural grazing cannot ensure the conservation of particular protected species or habitats, because their persistence or disappearance is subject to unpredictable grazing processes. *See also Chapter 19.4.1.*
Continuous stocking. Grazing is supervised by people, but grazing pressure is not regulated, and the entire territory of the pasture is freely accessible to animals during the entire season (or the entire year). **Natural pasturing is a term frequently used in Latvia** for pastures with bred-back semi-feral herbivores (for instance, '*Konik Polski*' horse breed, '*Heck*' cow breed). Animals are usually kept in the pasture all year round. However, unlike natural grazing, people significantly affect both grazing animals and vegetation: they regulate the number of animals, provide supplementary feed in winter by supplying hay from beyond the pasture, thus bringing nutrients into the pasture. Mowing of the pastures or their parts is frequently practised, especially, if agricultural support funds are received for land management. Thus, natural pasturing is also a type of continuous stocking.	The more diverse the area of the pasture is, the more selectively it is used. If the grazing pressure has been unchanged for a long period of time, the vegetation becomes uniform in both overgrazed (low vegetation, mainly consisting of species resistant to grazing) and in insufficiently grazed areas (tall grass, dominated by most competitive species), therefore some areas suffer from overgrazing, while others – from insufficient grazing. In very homogeneous areas this type of grazing (if the appropriate grazing pressure has been selected) is no different from controlled stocking. In very vast and heterogeneous areas, where people do not affect grazing animals and vegetation (do not regulate animal number, do not provide supplementary feeding, do not mow) and only maintain fencing infrastructure, this type of grazing transforms into natural grazing.
Controlled stocking. Semi-feral herbivores or livestock, the grazing of which is supervised by people, who control grazing pressure, the number of animals, as well as the duration of grazing. The manipulation is achieved by means of enclosures (by allowing the animals to stay in the particular part of the pasture for a particular period of time), a shepherd or tethering. The duration of grazing in each enclosure depends on the habitat, grass productivity and the desired impact on biodiversity. Where the grass is lower, the animals are allowed to graze for a shorter period of time. In places with higher vegetation they are kept for a longer time. Grazing in areas with a larger diversity of habitats and variable height and productivity of grass should be controlled more than in homogeneous areas.	The most beneficial to biodiversity, if manipulated in accordance to the biodiversity needs of the particular territory. It is recommended to graze the paddocks in a mosaic-like pattern, instead of grazing them consecutively one after another. In the areas suitable for the nesting of waders grazing must be started after 10 June, in areas suitable for Corncrake – after 10 July. Changing of paddocks during the season and leaving one of them ungrazed every year is beneficial for invertebrates. Earlier experience on the distribution of populations of protected plants and areas most favoured by different birds can help determine the grazing mode to be used in each place (Gusewell et al. 2007).
Mobile stocking (mobile grazing) – the herd is moved from one grassland to another, a particular area is grazed for several days once a year (it is particularly suitable for places with many small semi-natural grasslands in a wide area).	The choice of grazing time and duration is limited by the area of the grassland and distances between them. Some of the grasslands are grazed in the first half of summer, others – only in late summer, when the grass has become coarse and overgrown, therefore the animals eat it unwillingly.

Fig. 22.3.4. Controlled stocking by dividing the pasture into several paddocks with permanent fences. Photo: A. Priede.

Fig. 22.3.5. Controlled stocking using a portable electric fence. Photo: G. Dolmanis.

ses, the animals are concentrated mostly in the feeding areas and do not use or only partially use the area of the pasture. Such cases must be considered a transition between seasonal and year-round grazing.

Traditionally, only seasonal grazing has been used in Latvia. Year-round grazing is a new phenomenon. Year-round grazing is only possible with some animal breeds in Latvia. Mainly they are beef cattle and horses. In order to maintain and promote biodiversity, the beginning and duration of grazing has to be regulated based on biodiversity values (Table 22.3.2).

22.3.1.2 Stocking Methods

Stocking method (also referred to as grazing method) is a defined procedure to manipulate grazing animals in space and time to achieve specific objectives (Allen et al. 2011). The main objective of the stocking method is to improve the efficiency of forage use and to reduce negative effects on soils and biodiversity. The main stocking methods are:

- natural grazing – completely without human influence, assistance or surveillance;
- continuous stocking – continuous pasturing in one large enclosure, where animals have unrestricted and uninterrupted access to the whole pasture without altering the grazing pressure and duration during the entire grazing season;
- controlled stocking – manipulation of grazing pressure and duration by regulating the number of animals, dividing pasture in paddocks, controlling grazing time and pressure by a shepherd or otherwise (Fig. 22.3.1 – 22.3.5). Controlled stocking includes several types, for instance, alternate stocking (repeated grazing and resting using two enclosures), first-last stocking (a method of utilising two or more groups of animals with different nutritional requirements), frontal stocking (using a sliding fence that livestock can advance to gain access to ungrazed areas), non-selective stocking (using short-term high grazing pressure that increase the consumption of less preferred vegetation).

Continuous and controlled stocking can be organised both in seasonal and year-round pastures (Table 22.3.3).

22.3.1.3 Choice of Pasture Animals

Traditionally only domestic livestock was used in semi-natural grasslands; nowadays, semi-feral horses and cattle, as well as deer and European bison are also used. Their food base includes not only grass, but also trees and shrubs. Grass is more difficult to digest than shrub shoots, as a result the digestion of grass takes more time than the digestion of shrubs, however, shrubs contain more lignin, which is why the food is harder, and adaptation of the mouth organs to facilitate biting them off is necessary (Clauss et al. 2008).

The mouth anatomy of browsers (moose, roe deer) is not adapted to tearing grass close to the ground. Their front teeth are differentiated, they have a narrow snout with long lips and pronounced tongue muscles. These species are adapted to tolerate toxic compounds, they have a larger liver, larger salivary glands and tannin-binding proteins in saliva. Grazers lack such adaptations. They have less differentiated front teeth, with thick enamel and a rough, wide teeth surface, their snout is wide, lips are shorter and tongue muscles are less expressed. The food stays in the stomach of grazers longer, their intestinal capacity is higher and the loss in excrement is lower, and their protozoan intestinal fauna is more diverse (Clauss et al. 2008).

Different animals eat vegetation differently and a herd uses the territory of pasture very selectively, if there are various plant communities. It is there-

Table 22.3.4. Characterisation of grazing animals (Crofts, Jefferson (eds.) 1999; Clauss et al. 2008).

Species of grazing animals, character of grazing, most appropriate type of grasslands; preferred and undesirable management measures
Sheep
Character of grazing. Sheep cut the grass with lower teeth that are pressed against the hard palate. They can nibble the grass very low (up to 3 cm). They avoid eating tall plants, areas with tussocks, and do not eat old grass. They can successfully eat low shrubs – completely eat off their leaves. They do not avoid grazing in areas with excrement left by other animals. Very diverse food base (choice of palatable plants), they readily consume not only grasses, but forbs as well. Sheep like to consume flowers, therefore overgrazing should be avoided to retain the diversity of plant species. In general, grasses are more abundant while forb diversity is lower in sheep pastures in comparison with pastures of other animals. *Most appropriate grasslands, preferred measures*. Dry and mesic grasslands with low, fine grass. Well suited for early grazing, steep slopes and very dry places. Less suitable for habitat restoration than other animals, but efficient in combating pasture weeds such as Senecio jacobaea, since sheep are less susceptible to plant toxins. *Inappropriate grasslands, undesirable measures.* Wet grasslands because sheep here contract liver parasites. Not suitable for pastures where insect diversity must be preserved and for pastures very rich in plant species, except for in the cases where low grazing pressure is selected.
Goats
Character of grazing. Very flexible in terms of food choice, they eat not only grass, but also branches and tree shoots, and forbs. Goats cut the grass with lower teeth that are pressed against the hard palate. Goats can eat while standing on hind legs, thus reaching tall shrubs. The food base of goats should contain 60% of woody plant shoots. *Most appropriate grasslands, preferred measures*. Grasslands scheduled for restoration, wooded pastures, grasslands with a large amount of shrubs. Goats readily consume *Centaurea jacea*, which is avoided by cattle. If animal density (grazing pressure) is increased, goats consume *Deschampsia cespitosa, Nardus stricta, Cirsiumi spp., Juncus spp., Carex* spp. and ferns well.
Cattle
Character of grazing. They pluck the grass, therefore in pastures with low grazed grass it is difficult for cattle to obtain food. Increased trampling occurs, as the cattle walk through the pasture several times in search of taller grass. They can eat the grass to a height of up to 5–6 cm. Together with the green grass they eat litter, stalks, they do not avoid tussocky areas with coarse and high grass. Cattle create a mosaic while grazing, they do not eat the patches where manure was left. Cattle prefer grasses to forbs. *Most appropriate grasslands, preferred measures*. Dairy cattle should be pastured in mesic and moist grasslands, since they have higher requirements for feed quality and nutritional value. Beef cattle can be used in different habitats, including areas with coarser grass. Very appropriate for habitat restoration and places where structurally diverse vegetation suitable for invertebrates must be developed. *Inappropriate grasslands, undesirable measures.* Dry grasslands, because they lack feed there. Wet grasslands, in order to protect them against poaching. It is not recommended to graze the sward to less than 6–10 centimetres.
Horses
Character of grazing. Horses browse the vegetation with their teeth very low, even lower than sheep (up to 2 cm from the ground). Able to selectively bite out the plants that they like. Eat litter together with green grass. In winter they use hooves to dig the old grass out of the snow. Do not avoid tussocky areas, coarse and tall grass. They are not ruminants, therefore consume a larger amount of food (almost two times more than cattle) and tend to graze for even as many as 18 hours a day. Mosaic-like grazing can be observed – they frequently return to recently grazed patches, while not using other patches at all. Horses are more prone to stomach-ache or colic than ruminants if they suddenly change food base, for instance, eat a lot of grass rich in carbohydrates or easily digestible grass. The grass of semi-natural grasslands contains less carbohydrates, therefore colic is less frequent in horses while grazing in semi-natural grasslands. Horses require food that is rich in micronutrients, and semi-natural grasslands are particularly suitable for them. They create "toilets", where the grass is not eaten, and nitrogen-rich soil develops, resulting in the proliferation of weeds. *Most appropriate grasslands, preferred measures.* Horses are useful in the restoration of grasslands, because they well tolerate hard, coarse, nutrient-poor food. By nibbling the grass low, they reduce the amount of undesired plant species. Suitable for dry grasslands, where mosaic-like vegetation with open sand patches must be promoted to conserve the diversity of invertebrates. Once every few years the pastures must be given a break in June to ensure the dispersal of seeds, or they must be divided into paddocks by giving a break to each paddock at least once during the grazing season. Manure from "toilets" must be gathered and removed from the grassland. *Inappropriate grasslands, undesirable measures.* Wet grasslands, where the probability of trampling is increased, because horses can seriously damage the turf with their legs, especially, if they have horseshoes. Continuous stocking in the grasslands where the greatest nature value is the diversity of plants (however, if grazing pressure is regulated and the duration of grazing and pasture breaks are observed, grazing of horses will do no harm).

Table 22.3.5. The number of pasture animals in livestock units

Type of pasture animal	Recalculation coefficient*	The number of animals in 0.3 livestock units	The number of animals in 0.9 livestock units	The number of animals in 1 livestock unit
Cows, heifers	1.0	0.3	0.9	1
Bulls	1.0	0.3	0.9	1
Young cattle (1–2 years)	0.7	0.3–0.42	0.9–1.26	1–1.4
Calves (6 months)	0.7	1	3	3.3
Calves up to 6 months	0.4	0.27	7.5	8.3
Sheep, goats, mixed age	0.15	3	9	10
Sheep, goats, adult	0.15	1.8	5.4	6
Lambs	0.15	4.8	14.4	16
Horses of different ages	1.0	0.4	1.2	1.3
Horses, adult	1.0	0.3	0.9	1
Colts (1–2 years old)	0.8	0.6	1.8	2
Colts, up to 1 year old	0.8	1	3	3.3

(*recalculation coefficient according to Anon. 2015c).

Table 22.3.6. Recommended grazing area for seasonal grazing for one livestock unit depending on the type of grassland habitat (Tērauds 1955). If the animals are grazed year-round, the grazing area should be greater.

Type of habitat	Hectares per 1 livestock unit
Improved pastures	0.3–0.5
Wet floodplain grasslands	0.5–1
Mesic and moist grasslands	1–2.5
Dry grasslands and mesic grasslands in poor soils	2.5–3.5
Wooded pastures	2–5

fore important to choose the most appropriate grazing animals for the conservation of biodiversity in each grassland (Table 22.3.4). The choice of the breed is also important. The effect of breed on biodiversity does not differ as much as the behaviour and requirements for food quality (Džeimisone, Strazdiņa 2013).

Goats are suitable for scrubby pastures, sheep eat finer grass, cattle and horses are good at reducing the amount of large, woody plants, especially if grazed very early in spring. The biodiversity in sheep pastures is lower than in cattle or horse pastures. Horses are recommended as the most appropriate pasture animals for the maintenance of a high diversity of species (Stewart, Pullin, 2006).

Mixed herd is most appropriate for biodiversity conservation, however, this is not critical, because biodiversity is most significantly affected by grazing pressure.

22.3.1.4 Grazing Pressure (number of animals per area, duration and frequency of grazing)

Grazing pressure is the influence of pasture animals on the ecosystem of the grassland – including plant and animal species, as well as vegetation. Grazing pressure is characterised by two indicators – the density of animals (number per hectare) and grazing intensity, which is determined by how long the animals stay in the pastures, as well as how many times the sward of the pasture is grazed.

In agriculture it is common to evaluate the grazing pressure in relative livestock units by calculating the number of animals per total area of the

Table 22.3.7. Recommended initial grazing pressure in lowland semi-natural pastures of Great Britain (Crofts, Jefferson (eds.) 1999)*.

Habitat type	Grazing duration in weeks and number of animals per hectare (sheep / cattle)								
	2	4	6	10	14	20	24	36	52
Calcareous grassland (0.25 LU ha^{-1} $year^{-1}$)	60 / 15	30 / 8	20 / 5	12 / 3	8.5 / 2	6 / 1,5	5 / 1	3,5 / 1	2,5 / 0,5
Neutral grassland (0.5 LU ha^{-1} $year^{-1}$)	100 / 25	50 / 12,5	33 / 8	20 / 5	14 / 3,5	10 / 2,5	8 / 2	5,5 / 1,5	4 / 0,5
Acidic grassland on poor soils (0.2 LU ha^{-1} $year^{-1}$)	50 / 12	25 / 6	16 / 4	10 / 2,5	7 / 1,5	5 / 1	4 / 1	3 / 0,5	2 / 0,4
Wet grassland (0.2 LU ha^{-1} $year^{-1}$)	50 /12	25 / 6	16 / 4	10 / 2.5	7 / 2	5 / 1	4 / 0	3/ 0	2 / 0

* This scheme cannot be replicated without adjustments in Latvia because the vegetation season is longer in Great Britain and biomass production is higher due to the milder climate

grasslands at the farm, assuming that the grazing season is from 15 May until 15 September, in accordance with the following formula (Anon. 2015c):

$$R_{LU} = ((AN1 \times k1) + (AN2 \times k2) + (ANn \times kn)) / L,$$

where

R_{LU} – stocking density in relative livestock units;

L – the total area of perennial grasslands and grasslands sown in arable land (ha);

AN 1; 2 ... n – average number of animals belonging to one species at the farm during the grazing period;

k 1, 2 ... n – coefficient applicable to the recalculation of animals (table 22.3.5).

The grazing pressure calculated according to this formula still fails to provide a clear picture on the use of each pasture and potential impact on biodiversity. Therefore the time spent in a paddock and the productivity of the grassland should be evaluated as well. In wet grasslands the risk of trampling must also be considered – establishment of permanent pastures in excessively wet grasslands should be avoided.

In Latvia, no research about optimal grazing number in each habitat type has been carried out. The principle must be followed – a shorter grazing period can support a higher number of animals, while a longer grazing period should involve less animals. Still, the number of animals must not be so high that it causes soil compaction, turf damage or overgrazing. Table 22.3.7 gives an example of the initial setting of grazing pressure according to animal type, grazing duration and habitat type in lowland grasslands of Great Britain. Grazing pressure should be adjusted after some time to suit local site conditions, soil and vegetation. The grazing pressure can be evaluated based on:

- the structure of the pasture;
- sward height;
- abundance of unpalatable species and indicator species of overgrazing (Fig. 22.3.17).

The grazing pressure is considered optimal, if it promotes and maintains the mosaic of vegetation – leaving uneven sward lengths and producing tussocky field. This is only possible if the grazing animals are allowed to selectively graze the sward. Only extensive grazing creates an opportunity to selectively consume plants. In contrary, intensive grazing produces uniform sward height leaving less

Constant monitoring and evaluation of vegetation structure and biodiversity condition, instead of monitoring the number of permitted livestock units per hectare, is best for the adjustment of **grazing pressure**. The density of livestock should always be evaluated in conjunction with the time spent in the paddock, productivity of the grassland and moisture conditions. High grazing pressure causes overgrazing, while insufficient grazing facilitates the accumulation of litter. In both cases, the diversity of plant species decreases.
In the case of short-term overgrazing (1–2 years), the biodiversity can be restored by the reduction of grazing pressure. However, the impact of regular overgrazing cannot be reversed by merely "giving a break" to the pasture. Biotechnical measures such as deep tilling of the soil and facilitating of species diversity, will be necessary.

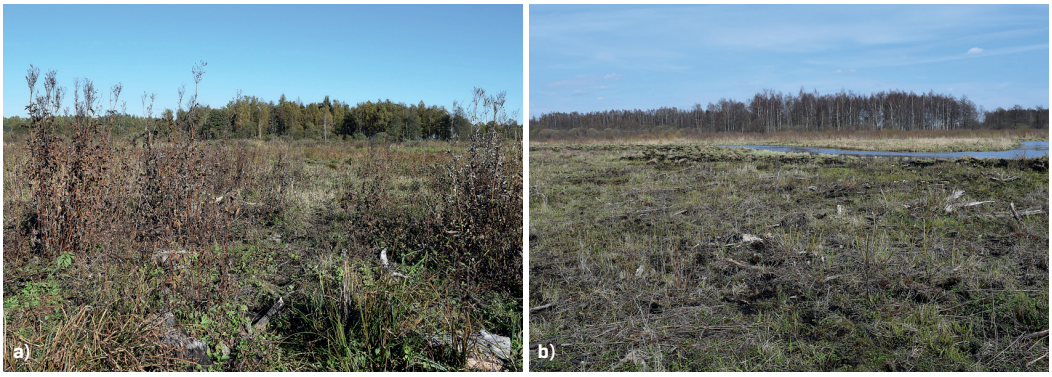

Fig. 22.3.6. Sufficiently grazed year-round pasture in the floodplain of the River Dviete, in Dviete Nature Park, which was restored two years ago by shrub felling. (**a**) Situation in October, when shrub shoots have been browsed, but not to the ground. (**b**) Situation in April of the following year, where shrub shoots have been fully browsed during the winter. Photo: S. Rūsiņa.

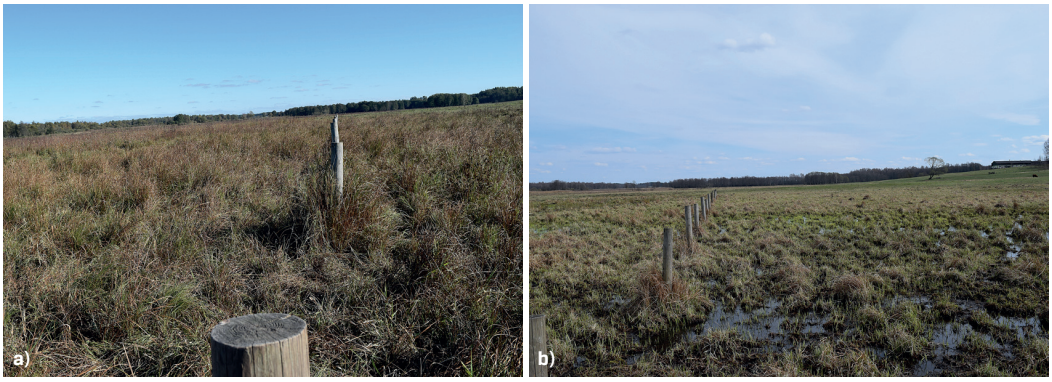

Fig. 22.3.7. Sufficiently grazed year-round pasture in the floodplain of the River Dviete, in Dviete Nature Park, which was restored two years ago by shrub cutting. (**a**) Situation in October, when tall sedges still remain (they were only eaten in spring and early summer, while they were still soft). (**b**) Situation in April of the following year, where all sedges have been eaten to the ground, only some uneaten cushions are left around pasture poles. Photo: S. Rūsiņa.

Fig. 22.3.8. A path trodden by cattle is not an indicator of overgrazing. Photo: S. Rūsiņa.

Fig. 22.3.9. Trampling and overgrazing cannot be avoided in animal concentration areas of permanent pastures (drinking bowls, supplementary feeding sites, gates). However the establishment of such sites in localities of protected species, in sites with very rich vegetation or in sites important for waders should be avoided.

Fig. 22.3.10. In the case of optimal grazing pressure herbaceous plants abundantly bloom in summer. Photo: S. Rūsiņa.

Fig. 22.3.11. Uneaten grass around excrement is very important for the dispersal of plant seeds. It also serves as a feeding place for invertebrates. Photo: S. Rūsiņa.

Fig. 22.3.12. In extensive pastures the plants (in the figure – *Iris sibirica*) have the opportunity of blooming as well as shedding seeds. Photo: A. Priede

Fig. 22.3.13. Appropriate grazing pressure enables early blooming flowers (in the figure – *Tulipa sylvestris* and *Primula veris* in the floodplain pasture at the River Lielupe) to bloom and shed seeds. Photo: E. Nordmanis.

Fig. 22.3.14. *Trollius europaeus* blooms in a pasture in spring. Photo: G. Dolmanis.

Fig. 22.3.15. Signs of overgrazing – trampled turf and rich cover of overgrazing indicator species *Plantago major* in the sward. Photo: S. Rūsiņa.

Fig. 22.3.16. Signs of overgrazing – trampled turf, areas of open soil poached by animals and rich cover of overgrazing indicator species *Plantago major* and *Polygonum arenastrum* in the sward. Photo: S. Rūsiņa.

Fig. 22.3.17. (**a**) The plants do not have an opportunity to bloom in an overgrazed pasture or (**b**) only the hardiest species can bloom. Photo: S. Rūsiņa.

possibilities for different plant and animal species to survive. Under the influence of heterogeneous grazing, a diverse vertical structure of vegetation develops (different height, patches of uneaten grass characteristic for cattle pastures, tussocks, because cattle avoid grazing places around excrement) (Bakker et al. 1984). No more than approximately 25% of vegetation should be left ungrazed at the end of the grazing period to consider that the pasture is optimally grazed (in seasonal pastures – in early autumn, in year-round pastures – in spring). The presence of animal trails, trampled areas in the vicinity of resting places and drinking bowls or around large trees, is a normal part of pasture landscape and should not be regarded as an indicator of overgrazing (Fig. 22.3.6–22.3.14).

Heavy grazing pressure is not desired in either improved or semi-natural pastures, neither is it favourable for the maintenance of productivity, nor conservation of biodiversity. Too intensive grazing results in the similar consumption of tasty and less tasty plants and creates a uniform sward that resembles a meadow. The plants are regularly eaten, therefore they can neither bloom, nor ripen their seeds. In the case of frequent grazing plants continuously develop new shoots, which happens at the expense of accumulated nutrient reserves. The livestock often eat (bite off) the nutrient depots of plants – root necks. Plant nutrient reserves are depleted, the plants are weakened and recover more slowly, while those that fail to resist disturbance of high intensity, die off. Only species that are especially resistant to grazing persist and grassland biodiversity declines sharply.

The signs of overgrazing include trampled turf to the extent of being torn, the surface of the soil is poached, open patches without vegetation are abundant, the sward is very low (less than 3–5 cm), no blooming plants occur, indicator species of overgrazing and unpalatable species dominate, for instance, *Cirsium vulgare, Senecio jacobaea* (Fig. 22.3.15–22.3.17). Pasture that has been continuously overgrazed may have a high proportion of unpalatable species. If these species are controlled by

Potentilla anserina

Polygonum hydropiper

Ranunculus repens

Agrostis stolonifera

Bidens tripartita

Poa annua

Prunella vulgaris

Leontodon autumnalis

Polygonum arenastrum

Capsella bursa-pastoris

Senecio jacobaea

Rumex thyrsiflorus

Fig. 22.3.18. Indicator species of overgrazing. Photo: S. Rūsiņa, A. Priede.

Fig. 22.3.19. Undergrazed pasture at the end of the season. Photo: S. Rūsiņa.

Fig. 22.3.20. Undergrazed pasture at the end of the season. Photo: B. Laime.

Table 22.3.8. The condition of pasture vegetation in an appropriately grazed pasture (Crofts, Jefferson (eds.) 1999, modified).

Period	Desired condition of vegetation and management
Early spring (March – mid-April)	**Vegetation.** Open muddy areas from March until early or mid-May are present in the wettest places in pastures significant for waders (depending on weather conditions). **Preferred management.** Grazing mainly in mesic and well-drained areas.
Preferred management. Grazing mainly in mesic and well-drained areas.	**Vegetation.** Spring plants are in flower, for instance, *Orchis* spp., *Fritillaria meleagris, Gagea* spp., *Corydalis* spp., *Fragaria viridis, Trollius europaeus, Primula veris, Cardamine pratensis, Ranunculus bulbosus, Saxifraga granulata.* **Preferred management.** If rare or protected spring plants occur, grazing must be delayed until seeds have shed; no grazing is permissible in those parts of the pasture with wader semi-colonies.
Summer (late May – July)	**Vegetation.** Blooming plants occur frequently throughout the entire pasture – on average in at least 25% of the area (has not been grazed to the degree where plants do not bloom). **Preferred management.** Extensive grazing (approximately 0.2 – 0.9 LU ha^{-1}). Leaving the pasture "for a break" during a certain period within the grazing season. It is best to leave the pastures "for rest" in the beginning of season (until mid-June or at least early June) in the parts of pastures with wader semi-colonies.
Summer–autumn (June – early September)	**Vegetation.** A mosaic with patches grazed very low (up to ~ 20% of the area with a 3–5 cm high sward) and almost ungrazed patches (up to 25% of the area with vegetation of over 50 cm) and areas of sward grazed to medium height (sward is 10 cm high). There are flowers on late blooming plants in the ungrazed areas (for instance, *Solidago virgaurea, Knautia arvensis, Centaurea* spp., *Succisa pratensis*). **Preferred management.** Extensive grazing (0.2 – 0.9 LU ha^{-1}). Leaving the pasture for a break during a certain period within the grazing season. Grazing of the vegetation as short as possible in the wettest areas and water edge areas at the end of the season.
Autumn (September – October)	**Vegetation.** Most of the vegetation has been consumed (grazed), but there are rare patches where it has remained, the average height of the sward is 5–15 cm. Areas of ungrazed grass constitute up to 25% of the area. **Preferred management.** Remove animals from the pasture, when no growth of grass occurs anymore. Do the same in the areas significant for biodiversity, if the risk of excessive trampling exists due to moisture. Grazing should be continued in the areas significant for birds to maintain or establish feeding places suitable for waders in spring (excessively wet valleys with very low vegetation and open soil (mud)).

means of agrotechnical measures, they can be absent and grazing pressure must be evaluated based on other parameters.

Insufficient grazing results in uniform vegetation, because animals can selectively eat in the entire territory of the pasture and the vegetation regrows faster than the time it takes for animals to return to the grazed areas. Undergrazing adversely affects semi-natural grassland – litter accumulates and trees and shrubs establish, the diversity of plant and animal species declines.

Insufficiently grazed pasture is a pasture, where a micro-terrain typically created by grazing cannot be observed; vegetation is dominated by forbs, tall grasses or sedges. Creeping, decumbent or rosette-forming plants, for instance *Trifolium repens*,

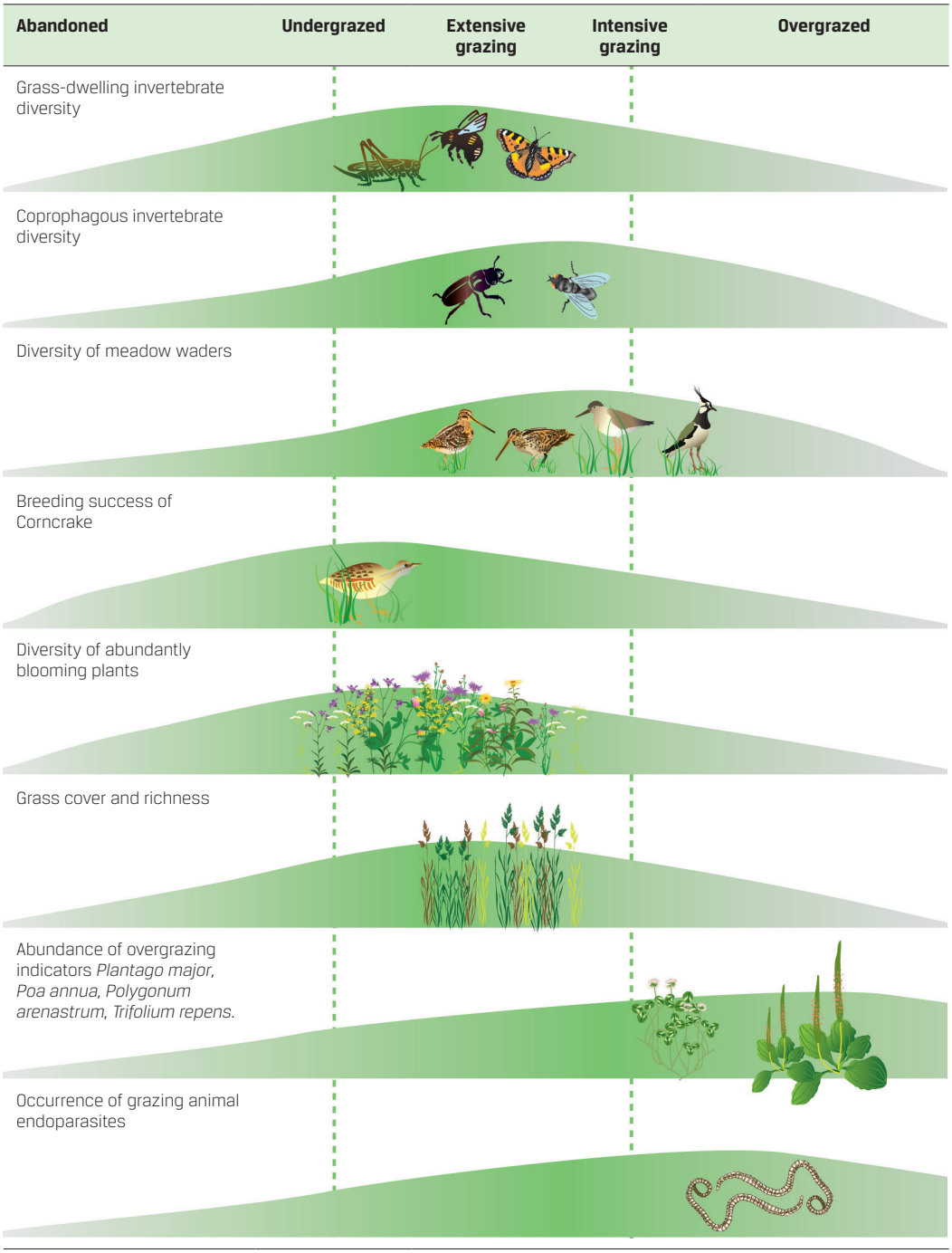

Fig. 22.3.21. The influence of grazing pressure on the grassland ecosystem in semi-natural pastures (the width of the green band represents the diversity of the respective group of species). To ensure maximum species diversity, most of the pastures in the landscape should be extensively grazed, but a few insufficiently grazed areas must be retained (suitable for snails and Corncrake), as well as a few comparatively heavily grazed areas (relatively intense grazing in autumn is recommended to ensure sufficiently low vegetation for meadow waders in spring). The general trend – the highest biodiversity exists at medium grazing pressure. Biodiversity decreases by both increasing and reducing grazing intensity.

Prunella vulgaris, *Plantago media* are absent; the animal movement has left trails in the grass and flattened it (Fig. 22.3.19, 22.3.20).

If rare and protected plant or bird species occur in the area it should be monitored to ensure overgrazing is avoided. It is recommended to fence off grasslands with protected plant species once every few years to prevent animals from grazing there until the seeds have matured and are shed. If the area has a large population of Corncrake, or there is an intention to promote it, grazing should be replaced with mowing or low grazing pressure must be ensured.

It is recommended to graze the grassland only 1–3 times per season depending on the productivity of vegetation, as well as plant, bird, or invertebrate conservation. More frequent grazing develops species-poor vegetation. The sward is dominated by extensive grazing tolerant plants (indicators of overgrazing) and resembles the vegetation of a frequently mown lawn. High grazing pressure interferes with the conservation of invertebrate and bird diversity. Grazing pressure that develops a sward of varying height is recommended (Pärt, Söderström 1998). Sward should be no lower than 5–10 cm even in the most intensively grazed areas.

Insufficient grazing pressure leads to a too high sward for meadow waders in the beginning of the breeding season. In the case of overgrazing, the risk of trampling of nests during the nesting season increases significantly. This depends on the type of grazing animal and on whether the grazing is performed during the day only or at night as well. Less than one livestock unit per hectare could be insufficient to maintain the pasture structure that is required for waders. On the other hand, the proportion of nest damage due to trampling could significantly increase, if the stocking density exceeds five livestock units per hectare. In the evaluation of grazing density in the particular grassland, both the required minimum grazing pressure to maintain the pasture structure and the planned type of grazing (day or 24-hour grazing) must be taken into consideration. To assess the impact of grazing pressure on the grassland biodiversity, continuous monitoring of the structure and condition of vegetation during the grazing season is necessary (Table22.3.7, Fig. 22.3.21).

To ensure maximum species diversity, most of the pastures in the landscape should be extensively grazed, but a few insufficiently grazed areas must be retained (suitable for snails and Corncrake), as well as a few comparatively heavily grazed areas (relatively intense grazing in autumn is recommended to ensure sufficiently low vegetation for meadow waders in spring). The general trend – the highest

Fig. 22.3.22. The hay remaining at the places of supplementary feeding fertilises the soil. Photo: S. Rūsiņa.

Fig. 22.3.23. The accumulation of manure in the supplementary feeding place for horses and cattle is too high. The manure must be removed from the grassland or spread in the parts of the grassland where animals are not frequently present to maintain a semi-natural grassland. Photo: S. Rūsiņa.

Pasture mowing is desirable only, if at the end of season there are more ungrazed patches than grazed. Mown grass must be removed. Mowing in autumn is undesirable, if pasture animals stay in the pasture all year long and in winter eat the grass, which has not been consumed in summer.

Annual burning for more than five consecutive years is not permissible for semi-natural grassland management. Burning may only be a single measure of grassland restoration, to get rid of litter that has accumulated over several years and prepare the grassland for mowing or grazing. For more information on the use of fire in the restoration and maintenance of semi-natural grasslands *see Chapter 21.2.*

Fig. 22.3.24. This pasture requires mowing and the removal of mown plants. *Arctium tomentosum* has proliferated. Photo: A. Priede.

Fig. 22.3.25. A belt of trees and clusters of shrubs increase plant and animal biodiversity in pastures, however, they should be avoided in the areas of floodplain grasslands that are significant for waders. Photo: S. Rūsiņa.

biodiversity exists at medium grazing pressure. Biodiversity decreases by both increasing and reducing grazing intensity.

If there are both groups of shrubs in the pasture, as well as grasslands differing in moisture conditions, productivity and composition of vegetation, no decisions on the degree of grazing pressure can be made during the first years of grazing. Pasture animals gradually explore the territory and the food to be found in different areas of the pasture. Many cases of cattle mortality may occur in the first years due to the failure to adapt to new circumstances, especially after being moved to a semi-natural pasture from the farm where they grazed in sown or improved grasslands, or where the animals received supplementary feeding. In the new pasture the animals will initially stay in the most productive parts of the pasture, which resemble their previous territory most. The adoption of experience from successful farms is an important prerequisite for the successful commencement of grazing. The same number of pasture animals per hectare will have different grazing impact in different years (grazing pressure will be stronger in dry years and smaller in wet years).

22.3.1.5 24-hour Grazing

From the point of view of animal husbandry, the keeping of livestock at the pasture should occur not only during the day, but also during the night. If the farm has both improved and semi-natural pastures, then semi-natural pastures should not be used for night grazing only. Animals, which during the day have consumed lush grass of improved pasture, will not eat the poor grass of semi-natural grasslands properly. Semi-natural grasslands should not be situated in the same enclosure as improved pastures, because then the semi-natural pasture will be grazed insufficiently and biodiversity will decline. Night grazing considerably increases the risk of nest trampling, therefore only day grazing should occur in the grasslands that are significant for birds.

Research in the Netherlands shows that the lowest rate of nest destruction was reached, if dairy cows were grazing during the day only. Under such circumstances, the destruction of nests of all studied bird species (*Vanellus vanellus, Limosa limosa, Tringa totanus* and *Haematopus ostralegus*) by trampling was low, even at a high density of livestock (up to 10 cows per ha). Night grazing of cattle under similar circumstances at the minimum doubled the risk of nest trampling. In the case of grazing young stock for 24 hours – the risk increased as much as 10 times. If recalculated in animal units (1 cow – 10 sheep), considering the same density of animal units the destruction rate of nests in 24-hour pastures of sheep was much higher than in day pastures of dairy cows (Beintema, Muskens 1987).

Trees and shrubs. In order to conserve pasture-specific biodiversity, trees and shrubs are not desirable in small or narrow pastures, which are already shaded by a forest nearby. In pastures that are larger than 1 ha, trees and shrubs occupying up to 10% of the meadow area increase the overall biodiversity and in pastures that are larger than 5 ha the development of clusters of trees and shrubs as wind breakers is even recommended. In wide floodplain pastures, which are significant for the conservation of waders, trees and shrubs should be avoided in the nearest vicinity of the areas inhabited by them. For information on the tree and shrub layer in wooded pastures, as well as large pastures that include both grassland and forest habitats, *see Chapter 19.*

22.3.1.6 Supplementary Feeding During the Grazing Season

Supplementary feeding in semi-natural pastures is impermissible, because additional nutrients are introduced to the grassland resulting in fertilisation (Fig. 22.3.22, 22.3.23). If pasture is grazed all year long, supplementary feeding is required in the cases where most of the pasture is flooded or otherwise unavailable to animals, or the snow cover is very thick. Supplementary feeding should be provided in a biologically less valuable part of the pasture or manure must be gathered and removed at least weekly in winter and twice per week in summer.

22.3.2 Mowing of the Pasture and Spreading of Manure

In improved pastures, spreading of manure and mowing of ungrazed grass is necessary to increase the productivity and reduce pasture weeds. This can also be done in semi-natural pastures, but excessive diligence should be avoided. Unspread pieces of manure are important for insect diversity and other invertebrates as a living environment and direct feeding environment. It also benefits invertebrates indirectly, because animals avoid eating the lush vegetation around manure stools and it serves as a hiding place and place, where flowering plants to feed on are present for long periods of time.

In optimally grazed pastures without the supplementary feeding of animals, the manure can cover 5–10% of the total area. In cattle pastures this means that at least 5–10% of the area is covered by tall grass. If the grazing pressure is very low and the area of uneaten grass is higher than the area with grazed grass, the pasture must be mown and the mown grass must be removed. If it is not done, litter will accumulate and species diversity will decrease over a period of several years. It is recommended to only mow the pasture at the end of the season if the ungrazed grass covers more than 25% of the area (taking into account the grass that has been growing since spring, not the aftermath).

If animals are kept in pastures all year long, the grass left in summer serves as an important source of food in winter, therefore mowing must only be performed if the grazing pressure is low. If the grazing pressure is low, ungrazed grass and litter covers more than 25% of the area at the end of April of the following year (*see Chapter 22.3.1.4*).

Pasture weeds increase the overall biodiversity, therefore they should not be completely eliminated in semi-natural pastures. However, their expansion is unfavourable because they inhibit the growth of other wild plant species, thus reducing biodiversity (Fig. 22.3.24). Poisonous plants can also spread (for instance, S*enecio jacobaea, Pteridium aquilinum*), which are dangerous for the health of pasture animals.

22.3.3 Use of Fire in Pasture Management

Fire was widely used for the management of pastures in the entire territory of Europe up to the mid-twentieth century, when it was prohibited in many European countries for safety reasons. Nowadays regular burning of litter in pastures would be permissible from the point of view of biodiversity conservation, however not every year, and depending on the type of habitat. Fire can affect pastures both positively and negatively, therefore the use of fire must be carefully evaluated. An efficient way of management practised in dry calcareous grasslands in Poland included extensive sheep grazing with burning once every five years in early spring, while the soil was frozen, in order to reduce the amount of litter.

22.3.4 Management of Trees and Shrubs in a Pasture

Periodic removal of trees and shrubs from pastures has been traditionally used (Draviņš 2000; Wahlman, Milberg 2002). While grazing, animals browse the seedlings of trees and shrubs. Frequently animals can suppress large trees by browsing their branches and bark and by rubbing against them causing their withering, breaking or uprooting. If trees have reached the height of 1.5–2 m, animals do not affect them so much and these trees frequently remain in pastures for many years. Animals avoid browsing common alders *Alnus glutinosa*, because of the bitter taste, which is why they must be constantly controlled in pastures. If the grazing intensity in the pasture is too low, the tree vegetation can become too dense. However the removal of woody plants cannot be the main type of pasture management, it must be combined with appropriate grazing. In mesic areas periodic removal of woody plant vegetation without mowing facilitates the proliferation of nitrophilous vegetation (Wahlman, Milberg 2002).

Influence of trees and shrubs on pasture animals (livestock and semi-feral large herbivores). The presence of trees and shrubs is

very important for grazing animals. Larger trees with a wide crown serve as shelter during rain and as shade trees in sunny, hot weather. Groups and belts of shrubs reduce the influence of blood-sucking insects – animals squeeze through the shrubs to brush them off. Shrubs constitute a significant source of food for some animal species and breeds (goats, semi-feral cattle) and favourably affect the health of these animals. Groups of *Salix* spp. are significant because animals eat their shoots, which are rich in vitamins and biologically active substances.

Influence of trees and shrubs on plants. Small quantities of shrubs and trees in pasture (up to 10–20% of the total area) increase both the total number of plant species, and the number of herb species, because plants that cannot survive under the full sun can grow in the shade of shrubs (Fig. 22.3.25). It was observed in Sweden that the number of herbaceous plant species is higher in pastures with a larger number of trees and shrubs. The spatial distribution of trees and shrubs has high importance for wooded pastures. Heterogeneous distribution of trees and shrubs is more favourable, because otherwise they would evenly overshadow the soil and light-demanding species could not survive. However, it was concluded that the species richness is related to light intensity. Therefore, if a wooded pasture consists of a mosaic of completely lit and partially shaded areas, the overall diversity of species will be higher (Einarsson, Milberg 1999).

In small pastures (up to 1 ha) bordering the forest with at least one edge, it is recommended to remove trees and shrubs otherwise the shadow will be too dense and the plant species diversity will decrease. Tree leaves fertilise the soil in autumn, which also reduces the diversity of plant species.

Influence of trees and shrubs on birds. The presence of trees and shrubs can affect birds either positively or negatively. The influence depends on their quantity and the configuration of trees, as well as the target bird species (*see Chapter 22.2.4*). For more on the quantity of shrubs and trees and their configuration in pastures that are important for birds *see Chapter 21.4* on the restoration of grasslands and the tree and shrub canopy in wooded pastures – *see Chapter 19*.

Influence of trees and shrubs on invertebrates. Trees and shrubs are an important food source for insects. For instance, wild bees and bumblebees collect pollen in *Salix* spp. in early spring. The more tree species in the pasture, the greater the diversity of insects, however, overgrowth of pastures should not be allowed. Access of grazing animals to certain clusters of shrubs should be restricted (Soderstrom et al. 2001).

Thus, the quantity and configuration of trees and shrubs may affect plants, birds and invertebrates differently, therefore all groups of organisms must be evaluated when the felling or preservation of trees and shrubs is planned.

If a river flows through a pasture, the quantity of trees and shrubs along the river must be evaluated, considering not only the value of the pasture, but also the diversity of the river (Urtāns (ed.) 2017).

22.3.5 Harrowing, Fertilising and Other Pasture Maintenance Works

Pasture maintenance, including harrowing and fertilisation, does not differ from meadow maintenance (*see Chapters 22.2.3–22.2.7*), except for the repair of fences and enclosures (however, this does not affect the biodiversity).

Sedge tussocks can be effectively removed by pouring salt onto them. The animals then graze the tussocks to a degree that causes the death of plants. Tussocks interfere with pasture maintenance less, therefore it is recommended to retain larger structural diversity than can be afforded in meadows.

Spread of weeds is more common in pastures than in meadows, especially in overgrazed or overfertilised pastures, as well as in animal feeding sites and regularly burnt areas. The most common weeds spreading in such areas include *Senecio jacobaea, Ranunculus acris, Rumex* spp., especially *R. thyrsiflorus*, *R. crispus* and *R. obtusifolius* (Fig. 22.3.18), *Cirsium vulgare, Cirsium arvense,* and, in wet places, *Juncus* spp.

These species are a part of the typical pasture vegetation and therefore should not be completely eliminated, but only limited. For instance, *Rumex spp.* are the only plants used as food by the larval form of a very rare and protected butterfly species *Lycaena dispar.* They also contribute to the diversity of sward structure, which is important for the diversity of invertebrates.

The main method of weed control is appropriate pasture management that prevents the spreading of weeds. If weeds are still widely distributed, the causes of the spread must be eliminated (trampling and overgrazing must be reduced, supplementary feeding in the territory of the pasture must be stopped, etc.). Usually mowing and removal of the mown plants prior to seed maturation is

used twice to three times per season (*see Chapter 22.3.2*), but other more labour intensive methods could be necessary as well. Weeding can be done in smaller areas (*Senecio jacobaea* can be pulled out, but, for instance, *Cirsium vulgare* and *Rumex spp.* have deep roots and are usually controlled by digging their roots with a spade). This should be repeated several times per season. The weeded plants must be destroyed to prevent the further spread of the species. The only effective method in large areas is the local use of selective herbicides. When herbicides are used, the damage to the sward should be reduced to the minimum, and requirements of the regulatory enactments as well as labour safety rules, must be followed.

22.4 Experience of Semi-natural Grassland Grazing and Mowing at a Farm in Vidzeme Region (G. Dolmanis)

Agricultural farm *Lielkrūzes* is an old farm in Jaunpiebalga rural territory. The Dolmaņi family have been owning the land plot since 1878. Our connection with the place has been lasting for at least eight generations. In recent years, the area of our land has doubled, reaching 100 hectares. The forest land includes 40 hectares. The farm has fish ponds of 10 ha in area, the rest of the land is agricultural land. We are managing our land by means of organic, environmentally friendly methods. In addition we rent land from another nine owners. The rented area amounts to 45 ha, which predominantly consists of former abandoned meadows on the banks of the River Gauja. Luckily, they are semi-natural, because they have not been drained. These meadows were established for hay harvesting from the most remote meadows during the period of the first independent Republic of Latvia. These floodplain meadows were mown, when grasslands around houses were harvested. The hay was kept in especially built log sheds for hay storage until winter, when it was transported home from these sheds by means of horse-pulled sledges.

Until 1990, we only managed 2.5 ha and mowed the grass by hand. Later we regained buildings and land and gradually expanded the farm. We grow beef cattle and graze semi-natural grasslands all year long. Currently 60 cows of various ages and 10 semi-feral horses are grazing in the pastures, as well as 40 sheep – on the land around the house. Some of the pastures are mown for hay, depending on our needs, we also collect hay from sown grasslands around the house, where animals graze in the aftermath only.

Livestock farming is of great importance in landscape management and development. Our well managed farmhouse and high quality natural environment has sparked the interest of public event organisers. We have created a place for seminars, we offer materials on the historical nature conservation experience to groups of tourists. An open-air stage built in the territory of our farm hosts various open-air events, frequently of national significance, for instance, the All-Latvian Meeting of Bards and People. We use populous events to promote environmentally friendly farming and make profit from the maintenance of a high quality environment.

Pastures. Cows together with horses effectively consume the vegetation of the grassland, because horses graze the spots that cows do not graze, including the places of droppings of the previous year, as well as taller, coarser grass. This creates the effect of mowing. We graze sheep separately, because they are picky and, if pastured together with cattle, they trample the grass. Due to stray dogs it is risky to leave the sheep far from the house.

We graze the pastures all year-long. Each paddock is grazed on average three times a year. In spring the animals graze in the entire territory of pastures. When the grass starts growing faster and the animals cannot eat all of it, gradual grazing is started. We divide the territory into paddocks by electric fencing. The size of paddock varies depending on the characteristics of the site. Animals graze in one paddock for approximately a week, until the grass has been eaten low and the sward is homogeneous. As soon as the pasture is grazed, the animals are transferred to the next paddock. Biologically less valuable grasslands are grazed first, while in the most valuable grasslands we allow plants to bloom. We mow them when the seeds have ripened and in autumn we transfer the hay with all seeds for supplementary feeding to biologically less valuable grasslands, in order to achieve higher diversity there, since the seeds from the hay are spread.

The average stocking rate at the farm is 0.33

livestock units. We also use higher grazing pressure by fencing the animals off in smaller areas, where old grass or shrubs must be controlled. We place blocks of salt licks into the shrubs. Then animals browse on the shrubs in a manner that prevents them from regrowing.

If grazing is performed all year long, the horses dig and eat the tussocky areas with sedges to the degree where the tussocks become black, thus controlling their expansion. Animals eat tussocks more efficiently, if salt is sprinkled on them. The tussocky areas are also eaten well in early spring, because sedges are the first green plants in spring.

We have intentionally left clusters of shrubs and willows in the pastures. Shrub clusters are required by animals in early summer in order to brush off blood-sucking insects. Large trees are required to ensure rest in the shade. The willow shoots are readily browsed by pasture animals, thus providing themselves with the required trace elements. Over the entire period of farm management we did not require the supplementary addition of selenium.

We do not use concentrated food and food additives either in summer or in winter, we use only blocks of salt licks. We do not feed silage to animals, otherwise they become picky and refuse to eat overgrown grass.

Early grazing. Preparation of animal food in ancient times was much more of a problem than now. The reserves of hay were often depleted by spring, therefore farmers let their sheep and horses out to graze litter together with freshly sprouting grass and animals have successfully done that. Fields of seed clover, which were grazed or even mown in early spring, yielded higher crops, because in the aftermath bees pollinated clover seeds better. Thus, the optimum mowing time of grasslands that were grazed in early spring was shifted by even as much as a month. The main blooming of plants occurred at a time when other meadows were already mown. Butterflies, bees and other insect communities followed the flowering of the meadows. Being aware of these causal relations, as well as the fact

Fig. 22.4.1. Controlled grazing. Photo: G. Dolmanis.

Fig. 22.4.2. Tussocks enrich the diversity of nature. Photo: G. Dolmanis.

Fig. 22.4.3. All habitats of the farm are interconnected. Raptors feed on moles. Photo: G. Dolmanis.

Fig. 22.4.4. Early grazing. On the right side spring grazing was used, on the left – plants were allowed to ripen seeds. Photo: G. Dolmanis.

Fig. 22.4.5. Mowing had to be postponed while the brood of wagtail hatched. Photo: G. Dolmanis.

Fig. 22.4.6. Sedge tussocks are readily eaten by livestock in spring. Photo: G. Dolmanis.

Fig. 22.4.7. Lielkrūzes from a bird's eye view. Photo: J. Šāvējs.

Fig. 22.4.8. Spring floods. Photo: G. Dolmanis.

Fig. 22.4.9. Spring floods. Photo: G. Dolmanis.

Fig. 22.4.10. Migrating ducks and geese use the grasslands for rest and food in spring. Photo: G. Dolmanis.

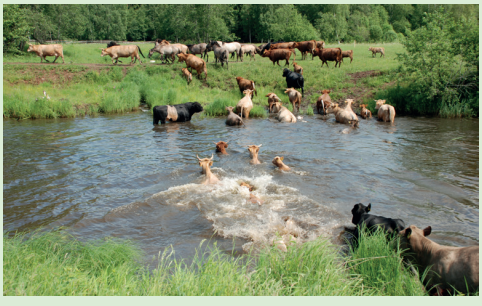

Fig. 22.4.11. Swimming cows. The herd is particularly happy, if they are allowed to swim to the island in hot weather. Photo: G. Dolmanis.

Fig. 22.4.12. A flooded meadow. This type of meadow would be very difficult to mow, and animals do the best job of eating the grass! Photo: G. Dolmanis.

that mowing all meadows at once would create a critical situation in the kingdoms of flowering plants, birds and insects, we have developed a non-traditional solution for the optimum extension of the mowing period at our farm.

The effect of early grazing lies in the inhibition of large, aggressive plants that overtake the growth space in spring. This allows environmental diversity to settle in these areas, while postponing the mowing to a later time and, thus, maintaining the richness of nature. Since our herd is grazing in the pastures all year long, we have figured out that the most difficult period is spring, when the grass starts to grow. This is the time, when keeping animals in enclosures is difficult, as they are lured by the smell of fresh grass. They wish to eat until full, while refusing to eat hay any longer. This risk is not experienced by farmers who start the grazing season with delay. In late May, we hear the Corncrake in 2 – 3 places of the meadows mown by us every year, but, as the preparation of silage starts in our neighbour's territories, the ones that survive move to our early grazed late meadows, which are only mown after the breeding of birds.

Bird conservation in pastures. I am sceptical about the theory that extensive grazing in flat grassland, which is required by the Rural Support Service, could save the breeding birds, because the surrounding of the herd is watched by storks, as well as predators, which are in search of food to feed their babies. Therefore storks and herons are also attacked by terns and northern lapwings. For the conservation of birds, the tussocky areas of pastures are significant. Even after grazing duck nests were found on large tussocks, because grazing animals do not step on the mounds and cannot trample the eggs. Corvids will also not see them easily, if they walk on the ground. Our herd does not disregard cushion grass either in summer, or in winter, when semi-feral horses clear the tussocks so thoroughly that some of them do not even sprout in spring.

Manure generated by animals in the pasture. The animals in the pastures lie in the highest places, which are dry and windy. This has to be taken into consideration. Animals leave manure in these areas, which balances the fertiliser flow – drier places where the grass is low are fertilised, while the nutrients are brought away from more fertile places. Dry places also do not suffer from excessive fertilisation, because the nutrients are rapidly washed away by rainwater to lower places. This is the way nutrients circulate in the nature.

In earlier times, all of the aftermath grass was grazed. This maintained and increased biological diversity. Nowadays, where due to a shortage of homesteads with livestock ecosystems do not work, this can only be compensated by means of specially organised grazing. Animals leave manure in their lying places, but the choice of lying place is additionally affected by the network of groundwater veins. This creates additional variety in soil fertility and strengthens the diversity of plant species.

Farmers must take care to ensure that the meadow is fertile, therefore in winter the hay is fed to animals in the least fertile areas of the pasture.

Meadows. We do not even suspect the presence of multiple tiny beings. There are not many people, who, while mowing their meadows, hold a scythe in their hands. The racket of trimmers or tractors does not allow one to learn and observe nature. The introduction of these methods does not allow one to compare and realise that something unnoticed is disappearing.

There is a meadow in my farm, which I have been mowing with a hand scythe for 50 years. In the early years, when I mowed the grass in the morning, the infuriated bumblebees pointed to three or more nests and my children used to taste this treat. Now these bees can be observed on flowers, but their density is impossible to compare. Their nests occur every second year in the meadow, which has not suffered any change over a century, or there are simply none of them. When *Luksti* (on the bank of the Gauja) meadows were not drained and were still mown with horses, *Bukans meadow* frequently remained unmown, because there were always problems with bumblebees and horses. Now this meadow is our property, and we clearly know that after the land drainage managed by the collective farm, no wild bees have been nesting in this meadow. The extinction was caused by the introduction of rotary mowers. They are very undesirable for nature, because blade covers do not allow the insects to escape.

Mowing that preserves bird and plant species diversity. In Piebalga haymaking actually started after Midsummer's Eve and people tried to mow everything by 15 July. Many farmers did

not have the equipment and they waited when the collective farm could spare a tractor for the private owners and therefore the mowing was extended, and biological diversity was preserved.

We introduced late mowing at our farm – we mow after 1 August. This type of management protects approximately five nests of Corncrake in the territory of the farm, simultaneously improving the populations and promoting the conservation of plant, insect, bird and other habitats. While working on the field, we can observe that birds are not afraid of agricultural equipment and compromise their nest locations, which are not shown to a walking human. They let humans approach no closer than the distance of a gunshot. In the case of responsible management, tractors may drive around the nests of northern lapwing, curlew and other birds. In this favourable place, birds will nest during the following years as well. This approach has enabled us to preserve nesting birds for several years.

The meadows of *Lielkrūzes* are mown from the centre, thus trying to protect several living creatures from extinction. Habitats of diverse meadow flowering plants are mown late, to enable these plants to spread their seeds. The bales of this hay are marked as a special asset. After removal from the shed, they are taken to meadows poorest in species, where, as they are unrolled and fed to animals, the seeds can spread. This type of management has increased the area of biologically valuable grassland territories on our land. The diversity of plants fed to the animals, with their healing potential, compensates for the shift in the optimum time of mowing. The problem of manure is resolved by means of ensuring a homogeneous density of animals throughout the entire year (evenly and proportionally distributing the hay that is fed to animals throughout the territory and thus preventing the development of overfertilised or trampled areas).

In meadows and pastures, where Corncrakes are calling, mowing is adapted to the needs of bird survival. While working in the fields, the nests of northern lapwing and other birds are avoided by driving around them. The ground water table in the meadows is maintained as close to natural as possible, which is ensured by specially engineered wetlands as well. Grazing of wet meadows is the major guarantee of non-transformation of such meadows, because it will be impossible to mow such slacks with equipment. Special shrub clusters and specific places of the pasture that are favoured by animals are maintained in order to ensure animal welfare and conserve nature diversity. No clear felling is implemented in the forests of *Lielkrūzes* deliberately, with the purpose of ensuring beneficial meadow-forest interaction. A micro-reserve for two species of eagle has been established in the forest. Grassland management was adjusted for the benefit of flowering plants, insects, amphibians and birds. This is non-traditional, controlled stocking in semi-natural grasslands. The presence of different life forms ensures the fertility of land and serves as the basis for the sustainability of agricultural production. Many owners are afraid of the expenses of nature conservation, which is stimulated by agricultural policy and the lack of knowledge on ecosystem benefits. The attitude towards natural processes has never been different at our farm. This kind of thinking comes from ancestors, conforms to the principles of sustainable development and is rooted in folk traditions.

Nowadays nature is incapable of adapting to man-made changes and it must be admitted that the introduction of rotary mowers and silage preparation is the destruction of nature. No elementary observation of nature conservation regulations is required to do these works. Firstly, every insect or living creature that happens to be covered by the hood of the mower is doomed to death. Therefore it is no surprise that honey bees disappear inexplicably. The other problem lies in the attempts to mow as early as possible, in order to obtain competitive animal feed, however – this creates conditions unsuitable for nature conservation. After simultaneous mowing of all meadows, the insect kingdom is subject to famine. Beekeepers transport their bees to other pastures, but who will save butterflies, wild bees and meadow insects that maintain fertility?

Our ancestors were able to live self-sufficiently by maintaining both the attraction of the rural farm and providing for themselves; at the same time, they did not separate their actions from the awareness of the importance of natural environment conservation. Earlier, a child was taught to understand and love all that is alive. While resting on the verge of the field, people examined every tiniest insect or flower next to them. The bumblebee nest, which was found and brought by parents while mowing with hand scythes, taught children to love the earth. Then many of my peers built

bumblebee nests out of birch bark. The calling of Corncrake in the nearest meadow urged one to preserve this idyll. The nest of Corncrake that was damaged while mowing made people think about the existence of species.

Earlier people used to say "the swamp feeds the field" because all slacks were mown then. The lowest areas were fertilised by flood waters. Later, for the sake of technical convenience, they were drained. During the times of collective farms, the places that were unsuitable for equipment were handed over for private mowing and all ditches, depressions and river banks were mown. I remember an old lady, who complained during the collective farm meeting that she had to mow mere cotton. She referred to marshy cottongrass meadows. But in these meadows, there are rare purple marshlocks and bog-star (marsh grass of Parnassus), as well as other plants that depend on mowing.

Grassland management methods cannot be evaluated unequivocally. Maintenance of plant diversity requires much more complicated systems than our agricultural practices can offer. Without maintaining the seed bank of the plants and ensuring the possibility of plants to bloom and ripen seeds, no nature diversity or recovery is possible. The diversity of flowering plants can only develop in appropriate plant communities, and the appropriate time of mowing must be adapted to that. Those summers, when due to rainy weather the haymaking season extends, are most favourable in terms of conserving nature assets. Similar conditions can only be ensured by the systematic introduction of extensive grazing. The disturbances caused by grazing animals can have a negative effect, therefore the areas that need no disturbance, must sometimes be fenced off for a certain period of time.

Along with the development of agriculture, various changes have occurred in natural systems and we pay too little attention to the times when horses served instead of equipment. Horses mostly grazed the areas that are not suitable for management. This created the conditions for the introduction of semi-feral horse grazing. The meat of the herd, which is grazed all year in natural habitats, is comparable in quality to the meat of game animals. It is not artificially grown excessive weight, but rather the natural health and exterior of animals that matters when determining the quality of an animal. This would partially compensate for the costs, which must be invested to conserve the ecosystem that maintains the diversity of nature.

Difficulties that arise when dealing with nature-friendly farming. The intensive management of agricultural land by the neighbours that border our farm harms natural diversity on our land as well. Good housekeeping practices in private natural areas are not required even for the meadows and pastures of organic farms. An intensively managed meadow of a neighbour is situated in the very middle of our farm land. It is mown for silage considerably earlier than when the breeding season of Corncrake ends and the mowing is performed from the sides to the centre. As a result, the calling of Corncrake is not heard there anymore; furthermore, it has disappeared from our meadow that lies next to the intensively mown meadow of our neighbour.

Our herd tries to break their way from our pasture fences to the adjacent fresh aftermath, where the silage bales are left on meadow edges. Many people do not know that an extensively grazed herd is not accustomed to eating silage, and the risk of animal break outs associated with silage is low. Each accidental escape of an animal from the enclosure or electric fencing, resulting in a damaged bale of silage, comes at a high cost to the local farmer, who keep animals in the pastures. Animal breakout can be caused by wild animals that find their way into the enclosure or even a tree broken by a beaver or wind that falls onto the fence. Even the presence of the owner cannot stop the bewildered animals then, and harm is inflicted.

For animals that graze in the wild, the taste of these bales is like ice-cream, which stimulates them to break out and damage other storage places of bales. As air enters the damaged bale, it becomes useless. Their presence on the border with the neighbouring land is one of the reasons why keeping animals in enclosures has become more expensive or even impossible.

Earlier the meadows were decorated with hay stacks, however now the film covered bales decrease the scenic value of places. These problems have been explained to the groups of farm visitors several times.