STUDIES REGARDING THE EVOLUTION OF GRASSLAND PRODUCTIVITY FROM CODRU MOMA MOUNTAINS (WESTERN CARPATHIANS)

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Abstract. *Knowledge of the dynamics of floristic composition and the productivity of permanent grasslands has a special scientific and practical value. This work presents a comparative study of grassland vegetation in 1937 and in 2011 in terms of floristics and productivity for 4 phytocoenoses spread in the Codru Moma Mountains in the northern part of Western Carpathians (Apuseni Mountains). After almost three quarters of a century, Festuceto rubrae-Agrostetum capillaris and Anthoxantho-Agrostetum capillaris associations located near the localities used for grazing as communal pastures or hayfields, have generally preserved their biodiversity, increased their pastoral value by 8-23% and the fodder green mass production by 21-22%. Instead Poterio-Festucetum valesiacae association located on steep slopes and sunny exhibitions together with the Nardo-Festucetum rubrae fallax association, both located at greater distances from localities, during the same period, decreased their pastoral value by 13-39% and fodder green mass production by 17-35%. At a more detailed analysis of the Nardo-Festucetum rubrae fallax association, it was found that the invasive Nardus stricta species from an average participation of 45.6% in 1937 reached 66.9% in 2011, respectively by more than 20%, indicating the stage of continuous degradation of the herbaceous layer and decreasing productivity.*

Keywords: grassland vegetation, productivity dynamics, carrying capacity

1. Introduction

The study of the herbaceous layer of the grasslands has a special importance both for phytocenological classification and for establishing improvement measures and rational use included in pastoral arrangements.

New evaluation methods of grassland phytocoenosis productivity based on floristic surveys made it possible to establish the evolution in dynamics of this very important indicator for the pastoral economy [3].

Till now there have been few studies on grassland productivity dynamics of which we mention the one made on the steppe grasslands after 45-50 years from the Babadag and Casimcea plateaus from Dobrogea [4].

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In this paper we performed a comparative study of grassland productivity after almost 75 years, in Codru-Moma Mountains (Figure 1).

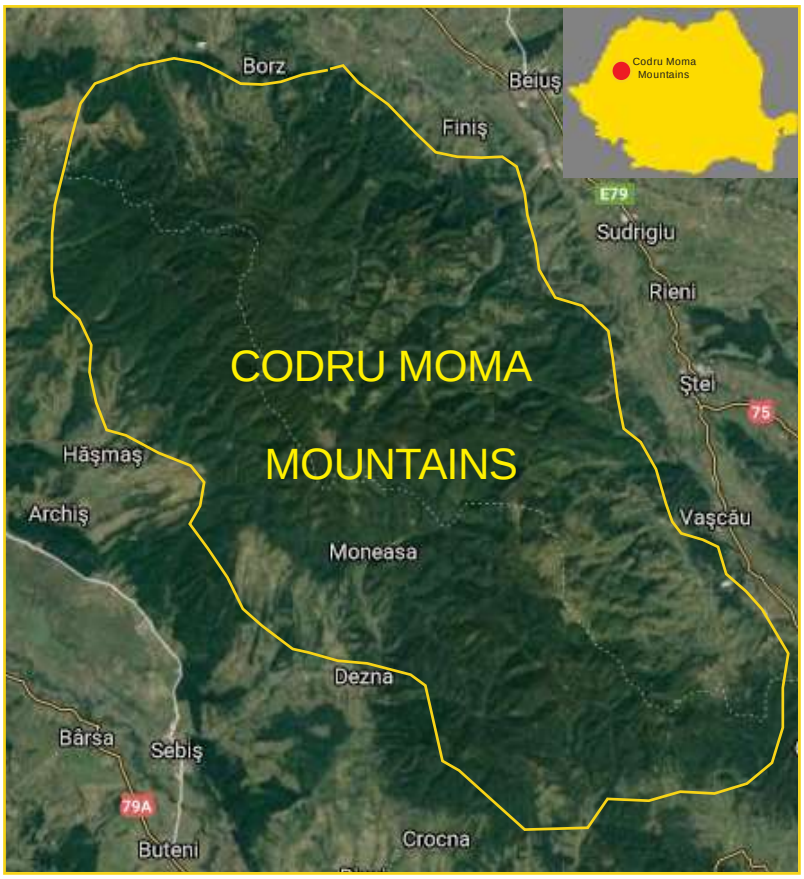

Fig. 1. Geographical location of Codru Moma Mountains [10] (modified)

2. Materials and methods

For studying grassland productivity dynamics from Codru Moma Mountains, the following synthesis works were examined: ''*Photosociological studies in the Codru Muma Mountains*'' made by Ana Paucă [5], ''*Flora and vegetation of the Codru Moma Mountains*'', doctoral thesis prepared by Păşcuţ C.G. [8], and some more recent works [6, 7].

Floristic surveys for the description of vegetation were drawn up according to the methodology of the floristic school of Zurich-Montpellier or Braun-Blanquet in the summers of 1937 and 2011, during a period of almost 75 years [2]. For the determination of the species in the field we used specialised works developed by Ciocârlan and Sârbu et al. [1, 9].

In order to be compared, we studied only the associations of the same stationary conditions, which overlap (Table 1).

At the evaluation of grassland productivity the method based on floristic surveys was used [3, 4].

These results which can be compared in dynamics, after a longer period of time, allow us to know the direction of evolution of grassland productivity considering their management.

Table 1. Stationary conditions of the grasslands associations from the Codru Moma Mountains (Western Carpathians)

No.	*Association*	*Altitude (m.s.m)*	*Exposition*	*Slope (degrees)*	*Location*
1	*Poterio-Festucetum valesiacae*	490-510	V, SV	14-40	Rasteț Hill
2	*Anthoxantho-Agrostietum capillaris*	290-350	Plane - N	0-6	Gropi Hill
3	*Festuceto rubrae-Agrostetum capillaris*	640-700	E,V,SV,N	4-18	Bănișoara Sfăraș
4	*Nardo-Festucetum rubrae fallax*	640-800	Plane, S,V,N,NE	0-25	Ponoare Glade, Brătcoaia Glade, Ronțaru Hill

3. Results and discussions

Calculations on the evolution of grassland productivity were performed for all four more widespread associations, of which we show you the most representative with the most surveys presented in both mentioned syntheses (Table 2).

Table 2. Evolution of the floristic composition of the *Nardo-Festucetum rubrae fallax* association from Codru Moma Mountains, Bihor county

Species	*Attendance (class)*		*Participation (%)*			*%*	*Indices*	
	1937	*2011*	*1937*	*2011*	*Diff. +;-*		*F*	*M*
Vegetation cover	x	x	99.8	94.2	-5.6	94	x	x
Poaceae								
Nardus stricta	V	V	45.6	66.9	+21.3	147	3	0
Festuca rubra	V	V	2.6	6.6	+4.0	254	7	6
Danthonia decumbens	V	V	0.5	0.5	0	100	4	3
Deschampsia flexuosa	V	IV	12.8	2.2	-10.6	17	4	3
Agrostis capillaris	V	IV	2.6	0.4	-2.2	15	7	5
Anthoxanthum odoratum	V	II	4.4	0.2	-4.2	5	5	3
Calamagrostis arundinacea	V	I	0.5	0.1	-0.4	20	3	0
Holcus lanatus	IV	II	0.4	0.2	-0.2	50	6	6

Briza media	III	II	0.3	0.2	-0.1	67	5	2
Deschampsia caespitosa	III	II	0.3	0.2	-0.1	67	3	0
Molinia coerulea	V	-	8.2	-	x	x	3	0
Cynosurus cristatus	III	-	0.3	-	x	x	7	4
Dactylis glomerata	III	-	0.3	-	x	x	9	8
Phleum pratense	III	-	0.3	-	x	x	9	8
Calamagrostis epigeios	I	-	0.1	-	x	x	3	0
Agrostis gigantea	-	IV	-	1.3	x	x	7	7
Fabaceae								
Gemistella sagittalis	IV	III	0.4	2.1	+0.7	525	3	0
Cytisus nigricans	IV	I	0.4	0.1	-0.3	25	3	0
Genista tinctoria	IV	-	0.4	-	x	x	3	0
Trifolium pratense	I	-	0.1	-	x	x	8	7
Trifolium repens	I	-	0.1	-	x	x	8	5
Trifolium medium	I	-	0.1	-	x	x	6	4
Vicia tetrasperma	I	-	0.1	-	x	x	6	3
Others Families								
Luzula campestris	V	V	0.5	0.5	0	100	4	2
Potentilla erecta	V	IV	1.5	1.3	-0.2	87	5	2
Succisa pratensis	V	III	1.5	0.3	-1.2	20	3	0
Vaccinium vitis-idaea	V	III	1.5	1.2	-0.3	80	3	0
Stachys officinalis	V	II	0.5	0.2	-0.3	40	3	0
Polygala vulgaris	V	I	0.5	0.1	-0.4	20	4	1
Hieracium pilosella	IV	III	0.4	0.3	-0.1	75	4	1
Rumex acetosa	IV	III	0.4	0.3	-0.1	75	4	5
Veratrum album	IV	III	0.4	0.3	-0.1	75	1	0
Carex pallescens	IV	II	0.4	0.2	-0.2	50	4	3
Leucanthemum vulgare	IV	II	0.4	0.2	-0.2	50	5	5
Luzula luzuloides	IV	II	0.4	0.2	-0.2	50	3	0
Vaccinium myrtillus	IV	II	1.5	3.6	+2.1	240	3	0
Dianthus carthusianorum	IV	I	0.4	0.1	-0.3	25	3	0
Cytisus nigricans	IV	I	0.4	0.1	-0.3	25	3	0
Gentiana asclepiadea	IV	I	0.4	0.2	-0.2	50	3	0
Veronica officinalis	III	IV	0.3	0.4	-0.1	133	4	4
Achillea millefolium	III	III	0.3	0.3	0	100	6	4
Campanula patula	III	II	0.3	0.2	-0.1	67	3	0
Centaurea phrygia	III	II	0.3	0.2	-0.1	67	4	6
Galium verum	III	I	0.3	0.1	-0.2	33	5	4
Lychnis viscaria	III	I	0.3	0.1	-0.2	33	4	4

Antennaria dioica	III	I	0.3	0.1	-0.2	33	4	2
Galium mollugo	I	III	0.1	0.3	+0.2	300	3	0
Thymus glabrescens	I	III	0.1	0.3	+0.2	300	4	2
Ajuga genevensis	I	I	0.1	0.1	0	100	4	2
Plantago lanceolata	I	I	0.1	0.1	0	100	6	1
Gnaphalium sylvaticum	III	-	0.3	-	x	x	3	0
Gymnadenia conopsea	III	-	0.3	-	x	x	3	0
Hypericum perfgoratum	III	-	0.3	-	x	x	2	0
Hypericum tetrapterum	III	-	0.3	-	x	x	2	0
Rhinanthus minor	III	-	0.3	-	x	x	3	0
Viola tricolor	III	-	0.3	-	x	x	3	0
Pimpinella saxifraga	III	-	0.1	-	x	x	5	3
Prunella vulgaris	I	-	0.1	-	x	x	4	2
Prunella laciniata	I	-	0.1	-	x	x	4	2
Other species 1937 (K 1; P 0.1%; F 1.2.3.): *Anthenus arvensis. Campanula glomerata, Campanula persicifolia, Carex flava, Carex ovata, Carlina acaulis, Cerastium holosteoides, Crepis paludosa, Dactylorhiza maculata, Dactylorhiza sambucina, Gentianella lutescens, Gladiolus imbricantus, Hypochaeris maculata, Lysimachia punctata, Polygonatum verticillatum, Prunus spinosa, Pteridium aquilinum, Solidago virgaurea.*								
Hypericum maculatum	-	IV	-	-0.4	x	x	3	3
Seseli osseum	-	III	-	0.3	x	x	3	0
Viola canina	-	III	-	1.2	x	x	4	1
Carex montana	-	II	-	0.2	x	x	3	0
Cruciata glabra	-	II	-	0.2	x	x	3	0
Lysimachia vulgaris	-	II	-	0.2	x	x	4	7
Thymus dacicus	-	II	-	0.2	x	x	4	2
Leontodon autumnalis	-	I	-	0.1	x	x	5	3
Thymus pulegioides	-	I	-	0.1	x	x	4	2
Other species 2011(K 1; P 0.1%; F 3.): *Betula pendula, Dianthus armeria, Hieracium umbellatum, Juniperus communnis, Seneccio jacobea, Veronica teucrium.*								

where: F - Fodder quality indices; M - Production indices.

These data show that for the *Nardo-Festucetum rubrae fallax* association, between the two studies carried out in 1937 and in 2011, there were quite big changes in the grassy layer of these permanent grasslands of secondary origin, after the deforestation that preceded them.

Thus *Nardus stricta*, the dominant species, increased in participation from 45.6% to 66.9%, that is more than 20%, *Festuca rubra* increased by 4%, *Deschampsia*

flexuosa decreased by more than 10%, *Molinia caerulea* disappeared and other minor changes occured.

Instead, *Juniperus communis* shrubs have appeared more recently, as well as *Betula pendula* seedlings, as a result of an underload of these grasslands, used for grazing.

As far as the number of plant species is concerned, respectively phytodiversity, in 1937 this association registered 81 species and in 2011 only 57, respectively only 70% of what it was 75 years ago.

Changes in the dynamics of floristic composition had a strong influence on the dynamics of productivity in the phytocoenoses of these grasslands (Table 3).

Table 3. Productivity dynamics and grazing capacity for some grassland phytocenoses from Codru Moma Mountains

Specification	*Year*	*Grassland association*				*Average*
		1.Anthoxantho-Agrostetum capillaris	*2. Poterio-Festucetum valesiacae*	*3. Festuco rubrae-Agrostetum capillaris*	*4. Nardo-Festucetum rubrae fallax*	
Pastoral value (PV)	1937	47.9	51.9	63.2	17.3	45.1
	2011	58.9	44.9	68.4	10.6	45.7
	Diff.+ -	+ 11.0	- 7.0	+ 5.2	- 6.7	+ 0.7
	%	123	87	108	61	101
Green mass production (GM t/ha)	1937	7.22	6.49	10.79	2.22	6.68
	2011	8,83	5,37	13.10	1.44	7.18
	Diff.+ -	+ 1.61	- 1.12	+ 2.31	- 0.78	+ 0.50
	%	122	83	121	65	107
Duration of the optimal grazing season (days)		190	175	160	160	170
Livestock units (LU/ha)	1937	0,58	0.57	1.04	0.21	0.60
	2011	0.71	0.47	1.26	0.14	0.65
	Diff.+ -	+ 0,13	- 0.10	+ 0.22	- 0.07	+ 0.05
	%	122	82	121	67	108

Thus, the *Nardo-Festucetum rubrae fallax* association has a pastoral value of about 7 lower indices and a green mass production of only 65% in 2011 compared to 1937.

Poterio-Festucetum valesiacae association located on the sunny slopes also records a decrease in pastoral value by 7 and a production of 83% in 2011, compared to 1937.

The other two plant associations *Festuco rubrae-Agrostetum capillaris* and *Anthoxantho-Agrostetum capillaris* located near localities and better managed, have better pastoral value indices by 7 and green mass production by 21-22% higher in 2011.

On average, for the 4 phytocoenosis, the optimal loading of livestock units was 0.60 LU/ha in 1937 and 0.65 LU / ha in 2011, fairly constant for a production around 7 t/ha green mass production for about an average season of 170 days of grazing.

Conclusions

(1) In the grasslands vegetation of Codru Moma Mountains significant changes occurred over a period of three quarters of a century.

(2) The grasslands belonging to the *Nardo-Festucetum rubrae fallax* association, located at a greater distance from localities, were further invaded by the worthless *Nardus stricta* species by more than 20%, which decreased the pastoral value by 7 and feed production by 35%.

(3) The grasslands belonging to *Anthoxantho-Agrostetum capillaris* and *Festuco rubrae-Agrostetum capillaris* associations, near the localities, were better managed and as a result, the pastoral value is better and green mass production increased by 21-22% in 2011 compared to the reference year 1937.

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