BABEŞ-BOLYAI UNIVERSITY
FACULTY OF ENVIRONMENTAL SCIENCE

PhD THESIS
(Summary)

THE INTERRELATION BETWEEN THE GEOLOGICAL SUBSTRATUM AND THE POPULATIONS OF SOME RARE HALOPHYTIC SPECIES FROM THE TRANSYLVANIAN BASIN

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CHAPTER I - HALOPHYTIC GEOLOGICAL ENVIRONMENTS FROM THE TRANSYLVANIAN BASIN

1.1. HALOPHYTIC GEOLOGICAL ENVIRONMENTS FROM THE EVOLUTIONARY AND STRUCTURAL POINT OF VIEW

1.1.1. Evolution of Central Paratethys during Badenian

During its maximum extension (approximately 55° longitude and 20° latitude), Paratethys province stretched from the molasse zone and Rhone basin to the Aral Lake (KOCH, 2007). The development of various ecosystems during the Neogene, as a result of changes in sea level in Paratethys, has caused the subdivision of this into three paleogeographic and geotectonic provinces: *Western Paratethys*, *Central Paratethys* and *Eastern Paratethys*. The Central Paratethys stretched between Bavaria to the west and Carpathians to the north and east (this area included a system of Neogene basins – the Pannonic Basin, the Vienna Basin, the Zala Basin, the Drava Basin, the Sava Basin, the Danube Basin, the Transcarpathian Basin and the Transylvanian Basin) (HARZHAUSER ET PILLER, 2007).

The birth of the Paratethys began in Eocene / Oligocene limit, its evolution being strongly influenced by the lifting of the Alpine mountain chain, which acted as a geographical barrier, isolating it from the Mediterranean area (HARZHAUSER ET PILLER, 2007). At that time, Europe looked like an archipelago formed by the Alps, Dinaride, Helenide, Pontide and Anatolian Mountains (STEININGER ET WESSELY, 2000).

During the Paleo- and Meso-Oligocene, the first isolation of the Paratethys realm occurred (BÁLDI, 1989; RÖGL, 1999a, 1999b; HARZHAUSER ET PILLER, 2007).

During the upper Oligocene, a connection between Paratethys and Indo-Pacific Ocean has been established, having, as consequence, the invasion of tropical-subtropical fauna consisting of mollusks, echinoids and foraminifers. This connection was maintained, with small interruptions, until the beginning of Ottnangian (FILIPESCU, 1996)

During the upper Ottnangian, the conections with western Mediterana sealed. This regressive phase ended the first Miocene marine cycle of Paratethys. Instead, during the end of Eggenburgian / the beginning of Ottnangian, a connection between Eurasia and Africa has appeared - the *Gomphotherium* landbridge - through which some species of mammals migrated (RÖGL, 1999a).

The lower Badenian was marked by a major transgression of the Indo-Pacific region, which affected the Mediterranean realm and the entire Paratethys (RÖGL, 1999a). In the Central Paratathys, this transgression is associated with a rise of sea level at the beginning of the Miocene. A northward migration of a variety of biota, such as *Globigerinoides* or *Globorotalia*, took place, favoured by a general warming trend of the climate and by the establishment of a new connection with the Mediterranean realm (PILLER ET AL., 2007).

The middle Miocene is characterized by the wielician salinity crisis, that determined the formation of evaporite deposits (hundreds of meters thick) in the Red Sea, Middle East and Carpathian region. The sedimentation of evaporites in the Carpathian region was caused by the uplift of the Carpathians, that led to the isolation of the Carpathian foredeep, the East Slovak Basin, the Transcarpathian Basin and the Transylvanian Basin (PERYT, 2006). The only region that maintained a connection with the Mediterranean area through the Slovenian corridor was the Pannonian Basin (PERYT, 2006; PILLER ET AL., 2007). Instead, marine sedimentation continued in the central and western basins of the Central Paratethys (RÖGL ET AL., 1978).

The seal of the connections with the Mediterranean realm during the upper Badenian (Kossovian), caused by the northward movement of Dinarides, was followed by the establishment of new connections with the Persian Gulf area (KOVÁČOVÁ, 2008). After this spectacular cycle, the total isolation of the Paratethys took place (FILIPESCU, 1996).

1.1.2. Biostratigraphy of the Badenian in the Central Paratethys

The biostratigraphy on the basis of foraminifera associations shows that the lower Badenian (Moravian) is marked by a great development of *Praeorbulina* and *Orbulina* species, which belongs to lower and upper Lagenide Zones. The Wielician belongs to Sandschal Zone or *Spiroplectammina carinata* Zone. The Kossovian belongs to *Bulimina – Bolivina* Zone (KRÉZSEK ET FILIPESCU, 2005). The end of the Badenian – beginning of the Sarmatian is characterized by a great development of endemic Sarmatian fauna, such as the first occurrence of the *Anomalinoides dividens* species (Filipescu, 2004a).

The calcareous nannoplankton associations of Moravian and lower Wielician age belong to *Sphenolithus heteromorphus* zone (NN5). The Wielician and the Kossovian belong to the *Discoaster exilis* zone (NN6) (MĂRUNȚEANU ET AL., 2000; CHIRA, 2002; KOVÁČ ET AL., 2007).

1.1.3. The Evolution of the Transylvanian Basin during Badenian

The Transylvanian Basin was formed in the upper Cretaceous (Maastrichtian) by the occurrence of a depression that suffered a continous subsidence (VANCEA, 1929; CIUPAGEA ET AL., 1970; SĂNDULESCU ET VISARION, 1978). At the beginning of Badenian, the heaving of the Carpathians was reduced (PETRESCU ET AL., 1990). In Wielician, the Apuseni and the Southern Carpathians isolated the Transylvanian Basin from the Pannonian Basin, which explain the total absence, during this period, of evaporite deposits from the Pannonian Basin (PERYT, 2006; PILLER ET al, 2007; IONESCU ET AL., 2008). Thus, the tectonic events from the Carpathian domain isolated the Transylvanian Basin in Wielician, which caused the sedimentation of salt and gypsum deposits (FILIPESCU, 2001c). Beside the uplift of the Carpathians, another major factor that influenced the subsequent development of the Transylvanian Basin is the salt tectonics (KRÉZSEK ET BALLY, 2006).

Opinions are divided regarding the formation of the salt deposits from the Transylvanian Basin: VOITEȘTI (1934), PAUCĂ (1967a; 1967b), DRAGOȘ (1969) and MÂRZA ET NIȚĂ (1985) were among the first authors to enunciate opinions regarding the salt sedimentation. GIVULESCU (1982) and then PETRESCU ET MESEȘAN (1993) referred mainly to the climatic conditions during salt sedimentation.

1.1.4. Stratigraphy and biostratigraphy of the Badenian in the Transylvanian Basin

The first early badenian sedimentary units have been included in the Câmpie Group (FILIPESCU, 2001b)

CÂMPIE GROUP (KOCH, 1884) is situated between Hida Formation and Feleac Formation.

Dej Formation (Popescu, 1970) (Lower Badenian/Langhian)

Dej Formation (= Dej Tuff Complex, POPESCU, 1970) is the first term of the badenian suite from the Transylvanian Basin, being located between the conglomerates from the terminal side of Hida Formation and the formation with salt and gypsum (FILIPESCU, 2001b).

It consists of conglomerates or gravels (upper limit of Hida Formation) (FILIPESCU, 1996), tufites and tuffs with intercalations of clays and silty clays, limestones and compact marls in the upper sequence (POPESCU ET AL., 1995). The lower part of the formation was separated as a Member of Ciceu - Giurgeşti (POPESCU, 1970). The literature also mentioned the Conglomerates of Tălmaciu and the Formation of Perşani (GHEORGHIAN 1975) as corresponding to the Member of Ciceu - Giurgeşti in the south and in the south-east of the basin.

The plankton associations correspond to the M5a foraminiferal zone, with *Candorbulina glomerosa, Candorbulina transitoria, Globoquadrina dehiscens, Globoquadrina praealtispira,* and *Globigerinoides sicanus* (FILIPESCU, 1996; 2001b).

The calcareous nannoplankton associations are very rich in lower Badenian deposits these belonging to the NN5 zone with *Sphenolithus heteromorphus* of Moravian age (Chira, 1999, 2001; Mărunțeanu et al., 2000). NN5 zone was placed between the last occurrence of *Helicosphera amliaperta* species and last occurrence of *Sphenolithus heteromorphus* and / or first occurrence of *Discoaster exilis* (MĂRUNȚEANU ET AL., 2000; CHIRA ET AL. 2000b; CHIRA ET DRAGHICI, 2002).

An important feature of the Dej Formation is the appearance on the western edge of the basin, between Arieş and Ampoi valleys, of a marginal facies with limestones with algal-bioclastice (BUCUR ET FILIPESCU, 1994). They were separated by FILIPESCU ET GÎRBACEA (1994) as the Formation of Gârbova de Sus equivalent to the top of the Dej Formation.

b. **MIREŞ SUBGROUP** (POPESCU, 1972) (middle Badenian – upper Badenian / upper Langhian – lower Serravallian)

This unit is over the Dej Formation and consists of chemically precipitated deposits (salt and gypsum), the ”schists with radiolarians” and the “marls with Spirialis” (FILIPESCU, 2001b).

Ocna Dejului Formation (MESZAROS, 1991)

Includes the salt deposits (Wielician) located on the top of Dej Formation.

The decrease of sea level, due to restrictions of movement within the basin, lead to the sedimentation of thick salt deposits in deeper environments from the central and eastern side of the basin (KREZSEK ET FILIPESCU, 2005) and, at the same level with Ocna Dej Formation, marginal gypsum deposits (Sabkha type) described as the Cheia Formation (FILIPESCU, 1996), which outcrop in the western side of the basin (at Podeni, Lopadea and Cheia) (GHERGARI ET AL., 1991; FILIPESCU, 2001a).

The foraminiferal associations within the Ocna Dejului Formation only indicate that the chemical precipitation phase took place in the interval between the associations with *Pseudotriplasia ex. gr. minuta – Uvigerina asperula – Globigerina druryi* and the ones with that with *Pavonitina styriaca – Globigerina grili – Velapertina* (FILIPESCU, 1996).

Wielicianul is defined as the period that began with the first occurrence of *Discoaster brouweri* or of *Helicosphaera wallichii* in the subzone NN5b and the beginning of NN6 (NN6a) zone (MĂRUNȚEANU ET AL., 2000; CHIRA, 2001).

Pietroasa Formation (FILIPESCU, 1996)

The interval, to which this formation – located on the top of the chemically precipitated deposits - belongs, contains the “Schists with radiolarians” and the “Marls with *Limacina* (=Spirialis)” (Kosovian). At north of Arieş Valley, as the equivalent of this formation, **Câmpia Turzii** Formation was defined (MESZAROS ET CHIRA, 1996).

The “Schists with radiolarians” represent the unit located right on the top of the chemically precipitated deposits and consists of clay marls containing numerous siliceous fossil (POPESCU ET MARINESCU, 1978) and calcareous plankton (foraminifers and phytoplankton) (FILIPESCU, 2001b).

The calcareous nannoplankton associations belong to the NN6b zone of late Badenian (Kosovian), its superior limit being marked by the extinction of *Cyclicargolithus floridanus* species (MĂRUNȚEANU ET AL., 2000; CHIRA, 1999).

Both at the top of both of "shales with radiolarians" and of "marls with *Limacina*" a marker interlayer of tuffite occurs. The Borşa – Apahida Tuff is considered a marker between the lithostratigraphical units of Badenian and of Sarmatian (CIUPAGEA ET AL., 1970; FILIPESCU, 1996).

1.1.5. Geological structure of the Transylvanian halophilic environments

Several hypothesis, regarding the emergence and formation mechanisms of salt massifs, have been issued.

The most accepted hypothesis regarding the presence of salt massifs is the tectonic one, issued by MRAZEC (1907). According to this hypothesis, the folding was not caused by salt, but by the tangential centripetal forces from Pliocene, after the folding phase of the Carpathians. After Mrazec's definition (1927), diapiric folds are anticline structure with a core (kernel) of plastic rocks, which pierce the roof formations. Diapirism (phenomenon revealed for the first time in the world by the same author) is a specific phenomenon for the crust and surface coatings, in particular the areas surrounding and accompanying the cute young mountain systems. This is the breakthrough by a fine of deep rock (salt or gypsum) to cover the toughest rocks (ANASTASIU ET AL., 1998). Diapire crease formation is due, on the one hand, plasticity of salt, which is increasing as pressure and temperature increase deposits from the roof and on the other hand, tangential forces. Under their influence, as originally filed leaves salt and drain stratiformă the areas of minimum resistance anticlinalelor vaults, where they form large lumps (PENE ET STANESCU, 2003). However, another step in increasing the action of tangential forces, are compressed and expelled to the surface. In the last phase of development diapire wrinkles, leaving the salt and low pressure days, pours a viscous mass that covers the top of the deposit pierced (MRAZEC, 1927).

MRAZEC ET JEKELIUS (1927) divided the Transylvanian Basin into three areas, corresponding to the structural forms determined by salt tectonics:

– the external area, of the layers with slight inclination towards the interior of the basin; - the area immediately inland, heavily wrinkled wrinkles diapire with massif jumps to the day;
– the inner area of the basin, folded into domes and anticlines.

The process of salt migration from the center to the periphery (where the blanket was thin and fault), due to the lithostatic pressure and to the plasticity of the salt, resulted in myo-Pliocene deposits vaulting roof, resulting in the formation and brahianticlinale2 domuri1 (CIUPAGEA ET AL ., 1967, 1970; PENE ET STANESCU, 2003). These domes were the control factors: Badenian relief items, and some cargo litostatică tipping trends occurring in swimming. Towards the basin margins, vaulting ever smaller in size and inclination increased, reaching as eastern and western edges of the massif salt formations to break cover and come to the surface (FALK, 2007). The domes and marginal folds have affected than the upper deposits of salt formation.

Deformation of the roof configuration with salt deposits was due to their departure to the deeper basin, salt being a software layer that favored slip (SANDULESCU, 1984). Slip took place under the influence of gravitational forces, is triggered by isostatic imbalances following the lifting of the Eastern Carpathians and putting in place vulcanitelor Neogene, and because of the resulting heat flux instead of volcanic chain in eastern basin, which plasticity increased salt and reduced the limits of strategic cohesion, thus favoring the onset of the phenomenon (BALLY ET KRÉZSEK, 2006).

1.2. HALOPHYTIC GEOLOGICAL ENVIRONMENTS FROM THE ECOLOGICAL POINT OF VIEW

1.2.1. Halomorphic soils

Origin and accumulation of salts in soils

Salinisation is the process that leads to an excessive increase of soluble salts, both in soil and in soil solution. Accumulated salts are represented, mainly, by sodium, potassium, magnesium and calcium, chlorides, sulfates, carbonates and bicarbonates.

The processes of salt accumulation in soil have two major pedogeographic characteristics, namely:

- their occurrence in arid and semi-arid areas, with defective drainage, where potential evapotranspiration exceeds the real one and where the upward current of water which carries the salts dominates the downward current;
- their distribution on the lowland and accumulative relief forms, where the groundwater is near the surface (MĂIANU, 1964).

CHAPTER II - THE DESCRIPTION OF THE RARE HALOPHYLE SPECIES STUDIED

2.1. *PLANTAGO SCHWARZENBERGIANA* SCHUR.

Plantago schwarzenbergiana is an endemic species to alkaline steppes in the eastern half of the Carpathian Basin, with highly biogeographical importance (GÖRI, 2008), and is present only in Hungary (FARKAS, 1999), Romania, Serbia (KNEŽEVIĆ ET AL., 2009) and southern Ukraine (KAWADA ET AL. 2005, CHENG ET NAKAMURA, 2006). The species is mentioned in the "Red list of threatened plants and animals of Croatia" (2004), but we could not found any quotation about the location where the species occur in this country. *Plantago schwarzenbergiana* was first described as a species from Baile Sarate Turda (Turda Salt Spa) by F. SCHUR, in 1853, in his study "*Truppenweise bei Thorda an den Salzlachen den 11 Juli 1853 in Bluthe und Frucht beobachtet*", and therefore this location is "locus clasicus" of the species. In the Transylvanian Basin, *P. schwarzenbergiana* has been reported in 1886 by SIMONKAI , at Turda, Ocna Dej, and between Dej and Gherla localities. Its presence was confirmed in 1948, by TODOR, at Baile Sarate and at Valea Sarata Turda, and by POP ET AL. (1983) at Ocna Dej. The Flora of Romania (PAUCĂ ET NYARÁDY, 1961, CIOCÂRLAN, 2000) quoted the species in the following locations: Turda, Ocna Mures and Ocna Dej.

2.2. *PLANTAGO MAXIMA* JUSS.

This is a species with Pontic-Pannonian-Southwest Siberian range of distribution (SCHNEIDER-BINDER, 1978). The main area of the species circumscribe the steppe and forest steppe regions of Eastern Europe and Western Siberia, spreading into the European part of Russia (SCHNEIDER-BINDER, 1980). In Europe, the species was cited in Hungary (FARKAS, 1999; VIDÉKI ET MÁTÉ, 2003), in Bulgaria (TZONEV ET KARAKIEV, 2007) and in Romania, here in Ruşciorului and Strâmb meadows (Sibiu Depression) (SCHNEIDER-BINDER, 1980). It prefers marshy meadows, slightly saline.

2.3. *PLANTAGO CORNUTI* GOUAN.

This is a species of Ponto-Mediterranean distribution. The range of species in Europe is quite extensive, and it includes Georgia, Russia, Romania, Moldova, Bulgaria, all countries of former Yugoslavia, Italy, France and Spain (BALL, 1976). In the Transylvanias Basin, it has been quoted at: Someşeni, near Gherla, Valea Florilor, Boju, Berchieşu (Frata, Cluj), Cunţa (Şpring, Alba), Turda, Tiur, Ocna Sibiului (SIMONKAI, 1886). PRODAN (1931) has cited the species from Apahida, reconfirming its presence in 1948, when he reported the species at Someşeni (near aerodrome) and at Dej (near the train station). In 1948, TODOR confirmed the presence of species at Valea Florilor and at Valea Caldă and Băile Sărate Turda. CSÜRÖS - KAPTALAN (1965) found the species in the slightly saline meadows from Aitonului Valley. POP ET HODIŞAN (1980) cited *Plantago cornuti* among the halophytes considered rare at the solochaks from Băile Cojocna. It prefers slightly saline wetlands (PRODAN, 1922b).

2.4. *PEUCEDANUM LATIFOLIUM* (BIEB.) DC.

The distribution range of the species is Central and South-Eastern Europe (TUTIN, 1968); in Italy and in Slovenia it is considered to be a relict species (BOJŇANSKÝ ET FARGAŠOVÁ, 2007). In the Transylvanias Basin, the species was cited as being present in the wet and saline valleys surrounding Cluj, such as: Băile Someşeni, Apahida, Valea Florilor, Sic and Gherla (SIMONKAI, 1886). IULIU PRODAN (1931) has cited the species from Apahida salt meadows. In 1948, the same author confirmed its presence in the meadows located between the right side of Someşul Mic river and the road to Apahida, and also in the meadows from Someşeni (near the "aerodrome") and at Dej, near the train station. CSÜRÖS ŞT. (1947) reported the species from Dezmir train station and from Puşului Hill. TODOR (1958) reported the presence of the species at Dej, Someşeni, Dezmir, Apahida, Sînmiclăuş, Valea Florilor and between Gherla and Sic localities. The species usually prefers slightly saline but wet hayfileds (PRODAN, 1922b), groves, briers or meadows (ŢOPA, 1954).

2.5. *PEUCEDANUM OFFICINALE* L.

The distribution range of the species includes Southern and Central Europe, reaching through the north-western part of the continent, in England (TUTIN, 1968). It is not considered a rare species in Europe, but it is quite rare in Romania and extremely rare in the Transylvanian Basin; here, the scientific literature mentions only two locations - Berind and Cara (Büdőstó) (NYARADY, 1939). Sporadically it occurs in dry hayfields, sunny coasts, meadows (TODOR, 1958).

CHAPTER III – METHODOLOGY

Using scientific literature and datas available, we did the geological characterization of each studied area. The geological maps were digitized using Global Mapper software package v. 11.

3.1. Chemical and physical analysis of soils

To characterize the chemical and physical composition of the soils from the studied sites, we did structural analysis by X-ray diffraction (DRX) and electrochemical analysis.

3.2. Flora and vegetation analysis

For mapping populations, we've used a portable GPS unit Gramin GPSMAP 60. Species distribution maps have been done using ArcGIS v. 9.2 software package. Flora analysis has been performed after CIOCÂRLAN (2000) and POPESCU ET SANDA (1998), from several points of view: environmental, phytogeographic and biologically.

Vegetation survey was based on the principles of the Central European phytocenological school (Braun-Blanquet). We collected a total of 38 relevees, the surface of samples ranging from 15 m^2 to 40 m^2. The coenotical analysis was peformed after SANDA ET AL. (1998) and OBERDORFER (2004). For statistical analysis of phytocenological data, we used PAST v. 0.93 software package (PAlaeontological STatistics) (HAMMER ET AL., 2005). Thus, we performed ordination and cluster analysis.

CHAPTER IV - RESULTS AND DISCUSSIONS

4.1. GEOLOGICAL CHARACTERIZATION OF THE STUDIED AREAS

In terms of tectonic, the regions studied (except Sesul Sibiului) belong to the western area of the Transylvanian Basin, area characterized by the presence of salt domes diapirs, diapirs associated with quasi-linear folds, located in relay (RAILEANU ET AL., 1968) .

4.1.1. Turda – Valea Florilor Region

Turda region is stretching from north of Aries Valley to the junction between Somes Valley and Aries Valley (ILIE, 1952b).

Valea Sărată anticline is outlined by a constant level of dacite tuff and by the salt massif from the axis. It has almost the appearance of a lens, oriented NNE-SSW, ending in sharp points on both sides, covered by gypsum deposits (MAXIM, 1936) (Fig. 4.1.1). Here, salt breaks to the surface a strong complex of compact purple marls (that become gypseous mainly at the southernmost end of the massif), marls that pass up to sandy marls and yellowish clays and in which two intercalations of dacite tuff appear (Voitești, 1934). The upper deposits, which at depth are almost vertical, turn upside down to the top, mainly on the northwestern flank of this anticline (FILIPESCU, 1994). Diapir penetration, almost to the surface of the massif, took place during lower Post-Sarmatian (MAXIM, 1936). Neogene deposits, which occur at the surface in Turda Salt Valley perimeter, are Badenian and lower Sarmatian in age. Badenian evolves along the anticline (the center of which salt appears to the surface), while on its flanks newer Badenian deposits and Sarmatian deposits occur (MÉSZÁROS ET AL., 1989).

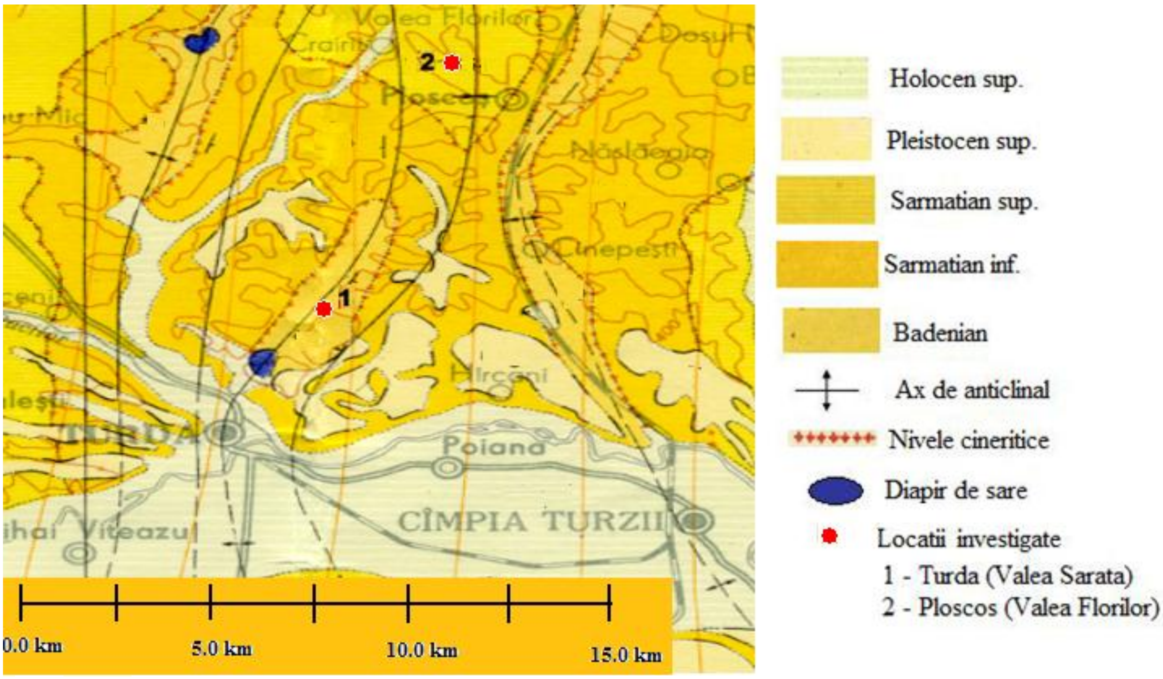

Fig. 4.1.1. *Location and geological context of the Turda - Valley of Flowers Region* (amended after GIUŞCĂ ET AL., 1967, 1:200000 map, sheet Turda)

Ploscos salt meadow is located between Crairât and Ploscoş, at about 1.2 km east of the axis of Ocnele Turzii anticline. The area is characterized by the presence of upper Sarmatian deposits, consisting of marls, sandy marls and sands (GIUŞCĂ ET AL., 1967).

4.1.2. Gherla Region

In terms of tectonics, three anticlines have been highlighted in this region, oriented from west to est: Ocna Dej brachianticline, 3 km in length and NE-SW orientation, that presents a flattening trend in depth - as shown by the salt massif from Ocna Dej, who has preserved its original position and has the form of a a horizontal lens (IORGULESCU ET AL., 1962); Bunesti – Valea Florilor anticline, 50 km in length and NS orientation and on the east of this the Nireşti - Petresti anticline with NNE-SSW orientation. The most important of these anticlines is Bunesti – Valea Florilor anticline, which to the south of Somes river overflows westwards (the western flank tilt up with inclinations of up to 50° compared with the eastern slopes of up to 30°) until Cojocna region. This fold is crossed by three salt cores at Sic, Cojocna and Valea Florilor, where diapiric salt domes arise (RAILEANU ET AL., 1968).
Neogene deposits that emerge in Bunesti region are Badenian, Sarmatian and Quaternary in age. Badenian develop on quite large surfaces and is represented by marly clays with sandstones and gypsum lenses. Sarmatian outcrop in the western side of Bunesti region and it consists of marly clays. Quaternary is represented by gravels and sands developed on Someş Valley and are upper Pleistocene and Holocene in age (Fig. 4.1.2). In the eastern part of this salt meadow, a salt spring emerges from under the road bed and supplies the salt meadow.
Salt massif from Hăşdate, with SW-NE direction, is located in the basin of Hăşdate brook (near Gherla), an affluent of Nicula - Săcălaia valley, which flows into the Valea Mare (Fizeş) that flows into Somesul Mic (MAXIM, 1961). This depression, located entirely on the salt massif surface, began to form during the medium Pleistocene (MAXIM, 1962).

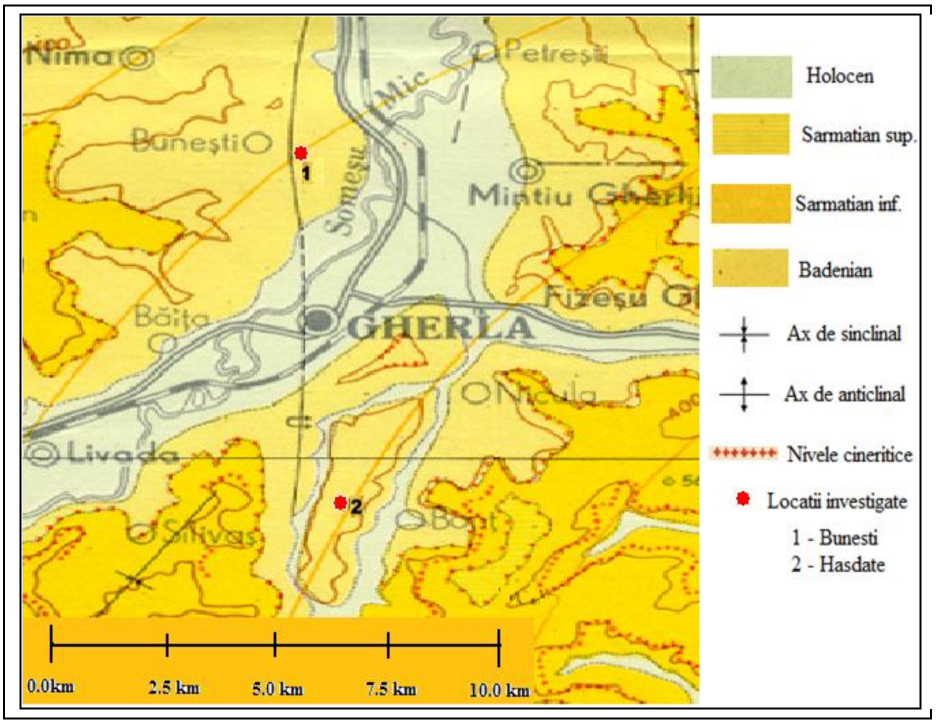

Fig. 4.1.2. *Location and geological context of the Gherla region* (amended RAILEANU ET AL., 1968, Geological Map 1:200.000, sheet Cluj)

In terms of lithological composition, the area is characterized by Badenian rocks with marly clay rocks (which tilts at an angle greater than salt), present on the banks of the stream, and by recent river deposits composed of gravels and sands belonging to the Holocene, deposits located around the valley (Fig. 4.1.2). On the eastern slope of the valley we noticed the presence of a salty spring.

4.1.3. Cluj - Apahida - Cojocna Region

The geological composition of this region includes Paleogene epicontinental and Neogene molasse sedimentary deposits (RAILEANU ET AL., 1968).

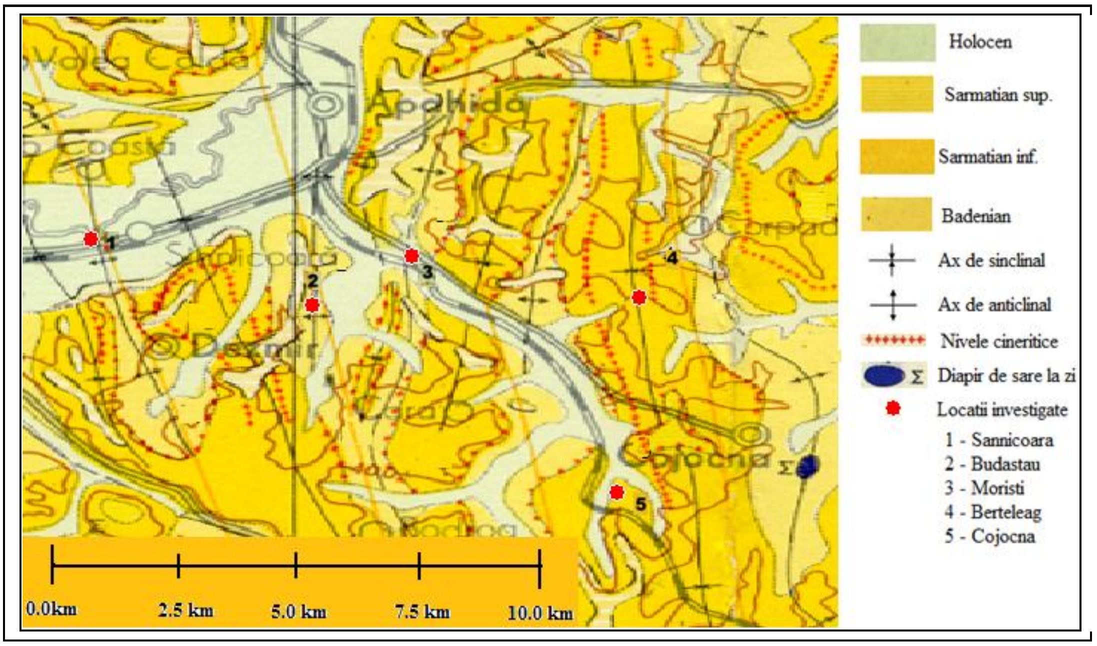

Fig. 4.1.3. *Location and geological context of the Cluj - Apahida - Cojocna region* (amended RAILEANU ET AL., 1968, 1:200000 map, sheet Cluj)

In this area, with N-S orientation, that is developing between Cojocna to the east and Someşeni to the west, a major fold has been highlighted – the Bunesti-Valea Florilor anticline, and also a series of tight folds (RĂILEANU, 1955b).

Sânnicoara salt meadow is located in the axis of Dezmir-Sânicoara anticline. The anticline can be traced south of the Dezmir village to the north of the Someş river. It has a NS orientation and it is composed of marls and sandy marls with intercalations of dacitic tuffs. The maximum inclinations of the flanks are up to 35° (RAILEANU, 1952). The area is characterized by the presence of Holocene river deposits with gravels and sands.

Budaştău salt meadows are developing on the axis of Fânețe - Apahida anticline. This anticline has a NS orientation and can be traced over a distance of 5 km. Its flanks are marked by three layers of dacitic tuffs with inverse inclinations of up to 40^0 (RAILEANU, 1955b). It consists of the same deposits as Dezmir-Sânicoara anticline (marls and sandy marls with intercalations of dacitic tuffs). In the axis it presents strong saline occurences, highlighted by the salt springs from Fânețe Valley (RAILEANU, 1952, 1955a). Morişti salt meadows are developing on the axis of Tău anticline.

Berteleag Valley is developing on the axis of Cojocna syncline, bounded by Bunesti-Valea Florilor fold to the east and by Zem anticline to the west (RAILEANU, 1955b). This syncline is inclined to the west, and in its axis lower Sarmatian deposits made of marls and sands occur (RAILEANU ET AL., 1968). Salt meadow from southwest of Cojocna is located on the west side of Cojocna syncline, the area being characterized, beside the marls and sands deposits of lower Sarmatian age, by the presence of gravel and sand deposits of Holocene age (Fig. 4.1.3). In the western part of the salt meadow we noticed the presence of a salt spring, which rise from under the Cojocna - Cluj-Teiuş railway embankment.

4.1.4. Sibiu region

The area is included in plain type relief with terraces and meadows, developed on quaternary deposits. Sibiu Depression was formed in the upper Cretaceous, as a drowning area that has emphasised during Paleogene and Neogene (ALEXANDRU, 1962). Its fundament exhibited as a synclinal fold with continuous downward movement (ILIE, 1955). The structure of this region is relatively simple. Although the depression is considered to be tectonics, it is mainly characterized by the development of quaternary deposits and by the absence of tectonic deformation. (ILIE ET STOENESCU, 1955). The quaternary deposits cover most of the ancient Badenian and Pontian formations (ILIE, 1955).

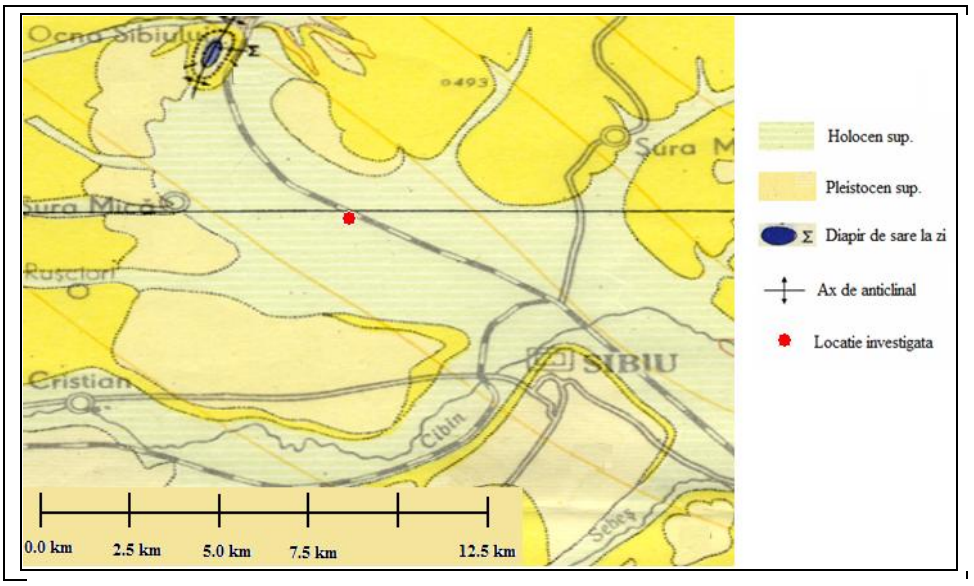

Fig. 4.1.4. *Location and geological context of Sibiu region* (modified after Codarcea et al., 1968, Geological Map 1:200.000, sheet Sibiu)

Quaternary is represented by the upper Pleistocene, consisiting of gravel and sandy clay deposits, which distinguishes between Turnişor and Cristian and also between Ruşcior and Şura Mică, and upper Holocene, that forms alluvial deposits consisting of gravels and clays accumulations (Fig. 4.1 4).

4.2. PHYSICO-CHEMICAL ANALYSIS OF SOILS

4.2.1. Structural analysis by X-ray diffraction

To identify and to determine the balance of structural phases within the composition of each sample, it has been chosen an interval analysis 2θ between 5 and 70 °, a step of 0.03 ° and acquisition time of 2 seconds for each step. The scientific support used for analysis was the existing database from the software provided by the manufacturer of the diffractometer. Percentage analysis was performed by normalizing the diffraction intensities for each phase.

We collected the samples both from the soil surface and from a depth of 20 cm. Due to the climate factors (heavy rainfall in the period of time before we've collected the samples), we used for analysis the samples collected at a depth of 20 cm. This reasoning was confirmed by the X-ray diffraction analysis on two samples taken from the same area but at different depths. As we may see in the following figure (Fig. 4.2.1), the sample taken at 20 cm in depth has a diffraction peak unnoticeable in the diffractogram corresponding to the sample taken from the surface.

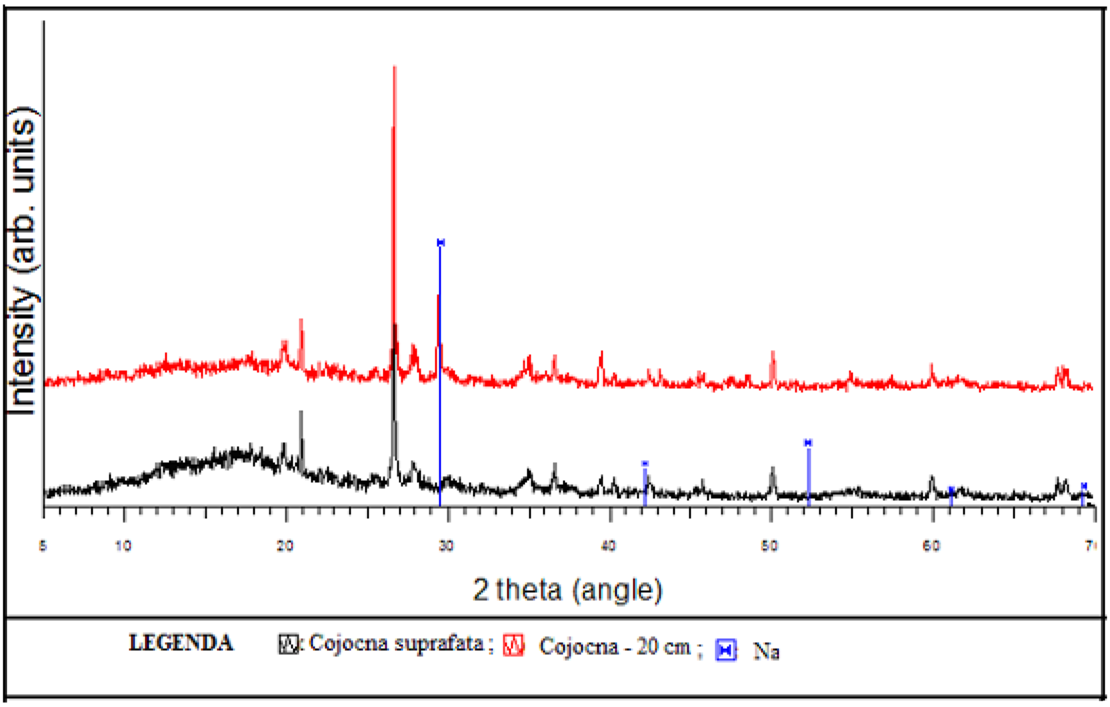

Fig. 4.2.1. *Diffraction spectra of the soil samples from Cojocna (sample 2), from soil surface and from 20 cm in depth*

Next we'll present the structural analysis of the 18 soil samples. Figure 4.2.3 shows the diffraction diffractograms corresponding to the samples collected from a depth of 20 cm. As it may seen, there are no significant differences between the diffraction peaks of the 18 soil samples collected from the 10 studied locations(Budaştău, Cojocna, Sânicoara, Valea Sărata - Turda, Valea Sărată Turda - SW, Buneşti, Morişti, Berteleag, Ploscoş, Hăşdate). When the location studied occupies a larger area (as it is for Budaştău, Cojocna, Hăşdate and Ploscoş), we collected several soil samples in order to see if there are significant differences between them. For the same reason we collected several soil samples in locations where several soil types occur (such as Valea Sărată Turda, where we have an alternation of erodosoils and solonchaks).

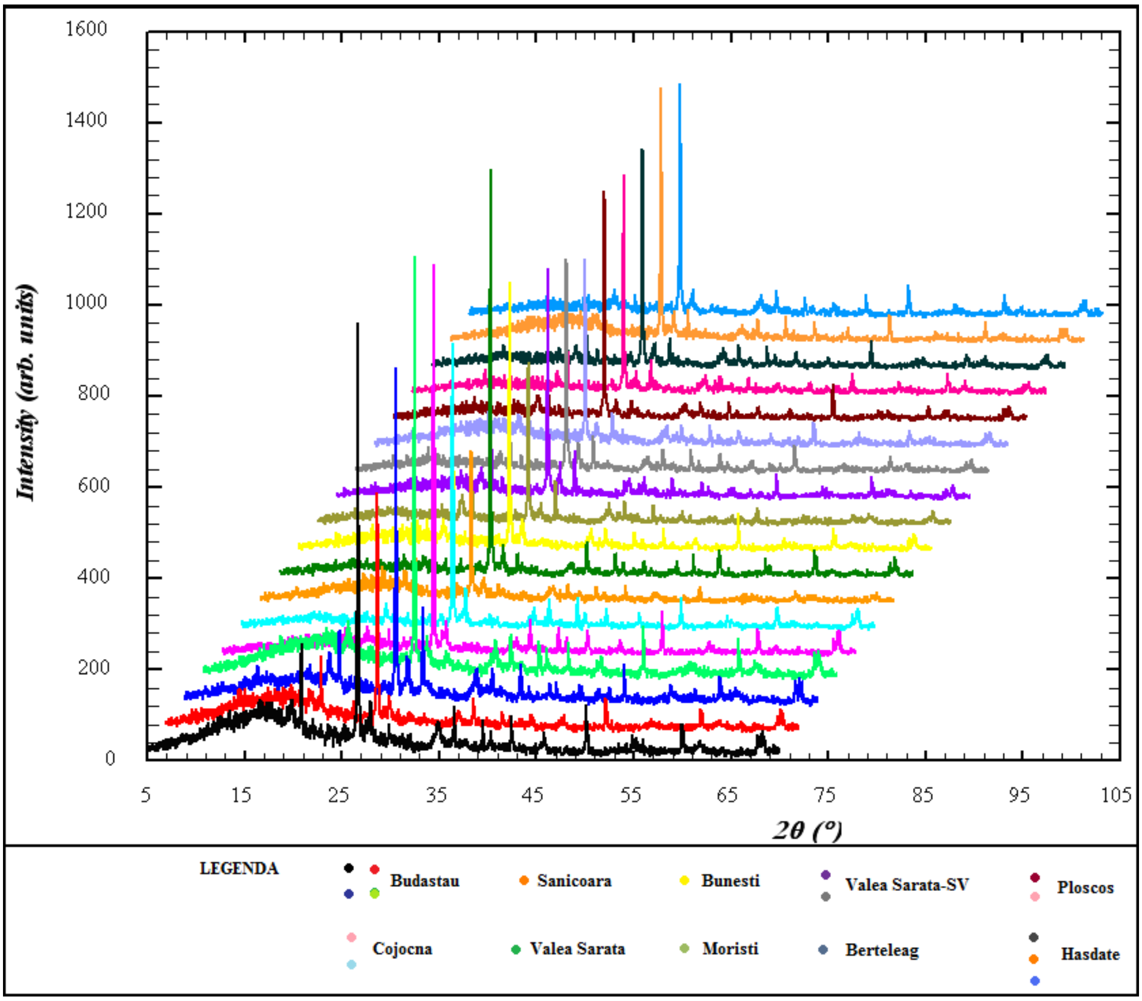

Fig. 4.2.3. *Diffraction diffractograms of the soil samples from a depth of 20 cm*

Analyzing each sample, we were able to give, within experimental errors (there are, samplebly, other combinations of elements, only that they don't form a detectable structure), the percentages of each of the constituent phases of the analyzed sample.

The percentage values, corresponding to each phase of the soil samples, are presented in Table. 4.2.1. We noticed that in all samples silicon oxide (quartz) is the predominant phase, with a weight between 69% - 84%. Majority ions in these samples are represented by Ca2 +, Mg 2 +, Cl- and to a lesser extent by Na +. We also noticed the presence, in all soil samples except two (soil samples no. 2 and 3 from Budaştău) of NaCl in one form or another.

Tabel. 4.2.1. *Ponderile de faze structurale (exprimate în procente) din probele de sol analizate*

Nr. crt.	Location	Soil type	K (%)	Na (%)	Ca (%)	Mg (%)	NaCl (%)	KCl (%)	$MgCl_2$ (%)	SiO_2 (%)	$CaCl_2$ (%)	NaCl (rare form) (%)
1	Hăşdate sample 1	Eutricambosoils	-	-	5	5	-	3	4	76	4	3
2	Hăşdate sample 2	Eutricambosoils	-	-	6	5	-	-	3	78	6	2
3	Hăşdate sample 3	Eutricambosoils	-	-	5	5	-	4	4	75	5	2
4	Buneşti	Preluvosol	-	-	8	6	-	-	4	74	5	3
5	Sânicoara	Gleyic	-	-	6	5	2	-	4	71	8	4
6	Budaştău sample 1	Cambic Chernozem	-	-	3	6	2	-	3	83	3	-
7	Budaştău sample 2	Cambic Chernozem	-	-	6	7	-	-	5	78	4	-
8	Budaştău sample3	Vertosol	-	-	6	8	-	4	5	74	3	-
9	Budaştău sample 4	Cambic Chernozem	2	-	8	7	-	3	4	69	4	3
10	Morişti	Solonchak	-	-	6	6	2	-	5	69	12	-
11	Berteleag	Cambic Chernozem	2	-	4	4	2	-	4	74	8	2
12	Cojocna sample 1	Cambic Chernozem	-	-	4	5	2	-	2	84	3	-
13	Cojocna sample 2	Cambic Chernozem	-	2	4	5	2	4	5	72	6	-
14	Valea Sărată	Erodosol	-	-	5	6	-	-	3	78	4	4
15	V.Sărată-SV sample 1	Erodosoil	-	-	7	5	2	-	4	72	10	-
16	V.Sărată-SV sample 2	Solonchak	2	-	6	5	2	-	3	69	10	3
17	Ploscoş sample 1	Cambic Chernozem	-	2	4	4	3	-	4	76	5	2
18	Ploscoş sample 2	Cambic Chernozem	-	-	5	4	-	3	3	76	6	3

4.2.2. Electrochemical Analysis

Changes in pH, conductivity and salinity for the soil samples are presented in Table 4.2.2.
The pH of soil is slightly basic, with values ranging from 7,34 to 9,83. In all analyzed samples, regardless of the soil type, a more or less pronounced salinity (between 0,2 $^{0}/_{00}$ – 0,9$^{0}/_{00}$) is noticeable.

Tabel 4.2.2. pH variation, conductivity and salinity of the soil samples analyzed

Nr. crt.	Location	Soil type	pH	Conduct. (μS/cm)	Salinity ($^0/_{00}$)
1	Hăşdate (sample 1)	Eutricambosoils	8.05	1782	0.7
2	Hăşdate (sample2)	Eutricambosoils	9.15	1920	0.8
3	Hăşdate (sample 3)	Eutricambosoils	8.55	1900	0.8
4	Buneşti	Preluvosol	7.97	2090	0.9
5	Sânicoara	Gleyic	9.14	2110	0.7
6	Budaştău (sample 1)	Cambic Chernozem	9.12	1092	0.3
7	Budaştău (sample 2)	Cambic Chernozem	8.72	818	0.2
8	Budaştău (sample 3)	Vertosol	7.34	798	0.2
9	Budaştău (sample 4)	Cambic Chernozem	7.45	824	0.2
10	Morişti	Solonchak	8.19	1906	0.7
11	Berteleag	Cambic Chernozem	8.46	1249	0.4
12	Cojocna (sample 1)	Cambic Chernozem	8.58	980	0.3
13	Cojocna (sample 2)	Cambic Chernozem	8.08	1345	0.5
14	Valea Sărată	Erodosol	9.0	1722	0.7
15	V.Sărată- SV (sample 1)	Erodosoil	9.9	1315	0.5
16	V.Sărată- SV (sample 2)	Solonchak	9.83	1794	0.7
17	Ploscoş (sample 1)	Cambic Chernozem	8.07	1996	0.9
18	Ploscoş (sample 2)	Cambic Chernozem	8.25	1794	0.7

Locations with the highest degree of salinization are Buneşti, Ploscoş and Hăşdate. It is likely that the salinity values are even higher, since the samples were taken after a period of heavy rainfalls. It is known that soil salinity increases during periods of prolonged drought (salt concentration, as a result of water evaporation, is higher during the summer months), the process of accumulation of slightly soluble salts in the upper soil profiles being characteristic to a exudative fluid regime, when the upward current of water laden with salts prevail over the downward one.

4.3. TYPES OF HALOPHYTIC HABITATS WHERE THE STUDIED SPECIES OCCUR

In the Transylvanian Basin, the halophytic vegetation occupies insular habitats, more or less large, that are not climatically but geologically determined. Halophytic habitats are linked with the inversion relief developed on diapiric folds and also with the Badenian marls with salt.

The halophytic vegetation from the Transylvanian Basin is concentrated in the western part of the basin because here there are large areas affected by diapiric folds. In the central and southern part, the halophytic vegetation is much rare and atypical because, here, the soils with a high salt content are missing. In the northern and eastern part the halophytic vegetation is rare and occurs only in the perimeters where the Mireş Subgroup formation appears.
In our field work, done between 2006-2010, we found the four studied species (*Plantago maxima* has disappeared) in 15 different plant associations.

4.3.1. *Juncetum gerardii* (Warming 1906) Nordh. 1923 association

The phytocoenosis of the association inhabits wet places with moisture excess during vegetation season. The ecological conditions imprint a mesohygrophyte, mesothermic to moderately thermophilic, and low acid-neutrophilous to neutro-basophilous character. The vegetation core is made of species characteristic to *Puccinellio -Salicornietea* class, alongside participates species characteristic to *Chenopodietea, Plantaginetea majoris* and *Artemisietea* classes, which illustrate a certain degree of degradation of these habitats.

4.3.2. *Staticeto-Artemisietum monogynae (santonicum)* Țopa 1939 association

The association vegetates mainly on lands with a low salt content, often dry and compressed, where the water is abundant only during spring while later, during the summer months, the land becomes arid. The phytocoenosis composition imprint to coenotic complex a xeromesophyte and mesophilous, moderately thermophilic and mesothermic, low acid-neutrophilous to basophilous character. We noticed the presence of relatively large number of euryionic species. In addition to the representatives of *Puccinellio-Salicornietea* class, the presence with a fairly high percentage of species characteristic to *Festuco-Brometea* class justifies the inclusion of this association between those with xeromesophytic character.

4.3.3. *Scorzonero parviflorae – Juncetum gerardii* (Wenzl. 1933) Wendelbg. 1943 association

The wet and moderately saline meadows are dominated by these phytocoenosis and *Scorzonera parviflora* is a characteristic species for these grasslands. The association has a mesohygrophilous, mesothermic and low acid-neutrophilous to basophilous character. Euryionic species are quite well represented (25%).The presence of species characteristic to *Chenopodietea*, *Artemisietea*, *Plantaginetea* classes, and the relatively high percentage of therophytes denote a certain degree of degradation of these habitats.

4.3.4. *Caricetum distantis* Rapaics 1927 association

This association vegetate areas characterized by excessive moisture during the vegetation season. From the ecological point of view, the association has a mesohygrophilous, pronounced mesothermic and low acid-neutrophilous to basophilous character (BĂDĂRĂU ET ALEC-FARCAȘ, 2010).

4.3.5. *Artemisio-Festucetum pseudovinae* (Magyar1928) Soó (1933) 1945 association

The floristic composition of this association includes a core of characteristic halophytic species, with high constancy, such as: *Limonium gmelinii, Podospermum canum, Puccinellia limosa*, *Chamomilla recutita*. Species characteristic for *Festuco -Brometea* class are present too, such as: *Achillea collina, Aster linosyris, Galium verum*. The association has a xeromesophytic, micro-mesothermal and neutro-basophilous character.

4.3.6. *Peucedano-Asteretum punctati* (Rapaics 1927) I. Pop 1968 association

This association is less common in the Transylvanian Basin. It inhabits moderately wet and weakly saline places from regions with moderate continental climate. These phytocoenosis has great conservative value (DONIȚĂ, 2006). The spectrum of ecological indices analysis shows the xeromesophytic, mesothermic to moderately thermophilic and low acid-neutrophilous nature of the association.

4.3.7. *Potentillo arenariae-Festucetum pseudovinae* Soó (1939) 1950 association

This association vegetates on higher places, where the water covers the soil for a relatively short period of time, usually only during early spring. From a floristical point of view, it is characterized by the dominance of the continental species *Festuca pseudovina* and *Aster linosyris*, accompanied by a series of xeromesophytes and mesophytes. The core of this association is made by representatives of *Festuco-Brometea* class - which determines the xeromesophytic character, but in addition they are present some halophytic species (*Artemisia santonicum*, *Limonium gmelinii*, *Lotus tenuis*, *Plantago schwarzenbergiana*, *Puccinellia limosa*). The ecological indices analysis denotes the xeromesophytic, moderately thermophilic and low acid-neutrophilous character of this association.

4.3.8. *Festucetum sulcatae (=rupicolae) mezophilum* Csűrös et al. 1961 association

This steppe association is characterized by the dominance of *Festuca rupicola* and by the participation of xeromesophytes and mesophytes. The floristic composition of the association is quite rich in species, a total of 28 species being recorded. The presence of *Festuca rupicola, Cytisus albus, Eryngium planum* and other species illustrate the xeromesophytic character of the association. Due to intensive grazing, *Euphorbia cyparissias* achieve a higher dominance. Most of species are mesothermic (50%), low acid-neutrophilous (39.3%), alongside euryionic species are quite well represented (35,71%).

4.3.9. *Poëtum pratensis* Răv., Căzăc. Et Turenschi 1956 association

The association structure is quite heterogeneous, xeromesophytes, mesohygrophilous and mesophytes participating in an approximately equal percentage. On their needs to the thermic regime, the dominant species are the mesothermic ones. The core vegetation consists of species adapted to low acid-neutrophilous soils and euryionic species.

4.3.10. *Agrostidetum stoloniferae* (Ujvárosi 1941) Burduja et al. 1956 association

The association populates flat terrains with moist-wet soils, where the groundwater level is near the surface. It consists mainly of mesohygrophilous species, alongside mesophytes have also a considerable proportion (35.71%). Regarding the temperature factor, mesothermic species are dominant (50%). Regarding the soil reaction values, euryionic species predominate (35.71%), but we also notice the presence of acid-neutrophilous and acidophilous (28.57%) species (BĂDĂRĂU ET ALEC-FARCAŞ, 2010).

4.3.11. *Festucetum pratensis* Soó 1938 association

The grasslands edified by *Festuca pratensis* occur on flat or gently sloped lands and include phytocoenosis that make the transition from mesohygrophilous to mesophilic. The association is composed of quite a few species (39), most of them mesophilic, but alongside several species that indicate moisture also appear, such as: *Lythrum salicaria*, *Plantago cornuti*, *Peucedanum latifolium*, *Poa trivialis*, *Ranunculus repens*, etc. The ecological indices analysis denotes the mesophilous to mesohigrophytic, mesothermic and low acid-neutrophilous nature of the association. In the composition of the association also appear the euryionic species in pretty high percentage (27%) (BĂDĂRĂU ET ALEC-FARCAŞ, 2010).

4.3.12. *Alopecuretum pratensis* Regel 1925 association

The coenosis of this association are widespread in our country, ranging from plains to hills. Usually it vegetates humic-gley soils with constant moisture and groundwater level near the soil surface. From ecological point of view, the indices values show the mesophilous to mesohigrophytic, micro-mesothermic to moderately thermophilic and low acid-neutrophilous to neutro-basophilous character of the association. Noteworthy is the high percentage of euryionic species (42.10%).

4.3.13. *Triglochineto maritimae - Asteretum pannonici* (Soó 1927) Ţopa 1939 association

The association vegetate the land with moderate salinity and excess of water, due to which vernal species are poorly represented. It consists of 21 species, and we notice a relatively large number of halophytic species, such as *Aster tripolium*, *Juncus gerardi*, *Plantago cornuti*; these species make the transition to the halophytic associations specific to *Puccinellio - Salicornietea* class. The ecological indices analysis reveals the mesohigrophytic, mesothermic and low acid-neutrophilous to basophile nature of the association. We also noticed the high number of euryionic species (9 species out of 21).

4.3.14. *Bolboschoenetum maritimi* Soó (1927) 1957 association

This association often inhabits marshy places, with brackish water, flooded during spring and dry during summer and autumn. The phytocoenosis of this association consist of a few species, the dominant ones being the characteristic ones - *Bolboschoenus maritimus* and *Phragmites australis*, which carries a 90% coverage. The ecological indices analysis reveals the mesohigrophytic, mesothermic to moderately thermophilic and low acid-neutrophilous to basophile nature of the association. We also noticed the high number of euryionic species (BĂDĂRĂU ET ALEC-FARCAŞ, 2010).

4.3.15. *Convolvulo arvensis - Agropyretum repentis* Felföldy 1943 association

Elymus repens, the characteristic species for this association, has large ecological amplitude, growing both on abandoned and fallow lands. This association prefers mainly the slopes. In the constitution of these phytocenosis we identified 18 species. The association is quite heterogeneous, most of the species being mesophilic (44.44%), with the participation of mesohygrophilous and xeromesophytes in equal proportions (22.22%). From the temperature point of view, the dominant are the mesothermic species (55.55%). The analysis of soil reaction index shows the dominance of euryionic species, that supports large range in pH (50%), alongside species adapted to low acid-neutrophilous soils also occur (27.77%).

4.4. STATISTICAL ANALYSIS OF PHYTOCOENOLOGICAL DATA

To check the accuracy of the data collected from the field and the coenotic phytocoenosis classification, we did a series of multivariate analysis of phytosociological data. Thus, we did divisive clustering and agglomerative clustering analysis, based both on the quantitative and binary data, but also CA, PCA, PCoA ordination analysis, using both quantitative and binary data.

Agglomerative clustering analysis ("non-metric dimensional scaling ordination") reflects the most complex type of spatial arrangement of the phytocoenosis, according to the type of environment (halophilic and non-halophilic), hydric regime of the soil (drier or wetter) and human impact (more or less pronounced) (Fig. 4.4.4). Thus, the phytocoenosis specific to the halophilic environments are clearly separated from the ones specific to non-halophilic environments; there is also an arrangement of the phytocoenosis (both the ones specific to the halophilic environments and the ones specific to the non-halophilic environments) depending on the edaphic humidity, these grouping into separate clusters. The degree of anthropogenic intervention also determines the arrangement of the phytocoenosis – the phytocoenosis group into separate clusters, corresponding to the human impact (more or less pronounced).

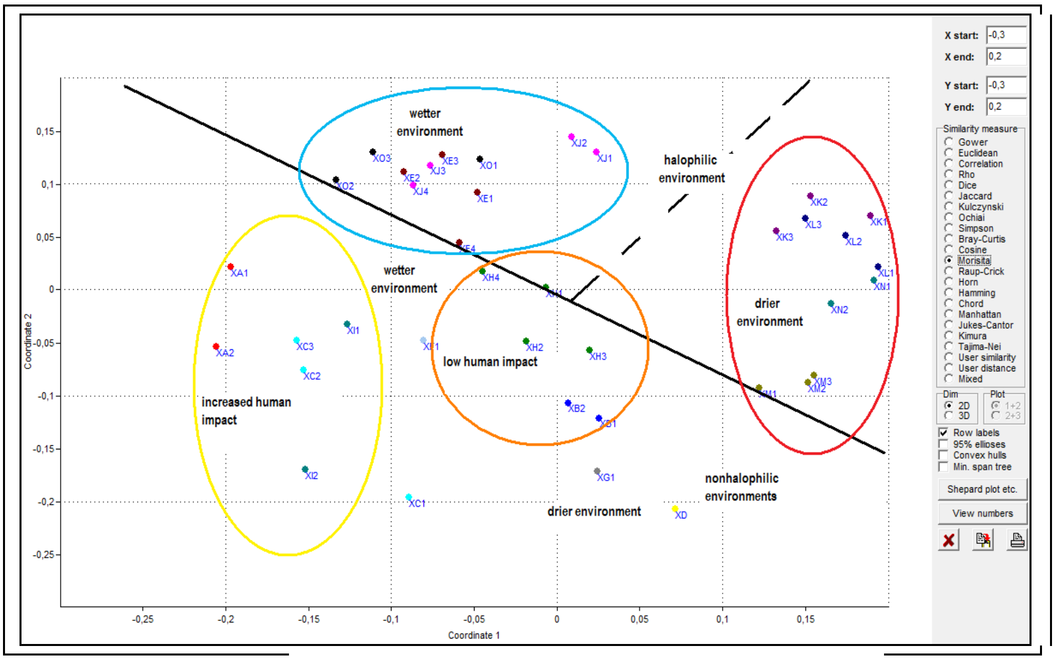

Fig. 4.4.4. *Agglomerative clustering analysis using Morisita index*

Agglomerative clustering analysis using Jaccard index and based on the binary data (Fig. 4.4.8) maintain a clear separation of the halophilic and non-halophilic environments, confirming the arrangement of the associations by a gradient of moisture and by one connected with the stronger saline characteristic of the soil, the last one obviously curving to the right the spatial arrangement of the halophytic phytocoenosis.

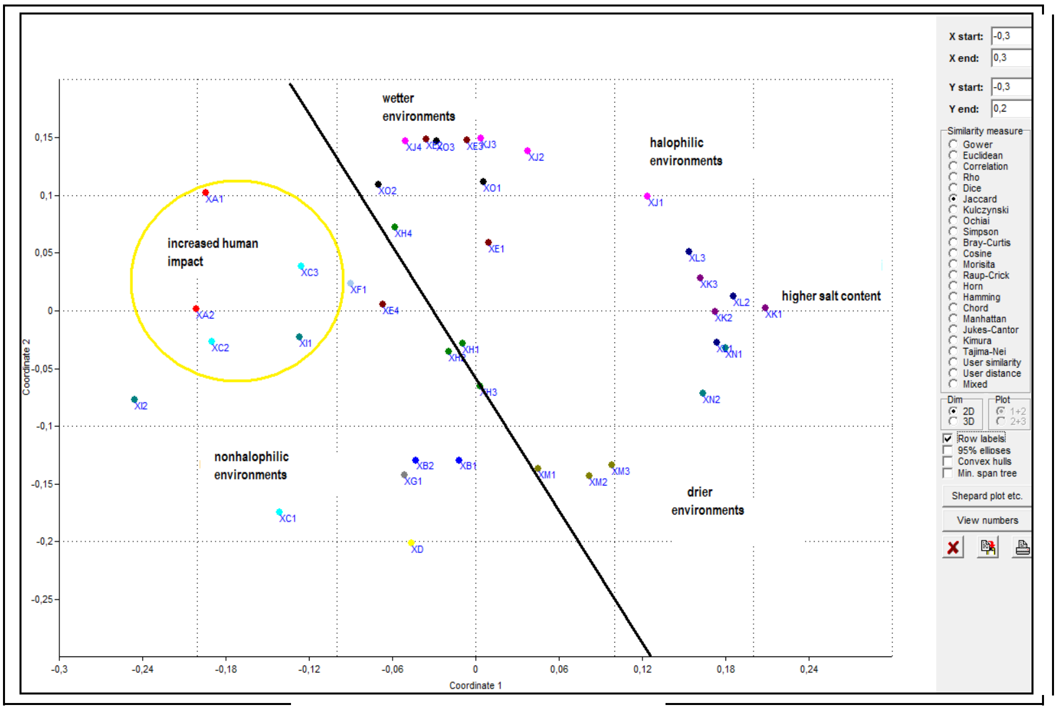

Fig. 4.4.8. *Agglomerative clustering analysis using Jaccard index*

CA ordination analysis, based both on the quantitative data (Fig. 4.4.9) and on the binary data (Fig. 4.4.10), show a clear separation of halophilic and non-halophilic phytocoenosis, the only difference between the two type of analysis is that the border between halophilic and non-halophilic environments (for the analysis based on the binary data) is blurring, due to the lack of discrepancy in the structure of data between the dominant, the codominant and the subordinated species. In both types of analysis, the arrangement of the phytocoenosis specific to the halophilic environments depends on the degree of humidity; in case of the phytocoenosis specific to the non-halophilic environments, the ones that belong to the mosaic of phytocoenosis that are subject to strong agricultural influences (XA , XC, XI) are grouping together.

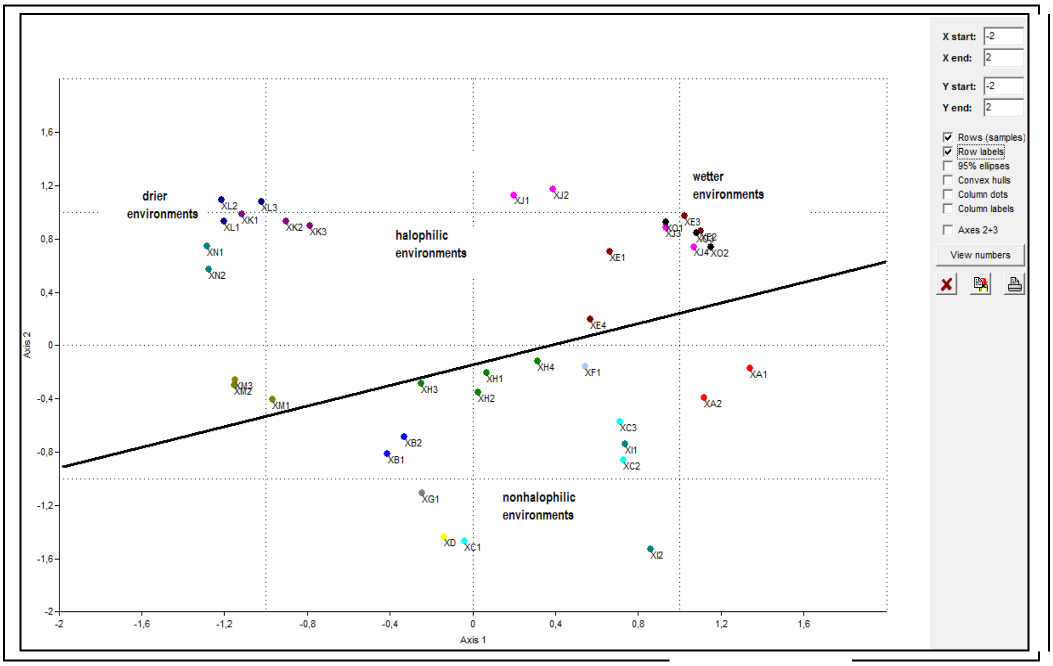

Fig. 4.4.9. *Correspondance Analysis using quantitative data*

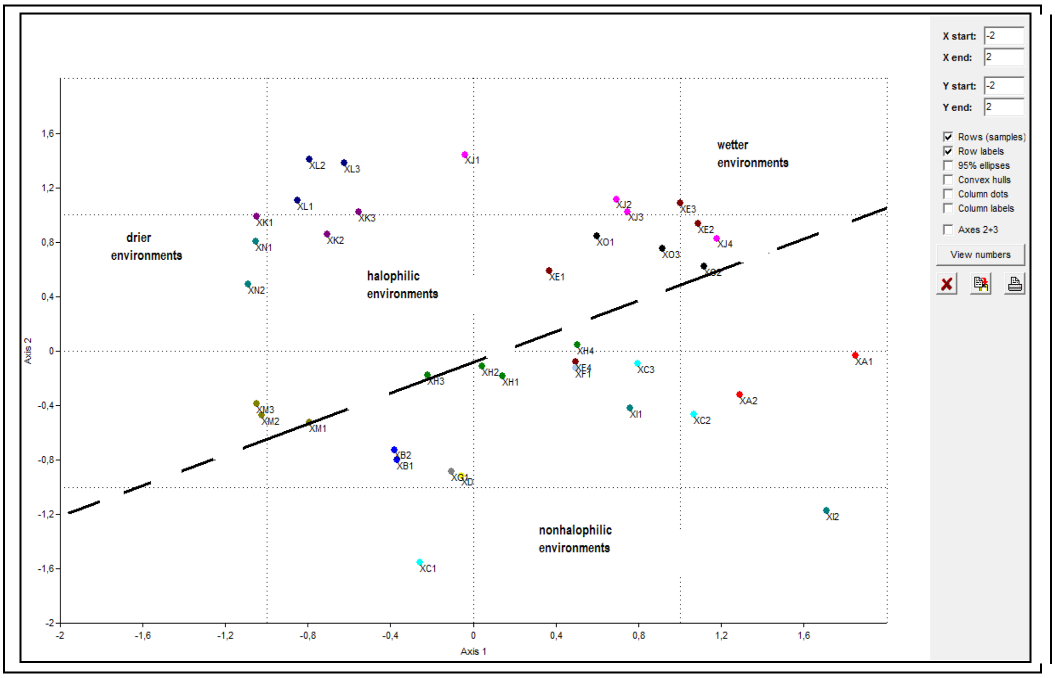

Fig. 4.4.10. *Correspondance Analysis using binary data*

There is a nearly perfect similarity between the results of clustering analysis (quantitative and binary) and ordination analysis (quantitative and binary), which denotes both the accuracy of the field data and the accuracy of phytocoenosis classification into different types of associations. In all cases, there is a clear differentiation between halophilic and non-halophilic phytocoenosis, a fact that was also observed in the field, where phytocoenosis specific to the environments with a higher degree of salinization never interfere with the phytocoenosis specific to non-halophilic environments. Moreover, this differentiation is maintain due to the edaphic moisture, the halophilic - hygrophilic associations grouping, in all cases, separately the mesophilic-mesoxerophilic ones. We notice the individualization of the phytocoenosis affected by anthropogenic intervention (the use of land for agricultural activities), phytocoenosis that constitute mosaics in the analyzed perimeters, where mesophilic meadows (*Festucetum pratensis*, *Convolvulo arvensis - Agropyretum repentis* – associations that indicate a fallow ground) alternate with hygrophilic grassland plots that are weakly halophilic (*Bolboschoenetum maritimae*).

4.5. THE STATUS OF THE HABITATS AND OF THE POPULATIONS

In the monitoring campaign of the halophytic vegetation from the Transylvanian Basin, carried out together with A.S. Badărău between 2006 and 2010, we followed, mainly, the citations from the scientific literature about the halophytic species studied but we also searched new locations where these species occur.

4.5.1. *Plantago schwarzenbergiana* Schur.

The only locations from the Transylvanian Basin where we found *Plantago schwarzenbergiana* are Valea Sărată Turda and near the salt lakes - Carolina, Durgău, Ocnei and Rotund - located at the southernmost extremity of this valley.

At Valea Sarata, the species is concentrated in five groups (Fig. 4.5.5), with an average area of 20m^2 (ALEC-FARCAŞ ET BĂDĂRĂU, 2010). From pedological point of view, species set on erodisoils. The favourite habitat of the species is represented by the small mounds located on the valley bed (the level difference between the bottom and the edge of these mounds is only a few tens of centimeters). *Plantago schwarzenbergiana* vegetate especially in *Artemisio-Festucetum pseudovinae* association and is quite well represented in this association with a density of 15 individuals/m^2; we also found the species in *Juncetum gerardii* association, where it has a lower density (2 individuals/m^2). The presence, along the valley, of no less than three sheepfolds and also the large quantity of garbage (despite the Natura 2000 status of the area) represents the major threat we've noticed, that might affect the further maintenance of *Plantago schwarzenbergiana* species here.

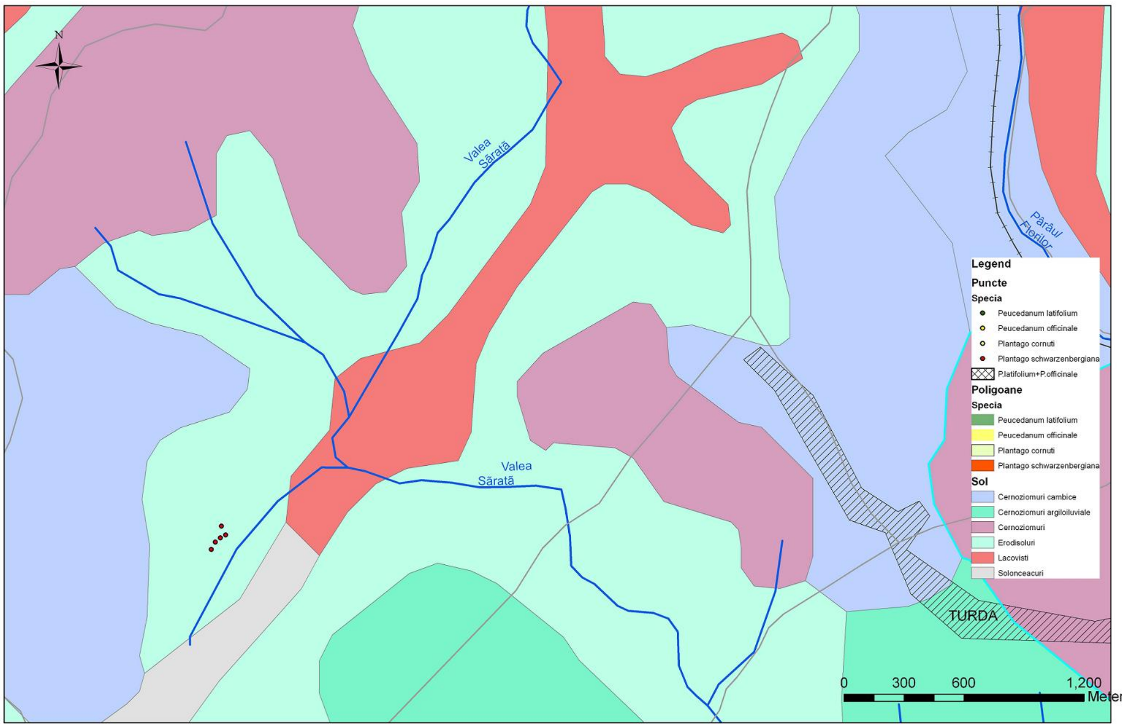

Fig. 4.5.5. ***Plantago schwarzenbergiana*** *at Valea Sărată Turda*

In the salt lakes area from the southernmost extremity of Valea Sărată we encountered the species grouped into six populations, relatively small in size (up to 40 m^2) (Fig. 4.5.7).

Here, the species inhabits mainly positive landforms, where salinity and humidity are less pronounced. The vast majority of the phytocoenosis inhabit the slopes of the hills with NNE and NW exposition, forming the S*taticeto-Artemisietum monogynae (santonicum)* Țopa 1939 and *Potentillo arenariae-Festucetum pseudovinae* Soo (1939) 1950 associations (ALEC-FARCAȘ ET BĂDĂRĂU, 2010).

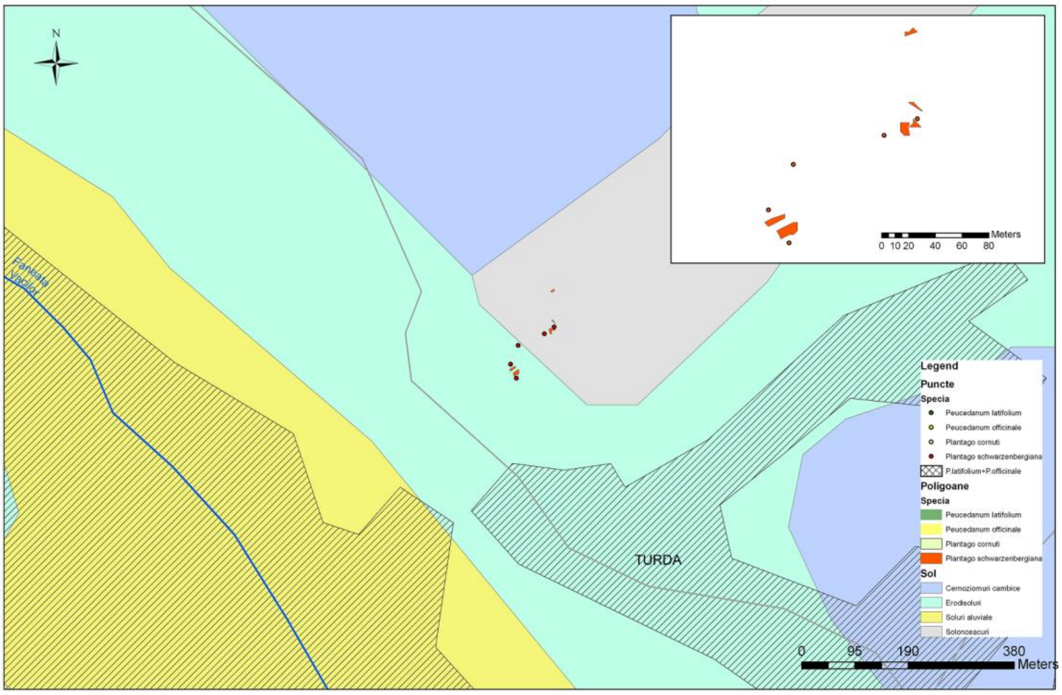

Fig. 4.5.7. ***Plantago schwarzenbergiana*** *distribution near the lakes from the southernmost extremity of Vălea Sărată - Turda*

4.5.2. *Plantago maxima* Juss.

Detailed studies about the spread of the species in Ruşcior meadow and Strâmb brook (Râsloavele) (Sibiu Plain) were made by E. Schneider - Binder (1970, 1974, 1978). From these studies, the author outlines the spread of *Plantago maxima* species in Sibiu Depression, where "populations smaller and smaller persist in their unique resorts from Romania" (Schneider - Binder, 1980). Although the author has shown the endangered situation of this species, unfortunately more than thirty years passed without any serious intent to protect the *Plantago maximum* species in this area. As a consequence, in 2007, when we visited and thoroughly searched the area and especially the places indicated on the map by Schneider – Binder, we had to conclude that the species and its habitat has disappeared. A few patches of its former habitat still remained on the east of DJ 106B (the road between Sura Mică and DN1 highway) and also on both banks of the Ruşcioru rivulet. Apart from these small patches, in Ruşcior meadow dominates a desolate landscape, populated almost entirely, by *Trifolio repenti-Lolietum* Krippelová 1967 association - indicating a high degree of degradation of the area.

4.5.3. *Plantago cornuti* Gouan

As a result of land researches we found the *Plantagi cornuti* species in the following locations: Morişti, Berteleag valley (in these two locations the presence of the species has not been previously mentioned in the scientific literature), Ploscoş-Valea Sărată, Buneşti and Hăşdate.

In Morişti, the species vegetates on solonchaks, being represented by two populations, relatively small in terms of surface (totalizing 130 m^2) but formed out of a great number of individuals (the average density being of 15 individuals /m^2), as well as by a group of isolated individuals who occupy a surface of 25 m^2, yet with a lower density of 3 individuals/m^2 (fig. 4.5.16). The presence of the species in this location has not been previously mentioned in literature.

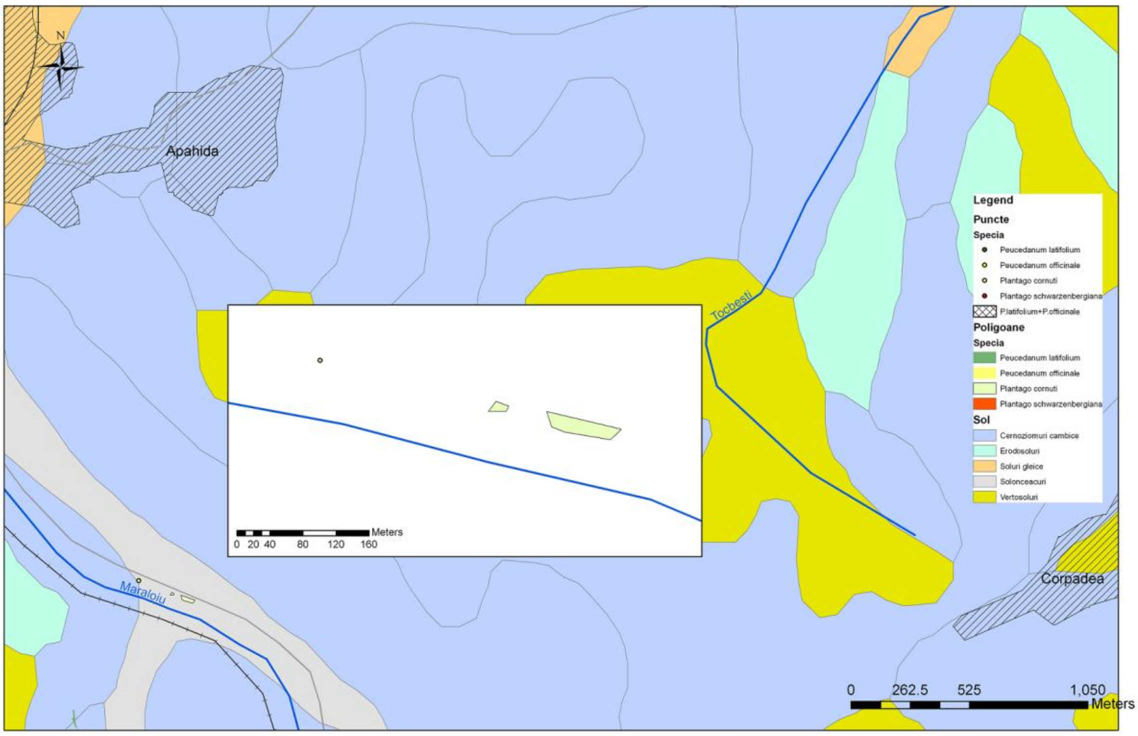

Fig. 4.5.16. *Plantago cornuti* *distribution at Morişti*

The species is very well represented in *Juncetum gerardii* association and less represented in *Bolboschoenetum maritime* association. The only anthropic threat we could identify is the use of the area for illegal storage of waste products resulted from constructions and demolitions, phenomenon noticed in the neighbourhood of the group of isolated individuals. Furthermore, on the edge of the Apahida-Cojocna road, we noticed, in several places, the presence of waste disposal.

Another location where, in premiere, we pointed out the presence of species *Plantago cornuti* is Berteleag Valley. The species is represented here by a single population which occupies a surface of 50 m^2 with a density of approximately 5 individuals /m^2, as well as by three groups of 2, 3 and 14 isolated individuals, situated at about 200 meters from the population (fig. 4.5.18).

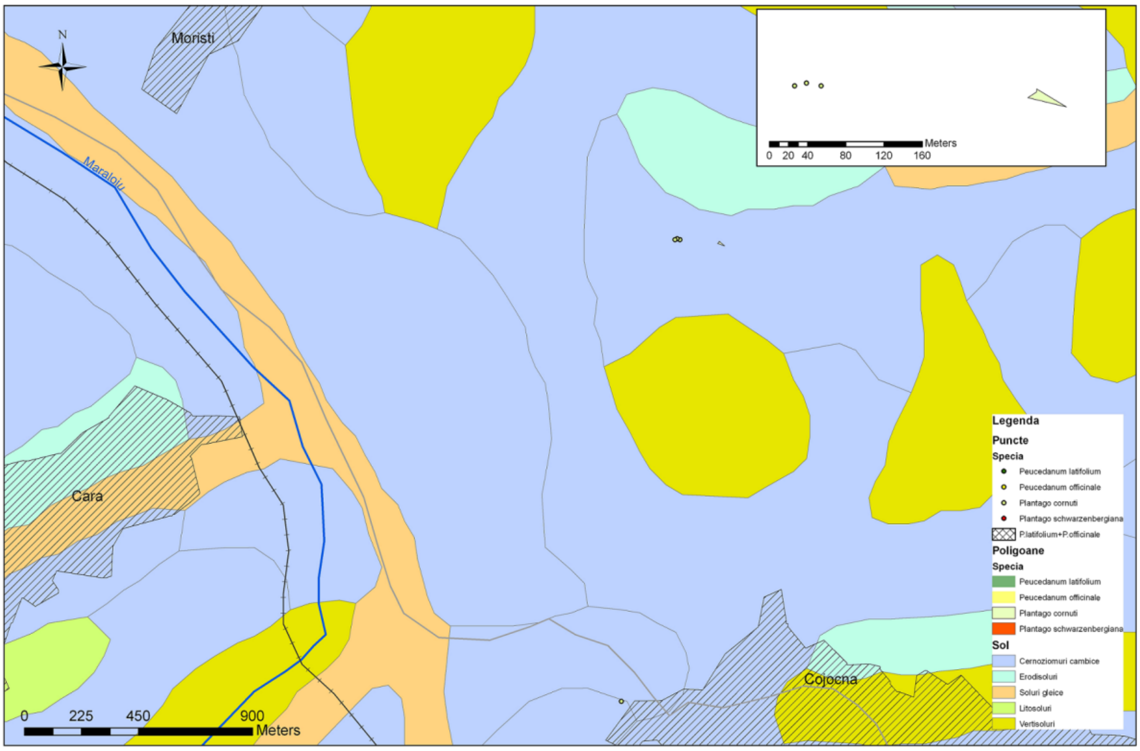

Fig. 4.5.18. *Plantago cornuti* *distribution at Berteleag Valley*

The species vegetates on cambic chernozem soil and has been identified in *Poëtum pratensis* association. The region is in a rather advanced stage of degradation due to overgrazing, the species being therefore exposed to inherent risks (beside, even in the salt meadow's perimeter we noticed the presence of numerous sheep traces, which shows that grazing is a practice in the salt meadow area).

Mentioned before in the literature at Ploscoş, *Plantago cornuti* is currently present here in a small location situated on the left side of Crairât-Ploscoş road, at about 500 meters from this.

The conditions are favourable for the species, this being well represented in the *Triglochineto maritimae – Asteretum pannonici* and *Scorzonero parviflorae - Juncetum gerardii* associations.

The species vegetates on cambic chernozem soil, and is represented by a single population, very large in size (fig. 4.5.20), occupying a surface of over 1,5 ha and having a high density (12 individuals /m^2).

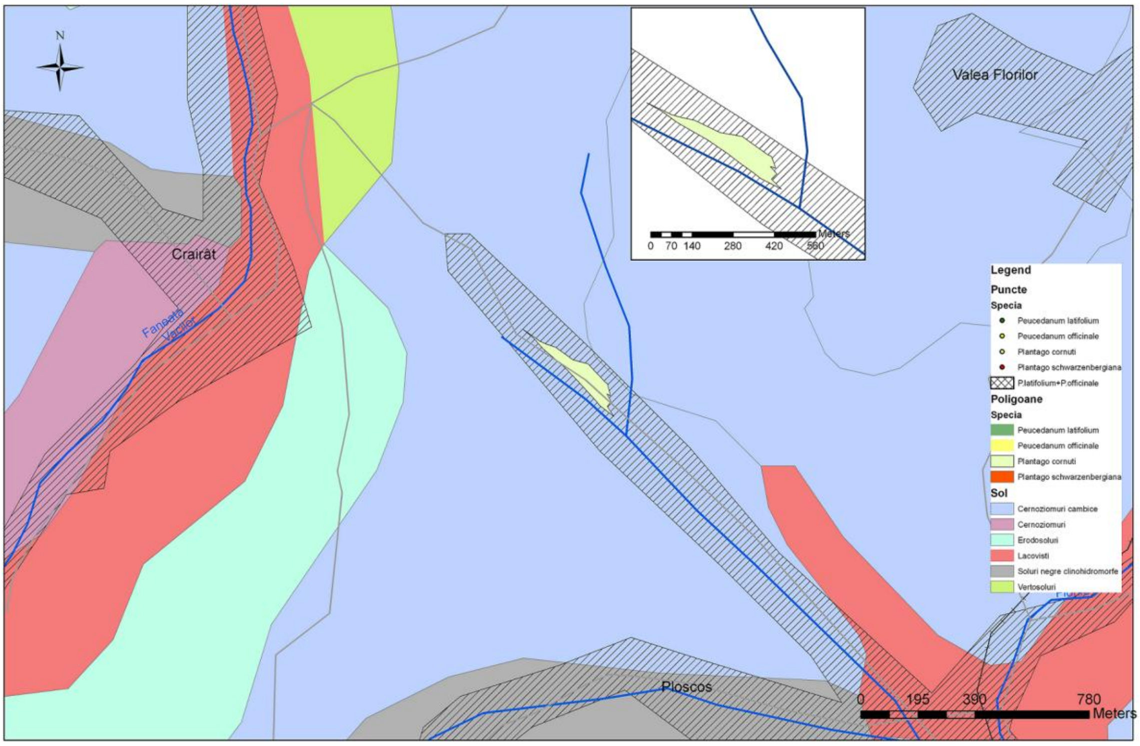

Fig. 4.5.20. ***Plantago cornuti*** *distribution at Ploscoş*

Although placed in the instant neighbourhood of some households and on the left side of Ploscoş road towards the communal pasture (which makes the area exposed to the daily cattle passage) the population is quite well preserved. A possible risk in what concerns the preservation of population is represented by early mowing.

The fourth location in Transylvanian Basin where we found *Plantago cornuti* species is a small salt meadow situated near Buneşti locality (near Gherla). *Plantago cornuti* vegetates on preluvosoil. The species is represented here by one compact population and several groups of isolated individuals; the surface occupied by these totalize approximately 200 m^2 (fig. 4.5.22) and the average density of the individuals is 12 /m^2. In this location, *Plantago cornuti* has been identified in the *Juncetum gerardii* and *Triglochineto maritimae – Asteretum pannonici* associations.

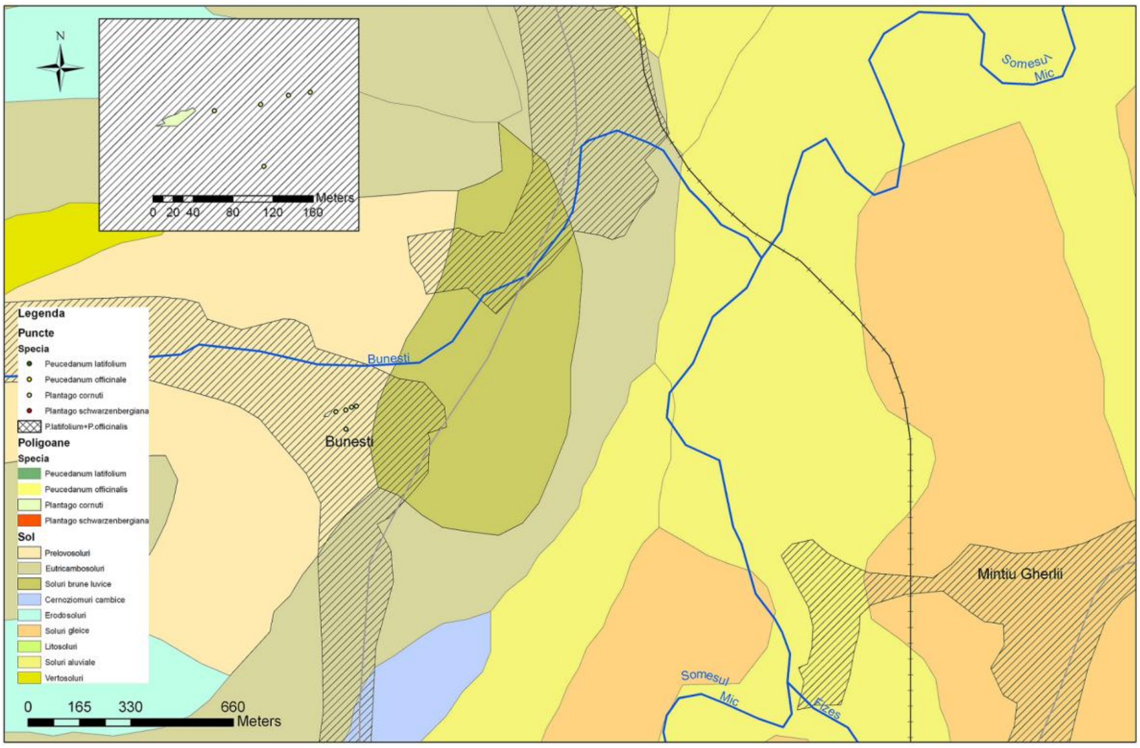

Fig. 4.5.22. ***Plantago cornuti*** *distribution at Buneşti*

The major threat identified is represented by the waste thrown here by the villagers and consequently by the risk of forming a waste dump on the surface of the salt meadow. Another risk, as in the case of Ploscoş, is represented by early mowing.

A location where we noticed the presence of *Plantago cornuti* as well as another species studied, *Peucedanum latifolium*, is in the neighbourhood of Hăşdate (a locality near Gherla), on Hăşdate valley. The pedological substratum is almost entirely represented by eutricambosoils and, in the northern extremity of the valley, by alluvial soils. The species is grouped in several populations distributed along the valley, populations which occupy an area of approximately 2.5 ha (fig. 4.5.24). These are mainly concentrated on the edge of the valley, where humidity of the soil is higher, the density of the species here being of 15 individuals/m^2. Still in some sections in the northern part of the valley, where the edaphic humidity is lower, *Plantago cornuti* overlaps with *Peucedanum latifolium*, situations when *Plantago cornuti* is less abundant (having an average density of 5 individuals/m^2). The *Plantago cornuti* species has been identified in the *Poëtum pratensis* and *Scorzonero parviflorae – Juncetum gerardii* associations.

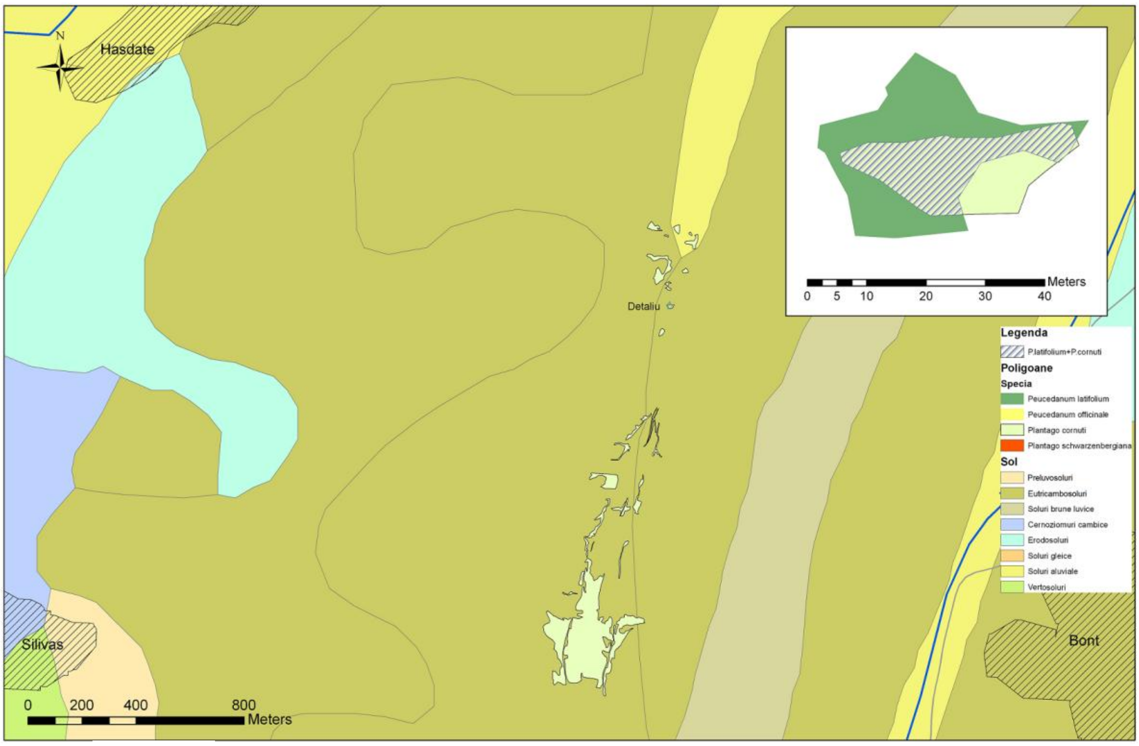

Fig. 4.5.24. ***Plantago cornuti*** *and* ***Peucedanum latifolium*** *distribution at Hăşdate Valley*

Peucedanum latifolium populates the hills on the northern side of the valley, with S-SE orientation, occupying a total surface of approximatively 184 m^2. The average density of the species is of 5 individuals/m^2. Species is better represented in *Poëtum pratensis* association comparatively *Festucetum sulcatae (=rupicolae) mezophilum* association - in the last one we found only sporadic individuals. The habitat of these species is in good conditions. The anthropic action, through grazing and mowing, exists though, fact underlined by the quite abundant development, mainly in some areas, of *Euphorbia cyparissias* species (which under the action of intensive grazing reaches its higher dominance, being avoided by herbivorous).

4.5.4. *Peucedanum latifolium* (Bieb.) DC

In our field work, we found *Peucedanum latifolium* in five locations: Hăşdate (the situation of the species in this place has already been presented before), Sânicoara, Budaştău (near Apahida), SW of Cojocna and Sibiu Plain (the last two locations, Cojocna and Sibiu Plain, have not been mentioned before in the literature).

If Iuliu Prodan was stating, in 1931, that *Peucedanum latifolium*, alongside *Plantago cornuti* and *Limonium gmelinii,* are choking up the fields from Sânicoara, at the present time the populations of these species have severely diminished, due to the building, exactly in the middle of the species' habitat, of a gas station (in 2006) and of a truck parking (in 2009), which led to its fragmentation. Thus, during the summer of 2009, only three populations of *Peucedanum latifolium* still preserved (between the gas station and the railway – fig. 4.5.28), *Plantago cornuti* having completely disappeared. *Peucedanum latifolium* vegetates on gleyic soils and has been identified in *Convolvulo arvensis* - *Agropyretum repentis* association (association which reflects the degree of degradation of the habitat). It is very likely that the only populations left here to be preserved because they are in the railways' protection area.

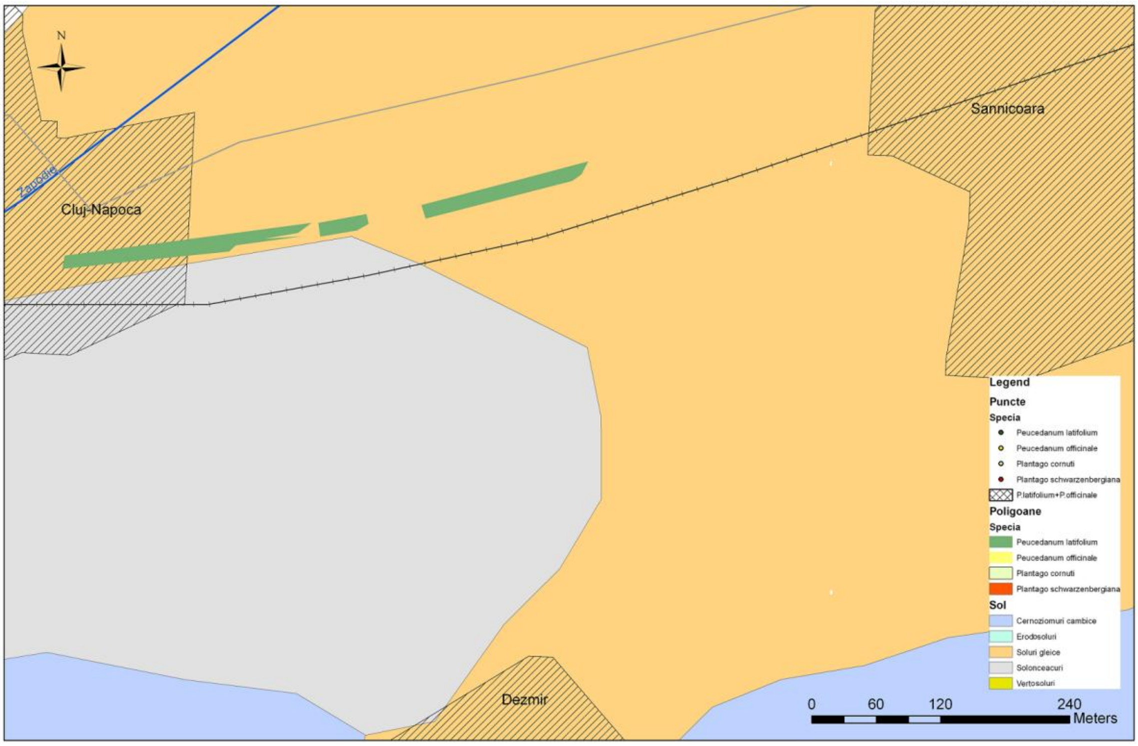

Fig. 4.5.28. *Peucedanum latifolium* *situation at Sânicoara in 2009*

Although not mentionned before in the literature, we noticed the presence of *Peucedanum latifolium* in a point situated southeast of Cojocna. Here, the species form a single population, which vegetates on cambic chernozem and is situated on a knoll of average dimensions with the highest altitude of 349 meters (the difference between the knoll's base and its peak is 10 meters), the surface occupied by the population being of about 0,7 ha (fig. 4.5.29).

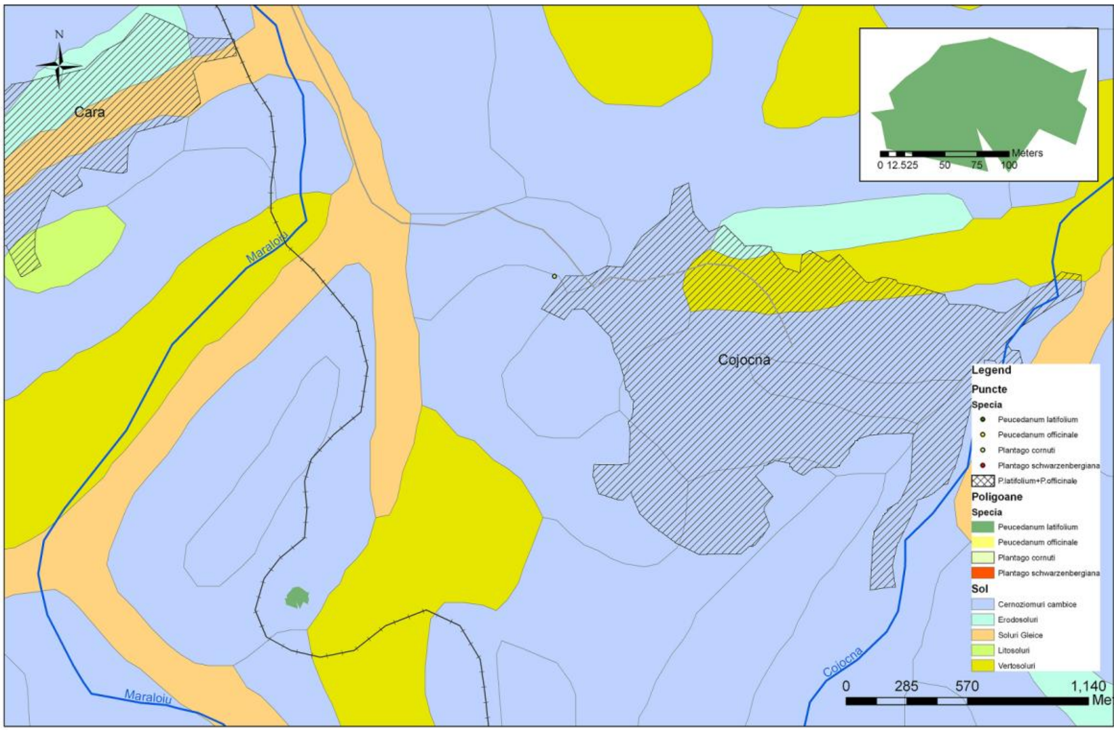

Fig. 4.5.29. *Peucedanum latifolium* *distribution at Cojocna*

The species has been identified in *Alopecuretum pratensis*, *Festucetum pratensis* and *Caricetum distantis* associations. Although the population occupies quite a large surface, it is in a relatively advanced stage of degradation; the main explanation for the degradation of the species' habitat is the overgrazing (the presence of a few sheep folds in the neighbourhood and the excessive development in some sections of this coenosis of *Bromus mollis* species proving that).

Although E. Schneider-Binder thoroughly investigated the Sibiu Plain area, she has not signalled the presence of *Peucedanum latifolium* here. Our researches have identified the species in a point situated in Ruşcior meadow, in the instant vicinity of the railway Sibiu-Ocna Sibiului (on the left side of the railway). The species is represented by a single poulation of small size, made up of only 11 adults and 15 youngsters and fills a surface of only 20 m^2 (fig. 4.5.31). It has been identified in *Agrostidetum stoloniferae* association.

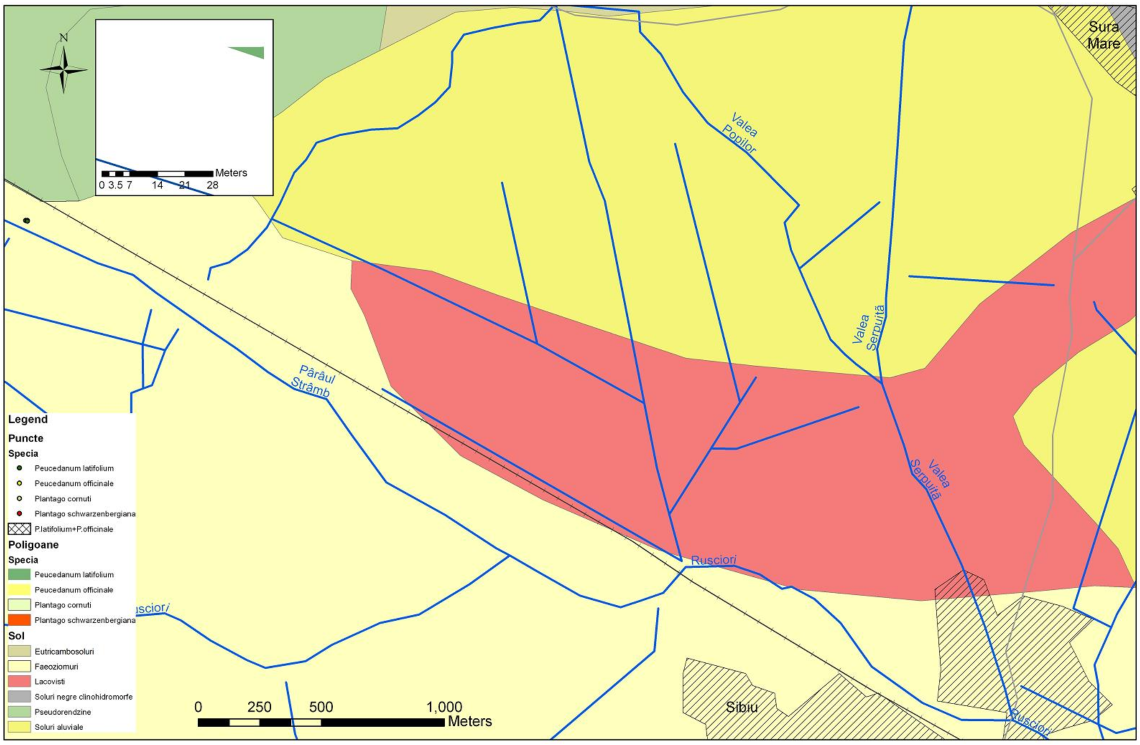

Fig. 4.5.31. *Peucedanum latifolium* *distribution near Sibiu*

4.3.5. *Peucedanum officinale*

The location from the Transylvanian Basin where we met the most abundant and well preserved populations of *Peucedanum latifolium* is Budaştău (near Apahida); alongside we also met another studied species, ***Peucedanum officinale***, Budaştău being probably the only location from the Transylvanian Basin where the latter species appears.

The salt meadow from Budaştău has the shape of a depression with a surface of about 30 ha. The pedological substratum in this area is represented by cambic chernozems and lithosols. Due to different needs concerning the humidity factor, the two species tend to preserve themselves separately and to populate distinct areas, although they overlap in some points (fig. 4.5.34).

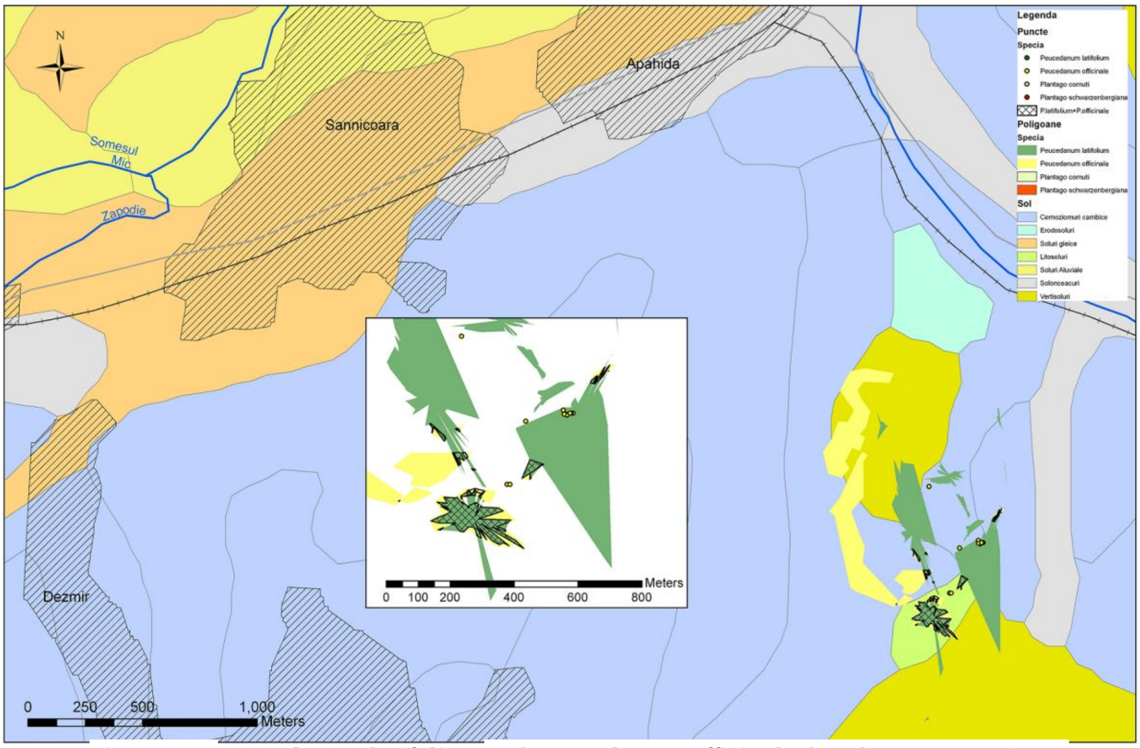

Fig. 4.5.34. ***Peucedanum latifolium*** *and* ***Peucedanum officinale*** *distribution at Budaştău*

Thus, *Peucedanum latifolium* inhabits mainly the bed of the depression, where the humidity is higher, while *Peucedanum officinale* inhabits mainly the slopes surrounding the depression. We found *Peucedanum latifolium* in *Bolboschoenetum maritimi, Alopecuretum pratensis, Festucetum pratensis, Convolvulo arvensis - Agropyretum repentis, Peucedano-Asteretum punctati* associations, in the latter association *Peucedanum officinale* being also present.

Except some sections where we noticed the impact of the agricultural activities, the proof being the installation of *Convolvulo arvensis - Agropyretum repentis*, *Festucetum pratensis* and *Bolboschoenetum maritimi* associations, the anthropic impact on the habitat of the species is relatively reduced, species being well preserved here.

4.6. Protection and conservation measures

One of the five species which were the subject of this study has disappeared (*Plantago maxima*), two species were identified only in one location - *Peucedanum officinale* (at Budaştău) and *Plantago schwarzenbergiana* (Turda – Valea Sărată) – this denote the extreme vulnerability of the species. We identified the studied species in several plant associations that require special conservation measures, being characteristic to habitats of Community interest (Alec-Farcaş et al., 2009), namely: 1530* Pannonic salt steppes and salt marshes, 6260* Pannonic sand steppes and 6440 Alluvial meadows of river valleys of the *Cnidion dubii*, the first two being priority habitats. Preserving these halophytic species, their habitats and the biodiversity that characterize them depends on the implementation of immediate conservation and protection measures. We recommended, in this context, the establishment of conservation areas in Budaştău (so far the only known location of *Peucedanum officinale* species, where we also found the richest populations of *Peucedanum latifolium*), Ploscoş and Hăşdate (locations that host the richest populations of *Plantago cornuti*).

CONCLUSIONS

In the Transylvanian Basin, the halophytic vegetation occupies insular habitats that are geologically determined, being strongly related to the inversion relief developed on diapiric folds and also to the marls and marly clays, rich in salts, of Badenian age. Except Sibiu Plain, all studied species appear in the western area of diapiric folds from the Transylvanian Basin.

The majority of the habitats of the species studied are situated on the anticline axis, being disposed as follow:

- Buneşti salt meadow – situated on Buneşti – Valea Florilor anticline axis;
- Sânicoara salt meadow – situated on Dezmir-Sânicoara anticline axis;
- Budaştău salt meadow – situated on Fânețe – Apahida anticline axis;
- Morişti salt meadow – situated on Tău anticline axis;
- Valea Sărată Turda (Ocnele Turzii) and Ploscoş salt meadows - situated on Măhăceni-Ploscoş anticline axis.

Other habitats studied are located in areas characterized by the presence of salt massifs, such as the salt meadow from Hăşdate Valley, valley that is totally superimposed on Hăşdate salt massif.

If the salt massifs are not exposed to the surface (cases when salt efflorescences occure), they are highlighted by the presence of halophytic vegetation, as well as by the groundwaters that gave birth to salt spings (as it is at Buneşti, Hăşdate Valley, Budaştău, Morişti and Cojocna).

From the litological point of view, the studied areas are characterized by the presence of marls and marly clays, rich in slats, of Badenian and Sarmatian age; the only two exceptions are the salt meadows from Sânicoara and Morişti (located in the river bed of the Someş river and Morişti brook), that are characterized by recent deposits of rivers with gravels and sands of Holocene age.

The decisive control factor for the deveopment and for the areal distribution of the halophytic species studied is the geological substratum, represented by salt massifs – exposed to the surface or close enough to the surface – the chemical and physical analysis of the soil highlighting, no matter on what type of soil the halophytic species vegetate, a certain degree of salinity.

Structural analysis by X-ray diffraction of the soil samples show that the majority of ions are represented by Ca^{2+}, Mg^{2+}, Cl^{-} and in a small amount Na^{+}. With two exception, NaCl is present in every soil sample analyzed.

Electrochimical analysis determined a pH of soil from slightly alkaline to slightly increased alkaline, with values ranging from 7.34 to 9.83, and a salinity of 0,2 $^{0}/_{00}$ to 0,9 $^{0}/_{00}$.

The presence of salt in geological substratum change the chemical composition of the soil in the areas where it get to or near by the surface, and so the required conditions for the installation and for the development of the halophytic vegetation occure. Therefore, we may conclude that there is a relationship between geological substratum and the presence of the halophytic species studied, the saline geological substratum not only influencing, but also causing their presence. The reverse relationship is also valid - the presence of the halophytic species studied showing the characteristics of the geological substratum, so the species studied are an indicator of the presence of salt in the geological substratum.

Except *Plantago maxima,* that, as our studies has shown, became an extinct species, the other four species studied - *Plantago schwarzenbergiana, Plantago cornuti, Peucedanum latifolium, Peucedanum officinale* - are very rare in the flora of the Transylvanian Basin, so they are highly important.

From a scietific point of view, this study is more than welcome because, beyond its complexity, it brings up-to-date the situation and the distribution of these rare halophytic species from the Transylvanian Basin (scientific data about the presence of these species were recorded a few decades ago, in some cases over 50 years) and, for the first time, it includes a detailed mapping of these species. Another major contribution of the present study is that it discovered new and previously unreported locations where these species occure.

The species studied were identified in 15 plant associations, belonging to six vegetation classes – *Puccinellio-Salicornietea Țopa 1939, Festuco-Brometea Br.-Bl. Et Tx. 1943, Molinio-Arrhenatheretea Tx. 1937, Juncetea maritimi Br.-Bl. 1931, Phragmitetea Tx. et Preising 1942, Agropyretea intermedio-repentis (Oberd. et al. 1967) Müll. et Görs 1969.*

The analysis of ecological indices showed the following results:

- In terms of humidity factor, the majority of associations are meso-hygrophilous (46.67%), followed by xeromesophytes (33.33%) and mesophytes (20%);
- In terms of temperature factor, the most of the associations are mesothermal (66.66%), 4 of the 15 associations are micro-mesothermal (26.66%) and only one is moderately thermophilous (6.66%).
- Regarding the soil reaction values, most of the associations (86.66%) have a low acid-neutrophilous character, only two associations having a neutro-basophilous or stronger acid-neutrophilous character. However, in most associations we noticed a high percentage of species that support large variations of pH values.

The analysis of floristic elements revealed that, in all 15 associations, the majority of the edifying species hemicriptophytes.

By analyzing the geoelements, we noticed the predominance, sometimes overwhelming, of the eurasian element in all 15 associations.

Ordination and cluster analysis confirmed entirely the accuracy of the field data and the accuracy of phytocoenosis classification into different types of associations.. In all cases, phytocoenosis of halophilic and non-halophilic associations are clearly separated. The same differentiation is maintain based on edaphic humidity and on the degree of anthropogenic intervention.

Plantago schwarzenbergiana is an endemic species for the Transylvanian Basin, and it was cited before from Baile Sărate Turda area (the "locus classicus" of the species), Ocna Mureş and Ocna Dej. Our field research showed that the species has disappeared from Baile Sărate Turda and from the other two previously mentioned locations. The only two locations – mentioned before in the scientific literature - where we founde the species are Valea Sărată Turda and near the lakes from the southernmost extremity of the valley. The species was identified in the following associations:

- *Juncetum gerardii* (Warming 1906) Nordh. 1923 and *Artemisio-Festucetum pseudovinae* (Magyar1928) Soó (1933) 1945 at Valea Sărată;
- *Staticeto-Artemisietum monogynae (santonicum)* Țopa 1939 and *Potentillo arenariae-Festucetum pseudovinae* Soó (1939) 1950 near the lakes from the southernmost extremity of this valley.

Plantago maxima has disappeared entirely from the Transylvanian Basin flora (probably even from the flora of Romania). Our field studies shown that the species is not even represented by a single individual in the locations from Sibiu Plain (probably the only locations from Romania) where it has been reported before. Although measures have been initiated to protect the habitat of this species, for *Plantago maxima* they come too late, since the species disappeared.

Our field studies reported the presence of *Plantago cornuti* at Ploscoş, Hăşdate (locations where it has been reported before in the literature), Berteleag, Morişti and Buneşti. In the last three locations listed above we reported the species for the first time. Although reported in 2007 at Sânicoara, at the present the species has disappeared due to the construction (after 2007) of a gas station and truck parking exactly over the former habitat of the species. Although it does not seem to be a rarity in the Transylvanian Basin, being present in quite a few locations (comparing with the other species studied), the species is represented in most of the locations by small populations or even isolated individuals or groups (except the populations from Haşdate and Ploscoş). We identified the species in the following associations:

- *Juncetum gerardii* (Warming 1906) Nordh. 1923 at Buneşti and Morişti;
- *Scorzonero parviflorae – Juncetum gerardii* (Wenzl. 1933) Wendelbg. 1943 at Ploscoş and Hăşdate;
- *Poëtum pratensis* Răv., Căzăc. Et Turenschi 1956 at Hăşdate and Berteleag;
- *Festucetum pratensis* Soó 1938 at Budaştău;
- *Triglochineto maritimae - Asteretum pannonici* (Soo 1927) Țopa 1939 at Buneşti and Ploscoş.
- *Bolboschoenetum maritimi* Soó (1927) 1957 at Budaştău and Morişti
- *Convolvulo arvensis - Agropyretum repentis* Felföldy 1943 at Budaştău

In the Transylvanian Basin, we found *Peucedanum latifolium* species in five locations: Budaştău, Hăşdate, Sânicoara, near Cojocna and Sibiu Plain. Near Cojocna and Sibiu the presence of the species was reported for the first time. Except the population from Budaştău, which is in relatively good conditions from the conservation point of view (except some sections of the habitat, where they suffer the interference with human activities), the situation of the species in the other sites is not that good, the species being exposed to threats (mainly overgrazing). *Peucedanum latifolium* was identified in the following associations:

- *Scorzonero parviflorae – Juncetum gerardii* (Wenzl. 1933) Wendelberger 1943 at Hăşdate;
- *Caricetum distantis* Rapaics 1927 at SW of Cojocna;
- *Peucedano-Asteretum punctati* (Rapaics 1927) I. Pop 1968 at Budaştău;
- *Festucetum sulcatae (=rupicolae) mezophilum* Csűrös et al. 1961 at Hăşdate;
- *Poëtum pratensis* Răv., Căzăc. Et Turenschi 1956 at Hăşdate;
- *Agrostidetum stoloniferae* (Ujvárosi 1941) Burduja et al. 1956 at Sibiu Plain;
- *Festucetum pratensis* Soó 1938 at south-west from Cojocna and Budaştău;
- *Alopecuretum pratensis* Regel 1925 at SW of Cojocna and Budaştău;
- *Bolboschoenetum maritimi* Soó (1927) 1957 at Budaştău;
- *Convolvulo arvensis - Agropyretum repentis* Felföldy 1943 at Budaştău and Sânicoara.

Peucedanum officinale species is a regional rarity, the only location from the Transylvanian Basin where we found this species being the salt meadow from Budaştău. Here, the environmental conditions are favorable for the development of the species, its situation being relatively good. The species was identified in the phytocoenosis of *Peucedano-Asteretum punctati* (Rapaics 1927) I. Pop 1968 and *Alopecuretum pratensis* Regel 1925 associations. There is no explanation so far for the rarity of this species (compared with other related species) in the Transylvanian Basin. Because of their presumed long-term isolation, populations from the Transylvanian Basin most likely have been individualized from an ecological and genetic point of view, therefore they must be protected before they disappear entirely.

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