Study of the Floristic Composition of Certain Secondary Grasslands in Different Successional Stages as a Result of Abandonment

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ABSTRACT

Important areas of semi-natural grasslands are affected by abandonment in Apuseni Mountains, situation that leads to a series of specific negative aspects. Semi-natural grasslands pass through certain successional stages, materialized by different types of grasslands. The aim of our study was to follow the successional stages of *Agrostis capillaris* L. – *Festuca rubra* L. grassland type, as a result of abandonment. The study included 27 grasslands with similar site conditions. There were three different categories of abandoned grasslands: abandoned up to 5 years, abandoned between 6 and 10 years, abandoned more than 10 years. The categories of abandonment caused changes at the level of phytocoenoses, registering a degradation of the vegetation from both, agronomic and ecologic point of view. The semi-natural grasslands, situated on sites with different disadvantages (defectuous orography, reduced trophicity, pronounced acidity, etc.) which are on the threshold to be abandoned, or are already abandoned, need to be mowed at least once at four or five years, to preserve their specific floristic structure.

Keywords: *abandonment, agronomic value, phytodiversity, semi-natural grasslands.*

INTRODUCTION

The abandonment of semi-natural grasslands in the mountain areas become a major threat and raises a series of questions and situations, which have to be solved in the whole Europe (Osterburg *et al.*, 2010). Grasslands in the mountain areas are very vulnerable habitats, losing their conservation value very quickly after the abandonment (Fischer and Wipf, 2002). In these areas secondary succession takes place, which could be found in the first stage as changes in specific floristic composition of the canopy (Habel *et al.*, 2013). Changes can be sometimes so obvious, that threaten the integrity of the grassland ecosystem (Kryszak *et al.*, 2012). Restoration of the grassland ecosystem to the original stage could be a very long process and almost impossible (Galvanek and

Leps, 2012). Romania's pastoral area is covering over 4.8 million ha and has been influenced over the last decades by natural factors and human activities, which have been affected the normal functioning of the grassland ecosystems (Vîntu *et al.*, 2011). From these grasslands, more than a half are located in upland areas (Vîntu *et al.*, 2011). In addition, the secondary grasslands from Apuseni Mountains and their high diversity are endangered by the land use's changes, caused by the direct and indirect influence of socio economic changes (Gârda, 2011). Even if the phenomenon in general is well known in other European countries, is needed a thorough understanding of the mechanisms, which occur at the phytocoenoses level because of the abandonment (Kahmen *et al.*,

2002; Bilz *et al.*, 2011; Habel *et al.*, 2013; Halada *et al.*, 2011; Socher *et al.*, 2013).

The aim of our study was to follow the successional stages of *Agrostis capillaris* L. – *Festuca rubra* L. grassland type, as a result of abandonment.

MATERIALS AND METHODS

The study included the floristic composition's determination of certain secondary grasslands in different successional stages as a result of abandonment. The plots were chosen so they have about the same site conditions. The length of plots' abandonment was divided in three categories, as follows: abandoned grasslands up to 5 years (F1), abandoned grasslands between 6 and 10 years (F2), abandoned grasslands more than 10 years (F3). The length of abandonment was determined by questionnaires applied to the owners. Also, the length of abandonment was assessed following the age of the present woody species. The floristic composition was determined by Bran-Blanquet method, when Poaceae were in flower. Floristic data processing was performed with PC-ORD, version 6, which use the multivariate analysis of the ecological data entered into the spreadsheet. This program focuses on nonparametric tools, on graphics, randomization tests, bootstrapped confidence intervals for analysis of community data (McCune and Grace, 2011). For data processing and interpretation we used multidimensional scaling (NMS), which is well suited to data coordination that are not normal or stairs arbitrary, discontinuous, or otherwise questionable (Peck, 2010). Also, we used the MRPP (Multi Response Permutation Procedure) and Summary for the Shannon-Wiener index (H) and the number of species (S) and the average abundance and dominance of the species. Based on the Shannon-Wiener index and the number of species, we compared the diversity of different abandonment categories. To evaluate the effects of abandonment on vegetation, from statistical point of view, we used STATISTICA by StatSoft. The analysis of variance was performed by Breakdown and One-Way ANOVA type. Based on F and p values was determined species on which, the different abandonment categories had the highest effect, using the average abundance-dominance of the species. To analyze in detail the effect of abandonment we used a comparative

analysis, *Post-hoc*, the Fisher LSD type. The choice of this test was based on the ability to highlight significant differences between the categories of abandonment and between the average abundance-dominance of dominant species, economic groups of plants and phytodiversity.

RESULTS AND DISCUSSIONS

The statistical analysis of the data highlighted that floristic composition can be separated in three different grassland types (Fig.1).

The phytocoenosis of abandoned grasslands up to 5 years (F1) is very different from the other categories of abandoned grasslands ($T = -6,7861$, $p < 0.001$ and $T = -6,5185$, $p < 0.001$; Tab. 1). The analysed groups are quite heterogeneous ($A = 0.1218$ and $A = 0,1431$). The phytocoenosis of abandoned grasslands between 6 and 10 years (F2) is different than the phytocoenosis of grasslands abandoned more than 10 years (F3), but this two are still overlapped, when are graphically presented ($T = -4.9935$, $p < 0.001$; fig. 1, Tab. 1).

Abandoned grasslands' phytocoenoses up to 5 years (F1) take part from *Agrostis capillaris* L. - *Festuca rubra* L. grassland type, which has in floristic composition 41.07% of *Poaceae*, 14.11% of *Fabaceae*, 0.14% of *Cyperaceae* and *Juncaceae* and 41.79% plants from other botanical families (Tab.2). The phytodiversity of these phytocoenoses have 31.71 species and a Shannon-Wiener index of 2.30. The phytocoenoses of abandoned grasslands between 6 and 10 years (F2) belong to *Festuca rubra* L. type with 18.62% of *Poaceae*, 3.94% *Fabaceae*, 1.11% of *Cyperaceae* and *Juncaceae* and 54.58% of plants from other botanical families. This phytocoenosis consists from 25.44 species and has a Shannon-Wiener index of 2.30. The abandoned grasslands more than 10 years (F3) belongs to *Nardus stricta* L. types and the floristic composition is composed from 33.09% of *Poaceae*, 2.95% of *Fabaceae*, 5.73% of *Cyperaceae* and *Juncaceae* and 43.39% of plants from other botanical families. The phytodiversity covers 23.09 species and the Shannon-Wiener index is 2.10. Kącki (2010) evidenced in a study, in the southeastern part of Poland, the fact that *Nardus stricta* L. occurs in abandoned grasslands with a high percentage at the expense of medium and high tolerant species on mowing. Mariott *et al.* (2004) in an experiment in 20 European countries

show that the abandonment of grassland ecosystems causes important changes in the canopy's structure in comparison to the mowed or pastured areas. Changes in the canopy, in their experiment, occurred after different time intervals from an experiment to other. Some changes could be observed after two years, others only after 12 years. They also state that changes strongly depend on site conditions, on original vegetation, on management's history and on vegetation in around.

From agronomic point of view, the phytocoenosis, because of the abandonment, degrades through installation of some less productive and lower quality grassland types. This degradation can be seen by the reduction of *Agrostis*

capillaris L. from 21.39 % (F1) to 1.47 % in the case of abandoned grasslands between 6 and 10 years (F2) and to 1.95% in the case of abandoned grasslands more than 10 years (F3; $p < 0.001$; Tab.1). Also, there is a reduction at *Festuca rubra* L. species too, especially for grasslands abandoned more than 10 years (F3), but without statistical assurance ($p > 0.05$). Grassland's degradation is highlighted by the increase of *Nardus stricta* L. cover, from 1.94% to 21.36% ($p < 0.01$), which is a species without forage value.

When pursuing the floristic composition's evolution at the economic groups level, we can find the same canopy degradation, by decreasing the cover of Poaceae ($p < 0.01$), reduction of the level of Fabaceae ($p < 0.001$; Tab.1). Plants from

Fig. 1. Ordination of floristic composition in function of different abandonment categories; P - relevés, F₁ - abandoned grassland up to 5 years, F₂ - abandoned grassland between 6 and 10 years, F₃ - abandoned grassland more than 10 years

Tab. 1. Comparison between the floristic compositions of different abandonment categories with MRPP

Comparison between variants	T	A	p
F1 vs. F2	-6.786198	0.121860	0.000044
F1 vs. F3	-6.518563	0.143136	0.000229
F2 vs. F3	-4.993546	0.098741	0.002312

Note: T - T test, A - group homogeneity, p - statistical significance

other botanical families increase slightly, but there is no statistically assurance for their evolution.

Da Ronch *et al.* (2013) show in a study, carried out in valleys of Val Menera (north-eastern Italy), that abandonment of mountain pastures resulted a significant reduction of agronomic value and forage digestibility, due to a strong installation of *Deschampsia caespitosa* L. species in the canopy. From conservative point of view, we find also a degradation at the grassland vegetation level, because the number of species is reduced in the case of abandoned grasslands up to 5 years (F1) from 31.71 to 23.09 at the abandoned grasslands up to 10 years (F3; $p < 0.01$; Tab.1). The Shannon-Wiener index shows a decrease of phytodiversity from 2.30 (F1) to 2.10 (F3), but without statistically assurance. In the studies of Zarzycki and Misztal (2010), the abandoned plots had a significantly lower Shannon-Wiener index than it was in the mowed plots. Musiał and Kasperczyk (2013) have the same results with ours in the Polish Carpathians, where the abandonment of permanent grasslands between 600m and 700m caused a significant reduction of the phytodiversity. Da Ronch *et al.* (2010) shows in a study carried out in Treviso (Italia), that abandonment changed significantly the phytodiversity after 12 years, but mowing once per year reduced the woody species participation. Kącki (2010) has shown that for grasslands species, diversity index values were significantly higher on permanently managed grasslands, than on abandoned pastures at least

since 5 years. Schrautzer *et al.* (2010) demonstrate that on abandoned grasslands for 9 years, in the region Schleswig-Holstein (Germany) and grazed later with cattle in an extensive system, the phytodiversity increased considerably.

In *Agrostis capillaris* L.- *Festuca rubra* L. grassland type the most abundant species in addition to dominant species are: *Centaurea pseudophrygia* C. A. Mey, *Cirsum palustre* L., *Trifolium pratense* L., *Trifolium repens* L., *Nardus stricta* L., *Leontodon autumnalis* L., *Plantago media* L., *Lotus corniculatus* L., *Alchemilla vulgaris* L., *Thymus pulegiodes* L., etc. The least dominant species are: *Silene vulgaris* Moench, *Deschampsia flexuosa* L., *Verbascum phlomoides* L., *Anthyllis vulneraria* L., *Veratrum album* L., *Trollius europeaeus* L., *Luzula campestris* L., etc. (Fig. 2).

The most frequent species are: *Leontodon autumnalis* L., *Centaurea pseudophrygia* C. A. Mey, *Lotus corniculatus* L., *Scabiosa columbaria* L., *Campanula patula* L., *Leucanthemum vulgare* Lam., *Thymus pulegiodes* L., *Potentilla erecta* L., *Carlina acaulis* L., *Pimpinella major* L., etc. The least frequent species are: *Galium verum* L., *Deschampsia flexuosa* L., *Veratrum album* L., *Trifolium pratense* L., *Luzula campestris* L., *Hieracium aurantiacum* L. (Fig. 3).

In *Festuca rubra* L. grassland type the most abundant species in addition to dominant species are: *Leontodon autumnalis* L., *Thymus pulegiodes* L., *Plantago media* L., *Alchemilla vulgaris* L., *Sanguisorba minor* Scop., *Hieracium aurantiacum*

Tab. 2. Floristic structure of grassland types in function of abandonment's categories

Treatments/Significance/ Grassland type		Dominant and codominant species			Economic groups				Phytodiversity	
		<i>A.c.</i>	<i>Er.</i>	<i>N.s.</i>	<i>P</i>	<i>F</i>	<i>CJ</i>	<i>OBF</i>	<i>S</i>	<i>H</i>
F ₁ - abandoned grasslands up to 5 years	A.c.- Er.	21.39	11.01	4.64	41.07	14.11	0.14	41.79	31.71	2.30
Sgf.		Wt.	Wt.	Wt.	Wt.	Wt.	Wt.	Wt.	Wt.	Wt.
F ₂ - abandoned grasslands between 6 and 10 years	Er.	1.47	12.53	1.94	18.62	3.94	1.11	54.58	25.44	2.30
Sgf.		000	ns	ns	00	000	ns	ns	0	ns
F ₃ - abandoned grasslands more than 10 years	N.s.	1.95	4.93	21.36	33.09	2.95	5.73	43.39	23.09	2.10
Sgf.		000	ns	**	ns	000	ns	ns	00	ns

Note: A.c. = *Agrostis capillaris* L., Er. = *Festuca rubra* L., N.s. = *Nardus stricta* L., P = *Poaceae*, F = *Fabaceae*, CJ = *Cyperaceae* and *Juncaceae*, OBF = Other botanical families, T = Treatments, Sgf. = Significance, H = Shannon-Wiener index, S = Species number, A.c.-Er. = *Agrostis capillaris* L. - *Festuca rubra* L., Wt. = witness, ' = $p < 0.05$, " = $p < 0.01$, "" = $p < 0.001$; 0 = $p < 0.05$, 00 = $p < 0.01$, 000 = $p < 0.001$, ns – not significant.

Fig. 2. Abundance of species in the phytocoenosis of *Agrostis capillaris* L.-*Festuca rubra* L. grassland type (Rankabund = Species abundance, Logsum= Logarithm with base 10 of species abundance; Achimill = *Achillea millefolium* L.; Agrocapi = *Agrostis capillaris* L.; Alchvulg = *Alchemilla vulgaris* L.; Antedioi = *Antenaria dioica* L.; Anthodor = *Anthoxanthum odoratum* L.; Anthvuln = *Anthyllis vulneraria* L.; Arnimont = *Arnica montana* L.; Arabhirs = *Arabis hirsuta* L.; Ajuggene = *Ajuga genevensis* L.; Brizmedi = *Briza media* L.; Campabie = *Campanula abietina* Griseb.; Camppatu = *Campanula patula* L.; Cardhale = *Cardaminopsis halleri* L.; Carepall = *Carex pallescens* L.; Carlacau = *Carlina acaulis* L.; Centmoll = *Centaurea mollis* Waldst. et Kit.; Centpseu = *Centaurea pseudophrygia* C. A. Mey.; Colcautu = *Colchicum autumnale* L.; Crepbien = *Crepis biennis* L.; Cerahole = *Cerastium holsteoides* Fr.em. Hyl.; Cynocris = *Cynosurus cristatus* L.; Descflex = *Deschampsia flexuosa* L.; Eryncamp = *Eryngium campestre* L.; Euphrosko = *Eupharsia roskoviana* Hayne; Festprat = *Festuca pratensis* L., Festrubr = *Festuca rubra* L.; Galiveru = *Galium verum* L.; Gnafsylv = *Gnaphalium sylvaticum* L.; Gymncono = *Gymnadenia conopsea* L.; Hieraura = *Hieracium aurantiacum* L.; Hypemacu = *Hypericum maculatum* Crantz; Leonautu = *Leontodon autumnalis* L.; Leucvulg = *Leucanthemum vulgare* Lam.; Lotucorn = *Lotus corniculatus* L.; Luzucamp = *Luzula campestris* L.; Luzumult = *Luzula multiflora* Ehrh.; Nardstri = *Nardus stricta* L.; Pimpmajo = *Pimpinella major* L.; Planlanc = *Plantago lanceolata* L.; Planmedi = *Plantago media* L.; Polycomo = *Polygala comosa* Schkuhr.; Polyvulg = *Polygala vulgaris* L.; Poteerec = *Potentilla erecta* L.; Prunvulg = *Prunella vulgaris* L.; Ranuacri = *Ranunculus acris* L.; Ranubulb = *Ranunculus bulbosus* L.; Rhinmino = *Rhinanthus minor* L.; Rumeacet = *Rumex acetosa* L.; Salvvert = *Salvia verticillata* L.; Sangmino = *Sanguisorba minor* Scop.; Scabcolu = *Scabiosa columbaria* L.; Scorrose = *Scorzonera rosea* Waldst. et Kit.; Silevulg = *Silene vulgaris* Moench; Stelgram = *Stellaria graminea* L.; Taraoffi = *Taraxacum officinale* Weber ex F.H.Wigg.; Thympule = *Thymus pulegioides* L.; Tragprat = *Tragopogon pratensis* L.; Trifprat = *Trifolium pratense* L.; Trifrepe = *Trifolium repens* L.; Trisflav = *Trisetum flavescens* L.; Troleuro = *Trollius europeaeus* L.; Verocham = *Veronica chamaedrys* L., Veraalbu = *Veratrum album* L.; Vicicrac = *Vicia cracca* L., Violcani = *Viola canina* L.; Violtric = *Viola tricolor* L.)

L., *Nardus stricta* L., *Arnica montana* L., *Carlina acaulis* L., *Lotus corniculatus* L., *Agrostis capillaris* L., etc. The least dominant are: *Rumex acetosa* L., *Ranunculus bulbosus* L., *Gymnadenia conopsea* L.; *Rhinanthus minor* L., *Taraxacum officinale*

Weber ex F.H.Wigg, *Trifolium pratense* L., *Luzula campestris* L., *Vicia cracca* L., etc. (Fig. 4).

The most frequent species are: *Thymus pulegiodes* L., *Plantago media* L., *Leontodon autumnalis* L., *Alchemilla vulgaris* L., *Carlina acaulis*

Fig. 3. Frequency of species in the phytocoenosis of *Agrostis capillaris* L.-*Festuca rubra* L. grassland type; Freq = Species frequency; Logsum = Logarithm with base 10 of species abundance; for species name abbreviation see the legend of Fig.2

Fig. 4. Abundance of species in the phytocoenosis of *Festuca rubra* L. grassland type; Rankabund = Species abundance, Logsum= Logarithm with base 10 of species abundance; for species name abbreviation see the legend of Fig. 2

L., *Scabiosa columbaria* L., *Plantago lanceolata* L., etc. The least frequent are: *Rumex acetosa* L., *Veratrum album* L., *Taraxacum officinale* Weber ex F.H.Wigg, *Ajuga genevensis* L., *Luzula campestris* L., *Trifolium pratense* L., etc. (Fig. 5).

In *Nardus stricta* L. grassland type the most abundant species in addition to dominant species

are: *Arnica montana* L., *Thymus pulegiodes* L., *Festuca rubra* L., *Carlina acaulis* L., *Lotus corniculatus* L., *Potentilla erecta* L., etc. The less dominant are: *Rumex acetosa* L., *Scorzonera rosea* Waldst. et Kit., *Alchemilla vulgaris* L., *Trifolium pratense* L., *Vicia cracca* L., etc. (Fig. 6).

Fig. 5. Frequency of species in the phytocoenosis of *Festuca rubra* L. grassland type; Freq = Species frequency, Logsum = Logarithm with base 10 of species abundance; for species name abbreviation see the legend of Fig. 2

Fig. 6. Abundance of species in the phytocoenosis of *Nardus stricta* L. grassland type; Rankabund = Species abundance, Logsum = Logarithm with base 10 of species abundance; for species name abbreviation see the legend of Fig. 2

Fig. 7. Frequency of species in the phytocoenosis of *Nardus stricta* L. grassland type (Freq = Species frequency, Logsum = Logarithm with base 10 of species abundance, for the species name see the legend of Fig. 2)

The most frequent species are: *Arnica montana* L., *Thymus pulegioides* L., *Festuca rubra* L., *Potentilla erecta* L., *Lotus corniculatus* L., *Carlina acaulis* L., etc. The least frequent are: *Rumex acetosa* L., *Arabis hirsuta* L., *Ranunculus bulbosus* L.; *Eryngium campestre* L., *Scorzonera rosea* Waldst. et Kit, *Vicia cracca* L., *Antennaria dioica* L., *Alchemilla vulgaris* L., *Trifolium pratense* L., etc. (Fig. 7).

CONCLUSION

The different categories of abandonment caused major changes in the floristic structure of phytocoenoses, determining the canopy's degradation both from agronomic and ecologic point of view. The major changes occur after 6 years of abandonment. The semi-natural grasslands, situated on sites with different disadvantages (defectuous orography, reduced trophicity, pronounced acidity, etc.) which are on the threshold to be abandoned or are already abandoned, need to be mowed at least once at four or five years, to preserve their specific floristic structure.

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