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THE EVOLUTION OF THE FLORISTIC COMPOSITION OF AN ECOSYSTEM IN THE AREA OF SANDS IN SOUTHWEST ROMANIA UNDER THE INFLUENCE OF ENVIRONMENTAL FACTORS

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Abstract

The present work aimed to analyze the influence of climate change on the floristic composition of an ecosystem in the sandy area located in southwestern Romania, namely in the Dăbuleni area, Dolj county. The research was carried out on areas where the influence of the zoo-anthropogenic factor is very low or absent and showed that changes in floristic composition occurred within these ecosystems. The observations made allowed the creation of a floristic list that was compared with the literature. Although the number of species has been reduced, the herbaceous cover has nevertheless been well covered. The dominant species which give the physiognomy of these sites belong to the category of those which are not characteristic of sandy soils but which have adapted very well to these conditions. Acclimatization of other species, brought from other regions, has not been possible. Typical psammophilous species such as Polygonum arenarium, Mollugo cerviana, Silene conica, Tragus racemosus, Plantago arenaria, Jasione heldreichii, Achillea ochroleuca, Centaurea soltitialis ssp. solstitialis, etc., prefer open sites because they do not seem to tolerate competition with other species.

Key words*: spontaneous flora, change climatic, Oltenia, Romania*.

INTRODUCTION

Climate change affects ecosystems, altering vegetation composition and ecosystem functioning. Globally, long-term analysis of climate change and its biological effect has shown that it affects species physiology, species distribution, organism phenology, composition and biocenosis dynamics (Cosmulescu & Birsanu, 2018; Cosmulescu et al., 2020; Parmesan & Yohe, 2003; Grimm et al., 2013; Jennings & Harris, 2017; Buican et al., 2021a; 2021b). Urbanization and environmental change is one of the main causes of the ecosystem and biodiversity loss and alteration worldwide (Blouin et al., 2018; Ilie & Cosmulescu, 2003). However, species invasion and extinction can follow complex pathways, depending on various factors (Blouin et al., 2018). Romania's sandy soils form a special world in terms of flora and vegetation (Păun et al., 1983). Information on the spontaneous flora of these surfaces in Romania can be found in specialized works published since the beginning of the 20th century. Prodan (1925) is the first Romanian botanist to make the first inventory of vascular plants on sandy soils in Romania, identifying 548 taxa. Valuable information can also be found in the monumental work "Flora R.P.R.-R.S.R." (Săvulescu et al., 1952-1976) and in publications by botanists (Buia & Păun, 1958, 1964; Păun, 1967a, b; Păun & Popescu, 1972, 1983, Simeanu et al., 2019). The existence of sands in this part of the country should not be correlated with the presence of steppe (Buia, 1960). The areas occupied by sandy soils in Romania total about 370000 ha, i.e. about 1.6% of the country's surface (Mihalache & Ilie, 2008). A good part of these places are occupied by mobile and semi-mobile sands that have a poor water retention capacity. They are found in the western and south-western part of the Romanian Plain. In the literature they are

known as "the sands of southern Oltenia" (Maxim et al., 1964). Changes, measuring the amplitude, direction, and rate of climate-induced changes in vegetation composition remain a serious challenge for specialists. The present work aimed to analyse the evolution of the floristic composition of an ecosystem in the sandy area of southwestern Romania under the influence of environmental factors.

MATERIALS AND METHODS

The study was carried out in the "museum plot", an area of land belonging to the Research-Development Station for Plant Culture on Sand, Dăbuleni (43°48′04″N 24°05′31″E). The area of land aims to preserve the spontaneous psammophilous vegetation of Oltenia. The total observation area comprises about 5 ha of unimproved sandy land, characterized by dunes and interdunes. From a climatic point of view, the area of sandy soils in the considered perimeter is classified, according to the Koppen classification, at the limit between Cf - temperate humid climate and BS - arid steppe climate (Șoimu et al., 2000; Dragomirescu, 1986). In the last ten years (2012-2021), the observation area includes mean annual temperatures ranging from 12.1°C -13.5°C and total annual precipitation ranging from 363 to 972.8 l/m^2. The wind pattern is characterized by a dominant V-E direction with a frequency of 59%. The strongest winds occur between March and June when intense deflation phenomena take place (Șoimu et al., 2000; Șoimu, 1998). Under the influence of these natural factors, the psammophilous vegetation has developed certain physiological adaptation characteristics. Wild flora and natural plant associations remained only on land that could not be cultivated for various reasons (Iuga & Stana, 2006). The first step in this work was to consult the bibliographic material on vascular psammophilous flora. Then, starting from this data, field trips were carried out several times in order to capture all the stages of development of the plants that would allow their correct identification. Where appropriate, specimens were also collected for those taxa where determination could not be made in the field. They were preserved by pressing, identified with the help of literature (Prodan, 1939; Beldie, 1977, 1979; Ciocârlan, 2000, 2009; Sârbu et al., 2013; Tutin et al., 1964-1980) and then included in the herbarium of the University of Craiova (C.R.A.). After the identification of all the material, a floristic list was compiled and compared with the one made about 40 years ago in order to observe the floristic dynamics of these sandy places and the influence of climatic changes on species distribution.

RESULTS AND DISCUSSIONS

The results obtained on the floristic composition of the research area, now and 40 years ago, are presented in Table 1. From the comparative analysis of the data inserted in Table 1, we found that there are some differences in floristic composition, which shows that climatic changes have influenced the physiognomy of these sites. Among the changes observed we mention: (1) reduction in the number of species from 157 to 130 taxa; (2) disappearance of some species (48 taxa) and appearance of others (26 taxa); (3) presence of new invasive species (*Ailanthus altissima*, *Gelditsia triacanthos*, *Phytolacca americana*, *Sorghum halepense*, *Morus alba*); (4) absence of wetland-loving plants (*Cyperus glomeratus*, *Juncus articulatus*, *Typha latifolia*, *Typha angustifolia*, *Trifolium fragiferum*, *Trifolium resupinatum*, etc), mentioned in studies by Păun et al. (1983), which explains the increasing aridity of these sites.

In terms of species reduction, according to studies by Yao et al. (2006) in arid and semi-arid regions, droughts can have major negative effects on plant species, but ground cover is spatially variable because species respond differently to different site conditions. Comparative analysis of the 1983/2022 moisture index (Figure 1) and the plant species present in the two periods analysed (Table 1) shows a decrease in the number of dryland-loving species, largely represented by annual plants growing in open areas (e.g. *Holosteum umbellatum*, *Ranunculus illyricus*, *Polycnemum majus*, *Polygonum arenarium*, etc.) and ruderal or segetal plants (e.g. *Solanum nigrum*, *Datura stramonium*, *Echium vulgare*, *Geranium pusillum*, *Lamium amplexicaule*, *L. purpureum*, etc). Yao et al. (2006) consider drought to be

the primary factor shaping the structure and dynamics of arid and semi-arid grasslands. In terms of changing species structure, the comparative analysis of extinct and emerging species can be explained by the advanced uncultivated of these areas. Some of the extinct species have not been able to compete with those species that have formed a vegetation cover with a very good cover (about 90-95%). If we add to this the aggressiveness with which some newly emerged species have developed in the areas analysed and the invasive potential that they show more and more from one year to the next, it explains why in some taxa the populations have become very poor or even disappeared.

Among the invasive or potentially invasive species found in the surveyed territory, we mention both woody species (e.g. *Ailanthus altissima*, *Gleditsia triacanthos*, *Morus alba*) and herbaceous species (e.g. *Phytolacca americana*, *Sorghum halepense*). The invasive potential of the adventive species *Ailanthus altissima* is explained by rapid growth in the early years of vegetation, strong draining, and high drought resistance due to an extensive root system (Kowarik & Saumel, 2007; Udvardy 2008; Wittenberg, 2005). *Gleditsia triacanthos* is a tree with strong, branched thorns, which is why it has been cultivated as a hedge on these sandy soils. It has spread by winds that are quite frequent in this part of the country and by sprouts. It is a drought and frost-resistant plant (Dumitru-Tătăranu, 1960; Haralamb, 1967). *Morus alba* is drought resistant and relatively undemanding in soil fertility. Like the 'ash tree' it is fast-growing, sprouts very well, and is easily spread by birds, mammals, and man. *Phytolacca americana* is an unpretentious adventive species that does not require heat, likes light soils such as sands, and tolerates drought conditions quite well. Only late spring and early autumn frosts affect it. Park et al. (1998) reported that the growth of *Phytolacca americana* depends more on sunlight than on inorganic nutrients. *Sorghum halepense* is a rhizomatous species that where established multiplies predominantly vegetatively via rhizomes (Anghel et al., 1972). The high temperatures in sandy soils favor the germination of seeds of this plant which have multiple pathways of spread: wind, agricultural machinery, via animals, etc. *S. halepense* is well known for its detrimental effects on the growth and development of neighboring plants through its strong competition and allelopathic potential (Huang et al., 2015).

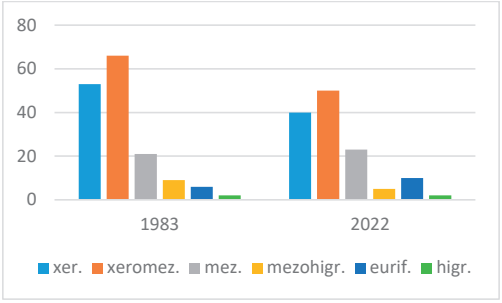

Figure 1. Humidity index analysis

The absence of some wetland-loving species that were mentioned about 40 years ago such as *Cyperus glomeratus*, *Juncus articulatus*, *Typha latifolia*, *Typha angustifolia*, *Trifolium fragiferum*, *Trifolium resupinatum* is explained by the destruction of irrigation systems that were used to irrigate crops in the past.

Table 1. List of species in the "museum plot"

Scientific name	Botanical family	Păun et al. 1983	Present 2022
Achillea ochroleuca Ehrh.; *A. setacea* Waldst. et Kit.	*Asteraceae*	+	+
Agrostis stolonifera L.	*Poaceae*	+	+
Ailanthus altissima (Mill.)	*Simaroubaceae*	-	+
Alkanna tinctoria Tausch.	*Boraginaceae*	+	-
Alyssum alyssoides (L.) L.; *A. desertorum* Stapf	*Brassicaceae*	+	+
Amaranthus albus L.; *A. retoflexus* L.	*Amaranthaceae*	+	+
Anagallis arvensis L.	*Primulaceae*	+	+
Anchusa officinalis L.	*Boraginaceae*	-	+
Anthemis arvensis L.	*Asteraceae*	-	+
Anthemis ruthenica M. Bieb.	*Asteraceae*	+	+
Apera spica-venti (L.) Beauv.	*Poaceae*	+	+

Scientific name	Botanical family	Păun et al. 1983	Present 2022
Arabidopsis thaliana (L.) Heynh.	*Brassicaceae*	+	+
Arenaria serpyllifolia L.	*Caryophyllaceae*	+	+
Aristolochia clematitis L.	*Aristolochiaceae*	+	-
Artemisia absinthium L.	*Asteraceae*	+	-
Bassia laniflora (S.G.Gmel.) A. J. Scott	*Chenopodiaceae*	+	+
Berteroa incana (L.) DC.	*Brassicaceae*	+	+
Bidens cernua L.; *B. tripartita* L.	*Asteraceae*	+	-
Bromus sterilis L.; *B. tectorum* L.	*Poaceae*	+	+
Capsella bursa-pastoris (L.) Medik.	*Brassicaceae*	+	+
Centaurea arenaria M. Bieb. subsp. *borysthenica* (Gruner) Dostál; *Centaurea calcitrapa* L., *Centaurea solstitialis* L. ssp. solstitialis	*Asteraceae*	+	+
Centaurea cyanus L.; *C. solstitialis* L.	*Asteraceae*	+	-
Cerastium dubium (Bast.) Guépin); *C. semidecandrum* L.	*Caryophyllaceae*	+	+
Cerinthe minor L.	*Boraginaceae*	+	-
Chamaecytisus austriacus (L.) Link	*Fabaceae*	+	+
Chenopodium album L.; *Ch. botrys* L.; *Ch. strictum* Roth	*Chenopodiaceae*	+	+
Chondrilla juncea L.	*Asteraceae*	+	-
Cichorium intybus L.	*Asteraceae*	+	-
Cirsium arvense (L.) Scop.; *C. vulgare* (Savi) Ten	*Asteraceae*	+	+
Clinopodium vulgare L. (*Calamintha vulgaris* (L.) Druce.)	*Lamiaceae*	+	-
Consolida regalis S. F. Gray	*Ranunculaceae*	+	-
Convolvulus arvensis L.	*Convolvulaceae*	-	+
Conyza canadensis (L.) Cronquist	*Asteraceae*	+	-
Crataegus monogyna Jacq.	*Rosaceae*	-	+
Crepis foetida L. subsp. *rhoeadifolia* (M. Bieb.) Čelak.	*Asteraceae*	+	+
Cruciata laevipes Opiz.	*Rubiaceae*	+	+
Cuscuta europaea L.	*Cuscutaceae*	+	+
Cynodon dactylon L.	*Poaceae*	+	+
Cyperus glomeratus L.	*Cyperaceae*	+	-
Datura stramonium L.	*Solanaceae*	+	-
Daucus carota L.	*Apiaceae*	+	+
Descurainia sophia (L.) Webb ex Prantl	*Brassicaceae*	+	+
Dichanthium ischaemum (L.) Roberty	*Poaceae*	+	+
Digitaria sanguinalis (L.) Scop.	*Poaceae*	+	+
Elymus repens)L.) Gould	*Poaceae*	+	+
Echinochloa crus-galli (L.) Beauv.	*Poaceae*	+	+
Echium vulgare L.	*Boraginaceae*	+	-
Equisetum arvense L.; *E. ramosissium* (Desf.)	*Equisetaceae*	-	+
Eragostis pilosa (L.) Beauv.; *E. minor* Host	*Poaceae*	+	+
Erodium cicutarium (L.) L'Hérit.	*Geraniaceae*	+	+
Erodium hoefftianum C. A. Mey. subsp. *neilreichii* (Janka) Soó	*Geraniaceae*	-	+
Erophila verna (L.) Chevall.	*Brassicaceae*	+	+
Eryngium campestre L.	*Apiaceae*	+	+
Erysimum diffusum Ehrh.	*Brassicaceae*	+	-
Euphorbia seguieriana Neck.; *Euphorbia virgata* Waldst. et Kit.	*Euphorbiaceae*	+	+
Falcaria vulgaris Bernh.	*Apiaceae*	+	-
Fallopia convolvulus (L.) Á. Löve	*Polygonaceae*	+	+
Festuca valesiaca Schleich. ex Gaudin	*Poaceae*	+	+
Filago arvensis L.	*Asteraceae*	+	+
Fumaria schleicheri Soy.-Willem.	*Papaveraceae*	+	-
Gagea villosa (M. Bieb.) Sweet	*Liliaceae*	+	+
Gagea pusilla (F. W. Schmidt). Schult. et Schult. f.	*Liliaceae*	+	+
Galinsoga parviflora Cav.	*Asteraceae*	+	-
Galium aparine L.	*Rubiaceae*	+	+
Geranium pusillum Burm.	*Geraniaceae*	+	-
Gleditsia triachanthos (L.)	*Fabaceae*	-	+
Gypsophila muralis L.	*Caryophyllaceae*	+	-
Heliotropium europaeum L.	*Boraginaceae*	+	-
Hieracium pilosella L.	*Asteraceae*	+	+
Holosteum umbellatum L.	*Caryophyllaceae*	+	-
Hordeum murinum L.	*Poaceae*	+	+
Hyoscyamus niger L.	*Solanaceae*	+	-
Hypericum elegans Stephan; *Hypericum perforatum* L.	*Hypericaceae*	+	+
Jasione heldreichii Boiss. & Orph.	*Campanulaceae*	+	+
Juncus articulatus L. em Richt.	*Juncaceae*	+	-

Scientific name	Botanical family	Păun et al. 1983	Present 2022
Kohlrauschia prolifera (L.) Kunth	*Caryophyllaceae*	+	+
Lactuca serriola L.	*Asteraceae*	+	+
Lamium amplexicaule L.; *Lamium purpureum* L.	*Lamiaceae*	+	-
Leonorus cardiaca L.	*Lamiaceae*	+	-
Linaria genistifolia (L.) Mill.	*Scrophulariaceae*	+	+
Linaria vulgaris Mill.	*Scrophulariaceae*	+	-
Lithospermum arvense L.	*Boraginaceae*	+	+
Lotus corniculatus L.	*Fabaceae*	+	+
Malva sylvestris L.	*Malvaceae*	-	+
Marrubium peregrinum L.	*Lamiaceae*	+	+
Marrubium vulgare L.	*Lamiaceae*	+	-
Medicago falcata L.; *Medicago lupulina* L.; *Medicago minima* (L.) L.	*Fabaceae*	+	+
Melica ciliata L.	*Poaceae*	-	+
Mollugo cerviana (L.) Ser.	*Molluginaceae*	+	+
Morus alba L.	*Moraceae*	-	+
Muscari neglectum Guss. ex Ten.	*Liliaceae*	+	-
Onopordum acanthium L.	*Asteraceae*	+	+
Onosma heterophylla Griseb.	*Boraginaceae*	+	-
Ornithogalum umbellatum L.	*Liliaceae*	+	+
Orobanche arenaria Borkh.	*Orobanchaceae*	+	-
Papaver dubium (L.) var. *albiflorum* Elk.	*Papaveraceae*	-	+
Papaver rhoeas L.	*Papaveraceae*	+	-
Phragmites australis (Cav.) Steud.	*Poaceae*	-	+
Phytolacca americana L.	*Phytolaccaceae*	-	+
Plantago arenaria Waldst. & Kit. (*P. indica* L.)	*Plantaginaceae*	+	+
Poa bulbosa L. subsp. *vivipara* (Koeler) Arcang.	*Poaceae*	+	+
Poa pratensis L.; *P. trivialis* L.	*Poaceae*	-	+
Polycnemum majus A. Br.	*Chenopodiaceae*	+	-
Polygonum arenarium Waldst. et Kit.; *P. aviculare* L.	*Polygonaceae*	+	-
Portulaca oleracea L.	*Portulacaceae*	+	-
Potentilla argentea L.; *P. reptans* L.	*Rosaceae*	+	+
Prunus cerasifera Ehrh.	*Rosaceae*	-	+
Padus avium Mill.	*Rosaceae*	-	+
Ranunculus illyricus L.	*Ranunculaceae*	+	-
Robinia pseudoacacia L.	*Fabaceae*	+	+
Rosa canina L.	*Rosaceae*	-	+
Rumex acetosella L.	*Polygonaceae*	+	-
Salix alba L.	*Salicaceae*	-	+
Salsola kali L. subsp. *ruthenica* (Iljin.) Soó	*Chenopodiaceae*	+	+
Sambucus ebulus L.	*Caprifoliaceae*	+	-
Scabiosa argentea L. (*S. ucranica* L.)	*Dipsacaceae*	+	+
Scleranthum polycarpos L.	*Caryophyllaceae*	+	-
Senecio vernalis Waldst. et Kit.	*Asteraceae*	+	+
Setaria pumila (Poir.) Roem. et Schult.; *S. verticillata* (L.) Beauv.; *S. viridis* (L.) Beauv.	*Poaceae*	+	+
Silene conica L.; *S. borystenica* (Gruner) Walters; *S. latifolia* Poir. subsp. *alba* (Mill.) Greuter et Burdet; *S. vulgaris* (Moench) Garcke	*Caryophyllaceae*	+	+
Sisymbrium orientale L.	*Brassicaceae*	+	-
Solanum nigrum L.	*Solanaceae*	+	-
Sonchus arvensis L.	*Asteraceae*	+	+
Sorghum halapense (L.) Pers.	*Poaceae*	-	+
Stellaria media (L.) Vill.	*Caryophyllaceae*	+	+
Syrenia cana (Pill. et Mitterp.) Neilr.	*Brassicaceae*	+	+
Thlaspi arvense L.; *Th. perfoliatum* L.	*Brassicaceae*	+	+
Torilis arvensis (Huds.) Link	*Apiaceae*	+	+
Tragopogon floccosus Waldst. et Kit.	*Asteraceae*	+	+
Tragus racemosum (L.) All.	*Poaceae*	+	+
Tribulus terrestris L.	*Zygophyllaceae*	+	+
Trifolium arvense L.; *T. campestre* Schreb.; *Trifolium echinatum* M. Bieb.; *T. pratense* L.; *T. repens* L.	*Fabaceae*	+	+
Trifolium fragiferum L.; *T. retusum* L.; *T. resupinatum* L.	*Fabaceae*	+	-
Typha angustifolia L.; *T. latifolia* L.	*Typhaceae*	+	-
Verbascum phlomoides L.; *V. thapsus* L.	*Scrophulariaceae*	+	+

Scientific name	Botanical family	Păun et al. 1983	Present 2022
Verbena officinalis L.	*Verbenaceae*	+	-
Veronica acinifolia L.; *V. hederifolia* L. subsp. *triloba* (Opiz) Čelak.; *V. triphyllos* L.	*Scrophulariaceae*	+	+
Vicia villosa Roth.	*Fabaceae*	-	+
Viola kitaibeliana Schult.	*Violaceae*	+	+
Vulpia myuros (L.) C.C. Gmel.	*Poaceae*	+	+
Xanthium italicum Moretti; *X. spinosum* L.; *X. strumarium* L.	*Asteraceae*	+	+
Xeranthemum annuum L.	*Asteraceae*	-	+

[1](+) = the presence of the species;
[2](-) = the absence of the species.

CONCLUSIONS

In conclusion, in areas occupied by sandy soils where the influence of the anthropic factor is reduced to a minimum, a greater cover of vegetation built by species that are not characteristic of sands, but which grow and develop relatively well on sands (e.g. *Cynodon dactylon*, *Bromus tectorum*, *Digitaria sanguinalis*, etc.) is observed. Annual plants which in the past formed self-sustaining associations (e.g. *Mollugetum cervianae* Borza 1961) are now rare in the few remaining sandy meshes not covered by vegetation. Although seeds or clones of typical psammophilous species (*Festuca vaginata* Waldst. et Kit., *Koeleria glauca* (Schkuhr) DC., *Secale sylvestre* Host., *Trigonella monspeliaca* L., *Teucrium polium* L., *Helichrysum arenarium* (L.) Moench) were brought to the reserve about 40 years ago, they have not adapted to these sites. Typical psammophilous species such as *Polygonum arenarium, Mollugo cerviana, Silene conica, Tragus racemosus, Plantago arenaria*, *Jasione heldreichii, Achillea ochroleuca, Centaurea solstitialis,* etc., prefer open sites because they do not seem to tolerate competition with other species.

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