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ROLE OF SOIL IN THE FUNCTIONING OF THE MAZURIAN LAKE DISTRICT ECOSYSTEM

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A b s t r a c t. The Macroregion of the Mazurian Lake District and the adjoining mesoregion of the Sępopol Plain were formed during Baltic glaciation and in the post-glacial period. The existing habitat differentiation, especially large variations in the soil cover, is divided into three distinct landscape zones. The northern areas of the district are typical heavy and very heavy soils, composed of tight clays and loams, represented by brown soils and black earths. They contribute to the ecosystem stability. Hydrogenic soils occupy only a small area. Agricultural production, when carried out correctly, should not threaten the habitat and should be in harmony with the area in question. The central, moraine area of the Mazurian Lake District, with unique natural qualities, is comprised of different soil forms and various soil covers. Brown and lessive soils are dominant among mineral soils. Deluvial soils are common, which is a warning sign on the danger of erosion. Contribution of hydrogenic soils is clearly seen. Protection of these soils, as well as re-naturalisation of the selected areas, is becoming vital. This area badly requires ecological farming. Light and very light soils, mainly rusty and podzol soils, accompanied by large areas of sensitive for transformation hydrogenic, muck, and mucky soils occur in the southern part of the district, in the area of outwash plains. Outwash plains call for complex solutions to improve the quality of their mineral soils, as well as utilisation and protection of hydrogenic soils.

K e y w o r d s: The Mazurian Lake District, soil cover, ecosystem functioning.

INTRODUCTION

The Macroregion of the Mazurian Lake District and the neighbouring mesoregion of the Sępopol Plain (Fig. 1) were formed during Baltic glaciation and on the post-glacial period [2,5]. This is a young glacial area with a high degree of separation of various habitat conditions, especially soil cover, unique natural qualities and relatively low pollution. Soil parts are clearly visible in the properly functioning ecosystems. Recognition of the soil problem is crucial for finding eco-agricultural solutions.

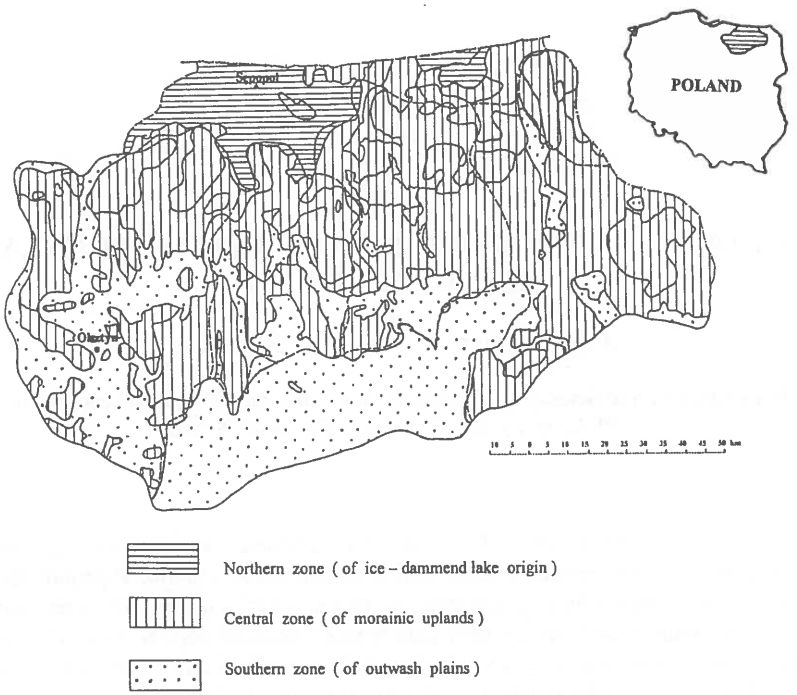

Fig. 1. Landscape zones of the Mazurian Lake District and Sępopol Plain.

MATERIALS

The rules of division in the Polish soils taxonomy [6] were applied in the present study on the soil cover. While evaluating hydrogenic soils, additional criteria worked out in the Institute for Melioration and Grassland Farming - IMUZ [4], were also adopted. The results were compared to nine separate kinds (based on the habitat conditions) of young glacial landscape which differed in the relief and lithology of superficial forms [1]. Regularity in appearance and quality factors of the landscape units allowed for their division into three landscape zones, defined as plains of glacial origin, moraine uplands and outwash plains. To maintain ecological balance in these meridionally differentiated areas, it is necessary to apply different rules of soil cover protection and different methods of farming.

RESULTS

Plains of glacial lake origin occur on the Sępopol Plain and northern part of the Mazurian Lake District (Fig. 1). Its origin is related to deglaciation of glacial

lake in the Pomeranian phase of the Baltic glacier [2,5]. The area is very flat, with 92% of the slopes not exceeding 6% (Table 1). Clays of glacial lake origin and boulder clay are less common. In some places clay facies are dominant among geological forms together with silts and sands of lacustrine origin (Table 2). Mineral soils made of these forms show high compactness. Very heavy and heavy forms occupy almost 55% of area (Table 3). Brown soils (Table 4) with useful farming qualities, neutral or alkaline reaction, good absorption qualities, rich in nutrients are found in about 39% of the mineral soils. Black earths (17% of all the areas of mineral soils) also occur, and were formed in lower places after transformation of organic forms deposited at bottoms, rich in calcium carbonate. Partly marshy areas favoured formation of grey soil (Table 4).

Table 1. Slope gradients in three lithological zones of the Mazurian Lake District and Sępopol Plain

Gradient rangers (%)	Lithological zones						Total	
	Plains of ice-dammed lake origin		Moranic uplands		Outwash plains			
	ha	%	ha	%	ha	%	ha	%
0-6	165597	91.5	395500	55.6	395670	88.4	956767	71.4
6-12	13316	7.4	152218	21.4	46010	10.3	211544	15.8
12-18	1987	1.1	121702	17.1	5820	1.3	129509	9.7
>18			42380	5.9			42380	3.1
Total	180900	100.0	711800	100.0	447500	100.0	1340200	100.0

Hydrogenic soils, formed by the waters flowing on impermeable forms and collected in depressions, occupy a relatively small area (over 7 000 ha - Table 5) on the plains of glacial lake origin. Their use in farming muck soils (among them peat muck soils formed after bog soil dehydration) is wide-spread. A very small area of peat soils (1% of hydrogenic soils - Table 5) occurs in its natural state.

The qualities of soil cover on the plains of glacial lake origin greatly influenced the balance and stability of the existing ecosystems. The area in question is distinguished by good quality of farming production areas. There are no erosion threats there. That is why, agricultural production if rationally run, does not threaten the habitat. It should occupy a leading position in the area in question. Hydrogenic soils demand more attention. Their pro-ecological usage should consist in maintaining perennial, heavy sodded arable lands. High moistening of the surface layer is necessary.

Table 2. Geological formations in tree lithological zones of the Mazurian Lake District and Sępopol Plain

Geological formation	Lithological zones						Total	
	Plains of ice-dammed lake origin		Moraic uplands		Outwash plains			
	ha	%	ha	%	ha	%	ha	%
Clays of ice-dammed lake origin	58910	32.6	24956	3.5			83866	6.2
Sands, silts and clays of lacustrine origin	25185	13.9	28887	4.0			54072	4.0
Boulder clay, in some places as clay facies	74386	41.2	321432	45.2	5330	1.2	401148	29.9
Gravels, sands and boulder clays of terminal moraine origin			129534	18.2			129534	9.7
Sands of glacial origin	15290	8.4	62065	8.7			77355	5.8
Silts, sands and gravels of kames and eskers			34426	4.8			34426	2.6
Sands and gravels of fluvioglacial origin			48913	6.9	405440	90.6	454353	33.9
Peats, muds and lacustrine chalks	7129	3.9	61587	8.7	36730	8.2	105446	7.9
Total	180900	100.0	711800	100.0	447500	100.0	1340200	100.0

The moraine upland zone in the middle part of the Mazurian Lake District covers the largest area (Fig. 1). The result of Baltic glaciation is a diversified relief of this zone and variety of soil covers. Areas with slopes exceeding 12% occupy 23% of the entire area. In the entire area of 42 000 ha, 18% are covered with areas with slopes (Table 1). There is a large variety of geological forms with boulder clay, gravel and sands as predominate (Table 2). Forms with an average granulometric content that contain a considerable part of light forms are predominating (Table 3).

Brown soils, generally considered as good and effective for wheat complexes, take up about half of the mineral soils. They are often accompanied by lessive soils with higher acidity. They make up almost 19% of the mineral soils

Table 3. Categories of grain-size distribution of mineral soils in three lithological zones of the Mazurian Lake District and Sępopol Plain

Categories of grain-size distribution of mineral soils	Lithological zones						Total	
	Plains of ice-dammed lake origin		Moranic uplands		Outwash plains			
	ha	%	ha	%	ha	%	ha	%
Very light	540	3.1	62109	9.5	341360	95.3	408869	34.6
Light	48714	28.0	156221	24.0	13620	3.8	218555	18.5
Medium	24950	14.4	302141	46.5	3210	0.9	330301	27.9
Heavy	36887	21.2	63494	9.8			100381	8.5
Very heavy	57820	33.3	66248	10.2			124068	10.5
Total	173771	100.0	650213	100.0	358190	100.0	1182174	100.0

Table 4. Area of mineral soil types in three lithological zones of the Mazurian Lake District and Sępopol Plain

Soil type	Lithological zones						Total	
	Plains of ice-dammed lake origin		Moranic uplands		Outwash plains			
	ha	%	ha	%	ha	%	ha	%
Arenosols			12526	1.9	16840	4.7	29366	2.5
Pararendzinas			27190	4.2			27190	2.3
Brown soils	66914	38.5	305470	47.0			372384	31.5
Soils lessive	21470	12.4	123168	19.0	4840	1.4	14978	12.7
Rusty soils			9870	1.5	213560	59.6	223430	18.9
Podzol soils					110360	30.8	110360	9.3
Black earths	29954	17.2	37574	5.8			67528	5.7
Pseudogley soils	42081	24.2	33195	5.1			75276	6.4
Gley soils	12550	7.2	12627	1.9			25177	2.1
River alluvial soils	802	0.5			12590	3.5	13392	1.1
Deluvial soils			8 8593	13.6			88593	7.5
Total	173771	100.0	650213	100.0	358190	100.0	1182174	100.0

area (Table 4). Deluvial soils made of movable material from the surrounding slopes are very common on the relief areas. They occur in very numerous contours situated in smaller land hollows as well as on the hill slopes. Deluvial forms with the depth of strata ranging from 30 to 150 cm usually occupy organic forms. Pararendzinas made from moraine uplands, rich in $CaCO_3$, cover over 4% of the

Table 5. Area of organic soil types in three lithological zones of the Mazurian Lake District and Sępopol Plain

Soil type	Lithological zones						Total	
	Plains of ice-dammed lake origin		Moranic uplands		Outwash plains			
	ha	%	ha	%	ha	%	ha	%
Mud soils	58	0.8	2700	4.4			2758	1.7
Peat soils	72	1.0	5741	9.3			5813	3.7
Moorsh soils	6999	98.2	53146	86.3	36730	41.1	96875	61.3
Moorshy soils					52580	58.9	52580	33.
Total	7129	100.0	61587	100.0	89310	100.0	158026	100.0

area of the mineral soils of the moraine uplands zone. The remaining soil types, i.e. black earths, arenosols, rusty soils and grey soils, cover a small area (Table 4).

Hydrogenic soils occupy over 615 000 ha (Table 5) which is 8.7% of the soil cover in the zone in question. Peat-muck soils predominate (86.3%) while peat soils, which occur on natural peat-bogs, make up 9.3% of the hydrogenic soils (Table 5). The environmental value of these soils is exceptionally high. They occur on very numerous peat-bogs situated in hollows lying irregularly in the drainage area. Therefore, they can form natural barriers for the waters carrying biogens. Thanks to water accumulation and influence on the adjoining areas, peat-bogs control water economics. They collect organic matter. Peat-bogs of the moraine zone are most frequently supplied with water in the form of effluents or spring outflows coming from their surroundings. This way of water influx, determined as soligenous type of hydrological feeding [3], maintains a constant moistening. It can make re-naturalisation of peat-bogs easier by restoring them to their natural shape.

Understanding of the role of soil cover in the functioning of the moraine zone ecosystems, distinguished by their unique natural values, should be utilised for the correct creation and protection of the young glacial landscape. There is a demand for pro-ecological farming based on the proper usage of agricultural drainage and limiting eutrophication of natural waters. Erosion processes leading to humus losses, and forming deluvial soils, are a real menace. Protection of hydrogenic sites, especially peat-bogs, is of great importance. Dehydrated objects should be restored to their natural shape, beginning with neglected, non-agricultural areas. The natural conditions of the area in question, including a great number of objects under protection, make introduction of ecological farming easier.

The zone of outwash plains in the northern part the Mazurian Lake District is of a different character. The slopes do not exceed 6% (Table 1) in the 88% of the area. The flat area is covered with deposits of the Leszno phase of the Baltic glaciation. Sands and gravel of fluvioglacial origin make over 90% of the forms (Table 2). Taking into consideration their granulometric composition, they can be included into the category of very light forms (95%) and partly light ones (4%). Forms with mean granulometric composition cover only about 1% of area (Table 3).

Predominance of very light forms conditioned formation of the existing types of mineral soils (Table 4). Rusty soils formed from loose or slightly loamy sands which make about 60% of the mineral soils of the outwash zone are predominant. These are very acidic soils with weak sorptive properties, lacking organic matter or nutrients. Podzols formed from the outwash sands in the forest sites take up a considerable area (about 31% of mineral soils). The third main soil type there are arenosols (4.7% of mineral soils); they are hardly formed, with very light granulometric composition. Fen soils (3.5% of mineral soils) were formed in some river valleys (Table 4).

Hydrogenic soil take up a considerable area of about 90 000 ha (Table 5) which accounts for 20% of the soil cover of the outwash plains. They were formed mainly by the influence of water which leaked through sandy forms creating extensive underground water body. This type of water influx is determined as a topogenous type of hydrological feeding. Situated on the outwash plains, part of the hydrogenic soils extend into river valleys in the places where backwaters occur. These are fluviogenous sites [3]. A definite majority of hydrogenic soils were dehydrated. Afterwards, bog soils were formed, represented by muck and mucky soils. Muck soils currently occupy 41%, and mucky soils 59% of the hydrogenic soil area. In comparison with other areas, the hydrogenic soils of the outwash plains have worse water properties and higher susceptibility to organic matter mineralisation. Such mineralisation produces losses in soil nitrogen, a constant loss in organic mass of the soil and a decrease in the depth of the soil strata and transformation. Transformations follow the scheme: peat-mucks, mucky soils, mineral soils.

The role of soils in the proper functioning of the outwash plain ecosystems is especially important. Infertile, very light and light mineral soils are not resilient to any threats and they undergo degradation easily. Re-forestation would be truly useful in this case, but social and economic rules make farming the priority. In order to keep ecological balance of the habitat, properties of the soils in question ought to be improved with land agri-melioration methods. Promotion of ecological agriculture is suggested.

Excessive organic matter mineralisation is harmful for the environment in the areas where dehydrated hydrogenic soils are susceptible to drying. This process can be limited by turf utilisation and high moistening of root soil passes. Due to the extension of the underground water basin, which is characteristic in these conditions, regulation of water relations is difficult and can be done only on a large scale. That is why isolation of similarly-utilised areas and optimum soil moistening adapted to the needs is advisable.

CONCLUSIONS

1. In macroregion of the Mazurian Lake District and the neighbouring Mesoregion of the Sępopol Plain, the role of soil in the proper functioning of the ecosystem is very clear. Meridional habitat differentiation, especially large variation in the cover, differentiate three landscape zones.

2. In the glacial plains in the northern part of the studied area, brown soils resistant to degradation and black earths made of very heavy and heavy forms are common. They balance and stabilise the ecosystem. Agricultural production when run correctly, does not threaten the habitat and should promote its proper functioning.

3. In the middle, moraine part of the Mazurian Lake District with unique natural qualities and differentiated soil forms and covers, pro-ecological farming is especially needed. Erosion processes and pollution of superficial waters are major threats. The positive role of hydrogenic soils is clearly seen. Protection of these soils, as well as their re-naturalisation is a necessity. The above should be easy due to favourable water access to the habitats.

4. In the area of the outwash plains in the southern region of the Mazurian Lake District, functioning of the ecosystem is conditioned by the presence of sensitive light and very light mineral soils. They are accompanied by large areas of sensitive hydrogenic soils. Properties of the mineral soils ought to be improved by agro-melioration methods. In order to maitain predominance of the topogenous type of hydrological feeding in the hydrogenic soils, there is a demand for complex solutions in water economics and management.

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