Protected habitat management guidelines for Latvia

Semi-natural grasslands

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Cover photo: Jānis Šlūke

Book quotation example: Rūsiņa S. (Ed.) 2017. Protected Habitat Management Guidelines for Latvia. Volume 3. Semi-natural grasslands. Nature Conservation Agency, Sigulda.

Chapter quotation example: Kļaviņa Ē. 2017. Legal framework. In: Rūsiņa S. (Ed.) Protected Habitat Management Guidelines for Latvia. Volume 3. Semi-natural Grasslands. Nature Conservation Agency, Sigulda, 83 – 90.

Produced by: printing house DARDEDZE HOLOGRĀFIJA

MIX
Paper from responsible sources
FSC® C014521

The book is available electronically on the Nature Conservation Agency of Latvia website www.daba.gov.lv.

ISBN 978-9934-8703-2-3

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Volume 3

Semi-natural grasslands

Sigulda

2017

Nature
Conservation Agency
Republic of Latvia

Administration of
Latvian Environmental
Protection Fund

The guidelines have been developed and published with the financial support of the European Commission's LIFE + program project "National Conservation and Management Programme for Natura 2000 Sites in Latvia" (LIFE11 NAT/LV/000371 NAT-PROGRAMME). The project is implemented by Nature Conservation Agency of Latvia with the support of Latvian Environmental Protection Fund.

Foreword

The bond between humankind and nature is eternal. The beauty and diversity of Latvian nature has been affected by ages of interaction between people and the environment. The future of people and the surrounding environment are inextricably linked, and in the contemporary world the diversity of nature cannot be conserved in isolation from humans by prohibiting any action. A responsible attitude is necessary to make the conservation of semi-natural meadows, sea coast, forests, rivers and lakes possible in the future as well. The rare, the unique and the beautiful can only be preserved by including nature conservation as an indispensable principle in the policies of all sectors of the economy, which includes planning, as well as action.

This book is an important resource for anyone, – those who have the authority to make decisions and plan the use of land in Latvia, as well as those who manage their land themselves. The guidelines are a comprehensive source of knowledge and methods that are applicable in nature conservation, providing every one of us with an option of taking sensible and sustainable action while also being caring owners, who benefit themselves, their family and nation by maintaining the balance between humans and nature diversity. The choice of the future lies in our wisdom, respect and awareness of life.

General Director of the Nature Conservation Agency
Juris Jātnieks

Acknowledgements

First and foremost we would like to thank the members of the established grassland working group who followed the development of the guidelines and actively participated by generously sharing their opinions, advice and experience in grassland management. Special thanks to Gunta Bāra, Uģis Bergmanis, Andrejs Briedis, Margita Deičmane, Oskars Keišs, Rūta Sniedze-Kretalova, Pēteris Lakovskis, Mārtiņš Lūkins, Ilona Mendziņa, Edmunds Mertens, Digna Pilāte, Agnese Priede, Verners Pudāns, Ieva Rove, Gintārs Rubenis, Dace Sāmīte, Dmitrijs Teļnovs.

We would also like to thank the guest speakers of the guideline workshops organised within the project, Gunta Bāra, Dzidra Kreišmane, Jānis Ķuze, Juris Smaļinskis, Andis Liepa and Anita Namatēva.

Development of the content and structure of the guidelines was greatly supported by the active participation of seventy seminar participants at the beginning of the project. We would like to especially thank Andris Avotiņš jun., Andrejs Briedis, Sandra Ikauniece, Mārtiņš Kalniņš, Anete Pošiva-Bunkovska and Andris Viesturs Urtāns who undertook to gather the ideas of the discussion groups and the recommendations for the development of the guidelines.

Thanks to Gunārs Ciglis, Guntars Dolmanis, Andris Dzērve, Tālis Lārmanis and Valda Lārmane, Brigita Lūkina and Dmitrijs Lūkins, Edmunds Mertens, Inese Balode and Raits Čakstiņš for sharing their extensive experience in the maintenance and restoration of grasslands and for supporting the vegetation studies in the grasslands under their supervision.

We would like to thank Naujene Parish Municipality, Cēsis City Municipality and the environment expert Inta Ādamsone, as well as the head of the Bebrene Rural Territory administration Benita Štrausa for cooperation in the restoration of semi-natural grasslands under this project.

We would like to thank the managers of the LIFE project "Restoration of Corncrake habitats in the Dviete floodplain Natura 2000 site" Ilze Priedniece and Edmunds Račinskis for their cooperation in the assessment of grassland restoration efforts in Dviete floodplain.

We would like to thank more than 200 respondents who shared their grassland management experience and completed the extensive project questionnaire.

Thanks to all the authors of the photos who allowed the use of their works in this publication. Many thanks to Vija Znotiņa for scientific editing of English translation.

The guidelines have been developed with the financial support of the European Commission LIFE programme and the Nature Conservation Agency.

Content

Introduction (S. Rūsiņa, A. Priede)

Guidelines for the conservation, management and restoration of protected habitats have been developed during the period from 2013 to 2016 within the framework of the European Commission LIFE+ programme funded project "National Conservation and Management Programme for Natura 2000 Sites" (NAT-PROGRAMME, LIFE11 NAT/LV/000371) implemented by the Nature Conservation Agency.

The purpose of the guidelines is to provide recommendations for the conservation, management and restoration of terrestrial and freshwater habitats listed in Annex I of Council Directive 92/43/EEC of 21.05.1992 on the conservation of natural habitats and of wild fauna and flora (the Habitats Directive), in Latvia. The guidelines are one of the tools to promote the implementation of the Habitats Directive and 2009/147/EC Directive of the European Parliament and of the Council of 30.11.2009 on the conservation of wild birds (Birds Directive) in Latvia. The guidelines are issued in six volumes: (1) coastal habitats, inland dunes and heaths, (2) lakes and rivers, (3) semi-natural grasslands, (4) mires and springs, (5) outcrops and caves, and (6) forests. This volume provides recommendations for the conservation of semi-natural grassland diversity.

The book aims at helping grassland managers and habitat experts to obtain information on the best practices in the restoration and maintenance of grassland biodiversity; proposing management and restoration methods, approaches for the assessment of management and restoration success; providing ecological justification for the selection of such methods; describing the practical actions of restoration and management measures and highlighting useful sources for detailed descriptions of specific methods or approaches.

The guidelines were developed by a leading expert in each group of habitats (coastal habitats, inland dunes and heaths, rivers and lakes, semi-natural grasslands, mires and springs, outcrops and caves, forests), who organised the compilation of the guidelines. The development of the guidelines was an open process: the drafts were available to all interested parties in various development stages – published on the project website and discussed in a number of well-attended seminars, giving the possibility for everybody to participate with suggestions. At the beginning of the project, working groups were established, allowing for the involved parties to follow the development of the guidelines and to participate with opinions and recommendations throughout the process. Representatives of various fields participated in the working groups – experts of species and habitat conservation, researchers from scientific institutions, representatives of governmental and non-governmental organisations – professionals of nature protection, forestry, agriculture and other industries. Twenty-five workshops were organised during the development of the guidelines – both as workshops and field visits to investigate the problem situations, and discussions were held among the representatives of various fields about possible solutions. The suggestions received were assessed carefully and used in the development of the guidelines. During the development of the guidelines the leading experts met and consulted with practitioners and researchers in Latvia and abroad, thus the best available experience is gathered. Therefore, the guidelines should be considered as a result of teamwork – it would not have been possible without the involvement of a wide range of experts who have helped to create the most voluminous edition of such type in Latvia so far.

The recommendations provided for in the guidelines have been tested in Latvia or geographically similar conditions, their effectiveness recognised as applicable. The project also carried out experimental habitat restoration by using less known or even never used methods in Latvia, to assess their applicability. The experience gained was used in the preparation of the guidelines. Some problem situations lack tested examples not only in Latvia, but also in other geographically similar regions worldwide. In such cases, we have identified activities to be tested.

For habitat management, restoration and creation, it is not possible to establish one recipe for all cases, and it is not likely to be possible in the future either. The diversity of conditions makes every case unique. So every attempt to restore a degraded ecosystem, even using well-known techniques and applying thorough feasibility studies, does not always guarantee success. One should be creative in the restoration of a degraded habitat and willing to adapt to the conditions, able to experiment and use additional solutions – including those not proposed by these guidelines. The approach should always be flexible when trying to restore affected or degraded ecosystems. Sometimes, even having done everything possible according to the best

recommendations and practice, adjustments are necessary to correct the mistakes or unexpected deviations from the plan. Each ecosystem restoration attempt is in a way an experiment, no matter how well-designed it is. Its success or failure in the longer term can only be affirmed by systematic observations and careful analysis of results, including errors.

This book is dedicated to the management of EU protected open and wooded grassland habitat types with the aim of preserving or enhancing the biodiversity. The main subject of the book is semi-natural grasslands of different quality, but it also addresses the conversion of sown and cultivated grasslands and ex-arable land into semi-natural grasslands.

The restoration and management matters related to the protection of certain species are addressed only insofar as required to explain the management and restoration of habitats. In this book, only three groups of living organisms inhabiting semi-natural grasslands are addressed:

- higher plants (mosses and lichens are addressed only under habitat characteristics, while detailed management and restoration required for the protection of particular species is not examined, as the knowledge on the species ecology and practical experience in Latvia and elsewhere in Europe are often insufficient);
- grassland birds are one of the best-studied animal groups in grasslands; for many protected bird species grasslands are the only suitable habitat, therefore this is addressed in more depth;
- invertebrates include a very wide range of mutually unrelated living organisms which cannot be fully addressed in this book both due to the volume implicated and the fact that the knowledge on many invertebrate groups in Latvia are insufficient. This book mainly addresses the insects, as well as snails and spiders to a lesser extent.

The target audience of the book is grassland managers, habitat experts, consultants, state and non-governmental organisations working in grassland management and nature conservation areas. It will be useful for professionals working in agriculture and nature conservation who develop regulations or plan and implement nature and biodiversity conservation measures.

This book can also be used as a reference for materials about the maintenance of particular grassland habitats or certain grassland restoration and management methods. It can also be used as a training tool in university programmes in agriculture, environmental science and environmental protection.

Recommendations for the management and restoration of grasslands are based on scientific knowledge, rather than on the requirements stated in the current legislation and planning documents. Therefore, when using any of the methods described in the book, the managers are responsible for ensuring that the actions do not contravene the regulatory requirements of environmental protection or agriculture, such as the support criteria of the Common Agricultural Policy.

The authors of the guidelines hope that the book will serve as a step towards a deeper understanding of ecosystems and a harmonised approach to the conservation of nature values in Latvia. Surely, as time goes by, the knowledge will improve, techniques and capabilities will change. However, these guidelines will remain the most complete summary of nature conservation experience of the last 25 years, and they will form the basis for solving problems in the future. The authors hope that this publication will serve as a source of inspiration for real action in preserving the nature values and restoring the degraded habitats of Latvia.

How to use this book (S. Rūsiņa)

The book covers theoretical subjects applicable on a national level, as well as practical issues of grassland habitat restoration and maintenance. Therefore, before seeking a particular solution or answer, it is recommended to get acquainted with the structure of the book to be able to find the required section. Those wishing to immediately proceed to grassland management without getting acquainted with the theoretical part, are kindly advised to start with Chapter 7 *Preparation for Grassland Habitat Management*.

The first part (Chapters 1–4) of the book covers general topics of ecology and protection of semi-natural grassland habitat types:

- what is a grassland and what types of grasslands are present in Latvia;
- how do semi-natural grasslands develop and to what type of management have they adapted;
- what is a protected grassland habitat and how does it differ from an ordinary grassland;
- what nature values are found in the grasslands and how do the semi-natural grassland ecosystems serve the well-being of humans;
- what factors and processes threaten the semi-natural grasslands and their biodiversity in Latvia;
- what has the semi-natural grassland conservation practice and its changes been like since the 20th century.

The second part of the book (Chapters 5–7) presents the key principles of habitat restoration and management planning:

- what grassland maintenance, restoration and creation is from the nature conservation point of view;
- how to identify the restoration and management objectives on a national level and on a local level in a specific grassland;
- what feasibility studies and preparatory work needs to be carried out prior to restoration and maintenance;
- how to plan grassland maintenance, restoration or creation to achieve the best result possible;
- why management success assessment (monitoring) is needed and how to plan it.

The third part of the book (Chapters 8–19) focuses on the description of 13 European Union (EU) protected grassland habitat types (including three wooded grassland habitat types) and recommendations for their maintenance and restoration, as well as providing recommendations for the management of perennial sown grasslands while reducing the negative impact on biodiversity. The following information is provided about each habitat type:

Brief description – definition of each habitat type, distribution and significance in the protection of a particular EU habitat type in Latvia. Description of the habitat type is based on the EU protected habitat type interpretation manual published in 2013 (Auniņš (ed.) 2013).

Important processes and structures – describes the most relevant environmental conditions (soil, moisture conditions) and ecological processes (e. g. spring floods, drought, effect of mowing) required for the existence of the habitat. This section is important to understand what restoration or management measures are required for a specific grassland to restore or ensure continuous environmental conditions necessary for the habitat.

Succession – provides a brief insight into the process of habitat establishment and disappearance.

Pressures and threats – lists the major human activities that threaten the existence of the habitat or its conservation status.

Maintenance and restoration – lists the parameters that characterise a habitat in a favourable condition and the indicators that show whether the grassland requires restoration. The chapter provides insight into the restoration options, names the key methods (however, a detailed description of the methods is given in the fourth part of the book, since they are mostly the same for a number of grassland habitat types). Additionally, the chapter names and describes the optimal, suboptimal and inappropriate management methods for the habitat type.

The fourth part of the book (Chapters 20–24) focuses on the description and comparison of methods used in the maintenance, restoration and creation of semi-natural grassland:

- what management methods can be used, what are their advantages and disadvantages; what is the environmental justification for the use of each method;
- how to properly maintain semi-natural meadows and pastures to preserve their biodiversity;
- how to restore a semi-natural grassland where it still exists, but is degraded due to

the abandonment or cultivation;
- how and where a semi-natural grassland can be created;
- how to manage the landscape to facilitate the spread of semi-natural grassland species.

The book also contains five **annexes**:
- annex I includes the grassland health (quality of biodiversity) indicators which allow one to evaluate the grassland condition and determine the necessity for restoration;
- annex II is a summary of the optimal, suboptimal and inappropriate management types for each semi-natural grassland habitat type;
- annex III includes brief description of expansive and invasive plant species and their control methods will help in planning the restoration measures in grasslands dominated by these species;
- annex IV contains photos of semi-natural grassland indicator species to help in finding them in the grassland and determining the degree of transformation of a previously sown grassland or ex-arable land into a semi-natural grassland;
- annex V contains photos of meadow and pasture birds. It be useful for identifying grassland birds and determining whether the grassland is a significant bird habitat.

The Latin names of species are used according to Kavacs (ed.) (1998), Latin names of bird species according to Clements et al. (2015).

Part I ECOLOGY AND CONSERVATION OF SEMI-NATURAL GRASSLANDS

Chapter 1. Characteristics of Grasslands

1.1 Definition of Grassland and Types of Grasslands in Latvia (S. Rūsiņa)

Grasslands are ecosystems, where plant biomass is produced by perennial grasses, sedges, and herb species and constant biomass offtake from the ecosystem by wild animals (grazing) or humans (haymaking and livestock grazing) occurs.

Both semi-natural and man-made grasslands occur in Latvia. The difference between them is the extent of human influence on the grassland species composition and environmental conditions. In both cases humans are very important for the long-term existence of grassland.

Different criteria and principles are used to classify grasslands in the agriculture and nature conservation sectors, which often causes confusion, therefore an explanation of grassland names currently used in Latvia is provided below (Table 1.1.1, Fig. 1.1.1).

Table 1.1.1. Grassland names used in agriculture and nature conservation.

Name of grassland	Explanation
Natural grassland	Grassland completely supported by natural conditions (precipitation, fire, wild herbivores, soil conditions) that does not require human agricultural activity (mowing or livestock grazing). This type of grassland most commonly occurs in steppes and savannahs. In Latvia it is used as a synonym for the term *semi-natural grassland*. Agriculturalists tend to use this term in the meaning that is somewhat wider than that used by environmentalists. Any sown grassland where sown grasses have become partially extinct and a relatively high number of wild plant species occurs is referred to as a natural grassland by farmers. Only grasslands characterised by a wild species pool that occurs in grasslands mown and grazed extensively in the long term, where no substantial indicators of cultivation are observed, are referred to as natural in nature conservation.
Semi-natural grassland	Grassland existing as a result of human activity (mowing or livestock grazing), where environmental conditions and the species pool are maintained by natural processes. In Latvia, it is mostly used in the scientific literature, and the most frequent synonym of this term in Latvian is *natural grassland*.
EU protected grassland habitat	A grassland habitat that falls under any of the habitat types listed in the European Union Habitats Directive 92/43/EEC.
Biologically valuable grassland	Includes EU protected grassland habitat types (in Latvia these are all semi-natural grasslands) and important bird habitats (in Latvia these are both semi-natural grasslands and some cultivated perennial grasslands). A habitat is important for birds if it contains: a species listed in Annex I of the Birds Directive; a rare bird species breeding in grasslands; a species belonging to the meadow wader community; a grassland bird species in decline. A term introduced and used for the purposes of the Rural Development Programme.
Perennial grassland	Grassland, which has existed for more than five years. Thus, both semi-natural and cultivated grassland can be perennial. A term used in agriculture. A synonym is *permanent grassland*.
Permanent grassland	Grassland, which has existed for more than five years. Since 2014 this term has been replaced with the term *perennial grassland* in the Latvian Rural Development Programme. A term used in agriculture.
Improved grassland	A grassland that has been created and maintained by humans, where the environmental conditions are controlled by means of agrotechnical measures (fertilisation, drainage, etc.) and the vegetation is created by admixture sowing of grasses and legumes. A term used in agriculture, and also in nature conservation when referring to grasslands that are not semi-natural. Synonyms: *sown grassland, cultivated grassland.*
Temporary grassland	Grass sward for grazing, hay or silage included as a part of a normal crop rotation in arable land, lasting less than five years, sown with grass or grass mixtures. A term that refers to a common type of land use in agriculture. In nature protection, this type of grassland plays a minor role as habitat of the species, because ploughing every five years is too severe a disturbance for wild species to use the grassland as habitat. Birds can use these grasslands as feeding areas, however, perennial grasslands are much more important for them.

Fig. 1.1.1. Latvian grasslands categorised by importance for nature conservation

Most of the area (90% of all grasslands) in Latvia nowadays is occupied by improved permanent grasslands, while semi-natural grasslands account for 10% of the total grassland area, or 0.7% of the territory of Latvia only (Fig. 1.1.1). Perennial sown grasslands are of various ages. Older ones have already gained some traits of semi-natural grasslands. However, they have not yet fully developed into semi-natural grasslands and can be referred to as semi-improved grasslands with a potential to develop into semi-natural grasslands.

1.2 How to Distinguish Semi-natural Grassland from Improved Grassland or Ex-arable Land (S. Rūsiņa)

If it is known that the grassland has not been ploughed or sown, then it is a semi-natural grassland. For instance, a forest can develop into semi-natural grassland under continuous grazing; haymaking for years creates semi-natural meadow on a river bank or in a floodplain.

The vegetation of semi-natural grasslands is usually very diverse and contains many spectacular flowering plant species. However, very old semi-natural grassland can also feature very low plant diversity. This can be due to a variety of reasons, for example, (1) if the grassland is located in a floodplain, inundated with waters rich in fertiliser from arable land, then the grassland is dominated by nitrogen-demanding forbs; (2) if the grassland is frequently visited by wild boar and "ploughed up", resulting in the dominance of ex-arable land species; (3) if the grassland is very small and isolated, the small area cannot provide sufficient living space for all species or they cannot reach the grassland because of isolation. In such cases, the semi-natural grassland requires restoration (*see Chapter 7*).

It is more difficult to determine whether the grassland is semi-natural if it has been ploughed or intensively improved at some point (fertilised, sown with grasses or legumes). In such cases the only criterion is the composition of plant species and vegetation structure, for instance, turf condition (Fig. 1.2.1, 1.2.2). The vegetation of sown grasslands, ex-arable land, as well as semi-natural grasslands consists of perennial herbs, grasses being the most important among them. If cultivation of ex-arable land

Natural or semi-natural grasslands?

Natural grasslands existed in the territory of Latvia before it was inhabited by humans. Ancient natural grasslands were formed and maintained by natural processes – mainly flooding and large herbivores (aurochs, European bison, horses). After the large herbivores became extinct and the flooding activity was heavily transformed and restricted by extensive drainage, the existence of natural grasslands became fully dependent on people. For this reason, it would be more accurate to refer to natural grasslands that have survived to this day as semi-natural grasslands. However, in the Latvian language tradition it is common to refer to semi-natural grasslands as natural grasslands (Rūsiņa 2008). Such grasslands are managed extensively (low-intensity management). They are neither fertilised nor drained, ploughed and sown with productive plant species. On rare occasions, they can be only fertilised by manure and only shallow ditches can be used for their drainage. In many Latvian agricultural publications today the term "semi-natural grasslands" is used incorrectly by either including ex-arable land and old cultivated grasslands or uniting all grasslands of Latvia under the term (e.g., Boruks 2004).

I know indicator species!
Grassland developed in mesic to moist (but not dry or wet) soil in arable land, by leaving it fallow and using it as a meadow or pasture; a sown grassland which cultivation is ceased and mowing or grazing continued

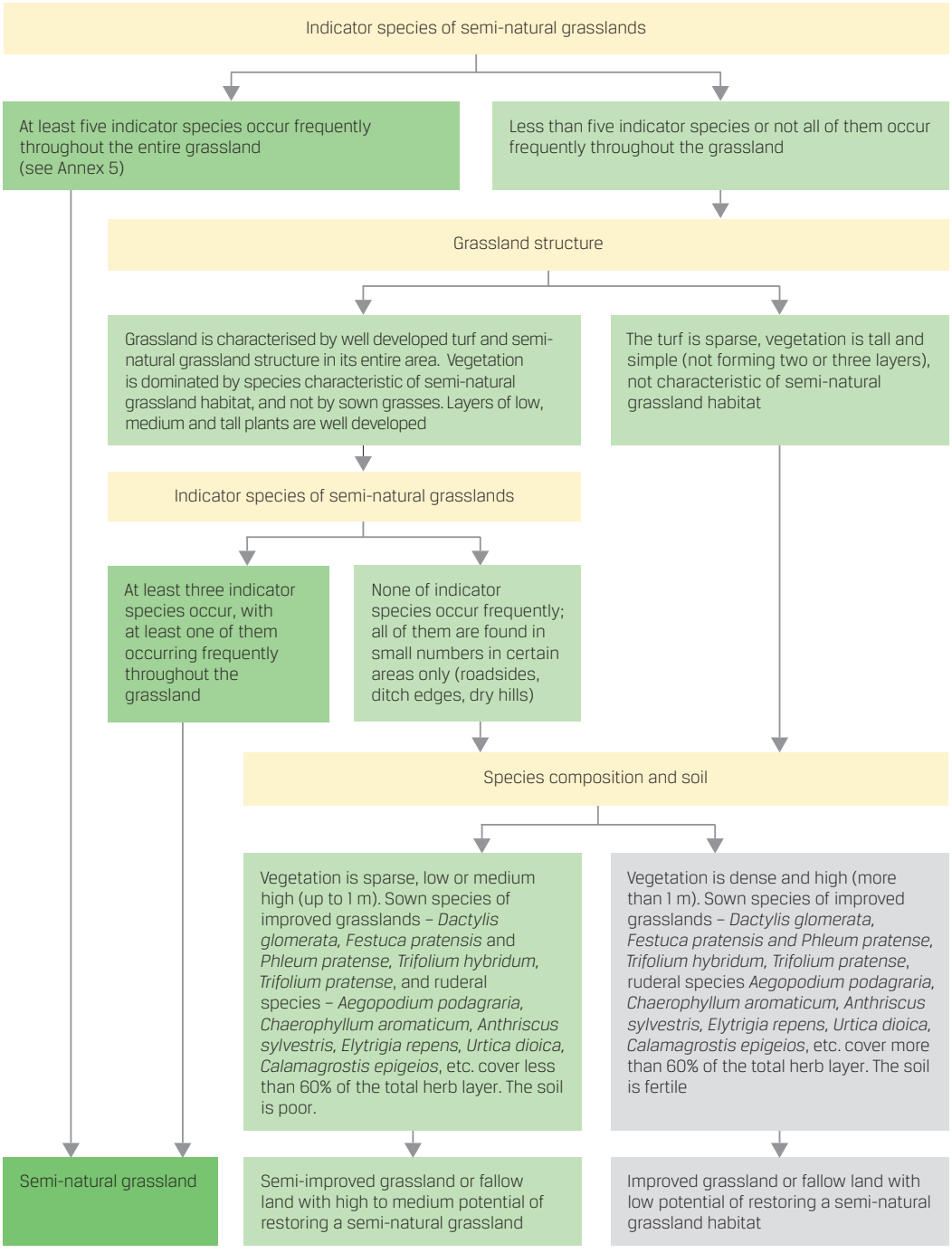


Fig. 1.2.1. Semi-natural grassland identification using semi-natural grassland indicator species (for the list of species, see Annex 4). The identification key cannot be used for wet floodplain grasslands (see Chapter 17 6450 Floodplain grasslands) and dry grasslands. An example of the frequency of indicator species is shown in Fig. 1.2.5.

Meadow

I do not know indicator species!
(The determination scheme cannot be used for wet floodplain and dry grasslands)
Meadow, which has been developed on arable land that is left fallow and used for mowing or grazing; sown grassland, which cultivation is ceased and moving or grazing continued.

Dactylis glomerata, Phleum pratense and *Taraxacum officinale* together cover less than 1/5 of the vegetation;
the vegetation is species rich (more than 15-20 species per 1 m^2) but in acid and nutrient-poor soils the number can be lower;
at least 1/4 of the vegetation consists of richly flowering plant species, not including *Taraxacum officinale, Trifolium pratense* and *Trifolium repens* and *Ranunculus repens*;
well developed, dense turf;
the soil is poor in nitrogen and phosphorus, the productivity is low (hay < 1–2 t ha^{-1}).

yes

Most likely, the meadow is semi-natural. In order to verify this, consult a certified grassland expert.

no

The meadow was ploughed more than 20–30 years ago, but later it was mown and used for hay making, and not fertilised;
Vegetation is medium rich (7–10–14 species for 1 m^2); *Dactylis glomerata, Phleum pratense* and *Taraxacum officinale* and expansive species cover 25–60% on average;
a high diversity of grass species (not only sown grasses, but wild species); the number of forb species is considerably high (excluding *Taraxacum officinale, Trifolium pratense, Trifolium repens, Ranunculus repens*), but their cover is not high (only few species occur in high abundance, for instance, *Leucanthemum vulgare, Prunella vulgaris, Veronica chamaedrys, Lathyrus pratensis, Vicia cracca*).

yes

Most likely, the development of semi-natural habitat is occurring successfully. In order to verify this, consult a certified grassland expert.

no

The meadow was ploughed less than 20–30 years ago or was abandoned for a long period, or was mowed with mulching, shredding of grass, or it was intensively cultivated (fertilised, sown);
vegetation is poor in species (1–5 species per 1 m^2), and predominantly consists of sown grasses and legumes, or ruderal species *Anthricsus sylvestris, Urtica dioica, Aegopodium podagraria, Elytrigia repens dominate*;
the number of forb species is low, their cover is insignificant;
the soil is medium rich or rich in nitrogen and phosphorus, the productivity is high (hay > 2 t ha^{-1}).

yes

Most likely, the meadow almost lacks signs of semi-natural grassland.
To develop a semi-natural meadow, time and resource consuming measures must be implemented. To determine the potential of restoration, consult a certified grassland expert.

no

Possibly, this is a wet or dry semi-natural meadow, therefore the indications included in this scheme do not manifest in it. See the descriptions of wet and dry habitats!

Fig. 1.2.2. Use of vegetation structure to determine naturalness of a meadow (not applicable to wet floodplain (*see Chapter 17*) and dry grasslands).

Pasture

I do not know indicator species!
(The determination scheme cannot be used for wet floodplain and dry grasslands)
The pasture on arable land that has been left fallow and used for mowing or instead of a sown grassland which cultivation was ceased while continuing to use it as pasture.

Dactylis glomerata, Festuca pratensis, Poa pratensis, Trifolium repens, Ranunculus repens, Potentilla anserina or *Taraxacum officinale* cover ⟨ 1/5 of the vegetation, *Lolium perenne* is not present, wild grasses dominate - *Cynosurus cristatus, Briza media, Festuca rubra*, *Festuca ovina*, etc.); vegetation is rich in species (⟩ 15–20 species per 1 m^2), at least 1/4 of the vegetation consists of forb species, for instance, *Prunella vulgaris, Plantago media, Alchemilla* spp.); well developed, dense turf.

yes

Most likely, the pasture is semi-natural. To verify this, consult a certified grassland expert

no

the pasture has been ploughed more than 20–30 years ago, but later it was used for grazing, no sowing or fertilisation was performed;
Vegetation is medium rich (5–15 species per 1 m^2), *Trifolium repens* covers less than 25%; high diversity of grass species (not only sown, but wild species as well), at least 10% of vegetation cover consists of various forb species (for instance, *Prunella vulgaris, Plantago media, Alchemilla* spp.).

yes

Most likely the pasture will positively respond to restoration of semi-natural habitat. To verify this, consult a certified grassland expert

no

The pasture has been ploughed less than 20–30 years ago or was abandoned, or intensively cultivated (grasses and legumes have been sown) and heavily grazed;
Vegetation is species poor (1–5 (10) species per 1 m^2), and predominantly consists of sown grasses and legumes, *Trifolium repens* covers more than 25%;
The pasture has been heavily grazed, overgrazing indicators (*Plantago major, Polygonum arenastrum, Poa annua, Ranunculus repens*) cover more than 25%.

yes

Most likely, the pasture completely lacks signs evidencing the development of a semi-natural habitat. To determine the potential of restoration, consult a certified grassland expert.

no

Possibly, this is a wet or dry pasture, therefore the indications included in this scheme do not manifest in it. See the descriptions of wet and dry grassland habitats!

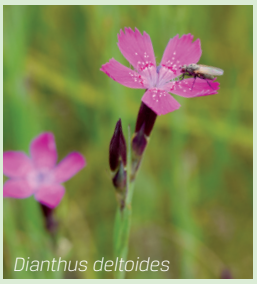
Fig. 1.2.3. Use of vegetation structure to determine naturalness of a pasture (not applicable to wet floodplain (see *Chapter 17*) and dry grasslands).

Table 1.2.1. The occurrence of some well-known plant species in grasslands of various levels of naturalness in mesic areas. Photo: S. Rūsiņa.

Intensively managed sown, cultivated grassland	sown grasses predominate	sown in admixture with other grasses	almost not present
Extensively managed sown grassland or ex-arable land	decrease; not so abundant as in intensively managed sown grassland	surpress oher grasses and starts to dominate	expand in free places, frequently dominate
Semi-natural grassland which has developed in a place of sown grassland or ex-arable land	almost always present but with low abundance	almost always present but with low abundance	almost always present but with low abundance


Prunella vulgaris


Leucanthemum vulgare


Dianthus deltoides


Centaurea jacea


Campanula patula


Fragaria viridis


Lathyrus pratensis


Vicia cracca


Galium album


Briza media

not present	not present	**Intensively managed sown, cultivated grassland**
expand in patches, developing characteristic patchy vegetation	can be present, but rarely	**Extensively managed sown grassland or ex-arable land**
usually present but do not dominate 	many indicatorspecies; do not dominate but occur with high presence 	**Semi-natural grassland which has developed in a place of sown grassland or ex-arable land**

and sown grassland is ceased but extensive grazing or haymaking is continued, the plant species pool evolves towards semi-natural grassland vegetation. This happens very gradually. Therefore a method for determining the condition of each grassland has been developed for the purposes of nature conservation. It allows one to determine whether the grassland already belongs to the semi-natural grassland category or is still considered a sown or semi-improved grassland (despite the fact that cultivation measures have been ceased for a long period of time). In transitional situations, where grassland features an equal number of indications of improved and semi-natural grassland, only a habitat expert with proper knowledge on plant species and vegetation structure can accurately verify the grassland type. However, the evaluation of the state of grassland in general can be performed by any interested party (Fig. 1.2.3–1.2.5, Table 1.2.1).

Fig. 1.2.4. (a) Prolonged extensive management of semi-natural grasslands results in a thick, well developed turf. (b) In ex-arable land, the turf is usually thin and poorly developed. Photo: S. Rūsiņa.

Some of the sown grasslands are important for rare and protected bird species. The importance of grassland to birds is determined primarily by its moisture regime and vegetation structure, as well as the available bird foraging resources (various invertebrates), rather than the origin or diversity of plant species. Many sown grasslands have the potential to become semi-natural grasslands. Thus, if according to the criteria given in Fig. 1.2.3–1.2.5 and Table 1.2.1 the grassland is categorised as an improved (sown) grassland, the idea of restoring/improving its diversity should not be abandoned. A habitat expert should be invited instead, to assess the restoration potential of the grassland (*see Chapter 7*).

To find out whether habitat experts[1] have assessed your grassland and recognised it as an EU protected habitat or bird habitat, visit the nature data management system "Ozols" (http://ozols.daba.gov.lv/). However, being labelled as a protected habitat on the map does not automatically mean the same status of the grassland on site, especially if it has been abandoned for several years or managed inappropriately. If the map contains no information about the grassland, a habitat expert should be invited to assess the grassland.

1.3 Defining a Semi-natural Grassland Habitat and EU Protected Habitat (S. Rūsiņa)

Semi-natural grasslands vary a lot by environmental conditions and species composition. They can develop on wet, moist or dry, fertile or nutrient-poor,

Fig. 1.2.5. (a) Frequent and (b) rare occurrence of semi-natural grassland indicator species *Trollius europaeus*. Photo: S. Rūsiņa.

1 An expert in the area of species and habitat protection. The experts' work is regulated by Cabinet Regulation No. 267 of 16 March 2010, Procedures for the Certification of Experts in the Field of Conservation of Species and Biotopes and Supervision of the Activities Thereof. The list of experts is available on the website of the Nature Conservation Agency www.daba.gov.lv.

acidic or calcareous soils, etc. Grazing and mowing affect environmental conditions differently, which leads to the development of different plant communities. The differences in environmental conditions determine suitable management approaches and options of their application.

In order to adjust the management methods according to environmental conditions, semi-natural grasslands are classified into various types of habitats. Each grassland habitat type has a distinct set of properties (soil moisture, fertility and pH, a certain composition of plant species, etc.), enabling anyone to determine the type of habitat that the grassland belongs to. Only this knowledge of habitat type enables proper planning of management measures that suit the grassland.

This book uses the EU protected grassland habitat type classification (Auniņš (ed.) 2013), since all semi-natural grassland types occurring in Latvia are included in the protected habitat list[2].

13 types of EU protected habitats are represented in semi-natural grasslands of Latvia, also including juniper stands as a significant proportion of this habitat is composed of grassland vegetation. Five of them are of priority importance (marked with an asterisk). The priority habitats are under the threat of extinction at the EU scale, thus the member states are particularly responsible for their conservation, considering the proportion of their natural distribution ranges in the EU (abbreviated name used further in this book in brackets):

1630[3] Boreal Baltic coastal meadows (coastal meadows);*
5130 Juniperus communis *formations on heaths and calcareous grasslands (*Juniperus *formations);*
*6110** Rupicolous calcareous *or basophilic grasslands of the* Alysso-Sedion *albi (rupicolous grasslands);*
6120 Xeric sand calcareous grasslands (sandy grasslands);*
6210 Semi-natural dry grasslands and scrubland facies on calcareous substrates (*Festuco-Brometalia*) (*important orchid sites) (calcareous grasslands);*
6230 Species-rich* Nardus *grasslands, on siliceous substrates in mountain areas (and submontane areas, in Continental Europe) (*Nardus *grasslands);*
6270 Fennoscandian lowland species-rich dry to mesic grasslands (species-rich pastures and grazed meadows);*
6410 Molinia *meadows on calcareous, peaty or clayey-silt-laden soils (*Molinion caeruleae*) (*Molinia *meadows);*
6430 Hydrophilous tall herb fringe communities of plain and of the montane to alpine levels (hydrophilous tall herb fringes);
6450 Northern boreal alluvial meadows (floodplain grasslands);
*6510 Lowland hay meadows (*Alopecurus pratensis, Sanguisorba officinalis*) (hay meadows);*
6530 Fennoscandian wooded meadows (wooded meadows);*
9070 Fennoscandian wooded pastures (wooded pastures).

Two habitat types (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*) are entirely natural habitats as their existence does not depend on human activity. The maintenance of the remaining eleven habitat types nowadays is related to human activity. They are semi-natural habitats where vegetation and fauna consists of wild species, while their preservation is ensured by low-intensity mowing and grazing. If mowing and grazing is ceased, these habitats overgrow with shrubs and forest. An individual chapter of this book is dedicated to each EU protected grassland habitat type (see *Chapters 8–19*).

1.4 Semi-natural Grasslands and their Development in Latvia (S. Rūsiņa)

There are two hypotheses on the origin of semi-natural grasslands in the European forest zone, where the natural vegetation, without human intervention, would be a forest. According to the hypothesis of the Dutch scientist F. Vera (Vera 2000), semi-natural grasslands arose even before humans started farming. Grasslands were created and maintained by large wild herbivores – aurochs, tarpans (wild horses) and European bison. Natural grassland belts developed in floodplains along the largest rivers due to regular disturbances caused by flooding and ice drift during spring floods. Such grasslands are natural, since they can exist without human influence. Since the large herbivores are extinct in the territory of Latvia and the flooding activity is limited by drainage, nowadays the existence of grasslands fully depends

2 Cabinet Regulation No. 421 of 5 December 2000, On the List of Specially Protected Habitats.

3 The code that has been assigned to habitat types in Annex I of the Habitats Directive. These codes added to names of habitat types will be used throughout the book without further specific explanations.

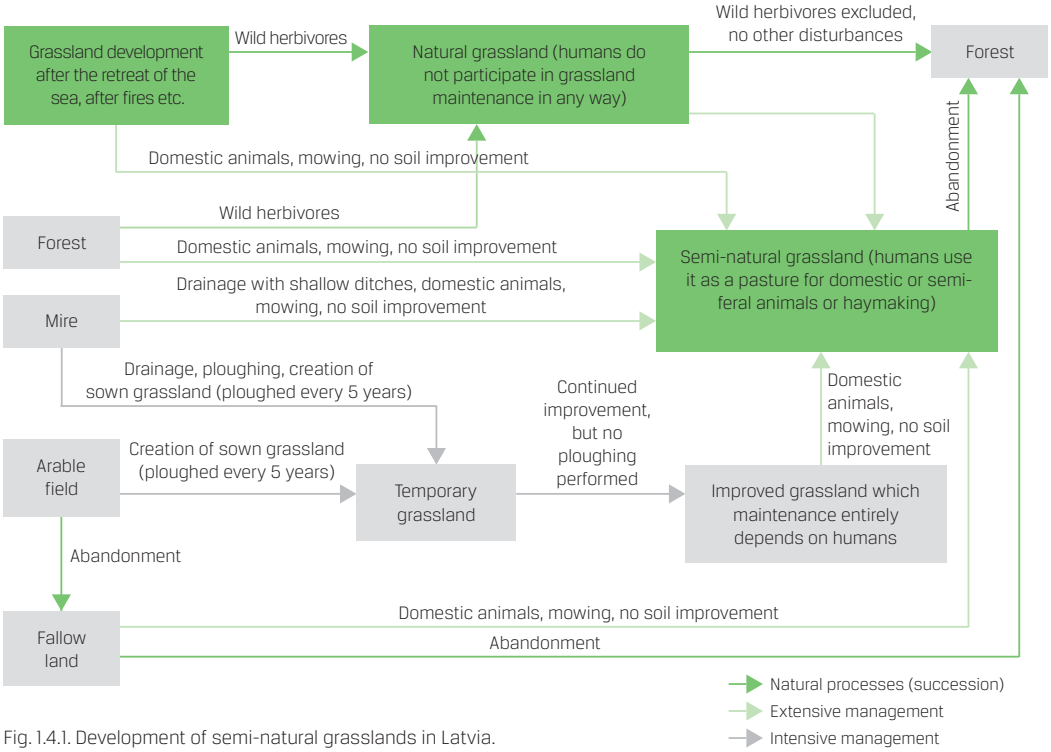


Fig. 1.4.1. Development of semi-natural grasslands in Latvia.

on human activity. Without mowing and grazing they overgrow with shrubs and forest. Thus, when abandoned, the open grasslands disappear. Nowadays *Heck* cattle and *Konik* horses are created by the breeding back of agricultural breeds with the purpose of resembling their wild ancestors, which once roamed through the European forests, and keeping grasslands open. However, the return of wild large herbivores to nature in large numbers to maintain the grasslands is virtually impossible today. To date the semi-feral herbivores are kept only in fenced areas with permanent human supervision.

Grasslands in Latvia have developed as a result of human interaction with natural processes in unvegetated patches (on exposed terrestrial areas following the retreat of sea or lowering of lake water level), in forest clearcuts and glades, in mires after drainage and on arable lands (Fig. 1.4.1).

Fig. 1.4.2. Kārkliņš' farm in Strenči Municipality in the 1920s. Hay was also collected in recently felled clearings. Photo: Digital library collection Zudusī Latvija (*Lost Latvia*) of the National Library of Latvia. Photo from the collection of the *Latvian Museum of Photography*, a branch of the *Museum of the History of Riga and Navigation*.

Fig. 1.4.3. Stump grubbing in Strenči Municipality in the 1920s. The vegetation indicates that the area was used as grassland. Photo: Digital library collection *Lost Latvia* of the National Library of Latvia. A photo from the collection of the *Latvian Museum of Photography*, a branch of the *Museum of the History of Riga and Navigation*.

Nowadays, semi-natural grasslands that are formed as a result of long-term grazing and mowing and have never been ploughed, can be found in some river and lake floodplains and at the sea coast (for example, Randu meadows near Ainaži and near Mērsrags). Some grasslands in Latvia have formed in forests through long-term grazing and mowing, eventually resulting in gradual transformation of the forest into grassland over several decades. For example, in 1923, the agronomist J. Vārsbergs wrote: "As meadows are sometimes established in felled clearings with many stumps and snags, the stumps and snags should be removed" (Vārsbergs 1923, P. 15). This shows that the establishment of such meadows and pastures was common practice until the early 20th century (Fig. 1.4.2, 1.4.3). Such grasslands may have survived to date in places that were not subject to active agricultural land drainage and cultivation in the Soviet period – on the outskirts of collective and soviet farms of the time, in hard to access areas (floodplains, wet areas, hills with steep slopes, areas with very poor soil), around farmsteads, on privately managed agricultural land.

However, most semi-natural grasslands of contemporary Latvia have had a stage of arable field or improved grassland. Semi-naturalness has developed gradually by mowing or grazing without taking any improvement actions for decades.

After ploughing, a stage of creeping grasses develops (dominated, for example, by *Agrostis gigantea, Festuca rubra, Elytrigia repens, Calamagrostis epigeios, Alopecurus pratensis, Phalaroides arundinacea*). In a mesic area, it usually only lasts for a few years. Mowing and grazing promote gradual soil compaction, accumulation of plant root remains, branching of plant roots (formation of turf) and lower levels of oxygen in the soil. Because of this, the creeping grasses disappear and are succeeded by bunch grasses (for example, *Festuca pratensis, Helictotrichon pubescens, Anthoxanthum odoratum*). This is the full maturity stage of the grassland when it has the highest diversity of species under the specific environmental conditions. This stage lasts for decades, especially in floodplains, where it is supported by flooding. However, with the gradual accumulation of organic material, the inflow of oxygen is constantly reduced, resulting in the introduction of compact tussock grasses (for example, *Deschampsia caespitosa, Molinia caerulea, Nardus stricta, Festuca ovina*). The overall species diversity reduces slightly, but plant communities that are very specific to the conditions and are not found in any other ecosystems, develop. The unique character of these communities characterises the value of semi-natural grassland biodiversity. In dry places, the compact tussock stage can last for a very long time (even several centuries), while in damp places fens gradually appear. The last two stages are the most favourable for the conservation of biodiversity, as a great majority of plant species, and consequently the related invertebrate (insect, spider) species, can only live in such conditions.

Stability of a semi-natural grassland ecosystem is ensured by three mutually interacting components - soil, vegetation and animals (Fig. 1.4.4). Invertebrates and mammals have the greatest role in the circulation of ecosystem matter and energy. Most of the semi-natural grassland plant biomass is accumulated under the ground - in plant roots and by substance exchange with soil organisms (e.g., fungi, bacteria). 80% of the terrestrial plant species form symbiosis with arbuscular mycorrhizal fungi. Without them, plants are more vulnerable to various types of stress and have poorer germination and rooting rates (Torrez et al. 2016).

Diversity of plant species within one meadow or pasture is encouraged by variations of micro-terrain (the more uneven it is, the more species there are). It creates seemingly negligible differences in soil fertility and moisture, which are, however, sufficient for various invertebrate species to find a suitable living environment. Various landscape elements also contribute to biodiversity (such as solitary trees, boulders, fences). All groups of living organisms are affected by the grassland area, especially birds – a larger area of grassland can support more species. The configuration of grassland is also important. If the grassland is narrow and affected by external

Semi-natural grassland cannot develop in abandoned farmland without mowing or grazing

Wild herbaceous species get introduced in ex-arable land or previously sown grasslands that have not been mown or grazed for years or even decades (left to natural development), in the first years after abandonment. They become similar to semi-natural grasslands and can retain vegetation characteristic to grassland for a long time. In some places, they do not overgrow with forest even for several decades, despite being unmanaged. But these habitats are not included in the semi-natural grassland category, they are rather considered to be ruderal vegetation. They have some biodiversity value, but it is usually temporary because the overgrowth with forest rapidly reduces open habitat species diversity.

Fig. 1.4.4. Semi-natural grassland ecosystem structure. Grasslands are the only or the most important nesting area for fifteen bird species of Latvia, another 34 species nest there regularly and 30 species feed during the nesting season. Birds also use grasslands as rest and feeding areas during transitory migration.
Grazing animals and haymaking are indispensable elements of the ecosystem, because semi-natural grassland ecosystem can only properly function if the grass is removed. Otherwise the grassland disappears (transforms into forest).
There can be up to 50-60 different plant species in a single square metre. One third of the plant species of Latvia are found in semi-natural grasslands. The plants are the primary source of biomass consumed by insects, herbivorous mammals and other groups of animals.
Grasses are the main group of plant species that make up the grassland vegetation. With their fibrous roots, they create turf and soil. Formation of turf is the most important soil formation process and it is most active in grasslands. In the root horizon, semi-natural grassland plant species often produce more biomass than the above-ground green biomass of the plant, ensuring the stability of the grassland ecosystem.
There can be up to 0.5 tonnes of insects in one hectare of meadow. They regulate the composition of plant species by consuming them and are the first step in the food chain – food for birds, other insects, spiders, reptiles and amphibians. The main role of insects is the pollination of plants and decomposition of nutrients produced by plants (nutrient circulation). A half hectare of meadow can sustain 2.25 million spiders.
Soil of semi-natural grasslands stores significantly more CO_2 than cultivated grassland soil or arable fields, therefore semi-natural grasslands reduce the amount of greenhouse gases in the atmosphere.
Grassland rich in plant species contains more fungi than bacteria. If there are more fungi than bacteria, then the amount of bioavailable nitrogen is lower and a greater diversity of plant species is possible. A greater amount of bacteria facilitates nitrogen mineralisation and its availability to plants, therefore the yield increases, but the diversity of species decreases. Drawing by D. Segliņa.

influences in almost the entire area, e.g., a shadow of a forest, tree leaf litter or agricultural fertiliser pollution, grassland species that require minimum disturbance or a characteristic microclimate, will suffer and the overall species pool will decline.

Grasslands are characterised by seasonal and annual vegetation changes, which promote biodiversity. Seasonal changes occur because species grow and develop at a different rate. Different plants bloom in spring and in the middle of summer, and the species composition before the first mowing and in aftermath also differs. The aftermath usually contains more legumes (*Trifolium* spp., *Vicia* spp., *Lathyrus* spp.) as these plants require light and regrow quickly after mowing. Annual changes are determined by the weather. In wet years, even a dry grassland can have lush vegetation throughout the summer. In dry years, the dry grasslands burn out and moist grasslands dry out. In more humid years, grasses (in dry to mesic grasslands) and sedges (in moist to wet grasslands) grow better; in dry years there are less grasses, while forbs proliferate.

Depending on grassland type and plant species composition, a unique set of invertebrate species (insects, spiders, snails) forms in each grassland. The composition of bird species depends on several factors. Moisture regime, terrain, grassland vegetation height and structure during the breeding season and the presence of various landscape elements affect birds most. These parameters are generally determined by whether the grassland is mown or grazed. During the breeding season, some species spend the entire time in the grassland – both feeding and nesting, while other species use it for foraging only and breed in other nearby habitats. During the passage migration (spring and autumn), the number of bird species in the grasslands is the highest, as species that do not breed in Latvia stay there as well.

1.5 Extensive Management as a Precondition for the Existence of Semi-natural Grassland Habitats (S. Rūsiņa, L. Gustiņa, A. Auniņš)

Semi-natural grassland as an ecosystem can be best understood by learning about its management history. Management has made semi-natural grasslands become the ecosystems that we know and aim to preserve. Such management is usually referred to as extensive – use of meadows and pastures with a typically low yield since almost no resources or work was invested in their maintenance. In contrast to extensive management, intensive management means high investment of work and resources into grassland management, but the resulting yield is also high.

Until the mid-20th century most of the grasslands were semi-natural grasslands – farmers only mowed and grazed them without interference with the environmental conditions (e.g., moisture, soil fertility, reaction) and the composition of plant species. This allowed for unhindered establishment and development of plant and animal diversity.

Using early-20th century photographs, we will highlight the key aspects of extensive management that played a role in the formation and development of biodiversity of semi-natural grasslands in Latvia (Fig. 1.5.1-1.5.19). For more detailed history of semi-natural grassland management in Latvia, see: Grase (1937); Dumpe (1999); Draviņš (2000); Gustiņa (2016).

All photographs are taken from the Digital library collection "Lost Latvia" of the National Library of Latvia (reference: NLL LL), personal archives (indicated for each photograph), the collection of the Baltic Central Library of Lettonica and Baltic Centre of the National Library of Latvia (reference: the collection of BCLL BC), the collection of the Latvian Museum of Photography, a branch of the Museum of the History of Rīga and Navigation (reference: the collection of LMP MHRN) or from the Art and Music Centre Art Reading Room of the National Library of Latvia (reference: the collection of AMC ARR).

The semi-natural grasslands of today's Latvia are special not only because of their high plant species diversity, but also because of the occurrence of animals, especially birds. The respect of our ancestors towards birds and other meadow animals is reflected in Latvian folk beliefs. Anyone who treated birds disrespectfully or destroyed bird nests was believed to receive a severe punishment, for example, freckles, blocked throat or even the death of a relative. The respect towards Corncrake is especially worth noting, the presence of which in arable fields and meadows was seen as a very beneficial sign (Gustiņa 2016).

Although no systematic data has been collected to numerically assess the frequency of occurrence of various grassland related bird species and their distribution structure in Latvia before large-scale drainage, species and habitat descriptions in historic literature sources (Transehe, Sināts 1936; Grigulis 1965, etc.) contain evidence and indications that can be used to restore the previous landscape and describe the frequency of occurrence of species and their relation to certain habitats or landscape elements. Bird diversity was ensured by the natu-

Fig. 1.5.1. A pasture in Lazdona rural territory, "Ceplinieki" homestead, 1935. Photo: NLL LL, the personal archive of J. Āboltiņa.
Grazing is the oldest type of semi-natural grassland management in Latvia. It dates back to approximately 5,000 years ago (Dumpe 1964). Mowing only started in around the 1st-3rd century when iron tools appeared in the territory of Latvia (Dumpe 1985). Only then could the development of meadow as a type of grassland use and a special type of ecosystem that differs from pastures in many respects start (*see Chapter 1.3*).

Fig. 1.5.2. A pasture in an arable field landscape. View from Elku hill in Amata rural territory, 1930s. Photo: NLL LL, the personal archive of V. Vēvers.
The poorest land was left for grazing. The area unsuitable for ploughing was used as meadows and places where mowing was impossible (such as marshlands, forests, shrubs, old fields, field edges) - as pastures.

Fig. 1.5.3. Pasture (location unknown), early 20th century. Photo: NLL LL, the personal archive of J. Prauliņš.
To get as much hay as possible for the winter, meadows were saved and the areas allocated for grazing were small. This contributed to the formation of very diverse landscapes containing both open pastures and wooded grassland elements - solitary shrubs and trees.

Fig. 1.5.4. A landscape near Kandava, 1930s. Photo: NLL LL, the collection of BCLL BC.
Rapid alterations between various light, microclimate and soil conditions within a small area made the pasture areas highly biodiverse.

Fig. 1.5.5. A pasture in Madliena rural territory, "Jaunsprukti" farmstead, circa 1910–1920. Photo: NLL LL, the collection of BCLL BC.
Shallow ditches and low shrubs in them increased the species diversity in pastures. Higher moisture in ditches supported hygrophilous species. In general, grassland drainage by ditches used during the period of extensive agriculture did not reduce grassland biodiversity.

Fig. 1.5.6. A pasture in Strenči Municipality, 1920s. Photo: NLL LL, the collection of LMP MHRN.
Boulders and solitary trees were important elements of pastures facilitating the distribution of species. Livestock could not reach all the grass close to the boulders, so species more sensitive to grazing could grow there and produce seeds. Species requiring less light could grow in the shade of the tree.

Fig. 1.5.7. Grazing cattle in Saikava, "Jaunzemji" farmstead, 1930s. Photo: NLL LL, the collection of BCLL BC.
Nowadays disappeared landscape - garden is fenced, but cattle are roaming freely. Movement of livestock over larger distances around the farmstead or village facilitated the dispersal of plant seeds and the development of a wooded grassland landscape. The distance over which the seed is carried in the animal's intestinal tract depends on digestive activity and the direction and speed of animal movement. Germination capacity of seeds that have passed through an animal's digestive system improves. Sheep can travel an average of 6.1 km per day in a pasture, while goats can make 9.6 km per day (Cousins, Lindborg 2008).

Fig. 1.5.8. A pasture in Jēkabpils, 1940. Photo: NLL LL, the personal archive of J. Zeps.
In villages all types of livestock were usually pastured together. Such herds often included cattle, sheep, pigs and, less commonly, also goats and horses (Dumpe 1973; Šuvcāne 2002). Grazing of mixed herds reduced the spread of expansive plant species. For example, the common dandelion can proliferate and spread excessively in cattle pastures, but sheep limit the spread of it by nibbling it down to the taproot, thus reducing its growth potential.

Fig. 1.5.9. A landscape of the River Imula near Matkule castle mound, Buses, early 20th century. Photo: NLL LL, the collection of BCLL BC.
Meadows were established on river banks and lake shores, along streams and brooks, and in terrain depressions. Thus, meadows shaped as narrow strips often reached far into forested areas and sometimes were far away from settlements. As the amount of hay collected was of great importance to the farms, all areas covered with grass were mown, including lake shores, sedge mires and heathlands. If the collected hay was not suitable for feeding livestock it was used for livestock bedding or bedstraw (Draviņš 2000).

Fig. 1.5.10. A pasture in the town of Baldone, 1920s. Photo: NLL LL, the collection of AMC ARR.
A pronounced pasture micro-terrain formed in permanent pastures. Overgrazed areas are alternating with longer grass less frequently visited by livestock. This mosaic creates suitable niches for various ecologically different species.

Fig. 1.5.11. A wooded meadow in Strenči Municipality, 1920s. Photo: NLL LL, the collection of LMP MHRN. Meadows were mown by hand, allowing the development of wooded grassland landscapes which does not occur anymore nowadays with mechanical mowing.

Fig. 1.5.12. Mowing starts in Madona Municipality Lazdona rural territory "Ceplinieki", 1923. When mowing machinery was introduced in the early 20th century, cutting of the first swathe with a scythe by all men of the family or household remained a tradition. Photo: NLL LL, the personal archive of J. Āboltiņa.
Different types of mowing are mentioned in ethnographic literature. For example, mowing was started from the centre - cutting through the meadow, turning around and moving back; the grass of the first two swathes formed a joint swathe (Draviņš 1937).

Fig. 1.5.13. Mowing with a horse-drawn mower in Ogresziedi meadow, Rembate rural territory, 1930s. Photo: NLL LL, the personal archive of A. Vilka.
It was usually thought that it is more useful to first mow meadows with taller and better grass and leave less valuable outskirts for later (Draviņš 2000). Thus, the plant species of the landscape generally had time to flower and disperse seeds, despite early mowing. A good mower was one who could cut the grass as low and as evenly as possible (Draviņš 1937; Grase 1937). This allowed the maximum amount of hay to be obtained from a meadow. Nutrients were also stripped along with hay. Since meadows were not fertilised, the soil was usually poor in phosphorus, potassium and nitrogen. Plant species adapted to it, therefore a high diversity of species in a meadow is only possible if the soils are infertile.

Fig. 1.5.14. Landscape in Latgale, 1930s. Photo: NLL LL, the collection of AMC ARR, the personal archive of V. Upītis.
Other approaches were cutting the first joint swathe only until the middle of the meadow and then mowing around it in a circular motion or mowing a small area around the barn or the location of the haystack and then mowing around it in a spiral motion. In Latgale region, where a strip farming system existed, farmers tried to mow all strips at the same time as any unmown strips in the meadow would inevitably be trampled (Dumpe 1964). Mowing by hand and from the centre of a meadow towards the edges was harmless to birds as they could escape and the person mowing could notice a nest and not cut it.

Fig. 1.5.15. Mowing in "Dzērvēni" meadow in Vecpiebalga, 1930s. Photo: NLL LL, the collection of BCLL BC.
The time of haymaking in manor and peasant meadows differed during the extensive agriculture period. In the manors of Kurzeme, the harvest started early, often a week before the summer solstice. Three factors determined the time of mowing in manor meadows: weather conditions that affected the grass growth rate, the manor lord, who gave permission to start the mowing, and the peasants, who were to carry out this work. Peasants tried to mow the manor meadow as soon as possible to obtain earlier aftermath, as they were allowed to keep it (Upenieks 2005). Early mowing with the aim of obtaining the aftermath has also been mentioned in folk songs (Grase 1937).

Fig. 1.5.16. A group of hay makers in Rucava, 1940s. Photo: NLL LL, the collection of BCLL BC.
Peasants often left the mowing of their own meadows until after midsummer to let the grass grow as tall as possible (Upenieks 2005). However, to avoid overgrowth and not to delay the cereal harvest because of hay cutting, peasants were often forced to mow their own meadows at night (Dumpe 1964).

Fig. 1.5.17. Piling hay in Strenči Municipality, 1920s. Photo: NLL LL, the collection of LMP MHRN. The mown grass was only raked immediately if it was fine and sparse to ensure that the hay is not pressed between stalks by heavy rain (Draviņš 2000). Grass was also raked out from between shrubs, shaded, wet and tussocky areas (Draviņš 1937). If the meadow sward was tall and dense, the cut swathes were first spread out across the entire meadow in an even, spongy layer. As evening approached, the slightly dried hay was raked into small heaps to prevent penetration by the night dew. Then it was spread out again in the morning and dried until the next evening. Spreading and drying was not carried out in wet meadows. There, the hay was raked immediately after mowing and moved to a dry location for drying (Dumpe 1964). The hay was turned and moved several times, which enabled the plants to ripen and disperse seeds.

Fig. 1.5.18. Raking hay in Strenči Municipality, 1920s. Photo: NLL LL, the collection of LMP MHRN.
Hay drying contributed to the spread of plant species within one meadow, as well as among several meadows and beyond. The same people often mowed several meadows using the same tools and vehicles (Draviņš 1937, 2000). Joint work parties were organised during the hay harvest season that were attended by people from more than one farm (Dumpe 1964). People, like animals, can serve as agents for plant seed dispersal, as they move seeds caught in clothes, tools or the cart from one place to another.

Fig. 1.5.19. A working party in a hay meadow next to a farm in Plāņi rural territory, 1898. Photo: NLL LL, the collection of BCLL BC.
If rain suddenly started while the hay was being dried, it was quickly piled into small dense heaps which were spread out and dried again later on (Dumpe 1964). When it was eventually impossible to collect the hay, and it became wet and yellow, it was still removed from the meadow and used for animal bedding because hay left in the meadow causes the rotting of grass (Draviņš 1937).

Fig. 1.5.20. Hay transportation in Strenči Municipality, 1920s. Photo: NLL LL, the collection of LMP MHRN
Carrying loose hay in a cart allowed plant seeds to spill along the road and establish on the road verge or forest edge, thus promoting species diversity in the landscape and the spread of meadow species from one place to another.

Fig. 1.5.21. Hay transportation in "Štramas" of Aloja Village, 1950s. Photo: DNLL LL, the personal archive of V. Apsītis. Seeds of grassland species were spread not only during hay harvesting, but also while carrying the large cartloads on narrow rough roads. Despite best efforts to secure it, some of the hay fell on the roadside and got caught in tree branches (Virza 1942).

Fig. 1.5.22. A hay barn in Dāvida meadow, near Slītere Blue Hills in Dundaga rural territory, 1920s. Photo: NLL LL, the collection of AMC ARR.
Since all cut grass was usually collected together near the barn, haystack or cart, every year there were places in the meadows with a high concentration of scattered seeds. These places were mostly dry, i.e., the highest points of the terrain, which contributed to the further spread of seeds with rainwater streams (Gustiņa 2016).

ral hydrological regime and terrain of grasslands, presence of various landscape elements (especially trees and shrubs), as well as extensive management methods. The natural hydrological regime and terrain supported high biodiversity, ensured a great diversity of ecological niches for various invertebrate species (such as worms, arthropods and snails) which occur in large numbers in grasslands. The invertebrate diversity provided the food base for many bird species, each specialising in obtaining a certain type of food. Most likely, at that time several wader species occurred in almost all sufficiently large grasslands, including species that have almost disappeared from the grasslands today, but still remain in mires. They formed breeding semi-colonies where several couples of different species nested nearby and provided the collective protection of all semi-colony nests against various nest predators. The majority of wader species are aggressive and join forces to successfully drive off approaching foxes or crows (Elliot 1985; Larsen et al. 1996). Other, less active bird species (such as ducks and passerines) are adapted to use the protection provided by waders and try to nest in the wader semi-colonies or nearby to increase their nest survival chances (Koenig, Dickingson 2004).

Ecological niche diversity was also increased by different management methods – grazing by different livestock species with different density and mowing at different times. Birds were practically unaffected by grassland management as the traditional methods did not substantially threaten the birds or their nests. Meadows used to be mown by hand, so the mowers could notice and spare the nests on the ground. In addition, natural conditions did not allow for early mowing of wet meadows, which enabled the majority of broods to hatch before the harvest began. In wet pastures, the broods of some birds nesting on the ground already hatched before the livestock was put to graze, so the amount of trampled nests had a low impact on bird populations.

Following large-scale drainage and the introduction of more intensive management methods in Latvia, the grassland bird communities have become poorer, often only the most ecologically adaptable species survive and mechanised mowing has increased the risk of destruction of nests and nestlings.

1.6 Differences between Meadows and Pastures

Mowing and grazing affect grassland vegetation and fauna in a very different manner and create completely different landscapes (Fig. 1.6.1–1.6.4).

1.6.1 Meadow and Pasture Plants (S. Rūsiņa)

There are four significant effects of grazing on plants:

- nibbling, plucking – animals nibble and pluck the plants, thus mechanically affecting their growth and creating different opportunities for different species to live because animals graze selectively – some species are consumed more intensively (those that are tasty and easy to chew), while others are avoided (poisonous, thorny);
- movement of nutrients – animals perform nutrient removal from the ecosystem by retaining a part of them in themselves (growth, fat deposition), and return some nutrients to pasture with manure, thus moving some nutrients from the grazing area to the resting area or removing them from the pasture completely (to the cattle-shed, night enclosure);
- trampling – with their feet and hooves, the animals tread the seeds into the soil enabling seed-soil contact, trample the turf providing areas of free soil where the seeds can sprout because there is no competition;
- transport of seeds – seeds get caught in animal fur or hooves or pass through animal digestive tract and get transported to another part of the pasture or even another grassland with manure. This is a very important factor for the process of plant species distribution in the landscape, because grass species can only travel for a few metres from the mother plant without the assistance.

With mowing, all above-ground parts of plants

Fig. 1.6.1. A meadow landscape in late summer. Stacked hay was a typical landscape feature in mid-summer and late summer, which has nowadays been replaced by hay or silage bales. Photo: S. Rūsiņa.

Fig. 1.6.2. A pasture landscape in late summer. Very typical landscape features are fences and grassland micro-terrain with tufts and tussocks of grasses. Photo: S. Rūsiņa.

Fig. 1.6.3. A meadow (the colours visibly show different plant communities in drier elevations and moister depressions). Photo: S. Rūsiņa.

Fig. 1.6.4. A pasture – the same grassland (Fig. 1.6.3) after three years of grazing. Almost no noticeable visual differences between different plant communities in depressions and elevations. Photo: S. Rūsiņa.

Fig. 1.6.5. Meadows have a high diversity of plant species. Photo: S. Rūsiņa.

Fig. 1.6.6. Pastures feature a high diversity of structures. Photo: S. Rūsiņa.

are removed at the same time (rather than selectively as it is in the case of grazing), thus all plant species have equal opportunities in regrowth. Mowing creates more uniform vegetation, all species are evenly spaced in the sward, there is normally no single dominating species (Fig. 1.6.5). Meadow landscapes feature strong variability from an annual perspective: there is a cover of flowering plants until mid-summer, then the landscape is dominated by haystacks (or, more frequently nowadays, bales or film-wrapped bales) and after mowing the aftermath develops.

Grazing is a suitable form of management in dry soils (Bakkers 2005), as well as moist and wet ones (Gusewell et al. 2007). In comparison with mowing, grazing leads to greater spatial diversity (mosaic) where low vegetation alternates with taller patches (Fig. 1.6.6). Grazing creates broad transition zones between open pasture and shrub and forest vegetation that increases the chances to find suitable conditions for full-shade, shade-tolerant and light-demanding species. The composition of plant species depends both on the nature of grazing (animals use the territory very unevenly, overgrazing occurs in some places and undergrazing in others) and by the excrement and urine left by animals. Grazing creates free spaces in the sward (nibbled or trampled more intensively), where plant seeds can sprout next spring. Such regeneration niches are particularly important for annual and low plant species that are less competitive than higher plants (Svensson, Carlsson, 2005).

However, the overall species richness is higher in meadows. Mowing and grazing differences in the same grassland have been researched in Sweden and it has been concluded that mowing preserves more plant species than continuous grazing. A meadow mown for 28 years had on average 19–21 species per 0.5 m^2, while grazed areas had on average 15–19 species per 0.5 m^2; furthermore there were 17 species that were found in the mown part only and just seven found in the grazed part only. Also, some species are more accustomed to the meadow and others to pasture. Research of *Gladiolus imbricatus* in Estonia revealed that a richer population of this species occurs in mown grasslands than in grazed grasslands (Moora et al. 2007). *Rhinanthus* spp. (Coulson et al. 2001) and *Succisa pratensis* (Bühler, Schmid 2001) also prefer mown grasslands to grazed ones. Thus, mowing is the most appropriate method of grassland management to maintain or increase plant species diversity. Mowing is also more suitable for grasslands with many plant species that animals avoid eating.

1.6.2 Meadow and Grassland Birds (A. Auniņš)

Nearly all grassland bird species can be found both in meadows and pastures. The suitability of grassland for a particular bird species is determined by the presence of various micro-habitats and micro-situations (humidity, access to bare soil and/or the water's edge, vegetation height and structure, landscape features) in the grassland. Due to such local circumstances, conditions suitable for the species can be created both by mowing and grazing. However, the optimum habitat for the nesting of

certain bird species (one that a species can inhabit with high density) in the long term is related to a certain management type.

Grazing affects birds in two ways. On the one hand, grazing maintains low vegetation, making it easier for the grassland birds to access soil and providing heterogeneous height of mosaic-type vegetation, creating the conditions for camouflaging the nests of birds nesting on the ground. On the other hand, grazing creates the risk of nest trampling of both waders (Beintema, Muskens 1987) and passerines (Pavel 2004).

The impact of grazing on different grassland bird species differs – it is extremely important for wader communities. This creates a diverse grassland with areas of different heights of vegetation and tussocks, providing suitable sites for feeding needs and appropriate vegetation for camouflage (Tichit et al. 2005). Wader bird communities in meadows are unstable — in wetter years there are many waders of different species, while in other years there are none or only *Vanellus vanellus* in small numbers. Wader communities in pastures are usually more stable.

The density of *Crex crex* in pastures is lower than in meadows (Keišs 1997). Meadows are more suitable for Corncrake because it requires vegetation that is already relatively tall (> 30 cm) and homogeneous at the start of the breeding season, however, such conditions may also develop in less intensively grazed areas of pastures.

Gallinago media may be found both in meadows

Fig. 1.6.7. A bull makes a pit, removing turf and sand with feet and horns. Photo: S. Rūsiņa.

Insect survival results in mown grassland in Switzerland

A study conducted in Switzerland found that mowing reduces both the number of species and that of specimens (70-80% of specimens are destroyed) in the meadows. However, if the insects have a shelter (meadow edge, forest front, unmown area), then the number of species in these areas soon recovers. *Orthoptera* (grasshoppers, locusts), spiders and beetles all move to the safe shelter areas (except for ground beetles which remain to feed on the dead insects and other invertebrates). Even butterfly larvae move to these places of refuge. Twenty-two of the 300 marked butterfly larvae were found in the place of refuge, having covered a distance of 25 metres in eight hours. The size of population across the entire area of the meadow is restored slower, as the number of invertebrates cannot exceed the ecological capacity of the refuge areas. After mowing, the number of ants and beetles increases as they feed on invertebrates killed during mowing, while the total number of species recovers soon after mowing (Humbert et al. 201b).

and pastures, since the management method does not affect the species as much as suitable vegetation structure and access to open soil (Auniņš 2001; Anon. 2004). Although pastures are considered a suitable habitat for Great Snipe in other countries of its breeding range (Anon. 2004), it prefers meadows in Latvia. This is probably due to the fact that almost all grasslands inhabited by Great Snipe are currently mown.

Gallinago gallinago is equally adapted to meadows and pastures, as long as their hydrological regime is suitable for the species.

The composition of grassland passerines is more determined by the configuration of shrubs and shrub clusters and other landscape features than the management method as such. Grazing ensures the presence of the required landscape features (e.g., for *Anthus pratensis*), grassland structure (for *Motacilla flava*) and foraging resources (*Lanius collurio*).

1.6.3 Meadow and Pasture Invertebrates (V. Spuņģis)

Meadows have a far greater diversity of invertebrate species than pastures. In various types of meadows the number of invertebrate species is measured in thousands, while in pastures it can be up to two times lower. It is determined by the pasture vegetation composition and the choice of livestock species. Grazing also creates soil disturbance that negatively affects soil fauna, reducing the diversity of epigeal (soil surface) beetles and land snails. Excessive grazing completely degrades the invertebrate fauna. Unlike meadows, pastures have a far greater diversity of saprophagous (feeding on decaying organic matter) invertebrates (insects, mites, nematodes), because they depend on animal excrement – rove beetles *Staphylinidae*, scarab beetles *Scarabaeidae*, hister beetles *Histeridae*, scavenger beetles *Hydrophilidae*. The main decomposers of excrements are, for example blow flies *Calliphoridae*, flesh flies *Sarcophagidae* and many other *Diptera*. *Scatophaga stercoraria*, *Copris lunaris* (mainly in Eastern Latvia), *Asilus crabroniformis* and *Emus hirtus* live on fresh excrements in dry pastures. These habitats also have a rich soil fauna – small arthropods, nematodes, insect larvae, earthworms (at least five species) and pot worms.

Increase of grazing intensity is initially followed by increased diversity of soil saprophagous, scavenger and parasitic invertebrates because of the increased amount of excrement. Areas trampled by livestock and free sand patches are very important in dry pastures. They often form in the previous autumn when livestock graze around *Malus* ssp. trees, or in spring when bulls kick the soil around with their feet (Fig. 1.6.7). In the summer, animals spend less time there and insects can live in the undisturbed sand.