Scientific Papers. Series A. Agronomy, Vol. LXVIII, No. 2, 2025
ISSN 2285-5785; ISSN CD-ROM 2285-5793; ISSN Online 2285-5807; ISSN-L 2285-5785

EVALUATION OF THE PRODUCTIVITY OF PERMANENT MESOPHILIC GRASSLANDS FROM CODRU-MOMA MOUNTAINS (NW ROMANIA)

Călin Gheorghe PĂȘCUȚ[1], Teodor MARUȘCA[2], Ghiță Cristian CRAINIC[1], Călin Ioan IOVAN[1], Szilard BARTHA[1], Petrică Tudor MOȚIU[1]

[1]University of Oradea, Faculty of Environmental Protection, 26 Gen. Magheru Street, Oradea, Romania
[2]Research and Development Institute from Grasslands Braşov, 5 Cucului Street, Braşov, Romania

Corresponding author email: pascutcalin@yahoo.com

Abstract

The paper presents a case study for evaluating the productivity of permanent grasslands of Festuco rubrae-Agrostetum capillaris Horvat 1951, Trifolio-Lolietum perennis Krippelová 1967, Anthoxantho-Agrostetum capillaris Sillinger 1933 and Nardo-Festucetum rubrae fallax, from Codru-Moma Mountains, based on floristic relevées. Following the floristic study and the assessment of the participation weight of the component species in each type of grassland, the production of green mass and animal load was determined for each type of grassland studied. Among the studied plant associations, the highest productivity was found in Trifolio-Lolietum perennis Krippelová 1967, with productions of 18.15 t/ha of green mass and a capacity of 1.59 livestock/ha, Festuco rubrae-Agrostetum capillaris Horvat 1951 with productions of 11.64 t/ha of green mass and a capacity of 1.02 livestock/ha loading with animals. The lowest productions were evaluated in the grasslands of Nardo-Festucetum rubrae fallax, with productions of 3.86 t/ha of green mass and a capacity of 0.37 livestock/ha. The data provided by the present study are useful in characterizing the pastoral quality of these grasslands in the context of the improvement and rational use of the pastoral fund.

***Key words**: grasslands, evaluation, green mass production, pastoral value, carrying capacity.*

INTRODUCTION

Grasslands are an essential element of sustainable farming systems that meet the demands of healthy, high-quality food (White et al., 2000). In addition grasslands have an important function in rural development and the environment, reflected by the conservation of biodiversity, improvement of soil fertility, hydrological balance, carbon storage, landscape quality and important cultural heritage (Wick et al., 2016).

Herbage mass production and forage quality of the plant species are the most important factors for grazing livestock performance and carrying capacity (Novák, 2004; Carlier et al., 2009; Soder et al., 2007).

The effects of grazing intensity on forage value as well as floristic diversity differ depending on the type of grazing animals and the ecological context (Liu et al. 2015; Schmitz & Isselstein, 2020). Some studies have found that cessation of grazing can lead to a decrease in the floristic diversity of pastures (Janišová et al., 2020; Bohner et al., 2019), while some research finds an increase in plant richness (Ford et al., 2012).

Methods for assessing grassland productivity that involve cutting and weighing phytomass are accurate but it requires a lot of time and high costs (Angerer, 2012; Peratoner & Pötsch, 2019).

In agronomic practice, pasture biomass can be assessed using the vegetation study method (visual estimation), which is considered comparable to the analytical method. (Novák, 2004; Angerer, 2012; Marușca, 2019; Peratoner & Pötsch, 2019).

The most widely used method for visual assessment of vegetation characteristics is the floristic relevées, which highlights the coverage of each species through the abundance-dominance class. (Cristea et al., 2004; Marușca, 2019; Peratoner & Pötsch, 2019). The estimation of species abundance-dominance is carried out using the Braun-Blanquet scale (1964), which has a variation range that differs between classes, namely: 4.5% between +-1 class, 12.5% between 1-2 class, 20% between 2-

3 class, 25% between 3-4 class and 25% between 4-5 class.
The large difference (25%) between 3-4 class and 4-5 class, 20% between 2-3 class leads to an inappropriate estimate for the quantitative assessment of biomass (Maruşca, 2019). To eliminate these estimation differences, another quantitative participation evaluation scale was developed, using the constancy (K) for each species (Maruşca, 2019; Maruşca et al., 2019, 2020).
This new method for quantitative biomass assessment was used in the present study mainly pursuing the following objectives:
1. Determining the pastoral value and green mass production of mesophilic grasslands in the Codru Moma Mountains, with determination of grazing capacity;
2. Comparative study of the main pastoral parameters (pastoral value, green mass production, grazing capacity) corresponding to the *Festuco rubrae-Agrostetum capillaris* Horvat 1951 association, from the Codru Moma Mountains with the situation in the neighboring mountainous areas (Bihor Mountains, Pădurea Craiului Mountains, Vlădeasa Mountains).

MATERIALS AND METHODS

The study is located in the Codru-Moma Mountains, which are part of the Apuseni Mountains group, being situated in their western part and presenting themselves in the form of a well-defined promontory, oriented in the NW-SE direction. The territory of the Codru-Moma Mountains is located in the Bihor county and Arad county, being comprised between 46°20'-46°41' north latitude and 22°06'- 22°32' east longitude (Buz, 1980).
Within the described limits, Codru-Moma Mountains occupy an area of about 675 km², having the shape of a parallelogram with a length of about 39 km and a width of 17 km (Figure 1). Mesophile grassland vegetation represents about 10% of the total area of the territory, being spread mainly in the area of the Vaşcău Plateau.
In order to assess the productivity of mesophilic grasslands in the Codru Moma Mountains, the study of flora and vegetation conducted by Păşcuţ (2012) was taken into account.

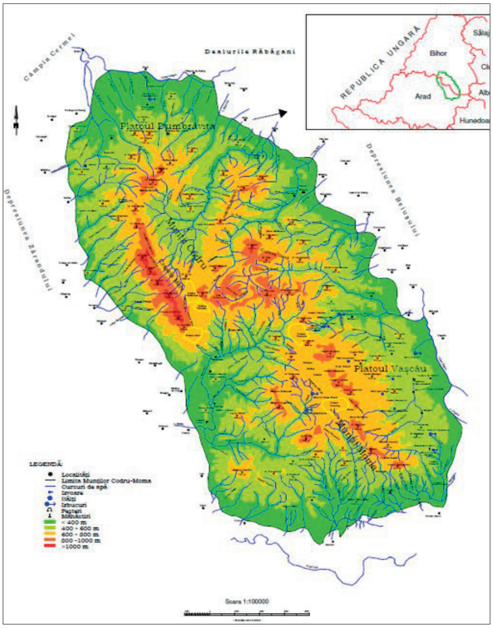

Figure 1. Geographical location of Codru Moma Mountains

The botanical nomenclature used for the identified species is in accordance with the work developed by Ciocârlan (2009). In the study of the floristic composition of mesophilous grasslands, relevées with an area of 100 m² were used.
In order to highlight the floristic similarity of the phytocoenoses corresponding to grasslands studied, the Jaccard index was used as a calculation model, determined with the help of the Past 5 statistical program.
The scientific name of the association and the name of the author were matched taking into account the International Code of Phytosociological Nomenclature, Edition 3 (Weber et al., 2000). The classification of the grassland association into higher syntaxonomic units, alliance, order and class was established on the basis of a group of characteristic species indicated in various specialized works, especially those developed by Pott (1995), Mucina (1997), Chifu (2004-2006).
Appreciation of abundance-dominance (AD) of species from the herbaceous layer in the grasslands of Codru Moma Mountains was performed on the Braun-Blanquet scale, described by Cristea et al. (2004).

Conversion of AD assessment notes into percentages (Table 1) according to constancy classes (K) was made after the model initiated by Marușca (2019).

Table 1. Appreciation of participation (P%) from synthetic floristic surveys, depending on the abundance-dominance scale intervals (AD) and average constancy (K%) for phytocoenoses of permanent grasslands (Marușca, 2019)

AD Scale Br. – Bl.	**AD according to K (%)**				
	V (81 – 100)	**IV (61 – 80)**	**III (41 – 60)**	**II (21 – 40)**	**I (<20)**
5	**87.5***	**61.3**	**43.8**	**26.3**	**8.8**
4 - 5	75.0	52.5	37.5	22.5	7.5
3 - 5	62.5	43.8	31.3	18.8	6.3
2 - 5	52.5	36.8	26.3	15.8	5.3
1 - 5	46.3	32.4	23.2	13.9	4.6
+ - 5	44.0	30.8	22.0	13.2	4.4
4	**62.5***	**43.8**	**31.3**	**18.8**	**6.3**
3 – 4	50.0	35.0	25.0	15.0	5.0
2 – 4	40.0	28.0	20.0	12.0	4.0
1 – 4	33.8	23.7	16.9	10.1	3.4
+ - 4	31.5	22.1	15.8	9.5	3.2
3	**37.5***	**26.3**	**18.9**	**11.3**	**3.8**
2 – 3	27.5	19.3	13.8	8.3	2.8
1 – 3	21.3	14.9	10.7	6.4	2.1
+ - 3	19.0	13.3	9.5	5.7	1.9
2	**17.5***	**12.3**	**8.8**	**5.3**	**1.8**
1 – 2	11.3	7.9	5.7	3.4	1.1
+ - 2	9.0	6.3	4.5	2.7	0.9
1	**5.0***	**3.5**	**2.5**	**1.5**	**0.5**
+ - 1	2.8	2.0	1.4	0.8	0.3
+	**0.5***	**0.4**	**0.3**	**0.2**	**0.1**

*)Appreciation scale transformation A+D, Braun-Blanquet in percentage, after Cristea et al. (2004).

After conversion into percentages of participation, according to the assessment scale, the indicators of forage quality (F4 - F9) and harmfulness (F1 - F3) are entered for each species in the floristic table, together with the indicators of useful forage phytomass (M1- M9) and harmful phytomass (M0 for F1 - F3) (Marușca, 2019; Marușca et al., 2020).

The fodder value indices (F) after Kovacs (1979), Păcurar & Rotar (2014), Marușca (2019) are the following:

Feed value indices (F): 1 = toxic to animals and humans; 2 = harmful to animal products; 3 = harmful to the vegetal layer; 4 = weak fodder (ballast species); 5 = mediocre fodder (former F1); 6 = medium forage (formerly F2); 7 = good fodder (former F3); 8 = very good fodder (former F4); 9 = excellent fodder (former F5); X = specis of unknown feed value.

The relevées thus prepared with the participation in % of the species in the vegetal layer with the mention of the fodder quality indices (F) and those of useful phytomass (M) make possible the calculation of the pastoral value (VP) according to the formula:

$$VP = \sum P(\%)\frac{F}{9}$$

in which: VP - pastoral value indicator (0-100) according to which the forage quality of a grassland is assessed: 0-5 degraded grassland; 5-15 very weak; 15-25 weak; 25-40 mediocre; 40-60 medium; 60-80 good; 80-100 very good.

F - has values between 4 and 9.

For the evaluation of the net fodder production, a new indirect method of determination was applied based on the floristic relevées and production indices (M) of the fodder species (F4-F9) from the vegetal layer of the grasslands (Marușca 2019; Marușca et al., 2020).

The average green mass production index (IM) of permanent grassland phytocoenoses was calculated with the following formula:

$$IM = \sum P(\%)\frac{M}{100}$$

in which: M - has values between 1-9 only for values of F between 4 - and 9.

After establishing the average green feed mass index (IM) the corresponding interval of the IM value is searched from Table 2 and multiplied by the coefficient of transformation into green mass production (CMV), resulting the production in tonnes per hectare, and finally the coefficient of appreciation for this indicator (Marușca 2019; Marușca et al., 2020).

The green mass production of phytocoenoses is very heterogeneous, starting with 0.2 t/ha (very weak) and can reach over 30 t/ha (excellent) on well-managed and well-exploited permanent grasslands.

Based on these data, the optimal load with animals or carrying capacity (CP) expressed in livestock units (LU) per hectare are further established using the formula:

$$CP(UVM/ha) = \frac{MV(kg/ha)}{NzxZp}$$

in which: Nz - the daily requirement of grass for 1 livestock unit (LU), 65 kg (50 kg + 30% (15 kg) seasonal climate fluctuations and unconsumed debris)

Zp = number of grazing days (season)

The duration of the optimal grazing season for the Codru Moma Mountains is on average 175 days at the altitude of 400-600 m and 160 days at the altitude of 600-800 m.

Table 2. Production indices for feed species and estimating the useful yield per hectar of permanent unfertilized grasslands (Marușca, 2019; Marușca et al., 2020)

Average production indices green mass forage species (IM)	Coefficients of transformation in green mass production (CMV)	Green mass production estimate (MV) (t/ha)	Appreciation of production value
0.1 – 0.5 0.6 – 1.0	x 1.8 x 1.9	0.18 – 0.90 1.14 – 1.90	Very weak
1.1 – 1.5 1.6 – 2.0	x 2.0 x 2.1	2.20 – 3.00 3.36 – 4.20	Weak
2.1 – 2.5 2.6 – 3.0	x 2.2 x 2.3	4.62 – 5.50 5.98 – 6.90	Weak - Medium
3.1 – 3.5 3.6 – 4.0	x 2.4 x 2.5	7.44 – 8.40 9.00 – 10.00	Medium
4.1 – 4.5 4.6 – 5.0	x 2.6 x 2.7	10.66 – 11.70 12.42 – 13.50	Middle - Good
5.1 – 5.5 5.6 – 6.0	x 2.8 x 2.9	14.28 – 15.40 16.24 – 17.40	Good
6.1 – 6.5 6.6 – 7.0	x 3.0 x 3.1	18.30 – 19.50 20.46 – 21.70	Good - Very good
7.1 – 7.5 7.6 – 8.0	x 3.2 x 3.3	22.72 – 24.00 25.08 – 26.40	Very good
8.1 – 8.5 8.6 – 9.0	x 3.4 x 3.5	27.54 – 28.90 30.10 – 31.50	Excellent

RESULTS AND DISCUSSIONS

Grassy vegetation occupies an area of 10.150 ha in the Codru Moma Mountains, representing 15% of the total area. Mesophilic grasslands occupy 10% of the total area, in which the grasslands represented by *Festuca rubra* L. and *Agrostis capillaris* L. predominate (Figure 2).

Four mesophilic grassland associations from the Codru Moma Mountains were studied, which are classified from a coenotaxonomic point of view as follows:

Molinio-Arrhenatheretea class (R. Tüxen 1937);
Arrhenatheretalia order (R. Tüxen 1931);
Cynosurion alliance (R. Tüxen 1947);
Festuco rubrae-Agrostetum capillaris association (Horvat 1951);
Trifolio-Lolietum perennis association (Krippelová 1967);
Anthoxantho-Agrostetum capillaris association (Sillinger 1933);
Nardo-Callunetea class (Preising 1949);
Nardetalia order (Oberdorfer 1949);
Potentillo-Nardion alliance (Simon 1959);
Nardo-Festucetum rubrae fallax association (Pușcaru et al. 1959).

Figure 2. *Festuco rubrae-Agrostetum capillaris* Horvat 1951, in Ponoraș Glade (Codru Moma Mountains)

The mesophilic grasslands of the *Festuco rubrae-Agrostetum capillaris* association grow on deep, humus-rich districambosol soils, occurring in the upper hilly area at altitudes of 480-880 m, on flat terrain and with slopes of up to 15º, with different exposures. On lands with higher soil moisture, compacted and with a low nutrient content, *Festuca rubra* L. dominates, while on lands with looser soil, *Agrostis capillaris* L. dominates.

The floristic composition of these grasslands is very varied, correspond to 157 species (Table 3). A total of 25 releveés were studied, carried out between 2008 and 2024. The largest number of relevées were carried out in the Vașcău Plateau, Ponoraș Glade, Brătcoaia Glade, Izoiu Glade.

These grasslands are characterized by the presence of a high percentage (76.4%) of species from *Poaceae*, of which the largest share is: *Agrostis capillaris* L., *Festuca rubra* L., *Holcus lanatus* L., *Phleum pratense* L., *Danthonia decumbens* (L.) DC., *Cynosurus cristatus* L., *Dactylis glomerata* L., *Brachypodium pinnatum* (L.) Beauv. The *Fabaceae* species have a reduced coverage (2.2%), being represented by a greater constancy of *Lotus corniculatus* L., *Trifolium repens* L., *Trifolium pratense* L., *Trifolium campestre* Schreber (Table 3). In these grasslands, some forage species from other families also appear with great frequency, *Achillea millefolium* L., *Centaurea phrygia* L., *Potentilla erecta* (L.) Räusch., *Hieracium pilosella* L., *Leucanthemum vulgare* Lam., *Plantago lanceolata* L., *Rumex acetosa* L., *Thymus glabrescens* Willd., *Thymus pulegioides* L. A number of species harmful to livestock products also enter these grasslands, *Carduus acanthoides* L., *Carduus nutans* L., *Rumex acetosella* L. and toxic and harmful plants *Stellaria graminea* L., *Hypericum perforatum* L., *Pteridium aquilinum* (L.) Kuhn, *Euphorbia cyparissias* L., *Hypericum maculatum* Crantz.

The meadows belonging to the *Trifolio-Lolietum perennis* association are spread in the Codru-Moma Mountains, at altitudes of 380-420 m, on almost flat (0-5°), tamped and compacted lands (Table 3). They are the grasslans with the highest pastoral value in which the *Poaceae* species have a high share (61.6%), and the *Fabaceae* species are present in a proportion of 29.9%. The species with the highest forage value are represented by *Lolium perenne* L., *Trifolium repens* L., *Lotus corniculatus* L., *Dactylis glomerata* L., *Poa pratensis* L.

Grasslands of *Agrostis capillaris* L. and *Anthoxanthum odoratum* L. are characterized by a fairly wide ecological amplitude, occupying stations from the understory of the common sedge to the understory of the beech. They are spread on lands with varying slopes (5-18°), on different exposures, at altitudes of 300-620 m (Table 3). The physiognomy of these grasslands is given by *Poaceae* species (76%), with *Fabaceae* species having a reduced presence (1.9%). The useful phytomass of these grasslands is represented by species with high forage value such as *Agrostis capillaris* L., *Anthoxanthum odoratum* L., *Briza media* L., *Cynosurus cristatus* L., *Festuca pratensis* Hudson, *Lotus corniculatus* L., *Trifolium repens* L., *Achillea millefolium* L., *Plantago lanceolata* L.

Grasslands of *Festuca rubra* L. and *Nardus stricta* L. are spread at altitudes of 600-800 m, on terrains with a slope of 5-25° and varied exposures (Table 3). They are present on soils of the districambosol type, well-drained, moderately acidic and of medium trophicity. They are the least productive grasslands with a lack of *Fabaceae* species and a low presence of forage *Poaceae* species (33.3%).

Dendrogram of mesophilous grasslands in the Codru Moma Mountains highlights a relative uniformity of their floristic composition, with pronounced similarity of the grasslands represented by the *Festuco rubrae-Agrostetum capillaris* (1) and *Anthoxantho-Agrostetum capillaris* (3) associations (Figure 3).

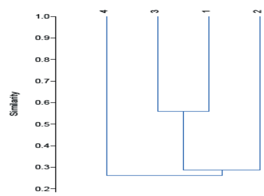

Figure 3. Jaccard similarity index from the grasslans studied in the Codru Moma Mountains, where: 1 - *Festuco rubrae-Agrostetum capillaris*, 2 - *Trifolio-Lolietum perennis*, 3 - *Anthoxantho-Agrostetum capillaris*, 4 - *Nardo-Festucetum rubrae fallax*

Table 3. The floristic composition of the mesophilous grasslands in the Codru Moma Mountains, Bihor county (where: F - Fodder quality indices; M - Production indices; K – constancy)

Plant association	*Festuco rubrae-Agrostetum capillaris*			*Trifolio-Lolietum perennis*			*Anthoxantho-Agrostetum capillaris*			*Nardo-Festucetum rubrae fallax*			Indicators	
		ADm	K		ADm	K		ADm	K		ADm	K		
No. of relevées	25			8			13			9				
Altitude (m)	480-880			380-420			300-620			600-800				
The coverage of grass layer (%)	99,6			98,8			99,8			99,6				
Exposition	V, E, NE, NV			E, SE			S, E, N, SV, SE			N, S, V, SV				
Slope (degree) (º)	0-15			0-5			5-18			5-25				
Area (m²)	100			100			100			100			F	M
0	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*	*13*	*14*
Poaceae														
Agrostis capillaris	40	2-4	V	2	+-1	IV	40	2-4	V	0.4	+	IV	7	5
Agrostis gigantean	0.1	+	I	·	·	·	·	·	·	1.4	+-1	III	7	7
Anthoxanthum odoratum	0.1	+	I	9	+-2	I	33.8	1-4	V	0.2	+	II	5	3
Brachypodium pinnatum	0.2	+	II	·	·	·	·	·	·	·	·	·	5	7
Briza media	0.1	+	I	·	·	·	0.3	+	III	0.3	+	III	5	2
Cynosurus cristatus	0.3	+	III	·	·	·	0.3	+	III	·	·	·	7	4
Dactylis glomerata	0.2	+	II	0.2	+	II	0.2	+	II	·	·	·	9	8
Danthonia decumbens	0.3	+	III	·	·	·	·	·	·	0.4	+	IV	5	4
Deschampsia flexuosa	0.1	+	I	·	·	·	·	·	·	9	+-2	V	4	3
Festuca pratensis	0.1	+	I	·	·	·	0.4	+	IV	·	·	·	9	8
Festuca rubra	33.8	1-4	V	0.2	+	II	0.2	+	II	21.3	1-3	V	7	6
Festuca rupicola	0.1	+	I	·	·	·	0.1	+	I	·	·	·	5	5
Festuca valesiaca	0.1	+	I	·	·	·	·	·	·	·	·	·	5	3
Holcus lanatus	0.3	+	III	·	·	·	0.3	+-1	I	0.3	+	III	6	6
Lolium perenne	·	·	·	50	3-4	V	·	·	·	·	·	·	9	8
Poa annua	0.1	+	I	·	·	·	·	·	·	·	·	·	7	2
Poa pratensis	0.1	+	I	0.2	+	II	0.2	+	II	·	·	·	8	6
Phleum montanum	0.1	+	I	·	·	·	·	·	·	·	·	·	6	5
Phleum pratense	0.3	+	III	·	·	·	0.2	+	II	·	·	·	9	8
Fabaceae														
Anthyllis vulneraria	0.1	+	I	·	·	·	0.1	+	I	·	·	·	6	5
Lathyrus pratensis	0.1	+	I	0.1	+	I	·	·	·	·	·	·	7	6
Lotus corniculatus	0.5	+	V	2	+-1	IV	0.5	+	V	·	·	·	8	6
Medicago lupulina	0.1	+	I	0.1	+	I	0.1	+	I	·	·	·	8	3
Trifolium campestre	0.2	+	II	0.1	+	I	0.2	+	II	·	·	·	7	2
Trifolium hybridum	0.1	+	I	0.1	+	I	0.2	+	II	·	·	·	8	6
Trifolium medium	0.1	+	I	·	·	·	·	·	·	·	·	·	6	4
Trifolium montanum	0.1	+	I	·	·	·	·	·	·	·	·	·	7	4
Trifolium pannonicum	0.1	+	I	·	·	·	·	·	·	·	·	·	7	5
Trifolium pratense	0.3	+	III	·	·	·	0.2	+	II	·	·	·	8	7
Trifolium repens	0.3	+	III	27.5	2-3	V	0.4	+	IV	·	·	·	8	5
Vicia cracca	0.1	+	I	·	·	·	0.2	+	II	·	·	·	7	6
Vicia tetrasperma	0.1	+	I	·	·	·	·	·	·	·	·	·	6	3
Forage species from other botanical families														
Achillea millefolium	0.5	+	V	0.5	+	V	0.5	+	V	0.3	+	III	6	4
Antennaria dioica	·	·	·	·	·	·	·	·	·	0.1	+	I	4	2
Bellis perennis	0.1	+	I	·	·	·	0.2	+	II	·	·	·	5	1
Carex pallescens	0.1	+	I	·	·	·	·	·	·	0.2	+	II	4	3
Carum carvi	0.1	+	I	0.1	+	I	0.8	+-1	II	·	·	·	6	3
Centaurea phrygia	0.4	+	IV	·	·	·	0.3	+	III	0.3	+	III	4	6
Cichorium intybus	0.1	+	I	0.2	+	II	0.3	+	III	·	·	·	5	6
Convolvulus arvensis	0.1	+	I	·	·	·	0.1	+	I	·	·	·	7	6
Daucus carota	0.1	+	I	0.1	+	I	0.8	+-1	II	·	·	·	6	5
Filipendula vulgaris	0.1	+	I	·	·	·	·	·	·	·	·	·	5	4
Fragaria vesca	0.1	+	I	·	·	·	0.2	+	II	·	·	·	5	1
Fragaria viridis	0.2	+	II	·	·	·	0.2	+	II	·	·	·	4	1
Galium verum	0.2	+	II	·	·	·	0.3	+	III	0.2	+	II	5	4
Helianthemum nummularium	0.1	+	I	·	·	·	·	·	·	·	·	·	4	2
Hieracium pilosella	0.3	+	III	·	·	·	0.4	+	IV	0.3	+	III	4	1
Knautia arvensis	0.2	+	II	0.1	+	I	0.2	+	II	·	·	·	4	4
Leontodon autumnalis	0.2	+	II	·	·	·	1.4	+-1	III	·	·	·	5	3
Leontodon hispidus	0.2	+	II	0.2	+	II	0.3	+	III	·	·	·	5	3
Leucanthemum vulgare	0.3	+	III	·	·	·	0.2	+	II	0.2	+	II	5	5
Luzula campestris	0.1	+	I	·	·	·	0.1	+	I	0.4	+	IV	4	2
Lysimachia vulgaris	0.1	+	I	·	·	·	0.1	+	I	0.2	+	II	4	7
Origanum vulgare	0.1	+	I	·	·	·	·	·	·	·	·	·	4	4

0	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*	*13*	*14*
Plantago lanceolata	0.3	+	III	2	+-1	IV	0.4	+	IV	0.2	+	II	6	1
Plantago major	·	·	·	0.1	+	I	0.2	+	II	·	·	·	5	3
Plantago media	0.1	+	I	0.8	+-1	II	·	·	·	·	·	·	6	2
Polygala vulgaris	0.2	+	II	0.2	+	II	0.3	+	III	0.2	+	II	4	1
Potentilla erecta	0.4	+	IV	·	·	·	0.2	+	II	0.5	+	V	5	2
Prunella laciniata	0.1	+	I	0.1	+	I	0.1	+	I	·	·	·	4	2
Prunella vulgaris	0.1	+	I	0.4	+	IV	0.4	+	IV	·	·	·	4	2
Ranunculus polyanthemos	0.2	+	II	·	·	·	0.1	+	I	·	·	·	4	4
Rumex acetosa	0.3	+	III	0.1	+	I	0.1	+	I	0.3	+	III	4	5
Rumex obtusifolius	·	·	·	0.1	+	I	·	·	·	·	·	·	4	6
Salvia pratensis	·	·	·	0.1	+	I	·	·	·	·	·	·	4	4
Sanguisorba officinalis	0.1	+	I	·	·	·	·	·	·	·	·	·	7	5
Scabiosa ochroleuca	0.2	+	II	·	·	·	0.1	+	I	·	·	·	4	4
Taraxacum officinale	·	·	·	0.2	+	II	0.1	+	I	·	·	·	7	3
Thymus glabrescens	0.3	+	III	·	·	·	0.3	+	III	0.2	+	II	4	2
Thymus pulegioides	0.3	+	III	·	·	·	0.3	+	III	·	·	·	4	2
Tragopogon pratensis	·	·	·	·	·	·	0.1	+	I	·	·	·	5	5
Verbena officinalis	·	·	·	0.1	+	I	·	·	·	·	·	·	4	4
Veronica chamaedrys	0.1	+	I	·	·	·	0.1	+	I	·	·	·	4	2
Viola canina	0.3	+-1	I	·	·	·	·	·	·	1.4	+-1	III	4	1
Plant species not consumed or with a low degree of consumability (F3), (M0)														
Acinos arvensis	0.1	+	I	·	·	·	0.1	+	I	·	·	·	3	0
Agrimonia eupatoria	0.1	+	I	·	·	·	0.2	+	II	·	·	·	3	0
Ajuga reptans	·	·	·	·	·	·	0.1	+	I	·	·	·	3	0
Asperula cynanchica	0.1	+	I	·	·	·	0.2	+	II	·	·	·	3	0
Betula pendula	0.2	+	II	·	·	·	·	·	·	0.2	+	II	3	0
Blechnum spicant	·	·	·	·	·	·	·	·	·	0.1	+	I	3	0
Calamagrostis arundinacea	0.1	+	I	·	·	·	·	·	·	0.2	+	II	3	0
Calamagrostis epigeios	0.3	+-1	I	·	·	·	0.2	+	II	·	·	·	3	0
Campanula glomerata	0.2	+	II	·	·	·	0.1	+	I	·	·	·	3	0
Campanula patula	0.4	+	IV	·	·	·	0.2	+	II	0.3	+	III	3	0
Campanula persicifolia	0.1	+	I	·	·	·	·	·	·	·	·	·	3	0
Cardamine pratensis	0.1	+	I	·	·	·	·	·	·	·	·	·	3	0
Carex ovalis	·	·	·	·	·	·	·	·	·	0.1	+	I	3	0
Carex tomentosa	0.1	+	I	·	·	·	0.1	+	I	·	·	·	3	0
Carlina acaulis	0.2	+	II	0.1	+	I	0.2	+	II	·	·	·	3	0
Carlina biebersteinii	0.1	+	I	·	·	·	0.2	+	II	·	·	·	3	0
Carlina vulgaris	0.1	+	I	·	·	·	0.2	+	II	·	·	·	3	0
Centaurea nigrescens	0.1	+	I	0.1	+	I	0.8	+-1	II	·	·	·	3	0
Centaurium erythraea	0.1	+	I	·	·	·	0.3	+	III	·	·	·	3	0
Cerastium holosteoides	0.2	+	II	·	·	·	0.1	+	I	·	·	·	3	0
Cirsium canum	0.1	+	I	·	·	·	·	·	·	·	·	·	3	0
Clinopodium vulgare	0.1	+	I	·	·	·	·	·	·	·	·	·	3	0
Corylus avellana	0.1	+	I	·	·	·	·	·	·	·	·	·	3	0
Crataegus monogyna	0.3	+	III	0.1	+	I	0.3	+	III	·	·	·	3	0
Cruciata glabra	0.3	+	III	·	·	·	·	·	·	0.2	+	II	3	0
Cytisus nigricans	0.1	+	I	·	·	·	·	·	·	0.2	+	II	3	0
Dactylorhiza maculata	0.1	+	I	·	·	·	·	·	·	·	·	·	3	0
Dactylorhiza sambucina	0.1	+	I	·	·	·	0.1	+	I	·	·	·	3	0
Deschampsia caespitosa	·	·	·	·	·	·	·	·	·	0.3	+	III	3	0
Dianthus armeria	0.1	+	I	·	·	·	·	·	·	·	·	·	3	0
Dianthus carthusianorum	0.2	+	II	·	·	·	0.1	+	I	0.2	+	II	3	0
Dianthus spiculifolius	0.1	+	I	·	·	·	·	·	·	·	·	·	3	0
Dichanthium ischaemum	·	·	·	·	·	·	0.1	+	I	·	·	·	3	0
Dorycnium pentaphyllum	0.1	+	I	·	·	·	·	·	·	·	·	·	3	0
Erigeron annuus	0.1	+	I	·	·	·	0.3	+	III	·	·	·	3	0
Eryngium campestre	·	·	·	0.2	+	II	0.2	+	II	·	·	·	3	0
Euphrasia officinalis	0.1	+	I	·	·	·	0.1	+	I	·	·	·	3	0
Euphrasia stricta	0.2	+	II	·	·	·	0.1	+	I	·	·	·	3	0
Filago arvensis	0.1	+	I	·	·	·	·	·	·	·	·	·	3	0
Galium album	0.1	+	I	·	·	·	·	·	·	·	·	·	3	0
Galium mollugo	0.3	+	III	·	·	·	0.3	+	III	0.2	+	II	3	0
Genista tinctoria	·	·	·	·	·	·	0.1	+	I	·	·	·	3	0
Genistella sagittalis	0.1	+	I	·	·	·	0.2	+	II	1.4	+-1	III	3	0
Gentiana asclepiadea	0.2	+	II	·	·	·	·	·	·	0.2	+	II	3	0
Gentiana cruciata	0.2	+	II	·	·	·	0.1	+	I	0.2	+	II	3	0
Gladiolus imbricatus	0.1	+	I	·	·	·	·	·	·	·	·	·	3	0
Gnaphalium sylvaticum	0.1	+	I	·	·	·	·	·	·	0.2	+	II	3	0
Hieracium umbellatum	·	·	·	·	·	·	·	·	·	0.1	+	I	3	0

0	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*	*13*	*14*
Hypochaeris radicata	0.1	+	I	·	·	·	0.2	+	II	·	·	·	3	0
Juncus conglomeratus	·	·	·	0.1	+	I	0.2	+	II	·	·	·	3	0
Juncus effusus	0.2	+	II	·	·	·	0.1	+	I	·	·	·	3	0
Juncus tenuis	0.1	+	I	·	·	·	·	·	·	·	·	·	3	0
Juniperus communis	0.3	+	III	·	·	·	0.2	+	II	0.2	+	II	3	0
Linaria vulgaris	0.1	+	I	·	·	·	·	·	·	·	·	·	3	0
Linum catharticum	0.2	+	II	·	·	·	0.1	+	I	·	·	·	3	0
Luzula luzuloides	0.1	+	I	·	·	·	·	·	·	0.3	+	III	3	0
Lycopodium clavatum	·	·	·	·	·	·	·	·	·	0.1	+	I	3	0
Lysimachia nummularia	0.1	+	I	·	·	·	·	·	·	·	·	·	3	0
Malus sylvestris	0.2	+	II	·	·	·	0.2	+	II	·	·	·	3	0
Mentha pulegium	·	·	·	0.2	+	II	·	·	·	·	·	·	3	0
Molinia caerulea	0.1	+	I	·	·	·	·	·	·	·	·	·	3	0
Nardus stricta	0.3	+	III	·	·	·	0.2	+	II	46.3	1-5	V	3	0
Orchis morio	0.1	+	I	·	·	·	·	·	·	·	·	·	3	0
Ononis spinosa	·	·	·	·	·	·	0.2	+	II	·	·	·	3	0
Peucedanum oreoselinum	0.2	+	II	·	·	·	·	·	·	·	·	·	3	0
Populus tremula	0.1	+	I	·	·	·	·	·	·	·	·	·	3	0
Prunus spinosa	0.2	+	II	·	·	·	0.2	+	II	·	·	·	3	0
Pyrus pyraster	0.2	+	II	·	·	·	0.2	+	II	·	·	·	3	0
Rhinanthus minor	0.1	+	I	·	·	·	0.1	+	I	·	·	·	3	0
Rosa canina	0.3	+	III	0.2	+	II	0.4	+	IV	·	·	·	3	0
Rubus sulcatus	0.2	+	II	0.1	+	I	0.3	+	III	·	·	·	3	0
Rumex crispus	0.1	+	I	0.1	+	I	·	·	·	·	·	·	3	0
Salix capraea	0.1	+	I	·	·	·	·	·	·	·	·	·	3	0
Sambucus ebulus	0.1	+	I	·	·	·	·	·	·	·	·	·	3	0
Senecio germanicus	0.1	+	I	·	·	·	·	·	·	·	·	·	3	0
Seseli osseum	0.3	+	III	·	·	·	0.2	+	II	0.3	+	III	3	0
Seseli peucedanoides	0.1	+	I	·	·	·	·	·	·	·	·	·	3	0
Setaria pumila	·	·	·	0.1	+	I	0.1	+	I	·	·	·	3	0
Sorbus aucuparia	·	·	·	·	·	·	·	·	·	0.2	+	II	3	0
Stachys officinalis	0.2	+	II	·	·	·	0.2	+	II	0.2	+	II	3	0
Stachys recta	0.1	+	I	·	·	·	·	·	·	·	·	·	3	0
Succisa pratensis	0.2	+	II	·	·	·	·	·	·	0.3	+	III	3	0
Teucrium chamaedrys	0.2	+	II	·	·	·	0.2	+	II	·	·	·	3	0
Thymus comosus	0.1	+	I	·	·	·	·	·	·	·	·	·	3	0
Veronica officinalis	0.2	+	II	·	·	·	0.2	+	II	0.3	+	III	3	0
Veronica teucrium	0.2	+	II	·	·	·	·	·	·	·	·	·	3	0
Viola arvensis	0.1	+	I	·	·	·	·	·	·	·	·	·	3	0
Viola tricolor	0.1	+	I	·	·	·	0.1	+	I	0.2	+	II	3	0
Vaccinium myrtillus	0.1	+	I	·	·	·	·	·	·	2.7	+-2	II	3	0
Vaccinium vitis-idaea	·	·	·	·	·	·	·	·	·	4.5	+-2	III	3	0
Vulpia myuros	0.1	+	I	·	·	·	0.2	+	II	·	·	·	3	0
Plants that harm livestock products (F2), (M0)														
Carduus acanthoides	0.1	+	I	·	·	·	0.2	+	II	·	·	·	2	0
Carduus nutans	0.1	+	I	0.1	+	I	0.2	+	II	·	·	·	2	0
Rumex acetosella	0.1	+	I	·	·	·	·	·	·	·	·	·	2	0
Toxic and harmful plants (F1), (M0)														
Aconitum vulparia	0.1	+	I	·	·	·	·	·	·	·	·	·	1	0
Colchicum autumnale	0.1	+	I	·	·	·	0.1	+	I	·	·	·	1	0
Coronilla varia	0.1	+	I	·	·	·	·	·	·	·	·	·	1	0
Euphorbia cyparissias	0.2	+	II	0.1	+	I	2	+-1	IV	·	·	·	1	0
Euphorbia villosa	0.1	+	I	·	·	·	·	·	·	·	·	·	1	0
Hypericum maculatum	0.2	+	II	·	·	·	0.1	+	I	0.4	+	IV	1	0
Hypericum perforatum	0.3	+	III	·	·	·	0.2	+	II	·	·	·	1	0
Hypericum tetrapterum	0.1	+	I	·	·	·	0.1	+	I	·	·	·	1	0
Pteridium aquilinum	0.8	+-1	II	·	·	·	0.8	+-1	II	·	·	·	1	0
Ranunculus repens	·	·	·	0.1	+	I	·	·	·	·	·	·	1	0
Stellaria graminea	0.3	+	III	0.2	+	II	0.2	+	II	·	·	·	1	0
Veratrum album	0.1	+	I	·	·	·	·	·	·	0.2	+	II	1	0
Verbascum nigrum	0.1	+	I	·	·	·	·	·	·	·	·	·	1	0
Verbascum phlomoides	·	·	·	0.1	+	I	·	·	·	·	·	·	1	0

The highest green fodder mass (MV) production was evaluated in the *Trifolio-Lolietum perennis* association of 18.15 t/ha, with a very good pastoral value (84.20 VP) and a grazing capacity of 1.59 large cattle livestock unit (LU)/ha. At the opposite pole are the *Nardo-Festucetum rubrae fallax* grasslands with 3.86 t/ha green fodder mass (MV) production, 24.85 pastoral value (VP) and a grazing capacity of only 0.37 large cattle livestock unit (LU)/ha (Table 4).

Table 4. Productivity of plant associations from mesophilous grasslans (Codru Moma Mountains)

Plant associations	Season duration (days)	Pastoral value (VP)	Useful phytomass index (IM)	Green mass production (MV) (t/ha)	Livestock units (LU)
Festuco rubrae-Agrostetum capillaris	175	63.40	4.48	11.64	1.02
Trifolio-Lolietum perennis	175	84.20	6.05	18.15	1.59
Anthoxantho-Agrostetum capillaris	175	57.80	3.53	8.47	0.74
Nardo-Festucetum rubrae fallax	160	24.85	1.84	3.86	0.37

In order to have an idea of the productivity of *F. rubra* L. and *A. capillaris* L. meadows in the Codru Moma Mountains, we considered it appropriate to compare them with similar grasslands in the neighboring Mountains. In this sense, we compared the productivity of these grasslands with those in Vlădeasa Mountains (Marușca et al., 2021, Coldea et al., 2008), Bihor Mountains (Togor, 2016) and Pădurea Craiului Mountains (Groza, 2008).

To carry out the comparative study of grassland productivity, a number of 46 relevées from the Vlădeasa Mountains, located at altitudes of 580-1300 m, totaling 109 species, were processed; 16 relevées from the Bihor Mountains, located at altitudes of 700-1360 m, with a total number of 144 species and 21 relevées from Pădurea Craiului Mountains, existing at an altitude of 300-720 m, with a total of 145 species.

The grasslands of *F. rubra* L. and *A. capillaris* L. that are present in Codru Moma Mountains are similar in terms of floristic diversity to those from Pădurea Craiului Mountains and different from those that are present in Vlădeasa Mountains and Bihor Mountains (Figure 4.). This is mainly due to the climatic and pedological conditions in which this type of grassland grows in the neighboring massifs.

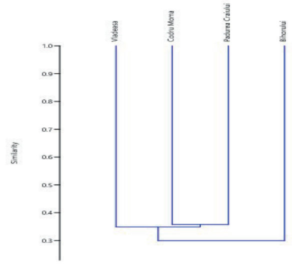

Figure 4. Jaccard similarity index from the grasslands in the regions surrounding Codru Moma Mountains

In terms of green mass productivity, the grasslands in the 4 geographical areas are similar with higher production in Pădurea Craiului Mountains (12.99 t/ha MV) and lower in Vlădeasa Mountains (9.05 t/ha MV). The highest grazing capacity is registred in the grasslands located in Bihor Mountains (1.22 LU) and the lower values in Vlădeasa Mountains (0.96 LU) (Table 5).

Table 5. Evaluation the productivity of the *Festuco rubrae-Agrostetum capillaris* association grasslands in the regions surrounding the Codru Moma Mountains

Geographical region	Season duration (days)	Pastoral value (VP)	Useful phytomass index (IM)	Green mass production (MV) (t/ha)	Livestock units (LU)
Vlădeasa Mountains	145	55.70	3.62	9.05	0.96
Bihorului Mountains	145	64.50	4.43	11.52	1.22
Pădurea Craiului Mountains	175	67.58	4.81	12.99	1.14
Codru Moma Mountains	175	63.40	4.48	11.64	1.02

CONCLUSIONS

The permanent grasslands from Codru Moma Mountains have a great variability from a phytocoenological and agroproductive point of view, with mesophilic plant associations, trampled places and calcareous hills.

The highest productivity (pastoral value and fodder production) can be observed within the grasslands belonging to *Trifolio-Lolietum perennis* association, with 84.20 pastoral value (VP), 18.15 t/ha green fodder mass and 1.59 large cattle livestock unit (LU) and *Festuco rubrae-Agrostetum capillaris* association, with

63.40 pastoral value (VP), 11.64 t/ha green fodder mass (MV) which allows an optimal loading of 1.02 large cattle livestock unit (LU)/ha in 175 days of grazing days.

The lowest productivity is evaluated in *Nardo-Festucetum rubrae fallax* association with 24.85 pastoral value (VP), 3.86 t/ha green fodder mass (MV), and 0.37 large cattle livestock unit (LU)/ha and in *Anthoxantho-Agrostetum capillaris* with 57.80 pastoral value (VP), 8.47 t/ha green fodder mass (MV) which barely allow 0.74 large cattle livestock unit (LU)/ha in a grazing season.

F. rubra L. and *A. capillaris* L. grasslands are the most widespread in Codru Moma Mountains and the neighboring massifs. The pastoral value of these grasslands in the studied mountain area is 55.70-67.58 (VP), with a green fodder mass productivity of 9.05-12.99 t/ha (MV) and a grazing capacity of 0.96-1.22 large cattle livestock unit (LU)/ha.

The data on the productivity of the grasslands determined through the new method of evaluation based on floristic surveys are used to prepare pastoral arrangements and research on the evolution over time of this main indicator.

REFERENCES

Angerer, J.P. (2012). Technologies, tools and methodologies for forage evaluation in grasslands and rangelands. *National Feed Assessments*, 165-202.

Bohner, A., Karrer, J., Walcher, R., Brandl, D., Michel, K., Arnberger, A., Frank, T., Zaller J.G. (2019). Ecological responses of seminatural grasslands to abandonment: case studies in three mountain regions in the Eastern Alps. *Folia Geobotanic*a, (54), 211-225.

Braun-Blanquet, J. (1964). Pflanzensoziologie. Springer Verlung, Wien-New York, 3, Aufl.

Buz, V. (1980). Codru-Moma Mountains. Physical-geographical study. PhD Thesis, University of Agricultural Sciences and Veterinary Medicine of Cluj-Napoca.

Carlier, L., Rotar, I., Vlahova, M., Vidican, R. (2009). Importance and functions of grasslands. *Notulae Botanicae Horti Agrobotanici*. Cluj-Napoca, (37), 25-30.

Chifu, T. (2004-2006). Syntaxonomy of the vegetal groups over Moldova territory (Roumania). Suceava, RO: *Yearbook of the Bucovina Museum Complex*, 51-114.

Ciocârlan, V. (2009). Illustrated flora of Romania, *Pteridophyta* et *Spermatophyta*. Bucharest, RO: Ceres Publishing House.

Cristea, V., Gafta, D., Pedrotti, F. (2004). Phytosociology. Cluj-Napoca, RO: Presa Universitară Clujeană Publishing House.

Ford, H., Garbutt, A., Jones, D.L., Jones, L. (2012). Impacts of grazing abandonment on ecosystem service provision: Coastal grassland as a model system. *Agriculture, Ecosystems and Environment* (162), 108-115.

Groza, G., (2008). Flora and vegetation of the Pădurea Craiului Mountains. Cluj-Napoca, RO: Risoprint Publishing House.

Janišová, M., Biro, A., Iuga, A., Širka, P., Škodová, I. (2020). Species rich grasslands of the Apuseni Mts (Romania): role of traditional farming and local ecological knowledge. *Tuexenia*, 409-427.

Kovacs, A. J. (1979). Biological, ecological and economic indicators of meadow flora. Bucharest, RO: Agricultural technical propaganda editorial office.

Liu, J., Feng, C., Wang, D., Wang, L., Wilsey, B.J., Zhong, Z. (2015). Impacts of grazing by different large herbivores in grassland depend on plant species diversity. *Journal of Applied Ecology*, (52), 1053-1062.

Marușca, T., Taulescu, E., Roșca, V., Băjenaru B.S., Memedemin D. (2019). Controbution to the evaluation of grassland productivity on the Macinului Mountains National Park. *Romanian Journal of grassland and forage crops*, (20), 17-26.

Marușca, T., (2019). Contributions to the evaluation of pasture productivity using the floristic relevé. *Romanian Journal of Grassland and Forage Crops*, (19), 33- 47.

Marușca, T., Dihoru, G., Doniță, N., Memedemin, D., Pășcuț C, G. (2020). Contributions to the evaluation of the productivity of permanent grasslands from the Babadag Plateau (Dobrogea). *University of Oradea Annals*, (35), 85-94.

Marușca, T., Roman, A., Taulescu E., Ursu T. M., Popa, R. D. (2021). Detecting trends in the quality and productivity of grasslands by analysing the historical vegetation relevés: A case from Southeastern Carpathians, Vlădeasa Mountains (Romania). *Notulae Botanicae Horti Agrobotanici*. Cluj-Napoca, (49), 1-20.

Mucina, L. (1997). Conspectus of Classes of European Vegetation. Folia Geobot. Phytotax., Praha, (32), 117-172.

Novák, J. (2004). Evaluation of grassland quality. *Ekologia Bratislava*, (23), 127-143.

Păcurar, F., Rotar I., (2014). Methods of study and interpretation of grassland vegetation. Cluj-Napoca, RO: Risoprint Publishing House.

Pășcuț, C., G. (2012). Flora and vegetation from Codru-Moma Mountains. PhD Thesis, University of Oradea.

Peratoner, G., Pötsch, E.M. (2019). Methods to describe the botanical co

mposition of vegetation in grassland research. Die Bodenkultur: *Journal of Land Management, Food and Environment*, (70), 1-18.

Pott, R. (1995). Die Pflanzengesellschaften Deutschlands, 2 Aufl., Ulmer Verlug, Stuttgart.

Schmitz, A., Isselstein, J. (2020). Effect of grazing system on grassland plant species richness and vegetation characteristics: Comparing horse and cattle grazing. *Sustainability* (Switzerland), (12), 1-17.

Soder, K. J., Rook A. J., Sanderson M. A., Goslee S. C. (2007). Interaction of plant species diversity on grazing behavior and performance of livestock grazing temperate region pastures. *Crop Science*, (47), 416-425.
Togor, G., C. (2016). Flora and vegetation from the northen side of the Bihor Mountains. PhD Thesis, University of Oradea.
Weber, H.E., Moravec, J., Theurillat, J.P. (2000). International Code of Phytosociological Nomenclature, 3 ed., Journal of Vegetation Science, Uppsala, 739-768.
White, R., Murray, S., Rohweder, M. (2000). Pilot analysis of global ecosystems: Grassland Ecosystems. Washington D.C., *World Resources Institute*.
Wick, A. F., Geaumont B. A., Sedivec K. K., Hendrickson J. (2016). Grassland degradation. In: Shroder JF, Sivanpillai R (Eds). Biological and Environmental Hazards, Risks and Disasters. Elsevier 257-276.