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The Impact of Management Practices on the Stability of Meadow Communities on a Mountain Slope

Volodymyr Kurhak [1], Lina Šarūnaitė [2,*], Aušra Arlauskienė [2], Uliana Karbivska [3] and Anton Tkachenko [1]

[1] NSC "Institute of Agriculture NAAS", Chabany, 08162 Kyiv, Ukraine
[2] Lithuanian Research Centre for Agriculture and Forestry (LAMMC), Instituto al. 1, 58344 Kėdainiai, Lithuania; lammc@lammc.lt
[3] Department of Forestry and Agrarian Management, Vasyl Stefanyk Precarpathians National University, 76018 Ivano-Frankivsk, Ukraine
* Correspondence: lina.sarunaite@lammc.lt

Abstract: Europe is currently experiencing a huge decline in biodiversity, with the greatest reduction observed in plant species associated with grassland areas. There is therefore a need for more appropriate land management practices that do not endanger native populations. The focus of our research was to assess the modification of the species composition of the phytocenoses found in sloping meadows in the mountain–forest belt using organic and mineral fertilization and by reseeding cultural swards (with a mixture of *Poaceae* or *Trifolium repens* L.), while applying various meadow usage methods: multipurpose use (cut four times) and hay production (cut two times). The highest botanic richness (41 species from 16 families and 90% of perennial plants) was observed from the multipurpose usage of the meadow, which resulted in 28.1% more species than the haymaking usage. With regard to species stability, the most appropriate fertilization of the meadows was $P_{30}K_{60}$, regardless of the usage method. Fertilization with nitrogen fertilizers improved the yield of meadows but reduced the number of species. When meadows were reseeded with *P. pratense* and *F. Pratensis* and fertilized for haymaking, the number of families and species reduced, with a 25% decline in the number of *T. repens* families. This study concludes that to maintain the richness of plant species in these grasslands, farmers must receive financial subsidies to limit fertilization and plant cultivated species.

Keywords: botanic composition; *Fabaceae*; fertilization; forbs; management types; mountain meadows; *Poaceae*

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1. Introduction

Biodiversity is declining in the world. In 40 years, the population of wild animal and plant species has decreased by 60%, and one million species are threatened with extinction [1]. This negatively affects nature and human well-being. The main reasons for biodiversity changes in natural habitats are intensive agricultural production, unsustainable use of resources, the spread of alien species, pollution, and climate change [2–4]. In human-created artificial monocultures, there is a pronounced decrease in species diversity and niches suitable for them, and increases in the amplitude and frequency of fluctuations in the abundance of populations are observed. Biodiversity cannot be preserved. Biodiversity decline is a relatively slow process; its negative effects appear gradually and are therefore not as clearly visible as other ecological problems [5,6]. Natural or seminatural grasslands are important elements of nature, creating habitats inhabited by native plant and animal species that adjust ecosystem services such as soil fertility, nutrient balance, and climate mitigation [7,8]. Biodiversity helps farmers sustain these populations while providing safe, sustainable and low-cost food and the added value and income needed for farm development and prosperity. The risk posed to farming by climate change is easing. In agriculture, a diversity of plants and animals is being replaced by a few of the most successful (in terms of productivity) species or breeds, and a decrease in the abundance of genetic variations within the species is becoming increasingly observed. Therefore, it is important to create favorable conditions for the cultivation of native plant species and varieties of local origin. The Food and Agriculture Organization of the United Nations (FAO) states that EU member states are committed to preserving the biodiversity of agricultural crops both within and around ecosystems and natural habitats (including on farms) as well as to the sustainable use of genetic resources, and it encourages agri-environmental measures to achieve this goal [9].

Native plant species are distinguished by a wide range of benefits: they do not cause conflict with populations of the same species growing nearby, are easily compatible with other native species, and attract target insect groups and other organisms. As a result, the general agroecological conditions and ecosystem services are restored and strengthened, and harmful effects on the environment and humans are reduced. These species reduce the yield of swards but are undemanding to the soil, effectively overshadow weeds, and have relatively low morbidity and a pronounced allelopathic effect [10].

In general, Ukraine has some of the best climatic and natural conditions for agricultural activities. Generally, priority is given to the development of new investment models, the renewal of agricultural machinery or the introduction of new technologies. Based on the experience of EU countries, the issues of biodiversity conservation, environmental protection, and climate mitigation are essential elements for consideration in order to increase the production from quality animal husbandry and crop production (IPBES 2019). The country has the potential to become a significant player in the field of agricultural products and bioenergy [1,11]. In the sensitive region of the Carpathians, this knowledge will enable farmers to change and adopt more appropriate land management practices as part of a wider transition to more sustainable food and farming systems.

To date, many of the studies conducted have focused on increasing the productivity of meadows [12–15]. Maintaining nonproductive properties and areas is particularly important to protect biodiversity (especially native populations) and increase the resilience of agroecosystems. Variations in the plant species composition in the mountain meadow phytocenoses of the Carpathian slopes and the productivity of meadows due to surface improvement measures are yet to be sufficiently studied. The purpose of our research was to establish the impact of modification of the phytocenoses in mountain slope meadows on management practice decisions.

2. Materials and Methods

2.1. Experimental Site and Conditions

Research on the transformation of the composition of plant species in the phytocenoses of the Carpathian mountain slope meadows during their surface improvement was conducted in 2017–2019 at a private farm (Krasnyk village, Verkhovynsky District, Ivano-Frankivsk Region, Ukraine, 48°14′ N, 24°74′ E)) located in the valley of the Black Cheremosh River on the slope of the second floodplain terrace (Figure 1). The soils on the experimental site have a brown sod and are deep, sandy, and loamy. At a depth of 0–20 cm, these soils are characterized by the following agrochemical parameters: pH 3.5, the sum of absorbed bases is 8.8 mg-equiv$\cdot$g^{-100}, hydrolytic acidity is 9.27 mg-equiv$\cdot$g^{-100}, aluminum 13.9 mg$\cdot$g^{-100}, mobile phosphorus 5.0 mg$\cdot$kg^{-1} and exchangeable potassium 8.5 mg$\cdot$kg^{-1} e. This region is characterized by a continental climate with temperate latitude meteorological conditions. The average annual amount of precipitation is 749 mm, ranging from 600 to 800 mm. About 73% of the annual precipitation falls during the warm season and 44% falls during the rainiest summer months (VI, VII, VIII). Most of the precipitation falls during the period of active grass growth in June, July, and August, which have an average monthly precipitation of 102–121 mm.

(**a**) (**b**)

Figure 1. Location of the experimental site, Krasnyk, Ukraine: (**a**) Map of Ukraine; (**b**) Haymaking and multipurpose usage in the experiment.

Weather conditions during the research years were typical and favourable for the growth of grasses in the experiment. However, it should be noted that the average annual temperature in these years, including during the period of active grass vegetation (May, June, July, and August) was 0.4–1.5 °C higher than the average long-term temperature. The average annual precipitation in these years ranged from 615 to 807 mm, and in May, June, July, and August, the average monthly precipitation ranged from 64 to 155 mm. In 2017 and 2018, this was below the average multiyear norm, but in 2019 it was slightly higher.

2.2. Experimental Design and Details

The studies were carried out in accordance with the requirements for methodological field experiments. The experimental design was established using an incomplete one-factor randomized block design with four replicates. The plot size for each treatment was 10 m^2 (accounting-8 m^2).

The investigation included two sward management practices: mineral and organic fertilizers and reseeded swards (factor A) and meadow usage methods (factor B), consisting of two cuts for hay production (haymaking use) and four cuts for grazing/silage (multipurpose use) (Table 1). According to the experimental scheme, reseeding with a mixture of *Poaceae* (*Phleum pratense* L., 6 kg·ha^{-1} + *Festuca pratensis* Huds., 10 kg·ha^{-1}), and *Trifolium repens* L. (6 kg·ha^{-1}) was carried out once in the spring of 2017 when the experiment was set up. Mineral fertilizers were applied in accordance with the experimental scheme: in particular, nitrogen (N) in the form of ammonium nitrate, phosphorus (P) in the form of granular superphosphate, and potassium (K) in the form of kalimagnesia. Mineral fertilizers were applied every spring after renewal of the sward vegetation (imitating a fertilizer spreader), and litter manure was applied to the surface annually in the spring after snowmelt. Mowing of swards for hay production was managed at the flowering stage of the dominant plant species in the meadow, and multigrazing mowing (to imitate pasture use) was carried out after hay production when the height of the sward was 15–20 cm. A small-sized trimmer was used for sward harvesting.

2.3. Analysis of Species Composition

The number of sward species in the meadow phytocenoses on the experimental site was investigated using management practices involving geobotanical description of swards before considering the harvest in accordance with DSTU 4687:2007 [16]. Herbaceous species density and floristic composition were determined based on a randomly selected 0.25 m^{-2} fixed area in four locations per experimental plot [17]. All samples were dried and weighed. The inventory of meadow plant species and their families was carried out in accordance with the modern nomenclature of taxa [18]. The data were statistically processed using one-factor analysis of variance. The significance of differences between the methods of treatment was estimated at the 0.05 probability level. The statistical analysis was performed using ANOVA version 3.1 software and SELEKCIJA software.

Table 1. Experimental design.

Management Practices	
Haymaking use (1)	Multipurpose use (2)
Without fertilizers	Without fertilizers
$P_{30}K_{60}$	$P_{30}K_{60}$
$N_{60}P_{30}K_{60}$	$P_{30}K_{60}$ + *Trifolium repens*
$N_{60}P_{30}K_{60}$ + *Poaceae* mixture *	$N_{60}P_{30}K_{60}$
Manure 15 t·ha^{-1}	Manure 15 t·ha^{-1}

Note. * Species in the mixture: *Phleum pratense*, 6 kg·ha^{-1} + *Festuca pratensis*, 10 kg·ha^{-1}.

3. Results

3.1. Floristic Composition of the Meadows and Its Variation

The initial grass cover before starting the experiment was grass–herbaceous consisting of wild *Poaceae* 64–65%, forbs 29–30%, and unseeded *Fabaceae* 6–9%. *Nardus stricta* represented 18–25% and was of little value in terms of fodder.

In 2017–2019, for both haymaking and multipurpose uses in the meadow without fertilization, the results showed that the ratio between *Poaceae* and forbs changed little on average compared with the first year of research, although there was a tendency for *Poaceae* to increase and for forbs to decrease (Table 2). The application of $P_{30}K_{60}$ fertilizers slightly increased the content of the wild perennial *Fabaceae* in the swards, by 2% for haymaking, and by 1% for multipurpose usage. The application of $N_{60}P_{30}K_{60}$ fertilizers, in comparison with $P_{30}K_{60}$ for haymaking use, resulted in an increase of 9% in the content of reseeded *Poaceae*, whereas the content of *Fabaceae* and forbs decreased by 5% and 4%, respectively. In certain instances, the share of *Poaceae* increased and *Fabaceae* decreased by 6% under multipurpose use.

Table 2. Botanical composition of sloping meadows according to management practices, % (average for 2017–2019).

Management Practices	*Poaceae*				*Fabaceae*		Forbs
	Total	Including *P. pratense*	Including *F. pratensis*	Reseeded	Total	Including *T. repens*	
Haymaking use							
Without fertilization	67	5	3	62	5	-	28
$P_{30}K_{60}$	66	8	3	55	7	-	27
$N_{60}P_{30}K_{60}$	75	9	4	62	2	-	23
$N_{60}P_{30}K_{60}$ + *Poaceae*	80	22	24	34	1	-	19
Manure 15 t·ha^{-1}	74	9	4	61	3	-	23
HIP_{05}, %	5	2	2	4	1		3
Multipurpose use							
Without fertilization	67	5	3	59	7	2	26
$P_{30}K_{60}$	66	5	3	58	8	2	26
$P_{30}K_{60}$ + *T. repens*	41	4	6	31	39	34	20
$N_{60}P_{30}K_{60}$	72	6	4	62	2	-	26
Manure 15 t·ha^{-1}	72	6	4	62	3	-	25
LSD_{05} %	5	1	1	4	2	2	3

A comparison between the meadows with manure application and those without fertilization revealed that the differences between the botanical groups were similar to those observed when $N_{60}P_{30}K_{60}$ and $P_{30}K_{60}$ were applied, although less pronounced. The application of manure increased the share of reseeded *Poaceae* by 7%, and decreased *Fabaceae* and forbs by 2% and 5%, respectively, compared with the meadow without fertilization for haymaking. In this case, the share of *Poaceae* increased by 5% and that of *Fabaceae* decreased by 4% under multipurpose use.

Further analysis of the results of the research on re-seeding the meadow in spring with the *Poaceae* grasses mixture containing *P. pratense* and *F. pratensis* together with the application of $N_{60}P_{30}K_{60}$ fertilizer for haymaking production showed the greatest changes occurred in the botanical composition of the grasses. The total share of *Poaceae* increased from 75% to 80%, a difference of 5% compared with the $N_{60}P_{30}K_{60}$ fertilizer application and the unfertilized meadow, and forbs decreased by 4% and 9%, respectively. With regard to the *Poaceae* grass botanical group, the total share of reseeded grasses increased to 46%, including *P. pratense*, which increased to 22%, and *F. pratensis*, which increased to 24%. In addition, the number of reseeded *Poaceae* grasses decreased by 28% compared to the unfertilized meadows and those to which $N_{60}P_{30}K_{60}$ fertilizer had been applied.

In spring, according to the averaged data from the three years, reseeded *T. repens* with the application of $P_{30}K_{60}$ fertilizer represented 34%, and Fabaceae increased from 8% to 39% or by 31% compared with the unfertilized meadow (34%). However, *Poaceae* decreased by 25–26% and forbs by 6%.

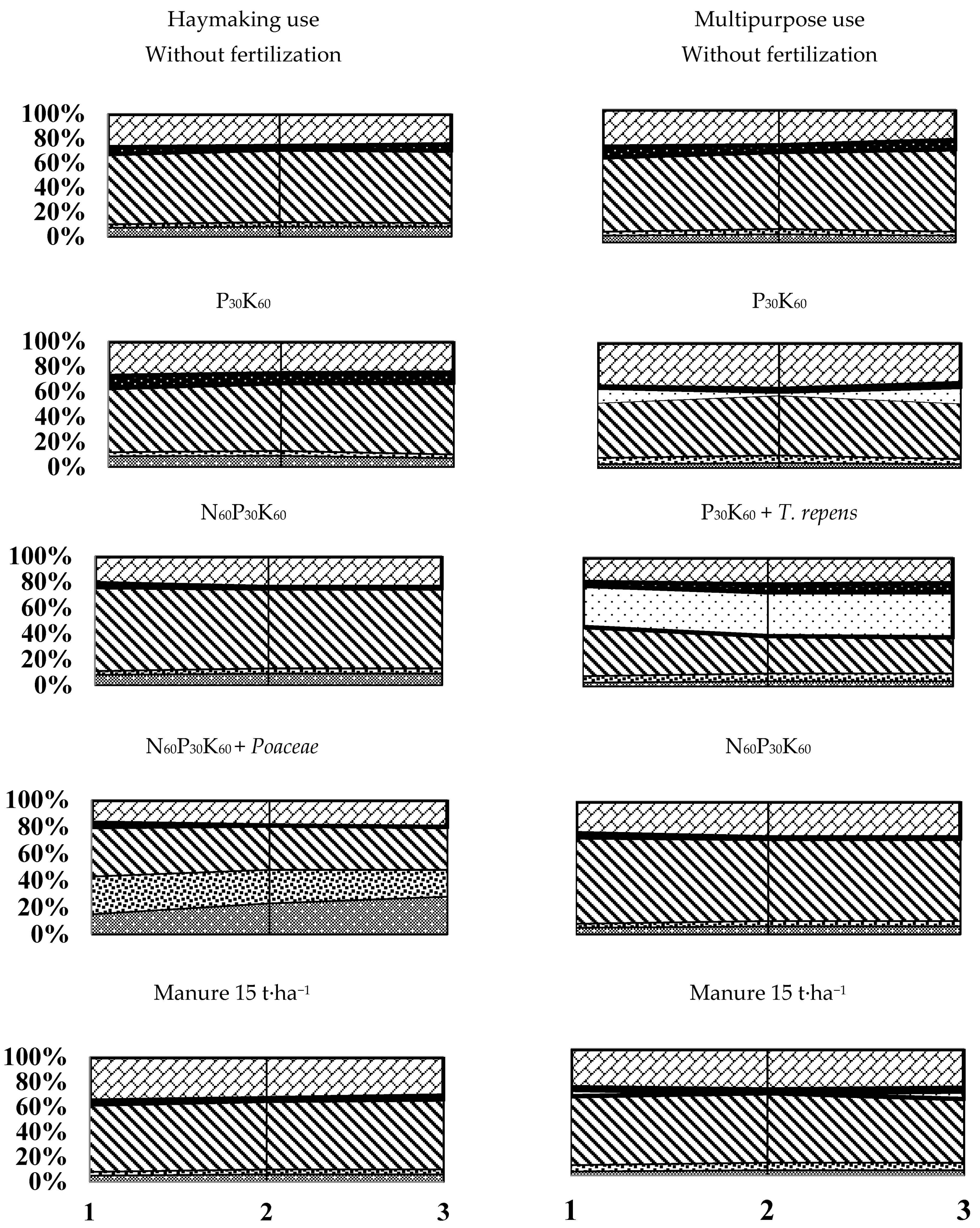
Analysis of the research results over the period of the experiment showed changes in the ratio of the botanical groups under both haymaking and multipurpose usage (Figure 2).

From the first to the third year, when the meadow was used for hay production, the total herbaceous share of *Poaceae* increased and the number of forbs decreased by 2–6%, except where nitrogen was applied. Comparing the reseeded meadows, the reseeded mixture of *Poaceae* grasses with $N_{60}P_{30}K_{60}$ application resulted in an increase in *P. pratense* and a decrease of 8–13% in *F. pratensis*.

With multipurpose use, the total amount of *Poaceae* in most of the meadows in the experiment was stable and ranged from 64% to 74%, with the exception of the meadow reseeded with T. repens with the application of $P_{30}K_{60}$, in which the number of *Poaceae* was smaller, ranging from 38% to 46%, and further decreased in the subsequent years. In the meadow reseeded with *T. repens*, its share in the swards was 32–35% and remained stable during all three years of research and even tended to increase. Because of wild species, the total number of *Fabaceae* increased by 3–7% every year. The total number of forbs for most management options changed little, ranging from 19% to 28%, and the smallest quantity was observed in the option with reseeded *T. repens* together with $P_{30}K_{60}$ application.

3.2. Distribution of Sward Species in the Meadow

The results of research with regard to the floristic richness of the natural meadow swards on the mountain slope in the third year are shown in Table 3. The results showed that the most effective protection measures for the meadows were recorded for multipurpose use (without fertilization, and $P_{30}K_{60}$) which had nine more species than in the meadow for hay production use, compared to the meadow phytocenoses on the mountain slope with the largest total number of species (41). It should be noted that the floristic richness of the studied meadows decreased by 13 species, from 41 to 28, in the case of multipurpose use, and from 32 to 24, or by 8 species, in the case of haymaking use, with the application of $N_{60}P_{30}K_{60}$ fertilizer compared with the application of $P_{30}K_{60}$. The lowest floristic richness was observed in the meadow with reseeded perennial swards. The total number of plant species decreased by 4 species, from 24 to 20, when reseeded with *Poaceae* mixture and with application of $N_{60}P_{30}K_{60}$ for haymaking use, and by 12 species, from 41 to 29, when reseeded with T. repens and fertilized with $P_{30}K_{60}$ for multipurpose use. The floristic richness of the meadows under the various management practices was greater in the case of multipurpose usage than haymaking.



Note: mixed grasses; reseeded *Fabaceae*; *Trifolium repens* L.; reseeded *Poaceae*; *Festuca pratensis* Huds.; and *Phleum pratense* L.

Note: 1, 2, and 3 indicate 2017, 2018, and 2019.

Figure 2. Botanical composition of the sloping mountain meadows by management practice during the experimental period from 2017 to 2019, percentage.

Table 3. Share of meadow sward species on the slopes by management practice, % (2019).

Types	Haymaking Use				Multipurpose Use			
	Without Fertilization	P_{30} K_{60}	N_{60} P_{30} K_{60}	$N_{60}P_{30}K_{60}$ + *Poaceae*	Without Fertilization	P_{30} K_{60}	$P_{30}K_{60}$ + *T. repens*	N_{60} P_{30} K_{60}
Poaceae								
Nardus stricta L.	25	24	28	9	18	17	10	15
Cynosurus cristatus L.	+	+	-	-	2	2	+	+
Dactylis glomerata L.	5	5	8	8	3	3	+	10
Festuca pratensis Huds.	3	3	4	20	3	3	6	4
Festuca ovina L.	-	-	-	-	2	2	-	-
Festuca rubra L. s. str.	12	11	13	3	22	21	12	22
Calamagrostis arundinaceae (L.) Roth	3	3	5	3	+	+	-	-
Agrostis gigantea Roth	3	3	6	5	+	+	-	-
Agrostis tenuis Sibth.	+	+	-	-	6	6	4	6
Elytrigia repens (L.) Nevski	5	6	2	3	2	2	+	3
Arrhenatherum elatius (L.) P. Beauv. ex J. Presl et C. Presl	6	5	-	1	+	+	+	3
Phleum pratense L.	8	7	9	28	5	4	4	6
Poa pratensis L.	-	-	-	-	2	2	-	-
Poa annua L.	+	+	-	-	5	5	2	3
Briza media L.	-	-	-	-	+	+	-	-
Total types, %	70	67	75	80	70	67	38	72
Total types, pcs.	12	12	9	9	15	15	10	10
Fabaceae								
Trifolium montanum L.	3	4	1	-	-	1	2	-
Trifolium pratense L.	1	2	+	-	-	-	-	-
Trifolium repens L.	-	-	-	-	2	2	35	-
Medicago lupulina L.	-	-	-	-	3	3	3	1
Lotus corniculatus L.	-	2	-	-	2	2	2	-
Total types, %	5	8	1	-	7	8	42	1
Total types, pcs.	2	3	1	-	3	4	4	1
Forbss **								

Table 3. *Cont.*

Types	Haymaking Use				Multipurpose Use			
	Without Fertilization	P_{30} K_{60}	N_{60} P_{30} K_{60}	$N_{60}P_{30}K_{60}$ + *Poaceae*	Without Fertilization	P_{30} K_{60}	$P_{30}K_{60}$ + *T. repens*	N_{60} P_{30} K_{60}
Blechnum spicant (L.) Roth	+	-	-	-	-	-	-	-
Heracleum sphondylium L.	-	-	-	-	+	+	-	+
Capsella bursa-pastoris (L.) Medik.	3	3	2	2	5	5	4	5
Achillea submillefolium Klokk. Et Krytzka	+	+	+	+	+	+	-	-
Rhinanthus alpinus Baumg.	2	2	2	1	+	+	-	-
Rhinanthus minor L.	-	-	-	-	+	+	+	+
Campanula carpatica Jacq.	2	2	2	1	3	3	3	3
Stellaria media (L.) Vill.	-	-	-	-	1	1	1	1
Erigeron Canadensis L.	1	1	1	2	+	+	+	+
Carum carvi L.	+	+	-	+	-	-	-	-
Leucanthemum vulgare Lam.	6	6	6	5	5	5	4	5
Taraxacum officinale Weber ex Wigg.	+	+	-	-	3	3	3	3
Daucus carota L.	2	2	2	2	+	+	+	+
Hieracium viscidulum Tausch ex W.D.J.Koch	+	+	-		-	-	-	-
Pteridium aquilinum L. Kuhn	+	+	+	-	+	+	-	+
Cirsium arvense (L.) Scop.	-	-	-	-	+	+	+	+
Clinopodium vulgare L.	7	7	7	6	4	4	3	4
Potentilla aurea L.	+	+	+		+	+	+	+
Potentilla argentea L.	+	+	1	+	3	3	2	3
Galium rubioides L.	+	+	+	-	+	+	+	+
Galium aparine L.	2	2	2	1	2	2	+	2
Plantago lanceolata L.	-	-	-	-	+	+	-	-
Equisetum sylvaticum L.	+	+	+	-	1	1	-	+
Vaccinium myrtillus L.	+	+	-	-	+	+	-	-
Total types, %	25	25	24	20	23	25	20	27
Total types, pcs.	18	17	14	11	23	23	15	17
Cyperacea **								
Carex montana L.	-	-	-	-	+	+	+	+
Total types, pcs.	32	32	24	20	41	41	29	28

Note. ** the amount of mixed swards is given together with *Cyperacea*. "-" no species; "+" very low species share (<1) of meadow.

The largest number of forb species (23) was found to be 25% (together with *Cyperacea)* in addition to the highest number of species overall recorded for multipurpose use without fertilization and with the application of $P_{30}K_{60}$ fertilizer. The most common species of the swards, all in the range of 1–5%, were *Capsella bursa-pastoris*, *Campanula carpatica*, *Stellaria media, Leucanthemum vulgare*, *Taraxacum officinale*, *Clinopodium vulgare*, *Potentilla argentea*, *Galium aparine*, *Equisetum sylvaticum*, and *Rumex carpaticus*. The other species listed in Table 3 were found singly, and fertilization did not naturally affect the proportion of species from the forb group. In contrast with the multimoisture regime, *Rhinanthus alpinus* and *Erigeron Canadensis* were present with a share of 1–2% under hay mowing.

The *Poaceae* sward was in second place with a share of 67–70% (15 species) in the meadows without fertilization and with the application of $P_{30}K_{60}$ fertilizer under multipurpose use. *Festuca rubra* and *Nardus stricta* took the largest share of the swards on these meadows (17–22% each), followed by *Dactylis glomerata*, *Festuca pratensis*, *Calamagrostis arundinaceae*, *Agrostis gigantea*, *Elytrigia repens*, *Arrhenatherum elatius*, *Phleum pratense*, and *Poa annua* (5–6% each), and then *Cynosurus cristatus*, *Festuca ovina*, and *Poa pratensis* (2–3% each).

For haymaking use, *Festuca rubra* and *Nardus stricta* had the largest share of the sward (11–28% each), followed by *Dactylis glomerata*, *Festuca pratensis*, *Calamagrostis arundinaceae, Agrostis gigantea*, *Elytrigia repens*, *Arrhenatherum elatius*, and *Phleum pratense* with shares in the range of 2–9%, which, during frequent use, were found in smaller numbers. Again, *Poa annua* L. was more abundant in the grasses under multipurpose use.

In the reseeded *Poaceae* grasses mixed with *F. pratensis* and *P. pratense* with application of $N_{60}P_{30}K_{60}$ fertilizer for haymaking use, the total number of *Poaceae* species did not change, whereas reseeded *T. repens* with application of $P_{30}K_{60}$ under multipurpose use showed a decrease in the number of *Poaceae* species from 15 to 10, and the share of the total number of *Poaceae* increased from 75% to 80%. The fewest species (5) were from the *Fabaceae* group, which had the largest share (42%) in the meadows under multipurpose use, which were reseeded with *T. repens* and to which $P_{30}K_{60}$ was applied. Because of the reseeded *T. repens*, its share in the third year of use increased by 32%. The share of *T. montanum* and *T. pratense*, in the range 1–4%, was greater under the haymaking than under the multipurpose regime.

3.3. Grouping of Swards According to Growth Duration and Families

From an analysis of the distribution of components according to the duration of growth of the sloping meadows, it was found that, regardless of the investigated improvements and usage regimes, the highest number of meadow species (16–33) were found in the perennial swards, representing 94–95% of the total mass of the herbage (Table 4). With regard to the meadow management practices under both usage regimes, the highest number of perennials with the highest percentage of the total mass of the herbage were found in the unfertilized meadows and the meadows to which $P_{30}K_{60}$ fertilizer had been applied. The lowest number was observed for the reseeded mixture of *Poaceae* with *P. pratense* and *F. pratensis*, together with the application of $N_{60}P_{30}K_{60}$ fertilizer (16 species). When an additional dose of nitrogen N_{60} was applied together with $P_{30}K_{60}$, the number of perennial swards decreased by 6 species under haymaking and by 9 under multipurpose use. The number of annual and biennial species were insignificant with fluctuations under the two regimes of 1–5 and 2–3 species, respectively, representing 2–4% of the total mass of the herbage.

The allocation of swards in the sloping meadows by family according to management practice is shown in Table 5. Analysis of the results showed that 44 types of meadow plants from 18 families were recorded in the sloping meadows under different management practices and types of usage. The species that participated in the formation of the meadow were represented by the following families: *Asteraceae*, *Araliaceae*, *Blechnaceae*, *Fabacea*, *Vacciniaceae*, *Caryophyllacea*, *Lamiaceae*, *Campanulacea*, *Poaceae*, *Apiaceae*, *Rubiaceae*, *Hypolepidaceae*, *Cyperaceae*, *Plantaginaceae*, *Scrophulariaceae*, *Rosaceae*, *Equisetaceae*, and *Brassicaceae (Cruciferae)*. The largest number of species (15) belonged to the *Poaceae* family. The

Asteraceae family was in second place with 6 species, followed by the *Fabaceae* family in third place with 5 species, and the *Araliaceae*, *Rubiaceae*, *Scrophulariaceae*, and *Rosaceae* families were in fourth place with 2 species each. The remainder of the families were represented by one species. The *Poaceae* family had the largest number of species on meadows under multipurpose use without fertilization and with the application of $P_{30}K_{60}$.

Table 4. Distribution of meadow components by growth duration under different management practices (2019).

Management Practices	Number of Types, pcs.				Total Sward Weight, %		
	Annuals	Biennials	Perennials	Total	Annuals	Biennials	Perennials
Haymaking use							
Without fertilizers	3	3	26	32	3	3	94
$P_{30}K_{60}$	3	3	26	32	3	3	94
$N_{60}P_{30}K_{60}$	2	2	20	24	2	3	95
$N_{60}P_{30}K_{60}$ + *Poaceae*	1	3	16	20	2	4	94
Multipurpose use							
Without fertilizers	5	3	33	41	3	3	94
$P_{30}K_{60}$	5	3	33	41	3	3	94
$P_{30}K_{60}$ + *T. repens*	5	2	22	29	2	3	95
$N_{60}P_{30}K_{60}$	5	3	20	28	2	4	94

Table 5. Distribution of components by sward families in mountain slope meadows according to management practice, pcs. (2019).

Families	Haymaking Use				Multipurpose Use				Total Types
	Without Fertilization	P_{30} K_{60}	N_{60} P_{30} K_{60}	$N_{60}P_{30}K_{60}$ + *Poaceae*	Without Fertilization	P_{30} K_{60}	$P_{30}K_{60}$ + *T. repens*	N_{60} P_{30} K_{60}	
Asteraceae	5	5	3	3	5	5	4	4	6
Araliaceae	1	1	1	1	2	2	2	1	1
Blechnaceae	1	-	-	-	-	-	-	-	1
Fabaceae	2	3	2	-	3	4	4	1	5
Vacciniaceae	1	1	-	-	1	1	-	-	1
Caryophyllaceae	-	-	-	-	1	1	1	1	1
Lamiaceae	1	1	1	1	1	1	1	1	1
Campanulaceae	1	1	1	1	1	1	1	1	1
Poaceae	12	12	9	9	15	15	10	10	15
Apiaceae	1	1	-	-	-	-	-	-	1
Rubiaceae	2	2	2	1	2	2	1	1	2
Hypolepidaceae	1	1	1	-	1	1	-	1	1
Cyperaceae	-	-	-	-	1	1	1	1	1
Plantaginaceae	-	-	-	-	1	1	-	-	1
Scrophulariaceae	1	1	1	1	2	2	1	1	2
Rosaceae	2	2	2	2	2	2	2	2	2
Equisetaceae	1	1	1	-	1	1	-	1	1
Brassicaceae	1	1	1	1	1	1	1	1	1
Total families	15	14	12	9	16	16	12	23	18
Total types	33	33	25	20	40	41	29	27	44

The largest number of plant families (23) was observed in meadows under multipurpose use both without fertilization and with the application of $P_{30}K_{60}$, whereas the smallest number (9–12) was observed in the case of the reseeded mixture of grasses (*P. pratense* and *F. pratensis*) with application of $N_{60}P_{30}K_{60}$ under haymaking use and for reseeded *T. repens* for multipurpose use with application of $P_{30}K_{60}$.

4. Discussion

Herbaceous plants in meadows are mainly communities of species-rich drought-prone land [19]. Intensive agriculture, overgrazing, pollution, and climate change are reducing the biodiversity of these complex ecosystems [20]. In recent decades, the effect of herbage use on the composition and diversity of grassland species has been intensively studied [21]. Researchers have found that grassland improvement, in particular, the application of organic and mineral fertilizers and the reseeding of perennial grass and legume swards into the meadows, has a positive effect on fodder production and its nutritional value, which is reflected in the species composition and variable meadow communities [3,21,22]. Research in the UK suggests avoiding the use of inorganic fertilizers, intensive spring grazing, and delaying mowing until late July [23]. In addition, a negative correlation was found between the abundance of plant species and the intensity of mowing and fertilization [24]. In our research, the application of long-term nitrogen fertilizers improved the growth and development of *Poaceae* grass; however, the number of perennial *Fabaceae* and forb decreased. Similarly, the floral richness of the legume swards decreased. The application of PK fertilizers stimulated an increase in the perennial swards in the meadow phytocenoses, in particular during favorable years for precipitation. In adapted ecological conditions, the share of sown species in meadow phytocenoses can be increased by reseeding the perennial *Fabaceae* without application of nitrogen fertilizers or reseeding the *Poaceae* mixture with application of NPK fertilizers. According to other researchers, reseeding adapted plants from wild species in degraded meadows improves the composition of herbage species and contributes towards the stabilization process [3].

Many studies have shown that fertilization of meadows has a negative effect on the coexistence of species [25]. An increase in above-ground mass yield leads to a shift from below-ground to above-ground plant competition [8,26]. Bryophytes have high species richness with low fertilizer input, and vascular plants show similar characteristics with an intermediate nitrogen supply [24]. Fertilization promotes the growth of tall grasses by reducing the availability of light for the lower ground-cover plants [20]. It decreases the overall taxonomic and functional diversity [10,27]. Hautier et al. [28] noted that competition for light is the main cause of diversity loss due to fertilization. In addition, the shade can decrease the temperature on the soil surface, disrupting seed germination [29,30]. Fertilization and the method of using above-ground mass are closely related [10,15], in particular when the mowing frequency is out of balance with the fertilizer doses [31].

Grazing activity is a major usage of mountain meadows, and it affects sward vegetation diversity according to the intensity, frequency, and periods of grazing, as well as the livestock species. Yan et al. [21] state that average grazing intensity is characterized by the highest plant species diversity and aboveground production. Intensive livestock grazing has a negative effect on plant vegetation and soil when stocking rates exceed the capacity of the meadow. It has been reported that selective grazing and differential adaptation of plant species and/or groups to changes in abiotic factors (e.g., light, soil water, and nutrients) under different grazing regimes are key mechanisms regulating plant properties, species, and diversity [5]. According to other researchers, grazing is a relatively effective measure to combat excess nitrogen in the soil, but it cannot prevent competitors becoming dominant [31]. In our studies, grazing meadows (four times) increased the number of all species, and forbs in particular. The species composition of grasslands and the method of use determine the competitive hierarchy, relationships between plant species and productivity and the availability of soil nutrients. Taxonomic and functional characteristics can be substituted during the growing season [32]. This is influenced by the warming climate and lack of moisture (<100 mm per year) [33]. Additionally, mowing in the middle of the season prevents tall plants from dominating [34] because of a reduction in asymmetric competition for light [3]. Plants can discourage competition and stimulate coexistence by using shared resources at different growing seasons [35]. Boob et al. [20] states that site-adapted fertilization is the main tool for maintaining the ecological value of meadows.

Suitable selection of fertilization, mowing, grazing, and removal of species identified as dominant can help maintain meadows with sufficient productivity and a high diversity of plant species, taking into account environmental limitations and the forage potential of the meadows. This requires precise knowledge of the flora and the determining factors, which are primarily the natural resources (environmental limits) and partly anthropogenic (management options). In order to protect biological diversity, it is important to promote the use of traditional knowledge [19] and to provide farmers with a financial incentive for agro-environmental protection [24].

5. Conclusions

Our study established that the slope meadow phytocenoses are principally composed of grasses and forbs. The number of species was increased to the greatest extent under multipurpose usage (cut four times) with approximately 28.1% or nine units compared to mowing twice (without fertilization). Fertilization and reseeding of *Poaceae* or *T. repens* reduced the number of sward species. The lowest negative impact was found when fertilizing with $P_{30}K_{60}$, regardless of the method of meadow usage. After the addition of nitrogen fertilizers ($N_{60}P_{30}K_{60}$) in the meadow for haymaking use, grasses and forbs decreased by 25% and 22.2%, respectively, and there was an even greater decrease in the multipurpose use meadow. When assessing the botanical composition of meadows, it was found that the presence of legumes was most reduced by fertilization with N fertilizers and increased by reseeding *T. repens*. When *P. pratense* and *F. Pratensis* were reseeded and fertilizer applied, the botanical composition of the meadows was improved, but the number of families and species was reduced in the meadow under haymaking use. The reseeding of T. repens reduced the number of families (25%) compared to multipurpose use without fertilizer. Maintaining the richness of plant species in these meadows can be achieved if farmers are adequately subsidized, fertilization is limited, and cultivated species are reseeded.

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