CONTRIBUTIONS TO THE EVALUATION OF THE PRODUCTIVITY OF NATURA 2000 GRASSLAND HABITATS IN THE APUSENI MOUNTAINS

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Abstract. *Knowledge of the green mass production (GM) and the pastoral value (PV) of grasslands is of particular importance in the development of development projects and their adequate management. The paper studied 10 doctoral theses and two scientific synthesis papers on grassland vegetation, based on which their productivity was evaluated. The GM production of grasslands used for grazing in Habitats 6210 and 6520 is on average 9.46 t/ha where we have normal vegetation and only 1.44 t/ha GM in those with degraded vegetation, over 6 times lower. The pastoral value in Habitats 6210 and 6520 was on average 53.8 PV which ensures 4,900 liters of milk per hectare on normal grasslands and barely 1,100 l/ha on degraded ones. The grasslands used mainly as hay in Habitat 6510 had the highest production of 18.5 t/ha green mass and 75.3 PV index, while Habitat 6410 had the lowest production of only 0.45 t/ha GM and 3.5 PV. Habitat 6440 had values of 14.55 t/ha GM and 66.4 PV index. The data are still used in the economic evaluation of the grasslands in Apuseni after their inventory and mapping.*

Keywords: mountain grasslands, pastoral value, green mass and milk production

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1. Introduction

In addition to knowing the vegetation of a permanent grassland, for the preparation of pastoral arrangements, it is necessary to know indicators of green fodder production and pastoral value on the basis of which to establish the optimal animal load during the grazing season and the milk production per hectare that can be obtained. [14]

For the mountainous area of the Carpathians, 33 resorts (mountains, watersheds) have been evaluated to date, of which 6 in the Apuseni Mountains, in a first approximation. [15]

By continuing the activity of evaluating the productivity of mountain grasslands, new data have been accumulated on the production of green mass and pastoral value, to which we add the estimation of milk production during the grazing

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season as a new element of economic appreciation of this invaluable agricultural use of the land.

This paper presents a more complete assessment of green mass production, optimal animal loading, pastoral value, milk production in the grazing season of the grasslands of the Apuseni Mountains, indispensable indicators for the preparation of projects and their optimal management.

2. Material and method

To evaluate the productivity of the grasslands in the Apuseni Mountains, 10 doctoral theses and 2 scientific synthesis papers of the Apuseni Natural Park were studied, which included from north to south the Plopiș Mountains [2], Meseș [27, 28], Pădurea Craiului [6, 9], Vlădeasa [10, 26], North Bihor [16,29], East Bihor [19, 21], Biharia [1, 17], Codru – Moma [11, 13, 23, 24], the mountains of the Apuseni Natural Park [12, 22], the Criș Repede [20, 25] and Arieș [4, 18] hydrographic basins.

The grassland vegetation was studied and classified according to the phytosociological method of the Zurich-Montpelier Floristic School and the names of component cormophyte species according to the Flora of Romania [3, 30].

The evaluation of green mass production and pastoral value was done according to the new method based on floristic survey, also mentioned in scientific papers published in these annals [8, 24, 28].

The formula used to evaluate milk production was:

Milk production (L/ha) = PV x Dsp x 0.6

in which:
PV= pastoral value index,
Dsp = duration of grazing season (days),
0.6= feed-to-milk conversion coefficient determined in long-term experiments with cows on pastures [7, 14].

For simplification and introduction into tables, a transformation coefficient composed of Dsp x 0.6 was used, which, by multiplying by PV, evaluated milk production per hectare.

3. Results and discussion

In Apuseni Mountains, 5 grassland habitats were identified, which mainly belong to 7 phytosociological alliances (Table 1).

Table 1. Existing NATURA 2000 grassland habitats in the Apuseni Mountains (Habitat Classification according to Gafta, Mountford, coord., 2008) [5]

EU Habitat Natura 2000 no.	Name	Main phytosociological alliances
6210	Semi-natural dry grasslands and scrubland facies on calcareous substrates *Festuco-Brometalia)* (important orchid sites)	*Festucion valesiacae Xerobromion Mesobromion*
6520	Mountain grasslands	*Cynosurion*
6410	*Molinia* meadows on calcareous, peaty or clayey-silt-laden soils *(Molinion caerulae)*	*Molinion*
6440	Alluvial meadows of river valleys of the *Cnidion dubii*	*Agrostion stoloniferae Deschampsietum caespitosae*
6510	Lowland hay meadows (*Alopecurus pratensis, Sanguisorba officinalis)*	*Arrhenatherion*

Two of these habitats are exploited almost exclusively by livestock grazing (6210, 6520) and three are used mainly as hayfields and only occasionally by grazing (Table 2).

Table 2. General distribution of Natura 2000 grassland habitats in the Apuseni Mountains and the duration of the optimal grazing season

Habitat Nature 2000	Location (authors)	Altitude (m)	Grazing season (days)
GRASSLAND			
6210	1. Vladeasa (Resmerita , 1970)	700-800	155
	2. Plopis (Coldea 1972)	300-650	170
	3. The King's Forest (Groza, 2008)	300-700	175
	4. Aries Valley (Frink , 2010)	350-900	165
	5. Codru-Moma (Pașcuț , 2012)	390-800	170
	6. North Bihor (Togor , 2016)	1,220	120
	7. Meseș (Sălăjan-Ștef, 2021)	500-700	165
	8. East Bihor (Mateș, 2024)	720-1,670	155
6520	1. Vladeasa (Resmerita , 1970)	750-1,000	145
	2. Plopis (Coldea, 1972)	340-760	170
	3. The King's Forest (Groza, 2008)	300-720	175
	4. Aries Valley (Frink , 2010)	450-1,280	155
	5. Codru-Moma (Pașcuț , 2012)	300-880	170
	6. North Bihor (Togor , 2016)	700-1,360	135
	7. Meseș (Sălăjan-Ștef, 2021)	400-980	170
	8. Apuseni Park I (Marușca et al. 2021)	1,115-1,425	115
	9. Apuseni Park II (Păcurar et al. 2023)	995-1,050	140
	10. East Bihor (Mateș, 2024)	1,040-1,670	120
	11. Biharia (Buia-Mateș, 2024)	300-1,620	150

Habitat Nature 2000	Location (authors)	Altitude (m)	Grazing season (days)
	12. Crişul Repede (Pop, 2024)	685-1,730	120
Hay, mixed			
6410	1. Vladeasa (Resmerita , 1970)	780-1,110	Occasional
	2. North Bihar (Togor , 2016)	1,240-1,360	
	3. Meseș (Sălăjan-Ștef, 2021)	575-620	
	4. East Bihor (Mateș, 2024)	1,010-1,585	
	5. Biharia (Buia-Mateș, 2024)	1,345-1,600	
	6. Crişul Repede (Pop, 2024)	605-1,415	
6440	1. Vladeasa (Resmerita , 1970)	600-1,110	
	2. The King's Forest (Groza, 2008)	300-800	
	3. Aries Valley (Frink , 2010)	340-620	
	3. Meseș (Sălăjan-Ștef, 2021)	400-450	
	4. Biharia (Buia-Mateș, 2024)	1,575-1,600	
6510	1. Plopis (Coldea, 1972)	300-740	
	2. The King's Forest (Groza, 2008)	700	
	3. Aries Valley (Frink , 2010)	350-580	

This table mentions the altitudinal limits where the habitats are found (300-1,670 m), based on which the duration of the optimal grazing season (115-175 days) was also established.

Habitat 6520 has the highest distribution in all 12 locations studied and Habitat 6510 has the lowest distribution in only three locations.

The presentation of results in ascending order begins with Habitat 6210, located at lower altitudes in a drier climate (Table 3).

Table 3. Evaluation of the productivity of grasslands in Habitat 6210 with normal and degraded vegetation used mainly by animal grazing

Location	GM production		LU/ha	PV		Coefficient transformation	Milk	
	t/ha	%		ind.	**%**		L/ha	%
A Habitat 6210 with normal vegetation								
1. Vladeasa	10.58	150	1.05	52.0	124	93	4,840	123
2. Plopis	8.41	120	0.76	46.8	112	96	4,490	114
3. Craiului Forest	7.11	101	0.63	33.7	80	105	3,540	90
4.Aries Valley	7.69	109	0.70	43.0	103	96	4,190	106
5.Codru-Moma	5.63	80	0.51	42.7	102	102	4,350	110
6.North Bihar	6.30	90	0.81	47.9	114	72	3,450	87
7. Message	5.21	74	0.48	41.7	100	100	4,170	106
8. East Bihar	5.35	76	0.53	27.4	65	93	2,550	65
Average A	**7.03**	**100**	**0.68**	**41.9**	**100**	**95**	**3,950**	**100**
B Habitat 6210 degraded by *Botryochloa ischaemum* and *Pteridium aquiline*								
1. Craiului Forest	0.24	30	0.02	2.8	33	105	300	36
2. Plopis	1.70	210	0.15	18.0	212	96	1,730	206

Location		GM production		LU/ha	PV		Coefficient transformation	Milk	
		t/ha	%		ind.	**%**		L/ha	%
3.Aries Valley		0.67	83	0.06	6.5	76	102	660	79
4.Codru-Moma		0.74	91	0.07	7.2	85	102	740	88
5.North Bihar		0.06	7	0.01	0.5	6	72	40	5
6.Meseș		1.45	179	0.14	15.7	185	100	1,570	187
Media B		**0.81**	**100**	**0.08**	**8.5**	**100**	**96**	**840**	**100**
Media AB		**3.92**	**x**	**0.38**	**25.2**	**x**	**95**	**2,395**	**x**
Difference	**+,-**	**-6.22**	**x**	**-0.60**	**-33.4**	**x**	**+1**	**-3,110**	**x**
B-A	**%**	**12**	**x**	**12**	**20**	**x**	**101**	**21**	**x**

The average production of green fodder mass at Habitat 6210 with normal vegetation is 7.03 t/ha with differences of 5.21 in the Meseș Mountains to 10.58 t/ha in Vlădeasa, which allow an optimal animal load of 0.68 LU/ha in 158 days of grazing when an average of 3,950 L/ha of cow's milk can be produced.

Through vegetation degradation due to lack of adequate management, Habitat 6210 was invaded in varying proportions by *Botriochloa ischaemum* or *Pteridium aquilinum* , which is why green mass production reaches only 12% of the normal Habitat 6210, pastoral value (PV) 20% and milk production 21%, almost 5 times lower.

The average forage production (GM) at the most widespread habitat 6520 in Apuseni was 11.89 t/ha for the one with normal vegetation and 2.07 t/ha (17%) for the habitat invaded by *Nardus stricta* and/or *Deschampsia caespitosa*. (Table 4)

Table 4. Evaluation of the productivity of grasslands in Habitat 6520 with normal and degraded vegetation used mainly by animal grazing

Location	GM Production		LU/ha	PV		Coefficient transformation	Milk	
	t/ha	%		ind.	**%**		L/ha	%
A Habitat 6520 with normal vegetation								
1. Vladeasa	18.30	154	1.94	85.5	130	87	7,440	127
2.Plopish	14.77	124	1.28	73.6	112	102	7,510	128
3. Craiului Forest	12.31	104	1.25	69.0	105	105	7,240	123
4.Aries Valley	9.02	76	0.90	56.8	86	93	5,280	90
5. Codru-Moma	13.17	111	1.19	70.0	107	102	7,210	123
6. North Bihar	11.44	96	1.30	60.9	93	81	4,930	84
7. Messes	10.79	91	0.98	74.1	113	102	7,560	129
8.Apuseni Park I	6.95	58	0.93	43.7	67	69	3,020	52
9.Apuseni Park II	8.17	69	0.90	51.0	78	83	4,230	72
10. East Bihar	11.51	97	1.48	64.8	99	72	4,660	79
11. Biharia	13.01	109	1.38	71.6	109	90	6,440	110
12. Fast Cris	13.29	112	1.70	67.3	102	72	4,850	83
Average A	**11.89**	**100**	**1.27**	**65.7**	**100**	**88**	**5,860**	**100**
B Habitat 6520 degraded by *Nardus stricta* and *Deschampsia caespitosa*								

Location		GM Production		LU/ha	PV		Coefficient transformation	Milk	
		t/ha	%		ind.	%		L/ha	%
1. Vladeasa		2.14	103	0.27	16.3	106	87	1,420	105
2.Plopish		1.60	77	0.15	13.2	86	102	1,340	99
3. Craiului Forest		1.12	54	0.10	13.9	90	105	1,460	108
4.Aries Valley		1.46	71	0.14	13.5	88	93	1,260	93
5. Codru-Moma		2.66	129	0.26	18.7	122	102	1,910	141
6. North Bihar		1.00	48	0.13	7.4	48	81	600	44
7. Messes		2.27	110	0.22	16.2	105	102	1,650	122
8. Apuseni Park		3.06	148	0.43	22.1	144	69	1,520	113
9. East Bihar		2.64	128	0.34	17.0	111	72	1,220	90
10.Biharia		2.27	110	0.30	15.1	98	90	1,360	101
11. Crisis Response		2.50	121	0.32	15.6	102	72	1,120	83
Media B		**2.07**	**100**	**0.24**	**15.36**	**100**	**89**	**1,350**	**100**
Media A+B		**6.98**	**x**	**0.76**	**40.6**	**x**	**88**	**3,605**	**x**
Difference	**+,-**	**-9.82**	**x**	**-1.03**	**-50.3**	**x**	**+1**	**-4,510**	**x**
nay	**%**	**17**	**x**	**19**	**23**	**x**	**101**	**23**	**x**

The most valuable Habitat 6520 is found in Vlădeasa with 18.3 t/ha GM, PV index 85.5, where 7,440 L/ha can be achieved in 145 days of grazing season.

The most degraded Habitat 6520 was found in Bihor-Nord, with 1 t/ha GM, 7.4 PV index and 600 L/ha milk in 135 days of grazing.

A comparison is made between Habitat 6210 and Habitat 6520 with their normal and degraded variants, which are mainly grazed by animals. (Table 5)

Table 5. Differences in green mass production and animal load on grasslands with normal (N) and degraded (D) vegetation of Habitats 6210 and 6520 in Apuseni

Habitat		Green mass (t/ha)				Animal load (LU/ha)			
		N	D	Diff . + -	%	N	D	Diff . + -	%
A.6210		7.03	0.81	-6.22	11	0.68	0.08	-0.60	11
B.6520		11.89	2.07	-9.82	17	1.27	0.24	-1.03	18
Media		**9.46**	**1.44**	**-8.02**	**15**	**0.97**	**0.16**	**-0.81**	**16**
Dif. B-A	**(+,-)**	**+4.86**	**+1.26**	**x**	**x**	**+0.59**	**+0.16**	**x**	**x**
	%	**169**	**256**	**x**	**x**	**186**	**300**	**x**	**x**

The average production of the two normal habitats 6210 and 6520 is 9.46 t/ha GM and the optimal loading of almost 1 LU/ha (0.97) and in the degraded variants of 1.44 t/ha GM and 0.16 LU/ha, 85% lower than the normal version.

The average PV index was 53.8 for the normal variants and only 11.9 PV for the degraded ones, respectively 78% lower. (Table 6)

Table 6. Differences in pastoral value and milk production on grasslands with normal (N) and degraded (D) vegetation of Habitats 6210 and 6520 in Apuseni

Habitat		Pastoral value (ind.)				Milk production (L/ha)			
		N	D	Diff . + -	%	N	D	Diff . + -	%
A.6210		41 .9	8.5	-33.4	20	3,950	840	-3,110	21
B. 6520		65.7	15.3	-50.4	23	5,860	1,350	-4,510	23
Media		**53.8**	**11.9**	**-41.9**	**22**	**4,900**	**1,100**	**-3,800**	**22**
Dif. B-A	**(+,-)**	**+23.8**	**+6.8**	**x**	**x**	**+1,910**	**+510**	**x**	**x**
	%	**157**	**180**	**x**	**x**	**148**	**160**	**x**	**x**

The average cow's milk production reaches 4,900 L/ha in the normal variants and only 1,100 L/ha (22%) in the degraded variants of H 6210 and 6520.

In terms of GM production, H 6520 is 69% higher than H 6210, the PV index is 57% higher and milk production is 48% higher in variants with normal vegetation, due to better humidity conditions.

In the degraded variants, GM production from H 6210 is 2.5 times lower than in degraded H 6520, due to periods of drought and higher temperatures.

As for the better managed Habitats 6140, 6440 and 6510, used mainly by mowing, they had normal vegetation, with GM and induced PV productions as expected. (Table 7)

Table 7. Assessment of grassland productivity in harvested Habitats 6410, 6440 and 6510 in hay and mixed regime

Location	Green table production		Pastoral value	
	t/ha	%	Ind.	%
A Habitat 6410 with normal vegetation (no forage value)				
1. Vladeasa	1.38	307	11.3	323
2. Bihar	0.20	44	1.6	46
3. Messes	0.34	76	2.1	60
4. East Bihar	0.05	11	0.5	14
5. Biharia	0.52	116	4.4	126
6.Crisul Repede	0.18	40	1.3	37
Average A	**0.45**	**100**	**3.5**	**100**
B Habitat 6440 with normal vegetation				
1. Vladeasa	13.95	96	64.8	98
2. Craiului Forest	18.90	130	65.9	99
3Aries Valley	12.34	85	60.6	91
4. Message	11.49	79	57.9	87
5. Biharia	16.08	111	82.6	124
Average B	**14.55**	**100**	**66.4**	**100**
C Habitat 6510 with normal vegetation				
1.Plopis	16.57	90	76.0	98
2. Craiului Forest	22.91	124	81.4	105
3.Aries Valley	16.01	87	75.3	97

Location	Green table production		Pastoral value	
	t/ha	%	Ind.	%
Media C	**18.50**	**100**	**77.6**	**100**
Media A,B,C	**11.17**	**x**	**49.2**	**x**
Media C+B	**16.52**	**x**	**72.0**	**x**
Diferența (%) C-B	**127**	**x**	**117**	**x**

However, one of them, H 6410, is not widespread and is dominated by the worthless forage species *Molinia caerulea* recorded 0.45 t/ha GM and 3.5 PV index, being devoid of economic value.

On the other hand, H 6440 and 6510 are particularly valuable, recording an average of 16.52 t/ha GM and 72 PV index.

The most valuable grassland habitat is H 65110, which was evaluated on average at 18.5 t/ha GM with 77.6 PV, of which 22.91 t/ha GM and 81.4 PV were the highest in Pădurea Craiului and at the opposite pole 16 t/ha GM with 75.3 PV in Valea Arieșului.

These habitat productivity data, after their inventory and mapping, can be used to evaluate the production of GM, the optimal animal load, the pastoral value and the milk production necessary for the optimal arrangement and management of the grasslands in the Apuseni Mountains.

Conclusions

(1). Grassland productivity indicators such as pastoral value, green mass production, animal loading and their products are necessary for the preparation of pastoral arrangements, grassland management, economic efficiency and others.

(2). The evaluation of grassland productivity based on floristic surveys and results obtained in long-term animal experiments has been applied with good results in the Apuseni Mountains.

(3). The highest grassland productivity was assessed in Habitat 6510 (Low-altitude meadows, *Alopecurus pratensis*, *Sanguisorba officinalis*) with 18.5 t/ha green fodder mass (GM) and 77.6 pastoral value index (PV), followed by Habitat 6440 (Alluvial meadows of river valleys of *Cnidion dubii*) with 14.55 t/ha GM and 66.4 PV, which were generally better managed.

(4). Good productivity was also evaluated in grasslands used for grazing, such as habitat 6520 (Mountain grasslands) with 11.89 t/ha GM, 65.7 PV index and 5,860 liters of milk per hectare, followed by Habitat 6210 (Xerophilic grasslands on calcareous substrates) with 7.5 t/ha GM, 41.9 PV index and 3,950 liters of milk per hectare.

(5). The evaluation of the productivity of permanent mountain grasslands in Romania according to the Natura 2000 Habitats model is urgently needed for integration and comparison with other mountain areas of European Union countries.

(6). The lowest productivity was recorded in Habitats 6210 and 6520 degraded by unvalued species such as *Botriochloa ischaemum, Pteridium aquilinum, Nardus stricta, Deschampsia caespitosa* and other weeds, where an average of 1.44 t/ha GM (15% of normal habitats), 11.9 PV index and barely 1,100 liters of milk per hectare (22% of normal) were evaluated.

(7). The concrete application of these productivity results on the field will be done after the inventory and mapping of pastoral habitat areas for the weighted average evaluation of GM production, optimal animal loading (LU/ha), PV index and milk production during the grazing season.

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