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ADDITIONAL GLACIAL RELICTS IN CAREI PLAIN NATURAL PROTECTED AREA, NORTH-WESTERN ROMANIA

SZATMARI Paul-Marian[1]

Abstract: This paper presents new scientific data on the spread of mountain elements in the plains of the northwestern part of Romania, species that managed to survive in this area since the last glacial period. Previous studies revealed that the northwestern part of Romania does not exhibit vegetation specific to the region of forest steppe, hills or low mountain areas, as expected. Many species common to mountainous regions were previously observed not only in Carei Plain, but also in Ier Plain, Tur Plain, Tăşnad Hills or Oaş region across Satu Mare, Bihor and Sălaj counties. The same observations were made in other parts of Carei Plain in Hungary, and conclusions were drawn that the area was a glacial refuge. On the Hungarian side of the Carei Plain, the ecosystems were also better preserved comparative to the Romanian side, where most of the natural ecosystems of the Carei Plain were destroyed due to the conversion to agricultural land starting with the 19th century and culminating in the communist period during the 20th century. The study is also intended to be a complement to the data on "Natura 2000" sites, whose goal is the protection of biodiversity in Europe along with their conservation in the most favorable conditions. An update of these sites is becoming increasingly necessary since in recent decades they have been greatly impacted by human activities.
Keywords: glacial relicts, protected species, Carei Plain, Romania

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Introduction

Both the current spread and survival of species present during the last ice age have always intrigued scientists. Most species were forced to migrate southwards in order to survive. It is known that such species have survived in major areas of Europe that were sheltered in the Iberian, Italian and Balkan Peninsulas (Pop 1979). But some species, less susceptible to frost, managed to survive in sheltered places further north up to Central Europe. One such place is the northwestern part of Romania and northeastern Hungary. These assumptions are based both on the species remains that were discovered in the area, especially pollen in peat bogs and swamps, and especially the presence of species that continued living in these locations through and since the last glaciation. While in most lowland areas these species retreated to higher mountainous regions, some have remained due to geographical elements.

In parts of the Western Plains of Romania, these elements comprised wide areas of swamps that maintained a wet and cool climate in the northern part, relative to the center and south parts of the Western Plains (Karácsonyi 1987). The extensive riverside

[1] Biological Research Center, Botanical Garden ”Vasile Fati” Jibou, Str. Parcului, Nr. 14, 455200, Jibou, Sălaj County, Romania, e-mail: paul_marian87s@yahoo.com

shrubby thickets and floodplain forests have substantially reduced evaporation, thereby preventing the withdrawal of the marshes, especially during the warm Boreal Period. The following periods (Atlantic and Subboreal), wetter and colder, further helped the perpetuation of these species in the area (Ardelean & Karácsonyi 2005). With the descent of beech forests into the plains, more mountain low altitude species are arriving here, which, like the previous ones, still have had favorable conditions for survival. The warming during the Subatlantic period seals the fate of the beech forests, which withdrew to the mountains, some species disappearing (Ardelean & Karácsonyi 2005, 2008). But the greatest danger of these relicts is represented by human activities. The widely spread marshes of northwestern Romania were drained and most riverside thickets and forests cleared since the nineteenth century. In addition to deforestation a main contribution was the activity of a society that was aimed to draining the swamps and marshes; followed by the expansion of vineyards and black locust plantations from 1892 (Ardelean & Karácsonyi 2005). With their disappearance, most relicts had no chance of survival, but in partial natural places (islands) they continue to persist.

In Carei Plain, islands with archaic vegetation were found in Ciumeşti (Răchitişul Lung) (Karácsonyi 1992), Sanislău (Vermeş Bog) as well as in numerous other smaller, scattered places. Scărişoara Nouă, Satu Mare County, is one such place where archaic vegetation was recently discovered and published in this paper.

Material and methods

1. *Species identification*

Plant species have been observed and identified in the field at Scărişoara Nouă, Satu Mare County. Unknown species were collected, preserved as herbarium specimens and their identity was determined using taxonomic keys (Ciocârlan 2009, Sârbu et al. 2013). Pictures were also made for each species and habitat, available on the website "mybiosis.info". A phytocoenology survey was used in order to find the percentage of dominant and relict species. The scientific names of plants are in accordance with the accepted names by the website "The Plant List" and they are taxonomically assigned to the APG III Classification System. The identification of present habitats was also performed according to the manual of the Romanian habitats (Doniţă et al. 2005).

The data presented here were collected during field research in the years of 2012, 2013 and 2014. Field research was conducted throughout the growing season (fall, spring and summer) to capture as many species as possible.

2. *Description of the site*

The sands from the northwestern part of the country form a distinct geomorphological unit in the high plains of the western lowlands. Its characteristic landscape is made by the presence of rows of sand dunes with a north (northeastern) – south (southwestern) orientation, alternating with low interdune lands, sometimes occupied by large swamps. In some parts of the region yellow, flying sands are still present. The wetlands are mostly covered with dark brown sands (Benedek 1969).

The site is located on the stretch of an interdune through which flows a stream, which at that time was dry, but in following years the water level has returned to normal. This interdune is covered entirely by riverside thickets and natural osiers (*Salix* spp.), who apparently escaped the deforestation nearby. The sand dunes that border the site, unfortunately are covered with planted black locust, forming two compact corridors on

south-north direction. The black locust forest on the north side stretches to the edge of the site, but without negative influences, forming a veritable curtain of protection. On the south side are large areas of wet meadows, almost in a natural, preserved state, as well as sand dunes with their characteristic vegetation from the Pannonian region with *Corynephorus canescens*. Nearby there are other interdunes with swamps that could be the object of further investigations. The coordinates of the newly found place are 47°37'20" N and 22°12'56" E, at an altitude of about 142 m. The place is depicted on a map within Europe in Figure 1 (Fig. 1).

Fig. 1. The new site with glacial relicts near Scărișoara Nouă, Satu Mare County (Google Earth) seen at European level (yellow mark)

Results and discussion

The new location with glacial relicts was documented following a field research, on 23 September 2012. Due to the unusual drought that year, the marshes throughout the northwest had dried up, therefore this new location was discovered because it became more accessible. Also, the location was noticeable from afar due to the presence of tree species, otherwise unusual in the plains.

The tree layer of the site consists strictly of birch (*Betula pendula*), downy birch (*Betula pubescens* subsp. *carpatica*) and aspen (*Populus tremula*). Other woody species are represented by natural riverside thickets consisting of various willow species (e.g. *Salix alba*, *Salix fragilis*) and white poplar (*Populus alba*). The three species of trees at the site are characteristic of the mountain regions, especially the birches. *Betula pubescens* subsp. *carpatica* are not usually encountered below the beech forest altitude (600-1200 m), also this subspecies is endemic to the Carpathian Mountains. *Betula pendula* and *Populus tremula* are also not usually growing below the sessile oak elevations (Ciocârlan 2009). In some places a few other tree species are appearing represented by one individual tree, such as: grey poplar (*Populus canescens*), narrow-leafed ash (*Fraxinus angustifolia* subsp. *danubialis*), the pedunculate oak (*Quercus robur*), and adventitious trees like the swamp oak (*Quercus palustris*) and the American ash (*Fraxinus americana*), probably from nearby plantations.

The shrub layer is extremely rich in marsh species. The most remarkable are the willows encountered at much lower altitudes than normal: eared willow (*Salix aurita*) and purple-osier willow (*Salix purpurea*). The dominant species is grey willow (*Salix cinerea*), accompanied by alder buckthorn (*Frangula alnus*), guelder rose (*Viburnum opulus*) and common dogwood (*Cornus sanguinea*). In the shrub layer there are also occasionally found species such as hawthorn (*Crataegus monogyna*), dog rose (*Rosa canina*) and dewberry (*Rubus caesius*). Another adventitious shrub, with invasive character is the black cherry (*Prunus serotina*), which also comes from the nearby plantations. Remarkable is the mistletoe (*Viscum album*) parasitizing the birches. The main vines encountered are: hops (*Humulus lupulus*), hedge bindweed (*Calystegia sepium*) and bittersweet nightshade (*Solanum dulcamara*), as well as the adventive North American vine (*Vitis vulpina*).

The herbaceous layer present amongst the clusters of trees and shrubs as well as the grasslands also contain many mountain species, presented in Table 1. Patches are dominated by reed (*Phragmites australis*), various sedges (*Carex acuta, Carex acutiformis, Carex hirta, Carex nigra*), the marsh fern (*Thelypteris palustris*), velvet bent (*Agrostis canina*), woodclub rush (*Scirpus sylvaticus*) and soft rush (*Juncus effusus*).

The moss layer is very rich, many species usually growing in the mountains, a very notable characteristic of the site: *Cirryphyllum piliferum, Brachythecium rutabulum, Eurhinchium (Oxyrrhynchium) hians, Plagiomnium rostratum, Plagiomnium undulatum, Amblystegium serpens, Atrichum undulatum, Leptodyctium riparium, Climacium dendroides, Plagiomnium ellipticum*, and on the sandy dunes *Polytrichum piliferum*.

The wet meadows from the interdune present an exceptional floristic diversity, growing here many species included on the national Red Lists, listed in Table 2 (Boşcaiu et al. 1994, Oltean et al. 1994, Dihoru & Negrean 2009). Also the present plant associations are very diverse for such a small area. The main dominant species that make up the associations are: purple moor grass (*Molinia caerulea*) (a grass typical of mountain regions), creeping bentgrass (*Agrostis stolonifera*), tufted hairgrass (*Deschampsia cespitosa*), tall fescue (*Festuca arundinacea* subsp. *orientalis*), meadow fescue (*Festuca pratensis*). These habitats are home to a wide range of rare species and glacial mountain relicts for the region (Tables 1 and 2), playing a part of the archaic vegetation of the past time. This study also reports plant species that were not previously known to occur in the Carei Plain area such as *Luzula multiflora, Danthonia decumbens, Silene otites* subsp. *hungarica, Trifolium dubium, Lathyrus nissolia, Lathyrus palustris, Salix aurita, Achillea ptarmica, Mentha arvensis* subsp. *austriaca, Rumex thyrsiflorus, Festuca arundinacea* subsp. *orientalis.*

Within the site nine types of habitats were identified, a particularly high number for a single interdune, a character that underlines once again the diversity of flora and fauna of Carei Plain in particular in the preserved natural islands, and the necessity of increased efforts to protect these oases of biodiversity. Of these, six belong to the wet meadows and pastures as well as the marsh vegetation, two types of alluvial forests and swamp thickets and one xeric habitat characteristic to the sand dunes bordering the valley. These nine types of habitats are as follows:

R3710 Dacian *Molinia caerulea* grasslands. It is probably one of the last standing areas of significant surface in northwestern Romania, *Molinia caerulea*

habitats being continuously diminished due to marsh draining and inappropriate use of the grasslands. In literature, these types of habitats are not recorded below 300 m altitude (Doniță et al. 2005), while patches of *Molinia caerulea* reported from the plains of northwestern Romania being at very low altitudes, around 100 m. Conservation value is presented as moderate (Doniță et al. 2005), but this Carei (Nir) Plain relict habitats require protection. The main species that make up the habitat are*: Molinia caerulea, Angelica sylvestris, Cirsium rivulare, Serratula tinctoria, Lathyrus pratensis, Succisa pratensis, Lychnis flos-cuculi, Carex ovalis, Galium uliginosum, Euphorbia lucida, Sanguisorba officinalis* etc. Among the outstanding species found here are *Angelica palustris, Salix rosmarinifolia, Achillea ptarmica, Dianthus superbus* and *Scirpoides holoschoenus*.

R3712 Dacian communities with *Deschampsia cespitosa* and *Agrostis stolonifera.* A habitat also found here at a lower altitude than usual, is affected due to marsh draining. The main species (*Deschampsia cespitosa*) is in decline, but its place is taken remarkably by *Festuca arundinacea* subsp. *orientalis*, which also form compact meadows particularly biodiverse. According to Doniță et al. (2005) the conservation value of this habitat is low, but as in previous habitat (R3710 Dacian *Molinia caerulea* grasslands) these habitats are some of the last remnants of tall herb vegetation from the ancient wetlands of northwestern Romania and we consider that it needs protection.

The main species encountered along with *Deschampsia cespitosa* and *Agrostis stolonifera* are: *Festuca arundinacea* subsp. *orientalis, Alopecurus pratensis, Juncus conglomeratus, Juncus inflexus, Briza media, Trifolium pratense, Phleum pratense, Euphorbia lucida, Cynosurus cristatus, Holcus lanatus, Thalictrum lucidum* and *Dianthus superbus*.

R3715 Danubian-Pannonic meadows of *Agrostis stolonifera.* It occupies the areas surrounding tall grasslands. Their conservative value is low (Doniță et al. 2005), but in the Carei Plain they host many rare and low altitude mountain species, that require protection. The main species found here are: *Agrostis stolonifera, Alopecurus pratensis, Poa trivialis, Ranunculus repens, Trifolium fragiferum, Trifolium pratense, Eleocharis palustris, Ranunculus acris, Poa pratensis, Equisetum palustre, Carex panicea, Carex flacca, Veratrum album* etc.

R3716 Danubian-Pontic grasslands of *Poa pratensis, Festuca pratensis* and *Alopecurus pratensis.* It occupies large areas in Carei Plain, but is becoming increasingly scarce in species due to mowing and overgrazing. In Romania they have a moderate conservation value (Doniță et al. 2005). Within the interdune of the site presented by this study this habitat is very rich in species diversity, the most representative are: *Festuca pratensis, Alopecurus pratensis, Poa pratensis, Dactylis glomerata, Juncus effusus, Lotus corniculatus, Lysimachia nummularia, Pulicaria dysenterica, Ononis arvensis, Galium palustre, Carex hirta, Cirsium rivulare, Briza media, Leucanthemum vulgare, Thalictrum simplex* subsp. *galioides* etc. Among the rare species stands out *Iris sibirica, Orchis laxiflora* subsp. *elegans Achillea aspleniifolia* and *Taraxacum palustre*.

R4407 Danubian forests of *Salix alba* with *Rubus caesius.* Forms narrow belts of vegetation along the creek that runs through the site. This habitat have a high conservation value (Doniță et al. 2005), an increased conservation value which further increases due to the rare and relict species contained in this habitat. Although the habitat

is mainly formed by *Salix alba*, in some places *Populus tremula* alongside with *Betula pendula* and *Betula pubescens* subsp. *carpatica* become dominant species. Other trees found here are: *Populus alba, Salix fragilis*, with rare specimens of *Fraxinus angustifolia* subsp. *danubialis* and adventive species such as *Fraxinus americana* and *Quercus palustris*. The shrub layer is dominated by: *Frangula alnus, Cornus sanguinea, Salix cinerea, Viburnum opulus, Rubus caesius* that are occasionally covered with creepers like *Humulus lupulus, Calystegia sepium* and *Solanum dulcamara*. The dominant grasses are: *Agrostis canina, Agrostis stolonifera, Lysimachia nummularia, Glechoma hederacea, Polygonum hydropiper, Scutellaria galericulata, Lycopus europaeus*, sometimes dominating *Phragmites australis* with *Thelypteris palustris*. These damp woods shelter important rare species such as *Urtica kioviensis, Peucedanum palustre* and *Carex nigra*.

R4419 Southeast Carpathian thickets of *Salix cinerea* with *Calamagrostis canescens*. This habitat is particularly interesting, being reported only in mountainous regions and Carei Plain, its conservation value is high (Doniță et al. 2005) primarily because shelters relict species in all areas of the country where it occurs, and also this thickets are found rarely in the northwestern part of Romania. The main associations between the defining species of this type habitat were found in the marshes at the borders of the villages Sanislău and Ciumeşti (Ardelean & Karácsonyi 2005). The habitat consists of the following species, which contains the following relicts: *Calamagrostis canescens, Betula pubescens* subsp. *carpatica, Salix aurita, Carex nigra, Carex cespitosa, Carex echinata, Peucedanum palustre, Salix rosmarinifolia, Angelica palustris*. The main dominant shrubs alongside *Salix cinerea* are: *Frangula alnus, Viburnum opulus* and *Cornus sanguinea*. The herbaceous layer consists of the *Carex* species mentioned above as well as *Carex acuta* or *Carex acutiformis, Poa trivialis, Lysimachia vulgaris, Scirpus sylvaticus, Urtica kioviensis, Urtica dioica, Angelica sylvestris, Lythrum salicaria, Lycopus europaeus, Galium palustre, Iris pseudacorus, Solanum dulcamara, Thelyperis palustris, Symphytum officinale, Oenanthe aquatica, Stachys palustris* etc. Special attention should be given to the fact that in one of the adjacent valleys near the investigated area presented here was reported another glacial relict in the Romanian flora: *Spiraea salicifolia*, a basic component of the habitat described by Ardelean & Karácsonyi (2005). The species here is of uncertain origin. The relict species *Calamagrostis canescens* and the impressive *Calamagrostis stricta* are endangered throughout the northwest of the country due to marsh draining, being already extinct from the most of the localities reported in the literature.

R5305 Danubian communities with *Typha angustifolia* and *Typha latifolia*. This habitat occupies a silted area that once was probably a former lake, the conservative value being generally low (Doniță et al. 2005). The main species found here are: *Typha latifolia, Typha angustifolia, Schoenoplectus lacustris, Lythrum salicaria, Glyceria maxima, Alisma plantago-aquatica, Carex riparia, Carex acutiformis, Epilobium hirsutum, Lysimachia vulgaris, Mentha arvensis, Bolboschoenus maritimus* etc.

R5310 Dacian-Danubian communities with *Carex elata, Carex rostrata, Carex riparia* and *Carex acutiformis*. These tall sedges occupy depressions with especially excessive humidity. Their conservation value, otherwise moderate throughout Romania (Doniță et al. 2005), increases considerably in the plains of the northwestern part of the country, where it forms large areas of archaic wetlands, which often escaped grubbing

and drainage works because of their high content in forage species. The dominant species of this particular habitat present at the site presented by this study includes *Carex acuta, Carex acutiformis, Carex riparia*, with *Carex elata* occuring only in minor clusters. The accompanying main species found here are: *Equisetum palustre, Lythrum salicaria, Peucedanum palustre, Rorippa sylvestris, Galium palustre, Eleocharis palustris, Lathyrus palustris, Phalaris arundinacea, Poa palustris, Lysimachia vulgaris, Thalictrum lucidum, Trifolium hybridum* subsp. *elegans, Sonchus arvensis* subsp. *uliginosus* etc.

R6401 Pannonian grasslands of *Corynephorus canescens* and *Festuca vaginata*. The habitat that is characteristic exclusively to the Carei (Nir) Plain throughout Romania, still preserves large areas of sand occupied by species having a priceless scientific value. It is one of the habitats with high conservative value in Romania (Doniță et al. 2005). The sand dunes bordering the studied valley are in a continuously stage of decay, being planted with black locust forests or turned into agricultural lands, thereby being plowed. The habitat was identified in low clusters in the areas escaped from the attention of the farmers. Among the few remaining sandy species and particularly adapted to this habitat were identified the following: *Corynephorus canescens, Anthemis ruthenica, Jasione montana, Petrorhagia prolifera, Dianthus giganteiformis* subsp. *pontederae, Trifolium arvense, Rumex thyrsiflorus, Rumex acetosella, Silene otites* subsp. *hungarica* etc.

The research site described above has not yet been reported in previous works on the flora of Nir Plain (Carei Plain). This is due to its location very close to the border with Hungary, an area forbidden to research or any other human activities during the communist period, which also might have contributed to its preservation. The new species found here reinforce the assumption that this region was a glacial refuge as they are among the last withstanding species of those periods. The new relict species for the sandy region includes *Salix aurita, Luzula multiflora* and *Achillea ptarmica*. *Salix aurita* was indicated only in older works from the Ecedea moor, north of Carei city, which was one of the largest forested floodplain wetland transformed into agricultural land. The vegetation of this old swamp was characterized by the presence of many mountain species, such as *Pedicularis palustris, Carex flava, Carex davalliana* or *Cirsium palustre* (Karácsonyi 1987). One of the most important remnants of the postglacial period is *Angelica palustris*, a relict in the flora of Romania. Its presence in the swamps of Carei Plain at a considerable distance from other populations scattered throughout the Carpathians, brings a new argument for the relict character of the region. The newly discovered populations of *Betula pubescens* subsp. *carpatica, Carex nigra, Carex echinata, Betula pendula* etc. indicates they were quite common in the Nir region, and their disappearance was probably caused primarily by human activities.

To better highlight the relict character of the site presented in this paper, in the autumn of 2012 the following floristic analysis was made for the grove with birch trees and aspens. The plant species found strictly in this grove are shown in Table 3 together with their environmental requirements (U - humidity, T - temperature, R - soil pH), considering the importance of analyzing these species in the context of their bioforms and geoelements (Sanda et al. 1983).

Table 1. The glacial relicts discovered at Scărișoara Nouă (Carei Plain)

Nr.	Relicts that are not usually found below the beech forest floor (most of these species are low altitude mountain elements, not being real glacial relicts at the country level)	
	Family	**Species**
1.	Betulaceae	*Betula pubescens* subsp. *carpatica* (Waldst. & Kit. ex Willd.) Asch. & Graebn.
2.	Apiaceae	*Angelica palustris* (Besser) Hoffm.- glacial relict in the Romanian flora
3.		*Peucedanum palustre* Moench
4.	Salicaceae	*Salix aurita* L.
5.	Asteraceae	*Cirsium rivulare* (Jacq.) All.
6.	Melanthiaceae	*Veratrum album* L.
7.	Cyperaceae	*Carex echinata* Murray
8.		*Carex nigra* (L.) Reichard
9.	Poaceae	*Calamagrostis canescens* (G.H.Weber)Roth - glacial relict in the Romanian flora
	Relicts that are not usually found below the sessile oak forest floor, found here at some of the lowest altitudes ever reported	
10.	Athyriaceae	*Athyrium filix-femina* (L.) Roth
11.	Dryopteridaceae	*Dryopteris carthusiana* (Vill.) H.P.Fuchs
12.	Betulaceae	*Betula pendula* Roth
13.	Rosaceae	*Potentilla erecta* (L.) Raeusch.
14.	Salicaceae	*Populus tremula* L.
15.		*Salix purpurea* L.
16.	Caprifoliaceae	*Succisa pratensis* Moench
17.	Asteraceae	*Achillea millefolium* L.
18.	Juncaceae	*Luzula multiflora* (Ehrh.) Lej.
19.	Cyperaceae	*Carex cespitosa* L.
20.		*Carex flacca* Schreb.
21.		*Carex ovalis* Gooden.
22.	Poaceae	*Agrostis canina* L.
23.		*Cynosurus cristatus* L.
24.		*Danthonia decumbens* (L.) DC.
25.		*Holcus lanatus* L.
	Other species that are usually encountered especially in mountainous areas, but here descend also at the oak forest floor level, with some exceptions even in the plains	
26.	Thelypteridaceae	*Thelypteris palustris* (A. Gray) Schott
27.	Caryophyllaceae	*Dianthus superbus* L.
28.	Rosaceae	*Sanguisorba officinalis* L.
29.	Salicaceae	*Salix rosmarinifolia* L.
30.	Asteraceae	*Achillea ptarmica* L.
31.	Iridaceae	*Iris sibirica* L.
32.	Cyperaceae	*Carex disticha* Huds.
33.		*Carex panicea* L.
34.	Poaceae	*Deschampsia cespitosa* (L.) P. Beauv.
35.		*Molinia caerulea* (L.) Moench

Table 2. Rare and protected species

Rare and protected plant species. Species found within the studied site and the outlying sand dunes, listed in the Red Book (Dihoru & Negrean 2009) (A), Red Lists [(Oltean et al. 1994 (B), Boşcaiu et al. 1994 (C)], Carpathian Red List of endangered species (Witkowski et al. 2003) (D) and Natura 2000 (E)

Species from national red lists			
Nr.	**Family**	**Species**	**Observations**
1.	Urticaceae	*Urtica kioviensis* Rogow.	A, B
2.	Polygonaceae	*Rumex thyrsiflorus* Fingerh.	A, B, C
3.	Apiaceae	*Angelica palustris* (Besser) Hoffm.	A, B, C, D, E
4.		*Oenanthe aquatica* (L.) Poir.	C
5.		*Peucedanum palustre* Moench	C
6.	Salicaceae	*Salix rosmarinifolia* L.	B
7.	Asteraceae	*Achillea aspleniifolia* Vent.	D
8.		*Achillea ptarmica* L.	B
9.	Iridaceae	*Iris sibirica* L.	C, D
10.	Orchidaceae	*Orchis laxiflora* subsp. *elegans* (Heuff.) Soó	B
11.	Poaceae	*Corynephorus canescens* (L.) P. Beauv.	A, C, E
Rare and endangered plant species from Carei Plain (rare – rare species in the Romanian flora, R – glacial relicts and low altitude mountain elements in the plains of north-western Romania, EN – endangered in Carei Plain and northwestern Romania, T – typical to the sandy region of Carei Plain)			
12.	Thelypteridaceae	*Thelypteris palustris* (A. Gray) Schott	R, EN
13.	Betulaceae	*Betula pendula* Roth	R, EN, T
14.		*Betula pubescens* subsp. *carpatica* (Waldst. & Kit. ex Willd.) Asch. & Graebn.	R, EN
15.	Caryophyllaceae	*Dianthus giganteiformis* subsp. *pontederae* (A.Kern.) Soó	T
16.		*Dianthus superbus* L.	R, EN
17.		*Silene otites* subsp. *hungarica* Wrigley	rare, T
18.	Fabaceae	*Lathyrus palustris* L.	EN
19.	Euphorbiaceae	*Euphorbia lucida* Waldst. & Kit.	EN
20.		*Euphorbia palustris* L.	EN
21.	Violaceae	*Viola stagnina* Kit.	EN
22.	Salicaceae	*Salix aurita* L.	R, EN
23.	Lamiaceae	*Mentha arvensis* subsp. *austriaca* (Jacq.) Briq.	rare
24.	Rubiaceae	*Galium uliginosum* L.	EN
25.	Campanulaceae	*Jasione montana* L.	rare, T
26.	Asteraceae	*Sonchus arvensis* subsp. *uliginosus* (M.Bieb) Nyman	rare
27.		*Taraxacum palustre* (Lyons) Symons	rare, EN
28.	Melanthiaceae	*Veratrum album* L.	R, EN
29.	Cyperaceae	*Carex acuta* L.	EN
30.		*Carex cespitosa* L.	R, EN
31.		*Carex echinata* Murray	R, EN
32.		*Carex elata* All.	EN
33.		*Carex nigra* (L.) Reichard	R, EN
34.		*Scirpoides holoschoenus* (L.) Soják	T
35.	Poaceae	*Calamagrostis canescens* (G.H.Weber) Roth	R, EN
36.		*Festuca arundinacea* subsp. *orientalis* (Hack.) Tzvelev	EN
37.		*Molinia caerulea* (L.) Moench	R, EN

Table 3. List of species found at the relict site of Scărişoara Nouă

Family	Species	Ecological indices
Equisetaceae	*Equisetum arvense* L.	G, Cosm;U3 T3 R0
Thelypteridaceae	*Thelypteris palustris* Schott	HH, Cp; U4 T0 R3
Dryopteridaceae	*Dryopteris carthusiana* (Vill.) H. P. Fuchs	H,Cp; U4 T3,5 R0
Cannabaceae	*Humulus lupulus* L.	H, Eua; U3,5 T3 R4
Urticaceae	*Urtica kioviensis* Rogow.	H,Pont; U4,5 T3,5 R4
Fagaceae	*Quercus robur* L.	MM,Eur;U3,5 T3 R0
Betulaceae	*Betula pendula* Roth	MM, Eua; U3 T2 R2
	Betula pubescens Ehrh. subsp. *carpatica* (Waldst. et Kit. ex.Willd.) Asch. et Graeb.	MM-M, Eua; U4,5 T2 R2
Polygonaceae	*Polygonum lapathifolium* L.	Th,Cosm; U4 T0 R3
Rosaceae	*Crataegus monogyna* Jacq.	M, Eur; U2,5 T3 R3
	Potentilla erecta (L.) Raeusch.	H,Eua;U0 T0 R0
	Rosa canina L.	N,Eur;U2 T3 R3
	Rubus caesius L.	H,Eua;U4,5 T3 R4
	Sanguisorba officinalis L.	H,Eua(bor); U3 T3 R0
Fabaceae	*Lathyrus palustris* L.	H,Cp; U5 T0 R4,5
	Vicia cracca L.	H,Eua;U3 T0 R3
Lythraceae	*Lythrum salicaria* L.	H,Cosm;U4 T3 R0
Cornaceae	*Cornus sanguinea* L.	M,Euc;U3 T3 R4
Santalaceae	*Viscum album* L.	Ch (N), Eua; U3,5 T3 R0
Rhamnaceae	*Frangula alnus* Mill.	M, Eua; U4 T3 R3
Apiaceae	*Angelica sylvestris* L.	H, Eua; U4 T3 R3
	Peucedanum palustre (L.) Moench	H,Eua; U5 T3 R0
Hypericaceae	*Hypericum tetrapterum* Fr.	H,Eur; U4 T3 R4
Salicaceae	*Populus canescens* (Aiton) Sm.	MM-M, Eua; U3,5 T3 R3
	Populus tremula L.	MM,Eua;U3 T2 R2
	Salix cinerea L.	M, Eua; U5 T3 R3
	Salix rosmarinifolia L.	M, Eua; U4 T0 R0
Primulaceae	*Lysimachia vulgaris* L.	H,Eua;U5 T0 R0
Oleaceae	*Fraxinus angustifolia* Vahl subsp. *danubialis* Pouzar	MM,Pont-Pan; U4,5 T4 R4,5
Convolvulaceae	*Calystegia sepium* (L.) R.Br.	H,Eua;U4 T3 R4
Boraginaceae	*Symphytum officinale* L.	H, Eua, U 4 T 3 R 0
Lamiaceae	*Lycopus europaeus* L.	HH, Eua; U5 T3 R0
	Prunella vulgaris L.	H,Cp;U3 T3 R0
	Scutellaria galericulata L.	H,Cp; U4 T3 R4
	Stachys palustris L.	H(G), Cp; U4 T3 R4
Plantaginaceae	*Veronica chamaedrys* L.	H-Ch,Eua;U3 T0 R0
Solanaceae	*Solanum dulcamara* L.	Ch(N), Eua; U4,5 T3 R4
Rubiaceae	*Galium palustre* L.	H, Cp; U5 T3 R0
	Galium uliginosum L.	H,Eua; U4,5 T3 R4
Adoxaceae	*Viburnum opulus* L.	M, Cp; U4 T3 R4
Caprifoliaceae	*Valeriana officinalis* L.	H,Eua(Med);U4 T3 R4
	Succisa pratensis Moench	H,Eua; U4 T3 R0
Asteraceae	*Achillea millefolium* L.	H,Eua;U3 T0 R0
	Bidens tripartita L.	Th, Eua; U 4,5 T 3 R 0
	Cirsium rivulare (Jacq.) All.	H,Euc; U4 T3,5 R0
	Eupatorium cannabinum L.	H,Eua;U4 T3 R0
Juncaceae	*Juncus effusus* L.	H, Cosm; U4,5 T3 R3
Cyperaceae	*Carex acuta* L.	HH-G, Eua; U5 T3 R0

	Carex acutiformis Ehrh.	HH, Eua(Med); U6 T3 R4
	Carex hirta L.	G, Eur(Med); U0 T3 R0
	Scirpus sylvaticus L.	HH(G), Cp; U4,5 T3 R0
Poaceae	*Agrostis canina* L.	H,Eua; U3,5 T3 R3
	Leersia oryzoides (L.) Sw.	HH, Cp; U6 T3 R0
	Molinia caerulea (L.) Moench	H, Eua; U4 T3 R0
	Phragmites australis (Cav.) Steud.	HH, Cosm; U5 T0 R4
	Poa palustris L.	H, Cp; U5 T3 R4
BRYOPSIDA		
Polytrichaceae	*Atrichum undulatum* (Hedw.) P. Beauv.	Cp
Mniaceae	*Plagiomnium rostratum* (Schrad.) T.J. Kop.	Cp
	Plagiomnium ellipticum (Brid.) T.J.Kop.	Cp
	Plagiomnium undulatum (Hedw.) T.J. Kop.	Cp
Amblystegiaceae	*Amblystegium serpens* (Hedw.) Schimp.	Cp
	Leptodictyum riparium (Hedw.) Warnst.	Cp
Brachyteciaceae	*Brachytecium rutabulum* (Hedw.) Schimp.	Cp
	Cirriphyllum piliferum (Hedw.) Grout	Cp
	Eurhynchium hians (Hedw.) Sande Lac.	Cp
Climaciaceae	*Climacium dendroides* (Hedw.) F. Weber & D. Mohr	Cp

Abbreviations: (MM - megaphanerophytes, M - mesophanerophytes, N - nanophanerophytes, Ch - chamaephytes, H - hemicryptophytes, HH - helohidatophytes, G - geophytes, Th – annual therophytes, Eur - European , Eua - Eurasian Euc - Central European, Pont - Pontic, Pont-Pan - Ponto-Pannonian, Cp (Circ) - Circumpolar, Cosm. – Cosmopolitan, Adv – Adventive, U2-U2,5 - xero-mesophyle, U3-U3,5 - mesophyle, U4-U4,5 - mesohydrophyle, U5- hygrophyle, U6 – hydrophyle, U0 - amphitolerant, T2 - microtherm, T3-T3,5 - micromesothermic, T4 - moderately mesotherms, T0 – amphitolerant, R2 - acidophiles, R3 - acid-neutrophile, R4 - R4,5 - weak acid-neutrophile, R0 - amphitolerant).

The analysis of the bioforms is particularly important because it provides information about the balance of the phytocoenoses with the entire environmental conditions and the specificities of the sites, giving us paleoecological information upon the flora and vegetation of the region, but also revealing the influence of the human factor (Cristea et al. 2004). In Figure 2 we notice the predominance of the hemicryptophytes (H) with a percentage of 51.72%, which is characteristic of the temperate zone within which the research site is located. Also, the large number of woody species (24.12%) indicates a natural place, characterized by very little disturbance as a result of human activity. The importance of woody species increases significantly if we consider both their unusual environmental requirements in the lowland and that most of these natural riverside thickets are endangered in Europe. The percentage of 12.06% of helohidatophytes (HH) emphasises the excessive moisture of this place. The extremely low number of annual therophytes (Th) – 2, also indicates an unspoiled, well preserved natural place, they of course, at this location, are aquatic (*Bidens tripartita* and *Polygonum lapathifolium*).

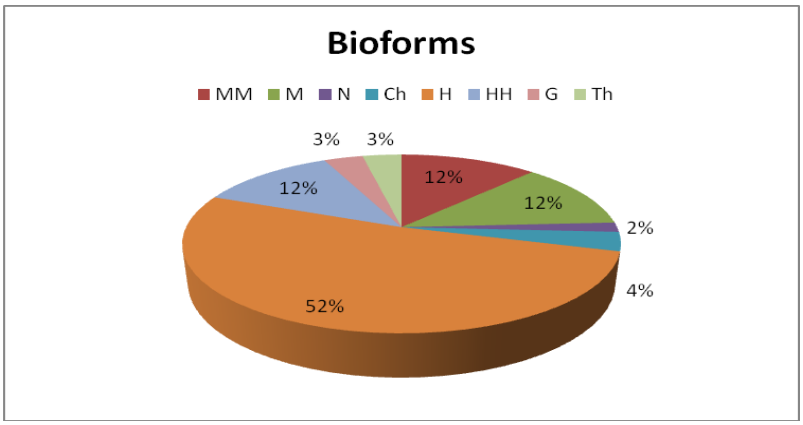

Fig. 2. Analysis of bioforms of flora near Scărişoara Nouă (abbreviations same as in Table 3)

The geoelements are categories of plant species that are more or less phylogenetically distant, but in the process of speciation have occupied the same geographical region, following specific routes of migration and the phytocoenosis integration leading to the present species composition of the researched site. The evolutionary implications of this study are particularly interesting as the species presented here are either: far away from their original homeland, have survived in the studied region from long gone geological eras, arrived in more recent times, or they evolved locally (Cristea 1991). The species found at this site also provide information about the macro- and microclimates in which the species have developed and bring further arguments in support of protecting these areas with special phytogeographical significance (Cristea et al. 2004).

To learn more about the history of this location we also took into account the moss species found here, which later confirmed the relict character of the location. Figure 3 provides data for this purpose. The predominance of the Eurasian species (Eua - 46.96%), normal for the region, was observed. In contrast stands the unusually high number of circumpolar species (Cp - 30.30%) from a station in the plains. These species are characteristic of mountain regions, finding shelter here in the ambience created by the woody species or in the microclimates created along watercourses or streams. The swamps of the Nir Plain interdunes appear to be almost perfect for the conservation of the above mentioned species. The conservational importance of this site is increased due to the presence of the pontic species (Pont) *Urtica kioviensis*, now extremely rare in our country's flora, and the woody ponto-pannonian (Pont-Pan) subspecies *Fraxinus angustifolia* subsp. *danubialis* that provides clues about the floristic region in which we are, namely the pannonian region. Again, the small number of adventive species is due to the low impact of human activities on the site presented by this study. There are only two species (*Prunus serotina*, *Quercus palustris*) that were probably brought over by animal seed dispersers, due to their nutritious fruits. Both species have similar ecological requirements at the studied site and adapt easily, but the wild black cherry (*Prunus serotina*) was also found in the permanent wetland areas as noted in other

places in Nir Plain (Szatmari 2012). I notice this issue since, within the most native areas, the wild black cherry is behaving differently, avoiding water ponding (Marquis, 1990). At the Scărişoara Nouă station the wild black cherry becomes invasive, although currently most individuals are seedlings, but they can threaten the biodiversity in the future (Anastasiu & Negrean 2007). It may cause unfavorable competition with the relict species, which has been reported from other parts of Europe (Robakowski & Bielinis 2011), and in Hungary (Juhász Kocsis & Bagi 2007, Zoltan-Botta & Balogh 2008).

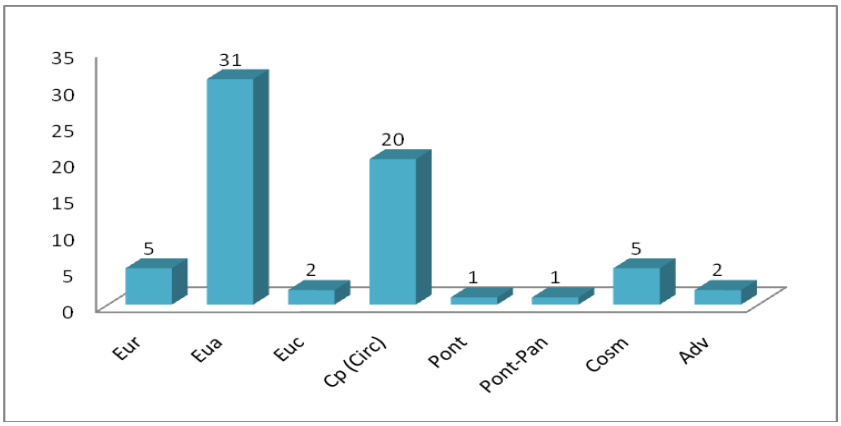

Fig. 3. Analysis of geoelements of flora near Scărişoara Nouă (abbreviations same as in Table 3)

The ecological indices from Figure 4 provides new data about the researched site. Thus, the behavior of the species towards humidity (U) indicates the predominance of the mesohydrophyle species (U4-U4.5) (48.21%). They are joined by mesophyle (U3-U3.5) and hydrophyle (U5) species. The many moisture-loving species indicates that groundwater is near the surface. According to temperature (T) preferences, the predominant species are the micromesothermic (T3-T3.5), which prefer moderate temperatures. These indicator species prefer moist or partially shaded places. Most species are typical to marshes and forests. The second place is occupied by eurythermic species (T0) that supports wide temperature oscillations. Among them are: *Thelypteris palustris, Salix rosmarinifolia, Potentilla erecta* or *Achillea millefolium* which usually prefer mountain regions. On the third place are the microtherm species (T2-T2.5), truly remarkable in lowland areas. The most unusual is that the three microtherm species form the upper floor of the canopy, represented by tree species: *Betula pendula, Betula pubescens* subsp. *carpatica* and *Populus tremula*, an irrefutable argument for the relict origin of the studied site. According to soil pH reaction (R), the investigated flora has a mainly weak acid-neutrophil character (R4-R4.5) - 30.35%. Their number is exceeded by species that tolerate a wide range of soil pH - R0) - 44.64%, which have been adapted to a wide ecological range of this parameter. Typically, these species may have an invasive character, but not at the moment because the amphitolerant species that are found here, are either swamp or mountain species at a lower altitude. If we consider that argument, the idea of survival of the mountain species in the lowlands is quite plausible.

They, not being related to a particular type of soil, had more chance of surviving if moisture remains constant throughout the year. Among these we have noticed *Peucedanum palustre, Dryopteris carthusiana, Cirsium rivulare, Salix rosmarinifolia* or *Molinia caerulea*. They are followed in smaller percentages by the acid-neutrophil species (R3-R3.5 - 19.64%) and the acidophiles (R2-R2.5 - 5.35%). Once again, the fact that the dominant woody or herbaceous species that fall within this category raises some questions (*Betula pendula, Betula pubescens* subsp. *carpatica, Populus tremula* – R2, *Salix cinerea, Frangula alnus, Thelypteris palustris, Agrostis canina, Juncus effusus* etc. – R3). The soil acidity formed under the influence of shallow groundwater facilitated the perpetuation of these mountain species. So, the combination of several factors together has created a true refuge for the mountain species which continue to survive here since the last glacial period.

The conclusion would be that since this ecological niche could not have been exploited by other tree or herbaceous species, the competition between them became almost zero, so the mountain species have managed to grow unhindered.

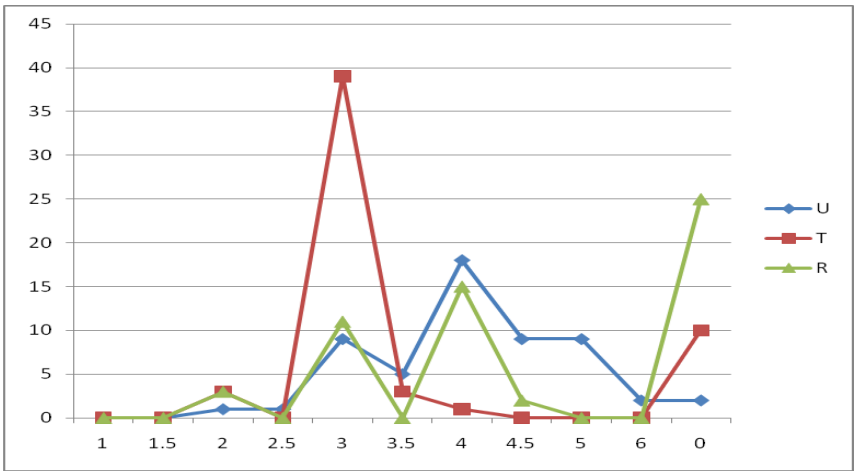

Fig. 4. The ecological analysis of the flora from the place at Scărişoara Nouă with relict character (Abbreviations same from Table 3. + U1-U1.5 – xerophytes,T1-T1.5 – cryophiles, T2.5 – microtherms, T4.5 – moderately mesotherms, T5 – thermophiles, R1-R1.5 – strong acidophiles, R2.5 – acidophiles, R3.5 – acido-neutrophiles, R5 – basiphilous-neutrophiles)

Another element to observe at the unusual species in the lowlands is that the study of their areas and the spread limits in our country. Thus, here we have species that are not usually found below the altitude limit of the spread of beech and sessile oak forests (Ciocârlan 2009). The region in which Scărişoara Nouă, and almost all of the Nir (Carei) Plain are within the forest steppe zone between 50-150 m altitude. The oak sublevel starts at 100 m (Doniță et al. 2005). In Carei Plain there are exceptions regarding the spread of oak forests, which once occupied a large part. Therefore, there is a gap in the northwestern part of the country, many woody species defining the forests at lower elevations. For this reason, many forest remnants are composed of a mixture of species from the forest steppe and the oak floor. Instead the species of sessile oak

sublevel (300-600 m) or beech forests (600-1200 m) (Ciocârlan 2009) were unable to take hold in the studied area by subsequent colonization, but only by their perpetuation since the ice age. Since the station at Scărișoara Nouă is located at 142 m altitude, the colonization of mountain species as adventive plants in the area is excluded. In the first table (Table 1) are shown the areas of distribution of the species considered mountain relicts in the lowlands, according to the *Flora Ilustrată a României* (Ciocârlan 2009).

The character of a relict station is highlighted also by the remarkable age of the species of birch and aspen, or white poplar and willow species nearby. Also the associations edified by *Carex acuta* and *Molinia caerulea* describe an archaic vegetation, yet unaltered in the region. The presence of the species *Molinia caerulea*, *Succisa pratensis* and *Sanguisorba officinalis* indicates the final stage of the marshes with permanent water, namely the lowering groundwater. Instead, the presence of *Carex* species, *Thelypteris palustris*, *Cirsium rivulare* and of *Betula* spp., suggests a significant amount of groundwater that reaches the surface, where these species exist. The fauna of this place is probably also remarkable, requiring some more detailed studies in the future. The presence of the mountain lizard (*Zootoca vivipara*) at this location, further underlines the fact that these plants did not reach this area later, and they remained here since the last ice age. Also in the nearby Vermeș Swamp there are two relict species of amphibians: *Rana lessonae* and *Rana arvalis* (Covaciu-Marcov et al. 2009).

Conclusion

The Carei Plain (Nir Plain) is a very special geographical region, profoundly different from the surrounding areas. Across the region are found a whole range of rare, protected or unusual plants, animals, fungi etc. This is why the plain received the status of Natura 2000 protected site (Ardelean & Karácsonyi 2005). Among the unusual plant and animal species stand out the steppe and glacial relicts, which coexist here together. This paper brings new data and arguments upon the spread and survival of these species. They managed to survive here until today because they had similar ecological conditions in the mountains, the swamps surrounded by forests maintaining the coolness and humidity they needed to remain alive. Noteworthy is the fact that they live here in places with much higher humidity that in the mountains, thus compensating the lower rainfall (Karácsonyi 1987).

The assumption of their coming as pioneer species is less likely because of the significant distance from the nearby mountain regions and because of their problematical ecological conditions, like the peat moss. Most likely during the warm period after the glaciation not all the marshes completely dried out in the region, forming islands of relict vegetation around them. These pockets of vegetation spread out rapidly across the region after the beech forest descended to the plains and also they retreated back to the marshes after the new warming period.

As mentioned in Table 1, the species listed here are not glacial relicts at the country level, only to the plains of northwestern Romania. Some authors call them low altitude mountain elements (Karácsonyi 1987). The nationwide glacial relicts, found here, are only *Angelica palustris* and *Calamagrostis canescens*, but the rest of the plain conserves numerous other glacial relicts from Romania (Pop 1976). The others are species found almost exclusively in the mountain regions, encountered only in exceptional cases under the beech or sessile oak forests floors.

In some swamped interdunes near Scărişoara Nouă were also found remarkable plant species, which grow probably near the previously described place, as the mountain or glacial relicts in Romania and Hungary (Karácsonyi 1987). Among them stands the glacial relict *Spiraea salicifolia* which is found only in the Carpathian Mountains at high altitudes, but here is of uncertain origin. Another low station for *Spiraea salicifolia* that I found was near Livada in Oaş, recorded also by Carol Karácsonyi (Karácsonyi 1995). The number of low-altitude mountain species, reported from the area of Scărişoara Nouă is astounding: *Menyanthes trifoliata, Epilobium roseum, Galium boreale, Carex appropinquata* and *Calamagrostis stricta* [the last two plants are glacial relicts in Romania (Pop 1976, Karácsonyi 1987)], *Carex hartmanii, Carex rostrata, Carex viridula, Calamagrostis canescens* etc. (Ardelean & Karácsonyi 2005). Numerous other relict species are found in this plain: peat moss (*Sphagnum* spp.), *Trollius europaeus, Alnus incana, Eriophorum angustifolium, Eriophorum latifolium, Equisetum fluviatile* etc., some of them forming mountainous plant associations in the lowlands such as: *Carici-Calamagrostetum neglectae* Soó (1938) 1971, unique in the country, *Carici-Menyanthetum* Soó (1938) 1955, *Salici cinereae-Sphagnetum recurvi* (Zólyomi 1931) Soó 1954, *Calamagrostio-Salicetum cinereae* Soó et Zólyomi 1955 etc. (Karácsonyi 1987). This suggests that in the area are swamps which still preserve the archaic and relict vegetation of the northwestern part of Romania, and indeed the vegetation is less impacted by human activities than in other parts of Nir (Carei) Plain. Therefore, further research studies are required within the area, both from botanical and zoological points of view, and stricter protection by the authorities to prevent further damage like the wildfires that took place in spring 2012.

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