Impact on the Abandonment of Semi-Natural Grasslands from Apuseni Mountains

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Abstract

According to The European Communion in Europe there are large areas of abandoned grasslands (Osterburg and colab., 2010). The abandonment of grasslands entails substantial changes to the vegetation cover. Usually, after a period of time, semi-natural grasslands start to develop forestlike features. In Romania despite the existence of a subsidiary system large areas with semi-natural grasslands are abandoned. The objective of this paper was to analyze the effect of abandonment on the structure of vegetation cover. The experiment consists in 3 experimental variants (1 mowed annually, 1 abandoned for 5 years and 1 abandoned for 15 years) and is located in the village of Ghețari, from Gârda de Sus commune at an altitude of 1130 m. Vegetation was studied using the Braun-Blanquet method, modified by Păcurar and Rotar in 2014. The scientific results were processed with the numerical analysis application (Cluster Analyses) belonging to PC-ORD program. Results showed that the grassland abandoned for 5 years did not show any statistical difference compared to the grassland mowed annually. The grassland abandoned for 15 years showed modification in the structure of vegetation cover translated by the disappearance of numerous species. Our recommendation is that semi-natural grasslands, which have numerous economical disadvantages because of their location, should be mowed at least every five years.

Keywords: *grasslands, abandonment, vegetational cover.*

INTRODUCTION

Grassland is a major resource of life biosphere that sustains approximately one billion people worldwide (Schnyder *et al.*, 2010). Semi-natural grasslands grow naturally in places where woody vegetation doesn't meet the required ecological conditions to install and develop. Inadequate conditions for forests are found in places where the average annual temperature is too low, on salty soils, on areas too wet or too dry for forests to install, on soils rich in heavy metals, on slopes with high dynamic erosion (clay soils, sandy soils) or steep cliffs, which do not form a sufficient ground. Savannahs and steppes represent phytogeographic formations of the largest areas occupied by grasslands (Stugren, 2011). By an abandoned agricultural land we generally understand an un-

cultivated land which evolved to fallow if we speak about arable land or an ungrazed or unmowed land which evolved to shrubs or even forest in the case of grasslands (Marușca, 2012). The permanent pastures which are usually abandoned or neglected will finally be invaded by woody species, expressing their natural return to forest vegetation from which they evolved after deforestation and management with animals (Marușca, 2010). The abandonment of arable land is followed, in all cases, by an excessive weed growth, which are first composed by annual plants and finally by perennial plant species including fallow land. Unvalorization of grass vegetation from former arable land will lead to the installation and expansion of woody vegetation and even into forest areas (Marușca, 2012).

The abandonment of seminatural grassland has become a major threat and raises a number of questions and situations to be resolved all across Europe (Osterburg *et al.*, 2010). Grasslands habitats located in mountainous areas are very vulnerable and lose very quickly their conservation value after their abandonment (Fischer and Wipf, 2002). In these areas secondary succession occur translated at first as changes in the floristic composition specific to one area (Habel *et al.*, 2013). Sometimes changes can be so obvious that they are threatening even grassland ecosystem integrity (Kryszak *et al.*, 2012). The restoration of a grassland ecosystem at the initial stage could be a very long and almost impossible process (Galvanek and Leps, 2012). After 1990 our country recorded a progressive and generalized abandonment of mountain pastures. Some people believe that this is due to the halving number of cattle and sheep from the last two decades and especially to the use of the reserve feed provided by arable land in the hilly and plain areas left fallow on the premises stretched more easily accessible, with conditions much more good living for carers and without danger of having damage caused by wild animals prey or phenomenal nature of the mountains, which are much tougher. The abandonment of mountain meadows produce great losses in the national economy for at least two important reasons:

- irrecoverable loss of free solar energy stored in the grassy carpet of meadow as they convert organic material susceptible to the animal by products useful to man (milk, meat, driving force, leisure etc.);
- underflow to abandonent, followed by the return to the former locations of woody vegetation, the hedges and woods, with generations of mountaineers have struggled to maintain grasslands in the state of normality livestock (Maruşca, 2010).

Abandonment of grasslands is a problem in the Apuseni Mountains. It suggests a rotational pasture management and the various stages, before reaching the stage of mature forest. This could be achieved by supporting traditional production and maintaining grassland stages with subsidies from the government and / or private organizations. A similar approach has been proposed for semi-natural grasslands nutrient

poor in Central Europe (Duffey *et al.*, 1974; Morris and Thomas, 1991; Erhardt, 1995; Dzwonko and Loster, 1998; Waldhardt and Otte, 2003). This approach requires a specific management plan to prevent the loss of unique species (Thomas, 1984, 1991). Regarding the changes that occur in the grassy carpet after abandonment and further study the floristic composition of secondary meadows in various stages of succession it was found that the categories of abandonment caused changes in the phytocoenoses. They recorded a grassy carpet degradation both in terms of agronomic and ecological especially phytocoenosis abandoned over 10 years. It has been proven that abandonment frequently leads to a decrease in the number of species and only a few of which are dominant (Tasser and Tappeiner, 2002; Willems, 1983; Maskova Z *et al.*, 2009). Total lack of maintenance of grasslands is reflected by the presence of molehills that degrades especially fallow pastures resulting in decreased production due to deterioration of its quality increases worthless vegetation on anthills (*Thymus* species, *Rumex acetosella* etc.). On hampers mowing meadows influencing the quantity and quality of hay obtained. Can be formed mounds of moles (return places), ants (often in the mountains), but may have their origin and bushes (death) of some grasses and sedges of dense bush (*Deschampsia caespitosa*, *Juncus* species). Sometimes forms on stumps, rocks or by the accumulation of organic matter plant (mosses, lichens), especially in the lower areas in the mountains (Rotar and Păcurar, 2011). The primary objective of the study is tracking the effect of abandonment on the grassy carpet structure.

MATERIALS AND METHODS

To determine the abundance dominance we used Braun-Blanquet scale, modified Păcurar and Rotar in 2014. To assess the agronomic value of meadows, the scale intervals are too broad and too remote central difference values. Often the agronomic value measured on the basis of collected data on the Braun-Blanquet scale (although improvements) is far from reality. The authors quoted above have proposed using three sub-scale scores and three sub-intervals with corresponding core values (Tab. 1., Fig. 1.).

Tab. 1. Scale of assessment of dominance Braun-Blanquet abundance, complemented Tüxen and Ellenberg (1937), modified with three sub-grades and three sub-intervals

Note	The range of coating	The central value of the class	Under-note	Under -ranges (%)	Central value adjusted below the range (%)
5	75-100	87,5	5c	92-100	96
			5b	83-92	87,5
			5a	75-83	79
4	50-75	62,5	4c	67-75	71
			4b	58-67	62,5
			4a	50-58	54
3	25-50	37,5	3c	42-50	46
			3b	33-42	37,5
			3a	25-33	29
2	10-25	17,5	2c	20-25	22,25
			2b	15-20	17,5
			2a	10-15	12,5
1	1-10	5	1c	6-10	8
			1b	4-6	5
			1a	1-4	2,5
+	0,1-1	0,5	-	-	0,5
R	0,01-0,1	0,05	-	-	0,05

Fig. 1. Scheme appreciation of abundance dominance after Braun-Blanquet method, using three sub-grades (Păcurar and Rotar, 2014)

RESULTS AND DISCUSSION

The results were classified after Sorensen index (Bray and Curtis) associated with average connection. PC-ORD program revealed the dendrogram presented in Fig. 2 which highlights how the joins of reports and the distance between variants. A highly debated topic within experts in the field is the level where we should cut off the dendrogram to determine the optimal number of groups. There are several theories in literature but none is universally accepted. Kent (2012) recommends cutting to a higher level dendrogram torso, which groups results show a justified sense phytosociological and ecological (Păcurar and Rotar, 2014)

The classification of vegetation made in PC-ORD revealed two groups of plants (Fig. 2). Is observed that the first two variants, namely the grassland mowed annually (V1) and the one abandoned for 5 years (V2) did not show significant changes in the grassy carpet, being very similar one to each other (red).

Compared with the first the second group (coloured in green) differs in terms of flora. In other words floristic distance between the two groups is high and presents statistical backing ($p \leq 0.05$).

An other method we used is the dual classification, which enables concurrent group of reports and both species (Fig. 3). Numerical analysis with a dual classification pointed out certain groups of species. On the dendrogram presented in Fig. 3 we observed that there are species that are common to all treatments and some species occur only in certain types of management.

The test of distance between groups resulting from the ordering process was done with multiple response permutation (MRPP). MRPP is a nonparametric procedure for testing the null hypothesis of difference (null hypothesis) between two or more groups (McCune and Mefford, 2011). In our case we compared the floristic composition of the grassland mowed annually with the grassland abandoned for 5 years and for 15 years.

Fig. 2. Dendrogram classification of reports

Fig. 3 Dendrogram classification of reports

MRPP statistical method involves the use of T test which describes the separation between groups. When T is negative the separation is stronger; 0 hypothesis assumes that land abandonment has no effect on the grassy carpet. Multiple response permutation procedure shows that the hypothesis 0 is not true, because the test has a value of -1.7991231 T therefore we can say that early experience changes statistically on the grassy carpet.

A statistical test described homogeneity / heterogeneity between groups. When all groups are identical A will be equal to one, and if they are very different, it will be zero. A statistical test has a value of 0.09284809 approaching zero, therefore it can be said that the groups are different.

Testing groups resulting from cluster analysis can be done using analysis of indicator species. Indicator species analysis of the three experimental variants showed the presence of 8 species indicator (Tab. 2).

Tab. 2. Indicator species compared with the experimental variant

Nr. Crt.	Species	Experimental version	Value indicator	Significance (p)
1.	<i>Anthoxanthum odoratum</i>	Martor	45.5	0.3287
2.	<i>Cynosurus cristatus</i>	Martor	100	0.0372*
3.	<i>Trisetum flavescens</i>	Martor	33.3	1.000
4.	<i>Carex pallescens</i>	Martor	50	0.6837
5.	<i>Luzula multiflora</i>	Martor	37.5	1
6.	<i>Trifolium repens</i>	Martor	78.9	0.0372*
7.	<i>Vicia cracca</i>	Martor	33.3	1
8.	<i>Alchemilla vulgaris</i>	Martor	44.4	0.1810
9.	<i>Campanula patula</i>	Martor	37.5	1
10.	<i>Gentianella lutescens</i>	Martor	100	0.0372*
11.	<i>Gymnadenia conopsea</i>	Martor	37.5	1
12.	<i>Hieracium aurentiacum</i>	Martor	42.9	1
13.	<i>Hieracium pilosella</i>	Martor	100	0.0372*
14.	<i>Knautia arvensis</i>	Martor	60	0.3639
15.	<i>Leontodon autumnale</i>	Martor	60	0.3595
16.	<i>Leucanthemum vulgare</i>	Martor	65.2	0.0754
17.	<i>Pimpinella major</i>	Martor	41.3	0.6459
18.	<i>Plantago media</i>	Martor	62.5	0.1438
19.	<i>Polygala vulgaris</i>	Martor	37.5	1
20.	<i>Prunella vulgaris</i>	Martor	22.2	1
21.	<i>Rhinanthus minor</i>	Martor	100	0.0372*
22.	<i>Rumex acetosella</i>	Martor	33.3	1
23.	<i>Stellaria graminea</i>	Martor	33.3	1
24.	<i>Taraxacum officinale</i>	Martor	60	0.3595
25.	<i>Thymus pulegioides</i>	Martor	22.2	1
26.	<i>Tragopogon pratensis</i>	Martor	37.5	1
27.	<i>Veronica officinalis</i>	Martor	100	0.0372*
28.	<i>Festuca pratensis</i>	Abandon 5 years	33.3	1
29.	<i>Festuca rubra</i>	Abandon 5 years	39	0.3669
30.	<i>Lotus corniculatus</i>	Abandon 5 years	55.6	0.15
31.	<i>Trifolium pratense</i>	Abandon 5 years	50	0.1412
32.	<i>Achillea millefolium</i>	Abandon 5 years	48.4	0.1488

33.	<i>Carlina acaulis</i>	Abandon 5 years	100	0.0372*
34.	<i>Centaurea pseudophrygia</i>	Abandon 5 years	38.1	0.3651
35.	<i>Colchicum autumnale</i>	Abandon 5 years	55.3	0.0724
36.	<i>Plantago lanceolata</i>	Abandon 5 years	37.5	0.8884
37.	<i>Potentilla erecta</i>	Abandon 5 years	57	0.1426
38.	<i>Trollius europaeus</i>	Abandon 5 years	47.4	0.3507
39.	<i>Agrostis capillaris</i>	Abandon 15 years	41.4	0.1786
40.	<i>Hypericum maculatum</i>	Abandon 15 years	53.2	0.0736
41.	<i>Myosotis sylvatica</i>	Abandon 15 years	47.6	0.6491
42.	<i>Ranunculus acris</i>	Abandon 15 years	55.6	0.1448
43.	<i>Veronica chamaedrys</i>	Abandon 15 years	90.6	0.0380*
44.	<i>Viola tricolor</i>	Abandon 15 years	60	0.2659

Note: Significance: * = $p < 0.05$, ** = $p < 0.01$, *** = $p < 0.001$

The grassland mowed annually has 6 indicator species: *Cynosurus cristatus*, *Trifolium repens*, *Gentianella lutescens*, *Hieracium pilosella*, *Rhinanthus minor* și *Veronica officinalis* while the grassland abandoned for 5 years has only 1 indicator species such as *Carlina acaulis*. The same for grassland abandoned for 15 years which has

as indicator the species *Veronica chamaedrys*. The presence of indicator species in each experimental variant reveals the importance of reports grouping.

As a result of the treatments applied several changes occur in the same type of grassland *Festuca rubra-Agrostis capillaris* (Tab. 3).

Tab. 3 Drop influence on the floristic composition

Species	Adm martor	Adm abandon 5 years	Adm abandon 15 years
Type meadow	<i>Festuca rubra-Agrostis capillaris</i>	<i>Festuca rubra-Agrostis capillaris</i>	<i>Festuca rubra-Agrostis capillares</i>
Poaceae			
<i>Agrostis capillaries</i>	12.5%	8.75%	15%
<i>Anthoxanthum odoratum</i>	2.5%	1.5%	1.5%
<i>Cynosurus cristatus</i>	0.5%	-	-
<i>Festuca pratensis</i>	-	0.5%	0.5%
<i>Festuca rubra</i>	17.375%	22.25%	17.375%
<i>Trisetum flavescens</i>	0.5%	0.5%	0.5%
Cyperaceae and Juncaceae			
<i>Carex pallescens</i>	0.5%	0.5%	-
<i>Luzula multiflora</i>	0.5%	0.5%	0.5%
Fabaceae			
<i>Lotus corniculatus</i>	1.5%	2.5%	0.5%
<i>Trifolium pretense</i>	1.5%	6.5%	5%
<i>Trifolium repens</i>	3.75%	0.5%	0.5%
<i>Vicia cracca</i>	1.5%	1.5%	1.5%
Alte familii botanice			
<i>Achillea millefolium</i>	1.5%	3.75%	2.5%
<i>Alchemilla vulgaris</i>	10.25%	8%	6.5%
<i>Campanula patula</i>	0.5%	0.5%	0.5%

<i>Centaurea pseudophrygia</i>	6.5%	8%	6.5%
<i>Colchicum autumnale</i>	1.5%	6.5%	3.75%
<i>Gentianella lutescens</i>	0.5%	-	-
<i>Gymnadenia conopsea</i>	0.5%	0.5%	0.5%
<i>Hieracium aurantiacum</i>	0.5%	0.5%	0.5%
<i>Hieracium pilosella</i>	0.5%	-	-
<i>Hypericum maculatum</i>	5.25%	3.75%	10.25%
<i>Knautia arvensis</i>	0.5%	-	0.5%
<i>Leontodon autumnale</i>	0.5%	0.5%	-
<i>Leuchanthemum vulgare</i>	3.75%	0.5%	1.5%
<i>Myosotis sylvatica</i>	0.5%	0.5%	2.5%
<i>Pimpinella major</i>	6.5%	6.5%	2.75%
<i>Plantago lanceolata</i>	2.5%	3.75%	3.75%
<i>Plantago media</i>	2.5%	1.5%	-
<i>Polygala vulgaris</i>	0.5%	0.5%	0.5%
<i>Potentilla erecta</i>	2.5%	3.75%	0.5%
<i>Prunella vulgaris</i>	0.5%	0.5%	0.5%
<i>Ranunculus acris</i>	0.5%	1.5%	2.5%
<i>Rhinanthus minor</i>	0.5%	-	-
<i>Rumex acetosella</i>	0.5%	0.5%	0.5%
<i>Stellaria graminea</i>	0.5%	0.5%	0.5%
<i>Taraxacum officinale</i>	0.5%	0.5%	-
<i>Thymus pulegioides</i>	0.5%	0.5%	0.5%
<i>Tragopogon pratensis</i>	0.5%	0.5%	0.5%
<i>Trollius europaeus</i>	-	1.5%	2.5%
<i>Veronica chamaedrys</i>	0.5%	0.5%	8%
<i>Veronica officinalis</i>	0.5%	-	-
<i>Viola tricolor</i>	0.5%	0.5%	1.5%

Note: Automatic Color: species that no changes compared to controls; Green: species that enhance their presence to control; Blue: species whose coverage decreases compared to the control, but do not leave even after dropping meadow phytocoenosis 15 years; Red: species that have disappeared from the grassy carpet after dropping the composition for 15 years

Therefore we observed that the species which don't show any changes compared to controls, which do not increase their presence and don't disappear from the floristic composition are: *Festuca rubra*, *Trisetum flavescens*, *Luzula multiflora*, *Vicia cracca*, *Campanula patula*, *Gymnadenia conopsea*, *Hieracium aurentiacum*, *Knautia arvensis*, *Polygala vulgaris*, *Prunella vulgaris*, *Rumex acetosella*, *Stellaria graminea*, *Thymus pulegioides*, *Tragopogon pratensis*.

The species which increase their presence compared to control variant after being abandoned for 5 and 15 years are *Agrostis capillaris*, *Festuca pratensis*, *Trifolium pratense*, *Achillea millefolium*, *Centaurea pseudophrygia*, *Colchicum autumnale*, *Hypericum maculatum*, *Myosotis syl-*

vatica, *Plantago lanceolata*, *Ranunculus acris*, *Trollius europaeus*, *Veronica chamaedrys*, *Viola tricolor*.

Species whose coverage decreases compared to the control, but do not leave the meadow phytocoenosis even after 15 years of abandonment are fewer: *Anthoxanthum odoratum*, *Lotus corniculatus*, *Trifolium repens*, *Alchemilla vulgaris*, *Leuchanthemum vulgare*, *Pimpinella major*, *Potentilla erecta*.

Species which have disappeared from the grassy carpet after abandonment for 15 years are *Cynosurus cristatus*, *Carex pallescens*, *Gentianella lutescens*, *Leontodon autumnale*, *Plantago media*, *Rhinanthus minor*, *Taraxacum officinale*, *Veronica officinalis*.

The floristic composition of the control variant numbers 41 species of which 33.37% *Poaceae*, 1% *Cyperaceae* and *Juncaceae*, 8.25% *Fabaceae* and 52.75% other botanical families. From *Poaceae* the dominant species is *Festuca rubra* (17.37%), followed by *Agrostis capillaris* (17.5%), and the other had a lower attendance. The species of the families *Cyperaceae* and *Juncaceae* are represented by *Carex pallescens* and *Luzula multiflora* low coverage of 1%, the family *Fabaceae* is the *Trifolium repens* (3.75%) and the other has a coverage of 1.5% (*Lotus corniculatus*, *Trifolium pratense*, *Vicia cracca*). From other botanical families the widest coverage have species: *Alchemilla vulgaris* (10.25%), followed by *Centaurea pseudophrygia* and *Pimpinella major* (6.5%), *Hypericum maculatum* (5.25%), *Leuchanthemum vulgare* (3.75%) and other plants have reduced coverage.

Following abandonment knows this phytocoenosis significant changes in the floristic structure. *Poaceae* increases their share with increasing the abandonment rate from 33.37% (control) to 33.5% (abandonment for 5 years) and up to 34.87% (abandonment for 15 years). *Festuca rubra* has a similar trend, increasing from 17.37% (control) to 22.25% (abandon for 5 years) and 15 years after dropping to 17.37% recovers. *Agrostis capillaris* species is reduced from 12.5% (control) to 8.75% (abandon for 5 years) after which participation increases to 15% (abandon over 5 years). *Cynosurus cristatus* species is the only one *Poaceae*, which appears only in the floristic composition of the control, after dropping 5 years and 15 years extinct.

Families *Cyperaceae* and *Juncaceae* neither increase nor reduce weight with increasing period of abandonment, except *Carex pallescens* species, which after abandon for 15 years disappear in the floristic composition of the grassy carpet. *Fabaceae* family react more strongly to the abandonment of 5 years (rising from 8.25% to 11%), then reduce to 7.5% in Abaddon 15 years.

Among the species from other botanical families, covering species *Alchemilla vulgaris*, *Leuchanthemum vulgare*, *Pimpinella major* scade față de martor, but do not leave even after abandon meadow phytocoenosis 15 years: *Alchemilla vulgaris*: 10.25% (control)-8% (abandon 5 years) - 6.5% (abandon 15 years); *Pimpinella major*: 6.5% (control) -6.5% (abandon 5 years) - 2.75% (abandon 15 years). Some species reduce their share to loss

grassy carpet as: *Gentianella lutescens*, *Hieracium pilosella*, *Plantago media* etc.

The intensive intrusion of abandonment caused species such as grassy carpet: *Festuca pratensis*, *Trollius europaeus*.

Following the abandonment diversity is restricted from 41 species (control) 37 species (abandon 5 years) and up to 34 species for abandonment 15 years

CONCLUSION

The grassland abandoned for 5 years didn't show any statistically changes compared to control while the grassland abandoned for 15 years registered changes in the grassy carpet, resulting in the disappearance of some species such as: *Cynosurus cristatus*, *Carex pallescens*, *Gentianella lutescens*, *Hieracium pilosella*, *Plantago media* etc.

Changes in vegetation structure occurred only within a single type of grassland phytocoenosis which didn't evolved to other successional stages. The results showed that abandonment is not a viable solution for maintaining grassland diversity, so semi-natural grasslands, which has many economic disadvantages because the resort is recommended to be mowed at least once in 5 years. For each type of treatment / experimental variant we had different indicator species. Therefore we recommend the use of indicator species when we want to make a grassland management plan (APIA commitments, conservation status, etc.).

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