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EFFECTS OF ANTHROPOGENIC CHANGES IN VEGETATION ON FOREST SOIL IN GÓRZNO-LIDZBARK LANDSCAPE PARK

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INTRODUCTION

Many papers have already been published on the effects of various tree species on soil properties [Binkley, Valentine 1991; Bockheim et al. 1991; Gower, Son 1992; Lefevre, Klemmedson 1980; Ovington 1953, 1954; Perala, Alben 1982; Raulund-Rasmussen, Vejre 1995]. Less attention has been paid to the influence of monocultural plantations on the whole ecosystem (vegetation and soil) and to the effects of admixtures of other tree species to such plantations.

From the beginning of 19th century in northern Poland there was a growing trend to replace natural forests with monocultures, viz. Scots pine (*Pinus sylvestris*). That practice frequently brought about the degeneration of plant communities [Olaczek 1974, 1976] and soil degradation. To minimize the adverse effects of pine plantations forests started to underplant other tree species [Stetkiewicz 1993]. The objective of the study was to evaluate the effects of anthropogenic changes in forest vegetation on the soils developed from outwash sand.

STUDY AREA AND METHODS

The study was conducted in Górzno-Lidzbark Landscape Park (GLLP) in the northeast of Poland. Pine stands predominate in the Park. From the geomorphological point of view the study area is located in the proximal part of the Dobrzyń outwash plain connected with the end moraines of Kuyavian subphase of Vistulian glaciation [Niewiarowski, Wysota 1994].

On a forest parcel planted with Scots pine, now 75-year old, three plots (50×50 m) with different admixtures of other species were selected: plot No 1 – with sessile oak (*Quercus petraea*), plot No 2 – almost pure pine monoculture with a few young silver birch tree (*Betula pendula*), and plot No 3 – with Norway spruce

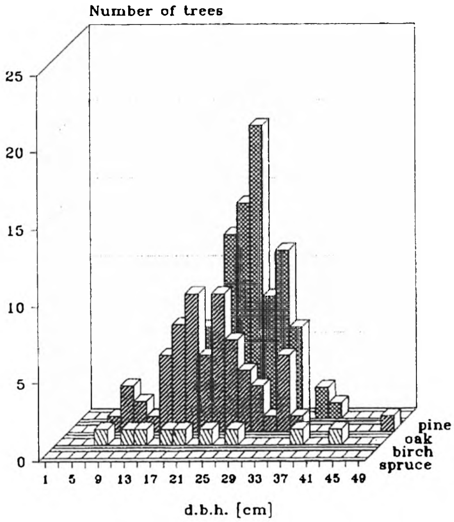

FIGURE 1. Stand structure in plot No 1

(*Picea abies*). In each plot the plant community was determined (Braun-Blanquet method) and some parameters of the tree stand were measured (number of individuals of each species and diameter at breast height – d.b.h.). From the data of d.b.h. diagrams of tree stand structure were plotted (Fig. 1–3). The diagrams indicate that oak was planted in plot No 1 together with pine, while spruce in plot No 3 was underplanted later. Birch in plot No 2 is surely self-sown.

The soils in the plots belong to the same taxonomic unit, i.e. rusty podzolized soil [Systematics of Polish soils, 1989] and according to FAO-UNESCO [1997] Podzoli-Cambic Arenosol. The characteristics of the soil profile in plot No 2 are given in Table 1. Detailed studies were carried out in the organic horizon O and the humus horizon showing week podzolization AEes, as only those can be altered in a relatively short time. The following parameters were measured: thickness of both horizons, bulk density, pH in H_2O

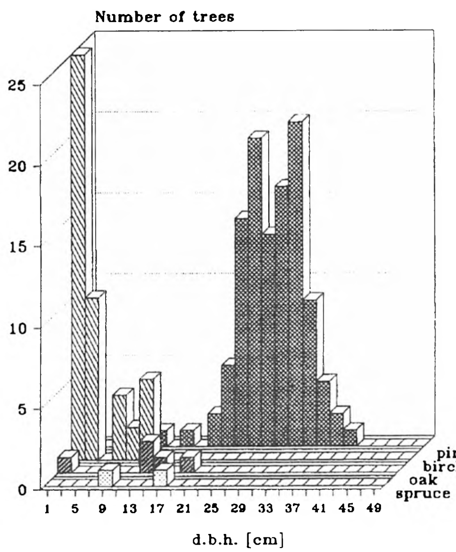

FIGURE 2. Stand structure in plot No 2; the number of birch of d. b. h. 0–2 cm exceed the scale of the diagram and reaches 90

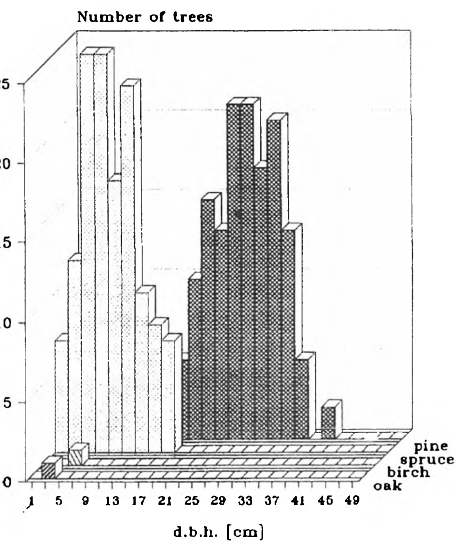

FIGURE 3. Stand structure in plot No 3; the number of spruce of b. d. h. 4–6 and 6–8 cm reaches 43 and 28 respectively

TABLE 1. Characteristics of soil profile

Hori-zon	Depth [cm]	Colour (moist)	Per cent particle-size distribution, ∅ mm					pH in H_2O	C_{org} [%]	N [%]	C/N
			>1	1–0,5	0,5 –0,25	0,25 –0,1	<0,1				
AEes	1–6	10YR 2/2	6	26	44	21	9	4.4	1.82	0.074	25
BfeBv	18–23	7,5YR 4/4	8	27	48	22	3	4.8	0.43	0.020	22
Bv	35–40	10YR 5/4	13	24	51	22	3	4.9			
BvC	75–80	10YR 6/4	4	18	54	24	4	5.7			
C	105–110	10YR 6.5/4	3	9	56	33	2	5.7			
IIC	145–150	10YR 5/4	19	22	52	23	3	6.7			

determined by the potentiometric method, and organic matter content – by loss on ignition. The samples were collected with a square metal frame (20 × 20 cm) from 25 locations (geometrical scheme) per each plot.

Plot differences in soil properties were tested by Student t-tests.

RESULTS

Data on forest vegetation obtained using the Braun-Blanquet method (Table 2) show that the selected forest parcel is now occupied by various forms of mixed pine-oak forest of subboreal character - *Serratulo-Pinetum* J. Mat. 1988 [Matuszkiewicz W. 1981, Matuszkiewicz J. 1988]. In pot No 1 there is a relatively most typical form of that plant community, in plot No 2 – its degenerated form with pine, and in plot No 3 – its strongly degenerated form with pine and spruce. The total number of species and cover of herb layer decrease, whereas the cover of moss layer increases with the growing degree of degeneration of the plant community. Moreover, the cover of species of conifer forest from the class *Vaccinio-Piceetea* increases from plot No 1 to plot No 3. The species of broad-leaved forest from the class *Querco-Fagetea*, and thermophilous and heliophilous species from the class *Trifolio-Geranietea sanguinei* occurring in plot No 1 disappear in the following plots.

The properties of humus containing horizons in most cases differentiate the plots with various vegetation (Table 3). In all cases significant differences concern the soil reaction. As a result of oak elimination from the stand and predominance of pine, and especially of spruce introduction, pH decreases. The differences in bulk density of the horizons are mostly insignificant. Only the bulk density of horizon O in plot No 1 is relatively higher. That is the result of substantial content of mineral material, which is the effect of wild boar activity.

One of the most important differences in soil properties in the plots concerns the redistribution of organic matter between the organic horizon and the mineral AEes horizon. That result consists of significant differences in thickness of the two horizons, differences in bulk density and in organic matter concentration. The ratio of organic matter accumulated in horizon O to that in horizon AEes increases from plot No 1 to plot No 3, i.e. with the increase in degeneration degree of the plant community.

TABLE 2. Main parameters of forest vegetation
Species and mean cover degree in 400 m^2 area (July 5 1995)
The cover classes are: 1, 2, 3, and 4, which represent < 5%, 5–25%, 25–50%, and 50–75% respectively; + = scarce, – = absent

Parameters			Plot Nos. 1	2	3
Density of upper tree layer	a_1	[%]	80	70	70
Density of lower tree layer	a_2	[%]	10	5	20
Density of shrub layer	b	[%]	5	15	5
Cover of herb layer	c	[%]	90	80	65
Cover of moss layer	d	[%]	50	75	75
Total number of species			39	33	15
Vaccinio-Piceetea:					
Pinus sylvestris	a_1		3	4	4
	c		–	+	–
Picea abies	a_2		–	+	2
	b		+	–	1
	c		–	+	+
Vaccinium myrtillus			3	4	4
Vaccinium vitis-idaea			+	1	1
Trientalis europaea			+	1	2
Melampyrum pratense			+	–	+
Betula pubescens	c		–	+	–
Pleurozium schreberi	d		3	4	4
Dicranum polysetum	d		2	1	1
Ptilium crista-castrensis	d		–	+	–
Querco-Fagetea:					
Anemone nemorosa			1	–	–
Carpinus betulus	c		1	–	–
Carex digitata			1	–	–
Acer pseudoplatanus	c		+	–	–
Melica nutans			+	–	–
Trifolio-Geranietea sanguinei:					
Galium album			1	+	–
Peucedanum oreoselinum			+	+	–
Geranium sanguineum			+	–	–
Anthericum ramosum			+	–	–
Other species:					
Quercus petraea	a_1		3	–	–
	a_2		2	1	1
	b		1	+	+
	c		1	2	1
Betula pendula	a_1		1	–	–
	a_2		–	1	–
	b		1	2	–
	c		–	1	1
Calamagrostis arundinacea			4	3	1
Dryopteris carthusiana			1	1	+
Convallaria majalis			1	1	–
Rubus idaeus	c		1	1	–

TABLE 2 – continued

Parameters		Plot Nos. 1	2	3
Other species:				
Rubus saxatilis		1	1	–
Festuca ovina		+	1	–
Luzula pilosa		+	1	–
Malus sylvestris	c	+	+	–
Potentilla erecta		+	+	–
Molinia caerulea		+	–	+
Agrostis capillaris		1	–	–
Viola riviniana		1	–	–
Scorzonera humilis		+	–	–
Juniperus communis	c	+	–	–
Moehringia trinervia		+	–	–
Sorbus aucuparia	c	+	–	–
Fragaria vesca		+	–	–
Lathyrus montanus		+	–	–
Quercus robur	c	–	+	–
Solidago virgaurea		–	+	–
Anthoxanthum odoratum		–	+	–
Genista tinctoria		–	+	–
Carex pilulifera		–	+	–
Rumex acetosella		–	+	–
Hylocomium splendens	d	+	1	1
Polytrichum formosum	d	–	1	1
Brachythecium curtum	d	1	–	–
Aulacomnium palustre	d	–	+	–
Plagiomnium affine	d	–	+	–

DISCUSSION AND CONCLUSIONS

One of the types of natural potential vegetation on outwash sands in north-eastern Poland is mixed pine-oak forest *Serratulo-Pinetum* [Matuszkiewicz 1981]. Forest management, which preferred pine plantations since the last century, brought about negative changes in that plant community and in its site. The present study conducted in a selected area of GLLP has recorded an example of the negative effects of artificial tree stands on the floristic composition of the field layer and on soil. Pine monoculture, which is the predominant stand in the area, has altered the forest phytocoenosis in a way designated as *pinetization* (Table 2, plot No 2).

Introducing into pine plantations other tree species may have (depending on the species) positive as well as negative effects on the regeneration of the potential forest community. The results of our study have shown that the introduction of spruce (plot No 3) brings about higher degree of degeneration of *Serratulo-Pinetum* compared with the effects of pine monoculture (the total number of species was reduced to a half, the cover of herb layer was much smaller etc.). On the other hand, the introduction of oak (plot No 1) makes the floristic composition of that plant community quite close to the typical form (Table 2). Therefore it is evident

TABLE 3. Properties of organic horizon O and mineral AEes horizon in the plots

Property	Horizon	Plot No. 1	Plot No. 2	Plot No. 3	Plot differences Plot Nos 1/2	1/3	2/3
		$x \pm s$	$x \pm s$	$x \pm s$			
Thickness	O	4.0 ±1.4	5.0 ±1.3	6.7 ±1.7	**	***	***
[cm]	AEes	9.2 ±3.1	5.5 ±2.4	7.1 ±2.0**	*	*	
Bulk density	O	0.31±0.12	0.18±0.07	0.21±0.10	***	***	
[g/cm^3]	AEes	1.37±0.22	1.43±0.24	1.37±0.23			
pH	O	4.38±0.15	4.04±0.18	3.81±0.16	***	***	***
in H_2O	AEes	4.38±0.14	4.11±0.20	3.98±0.13	***	***	**
Loss on ignition	O	49.8±14.1	73.6±8.6	71.0±15.2	***	***	
[%]	AEes	4.62±0.80	4.82±1.15	3.41±0.59		***	***
Organic matter store	O	5.19±2.34	4.83±1.40	7.21±2.04		***	***
[kg/m^2]	AEes	5.22±1.48	3.42±1.40	3.09±1.02	***	***	

Plot differences on 5%, 1% and 0,1% level are indicated by*, **, and *** respectively.

that the main cause of the differences in plant community in the area with originally identical soil was the establishment of tree species during reforestation.

Obviously, meeting the needs of various plant species on poor sandy soils depends to a large extent on the capacity and rate of nutrients cycling. An important part in that cycling is played by the stand and by humus containing soil horizons. Oak, pine and spruce differ markedly in the chemical composition of their leaf litter and the rate of its decay [Bockheim et al. 1991; Dziadowiec 1990; Zimka, Stachurski 1976]. Under identical site conditions oak litter shows the highest concentration of nutrients (particularly low C/N ratio) and the highest rate of their release, while the respective parameters for spruce litter are the least favourable. As a result, the accumulation of soil organic matter under different stands proceeds in different ways. In the pine-spruce stand (plot No 3) the store of organic matter accumulated in horizon O is much higher than that in horizon AEes, while in the pine-oak stand (plot No 1) the proportions of those stores in both horizons are the same (Table 3). It follows from the studies of many researchers that as the store of organic matter differentiates, so does the amount of nutrients which are available to plants [Binkley, Valentine 1991; Gower, Son 1992; Lefevre, Klemmedson 1980; Ovington 1954; Perala, Alben 1982; Pokojska 1992; Raulund-Rasmussen, Vejre 1995].

A high ratio of organic matter store in organic horizon to that in humus horizon is characteristic of poor ecosystems with mor type humus [Plichta 1981]. That type of humus occurs in plot No 3, while in plots No 1 and 2 it is the transitional moder-mor type. The changes in humus type are associated with an increase in acidity of horizons O and AEes from plot No 1 to plot 3. In soil morphology this is revealed by increasing podzolization symptoms. Higher acidity of the upper soil horizons is conducive to leaching nutrients down the soil (or even beyond the soil profile), which leads to the impoverishment of the whole ecosystem.

The results of our studies indicate that anthropogenic degeneration of the plant community proceeds simultaneously with deterioration of soil properties. To stop negative changes in forest ecosystems (degeneration of plant communities and deterioration of sites quality) there is the need for more rational and sustainable forest management. One of the more important suggestions is introduction into pine plantations of other tree species, which are right for the site and adequate for potential forest vegetation. Renaturalization of forest communities is a particularly desirable device in protected landscapes.

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WPŁYW ANTROPOGENICZNYCH PRZEKSZTAŁCEŃ SZATY ROŚLINNEJ NA GLEBĘ LEŚNĄ W GÓRZNIEŃSKO-LIDZBARSKIM PARKU KRAJOBRAZOWYM

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STRESZCZENIE

Teren badań znajduje się w kompleksie leśnym Górznieńsko-Lidzbarskiego Parku Krajobrazowego (G-LPK) na Glebowej Powierzchni Wzorcowej nr 9. W oddziale 116, obsadzonym 75-letnią sosną zwyczajną, wytypowano trzy powierzchnie różniące się gatunkami domieszkowymi: nr 1 – z dębem bezszypułkowym, nr 2 – prawie czysta monokultura sosny z młodym samosiewem brzozy brodawkowatej, nr 3 – ze świerkiem pospolitym.

Wyniki badań fitosocjologicznych wykazały, że na wytypowanych powierzchniach występują różne postacie boru mieszanego sosnowo-dębowego o charakterze subborealnym – *Serratulo-Pinetum*. Na powierzchni nr 1 występuje najbardziej zbliżona do typowej postać tego zespołu, na powierzchni nr 2 – postać degeneracyjna z sosną, a na powierzchni nr 3 – silnie zdegenerowana postać z sosną i świerkiem.

W miejscu badań stwierdzono obecność gleb bielicowo-rdzawych wytworzonych ze stosunkowo słabo przesortowanego piasku sandrowego (proksymalna część sandru dobrzyńskiego). Główne różnice we właściwościach gleb na powierzchniach badawczych dotyczą odczynu poziomów powierzchniowych oraz sposobu akumulacji materii organicznej. Wraz ze wzrostem stopnia degeneracji zbiorowiska roślinnego wzrasta zakwaszenie gleby, a także miąższość poziomu organicznego i stosunek zasobów materii organicznej w poziomie organicznym do zasobów w poziomie eluwialno-próchnicznym.

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