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ASPECTS OF VEGETATION SETTLEMENT ON WASTE DUMP DEPOSITS FROM THE NATIONAL PARK OF CĂLIMANI MOUNTAINS (EASTERN CARPATHIANS)

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Abstract: The waste dumps deposits are the most extended antropogenic relief forms on the Northern slope of the Călimani Mountains. Thus, there appear huge amounts of terrigenous material affected by the mining activities of a surface exploitation of sulphur and iron ores, between 1965 and 1997. Also, the soil quality has suffered great changes due to the toxic outcomes in various stages of the technological process.

As a result of the same mining activities, the vegetation and particularly, some rare plant species (e.g. *Larix decidua* ssp. *carpatica*, a globally threatened taxa, *Rhododendron myrtifolium*, and *Pinus cembra*, threatened taxa from the National Red List, Oltean & contributors, 1994) have been evidently affected, as a consequence as deforestations, storing the wast dumps, as well as the slooping of toxic effluents and waters from the separation factory and so on.

Our surveys followed the reconstruction of the vegetal communities from the sample plots, on natural ways. There has been established four sample plots, situated on four different sterile deposits, namely: Dumitrelul, Puturosul, Pinul, and Ilva.

Thus, we have found that the first colonizing plant species are the annual ones, followed by the bi-annual and perennial ones after it. The primary vegetation type is represented by those phytocoenosis edified by the next plant species: *Deschampsia cespitosa* ssp. *cespitosa, Festuca supina* and *Agrostis capillaris*, as dominant plant species; the other ones have a reduced frequency on our sample plots.

The foresters tried to plant, ten to fifteen years ago, on those four waste dumps deposits, various lignaceous plant species. All the experimental plantations indicate that some of the indigenuous species (e.g. *Picea abies, Pinus cembra, Larix decidua* ssp. *carpatica, Pinus mugo,* and *Sorbus aucuparia*) could have relatively good and forecasting results during the times.

The distribution of the vascular plant species on the four waste dump deposit is like the next ones: some plants has an isolated layout (e.g. *Trifolium repens*, *Salix caprea*, *Vaccinium myrtillus*, *Hieracium alpinum*, *Alchemilla subcrenata*, *Epilobium angustifolium*, *Vaccinium gaultherioides*). Others (e.g. *Deschampsia flexuosa*, *Deschampsia cespitosa* ssp. *cespitosa*, *Agrostis capillaris*) have a clumped distribution. Very few of them are distributed in clusters (*Festuca supina*). This last category has the most significant function, thus being the first colonizing species in the investigated area.

One can see that the best coverage with spontaneous vegetation is the waste dump Dumitrelul, and the less one is the waste dump deposit Pinului.

Key words: Călimani Mountains, waste dumps deposits, sulphur exploitation, ecological reconstruction.

Introduction

The ecological reconstruction of the damaged fields by mining activities represent the subject of some detailed and interdisciplinary investigations, from the biology, physics, chemistry and ecology fields. It is well known that the mining and other industries have among the outcomes an increasing amounts of waste dumps. Up to 1980, ca 1.6 x 10^{12} m^3 of mine spoils have been accumulated everywhere in the world. This amount is increasing yearly by ca 40 x 10^9 m^3 [5, 12, 15].

The waste dumps deposits of the formerly sulphur exploitation are the most extended forms of anthropogenic relief from the northern part of the Călimani Mountains. They are there

as a result of dislocation and shifting of a huge amount of terrigenous material, by the mining activities for extraction both of sulphur and iron ores. That activity has been made between the years of 1965 and 1997. The soil quality and and the vegetation have suffered great alterations, due to the toxic products outcomed in various stages of the technological processes [9].

Among the multiple effects of the sulphur and iron exploitation activities, the most destructive ones over the environment is the taking out from the natural patrimony of important areas both by the soil stratum uncovering and a totally inadequate sterile depositing.

An other outcome from the exploitation activity is the disappearance of some rare plant species in the area of minings, namely: *Pinus cembra* – a threatened plant species in Romania, included in the Romanian Red List [1, 2, 10, 11, 17]; *Larix decidua* ssp. *carpatica*, a globally threatened taxa [7]; *Rhododendron myrtifolium* – a threatened plant species in Romania, included in the Romanian Red List [17]; *Campanula serrata* – a strictly protected plant species on the Habitat Directive 92/43/EEC etc.

Their disappearance is a direct and negative consequence of: *i*. the vast deforestations in the area; *ii*. of the sterile storage; *iii*. of slooping of toxic effluents and waters from the separation factory and so on.

The problem of the reintroduction in the natural circuits of steril deposits (namely: Ilva, Dumitrelul, Pinului and Puturosul) from Călimani Mountains has been approached by some ecological reconstruction projects, that could not omitt the diversity of vascular flora, as well as the plant communities, spontaneous installed over there [3, 4, 6, 8, 14]. The aim of the ecological reconstruction is to convert the perimeter of the former sulphur exploitation into an area proper to be planted with those plant species peculiar for that region, for forestry purposes, or to include that area in the tourism circuit of the Natural Park of Călimani Mountains [16]. A secondary aim is to reduce or to eliminate the amounts of pollutants which is flowing constantly in all the rivers in that area, especially during the downpour [18].

All the attempts of the ecological reconstruction on the sterile deposits in Călimani Mountains are represented by the experimental plantations, in various conditions of growing, almost totally unfavourable, resulted from a high altitude (between 1600 and 1850 m) and antropogenic degraded soils. The lack of balance sources are presented in all technological stages of the exploitation, namely: uncovering the soil stratum, waste dump storage, exportation and transport, and preparation.

Also, the unfavourable factors for installing vegetation are characteristics for that geographical area, and usually increase the effects of the anthropic factors. Among these factors, are mentioned the next ones:

–orographical factors: long slopes, large declivities of the slopes, high relief energy;

–climate factors: low temperatures, high amounts of precipitations, a pretty large amount of snow lasting for a long period of time, high rates of wind speed;

–edaphic factors: soils having a low rate of biological activity, unfavourable physico-chemical parameters, low depth, high rate of skeleton-like soils and so on.

Material and Methods

Our surveys have been focused on the installation of the plant communities as primary succession on certain sample plots, previously established, on four sterile deposits in the area of Călimani Mountains.

The investigations have been made during the vegetation period (from June to October, 2007), consisting in an analyze of the spontaneous vascular flora, as well as the natural vegetation installed on those four waste dump deposits, namely: Dumitrelul, Puturosul, Pinul, and Ilva. The waste dump deposits have been resulted from the exploitation of sulphur and iron ores from the Summit Negoiul Românesc. In those over 30 years of mining activities, they cutted the top of that summit and, also, they excavated under the surface level, resulting thus a huge

hole. The whole amount of the ore was processed *in situ* and the resulted sterile has been stored in the four deposits, above quoted.

The vascular plant identified on the field consist in the existing of only 72 cormophyte species, among that *Deschampsia cespitosa* ssp. *cespitosa, Agrostis capillaris* and *Festuca supina* have the most significant abundance indices, constituting the first stages of the primary succesions.

The taxonomic nomenclature is that adopted by V. Ciocârlan [3] for some of the infrataxa and *Flora Europaea* [20].

Results and Discussion

The ecological analyzes concerning the life forms, floristic element, number of chromosomes and the ecological indices of the vascular plant species, alongwith the above mentioned indices, as well as their location have been made by us in a previous paper [13, 19]

In order to assess the installation of the natural vegetation, we've made some field observations, over the distribution of plant species on each of the four sterile deposits. Results are presented as follow.

A. The waste dump deposit **Dumitrelul**: there is a surface of ca 200 sq. m of planted arolla pine (*Pinus cembra*) and mugo pine (*Pinus mugo*). The age of the plants are of ca 10 years. The height of the juvenile trees is between 20 and 60 cm. Their vegetation state is a moderately to good one, having in mind the local conditions. The coverage of the spontaneous vegetation is around of 20%. The field is plane one.

The local coordinations are: N 47°06'39"; E 25°13'23.1"; altitude: 1747 m.

Vascular flora of this sterile deposit is edified by the next plant species: *Achillea distans* Waldst. et Kit. ex Willd. ssp. *stricta* (W. D. J. Koch) Janch.; *Agrostis capillaris* L.; *Alchemilla subcrenata* Buser; *Alchemilla vulgaris* L. emend. Frohner; *Betula pendula* Roth; *Briza media* L.; *Callitriche cophocarpa* Send.; *Campanula serrata*; *Campanula rotundifolia* L. ssp. *polymorpha* (Witasek) Tacik; *Carex curta* Good.; *Carex ovalis* Good.; *Cerastium fontanum* Baumg. ssp. *fontanum*; *Epilobium angustifolium* L.; *Cirsium arvense* (L.) Scop.; *Cirsium palustre* (L.) Scop.; *Cystopteris montana* (Lam.) Desv.; *Deschampsia cespitosa* (L.) Beauv. ssp. *cespitosa*; *Deschampsia flexuosa* (L.) Trin.; *Erigeron annuus* (L.) Pers. ssp. *annuus*; *Hieracium alpinum* L.; *Hieracium pilosella* L.; *Juncus articulatus* L.; *Juncus effusus* L.; *Luzula campestris* (L.) DC.; *Luzula luzuloides* (Lam.) Dandy et Wilmott, *Lycopodium clavatum* L.; *Phleum montanum* C. Koch; *Picea abies* (L.) H. Karst. (planted); *Pinus cembra* L. (planted); *Pinus mugo* Turra (planted); *Plantago lanceolata* L.; *Prunella vulgaris* L.; *Ranunculus montanus* Willd. ssp. *pseudomontanus* (Schur) Ciocârlan; *Rhododendron myrtifolium* Schott et Kotschy; *Rumex alpinus* L.; *Sagina procumbens* L.; *Salix caprea* L.; *Senecio glaberrimus* (Rochel) Simonkai; *Thymus pulegioides* L.; *Trifolium pratense* L.; *Trifolium repens* L. ssp. *repens*; *Tussilago farfara* L.; *Vaccinium myrtillus* L.; *Vaccinium gaultherioides* Bigelow; *Vaccinium vitis-idaea* L.; *Veratrum album* L. ssp. *lobelianum* (Bernh.) Rchb.; *Veronica officinalis* L.

We've made a horizontal plane projection, ilustrating thus the distribution of the vascular plant species on a sample plot (Fig. 1). The surface of it is of 100 sq. m. Date: 27th of July, 2007.

B. The waste dump deposit **Pinului**: there is a surface of ca 150 sq. m of planted rowan (*Sorbus aucuparia*) and Norway spruce (*Picea abies*). The age of the plants are of ca 10 years. The height of the juvenile trees is between 30 and 70 cm. Their vegetation state is a moderately to good one. The coverage of the spontaneous vegetation is around of 15%. The field is also plane one. The local coordinations are: N 47°07'31.1"; E 25°13'46.2"; altitude: 1584 m.

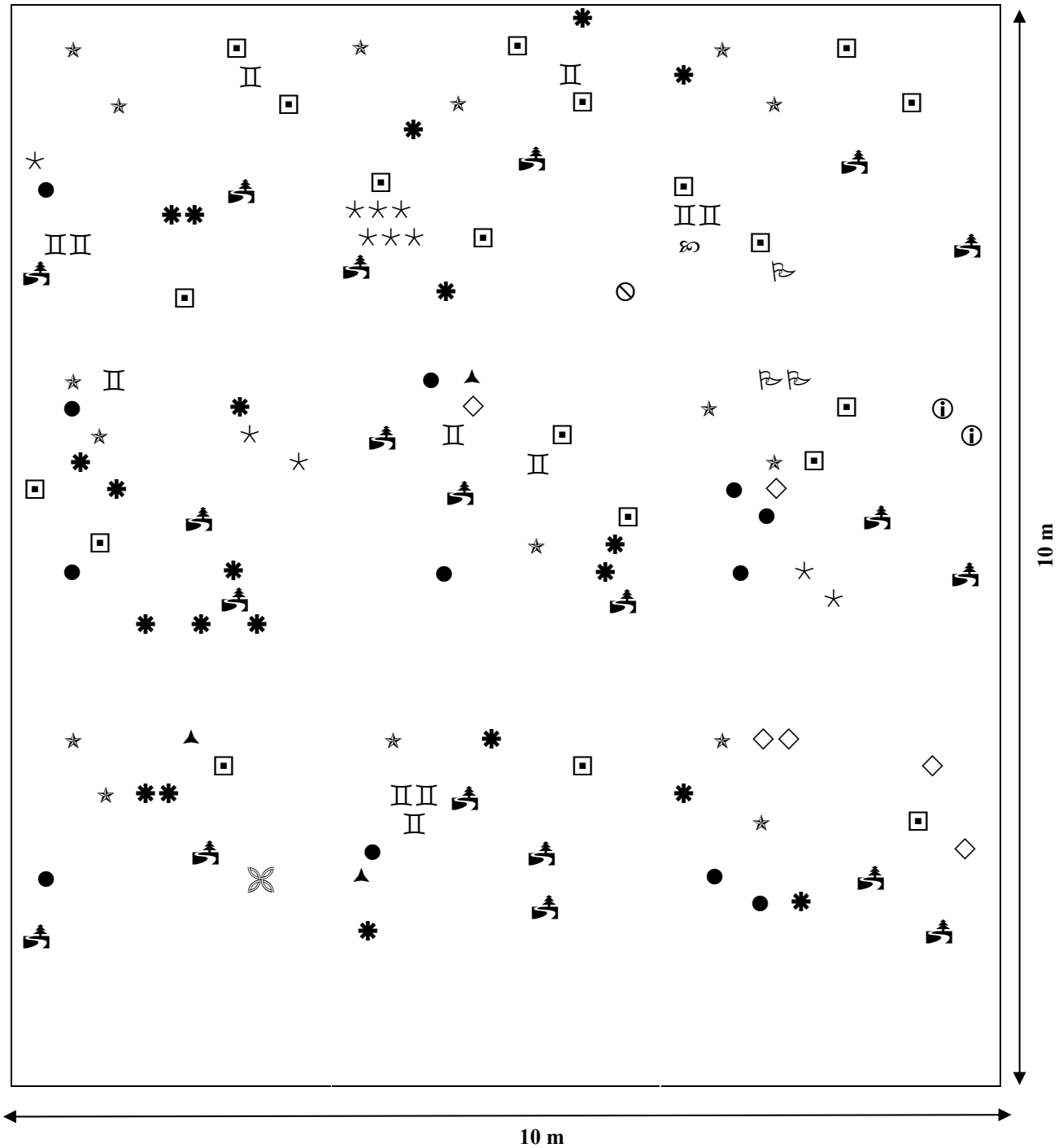

Fig. 1: The distribution of the vascular plant species on Dumitrelul waste dump deposit

Legend:

- *Pinus cembra*
- *Festuca supina*
- *Deschampsia flexuosa*
- *Salix caprea*
- *Pinus mugo*
- *Deschampsia cespitosa* ssp. *cespitosa*
- *Epilobium angustifolium*
- *Trifolium repens*
- *Prunella vulgaris*
- *Alchemilla subcrenata*
- *Populus tremula*
- *Trifolium pratense*
- *Vaccinium myrtillus*
- *Agrostis capillaris*

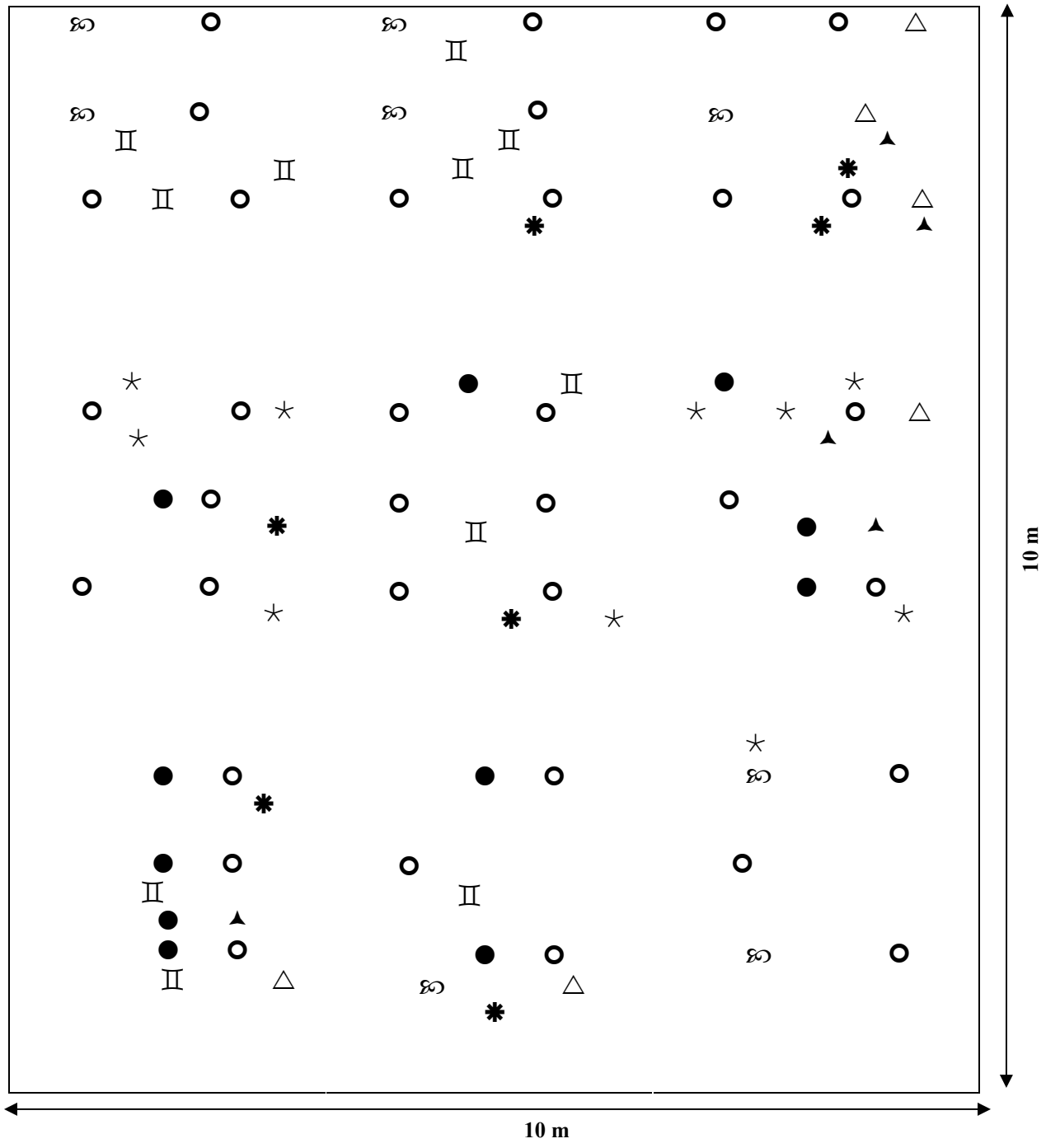

Fig. 2: The distribution of the vascular plant species on Pinului waste dump deposit

Legend:

- ❋ - *Festuca supina*
- ✶ - *Deschampsia flexuosa*
- △ - *Picea abies*
- O - *Sorbus aucuparia*
- ▲ - *Salix caprea*
- Ш - *Deschampsia cespitosa* ssp. *cespitosa*
- ● - *Agrostis capillaris*

Vascular flora of this sterile deposit is edified by the next plant species: *Betula pendula* Roth; *Epilobium angustifolium* L.; *Deschampsia cespitosa* ssp. *cespitosa* (L.) Beauv.; *Deschampsia flexuosa* (L.) Trin.; *Erigeron annuus* (L.) Pers. ssp. *annuus*; *Festuca supina* Schur;

Hieracium alpinum L.; *Juncus bufonius* L.; *Larix decidua* Mill. ssp. *carpatica* (Domin) Siman; *Luzula luzuloides* (Lam.) Dandy et Wilmott; *Picea abies* (L.) H. Karst.; *Salix caprea* L.; *Salix cinerea* L.; *Sorbus aucuparia* L.; *Vaccinium myrtillus* L.; *Vaccinium vitis-idaea* L.

The projection in an horizontal plane ilustrate the next distribution of the vascular plants (Fig. 2). The surface of the sample plot is 100 sq. m. Date: 27th of July, 2007

C. The waste dump deposit **Puturosul**: there is a surface of ca 100 sq. m of planted with white birch (*Betula pendula*) and Norway spruce (*Picea abies*). The age of the plants are of ca 10 years. The height of the juvenile trees is between 30 and 80 cm. Their vegetation state is a moderately one. The coverage of the spontaneous vegetation is around of 10%. The field is plane. The local coordinations are: N 47°06'68.8"; E 25°14'43.6"; altitude: 1551 m.

Vascular flora of this sterile deposit is edified by the next plant species: *Betula pendula* Roth; *Epilobium angustifolium* (L.) Holub.; *Deschampsia cespitosa* (L.) Beauv. ssp. *cespitosa*; *Deschampsia flexuosa* (L.) Trin.; *Festuca supina* Schur; *Luzula luzuloides* (Lam.) Dandy et Wilmott; *Picea abies* (L.) H. Karst.; *Rubus idaeus* L.; *Salix caprea* L.; *Vaccinium myrtillus* L.; *Vaccinium gaultherioides* Bigelow; *Vaccinium vitis-idaea* L.

The projection in an horizontal plane ilustrate the next distribution of the vascular plants (Fig. 3). The surface of the sample plot is 100 sq. m. Date: 27th of July, 2007.

D. The waste dump deposit **Ilva**: there is a surface of ca 100 sq. m of planted mugo pine (*Pinus mugo*) and Norway spruce (*Picea abies*). The age of the plants are of ca 10 years. The height of the juvenile trees is between 30 and 70 cm. Their vegetation state is a moderately one. The coverage of the spontaneous vegetation is around of 20%. The field is plane. The local coordinations are: N 47º06'30''; E 25º13'17.7'' E; altitude: 1741 m.

Vascular flora of this sterile deposit is edified by the next plant species: *Alchemilla subcrenata* Buser; *Anthoxanthum odoratum* L.; *Athyrium filix-femina* (L.) Roth; *Betula pendula* Roth; *Botrychium lunaria* (L.) Sw.; *Calamagrostis villosa* (Chaix) J. F. Gmel.; *Campanula patula* L. ssp. *abietina* (Griseb.) Simonk.; *Campanula rotundifolia* L. ssp. *polymorpha* (Witasek) Tacik; *Carex curta* Good.; *Cerastium fontanum* Baumg. ssp. *fontanum*; *Epilobium angustifolium* L.; *Cystopteris montana* (Lam.) Desv.; *Deschampsia cespitosa* ssp. *cespitosa* (L.) Beauv.; *Deschampsia flexuosa* (L.) Trin.; *Festuca rubra* L.; *Festuca supina* Schur; *Gnaphalium sylvaticum* L.; *Hieracium alpinum* L.; *Hieracium aurantiacum* L.; *Hieracium pilosella* L.; *Homogyne alpina* (L.) Cass.; *Huperzia selago* (L.) Bernh. ex Schrank & Mart.; *Juncus trifidus* L.; *Juniperus communis* L. ssp. *alpina* (Suter) Čelak.; *Luzula campestris* (L.) DC.; *Luzula luzuloides* (Lam.) Dandy et Wilmott; *Luzula sylvatica* (Huds.) Gaudin; *Lycopodium clavatum* L.; *Minuartia verna* (L.) Hiern.; *Nardus stricta* L.; *Picea abies* (L.) H. Karst. (planted); *Pinus mugo* Turra (planted); *Populus tremula* L.; *Potentilla aurea* L. ssp. *chrysocraspeda* (Lehm.) Nyman; *Rumex alpinus* L.; *Salix caprea* L.; *Salix cinerea* L.; *Scleranthus uncinatus* Schur; *Taraxacum officinale* Weber; *Thymus pulegioides* L.; *Trifolium repens* L.; *Tussilago farfara* L.; *Vaccinium myrtillus* L.; *Vaccinium vitis-idaea* L.; *Vicia cracca* L.

The projection in an horizontal plane ilustrate the next distribution of the vascular plants (Fig. 4). The surface of the sample plot is 100 sq. m. Date: 27th of July, 2007.

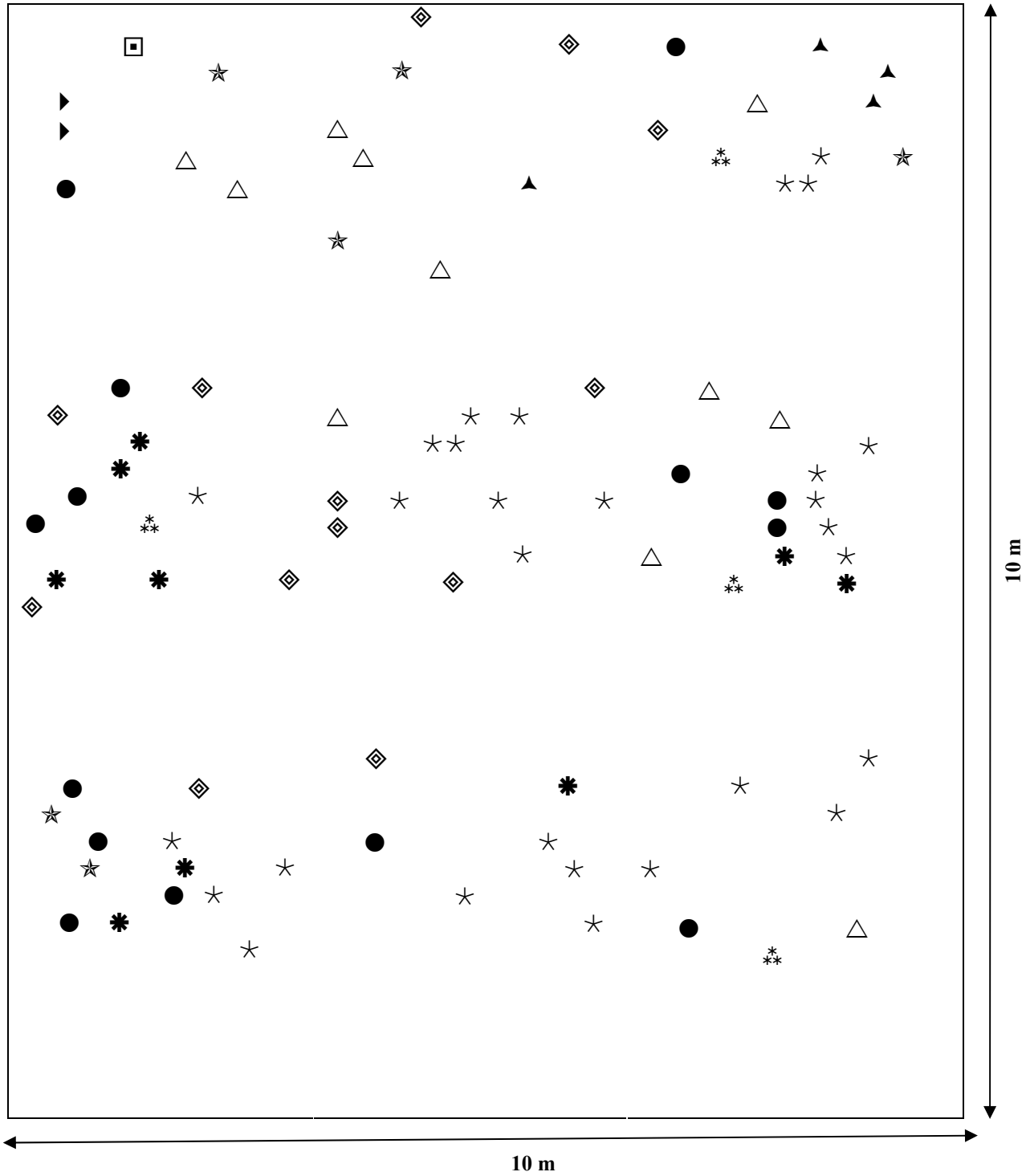

Fig. 3: The distribution of the vascular plant species on Puturosul waste dump deposit

Legend:

- ❋ - *Festuca supina*
- ✶ - *Deschampsia flexuosa*
- ▲ - *Salix caprea*
- ⊡ - *Pinus mugo*
- ⁂ - various species of bryophytes
- △ - *Picea abies*
- ✯ - *Vaccinium myrtillus*
- ◗ - *Vaccinium gaultherioides*
- ◈ - *Betula pendula*
- ● - *Agrostis capillaris*

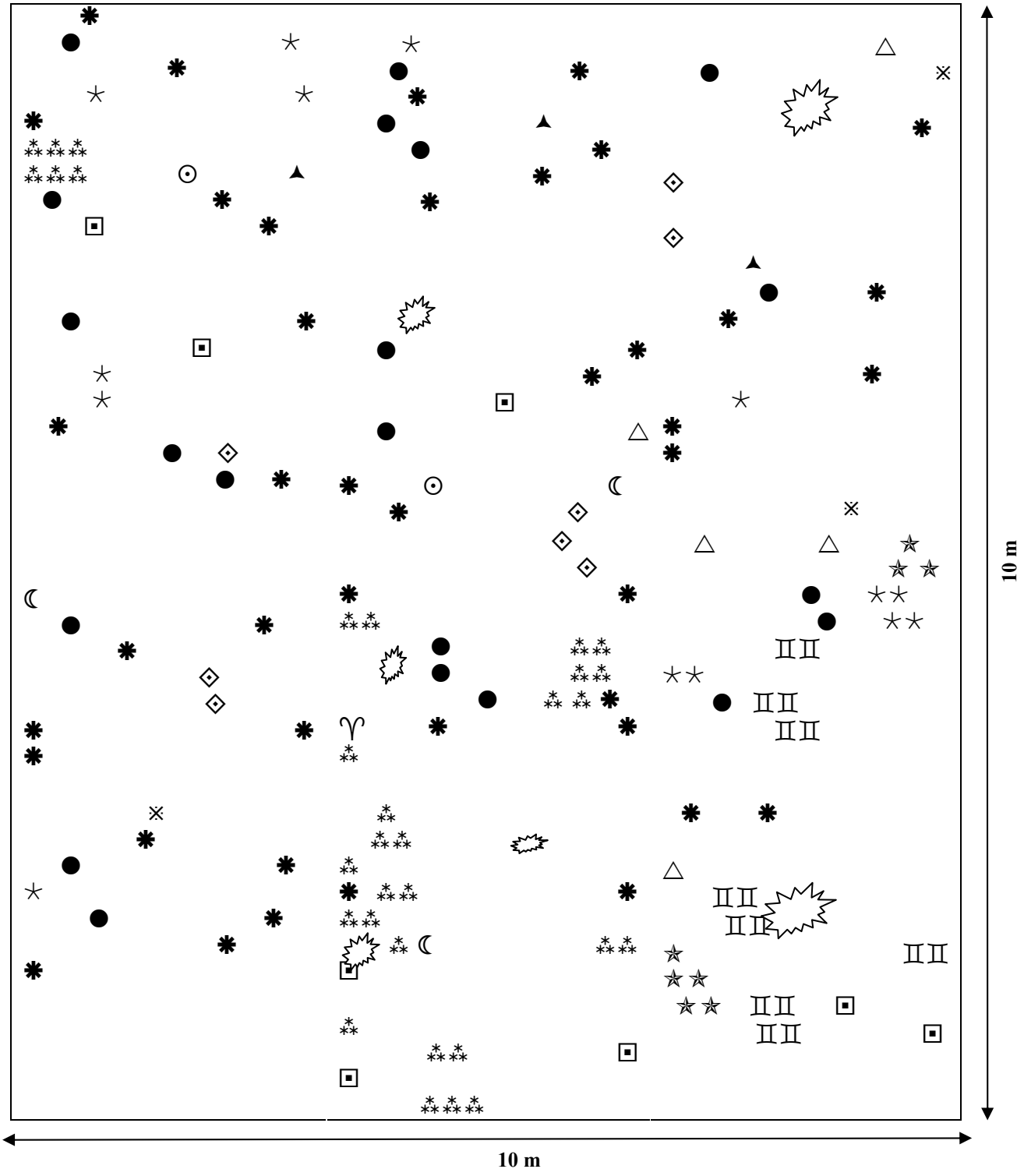

Fig. 4: The distribution of the vascular plant species on Ilva waste dump deposit

Legend:

- ❋ - *Festuca supina*
- ✶ - *Deschampsia flexuosa*
- ⊙ - *Potentilla aurea* ssp. *chrysocraspeda*
- ▲ - *Salix caprea*
- ⊡ - *Pinus mugo*
- ⁂ - various species of bryophytes
- ☾ - *Luzula luzuloides*
- △ - *Picea abies*
- ⟐ - *Scleranthus uncinatus*
- ※ - *Lycopodium clavatum*
- ♈ - *Hieracium alpinum*
- ✯ - *Vaccinium myrtillus*
- ♊ - *Deschampsia cespitosa* ssp. *cespitosa*
- ● - *Agrostis capillaris*
- rocks

On the same Ilva waste dump deposit, we were able to make only three relevées, which can be ascribed to the association *Deschampsietum caespitosae* Hayek et Horvatic 1930 (*Deschampsion* Horvatic 1930, *Deschampsietalia* Horvatic 1958, *Molinio-Arrhenatheretea* R. Tx. 1937). Those phytocoenoses are situated on the Western part of that site, in the inferior part of the sterile deposit, on a slope of ca 40º declivity (Tab. 1).

Having in mind that the sterile has been stored over there 20 years ago, we think the installation of the spontaneous vegetation (with coverage till 70% in some places) is a very important step in colonizing those degradated fields in the former sulphur and iron ores from Călimani Mountains.

Table 1: Structure of ass. *Deschampsietum caespitosae* Hayek ex Horvatic 1930

Surface (sq. m)	100	25	25
Coverage (%)	20	40	70
Aspect	-	W	W
Slope (º)	-	40	40
Altitude (m)	1741	1735	1738
Relevé no.	1	2	3
Car. ass.			
Deschampsia cespitosa ssp. cespitosa	2	3	4
Phyteumo – Trisetion			
Deschampsia flexuosa	+	+	+
Luzula luzuloides	+	+	-
Arrhenatheretalia			
Luzula campestris	+	-	+
Taraxacum officinale	-	-	+
Molinio - Arrhenatheretea			
Anthoxanthum odoratum	+	-	-
Festuca rubra	+	+	-
Cerastium fontanum ssp. fontanum	-	+	+
Juncetea trifidi			
Juncus trifidus	+	-	-
Festuca supina	+	1	+
Hieracium alpinum	+	+	-
Potentilla aurea ssp. chrysocraspeda	+	-	-
Hieracium aurantiacum	-	-	+
Loiseleurio – Vaccinietea			
Juniperus communis ssp. alpina	+	-	-
Vaccinium myrtillus	+	+	-
Vacinium vitis-idaea	1	+	-
Vaccinio – Piceetea			
Picea abies (juv.)	+	+	+
Campanula patula ssp. abietina	-	+	+
Pinus mugo	+	+	-
Lycopodium clavatum	+	-	-
Calamagrostis villosa	-	-	1
Epilobietea angustifolii			
Epilobium angustifolium	-	+	+
Aliae			
Salix caprea	+	+	-
Scleranthus uncinatus	+	-	-
Tussilago farfara	-	-	+
Minuartia verna	-	-	+
Salix cinerea	-	+	+
Populus tremula (juv.)	-	+	-

Date : 27th of July, 2007

Conclusions

The higher diversity, in terms of the presence of vascular plant species, has been registered on Dumitrelul sterile deposit (47 vascular plant species).

Concerning the plant layout on the four sterile dump deposits, one can observe a quite unevenly one; in general, the majority of individuals has an isolated distribution (e.g. the case of *Trifolium repens*, *Salix caprea*, *Vaccinium myrtillus*, *Hieracium alpinum*, *Alchemilla subcrenata*, *Epilobium angustifolium*, *Vaccinium gaultherioides* and so on).

Other few plant species have a clumped distribution on the surveyed areas (e.g. *Deschampsia flexuosa*, *Deschampsia cespitosa* ssp. *cespitosa* here and there, *Agrostis capillaris*, and so on).

The most significant part belong to the species *Festuca supina*, with its cluster dispersion on; thus, it has a very important part as the first colonizing plants on the sterile dump deposits in the Călimani Mountains.

The waste dump deposit Dumitrelul has the best coverage with plant communities, both from the number of plant species as well as the density of the individuals. The less covered with spontaneous vegetation is the waste dump deposit Pinului.

Taking into account that those sterile deposits lies on actual placement for 20 years, we think that the installation of primary vegetation represent the first and very important stage in the colonization with vegetation of the degraded areas from the former sulphur exploitation area.

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ASPECTE ALE INSTALĂRII VEGETAŢIEI PE HALDE DE STERIL DIN PARCUL NAŢIONAL CĂLIMANI (CARPAŢII ORIENTALI)

(Rezumat)

Haldele de steril sunt cele mai extinse forme de relief antropic prezente pe versantul nordic al Masivului Călimani, care au apărut în urma dislocării şi strămutării unor cantităţi imense de material terigen odată cu activităţile miniere de exploatare a sulfului şi fierului, desfăşurate între anii 1965 şi 1997. Calitatea solului şi a vegetaţiei au suferit importante schimbări cauzate de produsele toxice rezultate în diferitele faze ale procesului tehnologic.

Ca rezultat al activităţilor miniere, vegetaţia şi în special unele specii rare de plante (*Alnus viridis*; *Larix decidua* ssp. *carpatica*, taxon ameninţat la nivel global; *Rhododendron myrtifolium* şi *Pinus cembra*, specii ameninţate din Lista Roşie Naţională) au fost afectate puternic din cauza despăduririlor, depozitării sterilului şi deversării de ape încărcate toxic.

Cu cca. 10 ani în urmă au fost efectuate încercări de replantare a perimetrelor respective cu diverse specii lemnoase. Aceste plantaţii experimentale arată faptul că unele specii de provenienţă indigenă (*Picea abies, Pinus cembra, Larix decidua* ssp. *carpatica, Pinus mugo, Sorbus aucuparia*) pot conduce la rezultate relativ bune şi predictibile în timp.

Investigaţiile au urmărit refacerea comunităţilor vegetale din suprafeţe de probă stabilite pe haldele Dumitrelul, Puturosul, Pinul şi Ilva. Instalarea vegetaţiei primare reprezintă un prim şi foarte important pas, în colonizarea cu vegetaţie a terenurilor degradate de activităţile miniere. Vegetaţia primară este reprezentată de fitocenoze edificate de, *Festuca supina, Agrostis capillaris* şi *Deschampsia cespitosa* ssp. *cespitosa,* ca specii dominante, celelalte specii identificate având frecvenţă redusă în suprafeţele de probă.

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