

Early vegetation succession on lignite mine spoils of Ptolemaida, Greece.

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Abstract. The reclamation of environment at the lignite spoil heaps of Ptolemaida is composite and difficult due to the adverse ecological conditions. The soil of the spoil heaps was heterogeneous with many unfavorable physicochemical properties. The phytosociological analysis was done at 48 microplots, permanent for two consequent years. With the assistance of indicator plant-groups, seven plant communities were distinguished which differ among them by vegetation composition and soil type. The natural vegetation was very heterogeneous and only in small areas it could be used for further analysis of the site. None of the dominant species presented more than 80% stability. The average drought species, which appeared in areas of replaced topsoil, were increasing their population by time. Plant community represented from *Calamagrostis epigejos*, could be seen in a small marl area and remained constant for both years. Plant community represented from *Vaccaria pyramidata*, appeared in spots all over the spoil area in locations with high fly ash content and it may be an indicator of dry, calcareous and infertile areas.

Keywords: Vegetation succession; Rehabilitation; Indicator plant; Lignite spoil; Phytosociology.

INTRODUCTION

Lignite is the most important energy resource for the electric power production in Greece. However, the different lignite mining activities create peculiar problems. Except the environmental pollution from fly ash, dust, toxic or radioactive substrates and noises, one of the biggest problems that lignite mining creates is the destruction of large productive areas, habitat of many species and the creation of an unattractive landscape.

Lignite spoils are occupying large areas and the reclamation of them is a necessity. The mining consequences for the environment are more, especially because those areas are managed without appropriate planning and become useless. The Public Electric Company, which is responsible for the reclamation of the area, did not manage to store the surface soil and replace it after the end of the excavation. The advantages of topsoil replacement are arising mainly because of the presence of seeds and roots of the local natural vegetation and also because of the high percentage of organic matter in it (Gene and Samuel, 1979; Farmer et al., 1982). The high species diversity and the high percentage of soil cover, protect the soil from erosion, and increase the productivity of the planted species (Chambers et al., 1987). However, this advantage may turn in disadvantage when the replaced topsoil includes many weed seeds in it and the growing weeds are competing the desirable planted species (Andersen et al., 1992).

Many researchers have studied the role of natural revegetation and forest establishment on the spoils some years before their conversion to agricultural lands (Alexander, 1989; Wade, 1989; Panagopoulos, 1995^a). The establishment of natural vegetation and reforestation help to cover and stabilize the soil (Warman, 1988), to start microbiological activity (Cundell, 1977; Parmenter et al., 1985), to decrease the high surface soil temperatures (Helgerrson, 1990), to speed up soil genesis (Gonzalez et al., 1991; Panagopoulos and Hatzistathis, 1995) and generally impose the physical and chemical properties of the spoils soil, thus agricultural cultivation and grazing can be reestablished to these areas 20-30 years after reclamation (Warren and Topping, 1999).

Microorganisms and soil fauna are important factors in surface-mine reclamation and in many cases are vital parameters for the survival and growth of most plants and generally for the reestablishment of the natural ecosystems (Johnson and West, 1989; Lobry de Bruyn, 1999). Spoil soils are not completely free of microorganisms, but fewer species in smaller amounts are found (Fresquez et al., 1986; 1987). With the establishment of vegetation on the spoils the number of microorganisms start to increase, while some species will be artificially introduced by inoculation (Marx, 1991). Duration of perturbation of vegetation and microbial communities and processes in soil do not return to equilibrium for more than 10 years after a crude oil spill, 4-6 weeks after pesticide application and 50-100 years following strip mining (Lal and Stewart, 1990; Pakeman et al, 1997).

Soil characteristics with similar vegetation associations were shown to be reasonable autochthonous indicators of soil degradation and rehabilitation (Boerner et al., 1998; Paniagua et al., 1999). Bioindicator-based studies have the potential to make a major contribution to optimize different reclamation systems and to influence policies governing landscape management and transformation (Paoletti, 1999).

The vegetation of the Ptolemaida valley corresponds to the submediterranean vegetation zone of *Quercetalia pubescentis* (Athanasiadis, 1986). The main forest species planted in the area were *Pinus nigra* v. *pallasiana*, *P. nigra* v. *corsicana*, *Pinus brutia*, *Robinia pseudoacacia*, *Cupressus arizonica*, *C. sempervirens* and *Cedrus atlantica*, and wheat, corn, sugar beet and livestock forage were grown by farmers. Diamantopoulos (1985) mention that species composition on the spoils depends on the age of the spoil. *Chenopodiaceae* species dominate on newly-established spoils (2 years old) while *Compositae* species were more common on older spoils; *Leguminous* species found generally on younger and herbaceous species on older spoils (17 years old). This study examines the early succession of natural vegetation on rehabilitated lignite mine spoils in Ptolemaida and its relationship to soil characteristics.

MATERIAL AND METHODS

Study area. The lignite mines studied are located in the west area of Macedonia-Greece near the city of Ptolemaida, in a valley between the Vermio and Siniatsiko mountains, at

latitude 40° 30' North and longitude 22° East of Greenwich. The mean average altitude is 667.5m. The valley is rich in lignite, with six active lignite mines in the area. Fourteen electricity-generating plants produce more than 75% of Greece's electric power. Until recently, of the 12,500 affected by mining only 400ha were rehabilitated and by the year 2025, it is estimated that the area affected by mining will be 20,000ha.

The climate of the area is continental Mediterranean with very hot and dry summers and mild winters. Average annual precipitation is 551.26mm (35 years of record) with a maximum monthly average in November (68.19mm) and a minimum in August (27mm). The average annual air-temperature is 12.26°C with coldest month January (1.76°C) and warmer July (22.5°C). The absolute maximum air temperature during the research period was 41°C and the absolute minimum air temperature was -21°C.

Wind direction is principally Northwest (38.7%) and Southeast (24.4%) with slow to medium velocity. Cloudy days were 56% as average. From the meteorological data provided by the Ptolemaida National Meteorological Service frost (minimum air temperature <0°C), appears on average 74 days per year. Severe frost (maximum air temperature <0°C) appears as average 10 days per year. The average relative air humidity was 62.5%. The dry period starts at the end of June and finishes in September.

The spoils are generally consisted from the materials that arise after the extraction of lignite which are the surface layer of the soil before the mining began, the overburden of the lignite layers mixed together with bad quality lignite and lignite gasification ashes (fly ash). The new soils that arise from this mixture are heterogeneous, unstable and unconsolidated, without humus and soil horizons and with a high pH and low compaction. Soil analyses showed that the new soils are poor in nutrients and with some toxic elements (Panagopoulos, 1995^b). The color of the soil was between light gray (7/1 10YR) and black (2/1 10YR). Soil temperature is another indicator of the ecological status of an area and an important soil property. In the lignite spoils of Ptolemaida was generally high, presenting the highest values at bare black colored areas.

Methods. For the phytosociological study were established 48 sampling areas of 1 m², permanent for two years on a spoil in which soil preparation for reclamation activities terminated 3 years before and forest species establishment finished 6 months before. Plant samples were collected between 25 of May and 10 of June for both years. For every sampling area the Braun-Blanquet method was used (Athanasiadis, 1986) and soil type, percentage of soil cover by plants and plant vitality were also measured.

Species identification was done using the Flora Europea of Tutin et al., (1964-1980) and the assistance of the Pictured Botanical-Phytological Lexicon (Kavadas, 1956-1964), Flora d' Italia (Pignatti, 1982) and Forest Botany of Athanasiadis (1985). The collected plant samples were stored in the laboratory of silviculture at the department of Forestry and Natural Environment at Aristotle University of Thessaloniki. The names of the species are based in Flora Europea.

Phytosociological units were separated with criteria based on species physiognomy, ecology, flora and evolution (Athanasiadis, 1986). The method based on ecology and flora is

assisting better on the target of the study, which was the ecological description of the separated communities that will arise from the plant-table process. In the present research, the systematic determination of phytosociological units was not studied. Specifically, the plant communities were defined with the method of the comparative process and the construction of phytosociological units tables. The separation of the plant communities was done with the help of the indicator plant groups. This method is based on the presence or absence of specific groups.

The method used by the present study was not based on the characteristic or differential species, but on the combination of the indicator groups that were appearing in the phytosociological units (Dafis, 1966 based on Ellenberg, 1956; 1962). In the same group were included all the species with the same or similar ecological behavior. The ecological description of the separated plant communities was done with the help of the ecological properties of the indicator groups. The disadvantage of this method was that the separated communities had value only for the study of the research area and they cannot be used for larger areas without additional process.

The method of the school Zürich-Montpellier (Athanasiadis, 1986 based on Braun-Blanquet, 1951; 1964) was used for the plant table process. First was constructed the initial table with sampling areas and species in the order they were collected. In the second table sampling areas remain as they where, but species were written with appearance ascending order. In third table, species remained as they where but sampling areas were placed depending on their botanical relationship. In forth table, species were placed in groups with appearance ascending order. After continuous table process the indicator plant groups were separated.

RESULTS AND DISCUSSION

Determination of the phytosociological units. Phytosociological units were determined with the help of the indicator plant groups. After the plant-table process, 6 indicator plant groups were separated in the 1st year table of species sampling (Table 1) and 5 indicator plant groups in the 2nd year table (Table 2). The ecological description of those groups was done bibliographically after an "on site" research (Bazzaz, 1975; Dafis and Smyris, 1981; Zagas, 1990; Theodoropoulos, 1991; Ellenberg et al., 1992).

Group A. Constant in both years with average drought species. Those species appear in infertile, clay soils, with relatively high salinity, pH 8 and in relatively worm environments. The characteristic species of this group were: *Melilotus officinalis*, *Medicago lupulina*, *Cichorium endivia*, *Medicago coronata*, and *Dasyphyrum villosum*.

Group B. Constant in both years with higher number of species in the second sampling year. This group had species of average humid areas, indicators of fertile soil with normal moisture and pH 7-8. The characteristic species of this group were: *Bilderdykia convolvulus*, *Carduus sp.*, *Centaurea cf. depressa* and *Rumex crispus*.

Group C. Appearing only in the table of the 1st year. Include drought species, with large ecological adaptation, developing in medium fertile soil with pH 8 and warm environments. The characteristic species of this group were: *Tragopogon dubius* and *Reseda lutea*.

Group D. Constant in both years. Includes species of average drought, with large ecological adaptation, growing in warm environments and average fertile soil with pH 7-8. The characteristic species of this group were: *Sonchus arvensis*, *Crepis foetida*, *Lappula squarrosa*, *Elymus repens* and *Crepis pulchra*.

Group E. Constant in both years. The characteristic species of this group (*Calamagrostis epigejos*) can be seen in humid and cool environments, in soil of average fertility and pH 7-8.

Group F. Appearing only in the table of the 1st year. Include drought resistant species, growing in warm environments and soils with poor fertility and pH 9. The characteristic species of this group was: *Vaccaria pyramidata*.

Group G. Appearing only in the table of the 2nd year. Include drought resistant species, expanding in warm environments with fertile soils and pH 7-8. The characteristic species of this group were: *Crepis pulchra*, *Avena barbata* and *Linaria genistifolia*.

Description of the determined phytosociological units. With the above indicator plant groups were made the keys for the determination of the phytosociological units. Tables 3 and 4 show the range of the group appearance in the phytosociological units where those groups belong. From the coverage of the group appearance, it can be seen that the drought group A is limited in areas where clay topsoil was spread on the spoil. The average drought group B is decreasing as the soil fertility decrease. The groups C and D were increasing by time, with the first to develop in more infertile areas and the second in fertile soils with high percentage of lignite. Indicator group E appears as a spot in a small part of the spoil where marl was the dominant element and surface soil temperature was lower due to lighter soil color, while the F appears in small spots all over the spoil in areas where fly ash was the dominant material (fly ash pH was higher than 9). Finally the group G become visible always to areas adjacent to group D, but in spots where lignite was significantly higher.

Phytosociological unit E₁ (constant for both years). Indicator plant group (d). This unit appeared in areas affected from topsoil that exists in a depth of more than 30cm and covered with lignite spoils. Soil was fertile and pH varied between 7.5-8. The forest species planted at the specific area had fast growth, while the few dead trees noted in the area were caused from the high soil surface temperatures. Natural vegetation was covering the soil between 40 and 50% and with its shadow assisted in the survival of the new established forest species. Dominant species of this unit were: *Bromus tectorum*, *Tussilago farfara*, *Isatis tinctoria* and *Carduus thoermeri*. Indicator value for this community had only the species *Bromus sterilis*, *Crepis foetida* and *Lappula squarrosa* of group D, but because its representation in the table was minor it is recorded with small letter between parenthesis. This plant community was characterized by the absence of any other indicator groups.

Phytosociological unit E₂ (constant for both years). Indicator plant groups A(c) for 1st and A(d) for 2nd year. This unit appears in areas affected from topsoil. That soil had clay loam texture, pH 8-8.5 and high content of Na⁺ (0.5-0.6meq/lit). The forest species planted in that area had low growth and survival. The soil was compacted and waterlogged. Hydraulic conductivity and air porosity were lower than in the other soil types of the spoil. Soil cover by natural vegetation was less than 50%. Dominant species of this unit were: *Tussilago farfara*, *Bromus tectorum*, *Bromus squarrosus*, *Sonchus asper* and *Artemisia vulgaris*. Indicator value for this community had all the species of group A, *Tragopogon dubius* and *Reseda lutea* of group C and *Elymus repens* of group D. This plant community was characterized from its stability in both sampling years. *Melilotus officinalis* appears in compacted, clay and salty soils (Kavadas, 1956-1964) and *Sonchus asper* is resistant in high soil salinity as noted by Ellenberg et al. (1992).

Hatzistathis (1989) mention that, in many mines, the stockpiled topsoil is poor in nutrients, with acid reaction and high percentage of clay. When these soils are placed on a spoil are easily compacted from heavy machinery and create an unfavorable soil condition for plant growth. Iverson and Wali (1982) mention that when the stockpiled topsoil was stored for long period of time, great number of seeds and microorganisms is lost. More research is needed in the Ptolemaida area to determine if the topsoil which has been applied to some spoils is better than the mixed cast overburden, or if a part of the overburden can be used as a topsoil with improved results. Many coal mining areas have adequate natural soils for use as revegetation media, but in some other areas it is more difficult and less desirable to use natural topsoil than alternative spoil materials (Roberts *et al.*, 1988). Ashby and Kolar (1985) found that in many cases, mined land covered with surface soil materials had limited plant growth, in part because soil was compacted from traffic by earth-moving machinery and also because mixed cast overburden was superior to replaced surface materials in porosity, pH and nutrient reserves.

Phytosociological unit E₃ (for 1st year). Indicator plant groups (a)B. This unit become visible in areas affected from topsoil mixed with marl, lignite and fly ash. Soil was loamy with pH between 7 and 8. The forest species planted in the area had good growth and survival. Dominant species of this unit were: *Tussilago farfara*, *Bromus tectorum*, *Lappula squarrosa*, *Verbascum speciosum* and *Rumex crispus*, but indicator value had only the species *Bilderdykia convolvulus* and *Cichorium endivia*. Main characteristic of this plant community was its relationship with group A species, fact that became more clear in the second year.

Phytosociological unit E₃ (for 2nd year). Indicator plant groups ab(d). Developing in the same area as E₃ of 1st year, with dominant species: *Tussilago farfara*, *Bromus tectorum*, *Carduus thoermeri*, *Isatis tinctoria* and *Centaurea solstitialis*. Indicator value for this plant community had the species *Cichorium endivia* (group A), *Centaurea cf. depressa*, *Bilderdykia convolvulus* and *Carduus* sp. (group B), *Elymus repens*, *Lappula squarrosa* and *Crepis foetida* (group D), but with minor representation in the table so they were recorded with small letter. This plant community was the intermediate stage between E₂ and E₄ and *Cichorium endivia* was increasing its presence by time.

Phytosociological unit E₄ (1st year). Indicator plant groups (a)Cd. The soil of the area where the community was developing had well mixed all of the spoil materials with higher content of fly ash and marl. Texture was sandy loamy and pH was varying between 7 and 8. Dominant species of this unit were: *Tussilago farfara*, *Bromus tectorum*, *Bromus squarrosus*, *Lappula squarrosa*, *Cirsium arvense*, *Carduus thoermeri*, *Isatis tinctoria*, *Sonchus asper* and *Centaurea solstitialis*, but indicator value had the species *Cichorium endivia* (group A), *Tragopogon dubius* and *Reseda lutea* (group C) and *Crepis foetida* (group D).

Phytosociological unit E₄ (2nd year). Indicator plant group B. The characteristics of the area where this community was appearing were the same as E₃ of 1st year. Dominant species of this plant community were: *Tussilago farfara*, *Bromus tectorum*, *Bromus squarrosus*, *Cirsium arvense*, *Carduus thoermeri* and *Isatis tinctoria*.

Phytosociological unit E₅ (1st year). Indicator plant groups (c)D(f). This community was a developing on soil that was a mixture of all spoil materials. Texture was loamy and pH was varying between 7 and 8. The forest species planted in the area had good growth and survival. Dominant species of this unit were: *Tussilago farfara*, *Bromus tectorum*, *Bromus squarrosus* and *Lactuca serriola*, but indicator value for this plant community had the species of group D and *Tragopogon dubius* of group C and *Vaccaria pyramidata* of group F.

Phytosociological unit E₅ (2nd year). Indicator plant group D. This community was developing in soil that was a mixture of all spoil materials. Dominant species of this unit were: *Tussilago farfara*, *Bromus tectorum* and *Reseda lutea*.

Phytosociological unit E₆ (1st year). Indicator plant group (d)F. This community become visible in soil similar to E₅ unit but in spots where fly ash content was high and, as consequence, pH was higher than 9. Dominant species of this plant community were: *Tussilago farfara*, *Bromus tectorum* and *Cirsium arvense*, but indicator value had only the species *Crepis foetida* (group C) and *Vaccaria pyramidata* (group F). Kavadas (1956-1964) mentioned that *Vaccaria pyramidata* grows in calcareous soils, while Ellenberg et al. (1992) cited that this species is an indicator of dry and infertile soils with pH 9. Fly ash may increase soil fertility but it may cause deficiencies of some essential plant nutrients (Anguissola Scotti et al., 1999). Those species may be used as bioindicators of low quality zones and soil improvement of those areas should be done before reforestation.

Phytosociological unit E₆ (2nd year). Indicator plant group (b)DG. Appeared in soil similar to E₅ but in spots where lignite and topsoil were higher. The forest species planted in that area had low growth and high survival. Seedling growth was low due to high competition from natural vegetation, but survival rate was high due to shadowing effect of almost total soil cover that kept low surface soil temperatures during summer. Dominant species of this plant community were: *Bromus squarrosus*, *Isatis tinctoria*, *Sonchus asper*, *Bromus arvensis*, *Tragopogon dubius* and *Bromus tectorum*, but indicator value had the species *Carduus sp.* (group B), *Crepis foetida*, *Lappula squarrosa*, *Elymus repens* (group D) and *Crepis pulchra*, *Avena barbata*, *Linaria genistifolia* (group G). Those species may be used as bioindicators of

good quality zones on the lignite spoils and forest species density could be lower on the establishment.

Phytosociological unit E₇. Indicator plant group E(f) for 1st and E for 2nd year. This unit comes into view in areas of marl soil with loamy clay texture. Soil surface temperatures were lower than in the other sites of the spoil because soil color was white. The forest species planted in that area had low growth and high survival. Dominant species of this community were: *Tussilago farfara*, *Lappula squarrosa*, *Lactuca serriola*, *Carduus thoermeri* and *Bromus tectorum*. Indicator value had the species *Calamagrostis epigejos* which is increasing its presence with time and *Vaccaria pyramidata* which appears in spots around the area of *Calamagrostis epigejos*. Natural vegetation cover was less than 20%, but the forest species planted in that area had higher rate of survival because the lighter soil color did not permit high surface soil temperatures.

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Table 1. Phytosociological units and indicator plant groups at the 1st year, resulting from the combination of the sampling areas following the Braun-Blanquet method.

Sampling No	12 30 29 18	1 2 3 4 5 6	8 7 15 16 17	10 13 14 23 48 36 24 26 20 21 22 25 27 19 42 40 38	41 44 43 45 46 37 39	47 28 35 11 9	32 34 33 31
Cover (%)	40 50 50 40	40 40 30 30 50 50	70 50 60 50 60	60 70 40 70 50 50 60 50 60 80 50 60 30 40 40	60 40 50 80 50 70 40	50 30 50 70 60	10 20 20 20
No of species/sample	7 9 12 9	13 10 11 10 12 12	9 12 11 9 10	14 13 11 11 7 9 7 10 11 13 8 11 8 10 6 7 7	14 9 14 14 9 12 9	9 7 8 11 10	4 5 10 9
	2	3	4	5	6	7	8
<i>Medicago coronata</i>		1° + 1° + 1	1		1		
<i>Dasypyrum villosum</i>		2 + + + r					
<i>Medicago lupulina</i>		r + + +					
<i>Melilotus officinalis</i>		r + r r r +					
<i>Cichorium endivia</i>		1 1 1* + 1 +	1	+ 1 1 1	1		
<i>Bilderdykia convolvulus</i>			+ 1 1 + 1		1		
<i>Reseda lutea</i>		1 +	+	1 + 2 1 1		1	
<i>Tragopogon dubius</i>		1° 1		1 1 1 + 2 1 1 1	1 1		
<i>Crepis foetida</i>				+ + 1 + + + 1° + + 1 +	2 1 1 2 1 1	2	+
<i>Elymus repens</i>		+ 1		1	2 1 2* 1		
<i>Crepis pulchra</i>			r		+ + 1 +		
<i>Bromus sterilis</i>	+ +		+ +		+ + + +		+
<i>Sonchus arvensis</i>			r		+ + + +		
<i>Calamagrostis epigejos</i>							1 + + 1
<i>Vaccaria pyramidata</i>		1 +	+		1 1	1 1 1 1 1	r° r°
<i>Tussilago farfara</i>	1 + 1 1	1 1 + 1 2	1 3 3	2 1 + 1 + 1 1 2 1 2* 3 4* 1 1* 1 2	1 1° 1 1*	1 1 2 3	+ 1
<i>Bromus tectorum</i>	2 3	2 1 + 1	+ 1 +	2 1 2 1 1 1 1 r r r 1 1 + + 1	1 1 1 1	2 + +	+
<i>Lappula squarrosa</i>	+ +	1 + +	1* r + r	1 1 + + + r 1	1 r 1 + + 2		+ +
<i>Bromus squarrosus</i>		1 r r + r	1 + 1	+ + 1 1 1 1 + r	1 r 1 r	+ 1	
<i>Cirsium arvense</i>	+ 2	1 + 1	1 2	+ 1 2 + 1 1 3 1 + 1	1	1 + 2*	
<i>Lactuca serriola</i>	1 + +	1	+ + r	r + + 1 + +	+ 1 + 1	+ + +	+ +
<i>Papaver rhoeas</i>	+ 1* +	+ r	+ + +	r 1 + r	r	r° + r	r r r
<i>Carduus thoermeri</i>	1		1° 1	2 1 1 1 1 + 1 2 +	1	+ 1	1 1
<i>Isatis tinctoria</i>	1 1	+ 1	1	1 + 1 1 + 2	1	1 1	
<i>Sonchus asper</i>	1 1	1	1	1 + + 1 r 1*	+ +	+ 1	1
<i>Bromus arvensis</i>	1 +	r	1* +	1 r	+ + r	r	
<i>Lactuca virosa</i>	+ 1		2	r 1	1 +	1	+
<i>Conyza canadensis</i>				+ r	r	r r	
<i>Crepis agrestis</i>			+	+ +	+ + +		
<i>Fumaria vaillantii</i>			r		+ +	r°	+ +
<i>Centaurea solstitialis</i>				1 2 1	+ +		1
<i>Avena barbata</i>	r			r r	r +		
<i>Cirsium ligulare</i>	1	2*	1 1	1			
<i>Diplotaxis muralis</i>		+		+ +		+ + +	
<i>Taraxacum officinale</i>				1 1 1		1 +	
<i>Sonchus oleraceus</i>				+ 1		+ +	1
<i>Centaurea cf. depressa</i>		+	+	1 1			
<i>Lepidium campestre</i>				1		1	+
<i>Bupleurum rotundifolium</i>		r		r r			
<i>Carduus tmoleus</i>	1			1		2	2
<i>Carduus sp.</i>				1		2	
<i>Convolvulus arvensis</i>			1	1		1	
<i>Erysimum diffusum</i>			r	+			+ 1
<i>Polygonum arenarium</i>			1	1			1
<i>Sisymbrium irio</i>	1					1 1	
<i>Centaurea salonitana</i>				1 2*			
<i>Rumex crispus</i>	1		2				
<i>Artemisia vulgaris</i>		2*	1				
<i>Cardaria draba</i>			+ +				
<i>Diplotaxis tenuifolia</i>		1	+				
<i>Verbascum speciosum</i>			3			2	
<i>Achillea millefolium</i>						+ +	
<i>Amaranthus blitoides</i>						+	
<i>Astragalus glycyphylloides</i>			2				
<i>Camelina rumelica</i>	1						
<i>Chenopodium album</i>					r		
<i>Chondrila juncea</i>	r				r		
<i>Crepis vesicaria</i>					r		
<i>Daucus carota</i>		r					
<i>Erodium moschatum</i>					r		
<i>Juglans regia</i>						1	
<i>Erysimum sylvestri</i>							r
<i>Linaria genistifolia</i>					r		
<i>Lotus corniculatus</i>			r				
<i>Malus sylvestris</i>			1				
<i>Populus nigra</i>						2	
<i>Robinia pseudacacia</i>						2	
<i>Sanguisorba minor</i>		+					
<i>Scorzonera cana</i>					1		
<i>Setaria viridis</i>						2	
<i>Solanum nigrum</i>	1						
<i>Stachys recta</i>						r	
<i>Vicia villosa</i>							
<i>Xanthium strumarium</i>		1					

Table 3. Appearance of plant indicator groups in the phytosociological units that were separated at the 1st year (the darker the color the stronger the appearance, minor representations in the table were recorded with small letter and insignificant representations were placed under parenthesis).

Indicator groups	Phytosociological units						
	E ₁	E ₂	E ₃	E ₄	E ₅	E ₆	E ₇
A		■	▨	▨	▨		
B			■				
C		▨		■	▨		
D	▨	▨	▨	■	■		
E							■
F					▨	■	▨
	(d)	A(c)	(a)B	(a)Cd	(c)D(f)	(d)F	E(f)

Table 4. Appearance of plant indicator groups in the phytosociological units that were separated at the 2nd year (the darker the color the stronger the appearance, minor representations in the table were recorded with small letter and insignificant representations were placed under parenthesis).

Indicator groups	Phytosociological units						
	E ₁	E ₂	E ₃	E ₄	E ₅	E ₆	E ₇
A		■	■				
B			■	■		▨	
D	▨	▨	▨	▨	■	■	
G						■	
E				▨			■
	(d)	A(d)	ab(d)	B	D	(b)DG	E