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FOREST COMMUNITIES IN THE KUŹNICA WARĘŻYŃSKA SAND-PIT

ZESPOŁY LEŚNE PIASKOWNI KUŹNICA WARĘŻYŃSKA

Key words: sand-pits, ecological reclamation, spontaneous succession, forest communities, numerical methods.

Summary: The forest communities, which developed on the reclaimed areas of the Kuźnica Warężyńska sand-pit (Silesian Upland), approximate in reference to floristic composition *Querco roboris-Pinetum*. It occurs from 14 to 45 species in patches. The participation of character species of the *Vaccinio-Piceetea* class is relatively low and species from other phytosociological units such as *Molinio-Arrhenatheretea* class appear more frequently and abundantly. The phytocoenoses show significant differentiation which reflects moisture and trophic conditions, so two subassociations were distinguished: wet *Querco roboris-Pinetum molinietosum*, which is distinguished by wet meadow species, peat-bog plants and rush species and drier *Querco roboris-Pinetum* typicum with the participation of psammophilous species of the *Koelerio-Corynephoretea* class. The method [Krzaklewski, 1999], including in reclamation works plant communities, which develop during natural succession, increases success for re-establishment of self-regulating ecosystems and let create mosaic of plant communities, sometimes very interesting from the scientific point of view and valuable for biodiversity conservation.

Słowa kluczowe: piaskownie, rekultywacja, metoda sukcesji kierowanej, zbiorowiska leśne, metody numeryczne.

Streszczenie: Fitocenozy leśne, które wykształciły się na objętych rekultywacją obszarach piaskowni Kuźnica Warężyńska (Wyżyna Śląska) są zbliżone pod względem fitosocjologicznym do boru mieszanego *Querco roboris-Pinetum*. Poszczególne płaty buduje od 14 do 45 gatunków. Udział gatunków charakterystycznych klasy *Vaccinio-Piceetea* jest stosunkowo niewielki, natomiast większe znaczenie mają gatunki przechodzące z innych klas zbiorowisk roślinnych. Płaty wykazują zróżnicowanie odzwierciedlające panujące warunki wilgotnościowe i troficzne, dzięki czemu możliwe było wydzielenie na tym terenie dwóch podzespołów: wilgotnego *Querco roboris-Pinetum molinietosum*, którego fitocenozy wyróżniają gatunki wilgotnych łąk, torfowisk czy też zbiorowisk szuwarowych oraz suchszego z udziałem gatunków psammofilnych z

klasy *Koelerio-Corynephoretea*. Zastosowana na tym terenie obok całkowitego zalesiania, metoda sukcesji kierowanej [Krzaklewski i in. 1999], włączająca do procesu rekultywacji, zbiorowiska pochodzące z naturalnej sukcesji zwiększa szanse na odtworzenie się w pełni funkcjonalnych ekosystemów oraz pozwala na wytworzenie mozaiki zbiorowisk roślinnych często interesujących i wartościowych z punktu widzenia ochrony bioróżnorodności.

INTRODUCTION

In the silesian voivodeship occur 5700 ha of lands which are classified as degraded or devastated [Ochrona Środowiska, 2003]. Some of them were created by open-cast mining which in this region was connected mainly with exploitation of coal-mine. According to Polish law [Forest land and farmland Act 3.02.1995, Environment Conservation Act of 27.04. 2001] disturbed lands should undergone reclamation works. The basis for reclamation of worked-out sand-pits are: a kind of habitat and its granulometric compositions, bottom's configuration and the depth of the ground water table [Greszta i Skawina, 1965]. The open-casts are reclaimed mainly for forest (3600 ha) or agriculture use (500 ha) or they are used as water reservoirs (3000 ha) [Krzaklewski, 2001]. There were carried out some investigations on the sand-pits dealing with succession of vegetation and trials for their habitat factors which should be taken into account during preparation and conducting reclamation [Paprzycki i Jaromin, 1956]. Some scientists started to apply method, which enables to include in reclamation works plant communities, which develop during natural succession [Krzaklewski, 1999, 2001].

STUDY AREA

The „Kuźnica Warężyńska" sand-pit is localised in the middle part of the Czarna Przemsza Valley in the Dąbrowska Basin (The Silesian Upland) [Gilewska, 1963]. It belongs to the eastern region of sand deposits' location in the Upper Silesian Industrial District [Polak i Staniek, 1966].

Before the exploitation started they had grown mainly coniferous forests, rarely oak-hornbeam forest and riverside carrs. Rushes, meadows and peat-bog communities developed in wet places [Aparta, 1984]. The ground water table was situated at a depth of 1 to 6.5 m. The area was covered mainly by podsolic, pseudopodsolic soils. In the river terrain's alluvial muck soil on peat soil, half-bog soils and alluvial soils occurred [Aparta, 1984].

The pit was founded in 1963 year and the mining works started in 1967 year. Now 870 ha of the „Kuźnica Warężyńska" area are occupied by working and working-out open-casts. As a result of mining works changes were made to many components of the environment (water, land surface, soils, climate, fauna and flora) but also new habitats were created, where as a result of secondary succession spontaneous vegetation was established [Bąba et. al. 2003]. 132.02 ha of the open-casts were put into forest reclamation (tab. 1). The lands were divided into two categories: first one – where plant

communities developed during natural succession were incorporated into reclamation works and only supplementary afforestation and restocking should be made and the second category – which comprises lands prepared for artificial afforestation [Krzaklewski, 2000].

Table 1. The potential forest habitats in the „Kuźnica Warężyńska" sand-pits (prepared at the basis of Krzaklewski et al., 1999 material)

Categories	Granulometric compositon	Depth of ground water	The potential forest habitat	Trees proposed for forestration
Category I	loose sandy soils	< 2 m, 100-200 cm, 50-100 cm, >50 cm	coniferous forests (Bs→ Bśw, Bw, Bb	Ps, Bp, Qp., Qrub, Av, Ai
Category II	coarse sandy soils	100-200 cm, 50-100 cm, > 50 cm,	mixed coniferous forests (BMśw, BMw, BMb)	Ps, Qr, Qp, Av, Ain
Category III	medium sands with higher participation of silt and clay, loam soils, rarely silt loam	100-200cm, 50-100 cm, > 50cm	mixed forest (LMśw, LMw, LMb)	Ps, Pn, Le, Qr, Fe, Ap, Fs., Cb, Ag.

Abbreviations: Ag – *Alnus glutinosa;* An – *Alnus incana,* Av - *Alnus viridis;* Ap – *Acer platanoides;* Bp - *Betula pendula*; Cb – *Carpinus betulus;* Fe – *Fraxinus excelsior;* Fs – *Fagus sylvatica;* Ps - *Pinus sylvestris;* Qp - *Quercus petraea,* Qr- *Quercus robur;* Qrub - *Quercus rubra;* Bs – dry coniferous forest, Bśw – fresh coniferous forest; BMw – wet coniferous forest; BMb – peat-bog coniferous forest, LMśw – fresh mixed forest; LMw – wet mixed forest; LMb – peat-bog mixed forest; BMśw – fresh mixed coniferous forest; BMw – wet mixed coniferous forest; BMb – peat-bog mixed coniferous forest

The aim of this paper is to show the floristic composition and differentiation of forest plant communities that develop in the „Kuźnica Warężyńska" sand-pit.

METHODS

The field investigations in the „Kuźnica Warężyńska" sandpit have been performed during 1996-2003. There were made 225 phytosociological relevés, 18 of them, which represent the forest communities, were used for the purpose of this work.

The relevés were ordinated along the first two axes of environmental gradients with the use of Principal Component Analysis [PCA, Gauch, 1986]. A CANOCO package was used [Jongman et. al., 1995]. Only species which fit at least to 5% of explained variance were taken into analysis.

Then the relevés were classified using the numerical approach (Ward's method and Manhattan city block distance) with the STATISTICA package and the results of classification were imposed upon the ordination diagram. Prior the analysis the cover/abundance data were log-transformed. Additionally to show the full floristic differentiation of the forest community the phytosociological table was constructed according to the above-mentioned classification.

In order to identify the environmental gradients explained by the PCA axes, the eigenvalues were correlated with the mean L, F, R and N Ellenberg's indicator values for relevés based on the binary data. Additionally, to characterize the floristic differentiation of the communities, the correlation between the PCA axes and the number and percentage cover of xerothermic species (*Festuco-Brometea*), meadow (*Molinio-Arrhenatheretea*), peat-bog (*Scheuchzerio-Caricetea nigrae*) and woodland species (*Vaccinio-Piceetea*) species were calculated [Dzwonko i Loster, 1990].

RESULTS AND DISCUSSION

The forest phytocoenoses, which occur in the sand-pit area, approximate pine-oak forest *Querco roboris-Pinetum*, which represents *Dicrano-Pinion* alliance, *Piceetalia abietis* order and *Vaccinio-Piceetea* class [Matuszkiewicz, 2002].

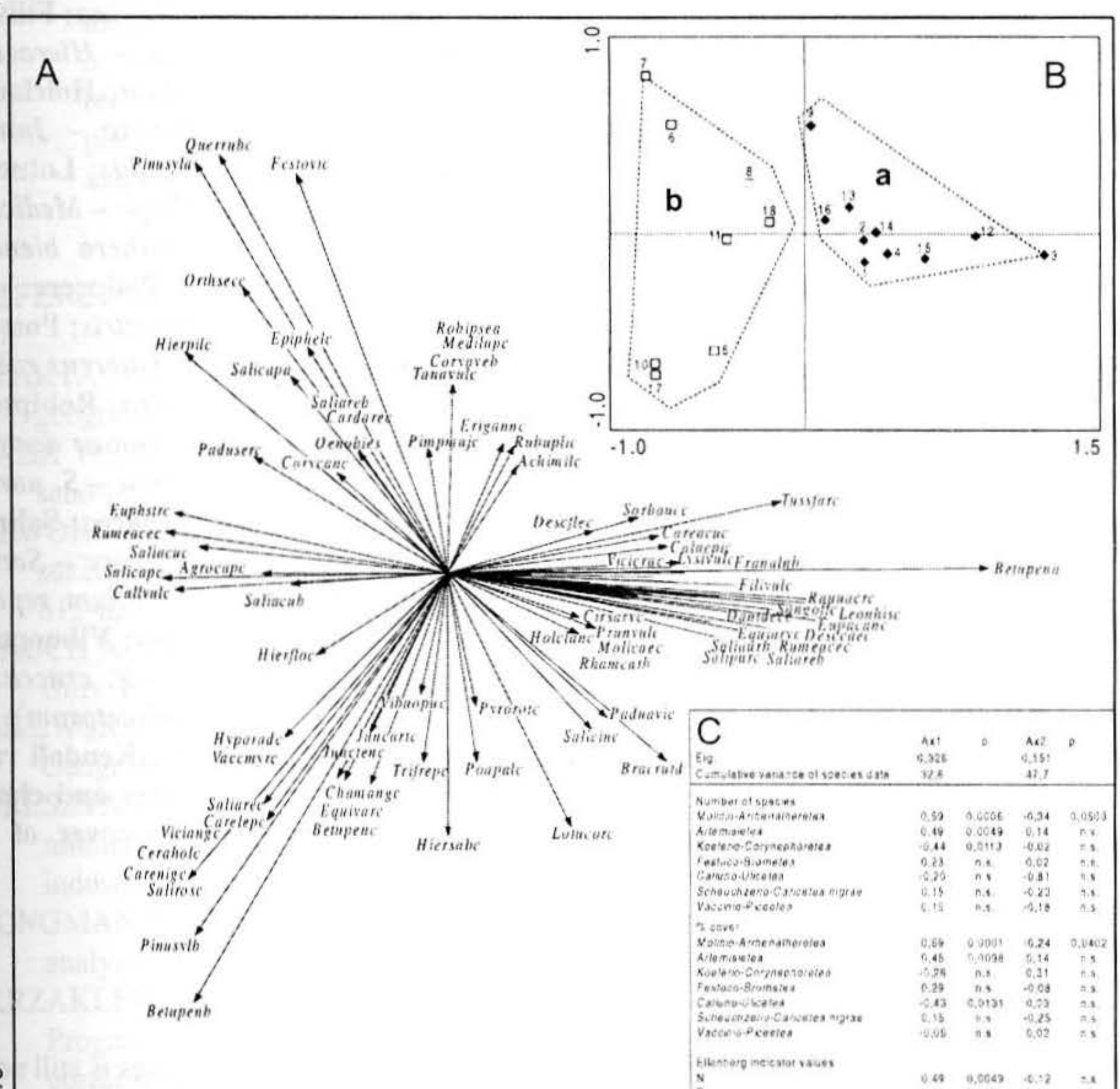
This community is strongly differentiated in reference to floristic composition. It occurs from 14 to 45 species in patches. However only few of them occur more frequently or reach higher values of cover. The cover of the herb layer varies from 15% to 80%. The percentage participation of mosses reaches from 5 to 65% in patches.

The tree stand is two-layered. Apart from *Pinus sylvestris* and *Betula pendula* such trees as: *Populus tremula, Robinia pseudacacia* build it. In the shrub layer appear species, which occur in the tree layer and some species from *Salix* genus (*Salix acutifolia, S. caprea, S. pentandra, S. purpurea*). It should be emphasized that character species of the *Vaccinio-Piceetea* class are uncommon and in most cases reach low values of cover.

The collected material is not homogenous, however, the I RDA ($\lambda_1 = 0.326$) axis arrange relevés in accordance with gradient, which is marked by trophy (N) and soils' reaction (R) indices (Fig. 1C). It is also positively correlated with number and abundance of meadow species from *Molinio-Arrhenatheretea* class and ruderal species from *Artemisietea* class and negatively with number of psammophilous species from *Koelerio-Corynephoretea* class. This enabled us to distinguish: (a) wet subassociation *Querco roboris-Pinetum molinietosum* because of occurrence in the floristic composition of phytocoenoses wet meadow species from the *Molinietalia* order (*Molinia caerulea, Lysimachia vulgaris*), peat-bog species and rush plant from the *Phragmitetea* class and (b) typical subassociation, which is positively distinguished by psammophilous species from *Koelerio-Corynephoretea* class (Fig. 1A, B). The II RDA ($\lambda_2 = 0.151$) axis is strongly negatively correlated with the number of heath and pasture species from *Calluno-Ulicetea* class. In minor degree some negative correlation occurs with the number and abundance of meadow species. However, these correlations are not statistically significant and importance of the second axis to the variance explained is low (Fig. 1C). The most striking feature is that the character species of peat-bogs and coniferous forest are not associated with any of the distinguished groups (Fig. 1C).

Such features as: high level of water table, abundance of water in Mg, Ca ions and occurrence of well-developed peat-bog communities in the vicinity of sand-pit areas are probably responsibly for creation of proper habitats for development of peat-bog communities [Krzaklewski, 2000]. The character species of peat-bog can be also found

in species composition of many non-forest communities which were recorded on the sand-pits area [Bąba et al. 2003].



C	Ax1	p	Ax2	p
Eig	0,326		0,151	
Cumulative variance of species data	32,6		47,7	
Number of species				
Molinio-Arrhenatheretea	0,59	0,0006	-0,34	0,0503
Artemisietea	0,49	0,0049	0,14	n.s.
Koelerio-Corynephoretea	-0,44	0,0113	-0,02	n.s.
Festuco-Brometea	0,23	n.s.	0,02	n.s.
Calluno-Ulicetea	-0,20	n.s.	-0,81	n.s.
Scheuchzerio-Caricetea nigrae	0,15	n.s.	-0,23	n.s.
Vaccinio-Piceetea	0,15	n.s.	-0,18	n.s.
% cover				
Molinio-Arrhenatheretea	0,69	0,0001	-0,24	0,0402
Artemisietea	0,45	0,0098	0,14	n.s.
Koelerio-Corynephoretea	-0,26	n.s.	0,31	n.s.
Festuco-Brometea	0,29	n.s.	-0,08	n.s.
Calluno-Ulicetea	-0,43	0,0131	0,03	n.s.
Scheuchzerio-Caricetea nigrae	0,15	n.s.	-0,25	n.s.
Vaccinio-Piceetea	-0,09	n.s.	0,02	n.s.
Ellenberg indicator values				
N	0,49	0,0049	-0,12	n.s.
R	0,41	0,0179	0,19	n.s.
F	0,35	0,0447	-0,19	n.s.

Fig. 1. RDA ordination of the forest community in the "Kuźnica Warężyńska" sandpit. A. species **- abbreviations (first 4 letters - names of genus; further 3 – names of species, the last one the layer of species occurrence): Achimilc -** ***Achillea millefolium*****; Agrocapc -** ***Agrostis capillaris*****; Betupen -** ***Betula pendula*****; Bracrutd -** ***Brachythecium rutabulum*****; Calaepic -** ***Calamagrostis epigejos*****; Callvulc -** ***Calluna vulgaris*****; Cardarec -** ***Cardaminopsis arenosa*****; Careacuc -** ***Carex acutiformis*****; Carelepc –** ***C. lepidocarpa*****; Carenigc –** ***C. nigra*****; Ceraholc -** ***Cerastium holosteoides*****; Chamangc -** ***Chamaenerion angustifolium*****; Cirsarvc -** ***Cirsium arvense*****; Coryaveb -** ***Corylus avellana*****; Corycanc -** ***Corynephorus canescens*****; Dantdec -** ***Danthonia decumbens*****;

Desccaec - *Deschampsia caespitosa*; Descflec – *D. flexuosa*; Epiphelc – *Epipactis helleborine*; Equiarvc - *Equisetum arvense*; Equivarc – *E. variegatum*; Eriganne – *Erigeron annuus*; Eupacanc – *Eupatorium cannabinum*; Euphstrc - *Euphrasia stricta*; Festovic - *Festuca ovina*; Filivulc – *Filipendula vulgaris*; Franaln – *Frangula alnus*; Hierfloc – *Hieracium floribundum*; Hierpilc – *H. pilosella*; Hiersabc – *H. sabaudum*; Holclanc - *Holcus lanatus*; Hyporadc – *Hypochoeris radicata*; Juncartc – *Juncus articulatus*; Junctenc – *J. .tenuis*; Leonhisc – *Leontodon hispidus*; Lotucorc – *Lotus corniculatus*; Lysivulc – *Lysimachia vulgaris*; Medilupc – *Medicago lupulina*; Molicaec – *Molinia caerulea*; Oenobies. – *Oenothera biennis*; Orthsecc – *Orthilia secunda*; Paduavic – *Padus avium*; Paduserc – *P. serotina*; Pimpmajc – *Pimpinella major*; Pinusyla – *Pinus sylvestris*; Poapalc – *Poa palustris*; Pyrorotc – *Pyrola rotundifolia*; Querrubc – *Quercus rubra*; Ranuacrc – *Ranunculus acris*; Rhamcatb- *Rhamnus catharticus;* Robipsea - *Robinia pseudacacia*; Rubuplic – *R. plicatus*; Rumeacec – *Rumex acetosa*; Rumeacec – *R. acetosella*; Saliacub - *Salix acutifolia*; Saliaurb – *S. aurita*; Salicapb – *S. caprea*; Salicinc – *S. cinerea*; Salipurb – *S. purpurea*; Salirosc – *S. rosmarinifolia*; Sangoffc – *Sanguisorba officinalis*; Sorbaucc – *Sorbus aucuparia*; Tanavulc – *Tanacetum vulgare*; Trifrepc – *Trifolium repens*; Tussfarc – *Tussilago farfara*; Vaccmyrc - *Vaccinium myrtillus*; Vibuopuc – *Viburnum opulus*; Viciangc – *Vicia angustifolia*; Vicicrac – *V. cracca*. B. Relevés: a – wet subassociation (*Querco roboris-Pinetum molinietosum*); b – typical subasocciation (*Querco roboris-Pinetum typicum*). C. Kendall rank correlation between the egenvalues of the first two RDA axes and chosen Ellenberg's indicator values and number and percentage cover of the species from selected syntaxonomical units

CONCLUSIONS

1. The floristic composition of the investigated forest phytocoenoses is still not in fully developed. The character species of *Vaccinio-Piceetea* class play minor role. Many occasionals can be found in their patches or with high frequency and abundance occur character species of other phytosociological units. There occur also some alien species, which were introduced during reclamation work. It is probably connected with unfinished reclamation works, short time of reclamation and unstable water regime.
2. The multidirectional reclamation conducted on the „Kuźnica Warężyńska" sand-pit and saving of plant communities which develop spontaneously cause that forest phytocoenoses create mosaic with water, rush, meadow, peat-bog and ruderal plant communities what significantly increases the biodiversity of this site [Bąba et. al., 2003].
3. There were found in forest communities some species which are under law protection in Poland such as: *Centaurium erythraea* subsp. *erythraea*,

Dianthus carthusianorum, *Dianthus deltoides*, *Epipactis atrorubens*, *E. helloborine*, *Frangula alnus*, *Listera ovata*, *Malaxis monophyllos*.

4. The method of directed vegetation succession, which includes in reclamation works plant communities that develop during natural succession let facilitate the process of restoration of the disturbed land to some kind of productive use or socially acceptable conditions and can significantly lower costs of reclamation comparing to engineered restoration. It lets develop in a given site plant communities which are the best adjust to the environmental conditions and ecosystems which are self-regulatory.

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