PLANT SPECIES DIVERSITY FROM PAUL VALLEY (THE AMPOI RIVER CATCHMENT, ALBA COUNTY, ROMANIA)

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Abstract. The plant species diversity of grasslands was studied from the former time due to the usage of the grasslands mainly as pastures for grazing and hay productions. In the Transylvanian region, Paul rivulet flows into the Ampoi River, a tributary of the Mureș River. Paul catchment area was affected over time due to atmospheric deposition from Zlatna extracting plant. The plant species diversity in the investigated plots varied and is correlated with overgrazing impact and natural soil structure rather than to soil pollution. The species number varied in relation to the season when the inventory was performed, the degree of the anthropogenic impact, natural substrate, slope and aspect (exposition). However, the local coverage of these species varied greatly with respect to the anthropogenic impact in the area and these species were not uniformly distributed in all investigated plots but achieved dominance in few plots. The grasslands of Paul catchment can be included within the category of sub-steppic calciphilous grasslands, recorded from Trascău Mountain. The phytocoenoses are dominated by species with xerophytic characters but including numerous mesophytic species, resulting in a heterogeneous species composition. There is great heterogeneity of micro-habitats within plots with, for example, abrupt transition from xerophilous vegetation to hygrophilous vegetation as a result of changes in the substrate (calcareous, acidic, argillous, etc.) or gradient and aspect (exposition) within a small area.

Keywords: species diversity, grasslands, Romania.

Rezumat. Diversitatea speciilor de plante de pe Valea lui Paul (Bazinul Ampoiului, județul Alba, România). Diversitatea speciilor de plante care formează pajiștile a fost studiată din cele mai vechi timpuri datorită utilizării pajiștilor în principal ca pășuni și fânețe. În Transilvania, pârâul Paul se varsă în râul Ampoi, care este la rândul lui tributar al râului Mureș. De-a lungul timpului, bazinul hidrografic al pârâului Paul a fost afectat de depunerile atmosferice datorate fabricii de extragere a metalelor din Zlatna. Diversitatea speciilor de plante din ploturile investigate variază și este corelată cu impactul suprapășunatului, a structurii naturale a substratului și mai puțin cu poluarea solului. Numărul de specii variază în raport de sezonul când s-au realizat inventarierile, gradul impactului antropic, substratul natural, panta și expoziția. Gradul de acoperire al speciilor variază mult depinzând de impactul antropic din zonă, speciile nefiind uniform distribuite în toate ploturile investigate, atingînd dominanța numai în câteva ploturi. Pajiștile din bazinul pârâului Paul pot fi incluse în categoria pajiștilor substepice calcifile din Munții Trascău. Fitocenozele sunt dominate de specii cu caracter xerofit dar includ și numeroase specii mezofite, ducând la o compoziție heterogenă a speciilor. Există un grad mare de heterogenitate a microhabitatelor în ploturi, de exemplu există o tranziție abruptă de la vegetația xerofilă la cea higrofilă ca rezultat al schimbărilor substratului (calcaros, acid, argilos etc.), pantei sau expoziției pe o arie mică.

Cuvinte cheie: diversitatea speciilor, pajiști, România.

INTRODUCTION

Grasslands around the world are subject to diminishing their distribution due to human land use changes (DIXON et al., 2014) prior to the 1950s in temperate grasslands (M. E. A. 2005). The European grasslands are an integrate part of pastoral and mixed-farming systems and have traditionally been used for haymaking, livestock grazing, or both (LIFE III, 2008). In Romania, around 1960s, natural grasslands used to have a surface of 4.3 million ha, most of them being situated in hilly and mountainous regions, in forestry and subalpine zones (CSÜRÖS & RESMERIŢĂ, 1960). In the present days, according with the Presidential Comity for Public Politics and Agricultural Development, 23.84 million ha representing the total surface of Romania comprise 62 % agricultural land from which 66.3% represent arable land and 29.2% natural grasslands. The natural grasslands are distributed: 50% in mountainous and alpine areas, 40% in hilly areas and 10% in plain area (C. N. S. R. 2014).

The survey on grassland ecosystem services (HÖNIGOVÁ et al., 2012) specify that natural and semi-natural grasslands provide ecosystem services framed in classes: provisional services (food, water, raw material, genetic, medicinal and ornamental resources), regulating services (air quality and climate regulation, moderation of extreme events, regulation of water flows, waste treatment, erosion prevention, maintenance of soil fertility, pollination, biological control), habitat services (maintenance of life cycles of migratory species, maintenance of genetic diversity), cultural and amenity services (aesthetic information, opportunities for recreation and tourism, inspiration for culture, art and design, spiritual experiences, information for cognitive development). The global hydrological cycle is modified by grasslands thus influencing the quality of the water passing through them (MCGILLOWAY, 2005).

The most comprehensive work regarding the geobotanical studies and productivity of the Romanian grasslands were done by PUȘCARU-SOROCEANU et al. (1963) highlighting that the pastures and hay fields are the most important areas especially in the mountainous regions where the semi-natural grasslands form a prevailing economic zone.

In Alba County belonging to central region of Romania, many phytosociological studies had been performed in different areas: Jidovu Massif (HODIȘAN, 1969), Cetii stone from the Apuseni Mountains (GHIȘA et al., 1965), Trascău depression (GERGELY, 1964), cliffs grasslands (GERGELY, 1967) and mountainous steppe grasslands

(GERGELY 1970a) from the northern side of Trascău Mountains, Breaza Massif (HODIȘAN et al., 1971), Fenеșului Gorges (HODIȘAN, 1965), Mamut Massif (HODIȘAN et al., 1970). Based on studies of plant species communities from Transylvania (CSÜRÖS & RESMERIȚĂ, 1960; CSÜRÖS & CSÜRÖS-KÁPTALAN, 1966; CSÜRÖS-KÁPTALAN, 1967) and the Apuseni Mountains (CSÜRÖS & POP, 1965; GHIȘA et al., 1970; CSÜRÖS & FURDUI, 1974) and their ecological requirements, the plants associations were characterized focusing on ecological indexes.

The semi-natural grassland belonging to the European temperate zones comprises habitats with extreme species richness at small scale (HABEL et al., 2013). Spatial patterns of species diversity change over multiple scales, from quadrat level toward landscape level (HERBEN et al., 1999; HOFMANN et al., 2005). The information about vegetation is extracted from phytosociological relevés, as basic data on species co-occurrence in a particular time and space (KORZENIAK, 2013). Csürös stipulated in 1970 that changes in land use, transformation of grasslands due to direct anthropogenic impact (*i.e.* deforestation, grazing, *etc*.) and especially indirect impact (pollution, lad slide, *etc*.) converged toward intensification of the disappearance of some areas or reduction of their distribution areas, thus increasing major changes in the structure of plant communities and their integrative habitats. GERGELY (1970b) line out that the steppic mountainous plant associations vegetating on the slopes (i.e. Trascău Mountains) are deteriorated by overgrazing during the vegetation period. Through trampling the soil by domestic animals (herds), especially along the contours, the vegetation cover is destroyed thus intensifying the erosion process. Also the distribution areas of the plant association diminish, some associations being gradually and naturally replaced with others. For instance, *Cariceto (humilis)-Brachypodietum pinnati transsilvanicum* association dominates the slopes but is distributed on small areas. Following the anthropogenic impact, within this association, there were installed in small patches the degraded association *Andropogonetum ischaemi* showing a regressive succession of the vegetation.

Our goal has been to produce tools that include erosion control and metals-buffering services provided by grassland plants as factors within Strategic Environmental Assessment (SEA, 2001) and Environmental Impact Assessment (EIA, 2014) of projects, plans and policies implemented in catchments with current and past mining and smelting activities (ASPABIR, 2012). The first step for achieving our goal is to investigate the plant species diversity from plot level to catchment level.

MATERIAL AND METHODS

In the Transylvanian region, the Ampoi Valley stretches along the course of the Ampoi River, penetrating deep into the heart of the Apuseni Mountains and making its way through Vlădeasa, Trascău and Metaliferi Mountains (Fig. 1). As well as these areas of great biodiversity value, the Ampoi Valley also crosses the region where mining activities have had the greatest impact on the environment. In Zlatna area, during the communist period, atmospheric deposition of heavy metals had a great impact on both grasslands and forests. The plant Zlatna started to function in 1747, extracting copper-and lead-bearing ores that were also rich in gold and silver (CLEPAN, 1999).

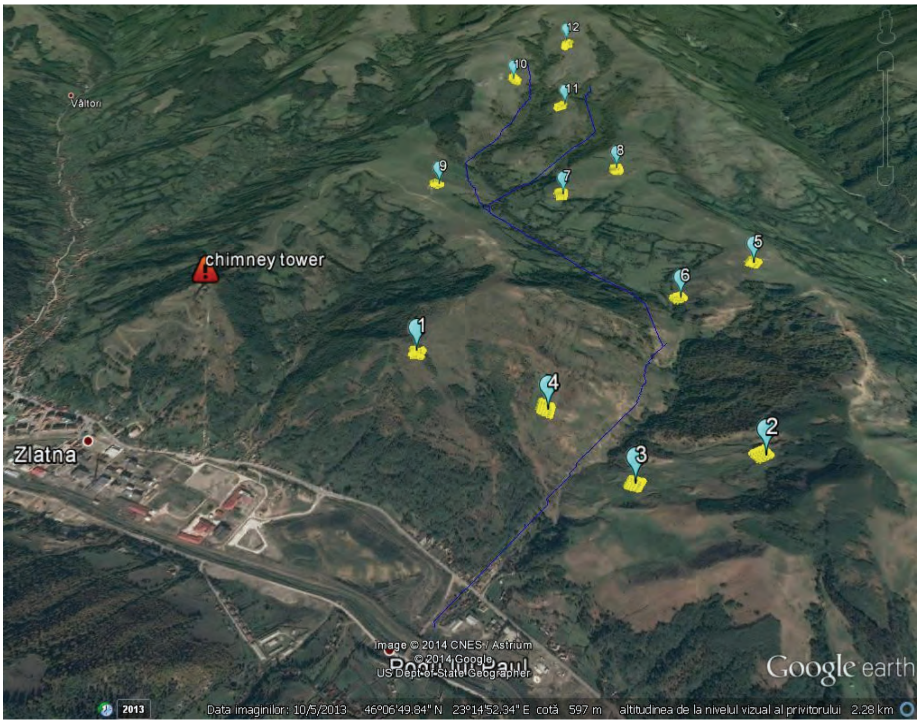

Figure 1. The locations of the plots in Paul rivulet catchment area (blue line – the rivulet valley) (from Google Earth, accessed: March 24, 2015).

This plant was modernised in 1988 and functioned till 2003. The dispersion chimney of the plant (220 m height) created atmospheric pollution not only in the immediate area but also at big distances. Paul rivulet flowing from Trascău Mountain is a tributary of the Ampoi River situated close to the dispersion chimney and its catchment area was affected over time due to atmospheric deposition from Zlatna plant. People from this area use the grasslands for grazing and hay productions; thus, there is also an overgrazing impact on the grasslands. Both these big impacts highly modified the vegetation cover and structure leading to frequent landslides, areas without vegetation, modified water regime, etc.

In 2013, we set up 12 investigation plots 50 m^2 at different altitudes (468-972 m) in relation to the different degrees of soil pollution, altitude and slope (Fig. 1). In every plot, we recorded the species composition and coverage of the vegetation (%) in 25 subplots, each of 10 m^2.

In order to assess the diversity aspects, the natural conditions and also the anthropogenic impact among the different grasslands, the data set were statistically processed. Species diversity (Shannon index), dominance (Simpson's index) and evenness (E index) were calculated using the procedures BioDiversity Pro 2.0, PAST (HAMMER et al., 2001) and XLSTAT software. The graphical representation of the diversity differences among the plots were highlighted using K-dominance analysis based on species abundance. Multi-dimensional scaling (MDS) analysis gives an overview of the abundance distribution in the 12 plots.

RESULTS AND DISCUSSIONS

The species diversity in the plots varied between a minimum of 30 species (plot 5 at 602-616 m altitude) and a maximum of 88 species (plot 4 at 531-543 m altitude) and was correlated with overgrazing impact and natural soil structure rather than to soil pollution (Table 1). These two plots were situated in close proximity, within the same area of the rivulet catchment.

Table 1. The total coverage (m^2) of the diverse grasslands components inside the plots with 2500 m^2 area.

Plot number	Total number of species	Total vegetation	Rosettes/offsprings	Skeletal	Bryophytes	Soil without vegetation
1	65	2,202.4	86.4	8,8	123.8	78.6
2	60	1,885.2	125.3	-	68.6	420.9
3	73	1,853.1	122.5	-	219	305.4
4	85	1,832.3	130.2	-	96.4	441.1
5	28	1,809.8	82.4	-	158.7	449.1
6	70	2,083.2	182.5	-	47	187.3
7	52	2062.6	68.6	-	34	334.8
8	58	2,174.1	80.4	-	116.8	128.7
9	43	2,334	17.7	-	40.8	107.5
10	48	2,180.2	97.4	19,6	14.8	188
11	63	2,249.4	41.7	-	51.4	157.5
12	49	2,408.2	11.7	-	35.7	44.4

Those plots with a low number of species typically had a shallow soil with the bedrock near the surface (skeletal and substrate without vegetation) and were also overgrazed and trampled by sheep and goats. In contrast, high species number was associated with well-structured deep soil in meadows that the private owners mow for hay and forbade the passing and grazing of the animals. The exposure of the bryophytes and especially soil without vegetation shows the destruction of the vegetation cover on big areas determining the high variation in space and time of the grasslands from the entire catchment region. Without an adaptive management applied by local stake-holders, corroborated with the natural variation of geomorphology of the catchment, the grasslands might shrink starting from plot level toward bigger areas (erosion, land slide, etc.).

Evidence from Shannon evenness, Shannon-Weaver diversity and Simpson dominance indexes indicate that in the areas with low species diversity there is a dominance of one or two species with individuals unequally distributed within and between plots. Simple correlations of these indices show that in those vegetation communities studied, species abundance and equitability play an important role in Shannon-Weaver diversity variation ($R=0.723$, $p<0.01$) (Table 2).

Table 2. Diversity indices of studied plant communities.

Indices	Plot 1	Plot 2	Plot 3	Plot 4	Plot 5	Plot 6	Plot 7	Plot 8	Plot 9	Plot 10	Plot 11	Plot 12
Shannon_H	3.27	2.96	3.01	2.89	1.74	2.78	2.63	2.61	2.48	3.00	3.10	2.86
Evenness_e^H/S	0.40	0.33	0.36	0.21	0.20	0.22	0.26	0.24	0.25	0.38	0.38	0.36
Dominance_D	0.07	0.07	0.07	0.10	0.25	0.14	0.11	0.11	0.12	0.07	0.06	0.08

Most of the species recorded are xerophytic, hemicryptophyte and perennial. The species number recorded in 12 studied plots varied in relation to the season when the inventory was performed, the degree of the anthropogenic impact, natural substrate, slope and aspect (exposition). Those species with the overall highest coverage percentage were *Agrostis capillaris, Festuca rubra, Nardus stricta, Rumex acetosella* and *Trifolium pratense*, very similar to that of apparently unaffected grasslands elsewhere on Trascău Mountain. However, the precise local coverage of these species varied greatly with respect to the anthropogenic impact in the area (overgrazing and pollution) and these species were not uniformly distributed in all investigated plots but achieved dominance in few plots (Fig. 2). MDS distribution showed that plot 1 and 7 are very different in spite of high diversity indices because of the aggregated distribution of plant species. The total coverage of bryophytes, skeletal and soil without vegetation (Table 1) determine the irregular distribution of plant species at micro-site level due to natural or anthropogenic impact.

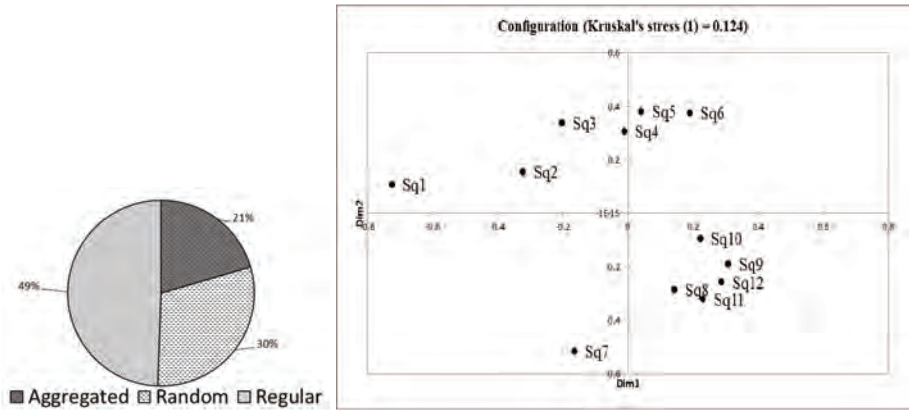

Figure 2. The distribution types of the inventoried species (left) and MDS distribution based on relative coverage similarity of the species in the investigated plots noted with 'Sq' (right).

The grasslands of Paul catchment can be included within the category of sub-steppic calciphilous grasslands, recorded from Trascău Mountains. The processes of soil formation influence the dynamics of vegetation cover. Once the soil substratum has accumulated, grasslands with a good vegetation cover replace the grassland type's characteristic of shallower soil areas (GERGELY, 1970b). The phytocoenoses are dominated by species with xerophytic characters but including numerous mesophytic species, resulting in a heterogeneous species composition.

From the total number of species, most of them are perennials (78 %) and hemicryptophytes (62%) showing that the species from the studies grasslands developed strategies for surviving in time and space (Fig. 3), most of them being short due to the grazing and trampling impact of domestic grazers (mainly sheep and goats) (Fig. 4).

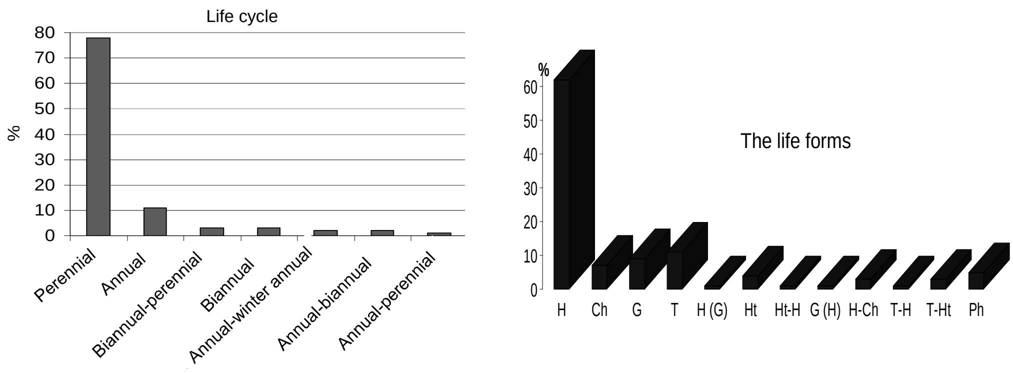

Figure 3. The life cycle (left) and life forms (right) of the inventoried plant species from the rivulet catchment area.

The traits of an organism represent distinct and quantitative properties; measured at the individual level, they are used at the species level, being very important for the understanding of local ecology of every site. The height of the plant species, their morphology/architecture, the depth reached by their roots, type of the roots, etc. define the habitats and control the ecological processes (KLIMEŠOVÁ & KLIMEŠ, 2013). The dominance of perennials and hemicryptophytes is revealed at the micro-site (plot) level but also at the catchment level. The height of the plant species is determined by the grazing and trampling, the highest individuals being found near shrubs, being protected by the influence of animals. Some micro-habitats are species-rich and the catchment species diversity is high and similar with other grasslands from Trascău Mountain with analogous anthropogenic impact. The intensity of the impact is changed due to the management applied by local stake-holders.

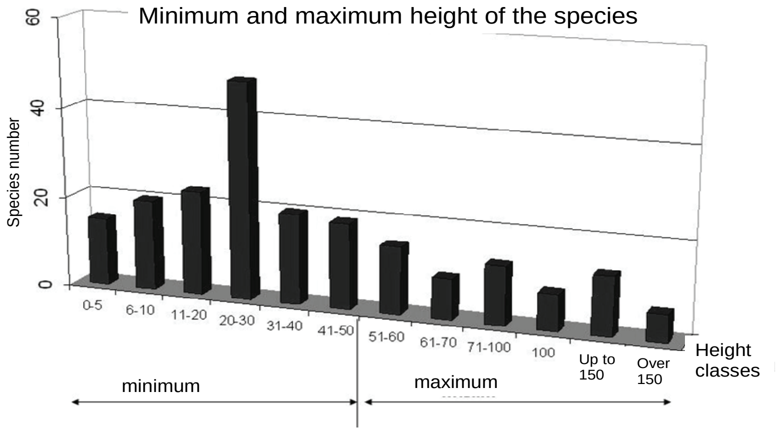

Figure 4. The minimum and maximum height of the recorded species.

CONCLUSIONS

The grasslands from Paul rivulet catchment are semi-natural grasslands managed by local stake-holders (grazing, mowing). There is great heterogeneity of micro-habitats within plots with, for example, abrupt transition from xerophilous vegetation to hygrophilous vegetation as a result of changes in the substrate (calcareous, acidic, argillous, *etc.*) or gradient and aspect (exposition) within a small area.

The grassland types are present in patches, those used for hay production are scattered among grasslands where overgrazing has led to destruction of the vegetation cover resulting in landslides in areas with more or less steep slopes.

Despite Zlatna plant ceasing to function in 2003, the heavy metal concentration in the soil remains high and, together with natural and other anthropogenic factors, determine a very varied species diversity and coverage in the grasslands from Paul catchment.

The applied management is very important for the species diversity in space and time and for the maintenance and distribution of the grasslands from Paul catchment especially due to increased historical soil pollution. Corroborated with other types of impacts it may results in grasslands disappearance.

ACKNOWLEDGEMENT

Project financed by UEFISCDI in the framework of Contract 50/2012 "A*ccounting for the service providing units of plants in the environmental assessment of plans and projects with biogeochemical impact at multiple scales in Rivers basins"*(ASPABIR) and by Romanian Academy in the framework of RO1567-IBB01.

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Received: March 31, 2015
Accepted: July 27, 2015