Grassland management survey on farms in Hungary

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In the spring of 2022, we conducted a nationwide survey on the state of grassland management in Hungary. The online survey was correctly completed by 1,027 people, providing insight into the 88,404 hectares (ha) of farms they cultivate, where approximately 159,815 adult animals (mostly cattle, sheep and goats) are kept. These grasslands represent 11.5% of the total grassland area in the country. The average grassland area for respondents was 86 ha, indicating that small and medium-sized farms were the main focus of the survey. Through our survey, we mapped the spread of the use of important farming and grassland management methods related to grasslands and the distribution of different grazing methods.

Introduction

Grasslands are dominant plant communities worldwide. As a result of their wide distribution, they cover 40% of the global land area (excluding Greenland and Antarctica) (Abberton et al. 2010, Stevens et al. 2022). They account for 34% of the European Union's agricultural area [1]. Grasslands provide numerous important ecosystem services, such as supporting rich biodiversity, supplying forage and living space for livestock and other herbivores, serving as habitats for pollinators, storing carbon, reducing soil erosion and regulating climate (Török et al. 2020). The greatest threats to grasslands are intensification and abandonment, invasive species encroachment and climate change (Liu et al. 2022).

Therefore, an increasing emphasis is expected on maintaining and managing permanent grasslands (Metera et al. 2010, Catorci et al. 2017). Grasslands play a key role in achieving climate-neutral farming through carbon sequestration (Steffens et al. 2009). Grasslands contain approximately 20% of the world's soil organic carbon (SOC), thus playing significant roles in global carbon and water cycles (Puche et al. 2019). Conant (2010) highlights the enormous potential for increasing carbon sequestration in grasslands. Studies have shown that carbon sequestration in grasslands can be significantly increased by improving grassland management practices, such as regular nutrient supply or rotational grazing, or by rehabilitating degraded grasslands (Szabó et al. 2021). Tessema et al. (2020) also found that different grassland management methods have a significant impact on soil organic matter. However, Conant et al. (2017) pointed out that the expected results strongly depend on climatic and soil conditions (Fuchs et al. 2010, 2019) as well as the vegetation composition of the area.

The FAO report, released in the summer of 2023, presents similar results and opportunities (Dondini et al. 2023). Based on Dondini et al. (2023) studies, they concluded that carbon capture into the soil of permanent grasslands is an effective and short-term feasible method. Increasing SOC can be facilitated by grassland management methods that increase the amount of root and plant residues in the soil. Among these methods, fertilization, irrigation, bred variety planting and agroforestry are commonly applied; nevertheless, the use of rotary grazing is equally important. According to the FAO report (Dondini et al. 2023) the introduced grassland management changes must be maintained for at least 20 years to achieve the desired SOC sequestration. The study investigated the amount of organic carbon stored in the top 30 cm of soil but emphasised that carbon build up also occurs in the lower layers, which was not considered in the model used.

According to Conant (2010), improving grassland management practices increases carbon uptake. However, this may require adequate nitrogen availability to facilitate plant growth and thus carbon sequestration in soil. The necessary nitrogen can also be provided in the form of bacterial nitrogen (e.g. through leguminous plants);

however, it may also be necessary to apply nitrogen-containing organic or inorganic fertilizers on agricultural grasslands (Liu et al. 2020). Notably, nitrogen introduced into soil promotes soil carbon sequestration but can increase methane and nitrous oxide emissions. The net greenhouse gas balance for each habitat should be calculated, which depends on whether the sequestration gains exceed other greenhouse gas emissions.

Spohn et al. (2023) highlighted the positive effect of plant diversity on soil carbon content, not through the amount of organic matter (plant biomass) entering the soil but through the quality of the organic matter. Plants grow taller in species-rich grasslands because of the competition for light. Increased stem contents of slowly decomposing structural carbon and less nitrogen.

In undisturbed ecosystems, the carbon balance is positive: through carbon uptake, photosynthesis exceeds losses from respiration (Luyssaert et al. 2008, Gough et al. 2008). However, permanent grasslands in temperate climates usually require some level of disturbance (Zimmermann et al. 2014), as most grassland communities have evolved through natural disturbances, usually with pasture herbivorous species (Valkó et al. 2014, Feurdean et al. 2018, Nerlekar−Veldman 2020).

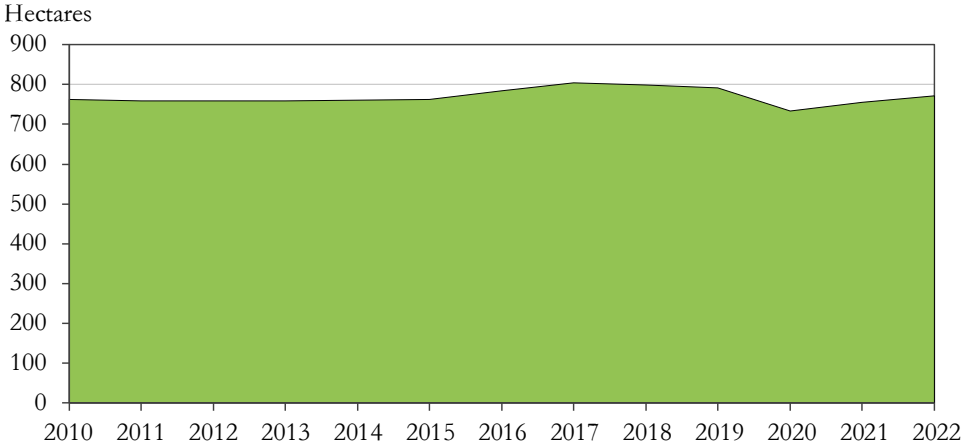
The most important role of such regular disturbances lies in preventing the spread of fast-spreading plant species, such as *Bothriochloa ischaemum* (Szentes et al. 2012, Bartha et al. 2013) and *Calamagrostis epigejos* (Házi et al. 2011, 2022, Fűrész et al. 2022) or shrubs, and preventing the formation of thick grassland felt, resulting in the formation of more species-rich and stable habitats (Szentes et al. 2007, 2008, Magyar et al. 2017). Absence of disturbances will lead to deterioration of the grassland or the development of alternative vegetation types, such as forests (Feurdean et al. 2018, Staal et al. 2018). Therefore, regular disturbance is necessary for the maintenance and possible rehabilitation of grasslands (Pykälä 2000). Widely feasible, sustainable and even profitable disturbance substitutes are grassland utilization techniques, such as professional grazing of livestock adapted to the specific vegetation of a grassland. However, mowing could also be a good solution to maintenance of grasslands, especially in wetter and more productive grasslands (Besnyői et al. 2012, Valkó et al. 2012). Consequently, owing to the lack of optimal disturbance, grasslands are often underutilized, causing adverse effects on the survival of stable plant communities; further, their condition and internal structure deteriorate, and less carbon dioxide is sequestered (Liu et al. 2015.).

A similar problem is caused by overutilization, i.e. disturbance beyond the optimal range of continued overgrazing is harmful to plant communities (Milchunas−Lauenroth 1993, Kiss et al. 2011) and soil carbon stocks (Conant–Paustian 2002). Follett et al. (2001) reported that if grazing resumes at the required rate and with appropriate grazing pressure/density after overgrazing, carbon stocks in grassland ecosystems can be rebuilt, thus sequestering significant amounts of atmospheric carbon dioxide.

Approximately 14.6% of the total area of Eastern Central Europe, Eastern Europe and the non-Mediterranean part of the Balkan Peninsula covers grasslands (Török et al. 2020). Although the proportion of grasslands in Hungary is less (~ 8.5%), it is still the second largest land-using sector of Hungarian agriculture. The permanent grassland areas did not fluctuate significantly between 2010 and 2022 (Figure 1). According to Article 43 of Commission Regulation (EU) No 639/2014 (Delegate), the reduction in the share of permanent grassland in Hungary should not exceed 5%; therefore, a significant reduction in the area of permanent grassland is not expected in the coming years.

Figure 1

Development of grassland area by the land use category 2010–2022, according to the survey of Hungarian Central Statistical Office (95% confidence interval)



Source: [2].

To maintain and rehabilitate permanent grasslands in the temperate zone of Europe, human utilization of these grasslands is almost always necessary. A significant part of the agricultural grassland area and grassland areas that participate in the Natura 2000 habitat protection programmes are privately owned in Hungary. Designated Natura 2000 grasslands may only be managed in compliance with the land use restrictions set out in the 'Government Decree 269/2007 (X. 18.) on the land use rules for the maintenance of NATURA 2000 grasslands'. The most important regulations are as follows: grassland areas must be used for grazing or mowing. Only legally allowed animal species can graze: cattle, sheep, goats, donkeys, horses and buffaloes. There are no regulations on animal density, but overgrazing of grasslands is prohibited. During grassland management activities, permanent damage to the surface is not allowed. Nutrients can only come from excrement from grazing animals. In the case of mowing, at least 5% and ≤10% of the area must be left

unmowed. Farmers can apply for support in designated areas. They are entitled to the Natura 2000 subsidy as long as they comply with the regulations. Grassland farming is carried out on farms of various sizes. Farmers and the farms they manage are the cornerstones of a country's agricultural structures. The current state of affairs is shaped by the combined effects of several factors, such as the biotic and abiotic environment and historical, cultural, political and social background (Ribeiro et al. 2021). For productive holdings to survive and operate economically and sustainably, we need to know the factors that distinguish farms from each other (Santos et al. 2021).

In most countries, including Hungary, the number of farms engaged in agricultural activities, types of farming and agricultural land use are regularly assessed. The Hungarian Central Statistical Office is collecting the Integrated Farm Statistics data in Hungary [2]. This assessment provides important information on the ratio of arable land, permanent grassland, orchards and vineyards. However, these data must be assessed on a national scale (which is currently available) and at the farm level. Hercule et al. (2017) developed a farm typification method, important elements of which were the share of permanent grassland within farms and the density of livestock on the farm. Enri et al. (2022) examined farms with permanent grasslands to preserve ecosystems created and maintained by permanent grasslands. In Europe, Enri et al. (2022) managed to isolate five biogeographical regions. Hungary belongs to the region of continental farms, which are characterised by the share of permanent grassland on farmed land between 10% and 30%, but unlike other categories, it is not possible to name a single animal species (cattle, small ruminants) or a typical density of animals associated with the utilized grassland. Because of the high variability of grasslands types and forms of utilization in the continental region, additional information about farms of this type is necessary.

As the greatest challenge of today is to implement environmentally friendly, sustainable and climate-friendly grassland management, we considered it important to collect information from farmers on the farming of permanent grasslands in Hungary. To the best of our knowledge, no similar survey has been conducted on the technological level of grassland management in Hungary, the grassland management work operations, the animals associated with grasslands and their grazing methods.

Material and methods

The tool of the survey was a structured, online questionnaire that the respondents independently answered and submitted online: computer-assisted web interviewing. The anonymous questionnaire, except the grassland location form, was of the multiple-choice type for evaluation and ease of summarising (with as many answer options as necessary).

The affected farmers met the questionnaire requirement through several channels: a printed and online call was published in the *Journal of Hungarian Livestock Breeders* and the Association of Hungarian Livestock Breeders and the Hungarian Sheep and Goat Breeders Association notified their members about the questionnaire via email and various forums (radio interview, advisory network and social media). The survey was conducted between 16 February 2022 and 1 April 2022. The number of evaluable respondents who duly completed and met all the criteria was 1,027. Only respondents who have permanent grassland on their farms and are located within the administrative boundaries of Hungary were considered.

During the survey, 21 questions were asked, sometimes with several sub-questions (see in Appendix). In our article, we present the results according to the following topics:

1. **Territorial distribution of respondent farmers**
   Settlers were required to indicate the location of their grassland.
2. **Utilized agricultural areas**
   We requested information on the size of the farm's permanent grassland areas (ha) and whether they were used as pasture, hay meadow or meadow. Definition of pasture, hay meadow and meadow are as follows: *pasture* = a permanent grassland area on which animals graze from spring; *hay meadow* = a permanent grassland area that is used exclusively for mowing; *meadow* = the first growth is mowed, and then, the permanent grassland is grazed. In addition, we asked for the size of the fodder cultivation land belonging to the farm (ha).
3. **Questions related to grassland management (farming practices other than mowing and grazing, e.g. cultivation and nutrient supply)**
   In Hungary, all farming practices on Natura 2000 grasslands, with the exception of autumn mowing, are prohibited or require approval. Consequently, we assessed the use of the following farming practices only for non-Natura 2000 grasslands: spike-tooth harrow use, aeration, chain harrow use, overseeding and manure and mineral fertilizer use.
4. **Questions about mowers (average yield and annual amount of mowing)**
   The average yield for Natura 2000 and non-Natura 2000 grasslands in hay value was asked.
5. **Grazing habits (method, number of rotations and length of grazing season)**
   We asked the method of grazing and the amount of grassland area it required. The main types of grazing methods in Hungary are continuous grazing, continuous grazing in fixed pens, pastoral grazing and rotational stocking. We asked about the average number of months of grazing season.

6. **Farm animals (per adult species)**
   We cannot define the livestock unit because we do not know how much area the farmers who keep several species graze per animal species.
7. **Satisfaction with the grassland (yield and crop stock)**
   For this type of issue, the separation of Natura 2000 grasslands was considered important. We enquired whether the farmer was satisfied with the crop stock and yield of the grasslands or whether the farmer considers his/her areas to be increasingly weedy or to reduce crop yields.
8. **Professional help and professional advice**
9. **History of farming (how many years have you been farming)**
   We were curious how long the respondents have been engaged in grassland management and pastoralist activities, as those who have accumulated sufficient experience can make well-founded statements on such important professional issues.

The data extracted during the survey were organised using Microsoft Excel. Data processing: tables and graphs and descriptive statistics (mean, standard deviation and standard error) were created using Microsoft Excel.

Results and discussion

1. Territorial distribution of respondent farmers

Based on questionnaires completed by farmers, 843 settlements were identified where farms contained permanent grasslands. These settlements could be classified into the four largest territories in Hungary (Table 1), covering 88.1% of the total area of the country. However, there were settlements from which several people submitted their answers; for example, 13 people from Hortobágy village, which is also famous for its extensive livestock husbandry, typically associated with grasslands.

Table 1

Share of grasslands surveyed per modern territory of Hungary

Name of territory	Km²	% (of the total area of Hungary)	Number of settlements identified in the survey
Alföld	52,000	55.9	445
Északi-középhegység	11,400	12.,3	144
Dunántúli-dombság	11,350	12.2	144
Dunántúli-középhegység	7,200	7.7	110
Nyugat-magyarországi peremvidék	7,100	7.6	0
Kisalföld	4,000	4.3	0

2. Utilized agricultural areas

All respondents had permanent grasslands, and 78% respondents also had arable lands. The total grassland area on the farms covered is 88,404 ha, representing 11.5%

of the country's permanent grasslands (Figure 1); in addition, 57,178 ha of arable land was also part of the farms. Figure A1 (see in Appendix) shows the distribution of farm grassland by size.

The average grassland size of Hungarian farms participating in this survey is ~86 ha, and 75% of farms had grassland under 100 ha in the size category. The most common is the size category between 10 and 49 ha, with a share of 32%. The proportion of small grasslands (<10 ha) is the second highest (26%), which is unfavourable from a professional perspective because it does not allow grazing livestock, but small grasslands are better suited for mowing. Despite this, many of them stock these small patches. Most of them also have arable land that they include in grazing (probably planted, temporary grasslands). Furthermore, 19.6% of the areas had more than 10 ha of arable area, and many of them had more than 50 ha arable area. A total of 43 farms (4.2% and 16.5% for those with grasslands less than 10 ha) do not have grazing animals among those with grasslands of <10 ha. They have grasslands between 1 and 6 ha in size. Most people with small grassland have 1–2 horses or sheep/goats (probably mostly goat farms) and do not graze their animals.

The total share of farms with more than 100 ha of grassland is 25%, of which 20% is in the size range of 100–299 ha. Farms with really large grasslands were only marginally accessed using the questionnaire. The utilization of grasslands on these farms is likely already complex; therefore, it takes too much time and preparation to complete the questionnaire, which only a few participants took part in.

Notably, 22% of farms had no fodder cultivation land in addition to permanent grasslands (see in Appendix Figure A2). Excluding such farms, the average area is 72 ha. A quarter of respondents produce mass fodder on arable land of <10 ha, and a third produces between 10 and 50 ha.

Regarding the use of grasslands, 79% of respondents had grazed grasslands, 76% had mowed grasslands and 50% had meadows (i.e. mowed and grazed). Based on the average area per respondent, the average grazing grassland area is 70 ha, hayfields 39 ha and meadows 40 ha.

The third sub-question of the grassland data concerned the Natura 2000 classification. Forty two percent of the 1,027 respondents did not have Natura 2000 grasslands, and 58% had Natura 2000 grasslands. In particular, 31% of farmers have only Natura 2000 grasslands. For farmers with grasslands within Natura 2000 sites, 54% exclusively had grasslands on their farms. This is particularly noteworthy because for them, only limited grassland management is possible, practically only the utilization and not the cultivation of the grassland.

3. Questions related to the management of non-Natura 2000 grasslands (practices other than mowing and grazing: e.g. cultivation and nutrient supply)

In investigation of the grassland management habits of the 710 farms examined, we found that livestock farmers performed the least grooming work in meadow areas

and 46% livestock farmers did not perform any operations at all (see in Appendix Figure A3). In the case of pastures and hay meadows, more than two-thirds of farmers used grassland management tools on their grasslands.

Autumn mowing and flailing on grasslands

Autumn mowing and flail mowing are the most conducted operations in all three uses (on pasture: 56%, on hay meadow: 48% and on meadow: 37%) to maintain proper farming practices. According to professional rules, autumn mowing should only be conducted in autumn, i.e. after the grazing season, in pastures and meadows, as no significant growth should occur on meadows after the last mowing. This act is conducted by 30%–40% of the farmers. Approximately 10% of farmers ventilate their grassland areas with grass slitter.

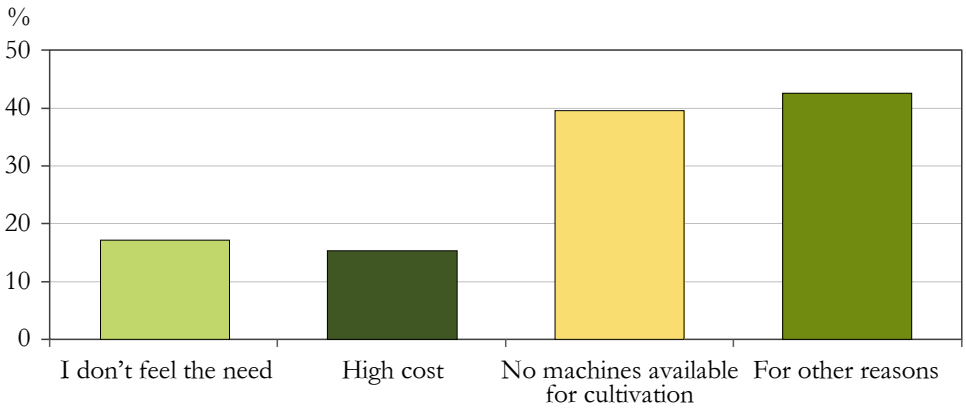
Overseeding on grasslands

Approximately 7%–10% of farmers have conducted overseeded grassland renovation on non-Natura 2000 grasslands in the last three years. The use of mowers is preferred because removing grassland growth without nutrient replenishment quickly extorts soil and reduces the amount of meadow hay, necessitating grassland renovation.

The reasons respondents cited for not using grassland management tools are notable (Figure 2). Given that the questionnaire was accessible to small and medium-sized farms at a significantly higher rate than large farms, the reasons included the lack of machinery for cultivation (40%) and the cost factor (15%).

Figure 2

Reasons for non-cultivation on non-Natura 2000 farms (n = 306)



Nutrient supply to grasslands

Two-thirds of the respondents did not apply organic fertilizers in the last three years (see in Appendix Figure A4). Half of the manure spreaders applied a small amount (<5 t/ha), which is negligible from a professional perspective given the low efficiency of the manure applied on the surface and its average nitrogen content of 0.5%. Only

5% of farmers fertilized their grasslands with a quantity of farmyard manure (>20 t/ha) that could have a meaningful impact (Harkess–Frame 1986).

Surprisingly, nitrogen, phosphorous and potassium (NPK) fertilization of grasslands is even more neglected among respondents than organic fertilization. Furthermore, 23% of farmers have used nitrogen fertilizers in the last three years (see in Appendix Figure A5). More than half of the farmers applying nitrogen fertilizers applied less than 100 kg of N-fertilizer, which is a very small dosage from a professional perspective, as it is no more than 30 kg/ha in active ingredients.

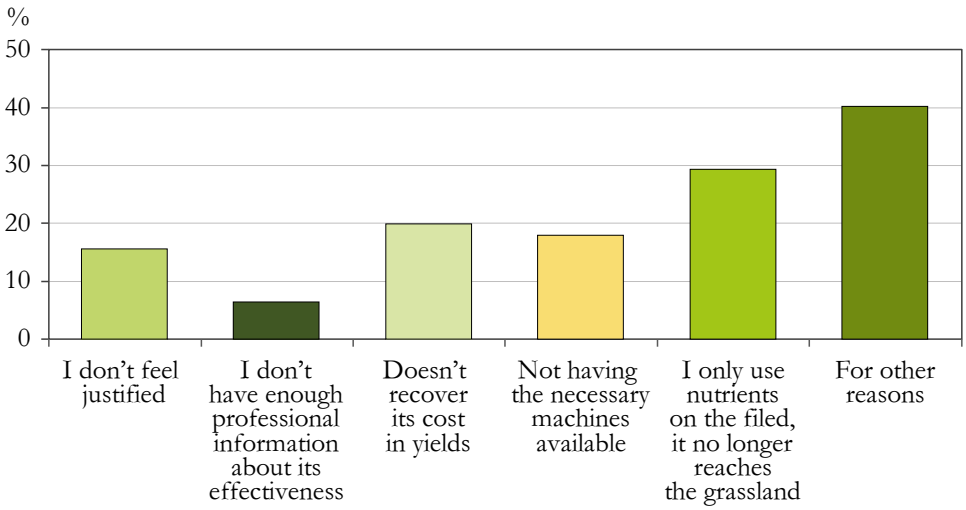
An important question is how much grassland farmers fertilize each year. Furthermore, 46% of respondents apply fertilizers annually.

Reasons for not fertilizing grasslands

We asked the reasons for not fertilizing grasslands; 473 respondents responded to this question (Figure 3). Regrettably, 40% of respondents cited other reasons, which does not reveal the real cause. Approximately 29% of farmers reported that fertilized fields and grasslands no longer possess sufficient soil nutrients. Furthermore, 20% of respondents believed that the cost spent on fertilizing grasslands was not recovered, and 18% did not even have machines for fertilization.

Figure 3

Reasons for non-fertilization (n = 473)



4. Questions about mowers (average yield and annual amount of mowing)

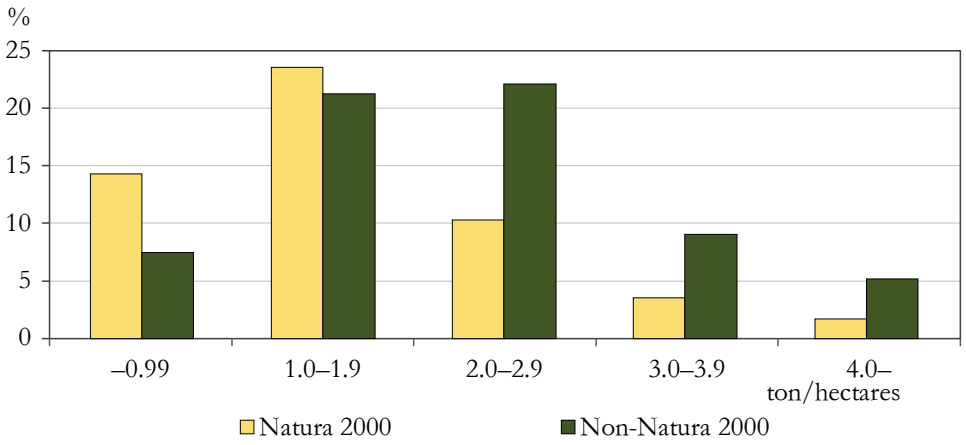
Approximately 65% of the 1,027 respondents have non-Natura 2000 hayfields, and only their data are considered in the assessment. One-third (33%) of haymakers have hay yields between 1 and 2 t/ha (Figure 4). The 34% ratio of farmers have hay yields between 2–3 t/ha is favourable (this is the median value), but it is also positive that

only 11% of mowers belong to grasslands with yields of less than 1 ton. Additionally, 22% of the mowers have high productivity (more than 3 t/ha).

Notably, the average hay yield on Natura 2000 hayfields (Figure 4) is less than 1 t/ha of hay on 27% of respondents' (549 people) hayfields, which is more than twice as high as in non-Natura hayfields. The share of mowers weighing 1–2 tons is 44% (this is the median value), which is also higher than in the other types. However, the proportion of mowers with a more favourable yield (2–3 tons) is significantly less, only 19%. The share of hayfields producing more than 3 tons of hay is only 10% compared with 22% for non-Natura 2000 haymakers. This can be attributed to the fact that all forms of fertilization are prohibited in Natura 2000 areas. However, regular mowing removes a large amount of organic matter from these grasslands. Yields are lower in nutrient-deficient areas.

Figure 4

Typical yields of Natura 2000 and non-Natura 2000 hayfields (in hay value)



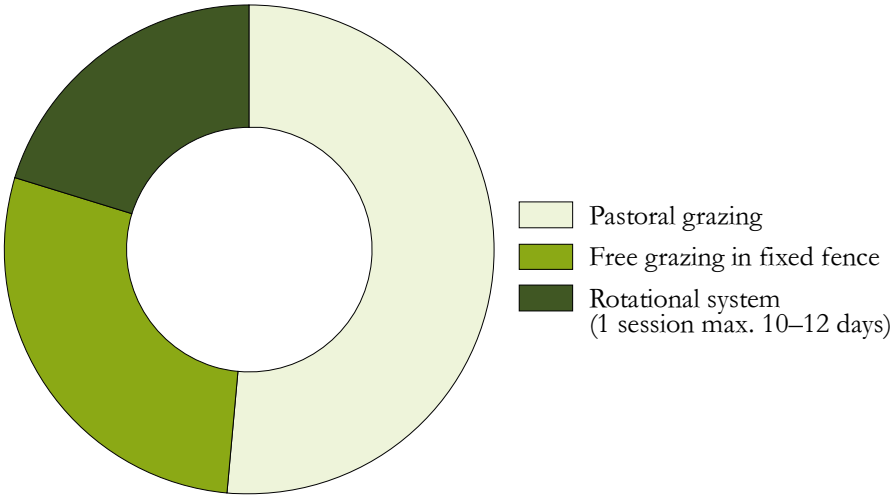
We were also curious about how many times respondents mow domestic grasslands annually. The result confirmed our expectations, as ecological conditions and the frequent lack of nutrient supply and irrigation do not allow anything else: 61% of respondents (902) mowed only once a year, 32% twice and 7% three times or more.

From the perspective of grassland management, animal husbandry and feeding, it is very important to know whether the amount of meadow hay produced is sufficient to feed the kept animals in winter or whether mass fodder must also be purchased in average years. The situation is unfavourable: 38% of surveyed farmers buy hay for their animals and only 12% can build up reserves.

5. Grazing habits (method, number of rotations and length of grazing season)
According to the responses on grazing methods, 42% of the farmers (corresponding to 51% of the grazed area of the farms) practice pastoral grazing and 33% of the farmers (corresponding to 28% of the grazed area of farms) graze in fixed pens, do not rotate sections and practice practically continuous grazing. Actually, only 25% of the farmers (corresponding to 21% of the grazed area of the farms) use rotational stocking, which is characterized by animals being kept for 10–12 days or less in 1–1 sections.

Figure 5

Share of grazing methods per grassland (n = 1,027)



Rotary grazing farmers (47%, n = 266) are likely to implement the rotation system professionally because they graze for at least four rotations in one season. Additionally, 30% of respondents grazed their pasture three times in one grazing season, and 18% grazed only twice.

Because the pastures are predominantly cattle and sheep, the grazing season should last for at least 200 days. In months, this represents a minimum of 6.5 months. In 2021, most farmers could still achieve this, as the average was 6.7 months. Those with an average season of less than 6 months (20% of respondents) may have problems with farm sustainability, as feeding in barns is much more costly than grazing.

6. Farm animals (per adult species)
Interestingly, half of the 1,027 respondents keep sheep and/or goats, i.e. small ruminants, and the other half keep cattle. In addition, 23% of the respondents keep horses, 6% have horses and 3% graze buffaloes. Other animal species kept are reported to be negligible (e.g. deer 1%), and 1% does not keep animals.

A total of 159,815 adult animal are kept by respondents on average over recent years (Table 2). The number of adult cattle is 98, and sheep and goats are 202. As the main activities for the maintenance of families, these numbers are borderline.

Table 2

Number of animals kept by respondents

Description	Livestock farmers (person)	Number of grazing animals (livestock)	Average livestock (number of grazing animals/livestock farmers)
Cattle	505	49,283	98
Buffalo	27	1,050	39
Sheep/goats	519	104,881	202
Horse	238	2,521	11
Donkey	65	696	11
Deer	6	1,135	189
Other grazing animals	18	249	14
Total	1,378	159,815	564

7. Satisfaction with the grassland (yield and crop stock)

A quarter of the respondents who manage non-Natura 2000 grasslands (825 people) are satisfied with their areas (see in Appendix Figure A6). Furthermore, 22% of the respondents saw grasslands becoming weedy. Dissatisfaction with yield is the most prevalent concern, with 469 people believing it so.

It is clear that Natura 2000 grassland managers (675) have a significantly low perception of their habitat-classified grasslands than grasslands without restrictive rules, although the differences are small. Satisfaction of yield and plant stock is only 14%–15%. However, 30% of the respondents think their protected grasslands are becoming weedy, and 67% consider the yield to be decreasing. Farmers experience decreased yields on both types of grasslands. This may be attributed to the changing precipitation distribution as a result of climate change. Overall, Natura 2000 grasslands are considered to have worse feeding conditions than non-Natura 2000 grasslands.

8. Professional help and professional advice

Almost half (47%) of the respondent farmers have not received professional assistance so far but would like to receive it, i.e. they confirmed our view on the need for knowledge-based grassland management advice (Table 3). Another important piece of information is that so far, a quarter of those who completed the questionnaire have received professional help and only 28% do not require it.

Table 3

Need for grassland management advice among farmers

Description	Number of respondents	Percentage distribution, %
Received professional grassland management assistance	255	25
Not received, but would claim	486	47
Has not received and does not feel the need	286	28
Total	1,027	100

9. History of farming (how many years have you been farming)

There are no significant differences between Natura 2000 and non-Natura 2000 grassland managers in history of farming respect (Table 4), and 60% of farmers have been using their grasslands for more than five years but less than 20 years. These data indicate that most respondents could be middle-aged farmers, neither too young nor old. Older farmers probably do not actively use the internet (the questions were available online).

Table 4

Duration of grassland farming

(%)

Grassland farming (year)	Non-Natura 2000 grassland	Natura 2000 grassland
1–5	20	17
6–10	27	28
11–15	13	14
16–20	20	18
21–30	17	17
31–40	2	2
>40	2	2
Number of respondents	768	633

Conclusions

Economic livestock farming is an important condition for the survival of grassland farms (Kemp–Michalk 2007), which involves allowing livestock farmers to produce most of their necessary feed themselves (Lebacq et al. 2013). This is not only an economic interest but also an environmental concern: we can significantly reduce the emissions from our transport if we use locally produced feed from grassland. Because dry, droughty weather is common in most parts of Hungary, forage production on arable land is of great importance in addition to grasslands (Stauder–Wagner 2001). Because of effective fertilization and the cultivation of early-harvest crops, arable land areas provide significant amounts of fodder, making farmers less vulnerable to weather variability. This is why 22% of the surveyed farmers did not have arable land. These farms are more vulnerable to reduced grassland yields caused by extreme

weather conditions. In a group of questions focused on the amount of meadow hay, 38% of farmers said they would buy some hay every year. In years of extreme weather, the economic vulnerability of these farms is considerably greater than that of farms that have the possibility of producing feed in the field.

In relation to grassland management methods, one-third of respondents (46% for meadow grasslands) did not undertake any grassland cultivation work. The fact that 48% of hayfields are flail cut in autumn suggests that only the first growth is mowed; then, with a long regeneration period, a significant amount of new growth is produced by autumn. To avoid a large amount of winter grassland coat and spring litter, farmers flail this growth in autumn. For those who do not perform autumn cutting, it is important to comb out their grassland coat in spring, i.e. they use a harrow. Non-Natura 2000 grasslands are allowed to apply fertilizers; however, 89% respondents did not apply any fertilizers to their grasslands in the last three years, and two-thirds of farmers did not apply organic fertilizers in recent years. The majority of the farms surveyed have extensive grassland management, as evidenced by the low intensity of cultivation work and nutrient supply. To preserve biological diversity, this approach is positive because extensification significantly increases grassland plant diversity. At the same time, farmers need to be compensated because extensive grasslands show considerably reduced productivity, as shown by low forage values and low nutrient availability (Valentin et al. 2023).

Meadow hay yields from fields vary between the Natura 2000 and non-Natura 2000 grasslands. The average yield for the Natura 2000 grasslands is 1.7 t/ha (±0.03), compared with 2.2 t/ha (±0.04) for non-Natura 2000 grasslands. The amount of mowing per year is usually 1 or 2. Mowing once a year is mainly caused by dry weather and a lack of nutrient supply and irrigation. This adversely affects the effectiveness of animal husbandry and poses significant economic risks. Owing to the increase in fuel prices, farms need to produce the feed they need for their animals and to be able to create a reserve base of at least 20%.

Responses on grazing show that only 25% of the farmers use rotational grazing. In pastures where at least four rotations are not performed, no professional grazing occurs because animals spend too much time in each section, while parts of the section are overgrazed by animals. In the survey, we observe an average of 3.7 rotations, indicating that more than half of the farmers could not form the sections well. From a professional point of view, correctly planned and executed rotational grazing is most beneficial. It improves grassland vegetation, regeneration and yield (Jordon et al. 2023). It can be used to improve organic carbon soil sequestration (Alemu et al. 2019, Schatz et al. 2020). From an economic and environmental perspective, it is in our interest that grassland farmers learn and apply this grazing method correctly.

Our survey mapped the spread of the most important farming and management methods related to grasslands and the distribution of different grazing methods.

However, we have only partially received answers to the reasons for these, and it would be worthwhile to conduct a survey to find them. As no survey of similar scale has been conducted on grassland farming in Hungary, the data presented here provide an excellent basis for comparison in future research. In a future study, we would like to analyse the differences between the Natura 2000 and non-Natura 2000 grasslands in more detail. Our research can be useful for the development of agricultural and support systems. It would be valuable to conduct another complementary survey that includes large farms to obtain a complete picture of grassland management practices on farms of different sizes.

In our opinion, it is a significant problem that 38% of the farmers included in the survey are not able to produce the feed needed for their animals. Low yields are caused by drought and inadequate agrotechnics. Farmers in non-Natura 2000 areas can be assisted by grassland management training and provisions supporting irrigation.

Acknowledgements

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Appendix

Questions of the survey

1) How many hectares of grassland and fodder cultivation area does the farm have?
2) How much of the utilized grassland is grazed, mowed and used as meadow (the first growth is mowed, and then, the permanent grassland is grazed)?
3) Do you have Natura 2000 grasslands?
4) What is the Natura 2000 grassland area (in hectares)?
5) What farming practices do you perform on non-Natura 2000 grasslands? a) autumn mowing (flail); b) spike-tooth; c) aeration; d) chain harrow; e) over seeding; f) grass roller; g) sward lifter; h) nothing.
6) If you don't make farming practices on non-Natura 2000 grasslands, why not? a) I do not feel the need; b) high cost; c) no machine available; d) other reasons.
7) How much nutrients have you applied to grasslands on average per year over the last three years?
8) What percentage of your permanent grassland areas do you fertilize each year?
9) If you do not replenish nutrients, why not? a) I do not feel justified; b) I do not have enough professional information about its effectiveness; c) does not recover its cost in yields; d) necessary machines are unavailable; e) I only use nutrients on the field; f) other reasons.
10) What is the average annual meadow hay yield for a mower?
11) On average, how many times a year do you mow for fodder production?
12) In an average year, is the amount of meadow hay harvested for animals sufficient?
13) What is the method of grazing on the farm and how much land is used?
14) Number of rotations for rotational stocking?
15) Number of grazing months (average per year)?
16) What type of grazing adult livestock do you keep on the farm?
17) Do you use a product with ivermectin as an active ingredient against external and internal parasites?
18) What is your general opinion on your grassland areas?

a) I am satisfied with the yield; b) I am satisfied with the plant stock; c) yields are decreasing; d) the area is becoming increasingly weedy.

19) Have you received any professional help with grassland management? a) received professional assistance in grassland management; b) not received but would claim; c) not received and does not feel the need.
20) How many years have you been using your grasslands?
21) Please list the municipalities where or near your grasslands are located.

Figure A1

Distribution of grasslands based on size classes (n = 1,027)

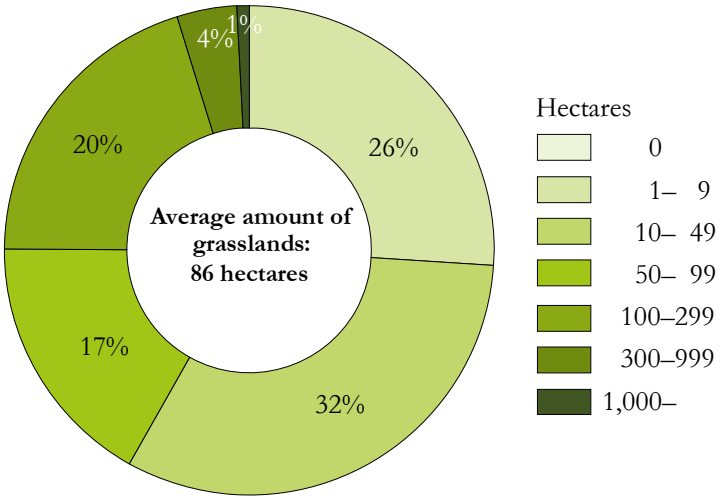


Figure A2

Share of respondents with fodder cultivation land (n = 1,027)

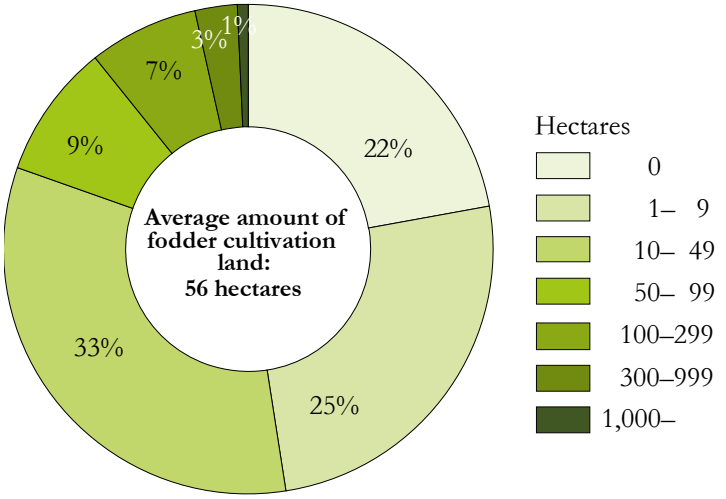


Figure A3

Cultivation methods on non-Natura 2000 farms (n = 710)

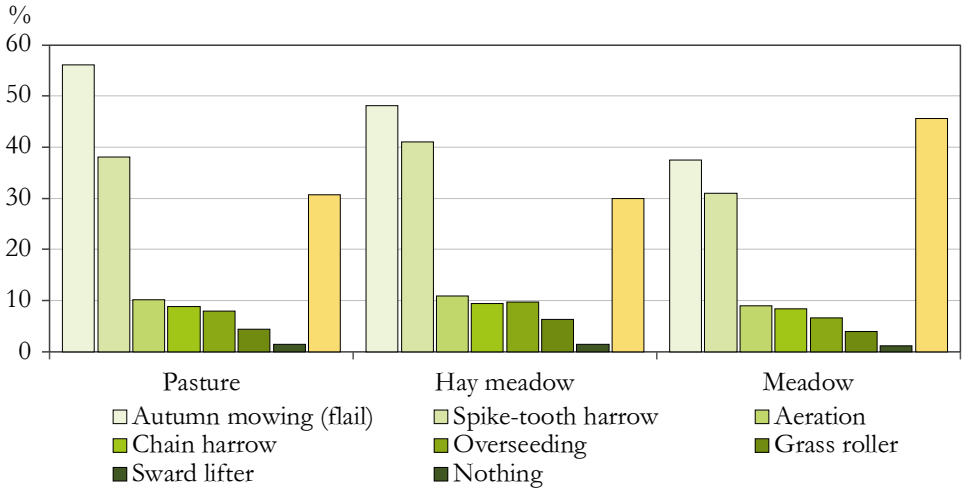


Figure A4

Manure used in the last three years (n = 709)

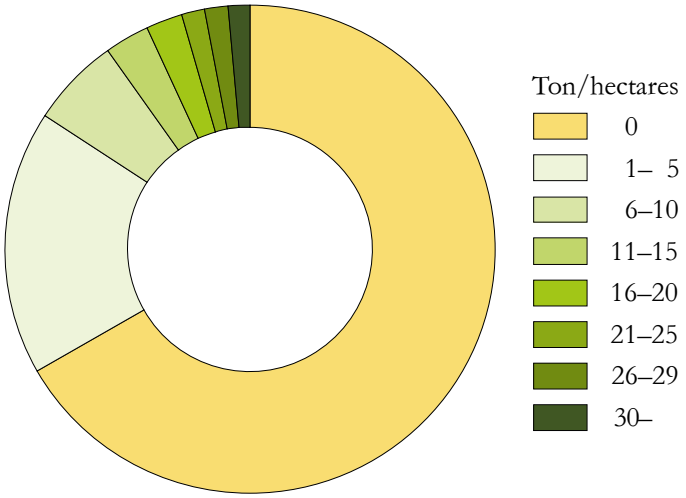


Figure A5

Nitrogen fertilization on grasslands (n = 709)

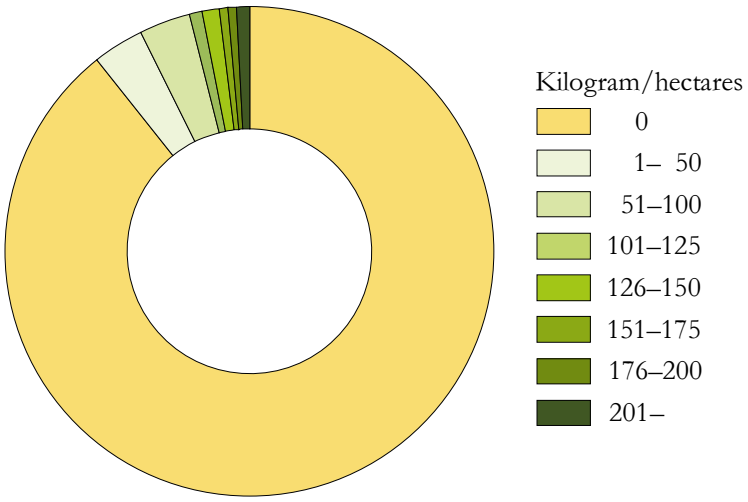
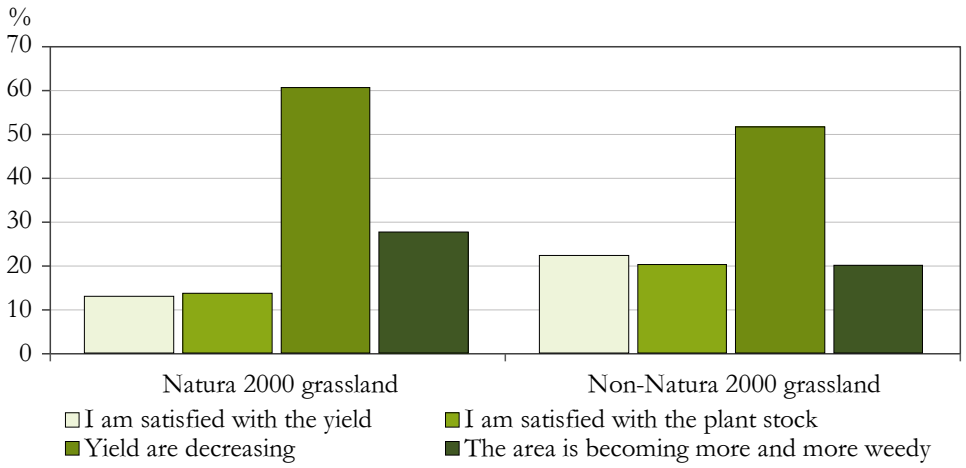


Figure A6

Results of the satisfaction questions (n = 1,027)



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