PÄRANDKOOSLUSTE
KAITSE ÜHING

COASTAL MEADOWS MAINTENANCE PLAN

Penijõe 2020

Silvia Lotman Riinu Rannap

Prepared by order of the Environmental Board

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Introduction

This support material is based on the need to describe the habitat types of coastal meadows to institutions and persons involved in Estonian landscape maintenance, to provide an overview of the basis for their formation and conservation, to provide general guidelines for optimal management of communities, and to create a theoretical basis for planning site-based maintenance. The guide is primarily intended for use by the Environmental Board's land conservation specialists, nature conservation organizers, land managers, and other institutions and persons involved in the maintenance of coastal meadows.

The guide contains the basic principles of coastal meadows and their maintenance, as well as the results of research and a list of literature and experts, along with comments. The guide offers solutions to a number of practical issues related to the management of coastal meadows, maintenance and restoration requirements, indicators of habitats being in good/poor condition, restoration and maintenance techniques, list of key biotypes, the priority of sites under restoration, and other issues described by the Environmental Board in terms of reference.

The first version of the Coastal Meadows Maintenance Plan was approved in 2011, and this plan is based on the first version, supplementing it with a description of new knowledge and changed circumstances. This maintenance plan must also be used as a basis for drawing up regulations and support schemes for the management of coastal meadows, including measures for the maintenance of semi-natural habitats under the common agricultural policy of the European Union.

The paper has been prepared on the order of the Environmental Board by the Estonian Seminatural Communities Conservation Association, the maintenance plan was prepared by Silvia Lotman and Riinu Rannap, the information on the vegetation of coastal meadows was updated by Elle Roosaluste, and the information on birds was updated by Triin Kaasik. A discussion with experts and managers was held on 18 February 2020 to prepare the maintenance plan.

The compilers thank all those taking care of the wellbeing of coastal meadows, including the managers and experts of the coastal meadows who participated in the maintenance plan involvement meeting, the land management specialists of the Environmental Board, Marika Kose and Meeli Mesipuu.

What is a coastal meadow?

A coastal meadow is a flat and low, largely flooded section of shore covered with grasses that requires mowing or grazing to survive. The coastal meadows are characterized by salt-loving vegetation and a rich and diverse selection of birds. Coastal meadows are semi-natural communities. This means that their emergence and survival are closely linked to human activity. Estonian coastal meadows are mostly of primary origin, i.e., formed due to the rise of the subsoil in the areas that emerged from the sea and remained open due to disturbances caused by the sea and due to herbivores. The vegetation of the coastal meadows is characterized by a zonation parallel to the sea border. The coastal meadows in good condition are open, which provides suitable habitat for birds nesting on the ground. However, if the value of a particular coastal meadow is only botanical (e.g., the meadow batches are too small for being habitats for birds), there may also be trees or shrubs in the area.

Although a distinction can be made between coastal meadows and coastal pastures according to the type of management, in the present paper, they are mostly considered synonymous, and the management methods are described in a separate chapter, “Maintenance of coastal meadows.”

More general literature on coastal meadows:

Articles on coastal meadows in the collection “Pärandkooslused. Õpik-käsiraamat.” Compiled by Kukk, T. (2004) Estonian Seminatural Communities Conservation Association

Rannaniidud” Keskkonnajuht. Lotman, A. (1996). Available online: http://www.roheline.ee/books/kkj296.html#RANNANIIDUD%20EESTIS

Rannaniitude hooldus”. Rannap, R., Briggs, L., Lotman, K., Lepik, I., Rannap, V. (toim.) (2005) Keskkonnaministeerium.

Pärtel, M. etc (2003) „Bioloogiline mitmekesisus Eesti poollooduslikes ökosüsteemides“ Tartu Ülikool. Available online: http://www.botany.ut.ee/partel_helm_roosaluste_zobel_lk223-302.pdf

Sirelbu, S. (2015) “Coastal meadows, their maintenance and protection” Elle Roosaluste, thesis supervisor. University of Tartu http://taurus.gg.bg.ut.ee/Loputood_2015/KKP_rak/Sirelbu_Sander.pdf

Ööpik, M. (2011) Study material on coastal grasslands University of Life Sciences http://rannarohumaad.weebly.com/

Habitat types in coastal meadows

According to the habitat types of the European Union's Habitats Directive Natura 2000, the coastal meadows of the central and northern part of the Baltic Sea are marked with the code 1630*. Coastal meadows are mostly found in a single complex with salt flats (muddy and sandy coasts with glasswort (Salicornia) and other annual plants 1310), of which coastal meadows predominate. Such a complex may also include cays flooded with seawater (1110), muddy and sandy sandflats exposed with low tide (1140), coastal lagoons (1150*), primary beach ridges with annual vegetation (1210), rocky shores with permanent grasses (1220), sandy shores with permanent grasses (1640), purple moorgrass meadows *(Molinion caerulea* communities) (6410). Protection is organized uniformly for the entire habitat complex. Some drier meadow communities may be present (6210, 6280), on sandy densely vegetated beach ridges also 6270*. Coastal meadows are also often the habitat type small islands and islets (1620). European coastal salt meadows extending south from the Baltic Sea are designated code 1330 - Atlantic salt meadows. The coastal meadows of the Baltic Sea differ mainly from the latter in terms of lower salinity.

According to the “Classification of Habitat Types of the Estonian Vegetation,” coastal meadows belong to the 2.3.1.1 geolittoral and 2.3.1.2 epilittoral habitat types. Descriptions of Natura 2000 habitats and their correspondence to vegetation habitat types in different classifications are described in more detail in the “Manual of the habitat types of the Habitats Directive” (Loodusdirektiivi elupaigatüüpide käsiraamat) Paal, J. (2007) Ministry of the Environment, available online: www.botany.ut.ee/jaanus.paal/n2000.pdf

Distribution and condition of coastal meadows

In Estonia, coastal meadows are common mainly in the mainland and islands of Western Estonia. There are also coastal meadows on the North Estonian cliff coast, but there are fewer of them there. In total, there are several dozen coastal meadows larger than 10 ha in Estonia, but more than ten coastal meadows are 100 ha or larger. The largest coastal meadow complexes in Estonia are located in the Matsalu wetland and in the Käina-Kassari region of Hiiumaa (see the chapter “Estonia's largest coastal meadow complexes” for more details).

In Europe, according to the classification of the Habitats Directive, there are Baltic Sea coastal meadows also in Sweden, Denmark, Finland, Latvia, and Lithuania. From the point of view of the maintenance of our coastal meadows, it is very important that Estonia has the largest and most wholesome coastal meadows in Europe, which is why Estonia is the responsible country for this type of habitat and has received increased attention from both the European Community and the Member States. At the same time, the great danger of coastal meadows is shown by the fact that the area of managed coastal meadows in Estonia decreased from 29,000 hectares to 8,000 hectares in 50 years. The total area of the preserved coastal meadows in Estonia is estimated at 20,478 ha, but most of them are covered in reeds and are not in favorable conditions. Due to the intensification of maintenance and restoration activities of coastal meadows in the last ten years, 10,700 ha of coastal meadows were already in maintenance and 1,100 ha in restoration in 2019. Thus, in terms of area, the goal of restoring coastal meadows by 2020 will be 10,800 hectares in care. For further spatial objectives, Aveliine Helmi and Aurele Toussaint will evaluate the ecological performance of semi-natural communities in their paper: "Assessment of the ecological performance of semi-natural communities": an area that would cover 90% of the protected species habitats in the coastal meadows would be 18,000 hectares, and 100% of the protected species habitats would be 22,400 hectares. The area that would cover 90% of the habitats on the coastal meadows of today's protected species across Estonia (incl. those outside protected areas) is 18,500 hectares, and 100% of the habitats of the species are 23,500 hectares. Thus, together with the areas outside the protected areas, the area of coastal meadows should approximately double so that we can prevent protected species from extinction. It is also important that, in addition to the spatial objective, a number of additional activities are needed on the coastal meadows that are being maintained today in order to restore ecosystems. Unfortunately, the coastal meadows that have been in maintenance recently have also dropped out of maintenance in recent years, and it would be important to include them in maintenance again: there are 120 ha of coastal meadows in Vilsandi and 65 ha of coastal meadows in Saaremaa.

Threats to coastal meadows

Until recently, only 10% of the historical distribution area of coastal meadows in Estonia has been preserved, but the rapid restoration of coastal meadows carried out during the last ten years has brought a significant amount of coastal meadows back into maintenance. Unfortunately, not all coastal meadows in maintenance today are in such good condition that characteristic ecosystems would have been restored there; for example, only 8,500 ha of today's coastal meadows are suitable for the birds whose habitat is coastal meadows.

The most important factors threatening the favorable condition of coastal meadows are:

- Reed beds and overgrowth, which is a direct result of exclusion from coastal meadow management due to the decline of extensive farming companies.

- The impact of drainage on the communities of coastal meadows has at times been an important cause of unfavorable changes in the habitat of the natterjack toad, as well as in the habitats of some shorebirds (e.g., ruff) habitats. Drainage has a significant impact on the ecological functioning of coastal meadows as wetlands; the remaining coastal meadows must certainly not be drained, and consideration should be given to rebuilding existing land improvement systems in these areas to suit natural wetlands.

- Afforestation of coastal meadows, which took place during the Soviet period, but as a result of which a large part of the meadows has been preserved in narrow strips and/or fragmented with tree stands.

- Due to the increase in the number of small carnivores (fox, raccoon dog, jackal, mink) and crows, coastal bird communities suffer from nest predation.

- Building up of coastal areas with boat sheds, summer cottages, and other buildings, including erection of wind farms in wind-rich areas. Therefore, at least in Natura 2000 areas, the planned buildings for coastal meadows must be treated with the utmost criticality.

- Eutrophication of the Baltic Sea due to excessive nutrient pollution from agriculture, leading to the accelerated spread of reedbeds and higher nutrient content of coastal soils. Thus, the implementation of water protection measures for farms both near and off the coast also constitutes part of the protection of coastal meadows.

This maintenance plan focuses in particular on the first four risk factors, which are directly interlinked and for the prevention of which extensive maintenance and restoration of coastal meadows are essential.

An overview of the problems and distribution of coastal meadows is provided by:
Rannap, R., Briggs, L., Lotman, K., Lepik, I., Rannap, V. (ed.) (2005) “Rannaniitude hooldus.” Keskkonnaministeerium.
Lotman, A. (1996) “Rannaniidud.” Keskkonnajuht, Eesti Roheline Liikumine. Available online: http://www.roheline.ee/books/kkj296.html#RANNANIIDUD%20EESTIS

Protection and demarcation of coastal meadows

There are no clear and straight boundaries in nature; ecologically, it is important to preserve the habitats themselves as well as their gradual transition to other communities. When maintaining coastal meadows and planning maintenance support, it must therefore be taken into account that the creation of too abrupt transitions (for example, from coastal meadows to forests, etc.) should not be supported, but smooth transitions from one community to another would be maintained.

Pursuant to the European Union's Habitats Directive, Natura 2000 sites are defined as protected areas in order to ensure the survival of valuable and endangered habitats. Each Member State, including Estonia, must regularly report to the European Commission on the status of protected habitats. Therefore, all habitats, including coastal meadows, are demarcated in databases so that they can be reviewed and changes monitored.

Coastal meadows, as semi-natural communities, require economic activity performed by people, and various subsidies are paid to managers to encourage this. Such remuneration for maintenance activities also requires a good overview of the boundaries of the areas to be maintained. The inventory of Natura 2000 habitats and the assessment of their condition are carried out by experts. The boundaries of the communities are determined during the inventory as an expert assessment.

Values of coastal meadows

This chapter deals with the values of coastal meadows based on wildlife. In addition, coastal meadows have values related to heritage culture, which are not covered in this guide, but which can be read about in more detail in Mall Hiiemäe's article “Poollooduslike kooslustega seonduvast rahvapärimuses” (On Semi-Natural Communities in Folklore) in the textbook “Pärandkooslused” (Seminatural communities) (Estonian Seminatural Communities Conservation Association 2004).

Characteristic communities

The plant and bird communities characteristic of coastal meadows are the most important values to be protected in coastal meadows.

Much of the variability in the ecological conditions of coastal meadows is determined by the influence of the sea, which is why plant communities in coastal meadows have zones of salt-tolerant and less salt-tolerant plants. Depending on the extent of the impact of seawater, coastal meadows are often divided into saline and suprasaline zones. The first of these, the flooded area is home to salt-tolerant species (halophytes) that cannot grow on other soils: the lysimachia maritima, the seaside arrowgrass, the sea plantain, the blackgrass, the leocharis uniglumis, and the sea aster, as well as the common glasswort, the halimione pedunculata and suaeda maritima that grow on salt flats. Soil microrelief and grazing also affect the appearance of coastal meadows, and therefore the diversity of coastal meadow plant communities is very high. For example, according to the Nordic classification of vegetation types, there are eight different vegetation types in coastal meadows, and E. Roosaluste's article “Rannaniidud” (Coastal Meadows) (in the textbook “Pärandkooslused” (Seminatural Communities”) describes 15 plant communities in coastal meadows, whereas different authors have described up to 17 vegetation types on coastal meadows. All vegetation types described in the coastal meadow are considered rare or endangered.

The plant communities of the coastal meadows are characterized by zonality and the effect of salt water. Photo: Silvia Lotman

The bird communities characteristic of coastal meadows form a whole, where the existence of more common and less demanding species ensures a safer environment, on which the success of nesting of endangered and more demanding bird species also depends. The diverse coastal meadow complex allows providing habitat for species with different needs.

The communities that have been out of maintenance for a long time can be superficially restored in a few years, but the inter-species relations characteristic of coastal meadows and the permanent return of rare species to the meadow will take almost ten years. Read also: “Rannaniit on palju enam kui „muruplats“ ja kaks kurvitsat” Eesti Loodus December 2016 http://www.eestiloodus.ee/arhiiv/Eesti_Loodus12_2016.pdf.

Plant species

The plant species of the coastal meadow are characterized by salt tolerance. A total of 390 species of vascular plants have been found in coastal meadows, which make up 26% of Estonian species, and 100 species of bryophytes, which make up 17% of all Estonian moss species.

More common plants characteristic of the saline zone of coastal meadows are Seaside arrowgrass *(Triglochin maritimum),* sea milkwort *(Glaux maritima),* sea plantain *(Plantago maritima),* blackgrass *(Juncus gerardii), Eleocharis uniglumis* and sea aster *(Aster tripolium).* The salt flats characteristic of coastal meadows is especially inhabited by salt-tolerant plants such as *Salicornia europaea* and *Suaeda maritima*.

According to an overview prepared by Elle Roosaluste in 2020, 37 protected plant species grow in coastal meadows, of which almost half are ungulates. Of coastal meadow plants, *Dactylorhiza ruthei* and Longbract frog orchid (*Coeloglossum viride)* are included in the most stringent list of protected species - category I. These two species are also critically endangered according to the Red List, and the species the slender hare's-ear (*Bupleurum tenuissimum*) of protection category II is also deemed to be critically endangered. The coastal meadow plants of category II are the pedunculate sea-purslane (*Halimione pedunculata*), the sea pearlwort *(Sagina maritima*), and the media sandspurry (*Spergularia media*) are in danger of extinction.

Annex II of the European Union's Habitats Directive includes the protected marsh angelica (*Angelica palustris*) characteristic to coastal meadows. An action plan has been drawn up for the protection of longbract frog orchid as a Category I species.

Although coastal meadow vegetation has adapted to regular disturbance (grazing or mowing), different plants have adapted to different management intensities.

Grazing facilitates the distribution of the following rare species: seaside brookweed *(Samolus valerandi),* slender hare's-ear *(bupleurum tenuissimum),* sea wormwood *(Artemisia maritima), Carex glareosa, Carex MacKenziei,* herbaceous seepweed, sea thrift *(Armeria maritima*), long-bracted sedge (*Carex extensa*), *Polygonum oxyspermum*, pedunculate sea-purslane (*Halimione pedunculata*), sea pearlwort *(Sagina maritima*), media sandspurry (*Spergularia media*), black bog-rush (*Schoenus nigricans*), the fringed pink (*Dianthus superbus*), *anthyllis coccinea,* dragon's teeth *(Tetragonolobus maritimus)*.

Mowing promotes the spread of the following rare species: *Dactylorhiza ruthei*, Turkish marsh gladiolus (*Gladiolus imbricatus*), marsh angelica, flecked marsh orchid (*Dactylorhiza incarnata*).

In addition, there are rare species that may benefit from management dormancy, such as longbract frog orchid, musk orchid (*Herminium monorchis)* and fen orchid (*Liparis loeselii)*.

The natural part of the coastal meadow complex also includes shallow water bodies - coastal lagoons. Twenty species were found in the coastal lagoons of Pärnu inventoried by Indrek Tammekänd within the framework of the URBANCOWS project in 2013; these water bodies were characterized by relatively poor but unique vegetation. In coastal lagoons with no direct connection to the sea, protection category II species soft hornwort (*Ceratophyllum submersum)* was found. Among the small species of duckweeds covering the water body, the protected species of protection category III was gibbous duckweed (*Lemna gibba) and L. turionifera*, which is rarely registered in Estonia. In coastal lagoons connected to the sea, as well as on a shallow

sand shore protected from waves by sand outcrops, the presence of spiny water nymph, protected species of protection category II (*Najas marina*) was observed. An important food object sago pondweed (*Potamogeton pectinatus),* is present especially in coastal lagoons with a larger water mirror. The species prefers areas connected to the sea and is very numerous everywhere in shallow seawater. The coastal lagoons, which do not have a permanent connection to the sea, have developed a characteristic plant community of considerable conservation value. When connected to the sea, it is destroyed, and species diversity increases, and in most cases, protected species disappear. The separation of coastal lagoons from the sea is a natural process, and therefore their artificial connection to the sea cannot be considered justified (Tammekänd 2013).

Of the rare moss plants, the category II species marrat's bryum moss (*Bryum marratii*) is found in coastal meadows; the spread of this species and the diversity of mosses, in general, is facilitated by keeping the coastal meadow open through both mowing and grazing (Ingerpuu and Sarv 2015).

More information about plant communities and species in coastal meadows:
Ingerpuu, N., Sarv, M. (2015) “Effect of Grazing on Plant Diversity of Coastal Meadows in Estonia” Annales Botanici Fennici 52(1–2) https://doi.org/10.5735/085.052.0210
Kose, M., Liira, J., Tali, K. (2019) “Long-term effect of different management regimes on the survival and population structure of *Gladiolus imbricatus* in Estonian coastal meadows” Global Ecology and Conservation Volume 20, October 2019, e00761 https://doi.org/10.1016/j.gecco.2019.e00761
Rannap, R., Briggs, L., Lotman, K., Lepik, I., Rannap, V. (ed.) (2005) “Rannaniitude hooldus”. Keskkonnaministeerium
Roosaluste, E. (2004) “Rannaniidud” õpik-käsiraamatus “Pärandkooslused” Pärandkoosluste kaitse ühing
Tali, K. (2009) “Roheka õõskeele kaitse tegevuskava 2010-2014” Eesti maaülikool
Tammekänd, I. (2013) “Pärnu linna sonnide ehk rannikulõugaste taimestiku inventuur” Keskkonnaamet
https://cdn.barn.ee/keskkonnaamet.ee/public/linnalehmad/Parnu_sonnide_taimestiku_inventuur2013.pdf
Übner, M. (2016) “Rannaniidukompleksi taimestik” in the collection “Pärnu rannaniidud ja linnalehmad” Environmental Board project URBANCOWS

Invertebrates

Coastal meadows are a valuable habitat for invertebrates. There is a peculiar community of predatory beetles associated with seaweed piles and saline marshes. One of the few endemic insects described in Estonian areas is the Baltic hawker *(Aeschna osiliensis*) associated with coastal meadows and other coastal habitats. Shallow ponds in coastal meadows can provide habitat for, for example, the rare large white-faced darter (*Leucorrhinia pectoralis).* The coastal meadows are diverse in terms of odonata, homoptera, auchenorrhyncha, and heteroptera.

Coastal meadows, where animals have been grazed for a long time, are characterized by anthills caused by ants and pismires.

Of macrolepidoptera, many common as well as less numerous and local species live on coastal meadows. The phengaris is a butterfly species of protection category III, the distribution of which has significantly decreased in Estonia during the last half-century. In Estonia the phengaris inhabits semi-natural habitats, where there are areas with low and sparse grass exposed to the sun, where the *Thymus*, the food plant of the caterpillar grows, and where there are plenty of ants of the genus *Myrmica,* on whom the species of butterfly mooches.

The molluscs of the coastal meadows have not been studied in detail, but for example, eight species of snails have been found on the beach ridge of Puhtu islet: large amber snail, small amber snail, round-mouthed whorl snail, wall whorl snail, ribbed grass snail, dwarf snail, pellucid glass snail, least slippery snail, moss chrysalis snail, and smooth grass snail. The same species (except for the round-mouthed whorl snail) even invade waterside areas that are occasionally flooded by waves. Snails can be found right at the edge of the water, where they attach to the underside of the limestone pieces of the pebbles. Apparently, they are not endangered by low salinity water. The most common seaside mollusk is the Vertigo pusilla.

The management of coastal meadows can have different effects on invertebrates. As many herbivorous insects are highly specialized in certain plant species, intensive grazing reduces the diversity of insects: the smaller the plants become under the influence of livestock, the less food there is for insects. Thus, for many invertebrate species, temporary cessation of grazing or low grazing load has a rather positive effect. On the other hand, overgrowing the meadow loses the habitat of the insects there. Thus, various sources suggest that the most suitable way of management for invertebrates is diverse landscape, with both intensively managed coastal meadows and parts of coastal meadows where plants are allowed to grow taller and bloom profusely (for example, when grazing is stopped for a year).

Grazing as a way of managing coastal meadows creates additional opportunities for invertebrates, as the excrement of herbivores acts as a fertilizer and the number of insects that eat manure or feed on carcasses increases in grazed areas.

Read more about the entomofauna of the coastal meadows:

- Talvi, T. (2004) “Putukad pärandkooslustel” (Insects on seminatural communities” in the textbook “Pärandkooslused” (Seminatural communities) Estonian Seminatural Communities Conservation Association.
- Pedmanson, R. (1996) “Rannaniitude selgrootud” in the collection “Eesti ranna- ja luhaniidud”. Comp. Leibak, E., Lutsar, L..
- Meriste, M. “Ämblikufauna Matsalu ranna- ja luhaniitudel, üleujutuste ja koosluste hooldamise mõju” Tallinna Tehnikaülikooli Tartu Kolledž.

- Rintala, T., Ahlroth, P. (2007) “Matsalun merenrantaniityjen luteista ja muista hyönteisista” in the collection “Ruovikot ja merenrantaniityt” Comp. Ikonen, I. ja Hagelberg, E. Suomen Ympäristokeskus (in Finnish).
- Wanner, A. (2009) „Management, biodiversity and restoration potential of salt grassland vegetation of the Baltic Sea: Analyses along the complex ecological gradient“. Doctoral dissertation defended at the University of Hamburg.

Vertebrate animals

Amphibians

Natterjack toad

In the first half of the 20th century, the natterjack toad (*Bufo calamita*) was a very characteristic species in the coastal areas and islands of Western Estonia and Pärnu County. By the end of the century, 73% of the natterjack toad populations in Estonia had been destroyed, while the loss of coastal meadow populations during the same period was 91%. Unfortunately, this tendency is not only characteristic of Estonia but also occurs in almost all countries where natterjack toads are spread. The main reason for the extinction of natterjack toads is the loss of habitats suitable for the species. In Estonia, the natterjack toad has mostly inhabited coastal meadows and coastal dunes, which have become covered in reed beds and overgrown, afforested, and/or drained over time. At present, only two coastal meadow natterjack toad populations have survived in Estonia in Manila and Kumari; the status of the Ruhnu population is unknown. However, with the improvement of the condition of the coastal meadows (recovery of large-area grazed wetlands), it would be possible to repopulate the natterjack toad to its former habitats. An action plan for the protection of the species has been prepared for the natterjack toad as a species of protection category I, which is also one of the bases for this work.

One of the rare but important species that shows the quality of the coastal meadow is the natterjack toad. Photo: Riinu Rannap

Read about the protection of the natterjack toad:

Rannap, R., Lepik, I., Pappel, P. (2010) “Tegevuskava kõre (*Bufo calamita*) kaitseks Eestis.” Keskkonnaministeerium.
http://www.envir.ee/orb.aw/class=file/action=preview/id=1144763/KK_1512_tegevuskava.pdf

Rannap, R. (2005) “Läänemere rannaniidud kõre elupaigana” kogumikus “Rannaniitude hooldus” Keskkonnaministeerium.

Briggs, L. (2005) “Ohustatud kärnkonnaliikide kudemispaikade taastamine rannaniitudele” in the collection “Rannaniitude hooldus” Keskkonnaministeerium.

Moor frog and common frog

In addition to the natterjack toad, the coastal meadows are also an important habitat and breeding ground for the moor frog (*Rana arvalis*) and the common frog (*R. temporaria*). The moor frog is listed as an endangered species in Europe in Annex IV of the EU Habitats Directive. The condition

of the moor frog in Estonia has also significantly deteriorated during the last ten years, and the Red List 2018 indicates that it is an endangered species. In addition, both common and moor frogs belong to protection category III. Both amphibians use shallow-water rapidly warming ponds and floodplains for breeding, which are also abundant in open coastal meadows with natural hydrology. However, as a result of ditching and overgrowing of coastal meadows (reedbeds, overgrowth), shallow water ponds exposed to the sun are disappearing, which makes these areas unsuitable for amphibians. 2012-2013 A study carried out on coastal meadows in the 1990s showed that both moor and common frogs prefer to breed on large, wide, and open meadows, with the larger total area of ponds favoring the reproduction of both species. In ditched meadows, the ponds suitable for reproduction dry faster than in non-ditched meadows. In addition, the reproduction of the moor frog is positively affected by the stronger grazing load of the meadow.

Read more:

Rannap, R., Sõber, V., Tiitsaar, A., Kraut, A. (2015) „Loopealsete ja rannaniitude majandamine ja elustiku seisund“ Tartu Ülikool ja Eesti Maaülikool. Available online: https://www.digar.ee/arhiiv/et/raamatud/19743

Birds

The most important value of the coastal meadows from the point of view of birds is the diverse community of meadow breeding waders. Indicators of high-quality coastal meadow include dunlin, pied avocet, black-tailed godwit, ruff, Eurasian curlew, common ringed plover, common redshank, northern lapwing, and Eurasian oystercatcher. As for passerines, the coastal meadow is used for nesting by the western yellow wagtail, Eurasian skylark, and meadow pipit. In addition, coastal meadows are an important migration period feeding and resting place for Anseriformes such as greylag goose, greater white-fronted goose, lesser white-fronted goose, mallards, and barnacle goose.

Grazing of livestock results in an open coastal meadow, which is a suitable stopover for migratory bird flocks. Photo: Silvia Lotman

The meadow breeding southern dunlin (*Calidris alpina schinzii*) is a subspecies of the dunlin, whose population by the Baltic Sea, including in Estonia, is rapidly declining. Due to the rapid decline and local disappearance (e.g., as a hatchery bird off the coast of North Estonia), the meadow breeding southern dunlin belongs to protection category I. The main reason for the decrease in the number has been the failure to maintain coastal meadows and the decrease in the area of open meadows as a result of afforestation and expansion of shrub-covered areas. Inadequate maintenance of meadows affects the well-being of the population in many ways - the area is too high and densely grassed (especially for chicks), without low puddles and grooves; whereas the abundance of other Charadriiformes, the so-called umbrella species, has decreased, and this, together with the shrubs and groves growing on the meadows, has increased the burden of predation; in narrow meadows fragmented with bushes and trees, the dunlin does not find a safe nesting place and does not nest in such meadows; declining numbers due to habitat degradation reduce genetic diversity and increase the risk of inbreeding. An action plan has been drawn up to coordinate the protection of the species.

The ruff (*Philomachus pugnax*) is one of the world's most wader species, but the population nesting in the European temperate zone has declined catastrophically in recent decades. In Estonia, the ruff, therefore, belongs to the protection category I animal species; the size of the surviving population is estimated to be 10-30 nesting females. The main reason for the decline of the species is considered to be the loss of suitably managed wet grasslands. The activities required for the protection of the ruff are described in the action plan for the protection of the species.

The lesser white-fronted goose (*Anser erythropus*) is globally defined as an endangered species; in Europe, as a particularly endangered species and the Estonian Nature Conservation Act of 2004, the lesser white-fronted goose is considered a protection category I species. Lesser white-fronted geese belong to species listed in Annex I of the European Union Birds Directive, Annex I to the Bonn Convention, and Annex II to the Bern Convention. Lesser white-fronted geese do not nest in Estonia; the entire natural population of Fennoscandia is likely to stop in Estonian coastal meadows: In the spring of 2019, a flock of 107 birds stopped in Aandi meadow. In order to ensure the protection of lesser white-fronted geese at migration stopovers, it is first and foremost necessary to ensure the preservation of large open coastal meadow areas where geese can rest, eat and spend the night on the migratory route. The activities of the lesser white-fronted geese are described in the action plan for the conservation of the species. A map of the species' migration stops can be viewed here

https://www.piskulka.net/distribution.php?maptype=locnumball&loccountry=All+countries&year=2019&month=All&season=All&loctext=

Read more about the strictly protected bird species in the coastal meadows:

Pehlak, H., Luhamaa, H. (2018) „Niidurüdi (*Calidris alpina schinzii*) kaitse tegevuskava" Keskkonnaministeerium.
https://www.envir.ee/sites/default/files/niidurudi_tegevuskava_avalik.pdf

Mägi, E., Pehlak, H. (2010) „Tegevuskava tutka (*Philomachus pugnax*) kaitse korraldamiseks Eestis" Keskkonnaministeerium.

Toming, M., Ojaste, I. (2008) "Tegevuskava väike-laukhane *Anser erythropus* kaitse korraldamiseks Eestis 2009 – 2013" Keskkonnaministeerum.

Rannap, R., Briggs, L., Lotman, K., Lepik, I., Rannap, V. (ed.) (2005) "Rannaniitude hooldus".

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Rannap, R., Sõber, V., Tiitsaar, A., Kraut, A. (2015) „Loopealsete ja rannaniitude majandamine ja elustiku seisund" Tartu Ülikool ja Eesti Maaülikool. Available online: https://www.digar.ee/arhiiv/et/raamatud/19743

Coastal meadow micro-habitats

Coastal meadows are not and should not be uniformly smooth. The diverse microrelief of the coastal meadow must be considered a separate value, as it is the basis for the presence of both plant communities and animals in the coastal meadow. The micro-relief is affected by water and ice activities as well as the maintenance of coastal meadows, especially grazing. It is important that lower spots and puddles form on the coastal meadow. Floodplains, ponds, and lagoons are also natural components of the coastal meadow. When such areas dry quickly, salt flats form. If the ponds remain wet for an extended period of time, they will be important feeding grounds for Charadriiformes and breeding places and habitats for amphibians, aquatic invertebrates, and fish. In wet meadows, the nesting density of meadow breeding waders is higher, and the probability of replacement clutches is higher in the case of destroyed nests. In addition, several species preferably nest near ponds. The abundance of shallow water ponds with an open edge in the meadows is also important for the survival and flight ability of the chicks, increasing their important feeding area.

When mowing coastal meadows, special attention must be paid to the maintenance of wetter areas. Mowing with tractors in wet areas may not be possible every year. The need for mowing of wetter areas and puddles should be especially emphasized to managers. If necessary, wet pits could be mowed manually. If the mowing has been done too high in smaller pits, post-grazing will help.

Ecosystem services

The coastal meadow, which serves as a coastal wetland, has many values that can be considered as ecosystem services from a human point of view. Thus, coastal meadows play an important role in buffering tidal water and flooding, and sequestering carbon. The treatment of surface water flowing towards the sea (binding of nutrients) and the storage of sediments transferred to the land by floods are carried out here. Coastal meadows also reduce erosion damage and play an important role in replenishing groundwater resources. In addition, coastal meadows, due to their diverse and unique biota, also have significant aesthetic value. The traditional cultural heritage associated with the landscape and coastal meadows is also a service provided by these communities.

Coastal meadow protection objectives

When restoring and maintaining semi-natural communities, it is important to keep in mind the nature values under which these activities are carried out. Different species and different values and environmental conditions may require different solutions. It must also be borne in mind that habitats as such are dynamic and that their protection objective should not be 'freezing' them. At the same time, natural habitat changes can only be taken into account in larger areas, so specific conservation objectives still need to be set for each area separately. In this chapter, we provide an overview of the objectives set for the protection of coastal meadows in the action plans for strictly protected species, what is an ideal coastal meadow, and which requirements are important for the protection of diversity in coastal meadows.

Objectives for the protection of species

In this subsection, we provide an overview of the objectives set in the action plans for protected species by species.

Longbract frog orchid

Of the approximately 30 places of the finding of longbract frog orchid historically known in Estonia, the population is preserved until this day in only a few locations, the most important of which are the Matsalu Keemu coastal meadow and the Paope juniper field in Hiiumaa; recently, the species has also been found in the coastal meadow community of Muratsi village in Saaremaa, and a finding place is also known in the wooded meadow of Kannastiku village in Lääne-Virumaa. Incidental findings of the species have been observed in two more places in recent years. Many of the known long-standing populations in Western Estonia have been destroyed as a result of overgrowth and accumulation of plant litter in habitats. Tests carried out on the Keemu coastal meadow show that the species tolerates grazing well, but in the case of a population that has faded to a very small size, short-term protection with temporary fences will help to increase the number of individuals to allow more seeds to mature. On the other hand, the species needs an environment that has been grazed to a low level, and that is free of plant litter so that mowing or a low grazing load are not suitable for maintaining the habitat of the longbract frog orchid.

Natterjack toad

Objectives of protection of the natterjack toad according to the action plan for the protection of the species:

- The grazing of coastal meadows in the habitats of the Manilaiu natterjack toad, the significant increase in grazing load, and the expansion of grazing/mowing areas are ensured.

- Grazing has started in the coastal meadows covered in reedbeds and overgrown dunes in the western part of Harilaid.

- Ruhnu has expanded grazed coastal meadows, and reproductive water bodies suitable for the natterjack toad have been restored and established.

- In the permanent habitat of the Hara natterjack toad and in the adjacent coastal meadow, grazing with a sufficient load takes place, the open area has been expanded, and at least two breeding water bodies have been cleaned.

- The grazing load in the Pikla natterjack toad habitat has been increased, and the breeding waters of the natterjack toad have been restored. The re-population of the natterjack toads will continue in Saastna and in the presence of a high-quality habitat complex in other coastal meadows of Matsalu (in Penijõgi, Haeska, Salmi, and Keemu) and in Võiste and Kihnu.

Longer-term goals for protection of the natterjack toad:

- The survival and favorable condition of all natterjack toad populations are guaranteed, including an increase in numbers in the smaller coastal meadow populations (Manilaid, Harilaid, Ruhnu, Hara, Pikla) to at least 250 and in the larger populations to 500 adults.

- Reserve populations that regenerate themselves annually have been established in the coastal meadows of Saastna, Penijõe, and Võiste. In case of favorable conditions of coastal meadows also in Haeska, Kihnu, and Keemu.

- Reserve populations have been established for all 15 surviving populations of the natterjack toad to ensure that genetic material is preserved.

- The Saastna-Teorehe meta-population (a population that includes several sub-populations that are interconnected through migration corridors) of the natterjack toad has been created.

Dunlin

The main objective of the action plan for the protection of the dunlin is to preserve it as a species living in a natural and semi-natural environment.

The conservation management objective for 2018-2022 is to halt the decline in the abundance of the species so that by 2022 dunlin would nest in Estonia with a population of at least 180-230

pairs, whereas the abundance of the species in meadow habitats would be at least 210 pairs. In order to achieve the goals, it is essential to ensure the quality of meadow habitats through adequate management that takes into account the habitat needs of the species. Restoration of coastal meadows in the immediate vicinity of existing populations, especially in large coastal meadows, is essential for the spread of this species, as the restoration of narrow areas far from existing nesting sites is unlikely to help the species. The habitat needs of the dunlin are known, and both general and detailed maintenance instructions have been prepared, and compliance with the instructions must be consistently required and monitored. It is also important to specify the distribution data of the species, to monitor the abundance and breeding success. The predation control also helps to increase the breeding success of the species - in 2019, 7 jackals were hunted in the vicinity of the Keemu coastal meadow just before the nesting season of the dunlin, as a result of which the breeding success of the pairs was high. The same action can be recommended in all key areas identified in the Species Protection Action Plan, at least as a temporary measure to increase species abundance in parallel with habitat quality improvement.

Ruff

The aim of the protection is to create preconditions for the preservation of the ruff in Estonia as a breeding bird. Considering that the protection of the ruff in Estonia is legally guaranteed, however, the species abundance is critically low, the information on its distribution is insufficient and the impact of all critical and important risk factors cannot be reduced locally in Estonia, and further work should focus on the maintenance of potential habitats of the ruff, the monitoring of breeding populations and international cooperation, as well as informing the public.

In the last few years, more observations have been made of nesting, especially from Pikla meadow/fish ponds, but also from other large meadows with permanent water bodies (Keemu, Põgari). Monitoring the restoration carried out in Denmark suggests that the restoration of small bodies of water on the coastal meadow would help to improve the species' well-being. The lack of suitable water bodies is most likely a problem for this species in Estonia, as the species nests later than other meadow waders, and most of the meadows are too dry by that time. Suitable coastal lagoons and ponds could be restored in areas where the species has been encountered in recent years. Where possible, predation controls should also be applied at breeding sites to improve breeding success.

Lesser white-fronted goose

Of particular importance from the point of view of the preservation of the lesser white-fronted goose as a species is the protection of their migratory routes and the entire range of stopping, nesting, and wintering areas in their entirety. Closely related to this is international cooperation within the distribution range of the species. No single activity, covering only one point in the life cycle of the lesser white-fronted geese,

can be very successful. In Estonia, as one of the most important stopover places on the European migration route, the preservation and restoration of areas suitable for geese, especially large coastal meadow massifs, and their continuous maintenance are of primary importance. As a result of the implementation of the action plan, the places where lesser white-fronted geese can stop during migration should be preserved in the first place, and the risk of any of them being killed by a bullet here should be minimized. It is important to avoid all areas during spring goose hunting and lethal scaring where lesser white-fronted geese can stop. In the light of changes in staging points, monitoring of the species should certainly be reintroduced to prevent erroneous hunting in places important to the species.

Perfect coastal meadow

In order to better understand the objectives of coastal meadow protection, a theoretical description of a perfect coastal meadow prepared with the help of the results of the joint project “Applied Nature Conservation Research” (LOORA) of the researchers of the University of Tartu and Estonian University of Life Sciences, the University of Tartu study of the breeding success of meadow-breeding waders and the Estonian University of Life Sciences study of coastal protection measures important for species protection is provided here.

A perfect coastal meadow should be large (at least 150-160 ha), wide (500-600 m or more), and not fragmented by forest stands. Many meadow-breeding shorebirds do not nest closer than 300 m to a stand or groves, so meadows with groves, regardless of their grazing load, never become a suitable habitat for waders. In addition, the wider meadow areas have a lower predation load: nest predation meadow-breeding waders nesting on the ground is higher in nests located closer than 400 m to the stand (forest edge, forest stands). Low grass areas should cover at least 50% of the meadow area to create a sufficiently diverse range of conditions for species with different habitat requirements. However, the coastal meadow should not be uniformly similar to a golf course. The meadow must be free of high vegetation, reeds, trees, and shrubs. The relief and vegetation of the perfect meadow are diverse, and there are many puddles and wet areas.

Tussocks, sods, rills and large shallow ponds, and grooves of water movement are needed to cover the nest and the clutch of waders. Clutches of Charadriiformes need lower, wet ponds and grooves where they can find food and shelter in the drier end of the nesting season. These, as well as the gaps between tussocks, should be "open", permeable to the clutch - not full of plant litter.

Ideally, the seaward edge of the meadow is open with low-cut vegetation and certainly free of reeds, thus allowing waders access to feeding areas located in the low coastal sea on exposed shallow shoals and coves full of seaweed. There are seaweed piles and cow piles in the meadow, which increase the number of insects, which in turn are eaten by the chicks of Charadriiformes.

The natterjack toad also needs large areas of meadows for habitat. A complete habitat complex, which includes low grassland feeding areas, spawning grounds, wintering grounds, and shelters, makes the coastal meadow suitable for the natterjack toad. Suitable spawning grounds for the natterjack toad are shallow fresh or brackish water ponds with low or sparse vegetation exposed to the sun. There must be several puddles in the meadow; they have shallow shores and dry out during the summer. For wintering sites, the natterjack toads need areas outside the floodplain with suitable soil for digging into the ground (e.g., dunes, stone fences, buildings), which are often away from the coastal meadow but can be reached by the natterjack toads without passing through the forest or high grassland.

Lightly-moderately grazed areas suitable for a large proportion of insects and spiders, where nectar-rich plants bloom profusely and where there are fewer disturbances, areas where grazing does not take place all the time, where seeds of orchids and other species manage to mature,

but which are however not allowed to close up, could exist on the mainland part of the coastal meadow.

Ideally, horses, cattle, and sheep are grazed mixed or alternately. Cattle are particularly important because they operate in the water and keep both the waterline and the shallow puddles open. In a perfect meadow, the animals are guided by a herdsman who respects nature, which ensures an even grazing load and the safety of the animals.

Requirements for coastal meadows

In this chapter, we discuss indicators that can be used to assess the quality of coastal meadows and their maintenance. It is very important that the condition of coastal meadows is assessed not only on the basis of the general appearance of the area but also of the functioning of the area as a habitat for species-specific to its communities (e.g., meadow-breeding waders, amphibians, plant characteristic to a coastal meadow).

Indicator species

If there is an abundance of dumping ground plants in the coastal meadow, such as thistles and nettles, or if Acrocephalus warblers or other birds atypical of the coastal meadow are found there, this is a signal that the condition of the meadow is not good. Among the birds, the overgrown meadow is indicated by the whinchat and acrocephalus warblers (common reed bunting, sedge warbler, Eurasian reed warbler, great reed warbler, Savi's warbler). There may be several reasons for the presence of atypical species: undergrazing, overgrazing, excess nutrients, etc. Coastal meadows are not well maintained if reeds, reed canary grass, meadowsweet, and tall fescue dominate and bolt there. The coastal meadow should also have no woody vegetation (junipers, willows, alders, pines). The need for the complete removal of woody vegetation depends on the suitability of the meadow for rare meadow-breeding waders.

If the coastal meadow is in a favorable condition, then there are many typical coastal meadow plants in its saline zone such as Lysimachia maritima, seaside arrowgrass, sea plantain, blackgrass, Eleocharis uniglumis, sea aster, common glasswort, suaeda maritimas, alkali grass, red fescue. In the case of suprasaline coastal meadows, in a favorable condition, there is a species-rich plant community similar to grasslands on mineral soil or a paludified meadow with a small plant litter layer where high-growing expansive species (tall fescue, meadowsweet, reed canary grass, etc.) do not predominate. The most common bird species in the coastal meadow, the abundance of which in the area indicates the good conditions of the meadow, are: northern lapwing, common ringed plover, common redshank. Rarer are black-tailed godwit, ruff, common sniper, and dunlin. The encounter of geese stopping during migration on the meadow also provides information on the relatively good condition of the meadow. A moor frog and/or common frog should also breed in a meadow that is in a favorable condition. In meadows that are in particularly good condition, it is also possible for the natterjack toad to start breeding again.

Height of grass in the coastal meadow

The concept of low-eaten grass is often used to assess the quality of the care (grazing) of coastal meadows. An area with a grass height of 3-5 cm is considered to be eaten down. As the wet, seaward part of the meadow is important from the point of view of Charadriiformes (especially the dunlin) and the natterjack toad, it is important for this part of the coastal meadow to be eaten down. The proportion of the grass eaten down is best defined on the basis of an area; for example, the Manija Island Coastal Meadows Management Plan sets the nature conservation objective as

a coastal meadow with at least 75% of the maintained area to be low grassland. However, it is not practical to set a low grassland rate of more than 50% in the general coastal meadow maintenance requirements, as in this case, the meadow area provides suitable habitat for species with different habitat requirements, but a sufficiently large area remains for species specifically requiring low grassland. At present, unfortunately, only 46% of the coastal meadows are suitable for the nesting of meadow-breeding waders in terms of grass height (Kaasiku, unpublished data).

It is important that the most seaward part of the coastal meadow (saline zone) is low grass. Photo: Riinu Rannap

A well-maintained coastal meadow must have an open water border (reed-free), at least 50-75% eaten down grassland, and the rest of the grass should not be higher than 50-75 cm, with areas with higher grass could remain at the forest side of the meadow. The grassland in the coastal meadow can be mosaic, forming spots of different heights, where there are areas with grass 10-20 cm high between the down eaten parts. It is also important that the low-grass part of the coastal meadow is low, even in the autumn of October. Otherwise, the second-cut hay may grow so high that a plant litter layer unsuitable for nesters is formed in the spring. In a well-maintained meadow, there is no layer of plant litter between the vegetation; neither is it possible to identify the residues of chopping. If it has been necessary to chop the meadow vegetation, it should definitely be followed by grazing.

The maintenance of a coastal meadow is not sufficient if a dense, even reed grows over the entire area or on the seaward side of the area. When controlling reeds, special attention must be paid to the wide coastal meadows, which must be designed to be free of reeds suitable for waders. The water boundary should be cleaned of reeds in any case, but whether or not to leave the reeds in the water is very site-specific; for example, for Anatidae, the mosaic alternation of reeds and open water is positive. There are also several small shallow water bodies in the coastal meadow, which need to be grazed in order to preserve them (to keep them open and low-grassed). If the grazing load is too low or the animals avoid entering the water, sedges which the cattle will not eat start growing in wetter dells and depressions. In this way, the layer of dead plants is deposited year after year, and the shallow waterholes become clogged, muddy, or dry out completely. If the grazing load is not sufficient, the grass in the puddles and their edges must be mowed, and the mowed grass must be removed. However, the depressions covered in sedges can also be cleaned by removing the vegetated turf and the layer of organic matter. This work is best done with a hydraulic bucket, which allows you to clean the puddle very precisely and not too deeply. The removed soil can be used, for example, to fill existing ditches, to spread in a thin layer in a previously agreed meadow area, or to be removed from the meadow. However, natural dells and impressions must not be filled with soil. Such restoration of shallow water puddles creates feeding grounds for waders and breeding grounds for amphibians in the meadow. Of course, such restoration work requires the permission of the Environmental Board.

Meadows in the upper parts of which there are habitats of endangered plant species may require mowing and the removing of the mowed grass. In this case, it is optimal to mow only in the second half of July after the seeds are ripe. Alternatively, a combination of grazing and mowing may be used. Mowing and subsequent late grazing are also more suitable for species that need sparse vegetation growth (e.g., the ruff).

The maintenance of meadows with Turkish marsh gladiolus is particularly difficult in terms of combining species conservation and community conservation objectives. Based on Marika Kose's long-term research and expert opinion, the Turkish marsh gladiolus reproduces very well with seeds, but cloves are also formed well on old bulbs, which is why the plants clone themselves very successfully even if flowering fails. The condition for the long-term survival of a species is not so much the annual mass flowering but rather the possibility of occasional flowering and seed dispersal in order, for example, to expand or strengthen the area. Existing specimens/clones also survive different management practices, except for overgrazing, which is not tolerated by this species. As the Turkish marsh gladiolus is a meadow plant with distribution over the entire area rather than with local distribution, the management measures of the area must be chosen in such a way that they are economically sensible and physically feasible over large areas. This logic could also be applied to, for example, the marsh angelica and the ungulates. In the management of meadows with the Turkish marsh gladiolus, it is suitable to leave 1/5 of the area unmanaged by rotation, use of intermediate years, or other models that support diversified biodiversity management. Further applied research is needed to achieve the best results in the management of coastal meadows with endangered tall perennials.

Open or trees and shrubs?

For wading species nesting in coastal meadows, it is important that the coastal meadow is large (at least 150-160 ha), wide (500-600 m or more), and open - free of reeds, shrubs, and trees. Therefore, if the coastal meadow is important from the point of view of the protection of the woodcocks, the aim of maintenance should also be a coastal meadow as large and open as possible. Many meadow-breeding shorebirds do not nest closer than 300 m to a stand or groves of trees or scrubs, so meadows with groves, regardless of their grazing load, never become a suitable habitat for waders. In addition, the nest predation of meadow-breeding waders is higher in nests located closer than 400 m to the stand (forest edge, tree groves). Today, however, many meadows have higher areas that are not flooded during high water, afforested or overgrown. Therefore, waders do not have enough nesting places in such meadows in spring. In grazed areas where invasive shrubs are a problem (e.g., young alders), they must be controlled by chopping. In order to reduce the viability of the trees, chopping of shrubbery should also be allowed in July.

Birds do not nest in the vicinity of single trees either, which is why single trees must be removed from the bird protection area in a coastal meadow if possible. If a single tree growing in the meadow is very old and of special importance or, for example, has a cultural heritage, such a tree can be preserved in exceptional cases. Extreme care must also be taken when erecting any structures on the meadow (including observation points, animal shelters). Observation sites and shelters may be established, or groups of trees suitable for shelter may be left only at the edge of the meadow bordering with the forest. The planting of trees on coastal meadows or their periphery should also be avoided, as it would significantly increase the incidence of predators and the predatory burden on waders' nests and chicks.

If the purpose of the protection of a particular meadow is only botanical, then single junipers or other trees and shrubs and also bunches of reeds color the landscape. In a coastal meadow where the presence of trees and shrubs is allowed, they could be placed unevenly by patches throughout the meadow.

Ditches, shallow ponds, and coastal meadow moisture

The coastal meadow is a wetland by nature, and the natural relief of the meadow allows the formation of many shallow water bodies. Such shallow ponds and floodplains are important for amphibians for spawning and for woodcocks for feeding. For both meadow-breeding waders and amphibians, wetness is the most important habitat feature on the coastal meadow. In wetlands, nesting densities and the likelihood of replacement clutches of meadow-breeding waders are higher. The abundance of shallow water ponds with an open edge in the meadows is also

important for the survival and successful flight ability of the chicks as well as for the successful breeding of amphibians. In addition, many species prefer to nest near puddles, and water-rich meadows also make it more difficult for predators to move, resulting in higher hatching success of wader chicks in wet meadows.

The small ponds and coastal lagoons on the coastal meadow must be flat at the edges and with grass eaten down. Photo: Riinu Rannap

Today, most of the coastal meadows are ditched. The ditches significantly affect the natural hydrology of the coastal meadows, draining water quickly from the meadow. As a result, the meadow ponds dry out too quickly and do not provide a high-quality breeding ground for amphibians or foraging areas for meadow-breeding waders. Therefore, under no circumstances should new ditches be built on coastal meadows or existing ditches be dredged.

Old ditches also affect the hydrology of the coastal meadow. Photo: Riinu Rannap

Existing ditches should be converted into puddles and coastal lagoons if possible. To do this, part of the ditch must be closed, and the part that is not closed must be widened to create small bodies of water with shallow banks instead of the ditch. The material that has been piled on the edges of the ditch, as well as the debris and soil removed during the construction of the expansion site, can be used to close the ditch. Replacing the ditch with a group of puddles allows excess water to accumulate in the puddles, but at the same time, slows down the rapid drainage of water from the meadow. The abundance of puddles creates better conditions for both meadow-breeding waders and amphibians. Old, partially sunken ditches should be completely closed and liquidated or partially transformed into shallow and gentle shored puddles. However, in those ditches passing through the coastal meadows, which cannot be closed or formed into puddles, the shores of the ditch must be made as gentle as possible in order to create shallow, gentle edge wetlands for the ditch.

A low puddle on the coastal meadow is suitable for the breeding of amphibians and for foraging for waders. Photo: Riinu Rannap

Shallow ponds beyond the reach of the sea are very important for amphibians (including the natterjack toad), the ruff, and many characteristic plants. These ponds contain freshwater, and no small fish (mainly three-spined sticklebacks) end up there during floods. Fish destroy tadpoles and spawn of amphibians. The ruff needs low-salinity ponds to feed, and aquatic plants need it to grow. If the grazing load is low, sedges which the cattle will not eat start growing in wetter dells and depressions. In this way, the layer of dead plants is deposited year after year, and the shallow waterholes become clogged, muddy, or dry out completely. If such ponds have overgrown and become muddy over the years, they should be cleared of sediment and excess vegetation. A hydraulic excavator with a wide track is best suited for this work, but for best results, the work must be supervised by an expert in the habitat requirements of the species (see the chapter on “Restoration of Hydrology” for more details).

Buildings and structures on the coastal meadow

Certain structures are occasionally required for the management of coastal meadows. For example, animals need bodies of water for drinking, for which natural coastal lagoons with low salinity are well suited (see the topic of ditches and bodies of water in the previous chapter for more details). It may also be necessary to set up a feeding area to care for the animals in the winter. As permanent supplementary feeding of animals on the coastal meadow is not allowed, a winter feeding area and storage conditions must be established on the landward side of the coastal meadow, for example, in a stand or farther away in a farm complex. Animals may also need shelter during summer grazing. The best shelter is natural tree groves, which should, however, not be kept in the middle of an open area of the coastal meadow, but should allow animals to move from the meadow to the mainland side areas with a forest stand to seek shelter. However, if there are no such shelter areas with a stand, a shelter for the animals can also be built in the most mainland side part of the meadow. Possible sites for the construction of a shelter should be coordinated with the Environmental Board. Old earth tracks have traditionally been used for the management of coastal meadows or for fishing, for example. The preservation and maintenance of such old tracks could be strongly encouraged in order to maintain access to the sea. Historic roads usually take into account the natural terrain of the area and are built from local materials. New roads and ditches for drainage must certainly not be built on the coastal meadow, as such activities will significantly damage habitats.

How to assess the priority of restoring coastal meadows?

Restoration of a coastal meadow overgrown with reeds or trees is a costly undertaking, and the decision to start restoration must be deliberated over and justified by taking into account both the scientific and social aspects. In this chapter, we list possible selection criteria to help assess and select which coastal meadows should be restored as a matter of priority. In the list, both oral assessments by coastal meadow experts and examples from the literature have been used. Aspects showing the biological value of the site and the socio-economic or pragmatic considerations that need to be addressed before restoration can begin are highlighted. Habitat restoration is all the more successful, the more clearly the goals of the restoration work are clear to all parties (landowner, land manager, public officials, the public).

Scientific criteria:

- Size: the larger the area of a particular habitat, the more valuable the habitat for the species. When assessing the restoration of coastal meadows, the extent to which coastal meadows can be restored at a given location should be taken into account, and priority should be given to those areas where larger meadows can be restored or expanded.

- Coherence: if the coastal meadow forms a complex with other pieces of meadow or is located between several meadows in good condition, its value as habitat is higher than that of an isolated meadow. The proximity of other coastal meadows also makes it possible for species to return to the restored meadow (e.g., it is unlikely that plant seeds or insects make it to a very distant land; even the dunlin, a philopatric nester, inhabits meadows close to existing nesting meadows). On the positive side, according to a study on the sustainability of semi-natural communities, the vast majority of coastal meadows out of maintenance and in need of restoration are located up to 5 km from already maintained meadows. These are the meadows that should be preferred for restoration.
- Condition: the more elements characteristic of the coastal meadow (e.g., salt flats, open meadows) and typical species are preserved in the area, the higher the priority is to restore the area. In most cases, the less time the site has been unmanaged, the better its condition. The longer time ago the overgrowth of the meadow began, the more likely it is that many species for which habitat will be restored have disappeared.
- Potential as an assembly and nesting area for migratory birds: coastal meadows along migratory routes of birds should be given priority as they play an important role in the life cycle of migratory birds. Coastal meadows restored in places suitable for migratory birds also help to reduce the accumulation of birds in the fields and thus prevent damage to crops. Large grasslands are usually more suitable for migratory birds, and the shape and position of the coastal meadow can also affect the area's suitability as a stopover place for migratory birds.
- Historical value: Historical data on the nesting of endangered bird species, the natterjack toad populations, or the growth of rare plant species in the meadow indicate that the area is of potentially high value and offers suitable conditions for the species if it is not permanently converted by ditches or buildings.
- Islands, islets: it is important to restore coastal meadows to the areas located separately from the mainland, as there the impact of small predators on nesting birds is lower. It is easier to arrange maintenance on islands close to the mainland.

Socio-economic aspects:

- Sustainability of maintenance: does the meadow have a manager who is interested in the long-term maintenance of the site after restoration? Information on past grazing in the area and a comparison of the location of historic paddocks with meadows or other open habitats currently maintained will also help.
- Recoverability: whether the area can be mowed or grazed up to the waterline; how densely woody vegetation or cultivated plantation has infiltrated the area, and whether it can be eradicated. Whether the area has not been damaged by drainage and whether this effect can be eliminated or significantly reduced.
- Economic motives: the restoration of the coastal meadow can benefit local people and maintainers in terms of diversification of rural life. Examples include the development of tourism in places with open sea views, an increase in species richness (e.g., birds, plants), and the grazing of animals that are attractive for tourists (Scottish mountain cattle, sheep, horses) add value to the area as a tourist attraction. Coastal meadows are also well-suited to the rearing of beef cattle of smaller breeds, and places where such activities are planned will increase the weight of coastal

meadow restoration for society. The positive socio-economic impact of the restoration and maintenance of coastal meadows has been shown, for example, after the LIFE project for the restoration of coastal meadows in Häädemeeste at the local government level and on the example of the URBANCOWS project in Pärnu.
- Rationale for restoration to society: as habitat restoration is a costly activity and is mostly funded by the public sector, it is important that all the values of the habitat to be restored in a given place are clearly expressed to society, and the potential is realized. The better we can explain the goals of the activity to local residents, visitors, and decision-makers, the more likely it is that the goals will be achieved.

Considerations for the restoration of coastal meadows are discussed in more detail in:

Holm, B. jt (2019) “Poollooduslike koosluste jätkusuutliku majandamise tagamise analüüs” Pärandkoosluste kaitse ühing & Eesti Rakendusuuringute Keskus CentAR OÜ http://www.pky.ee/siselinkide_materjalid/PLK_uuringu_aruanne.pdf
Holm, B jt (toim.) (2016) “Pärnu rannaniidud ja linnalehmad. Linnakeskkonna rannaniitude taastamise ja hooldamise juhend.” Keskkonnaamet https://cdn.barn.ee/keskkonnaamet.ee/public/linnalehmad/BBB_eesti_vahend.pdf
Wanner, A. (2009) “Management, biodiversity, and restoration potential of salt grassland vegetation of the Baltic Sea: Analyses along the complex ecological gradient” Doctoral thesis (http://ediss.sub.unihamburg.de/volltexte/2010/4596/pdf/Antonia_Wanner_dissertation_salt_grasslands.pdf)

The largest coastal meadow complexes in Estonia

An important factor in assessing the priority of coastal meadow restoration is whether the coastal meadow belongs to a larger coastal meadow complex. The largest and most important coastal meadow complexes in Estonia are Käina-Vaemla in Hiiumaa, Tahu in Lääne County and Salmi (Keemu) and Häädemeeste in Pärnu County. The most important coastal meadows for meadow-breeding waders are shown in the figure, which includes larger and longer-term maintained areas.

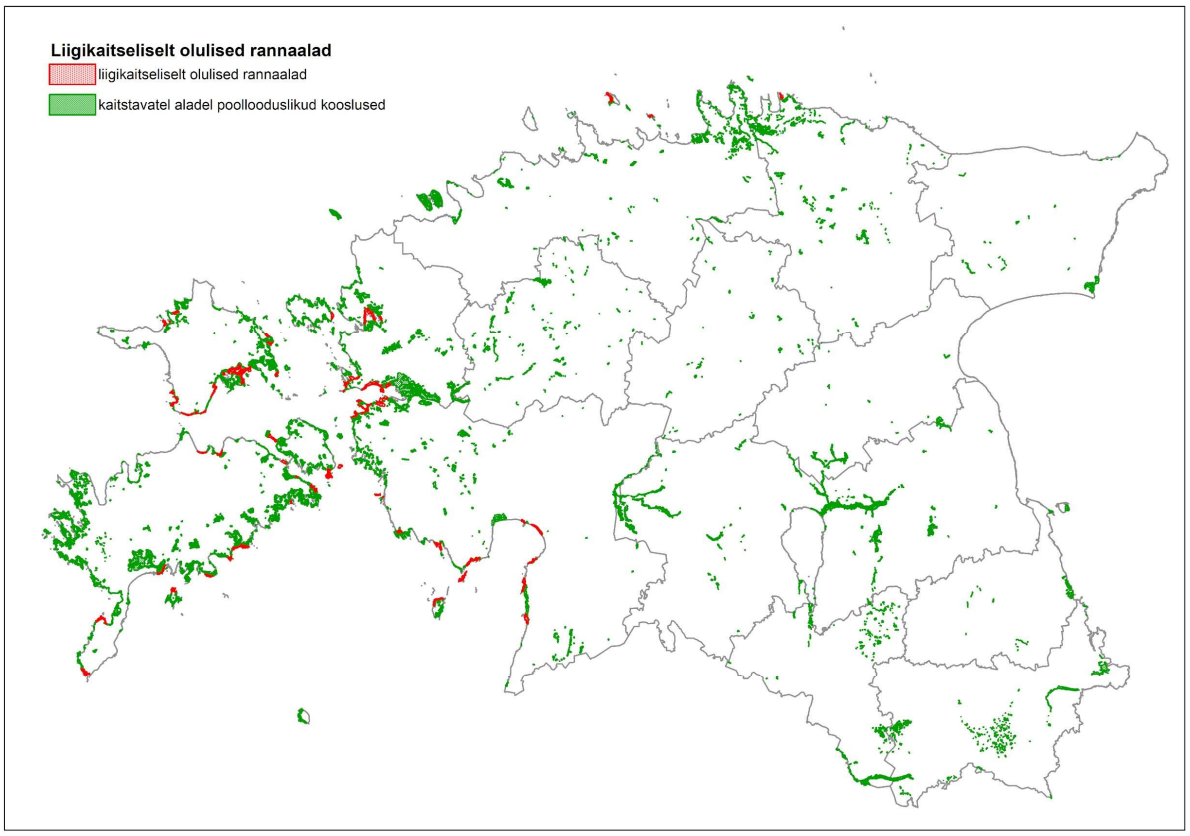

Figure: Coastal areas important for species protection (Eleri Pulk, Triin Kaasiku)

Coastal meadows important for species protection

These are meadows with at least 75% open water boundaries,> 50% low grass meadows, which are the most important nesting places and habitats of many endangered bird species and/or the natterjack in Estonia. In order to ensure optimal habitat conditions for endangered species, these areas must be as large and open meadow complexes as possible, preferably at least 45 ha in size, without fragmentation by trees and shrubs. Since 2015, separate maintenance support has been paid for such areas. The Environmental Board maintains an overview of the area corresponding to such support, the more detailed conditions of the support are defined in the regulation on maintenance support.

The preconditions for applying for compliance with the additional requirement for the coastal areas important for species protection are the following:

- the area must have an open waterline to the extent of at least 75%;
- there must be no woody vegetation in the area (if a single tree growing in the meadow is very old and of special importance or, for example, has a cultural heritage value, such a tree may exceptionally be preserved)
- area(s) must form a complete complex of at least 45 hectares;
- the 45 ha criterion does not apply to the islets, but the islet as a whole must meet the first two preconditions - at least 75% open waterline, and there must be no woody vegetation in the area, except for shelters for domestic animals.

Shelters for domestic animals must be planned in the area important for the protection of the species on its mainland side edge. If the meadow area borders with a stand, the stockyard must be established in such a way that the animals have access to the stand. In addition to the open meadow area unfragmented by tree stands, it also provides valuable edge habitats, which are currently mostly absent in the transition areas from meadow to stand. In addition to the species that specialize in the openness of coastal meadows, there are a number of species for which the transition community open from one side through a sparse stand to the forest is better suited. The edges of the coastal meadows should be shaped in such a way with the natural transition to stands, which will increase the species richness of the areas. The locations of animal shelters must be coordinated with the Environmental Board, which can grant exemptions in unavoidable cases.

Restoration of coastal meadows

The maintenance of a coastal meadow is the maintenance of the entire habitat complex, during which the needs of different species must be taken into account. We will first take a look at the techniques and problems of restoring coastal meadows, and in the following chapter, we will describe the annual maintenance of coastal meadows. Simply put, two things need to be done to restore the coastal meadow: to clear the area of reeds, tree stands and shrubs, and other woody

plants, and to start with annual grazing or mowing. As a first step, it is advisable to review the boundaries of the meadow area to be maintained and, for the sake of the safety of the livestock and equipment, to remove the old barbed wire, bottles, plastic, and other objects that pose a risk to the animals and equipment. The long-term goal of restoration activities is a perfect coastal meadow (see above), but it should be borne in mind that the formation of coastal meadow communities may take ten years. Therefore, it is expedient to assume that the restoration activity is completed when the area can be maintained with the planned stocking density without the area being overgrown with woody vegetation or reeds.

In the case of coastal meadow restoration activities in recent years, the average price of coastal meadow restoration per hectare has been 1192.4 euros for projects financed by the Cohesion Fund through the EIC and 1652.8 euros for projects carried out by RMK. According to the cost model for the restoration and maintenance of semi-natural communities, the average cost of restoring one hectare of the coastal meadow is 700 euros per hectare, and the cost at the maximum working time is 1298 euros per hectare. According to the model, in the case of the presence of trees in the restoration area, it is possible to obtain an average income of 82 euros per hectare for the wood removed during the restoration, and thus the average need for restoration support is 618 euros per hectare.

Reed control

In this chapter, we will discuss the situation where from the side of the sea, the coastal meadow is covered with dense reedbeds, which does not allow the entire area to be regularly maintained and requires restoration activities in advance.

To restore a coastal meadow overgrown with reeds, reeds must first be removed from the area. Photo: Ilona Lepik

In the case of the destruction of larger reedbeds, the impact of the activity on the water treatment capacity must also be considered. Consideration should be given to maintaining reedbeds between fields and wetlands or at the mouths of major ditches and rivers. If the ditch is located between the field and the meadow, the field side edge of the ditch may remain covered in reeds. Cleaning of these habitats of reeds can have a negative impact on the aquatic ecosystem, as reeds, as well as other vegetation, bind nutrients dissolved in the water, and their removal can increase the flow of nutrients to the aquatic ecosystem and thereby increase coastal eutrophication. It must be remembered that the aim is not to destroy reeds as a habitat but to restore coastal meadows as habitats. The value of reedbeds as habitat is highest in areas where the reed grows permanently in water at a depth of at least 5 cm. At the same time, it is important that the reedbed does not become dense and monolithic over time but that the mosaicity - areas with open water- is preserved there. The terrestrial reeds covering the coastal meadow areas have no special natural values.

Reed control through grazing

The animals do not like to penetrate the large reedbeds, so it is advisable to mow last year's reed before starting to graze. The best time to mow the reeds before grazing is right before or during flowering, in the second half of July or the latest in early August. Mowing at this time weakens the reed the most. Reeds can also be mowed from the frozen ground in winter, but then only old wooded reeds are cut. It is important to collect and remove the cut reeds from the meadow or to

burn it on site. Abandoned reeds prevent light from reaching the soil and the development of herbaceous vegetation. One of the negative aspects of mowing reed is the remaining rootstocks, which can injure the animals' feet in summer. This problem is not present when reeds are crushed with a maintenance mower in late summer-autumn. This allows the stalk to be crushed close to the ground and twists the end of the rootstock so that it no longer poses as great a risk to the animals' feet as the cut rootstock. The downside of crushing is that the crushed reeds remain on the meadow, which promotes paludification and prevents the development of meadow vegetation. Therefore, crushing should only be used to remove rootstocks left on previously mowed reed areas. Crushing of reeds must not become a continuous maintenance measure for the meadow, but can only be used as a means of restoring the meadow, which must be followed by grazing. In practice, reeds are rarely removed after mowing, as mowing itself is difficult at the waterline and is not possible in all places. Coming to the same place with tractors to remove the reeds is a double-cost job.

Alternatively, if the reed mass is very large or difficult to mow, then, alternatively, corridors suitable for animals
can be cut into the reedbed. When mowing the corridors, it must be made sure that the width of the mowed corridors is at least 2 meters (optimally 4 meters). The distance between the corridors must be less than 10 meters, and there must be cross-corridors connecting them at least every 20 meters. This structure ensures that cattle can move freely in the reeds and that air also flows there. In corridors that are too narrow, the air becomes stale, and the animals reluctantly go to such overheated areas. The grazing load must be higher than the normal grazing load during the maintenance period in order to control the young reed emerging in the following season. Mowing reeds only makes sense if high load grazing of livestock is planned for the following season.

The restorers of the coastal meadows have also successfully controlled the reeds by trampling before grazing - they drive a tractor 5-6 times over the surface of the entire reedbed in order to crush the reed plants and rhizomes. Grazing is then started.

Grazing must begin before the reed unfolds the leaves and turns green. The reed leaf only becomes visible (open green) when the plant has grown to a height of 30-40 centimeters; therefore, the presence of animal feed in the reedbed areas is not whether green plants are visible in the area and the height of the growths of the reeds of the same year must be checked on the spot and grazing must be started when the shoots are up to 15 cm high. Such a start of grazing greatly simplifies reed control. The green reeds in spring are very valuable for animals as a food plant. Cattle are very happy to eat young reed shoots. At the same time, reed biomass grows very quickly in the first half of the summer; the stalks become woody by mid-summer and are no longer of particular interest to livestock.

During the restoration of the coastal meadow, the grazing load must be higher than the normal maintenance load, as the vegetation growth and nutrient reserves in the soil are higher than in the longer grazed meadow area. During the restoration, various paddocks can be made in order to increase the grazing load on the sites - in the early spring, the animals are specifically directed to the reed areas and to limit the scattering of the animals with the fence.

It takes time to control the reeds and restore the coastal meadow. Photo: Riinu Rannap

Summer mowing of the reed

In areas where intensive grazing of animals is not possible, but reed control is important, repeated summer mowing can be used to control reeds. From mid-June onwards, reeds must be mown and removed at least three times (usually even more frequently) during the summer. In areas with ground-nesting bird species, reed mowing can start from 15 July. If possible, reed shoots should be cut below the water surface. This reduces the vitality of the reeds and can significantly weaken the reeds in three to four years. As a result of mowing, the reeds first become thinner and no longer grow as tall and strong. After repeated mowing for several years, holes begin to form in the reeds. The reed disappears from the coastal meadow completely after 5-10 years of active cutting. This method is much more labor-intensive and less ecologically efficient than grazing, so it is worth using it only in exceptional cases. In areas with low grazing load and no ground-nesting bird species, a combination of mowing and grazing may be recommended. In the summer, when reeds are mowed from mid-June to early July, new shoots appear after the mowing, which the cattle can use again for food. However, if at the end of the summer in August some of the reeds have managed to grow tall, it is necessary to mow them again to repeat the cycle. By combining mowing and grazing in this way, the underground rhizome system of the reedbed can be depleted more quickly and forced to retreat. Studies have shown that reed rhizomes can contain up to 7

years reserve of nutrients, making it very difficult to get rid of reeds by mowing or moderate grazing alone. Repeated trampling of the reed with a tractor can also help in combating reeds in the combined method.

The mowed reeds must be collected and removed from the meadow or burned. However, if this should not be possible due to wet soil or storms, mowing is still better than giving it up. With a high water level, the water removes the leftover mowed reeds and piles them in the higher meadow parts. It can be collected from there and burned. In shallow water and in rocky places, reeds are also removed manually by mowing with a weed eater or scythe. This is a very labor-intensive technique, but it has been used in many places.

Crushing of reeds

Both the maintenance mower and the conventional farm tractor can be used to crush reeds. In Finland, a maintenance mower, the blade of which can be attached in front of or behind the tractor, has been used for crushing reedbeds to restore coastal meadows. If the use of a 3-meter shredding blade requires a powerful tractor and is only suitable for meadows with hard ground, the narrower, 1.6m and 2.2m blades can also be used in wetter areas when attached to a crawler truck. The maintenance mower also allows you to cut shrubs and smaller trees. The maintenance mower chops the reed stalks into pieces about 10 cm long. It is practically impossible to remove such chips from the meadow, so chopping should not be considered as a method of maintenance but only as a means of restoration. Immediately after restoration, a sufficient amount of livestock should be allowed on the meadow (usually 1.5-2.5 IU/ha in reedbeds), it may be necessary to repeatedly crush reeds growing close to the waterline, but the most important thing is to start grazing with sufficient load immediately after crushing. On harder soils, where the maintenance mower can be attached to the tractor, it is possible to mow 5-8 ha in one working day. In areas of botanical importance, it should be borne in mind while crushing that as the sea-level changes, the crushed material usually accumulates on the meadows in a thick wall and can bury entire parts of the meadow. To overcome this problem, methods should be considered to collect the crushed material and remove it from the area to be mowed. If crushing is followed by a proper grazing load, livestock (especially cattle) will be able to trample the crushed reedbed into the soil and help it to decompose quicker. However, in the case of repeated crushing and a weak grazing load, the activity has a negative effect on the coastal meadow.

Burning of reeds

The burning of reeds helps to get rid of much of the dry biomass deposited on the coastal meadow. It does not produce harmful methane emissions from the decomposition of biomass in poor oxygen conditions. However, not all reedbeds are dense enough to make it possible to burn the entire surface. The burning of old reeds at the end of winter makes the coastal meadow a suitable nesting area for birds in spring and a suitable feeding area for livestock in early summer. Burning must be followed immediately by full-load grazing or regular mowing. Reed burning should be done with frozen ground - biomass is driest in late winter, early spring. Reeds should

not be burned in summer and late summer, as this activity would destroy invertebrates en masse. Fire will have a strong effect on reed growth in the next period only if it affects the soil deeply or is followed by flooding, which weakens the reed's ability to transport oxygen. In the case of burning, it is important to coordinate your activities with local rescuers and obtain permission from the Rescue Board and thoroughly plan all work in advance. Burning requires the presence of many people to control the burning and to be prepared for emergencies. Be sure not to burn at too high a wind speed when the fire may get out of control. Care must be taken with nesting birds: once nesting has begun, reeds must not be burned.

Milling of the topsoil

This soil removal guide is based on I. Huolman's article “Back to the Meadow - Restoration of Coastal Meadows Conquered by Reeds in the Lintulahdet LIFE Project,” describing the Finnish experience. When restoring coastal meadows as habitats for shorebirds and waterfowl, it is important to open the entire meadow up to the waterline. Opening the waterline is usually the most difficult part of maintaining a meadow, as the ground is usually very soft there. Two soil treatment methods have been used in Finland to open the waterline. In areas that can carry heavy machinery, it is possible to clean the waterline with an agricultural tiller, which is usually used for deforestation of a forest into arable land. The rotary cultivator requires a larger and heavier tractor, so such equipment can only be used in wetter areas during drought years, and in normal years it is not possible to use heavy equipment in the wetter parts of the coastal meadow.

The topsoil is milled to break the underground stems of the reed. The result is longer-term than the result of normal mowing or crushing. The tiller cuts through the underground stems to a depth of about 10-20 centimeters, which is probably enough to slow down root growth for several years. A 4-meter tiller attached to a tractor-trailer has been tested in Finland. This allowed one tractor to mill 0.5 ha of land per hour. In addition to the waterline, the tiller was also successfully tested at the edges of shallow puddles. Another method of creating an open water boundary is to break up the topsoil with a crawler. This method has been successfully applied in Sweden and Finland. The method seems to be suitable for soft surface areas where heavy machinery cannot access the waterline. In practice, the topsoil is broken by driving the machine back and forth along the waterline in an octagonal shape, thus gradually breaking the topsoil with the tracks. However, the milling of the soil layer must be regarded as an exceptional method of restoration, and its use is justified only if it is actually possible to start high load grazing or regular mowing immediately afterwards.
Examples of reed control in Finland include: Huolman, I. (2007) “Tagasi niidule – roostike vallutatud rannaniitude taastamine projektis Lintulahdet Life” from the collection “Põhjalik tutvus pillirooga” ("Read up on Reed"). Vammalan Kirjapaino Oy, comp. Ikonen, I. and Hagelberg, E. Online: http://www.pilliroog.ee/raamat/Read_up_on_Reed_eesti-keeles.pdf

Removal of woody vegetation

Overgrown coastal meadows are cleared of bushes either manually or with the help of machines. It is not difficult to cut down smaller individual shrubs one by one with a brush hook, but it is usually a matter of larger areas and more serious overgrowth, and chainsaws, brush cutters, or wasteland mowers must be used. It is important to keep in mind that any scrub removal must result in an area that can be grazed on or mowed.

Expansion of the coastal meadow complex through the restoration of edge areas - removal of woody vegetation would make the area more suitable for birds nesting on the ground. Photo: Riinu Rannap

The question of how to get rid of stumps that damage the legs of animals when cleaning an area overgrown with juniper or other bushes has caused a serious racking of brains. Both wasteland mowers and brush cutters retain stumps even with the most careful work, and in the following years, they will rise further from the ground as a result of erosion. It is very labor-intensive, but possible once a year to clear the area with a brushcutter and mow the stumps to keep them lower. It is rather sensible to use such a labor-intensive method if there are more people involved, for example, in the framework of volunteer work campaigns. Possible solutions are also the uprooting

of junipers in the spring when the ground is soft or the burning of warts round, but these are also large-scale manual works that require a number of volunteers.

It is important that woody vegetation be removed from the vicinity of shallow puddles to make the area a suitable feeding and nesting ground for waders. Photo: Riinu Rannap

In 2014-2018, in the framework of the project “Life to Alvars,” mechanized removal of woody vegetation was tested using a guillotine, harvester, chain crusher, and brush cutter to restore semi-natural communities. The most efficient restoration machine for woody plants turned out to be a chain crusher and guillotine attached to an excavator and a harvester and forwarder in case of larger trees. With a chain crusher, it is possible to crush smaller junipers, deciduous shrubs, and stumps. The result is stumps turned into brushes without sharp edges that decay and disappear from the pasture much faster than cut stumps. When crushing junipers and deciduous shrubs, care must be taken to ensure that the amount of biomass left behind is not too great. Junipers up to 1.5 meters high could be crushed without being removed. Higher woody plants and shrubs should be removed first with a guillotine, and then the stumps and finer shrubs crushed. If the ground is too wet after heavy rain or snowmelt, work must be stopped for this time to prevent damage to the ground and the formation of tracks. In the case of alvars, the time required for mechanized restoration of one hectare is one week, doing this work manually would take two months.

In the case of coastal meadows heavily overgrown with junipers, it is recommended to carry out the restoration in two stages. After the first removal of woody plants, to perform grazing for one season, starting as early as possible in the spring to control the emerging deciduous shrub. Then, during the winter season, to crush the stumps again. This is necessary because the litter surrounding the stump sinks due to the trampling of the animals and the weather, and the stump is up to 15 cm higher than after restoration.

Trees should be removed from the coastal meadow. Photo: Riinu Rannap

Every year an alder bush that will soon give off shoots after being cut down needs to be mowed. Alder shoots are not eaten by cattle, and therefore new shoots must be mown off in the pastures for at least three years in a row. From now on, scrub control must be repeated as needed.

Coastal meadows fragmented with groups of trees should be restored into large open areas. Photo: Riinu Rannap

Restoration of hydrology

Many Estonian coastal meadows have historically been wetter than today, as moisture is an important factor for many coastal meadow species. Old ditches on the coastal meadow, which are no longer part of the drainage system, should be closed.

A ditch on the coastal meadow. Photo: Riinu Rannap

If there are large ditches in the coastal meadow, efforts should be made to make their shores flatter and to ensure that livestock has access to the ditches, which in turn will help to make the shores flatter. In coastal meadows with ditches, partial or complete closure of ditches, flattening of ditch banks, or conversion of ditch mouths into multi-branch deltas or shallow ponds may be considered. In order to perform specific works, an expert examination with a list of works required for biota must be ordered in advance. The aim of the study should be to identify the effects of the ditch and to find solutions that promote coastal meadow biota but do not create excessive moisture in fields or gardens outside the coastal meadow. In most cases, it is then necessary to commission a land improvement project and/or modeling for preparing the terms of reference for the contractor. The activities must be coordinated with the Environmental Board, in the case of parts of the land improvement system with the Agriculture and Food Board, and in the case of state land also with RMK.

The ditches ruin the hydrology of the coastal meadow. Photo: Riinu Rannap

If the moisture level of the coastal meadow needs to be raised, it is possible to use different methods to close the ditches. If the catchment areas, drainage volumes, and flow velocities of the ditches are low, the ditch section can be filled with the soil of low water conductivity (for example, clayey moraine or sandy clay) to the extent of approx. 10-20 m and flat-edged ponds from can be formed of the intermediate unfilled portions. In this case, the tussocks and soil removed during the construction of the puddles can also be used to close the ditch sections. It is also possible to dam the ditches.

Dams formed of clayey backfill

In the case of small catchment areas and flow volumes of ditches, it is possible to close the ditches with backfill. Gravel and sand as porous and well-drained sediments are not suitable for this purpose. Clay or sandy clay moraine would be most suitable. It would make sense to turn the ditch sections between the dams into plain water bodies with shallow banks reminiscent of natural coastal meadow ponds, which can be used by meadow-breeding waders as feeding grounds and amphibians as breeding grounds. The material accumulated on the edge of the ditch during the digging of the ditch, as well as the sods and soil generated during the digging of the ponds, can be used for the construction of dams. To close the ditch, a 5-10 m long section should be filled

tightly with the backfill so that it extends as a flat pile to the meadow soil turfed over the ditch banks. The upper part of the dam should be built of turfed sods to ensure vegetation of the dam as quickly as possible. The “pile” of backfill is necessary so that the water flowing in the ditch would not flow over the newly built dam and easily eroded backfill. Instead, it would flow scattered along a turfed meadow that is less sensitive to erosion. Within a few years, the dam piles will be covered in vegetation and blend into the meadow landscape. The specific dimensions of the piles depend on the width of the ditches and the micro-relief of the area next to the ditch. A situation where the current concentrates at the edge of the pile and begins to erode the backfill should be avoided.

In 2011-2013, the transformation of old non-functioning ditches into flat water bodies with flat banks was carried out in Salmi coastal meadow. Although the ditches did not act as water diverters in the land improvement sense, the ditched coastal meadow area was too dry, and the area passed through 12 small ditches with steep edges. In 2011, expertise was conducted that recommended the closure of the ditches, after which the work was designed and carried out in 2013.

An old ditch before carrying out of the work. Photo: Silvia Lotman

Flattening of the ditches and closing the ends of the ditches. Photo: Silvia Lotman


After the work, a wide and shallow place has been formed of the narrow ditch with a sharp edge, and the end of the ditch is filled with a dam made of soil to ensure that water does not drain from the meadow into the drainage system. Conditions have been created for the formation of temporary puddles in the area. Photo: Silvia Lotman

Wooden dams

In most cases, the ditches of the coastal meadows are not so large and deep as to require the construction of wooden dams. In order to build such a dam, a channel perpendicular to the ditch, which is about 3 m long and 0.5-0.7 m deep, must be dug, a dam made of floorboards (grooved and plugged) must be built there, and the area around the dam must be compacted with soil to prevent the dam from leaking and eroding. The height of the dams could match the height of the ground. It is also possible to build adjustable overflow thresholds on such dams, which can be used to change the level of expansion. Adjustment may be necessary, for example, to combine the needs of meadow-breeding waders or spawning amphibians or fish and of grazing conditions. Wooden dams may not be suitable for the coastal meadow landscape and last only a few decades. A decision can be made in favor of wooden dams if the ditches are expected to overgrow by themselves, in which case the dams will help speed up the process. Wooden dams can be relatively expensive and building of them is likely to be feasible only if the necessary material is available for the site manager at low cost.

Examples of coastal meadow moisture restoration and planning:

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Maintenance of coastal meadows

General requirements

Fertilization, sowing and draining, as well as supplementary feeding of animals and treatment with antibiotics, are excluded in the coastal meadows under maintenance. If animals become ill, they should be removed from the coastal meadow while taking medication. Prohibition of chopping (except for post-grazing) in semi-natural communities is a scientifically justified requirement, as chopping significantly reduces the natural value of semi-natural grassland communities compared to traditional management and adversely affects most biota groups. With regard to non-agricultural factors, it should be borne in mind that no buildings are to be erected on the coastal meadows, and it may be necessary to restrict visits to the area during the nesting season. Coastal meadows need to be grazed more intensively by the shore, and it is important to ensure that there is sufficient grazing in the puddles and on the banks of ditches so that they will not grow reedbeds.

Stockyards and gates

When talking about grazing, the ancient profession of herdsman should once again be restored; however, in our country, grazing means mostly the building of stockyards. The construction of stockyards is one of the most labor-intensive processes in the maintenance of a coastal meadow, which can be optimized with good planning, but the annual picking up and putting back of near-shore fences is inevitable because winter ice and high water break down the fences on the area.

We mostly use reinforced iron poles or impregnated wooden poles for fence posts. Round pole fences are also available, and making them from local material is most welcome. Today, mostly various electric fences meant for farmers are used. To care for the fence, it must be trimmed regularly from the bottom so that the grass does not grow into the fence. It is more cost-effective to buy a thicker electric fence’s wire which will last for years to surround the upper area of the paddock. For more frequently moved fences, it is suitable to use a cheaper and thinner electric fence wire, net, cord, or tape. Electric fences with solar panels are available for grazing in remote areas.

In coastal meadows where ground-nesting birds are protected, consideration should be given to setting up so-called fox-proof fences to reduce predation. Such fences consist of several superimposed electric fence wires or electrified nets, and it is especially important to secure the lower part of the fence. A fence of at least five electric wires is also used to control large carnivores that endanger livestock; the fence must be 1.5 meters high so that the wolves will not be able to jump over it. The impact of such fences on large game needs further research, but it is not known today that predatory-safe gardens in coastal meadows would have a significant negative impact on other species. Herding dogs specially developed and trained (e.g., the Maremma-Abruzzi breed) for attacks by large carnivores are also suitable. At the same time, other breeds of dogs (e.g., border collies) come to the rescue for gathering and moving livestock.

The large paddocks of the coastal meadow give the animals the opportunity to naturally choose places suitable for different weather conditions. At the same time, dividing a large area into smaller paddocks and moving the same herd from one paddock to another will result in grass eaten lower down and enable to keep the feed in the pasture in a useful growth phase for the animals for a longer period of time. Therefore, it is important for each farmer to develop a system of paddocks suitable for his or her area and animals and, if necessary, to consult with the Environmental Board and/or a veterinarian.

Coastal meadows must be fenced so that the animals can also eat grass that grows on the waterline and in shallow water. To do this, either the stockyard reaching far into the water be built, or a ring-fence must be made, which also reaches into the water during shallow water. Due to large fluctuations in water levels, the construction, maintenance, and accommodation of such water fences is a complex, time-consuming and continuous activity. In areas where the water level fluctuates a lot, even during the grazing period, the managers recommend placing a bright, highly visible non-energized tape on the fence posts at sea. Such a tape is visible to livestock as well as waterfowl, but as it is underwater, it does not cause a problem for the operation of the rest of the electric fence. The coast manager must also pay attention to the fact that according to the law, the fences should allow access to the shore path, i.e., it should be accessible for pedestrians.

In the case of a road passing through a paddock, it is possible to use gates with different solutions, in which case the best solutions are those where a person or machine can pass them without moving the gates, whereas the animals are kept confined. One such convenient solution is the so-called tubular bridge, the principle of which is to build a cavity at the location of the gate and place a bridge made of parallel round pipes or narrow round logs over it. Animals do not cross such a barrier; at the same time, such a gate can be easily crossed by vehicles and on foot. For example, such a bridge has recently been built under the LIFE to Alvars project.

In the framework of the study on the economic sustainability of semi-natural communities, the managers of coastal meadows pointed out that they needed to acquire equipment related to the transport, collection, and welfare of animals, materials, and accessories for pasture fences and equipment related to the winter maintenance of animals. It was also pointed out that haymaking equipment was needed to collect feed for the livestock or to mow the coastal meadows.

Grazing load and grazing time

The grazing load on coastal meadows is 0.4-1.3 LU/ha (1 livestock unit (LU) = 1 adult bovine or equine, 2 heifers or foals, 3 calves or foals, 5 sheep or goats), the more specific recommendation depends on the specific meadow, however, in general, the grazing load should still exceed 0.4. In areas with high productivity, higher grazing load may also be recommended, especially during restoration. The higher grazing load promotes the formation of salt flats and the growth of plants characteristic thereof in coastal meadows. However, in some low-productivity areas, in the case of permanent grazing, it may be advisable to skip grazing for some years in order to promote the spread of invertebrates and better fertilization of flowering plants.

The soil map of the Land Board helps to assess the productivity of the areas. Saline underwater soils (symbol Ar) need a higher grazing load (1.3 LU/ha), whereas overgrazing can occur on Gleysols (ArG) already from approx. 1 LU/ha, in these areas, the recommended grazing load is 0.5 LU/ha. The lowest grazing load is required by saline primitive soil (Ar). Often the meadow soil (due to zonal formation) is a mixture of saline Glaysols and coastal Gleysols (Gr, ArG), in which case it achieves a good level of maintenance with a load of about 0.8 LU/ha.

With the current support requirements for the maintenance of semi-natural habitats, a situation has arisen where it is more beneficial for the manager to take care of more land and graze it with a minimum load. In most cases, the Environmental Board has the right and obligation to impose more specific maintenance requirements and grazing load on the site in accordance with conservation regulations and management plans, so more attention should be paid to whether the manager actually has enough animals to graze the planned site with a required load. In the case of obvious undergrazing, the entire area should be mowed, and the key elements of the area (seafront, shallow ponds, ditch edges) should be grazed more intensively by batch grazing. With the current grazing loads, trampling of animals is not a problem for ground-nesting birds - in the survey conducted in 2018-2019, only 2% of the killed clutches were related to the trampling of animals. At the same time, a very high load batch grazing in small paddocks can cause significant damage to bird clutches; such activity can be used to control reeds or intensify grazing of key elements of the meadow during the restoration period, but it is not suitable for permanent maintenance of a coastal meadow.

The vegetation of the appropriately grazed coastal meadow has been eaten down. Photo: Silvia Lotman

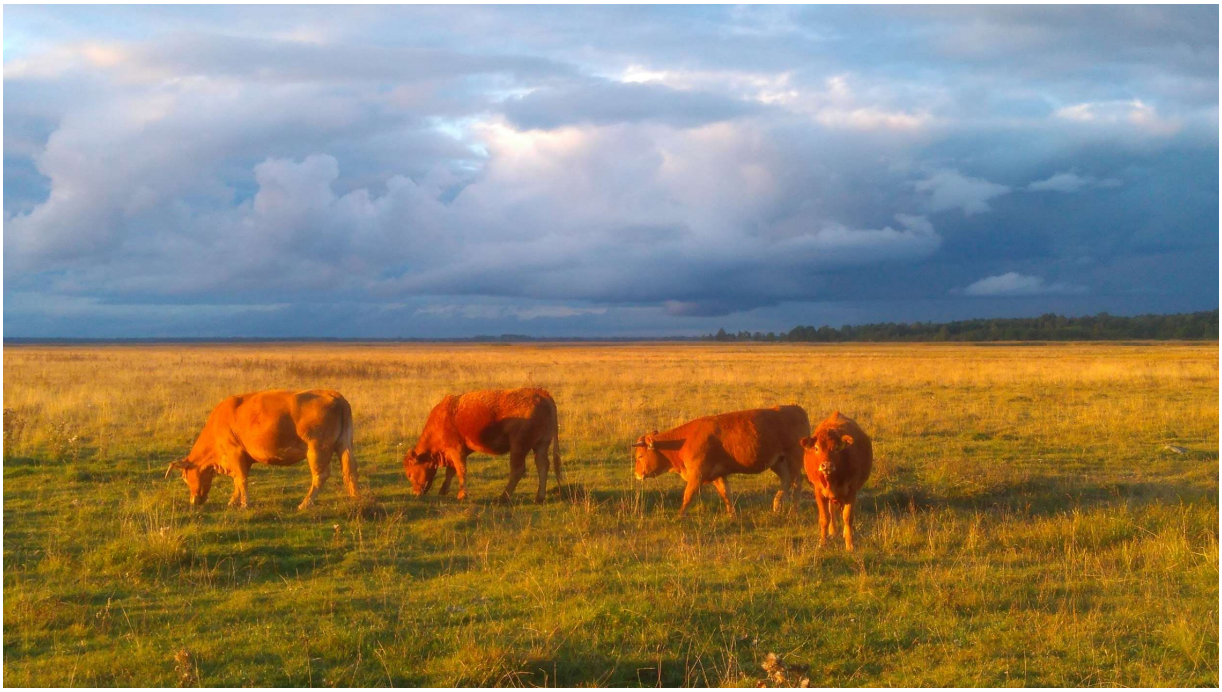
In the case of coastal meadows, the optimal grazing period in Estonian conditions is considered to be 130-140 days a year. The grazing period may change due to climate change. In order to maximize the conservation effectiveness of grazing, it is important to extend grazing as late as possible in the autumn. This is the most effective way to achieve low grass cover in the coastal meadow during spring. It also delays the start of spring grazing, which reduces the risk of the trampling of nests by livestock. In normal years, grazing should continue until the onset of persistent night frosts or until there is a sufficient amount of feed for animals. Optimally, at the end of the grazing period, the food supply of the year has been exhausted. This ensures the suitability of the meadows for the earliest nesters, such as the Northern lapwing and the dunlin. Grazing on well-maintained coastal meadows must begin in the spring no later than two weeks after the grass has turned green. If the coastal meadow is wide enough and there are higher hillocks (without bushes, shrubs, or forest stands), trampling of nests should not be a problem. In naturally narrow and fragmented areas, where permanent grazing took place for more than ten years in previous years, and there is no risk of rapid overgrowth, spring grazing at 50% load may be considered.

Selection of livestock

The selection of livestock for the maintenance of communities is important both in achieving the required results and taking into account the nature of the communities. Different domestic animals grazing together or alternately gives the best results, as different species have different preferences for food plants and thus affect the communities growing in the area. Grazing different species in the same area helps to reduce the impact of parasites on livestock. Parasites ingested with grass infect, as a rule, only their host species.

Animal feed preferences must also be taken into account. Higher and drier areas are well suited for maintenance with sheep, but wet and low areas need cattle or horses to control the reeds. Cattle also move on soft ground, in muddy bays where horses do not go. Cattle should definitely be used to fend off reeds from such areas. In the area with rare plants, there should be less grazing of goats and sheep as they are more selective in their diet and thus put more pressure on certain favorite plant species. In such areas, preference should be given to cattle and horses, especially in the first half of summer before the plants start their fruiting stage.

Preference should be given to breeds that are well adapted to natural conditions and have already proven their good endurance and suitability on Estonian coastal meadows (Scottish mountain cattle, Hereford, Estonian horse, etc.). Estonian indigenous breeds should be preferred due to their best adaptation to local conditions. Compared to dairy cattle, beef cattle are preferable because dairy cattle often move out of the area, their milk production depends significantly on the quality of the feed, and their health is often weaker than that of beef cattle. Heifers are well suited to coastal meadows, but with them, constant monitoring is very important, as they are much more mobile and less likely to stay put in their pasture. Beef cattle, especially suckler cows with calves, stay well on pasture, are calmer, less demanding on feed quality, and generally more resilient. They can be kept in pasture for a long time until late autumn when they will be happy to start pruning the bushes and eat plants that they do not eat in the summer.



In particular, however, the choice of livestock breed depends on the farmer's own economic model. However, it should be borne in mind that very heavy breeds of cattle or sheep breeds bred for intensive care that requires great care may not be suitable for coastal meadows due to their higher demand for fodder. Photo: Silvia Lotman

Mowing the coastal meadow

Although grazing is by far the most suitable economic method for coastal meadows, in fact, coastal meadows have traditionally been mowed. Even today, mowing is still a suitable way to manage and maintain many coastal meadows. Mowing is suitable for many tall plants, such as the marsh angelica, Turkish marsh gladiolus; some birds, for example, ruffs, prefer higher pre-mowing grass.

However, the rockiness of the coastal meadow and the complexity of the landscape often make mowing difficult, and it is not allowed to remove the stones from the area or otherwise change the natural variability of the area to make mowing easier. If the plan is to mow a rocky shoreline that is inaccessible for a tractor, the shoreline must not be left unattended but should be trimmed. In the case of wet meadow areas, care must be taken to ensure that the mowing machines were as light as possible and would not leave any track on the meadow turf. Mowing with a tractor on a waterfront, wet or muddy area is quite difficult and not possible every year. Thus, mowing is suitable as a continuous maintenance measure for higher and less rocky areas. For example, mowing is well suited for managing a purple moor-grass community.

Looking at the historical management pattern of coastal meadows, a combination of grazing and mowing can be suggested in several places so that the immediate seafront is grazed and the drier

areas on the mainland side are mowed. After mowing, it is recommended to graze the animals also on the second-cut hay.

The golden rule of bird-friendly mowing is that the mowing should be separated from the center or from edge to edge, as this will allow the animals in the grass to escape from the mower. However, if the mower does not allow mowing in a bird-friendly way, a small island with higher grass where the chicks can take refuge should be left in the middle of the mowed area.

An important piece of knowledge from recent research is that the predatory burden in coastal meadows is high, and the first clutches of nesting birds are often destroyed; the main offspring comes from secondary clutches. Therefore, it is important that the mowing time takes into account the time of abandonment of the nest of the secondary clutch. July 15 is suitable for such a mowing date. However, if the conservation objective of the site is high, plant species that require earlier mowing, the recommended mowing date is 1 July or another date set for the site by the species expert.

The mowing of coastal meadows should primarily take place in order to collect fodder for the animals from the area, so it is natural that the mowed biomass is not left lying in the area, not even in a crushed form. The biomass left on the meadow starts to accumulate over time, creating a plant litter layer unsuitable for the feed of birds and accumulating nutrients, leading to the impoverishment of the vegetation. It is therefore important to help site managers find economically viable uses for the resulting biomass.

Additional activities

In addition to grazing and mowing, other necessary activities may occur during the maintenance of coastal meadows.
For example, larger waves in some meadows regularly bring seaweed and other marine litter to the shore, which forms large ridges and promotes the proliferation of nitrophilic plants (nettle, thistle). In this case, it may be advisable to collect the marine litter and remove it from the shore. This material has traditionally been used to fertilize garden plots. Nitrophilic debris site plants can also be mowed, but such an activity is only needed if the nitrophilic plants really dominate large areas. As a rule, livestock eats most of the nitrophilic plants. Nettle and thistle may appear in the vegetation after the restoration of a high-grass meadow or after long-term overgrazing.

Even in well-maintained coastal meadows may create excessive plant litter over time, and to reduce it, plant litter may be burned in winter. There is no need to do this more than a few times in ten years.

Grazing on the second-cut hay has been a traditional way of managing coastal meadows in many places. The great advantage of grazing on the second-cut hay is that the following spring, the uneaten second-cut hay will form a plant litter that will not be tolerated by waders in their breeding area. The seeds of the plants can also start to germinate better if the cattle have trampled the

ground and created small vegetation-free spots there. Grazing on the second-cut hay is highly recommended for both birds and plants. In addition, second-cut hay is a valuable feed for livestock.

Livestock rewilding projects

Elsewhere in Europe, projects have been launched to restore and maintain semi-natural communities by releasing horses, cattle, and/or bison into the wild. The closest such project areas to us are located around in Latvia around lakes Pape and Engure. The most famous such area in the Netherlands is the Oostvaardersplassen nature reserve. In Estonia, only sheep have been released into the wild as semi-wild on some uninhabited small islets, and on one occasion, horses of the Konik breed. There is currently no such wild cattle area in Estonia. Although such areas are interesting as a project, there is currently no need for the maintenance of meadows in Estonia with the help of such wild animals. As an exception, some small islets may be suitable for such areas in Estonia.

Socio-economic aspects of coastal meadow management

According to the study on the sustainable management of semi-natural communities (http://www.pky.ee/siselinkide_materjalid/PLK_uuringu_aruanne.pdf), the maintenance of any type of semi-natural community without subsidies is not profitable today; the difference between the average cost and income of coastal meadow maintenance is 178 euros. At the same time, in the framework of the survey, the managers of coastal meadows most often pointed out that the management of at least some meadows is profitable for them. The reasons given were that the necessary equipment was available and that there were no additional costs. Farmers who managed coastal meadows starting from 40 hectares increased their chances of being profitable.

Livestock breeding and tourism play an important role in the profitability of coastal meadow management for the land manager, and the combination of both activities has resulted in the most sustainable combination of meadow maintenance with other economic activities. Extensive restoration and management of coastal meadows can be an important impetus for socio-economic development at the local government level. This has been shown, for example, in the Häädemeeste municipality after the LIFE project for the restoration of coastal meadows and in the city of Pärnu after the URBANCOWS project.

A study conducted at the University of Tartu showed that while only 43% of all coastal meadows provided suitable nesting sites for meadow-breeding waders, then among the coastal meadows receiving PLK maintenance support, there was 60%, and among the meadows receiving top-up support, there were as many as 76% of such meadows. The quality of the meadow was also

determined by the duration of the PLK support - 65% of the areas that had received PLK support for at least five years were found suitable for nesting of meadow-breeding waders (Kaasiku, unpublished data).

Nature protection, especially the protection of semi-natural communities, can only be successful if landowners, local people, farmers, and the general public are aware of nature values and conservation objectives. Increasing consumer awareness can also make a significant contribution to the profitability of coastal meadow management, leading to a change in meat consumption patterns so that local meat grown on grassland can be better upcycled.

Public events related to coastal meadows, such as scythe mowing competitions for holidaymakers, help to promote the contribution of coastal meadows to nature conservation and cultural heritage. Photo: Krista Kallavus

It is important for sustainability that managers also receive the necessary and specific advice and assistance regarding the nature of their meadow and herd, as well as production and marketing. The managers of the coastal meadows involved in the preparation of the management plan pointed out the marketing of animal products, the stockpiling of winter fodder (especially on islands, including unfavorable ferry transport conditions), the lack of a suitable slaughter service, the difficulty of finding contact with the landowner when wishing to lease land and the inappropriate design of support systems as sustainability problems. All of these issues need to

be addressed in a much more focused way, for example, by bringing together farmers and landowners, finding targeted training or flexible options for feed supply, and so on. Consideration should be given to setting up a separate system of consultants for managers of semi-natural communities.

An important part of the sustainable management of the coastal meadow is well-thought-out and planned production, including the possibilities of stockpiling and storing fodder. Photo: Silvia Lotman

Ideally, land managers should be so aware of nature values that they can be involved in easier monitoring and possible future performance-based agricultural measures. Measures are needed to protect herds and to reduce the number of jackals and foxes, and implement predator-resistant measures.

In most cases, the topic of the historical use of land and the introduction of protected species help to open the topic of semi-natural communities. Of the typical coastal meadow species, it would be advisable to compile easy-to-use support materials for coastal meadow managers and landowners. For the purpose of provision of information to land managers, the employees of the Environmental Board should have available information material consisting of modules, based on which each land manager could be provided with materials related to their particular meadow

(which species, their needs, etc.). In the case of coastal meadows, it is worthwhile to follow the outreach work carried out in the framework of the LIFE-Alvars restoration project for coastal meadows.

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