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Wooded meadows of Estonia: conservation efforts for a traditional habitat

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We provide an overview of the amount and ecological condition of wooded meadows throughout Estonia after significant changes in agriculture in the second part of 20th century. We also present the first attempt to estimate the success of recent conservation efforts for wooded meadows. Our analysis is based on recent exhaustive inventories. We found that Estonia, despite a decrease of the area in wooded meadows by two orders of magnitude during the 20th century, still has about 8400 ha remaining of which approximately 5800 ha are meadows with, at the least, an intermediate conservation value. The latter is directly dependent on mowing regime. Efforts to preserve wooded meadows include establishment of protected areas and financial support for mowing. The national conservation subsidy has been useful and supportive for wooded meadows, however the total amount of this subsidy has been small compared to the area that could be supported. The much larger funds of agri-environmental subsidies have largely not been available for wooded meadows. Moreover, there has been no record keeping about subsidisation of semi-natural grasslands using agricultural support schemes. Although the preservation of some good examples of wooded meadows in Estonia seems guaranteed, further degradation of this valuable habitat type on a national scale is very probable.

Key-words: abandonment, agricultural subsidies, conservation, diversity, grassland, management, restoration, wooded meadow

Introduction

The impact agriculture has had on ecosystems and biodiversity is two-sided (Sammul 2006). On one side, agriculture has been one of the main reasons for land transformation, habitat loss and fragmentation (Dobson et al. 1997, Vitousek et al. 1997, Pimm 2001, Hodgson et al. 2005), while on the other, traditional and extensive agriculture has created landscapes and habitats that are, at least in some cases, diverse and species rich (Hæggström

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1983, 1990, Pimentel et al. 1992, Sammul et al. 2000, Kull et al. 2003). One remarkable example of such ecosystems is a wooded meadow. This ecosystem has the highest diversity among the plant communities of Europe – challenging, on a small scale, the species density of tropical rain forests (Kull and Zobel 1991, Kukk and Kull 1997; see Table 1) – whilst simultaneously being a result of centuries-long utilization as an agricultural system. Thus, wooded meadows are a landmark of how moderate human influence can enrich nature (Kull et al. 2003). The conservation value of wooded meadows is well recognized, and they are included as a priority habitat into the EU Habitats Directive (92/43/EU) while on national level the Nature Conservation Act also prescribes protection of semi-natural grasslands.

The wooded meadow is a semi-natural habitat type. This implies that traditional continuous moderate agricultural management by mowing or grazing is needed for its preservation (Hansson and Fogelfors 2000, Myklestad and Sætersdal 2004, Imrichova and Vrahnakis 2005). Plant communities similar to wooded meadows were, during the Middle Ages, quite common throughout the Europe (Schama 1995) concentrating mostly in the region around the Baltic Sea and the mountains and hillsides of central and southern Europe (Kull et al. 2003). However, nowadays, the low-intensity management of grasslands does not provide sufficient economic profit (Hodgson et al. 2005). Therefore these sites have been largely abandoned all over Europe (Rosén 1982, Willems 1983, Bakker 1989, Poschlod et al. 1998) including Estonia (Sammul et al. 2000, Kukk and Sammul 2006), which consequently has lead to loss of this habitat type and corresponding biodiversity.

Owing to a large scale of abandonment of wooded meadows and the following vegetation changes (Hansson and Fogelfors 2000, Mitlacher et al. 2002) nature conservation has emphasised the importance of active preservation measures and even the restoration of wooded meadows in Estonia (Mägi and Lutsar 2001). However, formerly abandoned wooded meadows cannot easily be restored, because many of the meadows' plant species do not have persistent seed banks and immigration of species over large distances between fragments of wooded meadows is relatively slow (Stampfli and Zeiter 1999). The well-preserved wooded meadows should, therefore, be given a high conservation priority (Pärtel et al. 2005).

There are a few nature conservation and agricultural programs established with the aim of supporting the maintenance of semi-natural grasslands (including wooded meadows). However, these schemes were launched without a proper initial analysis of the condition and distribution of wooded meadows in Estonia. These types of analyses were not possible at the time because there was not enough available information concerning the distribution aspect. Only recently has the effort put into making an inventory of the wooded meadows (Kukk and Kull 1997, Luhamaa et al. 2001) yielded a sufficiently complete database. Therefore, so far an extant Estonian-wide summary of the distribution and of the environmental and management conditions of wooded meadows is not available. Furthermore no analysis has yet been carried out to determine whether the support schemes for conservation and maintenance of wooded meadows have been successful. We will in this review provide the assessment of the current status of wooded meadows as an important agriculturally created habitat in Estonia. Our aim is to evaluate ecological situation of wooded meadows, to estimate the development of wooded meadows and trends in their current management. We will assess the contribution and success of the support schemes established to enhance the management of wooded meadows.

Material and methods

Study area

Estonia is located at the eastern coast of the Baltic Sea. Wooded meadows, at the peak of their distribution at the beginning of the 20th century, were widespread all over the Estonia reaching in total about 850,000 ha (including wooded pastures) (Laasimer 1965, Kukk and Kull 1997), about 18%

Vol. 17 (2008): 413–429.

of the area of Estonia. At that time the extent of cultivated grasslands was not large and over 90% of grasslands used in agriculture were semi-natural grasslands (Jaska et al. 1940).

Throughout the 20th century the area of wooded meadows has constantly decreased in Estonia (Fig. 1). This has been caused by enforced collectivisation (the complete prohibition of privately owned farms and the establishment of collective farms) after Soviet invasion to Estonia and consequent reorganisation of agriculture (Viiralt and Lillak 2006) and later on by period of industrialisation of agriculture and by period of abandonment of seminatural grasslands (Kukk and Kull 1997, Sammul et al. 2000). Abandonment had, in most of the Europe, started earlier (Diekmann 1994, Baldock et al. 1996) than in Estonia, but here, it did not become prominent until the late 1960s, when the intensification of agriculture drastically increased the amount of cultivated grasslands. Large amount of natural grasslands also were drained, ploughed and fertilised, and new species were introduced to increase the productivity (Kukk and Kull 1997). Moist grasslands (e.g., swamps and floodplain grasslands) and wooded meadows were among first semi-natural grasslands to be abandoned. By now, the wooded meadows are mainly distributed in western counties of Estonia (Fig. 2) where soil conditions are unfavourable for intensive agriculture (except for pastoral use) and hence the pressure for amelioration of the land has been weaker.

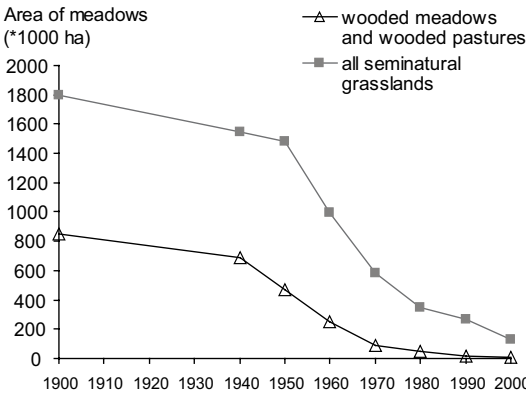

Fig. 1. Dynamics in the area of wooded meadows and wooded pastures compared to the dynamics of all semi-natural grasslands during the 20th century (based on data by Kukk and Kull 1997; Sammul et al. 2000; Kukk and Sammul 2006; and current study).

The decrease of wooded meadows received considerable attention from nature conservation in the end of 1990s. Several wooded meadows were restored and an effort was made to restart their management. In 1996 financial support scheme was established in the Matsalu Nature Reserve for farmers who either mowed or grazed semi-natural grasslands. The success of this test led to the establishment of a national level nature conservation subsidy scheme in 2001 (Lotman 2004). Subsequently, with implementation of Common Agricultural Policy in Estonia also agricultural incentives were introduced, aimed at the management of semi-natural grasslands (incl. wooded meadows).

Despite the drastic decline, there are still several highly valuable wooded meadows left in Estonia (see Table 1). Among these are two habitats (Laelatu and Vahenurme) where over 70 species of vascular plants have been found on 1 m^2 plot, and there are five more meadows where the respective number exceeds 60. The diversity of wooded meadow types is also noteworthy, as they can occur on various vegetation types (Paal 1997). The most common are dry and mesic calcareous boreonemoral wooded meadows, and the most species-rich among those is the *Filipendulo-Seslerietum coeruleae* assocation (Kukk and Kull 1997). Quite similar, but less productive and less species rich are wooded meadows on alvars, which are quite rare. One of the most severe declines has occurred in paludified wooded meadows (Kukk and Kull 1997), probably due to management difficulties and the low nutritional quality of forage, but partly also due to the drainage and melioration. The wooded meadows on floodplains can sometimes be quite large, and due to a much sparser tree layer and the effect of flooding are quite different from other types of wooded meadows (Klein et al. 2004).

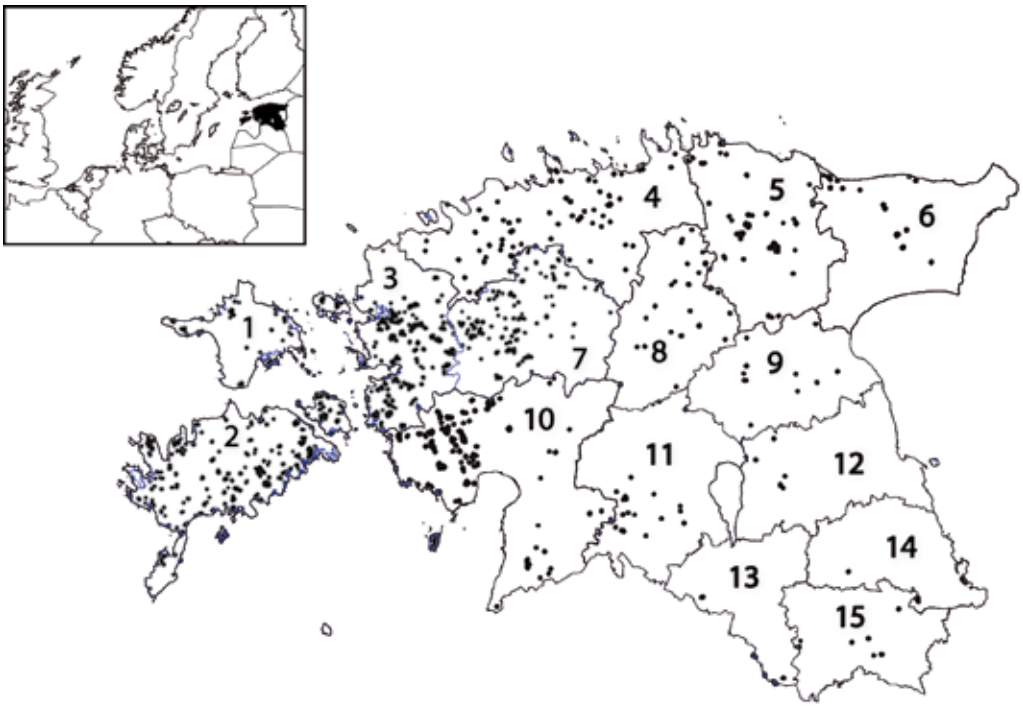

Fig. 2. Distribution of wooded meadows of Estonia. Numbers refer to counties and are labeled as follows: 1 - Hiiumaa, 2 - Saaremaa, 3 - Läänemaa, 4 - Harjumaa, 5 - Lääne-Virumaa, 6 - Ida-Virumaa, 7 - Raplamaa, 8 - Järvamaa, 9 - Jõgevamaa, 10 - Pärnumaa, 11 - Viljandimaa, 12 - Tartumaa, 13 - Valgamaa, 14 - Põlvamaa, 15 - Võrumaa.

Data on wooded meadows

Our analyses of the current distribution and status of wooded meadows are based on data from two different state-wide GIS-databases (see also Kukk and Sammul 2006).

The database of Estonian Semi-natural Communities' Conservation Association

The database of semi-natural grasslands held by Estonian Semi-natural Communities' Conservation Association (ESCCA) is the outcome of various inventories carried out since 1995, wherein the data about wooded meadows is mostly a result of the following audits.

A) Inventory of wooded meadows in western Estonia in 1995–1996 (Kukk and Kull 1997). The areas included in the inventory were based on the analysis of previous research on wooded meadows (including an attempt to carry out an inventory in 1986) and on public queries about possible locations of wooded meadows.

B) Inventory of wooded meadows, coastal and alluvial grasslands and alvars in 1999–2000 (Mägi and Lutsar 2001). The selection of areas to be included in this inventory was based on an inventory of semi-natural grasslands on agricultural land in 1978–1982 (Aug and Kokk 1983).

C) Inventory of all semi-natural communities in the counties of Läänemaa (Luhamaa et al. 2001) and Raplamaa in 1999–2001. This inventory attempted to be a locally thorough version of the country-wide inventory B (see above). Thus, all hints about possible locations of sites of interest were inventoried.

Vol. 17 (2008): 413–429.

Table 1. Examples of biodiversity of Estonian wooded meadows.

Diversity pattern of Estonian wooded meadows	Source
Habitat type level	
List of Estonian wooded meadows plant species comprises over 600 species of vascular plants (more than 40% of Estonian flora);	Kukk and Kull 1997
Wooded meadows have up to 225 vascular plant species per community;	Kull and Zobel 1991, Kukk and Kull 1997
Wooded meadows comprise 56 species of protected vascular plants (30% of protected plant species);	Kukk and Kull 1997
Approximately 1/3 of red-listed species prefer wooded meadows as a habitat;	Lilleleht 1998
121 species of spiders are found in wooded meadows of Matsalu National Park;	Luhamaa et al. 2001
Wooded meadows, compared to other biotopes, are more diverse in weevils (*Curculionoidea*) and terrestrial snails;	Kukk and Kull 1997
Site level	
Laelatu wooded meadow has up to 76 species of vascular plants per 1m², 42 species per 400 cm^2 and 25 species per 100 cm^2;	Kukk 2004; Kull and Zobel 1991
There are 7 wooded meadows in Estonia where over 60 species of vascular plants have been recorded on 1m^2 relevé	Kukk, T. and Sammul, M. unpublished
The species list of *Macrolepidoptera* of Laelatu wooded meadow consists of 418 species;	Kukk and Kull 1997
Wooded meadows have up to 100 moss species per site (including forest patches, stones, etc);	Ingerpuu et al. 1998
The list of ectomycorrhizal fungi of Tagamõisa wooded meadow comprised 88 species.	Tedersoo et al. 2006

D) In recent years (2002–2006) a number of additional sites have been inventoried during the continuous update of the database. One major source of new information has been the inventory of sites applying for the national subsidy for the management and restoration of semi-natural grasslands. ESCCA visited all sites, which landowners applied for the subsidy but that were not included in the database during previous inventories.

During the inventories a detailed description of each wooded meadow was compiled (see Luhamaa et al. 2001, p. 82) focusing on information needed for evaluation of the ecological condition and conservation value of the habitat. In current analysis we use following characteristics: habitat type according to the Estonian vegetation classification (Paal 1997); the coverage of tree layer (incl. species composition); the area influenced by shrub encroachment and the area with open meadow (estimated as a percentage of area); the time of the last mowing (has never been mowed, mowing ended more than 10 years ago, ended 4–10 years ago, mowed 1–3 years ago, mown in current year); suitability for mowing (unsuitable, poor, moderate, good); humidity of the site (dry, mesic, occasionally wet, flooded, paludified, marsh area); conservation value (high, intermediate, low). Conservation value mostly estimates the condition of a particular wooded meadow in terms of how well its' horizontal and vertical structure as well as vegetation is preserved. High conservation value is ascribed to the sites with particularly well-preserved, typical, well managed, and large plant communities. All visited sites were mapped during the fieldwork on the scale of 1:10,000 and later on the maps were digitalized on the basis of aerial photographs.

The database of Natura 2000 site selection inventories

The process of Natura 2000 site selection for Habitats Directive Annex I habitats (Paal 2001, 2004) took place in Estonia in 2001–2004. The site selection process relied initially on the existing GIS-databases of habitats from which the database of ESCCA was the most prominent one in respect of semi-natural communities. Two additional inventories had recorded the presence of wooded meadows: the inventory of woodland key habitats, 1999–2002 (Andersson et al. 2003) and the inventory of wetland habitats, 1997 (Paal et al. 1999). Additionally, information about the distribution of wooded meadows available to the local nature protection experts was used.

During the inventory the habitat type of the site was identified and ecological condition evaluated. The evaluation of the habitat status on the site comprised: total coverage and composition of tree layer and brushwood; representativity of the habitat; the size and the structure of the habitat; perspective to preserve the structure and functions in future; the possibility and need for restoration activities; overall importance for conservation. The evaluation of representativity of the habitat in the Natura 2000 inventory matches the conservational value of community assessed in ESSCA inventory. The habitats were mapped during the fieldwork on the scale of 1:10,000 to 1:20,000.

Table 2. The distribution of Estonia's wooded meadows and their conservation values.

County	Number of wooded meadows	Area of wooded meadows (ha)	Proportion of areas with different conservation value (% of the area) [1]		
			High	Intermediate	Low
Harjumaa	77	467	27	39	24
Raplamaa	151	645	19	36	30
Läänemaa	211	2052	7	52	21
Hiiumaa	57	216	30	56	15
Saaremaa	300	2296	39	37	20
Pärnumaa	209	1680	30	40	26
Viljandimaa	20	88	0	66	20
Valgamaa	9	60	63	34	1
Võrumaa	9	17	42	55	3
Põlvamaa	4	66	0	85	15
Tartumaa	6	20	37	36	27
Jõgevamaa	16	56	24	54	19
Järvamaa	27	95	21	60	19
Lääne-Virumaa	76	556	37	44	9
Ida-Virumaa	21	114	6	48	8
Whole Estonia	1193	8428	26	43	21
Protected areas	428	2731	34	45	14

[1] Approximately 10% of wooded meadows had no conservation value marked in the database.

Vol. 17 (2008): 413–429.

Information on economic support for wooded meadow management

The maintenance and restoration of wooded meadows could receive support from two parallel support schemes: national conservation subsidies and agricultural subsidies, financed by respective EU mechanisms. We requested information from the administrators of the respective support schemes about the level of support wooded meadows have received. The Ministry of the Environment and the State Nature Conservation Centre provided us with the information about conservation subsidies paid in 2001–2006 in each county.

The administrator of agricultural subsidies prescribed with Common Agricultural Policy (CAP) and National Rural Development Plan in Estonia is the Estonian Agricultural Registers and Information Board (ARIB). The information about agricultural subsidies was obtained from ARIB year books (PRIA 2005) and by querying the specialists of ARIB.

Data analysis

The nature of the data included in the databases allows for only basic descriptive statistical tests for differences between different groups and correlations between different variables. We used one way ANOVA to test for the differences in area, in coverage of tree layer, in area with shrub encroachment, and in proportion of the area with open meadow between the groups of wooded meadows with different conservation value. The same test was used also to determine the dependence of shrub encroachment on mowing history.

We used the Chi-square (χ^2) test to determine the difference between the wooded meadows with different conservation value in the time of the last mowing, the suitability of the area for mowing, and the humidity of the site. A correlation analysis was used to estimate relationships between quantitative characteristics as well as between the distribution of the conservation subsidy between the counties, and the amount and quality of wooded meadows in each county. We used the Kolmogorov-Smirnov test for the assessment of the difference in the distribution of tree layer densities between meadows with different conservation values.

Results

Distribution of wooded meadows of Estonia

There are about 8400 ha of wooded meadows in Estonia according to the ESCCA and Natura 2000 databases (see Table 2). There are also about 4000 ha of wooded pastures, but knowledge about the distribution and ecology of wooded pastures in Estonia is scarce (Kukk and Sammul 2006) and we can not estimate the reliability of the information about wooded pastures in these databases. On average the size of a single wooded meadow is about 7 ha, but the largest habitats exceed 100 ha in size. The majority of wooded meadows, about 75%, in Estonia are dry and fresh boreo-nemoral meadows and the second most frequent vegetation type is that of paludified grasslands, which can be found on 10% of sites. Thus, wooded meadows in Estonia are predominantly mesic. The other vegetation types are represented on less than 2% of sites.

Wooded meadows are most numerous in the western part of Estonia – in Saare, Lääne and Pärnu counties, where about 72% of the area of Estonia's wooded meadows is located (Fig. 2). The counties differ considerably in both the abundance and quality of these habitats (Table 2) and this difference between the counties is statistically significant in all conservation value groups ($\chi^2>55$; $p<0.001$).

A high conservation value applies to 26% of all Estonia's wooded meadows, an intermediate value applies to 43% and a low conservation value to 21% (see Table 2), i.e. more than 60% of local stands still have a relatively well-preserved structure and floristic composition. However, only 32% of the area of Estonia's wooded meadows is located

in various protected areas (Fig. 3) and of these a high conservation value applies to about 34% and an intermediate value to about 45% (Table 2).

Ecological characteristics of wooded meadows

We find no correlation between the size of the wooded meadow and its estimated conservation value (R^2<0.002), although there is a slight tendency towards a positive relationship. The average conservation value of wooded meadows of a particular county does not correlate with the amount of wooded meadows in the county (R^2<0.045; N=15).

The tree layer of Estonia's wooded meadows is dominated by *Betula pendula* and *B. pubescens* (see Table 3). The most abundant, after the dominant pair, are *Quercus robur*, *Populus tremula*, and *Fraxinus excelsior*. There are some statistically significant differences in the relative abundance of different trees between wooded meadows of different conservation value (Table 3). *P. tremula* is never the most abundant species on wooded meadows with a high conservation value, whereas the abundance of *Picea abies* is considerably higher

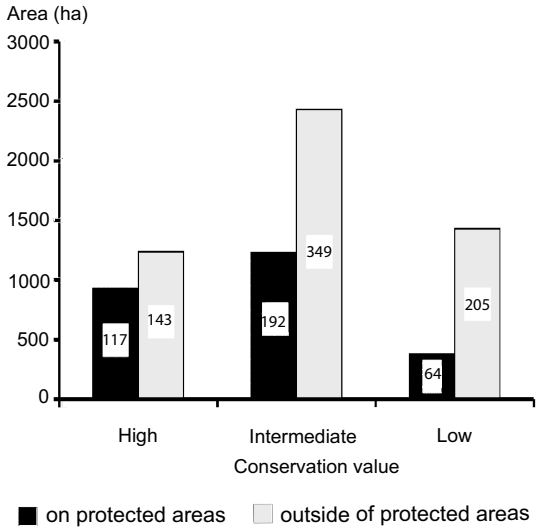

Fig. 3. Areas of wooded meadows with different conservation value located inside and outside protected areas. The quantity of wooded meadows is given inside the bars (there are 124 wooded meadows with the total area of 797 ha, which have no data about conservation value in the databases).

Table 3. The most abundant tree species on wooded meadows with different conservation value and the difference between classes of different conservation value estimated with the chi-square (χ^2) test. Ns – not significant.

Most abundant species in tree layer *	Conservation value of wooded meadows			χ^2	*p*-value
	Low **	Intermediate **	High **		
Betula sp.	48.0	47.0	44.0	0.2	ns
Querqus robur	15.0	19.0	20.0	0.7	ns
Populus tremula	10.0	9.0	0.0	9.6	<0.01
Fraxinus excelsior	10.0	8.4	6.6	0.7	ns
Picea abies	3.8	4.5	13.0	7.6	<0.05
Alnus glutinosa	3.1	3.9	9.8	4.8	ns
Alnus incana	3.1	2.1	0.0	2.9	ns
Pinus sylvestris	3.1	4.5	4.9	0.4	ns

* The most abundant species appearing on less than 2% of wooded meadows are: *Corylus avellana, Tilia cordata*, *Salix caprea*, *Padus avium*, *Ulmus glabra*, *Populus sp*, *Sorbus aucuparia* and *Acer platanoides*.

** Presented as percentage of all wooded meadows in respective group.

Vol. 17 (2008): 413–429.

on such sites. The coverage of the tree layer varies widely but mostly it is below 50%. The coverage of trees is higher in wooded meadows with a low conservation value than in meadows with an intermediate value (see Table 4) and in meadows with high conservation value, but does not differ between wooded meadows with intermediate and high conservation value. There are, nevertheless, high value wooded meadows with coverage of the tree layer up to 80%.

The wooded meadows with high conservation value have hardly any signs of shrub encroachment (Table 4). On only 1.5% of these meadows the area with shrub encroachment exceeds 10% of the meadow. There is a considerable increase in the proportion of the meadows influenced by shrub encroachment with a decrease in the conservation value of the site. 12.6% of wooded meadows with an intermediate conservation value have over 10% of their area influenced by shrub encroachment. On meadows with low conservation value, the respective changes have occurred on 14.5% of sites.

The conservation value is directly related to mowing. The relative amount of recently mown wooded meadows declines with the decrease of the conservation value of the site (Fig. 4 and Table 4). 62% of wooded meadows with a high conservation value are mown at the year of census whereas the majority of wooded meadows with a low conservation value (63%) were not mown for about 10 years or longer.

The suitability of an area to mowing differs between sites with different conservation values (Table 4). The conservation value is higher on meadows where the suitability to mowing is good. About 93% of wooded meadows with a high conservation value are suitable for mowing without the need for special preparations whereas about 38% of the wooded meadows with a low value and about 41% meadows with an intermediate value are not suitable for mowing without previous restoration efforts.

The suitability of the area to mowing also differs between the meadows with a different time of

Table 4. Average values of different ecological characteristics of wooded meadows (for discrete characteristics the most abundant class is presented) and statistical difference of the traits between classes of different conservation value. Statistical tests: F - Fisher's F based on one-way analysis of variance; χ^2 - chi-square test for discrete variables. Ns – not significant.

Characteristic	All wooded meadows	Wooded meadows with high conservation value	Wooded meadows with intermediate conservation value	Wooded meadows with low conservation value	Statistical test	*p* - value
Area (ha)	7.1	8.3	6.8	6.7	$F_{(2,1067)}=1.43$	ns
Coverage of tree layer (0-1)	0.4	0.3	0.4	0.4	$F_{(2,610)}=8.2$	0.0003
Proportion (%) of the area with shrub encroachment	15	5.7	12	27	$F_{(2,317)}=18$	<0.0001
Proportion (%) of the area with open meadow without the trees	29	38	30	19	$F_{(2,443)}=11$	<0.0001
Suitability for mowing	manually	good	manually	manually	$\chi^2_{(6)}=93$	<0.001
Presence of mowing	ended >10 years ago	current year	ended >10 years ago	ended >10 years ago	$\chi^2_{(6)}=122$	<0.001
Humidity regime	mesic	mesic	mesic	mesic	$\chi^2_{(2)}=1.8$	ns

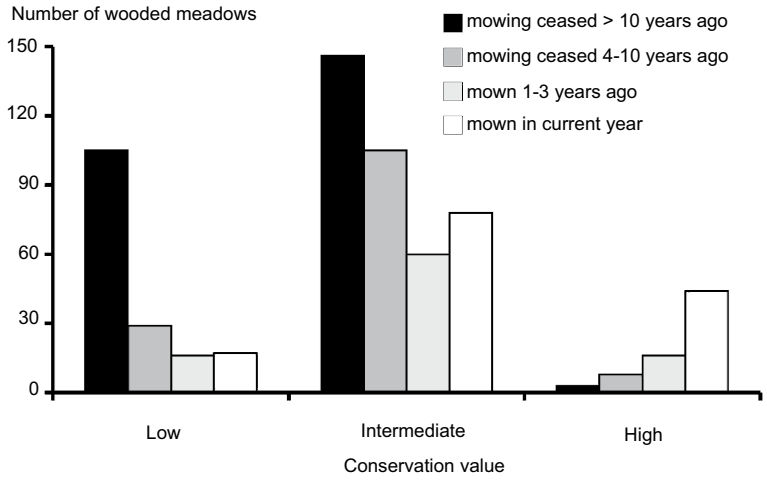

Fig. 4. The relation between conservation value of wooded meadows and mowing.

last mowing ($\chi^2_{(9)}$=173; p< 0.001). 76% of wooded meadows, which have not been mown for 10 years or more, are not suitable for mowing whereas 73% of wooded meadows, which have been mown during the last three years, are suitable for mowing without any need for preparation of the area. The pasturage of wooded meadows is casual, only about 2% of them are grazed.

The area with shrub encroachment on wooded meadows differs between sites with a different time of last mowing ($F_{3,316}$= 8,51; p< 0.001) in that the longer the meadow has not been mown the wider is the shrub encroachment.

Financial support schemes of maintenance of wooded meadows

The funding of the conservation subsidy of all Estonian meadows has been about 1.15 million Euros every year, out of which 0.15 million Euros have been used to support the management of wooded meadows. Every year between 2001–2006 about 1000 ha of wooded meadows have been mown with the support of the conservation subsidy and about 200 ha of wooded meadows and wooded pastures have been restored. These areas do not vary much between the years and there is no statistical significance in the slight increase of the area mown every year, hence the area of restored wooded meadows in any given year does not reflect in the area of mown meadows of the next year.

The proportion of the area of wooded meadows, which receives the conservation subsidy, differs between counties and in the majority of cases is between 5% and 20% (Table 5). There is a positive correlation between the area of wooded meadows in the county and the area receiving the conservation subsidy in the county (R^2>0.62; p<0.001). The proportion of the area of wooded meadows receiving the conservation subsidy also correlates with the proportion of high value wooded meadows (R^2>0.295; p<0.05 in all years in 2003–2006). There are some counties where the maintenance of wooded meadows has not been subsidised at all and in two counties – Saare and Lääne –, where the area of wooded meadows is the highest, on average 7% of the area of wooded meadows has been subsidised in 2003–2006 (see Table 5). The yearly average is that only 11–12% of all Estonia's wooded meadows have received a conservation subsidy. Out of all wooded meadows in protected areas the proportion of wooded meadows with subsidized maintenance is around 36% (Table 5).

As there is no separation between wooded meadows and wooded pastures in the official statistics for the restoration subsidy we can not accurately state the size of the area of restored wooded

Vol. 17 (2008): 413–429.

Table 5. The percentages of areas of wooded meadows receiving maintenance subsidy and restoration subsidy in different counties and on protected area as compared to whole Estonia.

County	Percentage of area receiving maintenance subsidy				Percentage of area receiving restoration subsidy[1]			
	2003	2004	2005	2006	2003	2004	2005	2006
Harjumaa	7.4	6.1	5.1	4.5	0.9	0	0.3	0.7
Raplamaa	14.7	14.5	13.6	13.2	0.3	0.7	0.3	0.3
Läänemaa	7.6	7.1	7.5	7.0	0.6	0.4	0.6	1.0
Hiiumaa	35.7	32.1	33.7	30.3	7.7	9.3	11.0	3.2
Saaremaa	6.0	6.6	7.9	7.4	2.6	1.7	1.7	3.0
Pärnumaa	19.7	17.6	19.0	19.3	2.1	3.1	3.2	0.7
Viljandimaa	4.6	4.9	8.9	8.2	0	4.4	0	0
Valgamaa	79.9	60.8	60.8	49.6	28.3	0	3.2	0
Võrumaa	2.5	0	0	0	0	5.9	0	0
Põlvamaa	0	0	0	0	0	0	0	0
Tartumaa	0	0	0	0	0	0	0	0
Jõgevamaa	26.4	19.3	14.7	13.6	6.4	3.5	0	0
Järvamaa	15.7	10.6	11.3	9.6	0.7	0	0.9	1.9
Lääne-Virumaa	11.5	12.7	11.1	23.4	0	0	0	1.2
Ida-Virumaa	8.4	7.9	8.5	8.5	2.2	5.7	0	0
Whole Estonia	11.7	11.0	11.6	11.9	1.8	1.6	1.6	1.5
Protected areas	36.1	33.9	35.7	36.7	5.7	5.0	4.9	4.5

[1] this percentage can include some wooded pastures, since the data of restoration subsidies for wooded meadows and wooded pastures does not discriminate between these habitat types.

meadows. The proportion of area of wooded meadows receiving restoration subsidy is, however, rather small (see Table 5) and does not exceed 1.8% of the aggregate area of wooded meadows.

The accounting procedure for agricultural subsidies distributed by the ARIB does not discriminate between separate grassland types (incl. cultivated grasslands). The ARIB's definition of a natural grassland (any grassland older than 10 years) or that of a permanent grassland (any grassland older than 5 years) does not correspond to definition of semi-natural grassland generally used in plant ecology. Thus, communities like old-fields and cultivated grasslands, which contribution to the conservation of biodiversity is minor compared to traditionally managed semi-natural grasslands, are applicable to the subsidy scheme. ARIB, as a result, is unable to provide any information about the area of semi-natural grasslands that received agricultural subsidies and does not keep a record of the amount of support given to different grassland types. It could be detected that agricultural producers applied for different support measures for permanent grasslands (which includes cultivated grasslands) for areas totaling 238,000 ha (2004) and 230,000 ha (2005) of which about 98% were approved and received support. However, among the supported grasslands in 2005, only 43,000 ha (PRIA 2005) or less than 20% of the total were older than 10 years (and still not necessarily semi-natural grasslands). As there is no more detailed information available, it is not possible to estimate

the exact area of wooded meadows or even of semi-natural grasslands that have received this support.

Circumstantial evidence, however, indicates that wooded meadows have not received much of the agricultural subsidies. The specific support measure for the management of semi-natural grasslands was scheduled to start in 2005 but it never was implemented as no funds were actually allocated to that particular measure (see also Nõuakas and Sammul 2006). Wooded meadows are in principle eligible for the following agricultural subsidies: support for less-favoured areas, support for environmentally restricted areas and agri-environmental support and single area payment. However, the areas with more than 50 trees per hectare are not eligible for agricultural support. An exception for this rule was applied in 2006 in four western counties of Estonia (Saare, Hiiu, Pärnu and Lääne counties). Still, only the management of these sites was supported where the coverage of the tree and shrub layer does not exceed 50%. Most of Estonia's wooded meadows are, therefore, ineligible for support from agricultural funds.

Discussion

Dynamics and current distribution of wooded meadows

Wooded meadows can be found in other regions besides Estonia, such as southern Sweden, southern Finland and the Alps, but they have decreased throughout the range (Hæggström 1983, Kukk and Kull 1997, Hansson and Fogelfors 2000, Mitlacher et al. 2002, Huhta and Rautio 2005). The same applies to Estonia – despite the relatively high amount of wooded meadows still found here their area has decreased by more than 90% during the 20th century (Fig. 1) and will probably continue to do so because of the lack of management.

Estonia's wooded meadows are, at present, mostly located in the western part of the country (see Fig. 2). We can not state, however, the degree to which this current pattern is concordant with historical distribution, as in all probability the pattern is the result of the different speed of degradation and transformation of wooded meadows in different parts of the country. The soils in eastern Estonia are much richer and consequently intensification of agricultural production has paid off. Western Estonia has traditionally had a poorer economy than the eastern region, partly due to the fact that the calcareous soils are relatively thin and drought-sensitive, which makes the area less suitable for intensive agriculture. Low intensity animal husbandry has, therefore, lasted longer and the semi-natural grasslands have persisted. However, even though the western part of Estonia is more species-rich, due to the calcareous soils and larger species pool, than eastern Estonia (Kukk and Kull 1997, Kull et al. 2004) there is no tendency towards western wooded meadows being systematically of higher quality. High conservation value wooded meadows are found also in other regions of Estonia (see Table 2) and larger amount of high value wooded meadows in western Estonia is only caused by a mass effect.

The loss of wooded meadows has drawn the attention of conservationists and ecologists leading to justified questions about the implications on species diversity. The estimation in Finland is that five species, which have as a primary habitat either wooded meadow or wooded pasture, are already extinct and sixty-three are threatened (Ikonen 2004). Considering that Finland has at most only 220 ha of wooded meadows, the number of threatened species is very high. No such analysis is available for Estonia yet, but 1/3 of species listed in Estonian Red Data Book (Lilleleht 1998) prefer wooded meadow as their habitat (Table 1). However, the decrease and even extinction of habitats should receive no less attention even though there is a fundamental difference between the loss of species and habitats: habitats can be restored (as long as their constituent species exist) while extinct species are not recoverable. On the other hand, the loss of the whole type of habitat or a specific type of ecosystem is more dangerous for biodiversity than the loss of a single species as the former affects many species simultaneously. Further research is required to determine whether

Vol. 17 (2008): 413–429.

the decrease of wooded meadows during the last century has already led to extinctions in Estonia. However, it is reasonable to assume that unless the loss of wooded meadow habitats stops, the extinction debt of wooded meadows will increase.

Ecological conditions of Estonia's wooded meadows

Our analyses show that the ecological quality of the majority of Estonia's wooded meadows is degrading. Even though there is a considerable amount of wooded meadows remaining with a high conservation value, shrub encroachment is not a rare occurrence even among these. The main value of wooded meadows – high diversity (see Table 1) – is a direct result of persistent, long-term, low intensity management (e.g., Kull and Zobel 1991, Myklestad and Sætersdal 2004). Our results confirm that mowing is essential to maintain the high value of wooded meadows. Almost all the parameters that somehow relate to ecological quality (e.g., shrub encroachment, coverage of the tree layer) are related to the presence of mowing. Once abandonment occurs, trees with a high growth-rate, such as *Alnus incana* and *Populus tremula* start to thrive instead of slow growing species like *Quercus robur*, which is common on high value meadows, and consequently the suitability of the area for mowing decreases. Other studies have shown that the cessation of management reduces the diversity of wooded meadows due to the changes in both ground layer (increased dominance of competitive species; e.g., Willems 1983, Tilman and Pacala 1993, Öckinger et al. 2006) and tree layer (reduced light availability; e.g., Newman 1973, Einarsson and Milberg 1999). The cessation of management, even for as short a time as 1–3 years, is enough to lead to the decline in the conservation value of a community (see Fig. 4). The current situation in Estonia is one of a cessation of management as perhaps only 12% (the meadows receiving a maintenance subsidy; Table 5) to 22% (those noted in the databases as being currently managed; Fig. 4) of wooded meadows are mown.

Lindborg and Eriksson (2004) suggest that the present-day variation in plant species diversity in semi-natural grasslands in Sweden is largely a legacy of land use from 50–100 years ago and plant species diversity patterns in the present-day landscape have been formed under conditions that no longer exist. They argue that the current locally high species richness is a legacy of historically higher connectivity and/or size of habitat; Helm et al. (2006) after their analysis of Estonia's alvars drew the same conclusion. We can argue that the lack of connectivity between the sites has not, so far, been an important factor for the degradation of Estonia's wooded meadows. The relatively high number of wooded meadows and close proximity with many other meadows, which contribute to plant dispersal, suggest that dispersal opportunities for plants are better in Estonia than in western parts of Europe. Moreover, the experiments of wooded meadows' restoration in Estonia (e.g. Zobel et al. 1996) and the national monitoring data of restored wooded meadows (Kukk and Sammul, unpublished) demonstrate a decent increase of diversity without any artificial introduction of species. This, however, does not mean that the problem with species migration and connectivity of wooded meadows may not be the problem in the future, especially if the conservation efforts fail to stop the decline of wooded meadows.

The degradation of the ecological situation and the decline of the area of wooded meadows could be reversed by means of ecological restoration. Such restoration is, considering the large number of meadows with signs of shrub encroachment and relatively high coverage of trees, greatly needed but abandoned wooded meadows cannot always be easily restored. The restoration of the structure of the tree layer is quite expensive (Nõuakas and Sammul 2006). The analysis of the management and restoration costs of abandoned meadows shows that restoration is twenty-five to thirty times more expensive than management, and furthermore that restoration costs increase by 50% every 4–5 years after abandonment occurs (Ehrlich 2004). Moreover, the recovery of the vegetation and diversity of a wooded meadow is a rather slow process. Due to the lack of persistent seed banks in soil

(Kalamees and Zobel 1998), the recovery of local species' richness depends on the dispersal of species from the surrounding landscape (Zobel et al. 1998). Gibson and Brown (1992) argue that the restoration of grassland vegetation on arable fields could take up to 100 years if the seed supply is in close proximity. Our own experience is that restoration of vegetation on wooded meadows takes two to ten times longer than has been the period of abandonment (unpublished). Moreover, this relationship is nonlinear increasing with increasing period of abandonment. There are therefore, if both economic and ecological restrictions to restoration are considered, rational reasons to maintain those communities while they still exist.

Conservation of wooded meadows

There are 2700 ha of wooded meadows located on protected areas (Fig. 3). This area accounts for about 32% of the aggregate area of Estonia's wooded meadows. Even though this proportion matches international commitments (20–60% should be protected according to the Habitats Directive), it is less than the amount of wooded meadows, which still comprise intermediate or high conservation value in Estonia (Table 2).

However, the establishment of protected areas *per se* is not enough to preserve these habitats, as there is the necessity to maintain the low intensity management of wooded meadows. Bearing in mind that the national conservation subsidy supports maintenance of wooded meadows on protected areas and that it should be possible to use various agricultural subsidy schemes to promote and regulate management of semi-natural grassland habitats outside of protected areas, we argue that the area of wooded meadows in protected areas is relatively satisfactory. But we would also argue that the management of wooded meadows in protected areas has not been at a sufficiently high level. The area of wooded meadows managed with the help of the national conservation subsidy is small – only 11–12% of the aggregate and only about 34–37% of protected meadows have been subsidized (Table 5). These proportions suggest that the national subsidy scheme is not sufficient to halt the decline of wooded meadows in Estonia. On the other hand, it appears that the proportion of the aggregate subsidy that the management of wooded meadows has received, 11% exceeds by a factor of two the proportion of the area of wooded meadows in all semi-natural grasslands (Fig. 1). Thus, the division of national support corresponds to the high priority of the habitats and all that is lacking is simply an adequate level of funding.

The much higher level of funding and an option to apply them outside of protected areas make agricultural subsidies an important component for motivation of landowners to manage semi-natural habitats. Unfortunately, so far the indications are that agricultural subsidies have had minor effect, if any, on the maintenance of wooded meadows. The decision to define the eligibility of grasslands for support schemes by the maximal amount of trees growing on that grassland instead of in accordance with agricultural activity (mowing or grazing) undermines the future of Estonia's wooded meadows. This is serious bureaucratic and financial pressure to change the traditional structure of wooded meadows where the tree layer very often exceeds 50% and has a distinctive mosaic of denser and more open patches (Kukk and Kull 1997). The regulation of agricultural subsidy would leave the denser patches without financial support despite the fact that they too are usually mown. Moreover, if the wooded meadow happens to be located in the "wrong" county (i.e. outside of Hiiu, Saare, Pärnu or Lääne county) it is automatically ineligible for the support, because it has too many trees. Hence, the feature that makes a wooded meadow, makes it also ineligible for agricultural support. There is a good reason, accordingly, to seriously doubt the adequacy of the regulation of agricultural subsidies for fulfilling the aim of preservation of biodiversity and natural heritage in agricultural landscape.

As the agricultural statistics do not enable to get information about support provided to semi-natural grasslands, we were not able to evaluate the efforts and effectiveness of subsidies paid on wooded meadows. The inadequacy of monitoring of the effect of CAP measures on biodiversity was noted al-

Vol. 17 (2008): 413–429.

ready by Kleijn and Sutherland (2003). They point out that only the UK and the Netherlands have put a considerable effort into investigating the effect of CAP implementation on biodiversity. Estonia has established a monitoring scheme of changes in rural areas but, to date, no results of their studies have become available.

Conclusions

Recent conservation measures and subsidy schemes have partly succeeded in reversing the degradation of some semi-natural plant communities and to stop the decrease of their aggregate area. However, this does not seem to be the case with wooded meadows. Continuing degradation is primarily caused by lack of management, which leads to abandonment and succession of the site into a forest. In current economic situation there is little hope that any other measure would be efficient in reversing the abandonment process than subsidising the management of wooded meadows.

Insufficient monitoring of the distribution of subsidies provided by CAP measures make it impossible to assess the success of the current EU funded incentives in preservation of biodiversity of grasslands and of agricultural heritage. Yet, the restrictions imposed during the determination of eligibility of a site for agricultural subsidies exclude most of Estonia's wooded meadows from receiving support and are in severe contradiction with the key objectives of rural development plans – to enhance biodiversity and support the preservation of natural heritage. This leaves only the nationally funded conservation scheme to contribute to the management of wooded meadows, but it alone is not sufficient to reverse the decline of wooded meadows. It is essential to remove ill-advised restrictions of agricultural subsidies on mowing and grazing of wooded meadows and to establish the adequate monitoring of distribution of agricultural subsidies in order to evaluate the effectiveness of these financial incentives.

Estonia has excellent and exhaustive databases about wooded meadows. This enables us to analyse the condition of wooded meadows and determine that there are still about 800 wooded meadows with a characteristic structure and that it could be possible to preserve 5800 ha of wooded meadows without major restoration efforts. This sets the goal for the future organisation of both conservational and agricultural incentives for the preservation of this unique habitat, which values are not merely biological but also cultural, historical, and educational. Estonia has a great chance to preserve wooded meadows that have been lost from most parts of Europe.

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Vol. 17 (2008): 413–429.

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