Biodiv. Res. Conserv. 24: 29-38, 2011

DOI 10.2478/v10119-011-0024-8

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The influence of surrounding vegetation on the flora of post-mining area

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Abstract: In 2007, extensive botanical studies were carried out in the Gagaty Sołtykowskie Reserve (Małopolska Upland, southern Poland) to compile comprehensive flora inventories – separately for a post-mining area and the surrounding forest. The main aim of the study was to assess the influence of the surrounding vegetation on the flora of a former ceramic clay mine located in the middle of a dense forest. The results show that over 30 years after closure, the former mine is now home to several valuable and protected species of vascular plants, with the rate and direction of succession determined mainly by the surrounding vegetation. Because ruderal species have no direct access to the area, non-synanthropic, indigenous species are dominant in the Gagaty Sołtykowskie Reserve (GS).

Key words: post-mining area, clay mine, succession, surrounding vegetation

1. Introduction

Post-mining landscapes have been the subject of extensive botanical studies for several years. The studies mainly aim at defining the direction and rate of succession (Schultz & Wiegleb 2000; Hüttl & Weber 2001; Wiegleb & Felinks 2001a, 2001b). In Poland, post-mining flora and vegetation were studied mainly in Upper Silesia (Sieradzki 1998; Kołodziejek 1999, 2001), Central Poland (Siciński & Sieradzki 2009) and Świętokrzyska Land (Podgórska 2010). One of the most important results of botanical studies conducted in post-mining areas was the useful insight into the importance of these areas for the protection of biodiversity and valuable species of vascular plants (Abresch *et al*. 2000).

Because of considerable transformations of land within a small area, post-mining landscapes are characterised by extraordinary habitat heterogeneity and, thus, also biodiversity (Antwi *et al*. 2008). If the areas are not recultivated after discontinuation of mining operations, they become regions of primary succession where phytocoenoses are formed as a result of distribution of propagules from other phytocoenoses (Faliński 1986). The dynamics and direction of succession depend mainly on the surrounding vegetation, soil characteristics and nutrient availability (e.g. Hillier 1990; Lavorel *et al*. 1994; Hobb & Mooney 1995; Crawley 2004; Prach & Rehounkova 2006).

Field studies were carried out in the Gagaty Sołtykowskie (GS) Reserve (Małopolska Upland, southern Poland), which is located in a dense forest complex. The main aim of this study was to determine the impact of the surrounding vegetation on the flora of post-mining sites. The following hypothesis was tested: a forest is a kind of ecological barrier which limits propagation of synanthropic species to strongly transformed areas, thus the flora of the post-mining area surrounded by woodlands is characterized by a high level of naturalness.

In order to verify this hypothesis, the authors examined the following tasks: (*i*) the inventory of vascular plants in the GS Reserve; (*ii*) the indication of plant species which colonized the post-mining area; (*iii*) estimation of the succession stage in 34 years after discontinuation of the mineral excavation; (*iv*) estimation of the importance of the post-mining area for rare and protected species conservation.

According to the physico-geographical division of Poland, the area is located in Małopolska Upland subprovince, Kielce Upland macroregion, Suchedniów Plateau (Kondracki 2002). In geological terms, the reserve is located within the Mesozoic margin of the Świętokrzyskie Mountains (Soja 2003), characterised

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by numerous outcroppings of Triassic and Jurassic acid sedimentary rocks.

GS geological reserve is located in the north-western part of the Świętokrzyskie Mountains, in Stąporków forest district, Końskie administrative district (Świętokrzyskie Voivodeship). The reserve was established by the Ordinance of the Minister of Natural Environment, Natural Resources and Forestry on July, the 25th 1997. Its area is 13.33 ha. It was created to protect Lower Jurassic rock projections and interesting mineralogical and paleontological pieces.

Southern part of the reserve is the former ceramic clay open cast mine, closed in 1977 – approximately 200 m wide and 300 m long pit with Lower Jurassic clays and silts with sandstone inserts, iron carbonate minerals – siderite and jet i.e. rare bituminous coal of characteristic conchoidal fracture (Ryka & Maliszewska 1991). The name of the reserve is derived from the Polish word "gagat" – meaning jet which is found in large numbers here. In the past, the stones were used to produce mourning jewellery (Ryka & Maliszewska 1991). Central part of the reserve has been profoundly transformed by human activity. The landscape is dominated by waste dumps, landslides and a small non-outlet area which is always filled with water. The reserve, apart from post-mining surfaces whose area extends over 9.2 ha, also includes a narrow strip of vast upland coniferous forests which are part of a big, dense forest (Fig. 1). Forest phytocoenoses cover a total of 30.8% of the reserve area. The distance from the nearest houses and open farming land is 1 km.

GS Reserve is known all over the world because of numerous dinosaur signs (e.g. dilophosaurus and sauropoda) and traces of their nests and eggs found here (Karaszewski & Kopik 1970; Pieńkowski & Gierliński 1987; Gierliński 1991; Gierliński & Pieńkowski 1999; Gierliński *et al*. 2001, 2004; Gierliński & Niedźwiedzki 2002; Niedźwiedzki & Niedźwiedzki 2004; Niedźwiedzki 2006). Ichnofossils (plant roots) and invertebrate trace fossils were discovered here as well (Karaszewski & Kopik 1970; Wegierek & Zherikin 1997; Pieńkowski & Niedźwiedzki 2009; Pieńkowski & Uchman 2009). Geological studies were conducted by Heflik *et al*. (2001) and Pieńkowski (1991, 2009) and paleobotanical studies by Wcisło-Luraniec (1991), Ziaja (1991, 2006) and Reymanówna (1991).

No extensive floristic studies have been conducted in the reserve before. Fragmentary data were reported by Bróż & Przemyski (1981, 1983, 1987, 1989), Podgórska (2005, 2007a, 2007b), Maciejczak (1988).

2. Material and methods

Field studies were carried out from spring to autumn 2007 and involved compiling a comprehensive inventory of the reserve flora divided into forest and post-mining areas. Then, the two types of flora were compared. The species affiliation to sociologic and ecologic

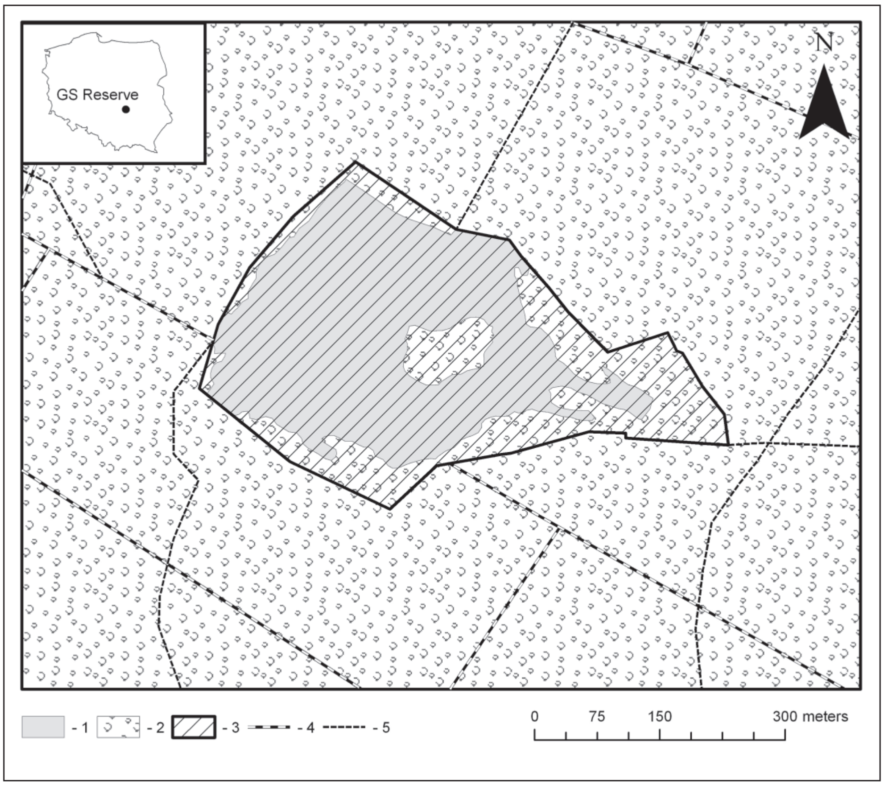

Fig. 1. The location of the study area
Explanations: 1 – post-mining area, 2 – forest, 3 – GS Reserve, 4 – borders of forest section, 5 – forest roads and paths

groups (Chmiel 2006), Raunkiaer's life forms (Zarzycki *et al*. 2002) and geographic and historic groups (Chmiel 2006) was analyzed. On the basis of species affiliation to geographic and historical groups, the naturalness index (NI) (number of non-synanthropic indigenous species/number of all species) and the anthropophytisation index (AI) (number of anthropophytes/number of all species) were calculated (Jackowiak 1990; with changes of Chmiel 2006). Habitat acidity, trophy and humidity were also determined based on ecological indicators (Zarzycki *et al*. 2002).

Latin names of species were given after Mirek *et al.* (2002), Latin names of families after Rutkowski (2006), and phytosociological affinity after Matuszkiewicz (2005). Legally protected species were defined in accordance with the Regulation of the Minister of Natural Environment of 09 July 2004 on wild species of plants under protection. Threatened and endangered species for the Świętokrzyskie region were listed after Bróż & Przemyski (2009) and for Poland – after Zarzycki and Szeląg (2006). Invasive species were determined after Tokarska-Guzik (2009).

3. Results

The total of 204 vascular plant taxa was discovered in the test area, out of which 125 were present only in the post-mining area, 9 – only in the surrounding forest ecosystem and 70 taxa were present in both areas within the reserve (Appendix 1). The species found within the reserve were members of 50 families and 136 genera. Most numerous families included: Astereaceae, Poaceae, Cyperaceae and Fabaceae (27, 25, 16 and 16 species, respectively). As many as 22 families were represented by only one species.

The investigations carried out in the GS Reserve allowed identification of 16 species protected, rare and threatened either in the entire territory of Poland (Zarzycki & Szeląg 2006) or in Malopolska Upland (Bróż & Przemyski 2009) (Table 1) Most of them (10 taxa) were present only in the transformed area, *Convallaria majalis* was present only within non-transformed forests and the remaining 4 species (*Daphne mezereum*, *Frangula alnus*, *Lycopodium annotinum* and *L. clavatum*) were present in both areas.

The affinity of the species to sociological and ecological groups was analysed. The species described belonged to 13 units. The most numerous group (13%) comprised species of acid oak mixed forests (Fig. 2) which dominated both within the forest and post-mining area species. The latter area was abundant in humid and marsh habitat species which were scarce in the surrounding forest.

Hemicryptophytes strongly dominated in the studied area – they comprised as much as 60% of all species (Fig. 3). They covered the biggest part of both the post-mining area and the surrounding forest.

The performed analysis of plant species affiliation to geographic and historic groups within the reserve demonstrated that it was dominated by non-synanthropic indigenous species (41%) (Fig. 4). The least numerous groups were archaeophytes (*Matricaria maritima* ssp. *inodora*, *Sonchus asper*, *Vicia villosa*) and kenophytes (*Chamomila suaveolens*, *Conyza canadensis*, *Epilobium ciliatum*, *Lupinus polyphyllus*, *Picea abies*) which were present only in the post-mining landscape. Based on the number of species from individual geographic and historic groups, the NI and AI indices were determined (Table 2). Index values determined for post-mining areas and the surrounding forest were not significantly different.

Table 1. Protected and threatened plant species in the GS Reserve

Name of species	Conservation status[1]	Threatened category	
		Małopolska Upland[2]	Poland[3]
Centaurium erythraea	SP	-	-
Convallaria majalis	PP	-	-
Dactylorhiza maculata	SP	VU	V
Dactylorhiza majalis	SP	-	-
Daphne mezereum	SP	-	-
Drosera rotundifolia	SP	NT	V
Euphrasia nemorosa	-	EN	R
Frangula alnus	PP	-	-
Glyceria declinata	-	CR	-
Hieracium lactucella	-	EN	-
Lycopodium annotinum	SP	-	-
Lycopodium clavatum	SP	-	-
Ononis arvensis	PP	-	-
Pedicularis sylvatica	SP	VU	-
Utricularia vulgaris	SP	-	-

Explanations: [1] – based on the Regulation of the Minister of Natural Environment of 09 July 2004 on wild species of plants under protection, SP – strictly protected, PP – partially protected; [2] – based on Bróż & Przemyski (2009), EN – endangered, CR – critically endangered, VU – vulnerable, NT – near threatened; [3] – based on Zarzycki & Szeląg (2006), R – rare, V – vulnerable

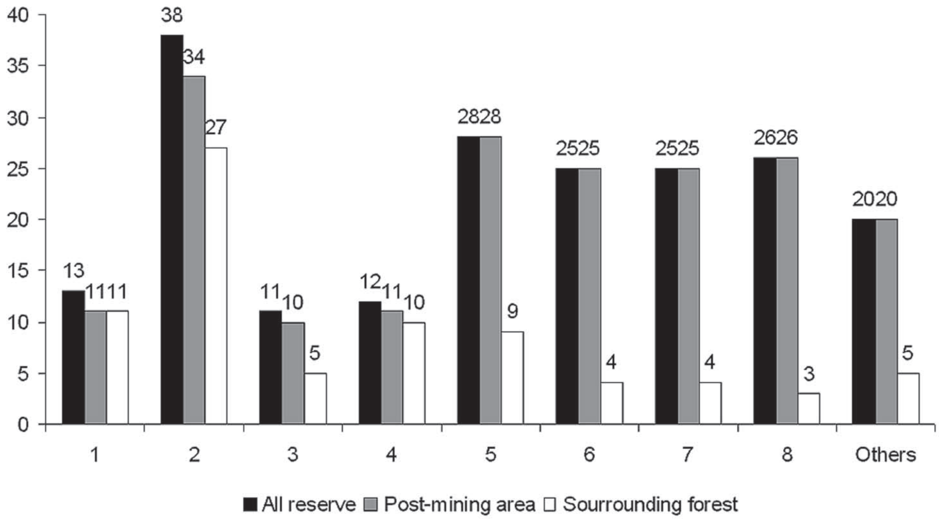

Fig. 2. Number of species in individual sociological and ecological groups

Explanations: 1 – rich deciduous forests, brakes and tall herb fringe communities, 2 – acid oak mixed forests and their substitutive clearing, meadow and grassland communities, 3 – thermophilous oak forests, thermophilous tall herb fringe communities and xerothermic grassland communities, 4 – pine forests and their substitutive ruderal psammophilic vegetation and carpet psammophilic communities, 5 – alder swamp forests, low, transitional and high tree-less peat bogs, 6 – riparian forests and brakes, riparian herbaceous plants and riparian tall herb fringe communities, rush and aquatic communities, 7 – humid grassland and herbaceous plants, as well as wet pastureland communities, 8 – fresh and moderately humid grassland and pastureland

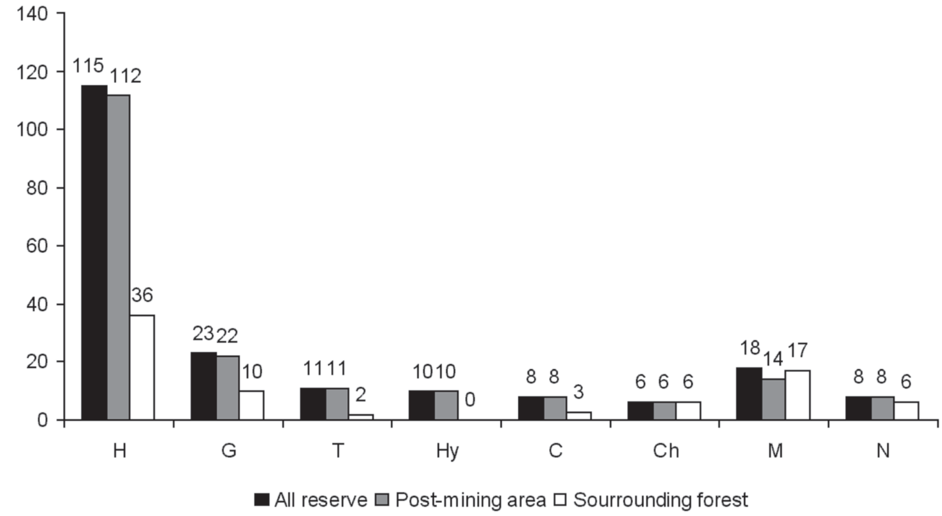

Fig. 3. Number of species of individual life-forms as per Raunkiaer

Explanations: H – hemicryptophytes, G – geophytes, T – therophytes, Hy – hydrophytes, C – herbaceous chamaephytes, Ch – arboreous chamaephytes, M – megaphanerophytes, N – nanophanerophytes

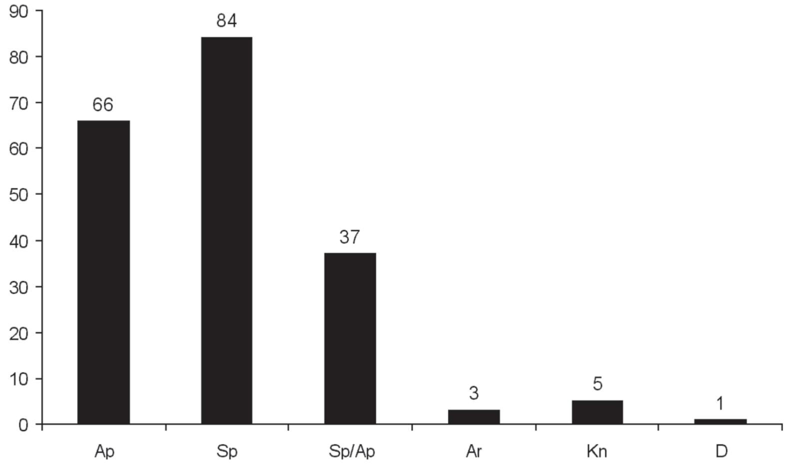

Fig. 4. Species per individual geographic and historic groups

Explanations: Ap – apophytes, Sp – non-synanthropic indigenous species, Sp/Ap – semi-synanthropic indigenous species, Ar – archaeophytes, Kn – kenophytes, D – diaphytes

Table 2. Floristic indices (based on the Chmiel's formula, 2006) for the Gagaty Sołtykowskie Reserve

Floristic indices	Whole reserve	Post-mining area	Surrounding forest
NI (nonsynanthropic indigenous species / all species)	42.86	41.27	39.16
AI (anthropophytes / all species)	4.59	4.23	3.09

Table 3. Habitat conditions in the Gagaty Sołtykowskie Reserve based on floristic indices

Habitat conditions			Number of species	Mean values of index
Feature of habitat		Range of index		
soil acidity	acidic	1-2.5	16	3.75
	moderately acidic	3-3.5	63	
	neutral	4-4.5	111	
	alkaline	5	9	
trophy	poor	1-2.5	28	3.34
	mesotrophic	3-3.5	106	
	rich	4-5	66	
soil moisture	dry	1-2.5	29	3.66
	fresh	3-3.5	90	
	moist	4-4.5	48	
	wet	5-6	27	
light value	shade	1-2.5	15	3.88
	half-shade	3-3.5	38	
	moderate light	4-4.5	116	
	full light	5	31	

Explanations: soil acidity values, 1 – highly acidic (pH<4), 2 – acidic (4≤pH<5), 3 – moderately acidic (5≤pH<6), 4 – neutral (6≤pH<7), 5 – alkaline (pH>7); soil trophy values, 1 – extremely oligotrophic, 2 – oligotrophic, 3 – moderately poor (mesotrophic), 4 – eutrophic, 5 – extremely fertile; soil moisture values, 1 – very dry, 2 – dry, 3 – fresh, 4 – moist, 5 – wet, 6 – aquatic; light value, 1 – deep shade, 2 – moderate shade, 3 – half-shade, 4 – moderate light, 5 – full light

The analysis of ecological indicators (Table 3) revealed that the biggest group of species comprised plants with preference for neutral (54%) and mesotrophic base (52%) and moderately sunny exposure (57%).

4. Discussion

Pits are formed as a result of intensive mining when production waste is not returned. These places are often over humidified – either because of scarce land permeability or because of high groundwater levels. Like all cavities, they have specific microclimate involving ground frost and weak air circulation. Plant succession rate and direction in such conditions is dependent on many factors. The rate is particularly affected by the type of rock bed, shape and geometric parameters of a pit, climate as well as the location and type of the surrounding vegetation (Hillier 1990; Lavorel *et al.* 1994; Hobb & Mooney 1995; Crawley 2004; Prach & Rehounkova 2006; Witt 2006). Overgrowing in areas like that is very quick. With susceptible land like clay, silty and carbonate rocks, vegetation appears as quickly as after 2 years and quickly overgrows the whole area (Paulo 2008). The above was confirmed by the studies conducted in the pit of GS geological reserve. 34 years after mining operations were discontinued, vegetation succession was quite advanced as demonstrated, for instance, by the analysis of the number of individual life-forms accordding to Raunkiaer's scheme. Like in many other pits (Młynkowiak & Kutyna 1999; Koszelnik-Leszek & Kasowska 2009), also in the studied pit hemicryptophytes were found strongly dominant (61%). Geophytes also constituted quite a big group (11%). The number of megaphanerophytes (9%) was of considerable importance here. Massive invasion of light seeded trees such as *Betula pendula*, *Populus tremula* and forest-forming species i.e. *Pinus sylvestris* was observed. Advancement of succession was also confirmed by the results of ecological indicator analysis. The biggest group of species included those that favour moderate sun exposure, neutral and mesotrophic base. Earlier stages were dominated by relatively small organisms that prefer direct sunlight and low trophy base (Krajewski 2009).

The most important local factors influencing the direction of spontaneous vegetation succession are: water level, soil pH and structure, vicinity of forests, grasslands and arable land, favourable winds and droppings of birds and rodents (Paulo 2008; Řehounková & Prach 2006). In the case of the examined reserve, the impact of the surrounding vegetation communities was easily noticed. The area was located within a relatively big forest, mostly composed of pine and fir trees, which prevented invasion of plants from other habitats. This was well confirmed by the obtained results. According to Balcerkiewicz *et al*. (1985), apophytes (67%) are strongly dominant in different types of pits among historic and geographic floristic groups. Another characteristic feature is a low number of spontaneophytes (15%) and anthropophytes (18%) (Balcerkiewicz *et al*. 1985). In the case of the examined GS Reserve, some differences were discovered. First of all, non-synanthropic indigenous species were the most numerous group (43%) followed by apophytes (34%) and semi-synanthropic indigenous species (19%). Anthropophytes were the least numerous (below 4.5%) (Fig. 3). Flora composition was strongly influenced by the existing migration barrier, i.e. the forest, as mentioned above and also most likely by the lack of seed bank for semi-natural and anthropogenic habitats. Moreover, it was also important that the pit was the area of natural vegetation succession and no recultivation was undertaken. In the event of recultivation, expansive plant species are involuntarily introduced and may, within a very short time, invade post-industrial areas (Szarek-Łukaszewska & Grodzińska 2007). Similar conclusions were drawn for studies in limestone quarries in Bohemian Karst, Czech Republic (Tropek *et al*. 2010), where unrecultivated quarries were characterised by a high number of rare species of arthropods and plants.

Among sociological and ecological groups, species of acid oak mixed forests and their substitutive clearing, meadow and grassland communities were most numerous. Also in sand, aggregate and gravel pits the community group mentioned above was mostly dominant (Młynkowiak & Kutyna 1999). This group of species was dominant both within the post-industrial zone and in the surrounding forests in the GS Reserve. The above showed that the surrounding vegetation was a decisive factor when it came to the post-mining area flora.

The available literature provides a few examples of protected and rare plant species in post-mining areas (Kołodziejek 2001; Czylok *et al*. 2008). It seems that at present, the most valuable surfaces of this type are located within strongly degraded mining areas. This is due to the fact that once the works were finished, people were not able to adapt the areas to new functions such as farming and, therefore, in the course of the ensuing succession, unique biocenotic relations were created (Molenda 2005; Czylok *et al*. 2008). Biological diversity of newly formed habitats may, in certain cases, be higher than that of the original habitat (Molenda 2005). They often are so valuable that they are assigned a protection status. An example of this phenomenon is Świnia Góra strict reserve. The area used to serve as an open cast mine of iron ore (between 17th and the beginning of the 19th century) (Barański 1959; Olaczek 2008). The reserve was created to protect natural, multi-storey mixed tree stands specific for the Świętokrzyska Forest (Kopeć *et al*. 2011).

Bottoms of former sand-pits are the most valuable of all former work areas (Błońska 2010). Gagaty Sołtykowskie geological reserve is home to plants which are protected and rare – both in Poland and in the region (Appendix 1). Anthropogenic, mining-related areas may thus become replacement niches in the degraded areas.

5. Conclusions

- Post-mining areas that were protected in the GS Reserve for over 30 years underwent spontaneous succession.
- Post-mining areas and the surrounding forest are dominated by species belonging to the same historic and geographic groups – non-synanthropic indigenous species and sociological and ecological groups – acid mixed oak forests. Advancement of succession and a strong impact of the surrounding forests on the direction and rate of natural, dynamic processes were confirmed.
- 1 km wide forest ring surrounding the former clay mine from all sides effectively prevented distribution of propagules from anthropogenically transformed habitats and, therefore, the quality of post-mining area flora is quite high.
- Surrounding vegetation is one of the main determinants of the species composition found in the post-mining area. The dense forest complex limits propagation of synanthropic species from the outside. Therefore, flora of strongly transformed areas is similar to the flora of the surrounding woodland vegetation.
- Post-mining landscapes that underwent natural succession became home to many precious and protected vascular plant species.
- Spontaneous succession of the post-mining areas, which are surrounded by natural or semi-natural vegetation leads to colonization of these areas by valuable species of vascular plants. Such areas should not undergo reclamation, which can disturb spontaneous succession.

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Appendix 1. List of vascular plant species found in the Gagaty Sołtykowskie Reserve divided into three groups: 1 – occurring only in the post-mining area, 2 – occurring only in the forest area, 3 – occurring in two separate areas (1 & 2)

1. Group of post-mining area species: *Agrimonia eupatoria* L., *Agrostis canina* L., *A. capillaris* L., *A. stolonifera* L., *Alchemilla monticola* Opiz, *Alisma plantago-aquatica* L., *Alopecurus geniculatus* L., *Anthoxanthum odoratum* L., *Artemisia vulgaris* L., *Barbarea vulgaris* R. Br., *Bellis perennis* L., *Bidens tripartita* L., *Calla palustris* L., *Caltha palustris* L., *Campanula patula* L., *Cardamine pratensis* L., *Carex canescens* L., *C. demissa* Hornem., *C. echinata* Murray, *C. flava* L., *C. hirta* L., *C. nigra* (L.) Reichard., *C. ovalis* Gooden., *C. pallescens* L., *C. panicea* L., *C. rostrata* Stokes, *Carlina vulgaris* L., *Centaurea jacea* L., *Centaurium erythraea* Rafn, *Cerastium holosteoides* Fr. em. Hyl., *Chamomilla suaveolens* (Pursh) Rydb., *Cirsium arvense* (L.) Scop., *C. palustre* (L.) Scop., *Comarum palustre* L., *Conyza canadensis* (L.) Cronquist, *Dactylorhiza maculata* (L.) Soó, *D. majalis* (Rchb.) P. F. Hunt et Summerh., *Danthonia decumbens* (L.) DC, *Daucus carota* L., *Drosera rotundifolia* L., *Eleocharis palustris* (L.) Roem. et Schult., *Epilobium ciliatum* Raf., *Equisetum arvense* L., *E. fluviatile* L., *E. palustre* L., *Erigeron acris* L., *Eriophorum angustifolium* Honck., *E. latifolium* Hoppe, *Euphrasia nemorosa* (Pers.) Wallr., *Festuca rubra* L., *Filipendula ulmaria* (L.) Maxim., *Galium palustre* L., *Glyceria declinata* Breb., *G. fluitans* (L.) R. Br., *Helianthemum nummularium* (L.) Mill., *Hieracium lactucella* Wallr., *Holcus lanatus* L., *Juncus articulatus* L. em. K. Richt., *J. bufonius* L., *J. bulbosus* L., *J. conglomeratus* L., *J. effusus* L., *Lathyrus pratensis* L., *Lemna minor* L., *Leontodon autumnalis* L., *L. hispidus* L., *Leucanthemum vulgare* Lam. s. str., *Lotus corniculatus* L., *L. uliginosus* Schkuhr, *Luzula multiflora* (Retz.) Lej., *Lychnis flos-cuculi* L., *Lycopus europaeus* L., *Lysimachia thyrsiflora* L., *Lythrum salicaria* L., *Matricaria maritima* ssp. *indora* (L.) Dostal, *Melilotus alba* Medik., *Myosotis palustris* (L.) L. em. Rchb., *Nardus stricta* L., *Ononis arvensis* L., *Pedicularis sylvatica* L., *Phalaris arundinacea* L., *Phragmites australis* (Cav.) Trin. ex Steud., *Plantago lanceolata* L., *P. major* L. s. str., *Poa annua* L., *P. compresa* L., *P. palustris* L., *Polygala vulgaris* L., *Potamogeton natans* L., *Potentilla anserina* L., *Prunella vulgaris* L., *Ranunculus acris* L., *R. flammula* L., *R. repens* L., *Rhinanthus alectorolophus* (Scop.) Pollich, *Rumex crispus* L., *R. longifolius* DC., *Salix aurita* L., *S. pentandra* L., *S. purpurea* L., *Sanguisorba minor* Scop. s. str., *Saponaria officinalis* L., *Scorzonera humilis* L., *Sonchus asper* (L.) Hill, *Sparganium emersum* Rehmann, *Stellaria graminea* L., *S. holostea* L., *S. uliginosa* Murray, *Taraxacum officinale* F. H. Wigg., *Trientalis europaea* L., *Trifolium alpestre* L., *T. arvense* L., *T. hybridum* L., *T. pratense* L., *T. repens* L., *Typha angustifolia* L., *T. latifolia* L., *Utricularia vulgaris* L., *Valeriana simplicifolia* Kabath, *Veronica chamaedrys* L., *V. scutellata* L., *V. serpyllifolia* L., *Vicia cracca* L., *V. villosa* Roth, *Viola palustris* L.

2. Group of surrounding forest species: *Abies alba* Miller, *Astrantia major* L., *Carpinus betulus* L., *Convallaria majalis* L., *Larix decidua* Mill., *Orthilia secunda* (L.) House, *Picea abies* (L.) Karsten, *Sanicula europaea* L., *Viola riviniana* Rchb.

3. Group of species occurring in two separate area (1 & 2): *Achillea millefolium* L., *Aegopodium podagraria* L. *Ajuga reptans* L., *Alnus glutinosa* (L.) Gaertner, *Anemone nemorosa* L., *Anthriscus sylvestris* (L.) Hoffm, *Astragalus glycyphyllos* L., *Betula pendula* Roth., *B. pubescens* Erhr., *Calamagrostis canescens* (Weber) Roth, *C. epigejos* (L.) Roth, *Calluna vulgaris* (L.) Hull, *Campanula persicifolia* L., *Carex elongata* L., *C. remota* L., *Chamaenerion angustifolium* (L.) Scop., *Daphne mezereum* L., *Deschampsia ceaspitosa* (L.) P. Beauv., *Equisetum sylvaticum* L., *Festuca gigantea* (L.) Vill., *F. ovina* L., *Fragaria vesca* L., *Frangula alnus* Mill., *Genista tinctoria* L., *Hieracium laevigatum* Willd., *H. murorum* L., *H. pilosella* L., *H. umbelatum* L., *Hypericum perforatum* L., *Juniperus communis* L., *Lupinus polyphyllus* Lindl., *Luzula pilosa* (L.) Willd., *Lycopodium annotinum* L., *L. clavatum* L., *Lysimachia nummularia* L., *L. vulgaris* L., *Maianthemum bifolium* (L.) F. W. Schmidt, *Malus domestica* Borkh., *Melampyrum sylvaticum* L., *Melica nutans* L., *Moerhingia trinervia* (L.) Clairv., *Molinia caerulea* (L.) Moench, *Mycelis muralis* (L.) Dumort., *Oxalis acetosella* L., *Padus avium* Mill. *Peucedanum palustre* (L.) Moench, *Pimpinella saxifraga* L. s. str., *Pinus sylvestris* L., *Poa nemoralis* L., *P. trivialis* L., *Populus nigra* L., *P. tremula* L. *Potentilla erecta* (L.) Raeusch., *Pteridium aquilinum* (L.) Kuhn, *Quercus petraea* (Matt.) Liebl., *Q. robur* L., *Rosa canina* L., *Rubus idaeus* L., *Salix caprea* L., *S. cinerea* L., *S. fragilis* L., *Scirpus sylvaticus* L., *Solidago virgaurea* L., *Sorbus aucuparia* L. em. Hedl., *Tanacetum vulgare* L,. *Trifolium campestre* Schreb., *Tussilago farfara* L., *Vaccinium myrtillus* L., *V. uliginosum* L., *V. vitis-idea* L.