THE ECOLOGICAL ROLE OF ABANDONED AGRICULTURAL LANDS IN BUFFER ZONES AROUND LANDSCAPE PARKS IN THE ŁÓDŹ VOIVODESHIP

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Contents

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1. Introduction

Jolanta Adamczyk, Stanisław Krysiak, Anna Majchrowska, Elżbieta Papińska

Political changes initiated in Poland in the 1980s and 1990s resulted in intense structural and functional transformations of the rural areas. They were based primarily on economical and social grounds. Decreased cost-effectiveness of agricultural production brought about massive collapsing of state farms, and discontinued cultivation of some private farmlands. Considerable areas of abandoned lands appeared in the agricultural landscape. Issues related to land abandonment have been presented in the nation-wide (Bański 1998, 2006, 2007; Harasimiuk 2013), regional and local scales (e.g. Łowicki 2008; Jaros, Woch 2010; Krysiak 2010, 2011, 2012; Majchrowska 2013, 2014). Arable land abandonment in Poland has been compared with other countries (Orłowski, Nowak 2004), where similar changes are occurring in the rural landscape (e.g. Molinillo et al. 1997; Strijker 2005; Navarro, Pereira 2012; Prishchepov et al. 2013; Terres et al. 2013). Positive and negative ecological consequences of land abandonment, in particular those concerning the landscape, have been presented in numerous publications (Höchtl et al. 2005; Bowen et al. 2007; Rey Benayas et al. 2007; Navarro, Pereira 2012).

Studies into transformations of landscapes which are located outside the suburban zones of the Łódź Voivodeship revealed some regularities in the spatial distribution of abandoned lands. Geocomplexes and natural landscape types with a rather low potential for biotic productivity were characterised by a considerable share of such lands. In agricultural landscapes, opposite directions of transformation were observed. On lands characterised by high agricultural suitability, there was an increase in the intensity of cultivation, expressed by enlargement of fields and simplification of landscape structure. In less fertile areas, significant acreages of abandoned lands appeared, representing various degrees of secondary plant succession (Krysiak 2006a, 2008a, 2008b). In the suburban zone of Łódź, around smaller cities, and on their outskirts, land abandonment is a common phenomenon. It takes place not only on poor soils but also on soils of medium quality. Presumably, some of these areas will be built-up or used for transport infrastructure. In such cases, abandonment may be only a transitory period before principal changes in the usage type (Krysiak 2014). Large amounts of abandoned lands around urbanised areas is a regularity observed in many regions of Poland where, before a farmland area can be built-up, it is usually excluded from cultivation for several years (Matuszyńska 2001; Orłowski 2003; Warczewska 2003; Łowicki, Mizgajski 2005; Łowicki 2008).

The scale of abandonment in regional studies has mostly been evaluated on the basis of standard statistical analyses or data from General Agricultural Censuses. Information from these sources only illustrates the scale of abandonment in administrative units – communes, districts or voivodeships, without providing any information on the distribution of this phenomenon within the boundaries of the units and its habitat conditioning (Łowicki 2008; Harasimiuk 2013).

There is no universally accepted, uniform notion of abandoned land. Generally, abandoned lands are considered to be post-cultivation areas, left without human interference for many years. In the traditional meaning, the term "abandoned lands" refers only to uncultivated arable lands. In land records they are also treated as arable lands (Rozporządzenie Ministra Administracji i Cyfryzacji... 2015). In this work, abandoned lands also include idle meadows and pastures. There are three reasons for expanding the meaning of the term "abandoned land" to encompass

unused grassland. Firstly, unmowed meadows and pastures where grazing no longer takes place are areas of progressing overgrowing, similarly to arable lands left without interference from farmers. Regardless of the original usage type, there is a similarity between ecological processes, expressed in spontaneous regeneration and plant succession. Secondly, in the functional dimension, the energy subvention directed by people during previous usage has disappeared. Thirdly, from the formal point of view, the overgrowing meadows and pastures can also be called abandoned lands because the dictionary definition states that to be abandoned means "to be set-aside, not used, neglected" (Uniwersalny Słownik Języka Polskiego 2003). The presented perspective refers to the landscape ecological definition of the process of land abandonment (Pointereau et al. 2008), for which the basis is the evaluation of vegetation land cover.

Abandonment of considerable areas makes it possible to observe the course and rate of spontaneous plant succession and regeneration. In these areas, vegetation "emancipated" from long-term anthropopressure appears; vegetation which develops as a result of autonomous activity of ecological processes (Faliński 2001). Many times, as years pass, the idle lands become more and more floristically diverse, often with the occurrence of rare and protected plants (Kurus, Podstawka-Chmielewska 2006). On the other hand, abandoned lands which have not been afforested or used in another way are in danger of overgrowing with weeds, and becoming occupied by the so called invasive species of plants, which often colonise abandoned lands. This poses a great threat to the nearby natural ecosystems, as the invasive species, particularly those of non-native origin, such as *Solidago canadensis*, *Impatiens glandulifera*, *Padus serotina*, or *Acer negundo*, grow even under unfavourable habitat conditions and spread quickly to large distances (e.g. Tokarska-Guzik 2005; Tokarska-Guzik et al. 2012; Woziwoda 2012).

Despite a large amount of research, not all processes occurring in abandoned lands during secondary succession and factors which influence the succession have been recognised. Besides, it has not been established how important abandoned lands can be for the functioning of the neighbouring ecosystems, especially in protected areas.

The scale of transformation of contemporary agricultural landscapes in Central Poland has resulted in the emergence of a large amount of abandoned lands. For the authors of this work, it is the reason for undertaking research into the spatial distribution and ecological role of abandoned lands in the buffer zones around landscape parks of the Łódź Voivodeship. In this respect, filling gaps in forest cover and correcting the field-forest boundary by the spread of abandoned lands is the most important, along with an increase in landscape heterogeneity, formation of ecological microcorridors, and improvement of food supply for a number of animal species (Jermaczek 2007).

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2. Aim and scope of the work

Jolanta Adamczyk, Stanisław Krysiak, Anna Majchrowska, Elżbieta Papińska

The aim of the work was to:

1. Recognise the location of abandoned lands in the study areas.
2. Identify the landscape ecological structure by delimitation of geocomplexes (morpholithohydrotopes) in order to describe geomorphology, lithology, hydrology and soils of the study areas.
3. Make an inventory of vascular plant species and macromycetes of selected abandoned lands.
4. Provide a description of vegetation that grows on the analysed abandoned lands.
5. Evaluate the relationship between the location of abandoned lands and the abiotic features of the natural environment.
6. Determine the relationship between the abandoned land vegetation and the abiotic features of the habitat.
7. Evaluate the ecological role of abandoned lands in the agricultural landscape of the Łódź Voivodeship, taking into consideration their abiotic conditions and specific features of vegetation and macromycetes.

The research was conducted in the 10-kilometre wide buffer zones which surround all landscape parks in the Łódź Voivodeship (Fig. 2.1). The research included an area of 7 205 km². In the case of the Łódź Hills Landscape Park, the Warta–Widawka Interfluve Landscape Park and the Sulejów Landscape Park, the surrounding 10-km zones are located within the borders of the voivodeship. The fragments of zones surrounding the Bolimów Landscape Park, Przedbórz Landscape Park, Spała Landscape Park and Załęcze Landscape Park which lie in the neighbouring voivodeships were excluded from the research.

The geocomplexes were delimited both in the areas of landscape parks and in their buffer zones. It enabled to present the relationships of landscape ecological structure of the surroundings of landscape parks and the parks themselves, and made the whole landscape ecological structure visible, in particular the continuous character of geocomplexes of river valleys (for example of the Pilica, the Warta and the Rawka river valleys).

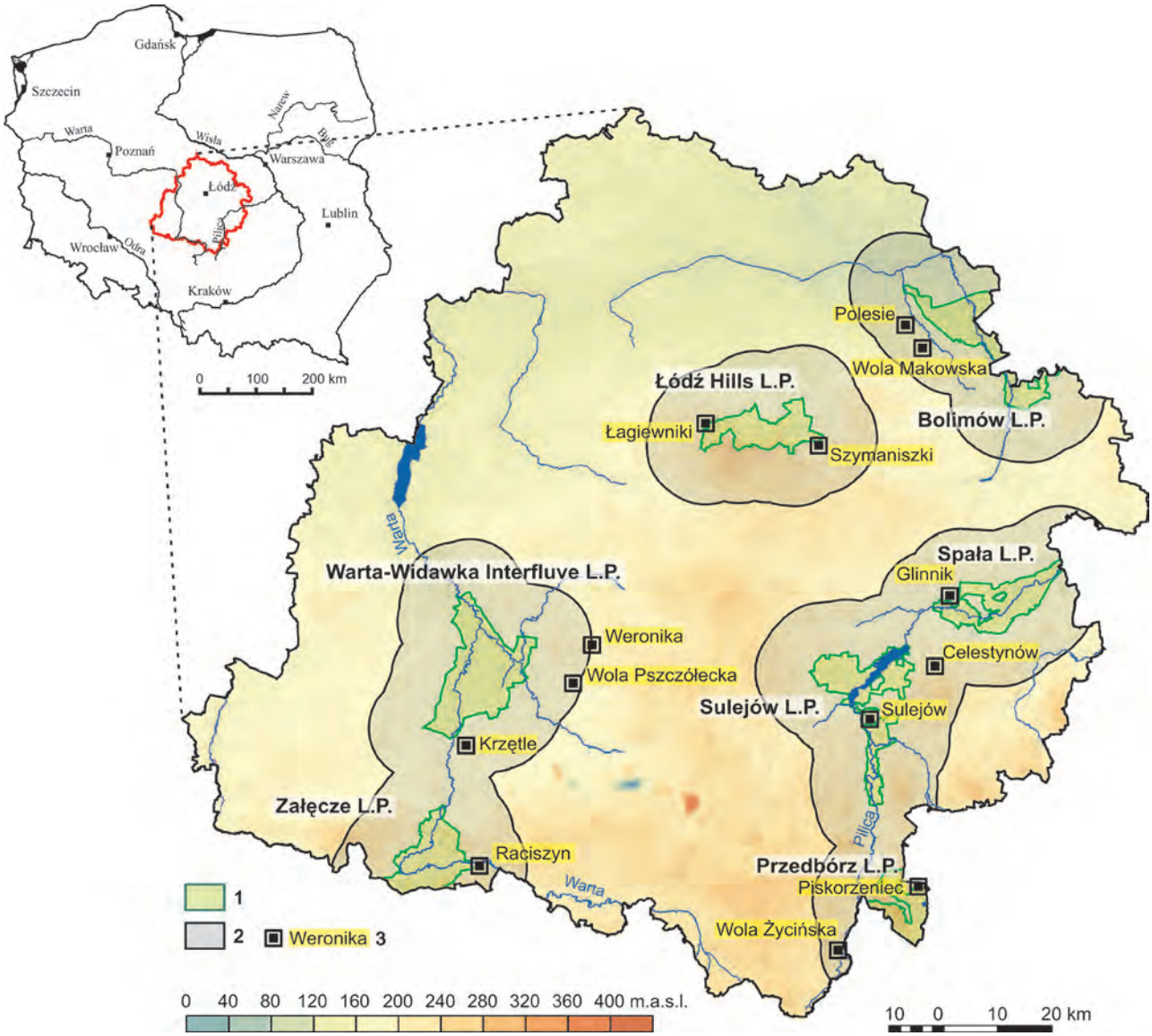

Fig. 2.1. The study area, encompassing the 10-km wide buffer zones around the seven landscape parks of the Łódź Voivodeship, and the location of study plot groups

1 – landscape park area; 2 – 10-km wide buffer zone around a landscape park; 3 – study plot group

Source: own elaboration based on digital elevation model with grid interval of at least 100 m and other data made available by CODGiK (www.codgik.gov.pl)

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3. Methods

The interdisciplinary character of the research topic required the application of field and desk research methods used in landscape ecology, pedology, phytosociology and mycology.

3.1. Landscape ecology methods

Stanisław Krysiak, Anna Majchrowska, Elżbieta Papińska

Preliminary identification of the location and scale of the phenomenon of land abandonment in the buffer zones of landscape parks in the Łódź Voivodeship was conducted as desk research. Identification of abandoned lands was performed on the basis of visual interpretation of orthophotomaps from 2009, made available by Geoportal (www.geoportal.gov.pl) as part of the Web Map Service (WMS). The basic areas of evaluation were squares of 25 ha each (500 x 500 m), with coordinates declared in the Quantum GIS 1.8.0 software. A total of 33 692 basic squares were interpreted during the research project.

Five intensity classes were used for evaluating the share of abandoned lands in the basic squares:

- class 0: no abandoned lands present among farmlands (0%),
- class 1: low intensity of land abandonment (0.1–25%),
- class 2: medium intensity of land abandonment (25.1–50%),
- class 3: high intensity of land abandonment (50.1–75%),
- class 4: very high intensity of land abandonment (75.1–100%).

Identification of abandoned lands based on interpreting the image of vegetation cover is difficult, as contours of the abandoned lands and other types of land cover are not clear. Young abandoned lands are very similar to the image of some pastures on the orthophotomaps (Faliński 1986). In this work, abandoned lands are defined as those which (Majchrowska 2014):

- are characterised by forest, thicket and grassland or mixed vegetation cover, resulting from secondary succession,
- were cultivated in the past,
- were not artificially afforested or urbanised.

Orthophotomap interpretation resulted in creating a map of abandoned land occurrence. In order to restrict the analysis only to areas related to agricultural activity, anthropogenic areas, forests, inland waters were excluded from the evaluation. The above areas were excluded using land cover classes from the Corine Land Cover programme (Corine Land Cover 2012).

For the purposes of explaining natural factors which influence the spatial pattern and intensity of land abandonment in the analysed buffer zones around landscape parks, the authors prepared maps of natural landscape units – partial geocomplexes, referred to as morpholithohydrotopes. These units represent a specific habitat potential, which results from the geomorphological location, lithological and petrographic character of surface deposits, and their properties related to aeration and moisture.

Geocomplexes were delimited using the method of leading factors, described among others by A. Richling (1982, 1993). Land relief, lithology of surface formations and moisture conditions were selected as the most important geocomponents which influence the habitat potential. The importance of the surface shape and geomorphological location for the dynamics of habitat functioning was decisive for the selection of

relief as a delimitation criterion. Lithology of surface formations was chosen due to its influence on the hydrotrophic properties, which naturally predispose lands for specific forms of usage (Krysiak 1996). Moisture conditions, accepted as the third delimitation criterion, are commonly recognised as important for shaping and differentiating habitats, influencing the dynamics of biological transformations and circulation of matter in the habitat (Oświt 1977). The water factor was used for grouping the delimited morpholithohydrotope types into lithogenic geocomplexes – which normally do not undergo excessive moisturising, semi-hydrogenic geocomplexes – shaped partially by periodical anaerobiosis, and hydrogenic geocomplexes – which exist in the conditions of long-term or permanent anaerobiosis. The presented typology of partial geocomplexes refers to earlier divisions introduced for the central part of the Pilica basin (Krysiak 1997, 1999a) and the Łódź Voivodeship (Papińska 2001; Majchrowska 2002). The following maps were used for mapping the geocomplexes: 1:10 000 and 1:25 000 scale topographic maps, Detailed Geological Maps of Poland (SMGP) at the scale of 1:50 000, and soil and agricultural maps of former voivodeships: Łódź at the scale of 1:50 000, Piotrków, Sieradz, Skierniewice, Radom and Kielce at the scale of 1:100 000 prepared by the Institute of Cultivation, Fertilisation and Pedology (Instytut Upraw Nawożenia i Gleboznawstwa) in Puławy (Województwo miejskie łódzkie. Mapa glebowo-rolnicza. 1986; Województwo piotrkowskie. Mapa glebowo-rolnicza. 1979; Województwo sieradzkie. Mapa glebowo-rolnicza. 1977; Województwo skierniewickie. Mapa glebowo-rolnicza. 1988; Województwo radomskie. Mapa glebowo-rolnicza. 1984; Województwo kieleckie. Mapa glebowo-rolnicza. 1985). Maps of geocomplexes were prepared with the use of ArcGIS 10.2.2 software. For all areas included in the research, the respective sheets of SMGP were scanned, and then georeferenced. In this form, they were used as a basemap for drawing – vectorisation of geocomplex limits, based on the interpretation of geological delimitations, in accordance with the table of morpholithohydrotopes of Central Poland (Tab. 3.1).

Morpholithohydrotope maps were prepared using the lithological categories from Detailed Geological Maps of Poland at the scale of 1:50 000:

- for areas on the Pilica river: Balińska-Wuttke 1960; Jurkiewicz 1962; Grzybowski, Kutek 1966; Makowska 1970a, 1970b; Szajn 1978, 1981; Kwapisz 1981; Ziomek 1982, 2001; Kurkowski, Popielski 1986; Janiec 1988; Kłoda 1988; Szałamacha 1989; Brzeziński 1990; Nowacki 1990; Trzmiel 1990; Turkowska, Wieczorkowska 1992; Włodek 2009;
- for areas on the Warta river: Baliński 1994; Baliński, Gawlik 1983; Bezkowska 1991; Haisig, Wilanowski 1979; Haisig, Wilanowski 1994; Haisig, Wilanowski 2000; Klatkowa 1985; Krzemiński, Bezkowska 1984; Sarnacka 1967; Skompski 1967; Ziomek, Baliński 2007; Ziomek, Gałązka 2013, and a 1:50 000 geotouristic map: The Załęcze Landscape Park and the Surrounding Areas – the Wieluń Upland (northern part of the Polish Jura) (Janus, Obarowska 2011);
- for areas around the Bolimów Landscape Park and the Łódź Hills Landscape Park: Balińska-Wuttke 1958, 1960; Różycki, Kulczyński 1962; Brzeziński 1984, 1986, 1990, 1995; Trzmiel, Nowacki 1984; Nowacki 1990; Trzmiel 1990; Klatkowa, Kamiński, Szafrańska 1991; Szalewicz 1993; Szalewicz, Włodek 2009; Włodek 2009; Ziomek, Włodek 2010.

The comparison between maps of land abandonment intensity with maps of geocomplexes (morpholithohydrotopes) was carried out using ArcGIS software. The built-in algorithm of intersection was used for isolating the geometric intersection between the geocomplex layer and the layer of land abandonment intensity classes. The result was a table composed of attributes of both processed layers. Then, using the Haskell programming language, an algorithm was created to group the ArcGIS output data. Application of the algorithm allowed to calculate the percentage share of land abandonment intensity classes in relation to geocomplex types and the percentage share of the area of geocomplex types in classes of land abandonment intensity.

The spatial identification of abandoned lands made it possible to isolate areas of their higher concentration, which were later used for selecting thirteen groups of study plots: Glinnik, Celestynów, Sulejów, Piskorzeniec, Wola Życińska around the Pilica Landscape Parks; Weronika, Wola Pszczółecka, Krzętle, Raciszyn around the Sieradz Landscape Parks; Polesie, Wola Makowska in the buffer zone of the Bolimów Landscape Park; Szymaniszki, Łagiewniki in the buffer zone of the Łódź Hills Landscape Park (Fig. 2.1). In each group, three study plots: A, B, and C were selected for phytosociological and mycological inventorying

Table 3.1. Morpholithohydrotope types of Central Poland

TYPES OF MORPHOLITHOHYDROTOPES OF CENTRAL POLAND	
LITHOGENIC GEOCOMPLEXES (morpholithohydrotopes which do not undergo excessive moisturising)	
Lithogenic geocomplexes associated with outcrops of solid rocks	
1	Outcrops of siliceous rocks
2	Outcrops of carbonate and marl rocks
Lithogenic geocomplexes associated with permeable Quaternary sediments	
4	Boulders, cobbles, gravels, sands and muds of moraine hills and kame hills
6	Glacial and fluvioglacial boulders, cobbles, gravels, sands and muds of plateaus, alluvial fans and erosional-accumulational terraces
7	Sands, silts and muds in bottoms of dry valleys (diluvia)
8	Fluvial sands and gravels of upper terraces
9	Fluvial sands and muds of lower terraces
19	Fluvial sands and muds of flood plains
14	Cover silts of plateaus
15	Aeolian sands of dunes and shields
20	Periglacial cover sands and silts of plateaus
Lithogenic geocomplexes with hydrologic conditions shaped partially by shallow low permeable formations	
5	Glacial tills of plateaus
16	Glacial and fluvioglacial sands and gravels upon glacial tills of plateaus
17	Cover silts upon glacial tills
18	Periglacial and aeolian sands upon glacial tills of plateaus
3	Clays, claystones, muds and mudstones of various origins
SEMI-HYDROGENIC GEOCOMPLEXES (morpholithohydrotopes shaped partially by periodic anaerobiosis)	
13	Mineral and organic formations in depressions of kettle holes, blowouts, spring niches and basin valleys
HYDROGENIC GEOCOMPLEXES (morpholithohydrotopes shaped partially by long term or permanent anaerobiosis)	
10	Fluvial sands, muds and organic sediments of terraces
11	Fluvial sands, muds and organic sediments of valley bottoms
12	Peats and mucks of wetlands

Source: own elaboration.

and evaluating the agrophysical and agrochemical properties of the habitats. The characterisation of each of the study plots consisted of: geographical coordinates, a set of photographs, description of soil profile, tables with results of agrophysical and agrochemical analyses, characteristics of the flora and fungi. Location of the central point of each plot was determined with geographical coordinates with the use of a GPSmap 62s device. The physiognomy of the surrounding area was documented photographically in a hexagonal system. With the camera placed on a tripod, the optical axis of the lens was pointed in six directions on the basis of compass readouts, for azimuths of 0°, 60°, 120°, 180°, 240° and 300°. After presentation of the documented plots, there is a short summary of characteristics for each study plot group.

3.2. Pedological methods

Stanisław Krysiak, Anna Majchrowska, Elżbieta Papińska

During field works, soil samples for laboratory analyses were taken from excavated soil pits and drillings with manual augers. Analyses of the sampled sediments were conducted in the District Chemical and Agricultural Station (Okręgowa Stacja Chemiczno-Rolnicza) in Łódź (accreditation certificate for the research laboratory No. AB 820). The following values were calculated using analytical methods:

- granulometric composition and specific surface area, using the laser diffraction method, in accordance with research procedure PB 34, edition 1 of 03.07.2006,
- total nitrogen content (N), using Kjeldahl's titration method (PB 49, edition 2 of 01.02.2007),
- pH in KCl, pH in H_2O (PN-ISO 10390: 1997),
- available phosphorus content (P_2O_5), using spectrophotometric method (PN-R-04023: 1996),
- available potassium content (K_2O), using flame photometry (P-N-R-04022: 1996+Az1: 2002),
- available magnesium content (Mg), using flame atomic absorption spectroscopy (FAAS) (PN-R-04020: 1994+Az: 2004 p. 4),
- content of exchangeable alkaline cations (Ca^{2+}, Mg^{2+}, Na^{+}, K^{+}), using Pallmann method (PB 47 edition 1 of 09.07.2004),
- hydrolytic acidity using Kappen's method (PB 33 edition 1 of 07.09.2004),
- humus content, calculated from organic carbon contents (C org.), determined using titration method (PB 29 edition 1 of 07.09.2004).

The obtained results allowed for such indicators of habitat quality to be determined as: organic carbon to general nitrogen ratio – C/N, cation exchange capacity – T, total bases – S, and degree of saturation with exchangeable alkaline cations – V.

3.3. Phytosociological and mycological methods

Jolanta Adamczyk

Botanical and mycological field observations were conducted in the years 2012 and 2013. The abandoned agricultural lands were identified in buffer zones around all landscape parks in the Łódź Voivodeship: Bolimów Landscape Park, Warta–Widawka Interfluve Landscape Park, Przedbórz Landscape Park, Spała Landscape Park, Sulejów Landscape Park, Załęcze Landscape Park, Łódź Hills Landscape Park. In the abandoned land areas, after preliminary selection, 39 study plots arranged in 13 study plot groups (Fig. 2.1) were chosen. The location of each study plot was precisely marked using the GPS system. In each study plot, the current flora, macromycetes and vegetation were inventoried. The flora and vegetation were evaluated once per each plot, but the fungi were observed 10–12 times during the period of 2 years. Phytosociological and mycosociological releve analyses were carried out in each study plot. Species of flora and lichens were estimated in percentage of land cover in each analysed plot, whereas for species of macromycetes, the estimation of the number of identified occurrences in the study plot was used. Data from observation of the vegetation cover were processed using Ward's hierarchical cluster analysis and IndVal of Dufrene and Legendre (1997).

Nomenclature of plant species was taken from Z. Mirek et al. (2002), mosses – from R. Ochyra et al. (2003), and of fungi and lichens in accordance with Index Fungorum (www.indexfungorum.org/Names/names.asp).

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4. Abandoned agricultural lands in buffer zones around landscape parks in the Łódź Voivodeship – habitat background, spatial distribution, scale of the phenomenon

4.1. Abandoned lands around landscape parks on the Pilica River (Przedbórz Landscape Park, Sulejów Landscape Park, Spała Landscape Park)

Stanisław Krysiak

The 10-km wide buffers around the three protected areas on the Pilica River – Spała Landscape Park, Sulejów Landscape Park and Przedbórz Landscape Park, form one integrated zone, because the parks are located close to each other. According to the physicogeographical division by J. Kondracki (2002), this area lies within the subprovince of the Central Polish Lowland (318) and the Lesser Poland Upland (342). The mesoregions which represent the Central Polish Lowland include: the Piotrków Plain (318.84), the Białobrzegi Valley (318.85), the Rawa Plateau (318.83), the Radom Plain (318.86) and small fragments of the Bełchatów Plateau (318.81) and the Łódź Hills (318.82). The southern part of the buffer zone around the Pilica parks, which lies in the subprovince of the Lesser Poland Upland, includes fragments of the following mesoregions: the Radomsko Hills (342.11), the Opoczno Hills (342.12), the Przedbórz–Małogoszcz Range (342.15), the Łopuszno Hills (342.16) and the Włoszczowa Basin (342.14) (Fig. 4.1). The analysed area encompassed 1 232.79 km².

A characteristic feature of the landscape of the 10-km wide buffer zone around the Pilica parks is the merging of lowland and upland landscape elements. This is expressed in the coexistence of marine, glacial, fluvioglacial, fluvial, limnic, aeolian and biogenic deposits of different ages. The resulting petrographic diversity of surface deposits is reflected in the habitat potentials which predispose different fragments of the analysed area for specific forms of usage. The spatial structure of the analysed areas on the Pilica River is illustrated in the map of partial geocomplexes – morpholithohydrotopes (Fig. 4.2).

The share of areas taken by individual types of geocomplexes reflects the high amount of habitats with low resource potential, characteristic for areas in the vicinity of the Pilica river valley, related to the occurrence of excessively permeable Quaternary and Mesozoic formations (Fig. 4.2 and 4.3). They include extensive patches of fluvioglacial and glacial sands and gravels (geocomplex type 6), fluvial sands, gravels and muds of terraces and flood plains which accompany the Pilica River and its tributaries (types 8, 9 and 19), periglacial cover sands and silts of plateaus (type 20), aeolian sands of dunes and shields (type 15), small, but very numerous geocomplexes of moraine hills and kames (type 4), deluvial sands, silts and muds in bottoms of dry valleys (type 7) and outcrops of sands and sandstones (type 1). The more fertile habitats, related to the occurrence of low-permeable sediments, both Quaternary and Mesozoic, are represented by six geocomplex types. Of them the highest share is held by geocomplex type 5 – glacial tills of plateaus (36.6%). Morpholithohydrotopes of type 16 and 18, in which the tills underlie permeable sediments, have a lower share (4.5% and 5.9%, respectively).

The spatial image of abandoned land distribution and abandonment intensity around landscape parks on the Pilica River was presented in Figure 4.4. The analysed area is dominated by agricultural lands, in which no abandoned lands were identified (59.3% of the area). The percentage of areas included in each of five classes of abandonment intensity is illustrated with Figure 4.5.

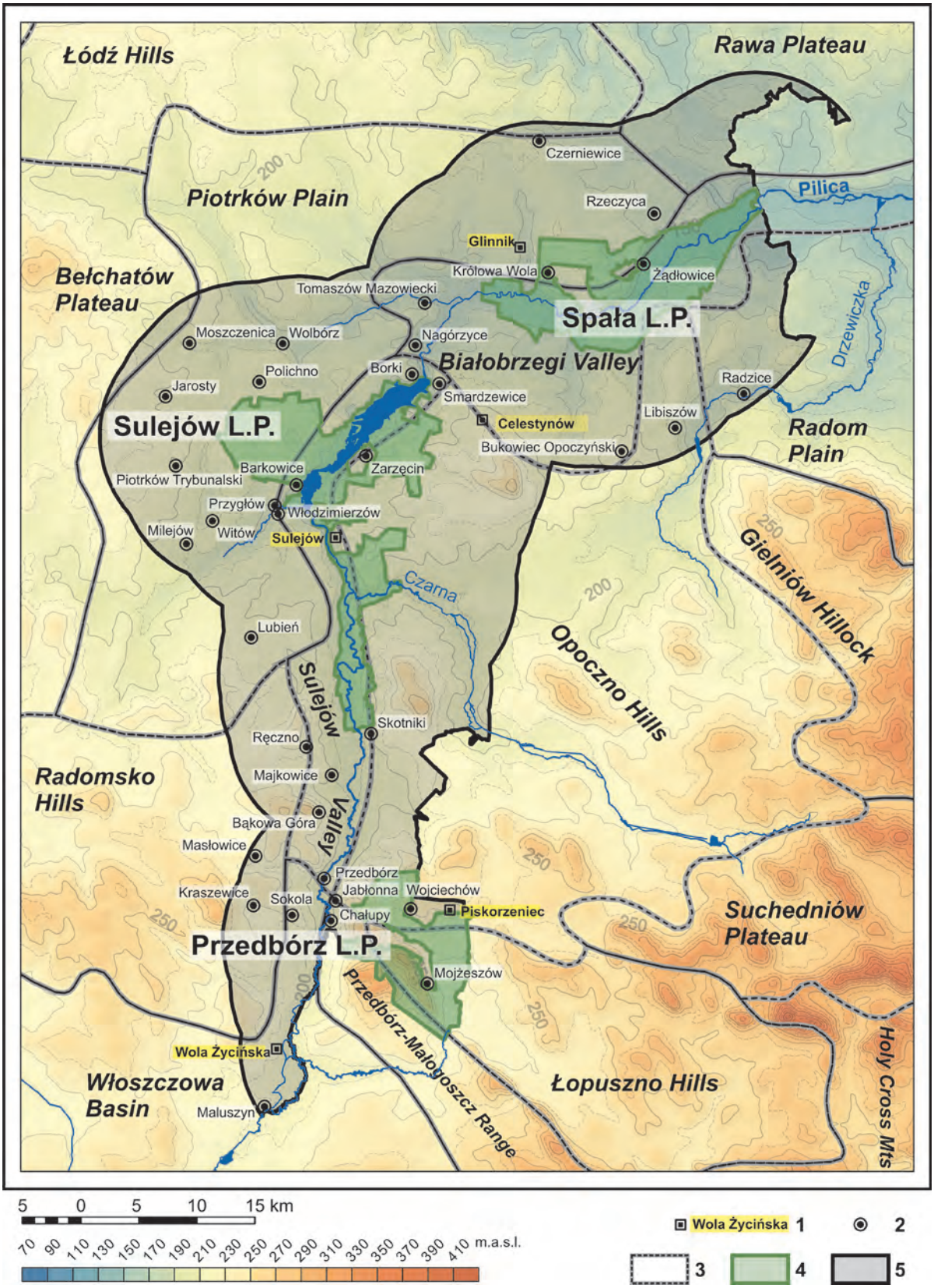


Fig. 4.1. Landscape parks on the Pilica River and their buffer zone, against the background of the physicogeographical units by J. Kondracki (2002)

1 – location of abandonment study plot groups; 2 – locations mentioned in the text; 3 – boundaries of physicogeographical units; 4 – landscape park areas; 5 – 10-km wide buffer zone around landscape parks

Source: own elaboration based on digital elevation model with grid interval of at least 100 m and other data made available by CODGiK (www.codgik.gov.pl)

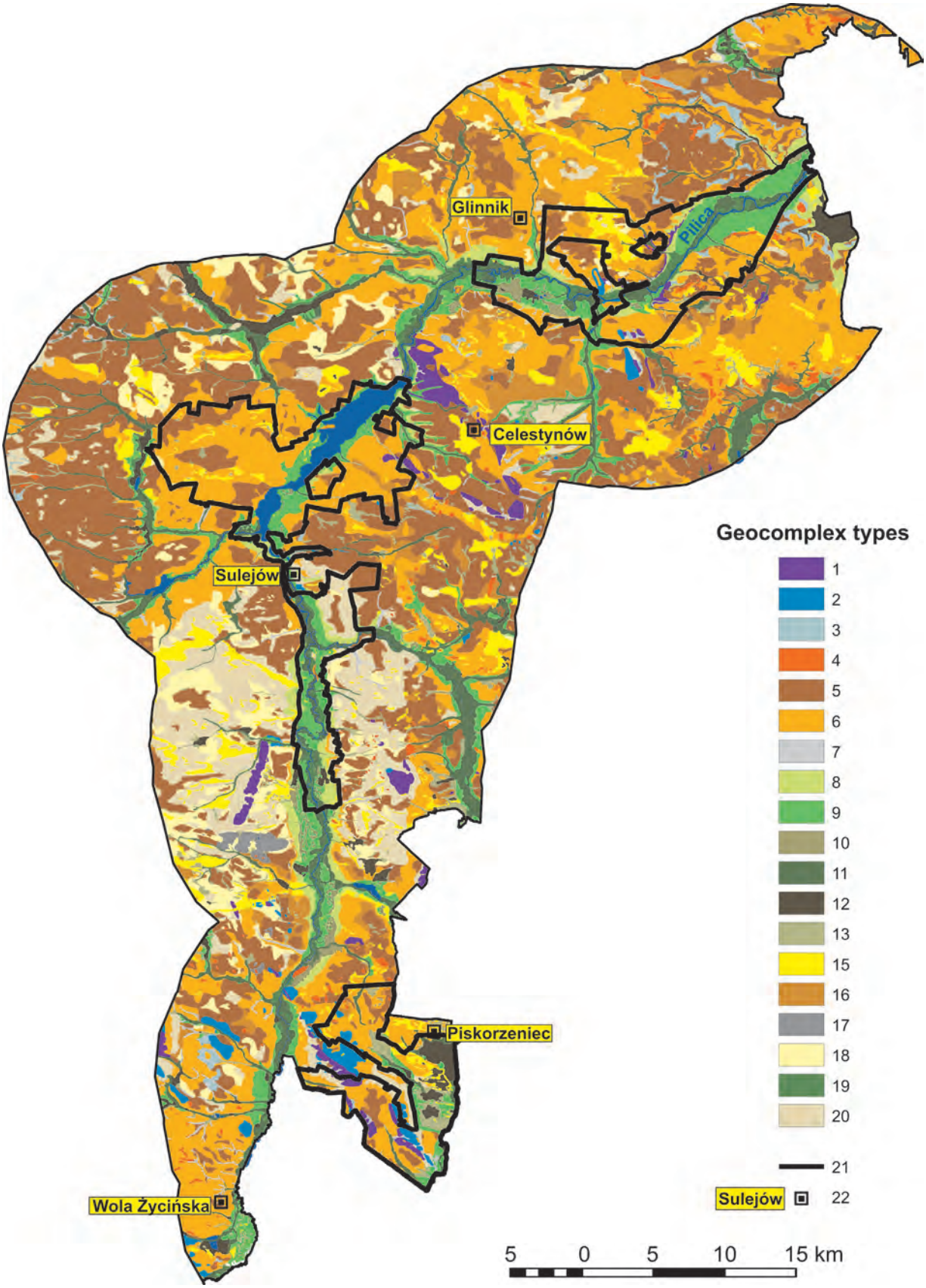


Fig. 4.2. Map of geocomplexes (morpholithohydrotopes) of the landscape parks on the Pilica River and their buffer zone
1–20 names of the morpholithohydrotopes are listed in Tab. 3.1; 21 – landscape park boundary; 22 – study plot group

Source: own elaboration

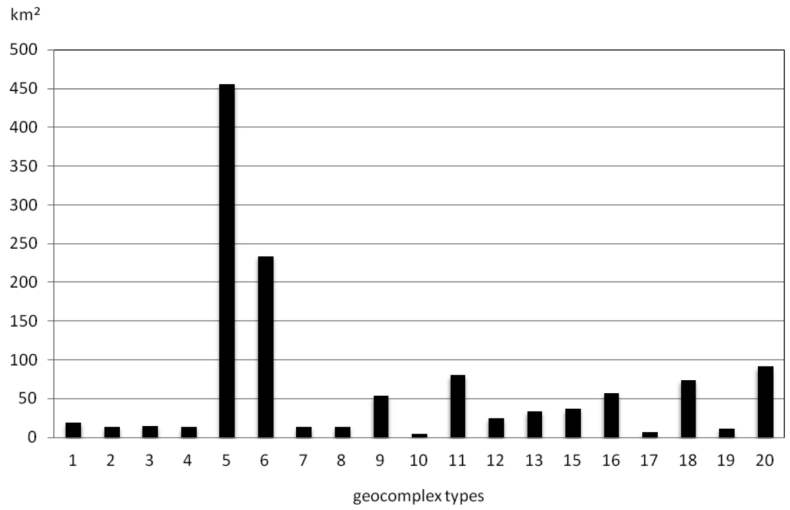


Fig. 4.3. The area of geocomplexes types in the structure of the natural environment of the buffer zone around landscape parks on the Pilica River

Source: own elaboration

The spatial layout of areas without abandoned lands (class 0) is related to areas with a high potential for biotic productivity. Class 0 areas cover vast fragments of the Piotrków Plain around Piotrków Trybunalski (the vicinities of Wolbórz, Polichno, Moszczenica, Jarosty, Przygłów, Witów, Milejów) and to the north of the Spała Landscape Park, in the area around Rzeczyca and Czerniewice. There are also no abandoned lands in some parts of the Radomsko Hills (the vicinities of Sokola Góra, Kraszewice, Masłowice, Bąkowa Góra, Majkowice, Ręczno) and the Opoczno Hills (the vicinities of Radzice, Libiszów, Bukowiec Opoczyński). Smaller areas without abandoned lands are also found in patches in other mesoregions around the Pilica landscape parks. In all cases, the lack of abandoned lands results from favourable agricultural conditions. Such conditions are mostly provided by places where the parent rocks are silts upon till (geocomplex type 17), glacial tills (type 5), clays, muds and mudstones (type 3) and other geocomplex types, where trophic and moisture conditions are shaped by the presence of glacial till in the lower part of the soil profile.

The occurrence of abandoned lands was found within the area of 502 km^2. The most numerous are areas which belong to class 1 (up to 25% of abandoned lands), whose share exceeds 27%.

Areas with a higher amount of abandoned lands (classes 2, 3 and 4) cover 13.4 % in total. They usually form larger areas with an increased concentration of abandoned lands. These are exemplified by outcrops of sands and sandstones (type 1), gravels and sands of moraine and kame hills (type 4), glacial and fluvioglacial sands and gravels of plateaus (type 6), aeolian sands of dunes and shields (type 15). Such concentrations are often found near forest complexes, e.g. in the northern and western part of the Opoczno Hills, in the northern fragments of the Radomsko Hills, or between Lubień and Felicja in the southern part of the Piotrków Plain.

Fluvial sands, gravels and muds of the lower and upper terrace in the Pilica river valley (geocomplex types 8 and 9) are usually areas where soils are classified as very poor rye complex (7). Similar agricultural suitability is exhibited by light alluvial soils in the flood plain (type 19). This fact is well illustrated by a concentration of abandoned lands along the valley between Maluszyn and Skotniki (Fig. 4.4) and the share of abandoned lands in geocomplex types 10, 11 and 12.

Areas of concentrated abandoned lands in the zone around the Pilica landscape parks also include grounds near urban settlement units.
Examples include areas around Tomaszów Mazowiecki, Piotrków Trybunalski, Sulejów and Przedbórz (Fig. 4.4).

A comparison between the map of land abandonment intensity (Fig. 4.4) and the map of geocomplexes (morpholithohydrotopes) (Fig. 4.2), conducted on the basis of output data from the ArcGIS software, made it possible to present in detail the percentage of abandonment intensity classes in different geocomplex types (Fig. 4.6). The results confirm the influence of the habitat potential of geocomplexes on the scale of the phenomenon of land abandonment. It is most well-

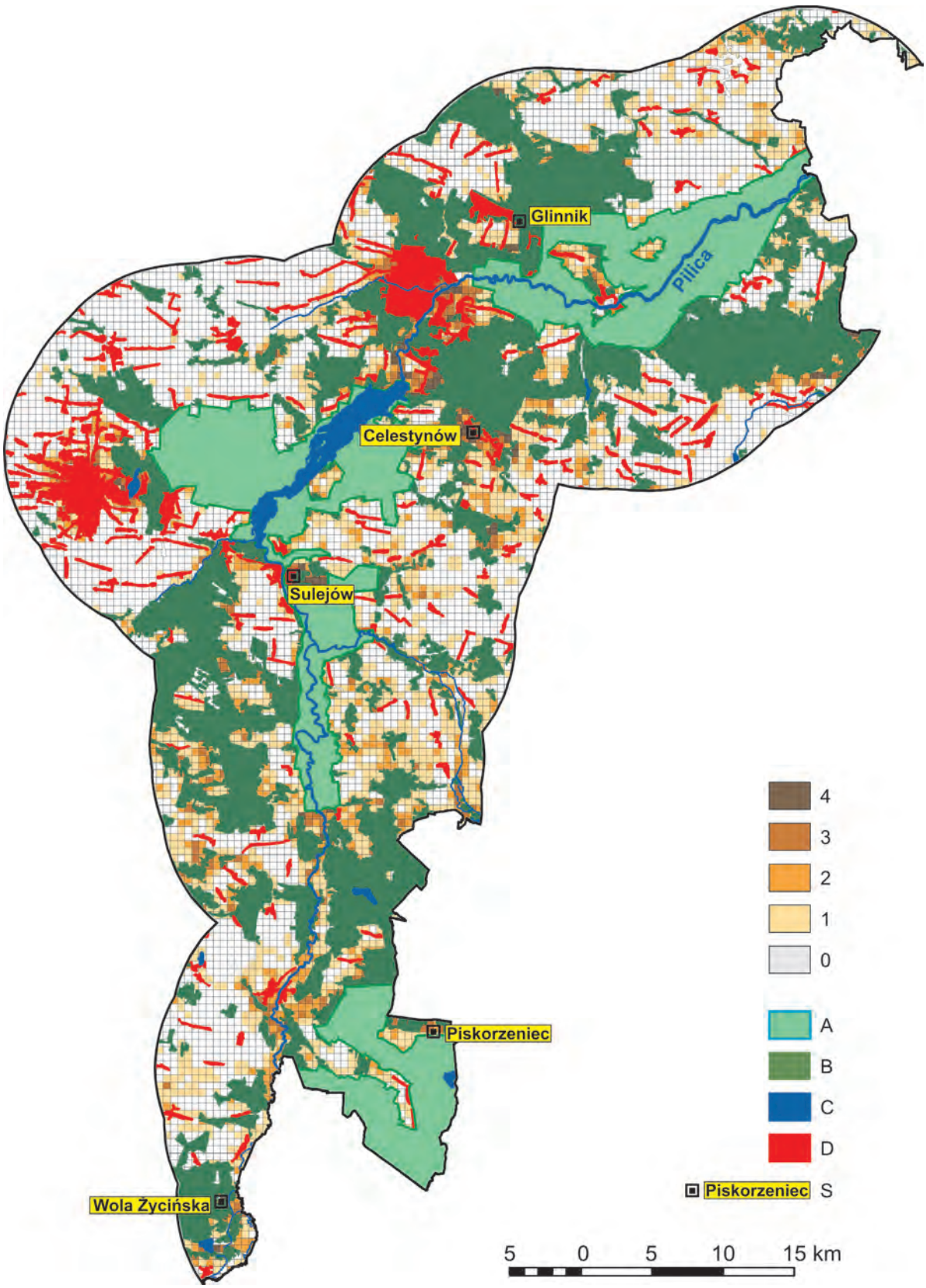


Fig. 4.4. Map of spatial distribution and intensity of land abandonment in the buffer zone around landscape parks on the Pilica River

A – landscape park areas; B – forest; C – water; D – artificial surfaces; S – study plot group
Farmland abandonment classes: 0 – no abandonment (0% area of basic square); 1 – low intensity (0.1 – 25%); 2 – medium intensity (25.1 – 50%); 3 – high intensity (50.1 – 75%); 4 – very high intensity (75.1 – 100%)

Source: own elaboration

-visible in the case of the most fertile geocomplex of type 17, built of silts upon glacial tills. It has the highest percentage of areas without abandoned lands and, at the same time, no lands in class 3 and 4 of abandonment intensity were found there. A similarly high share of areas without abandoned lands is recorded in plateaus built of glacial till (type 5), whose total area constitutes the basis for the development of agriculture on the Pilica River. A computer analysis allowed to obtain information on the percentage share of areas of different geocomplex types in the land abandonment intensity classes (Tab. 4.1). Because 55.9% of the area of buffer zone around the Pilica landscape parks belongs to two geocomplex types (5 and 6), they have the highest share in all abandonment intensity classes, and they also cover the largest area among grounds without abandoned lands.

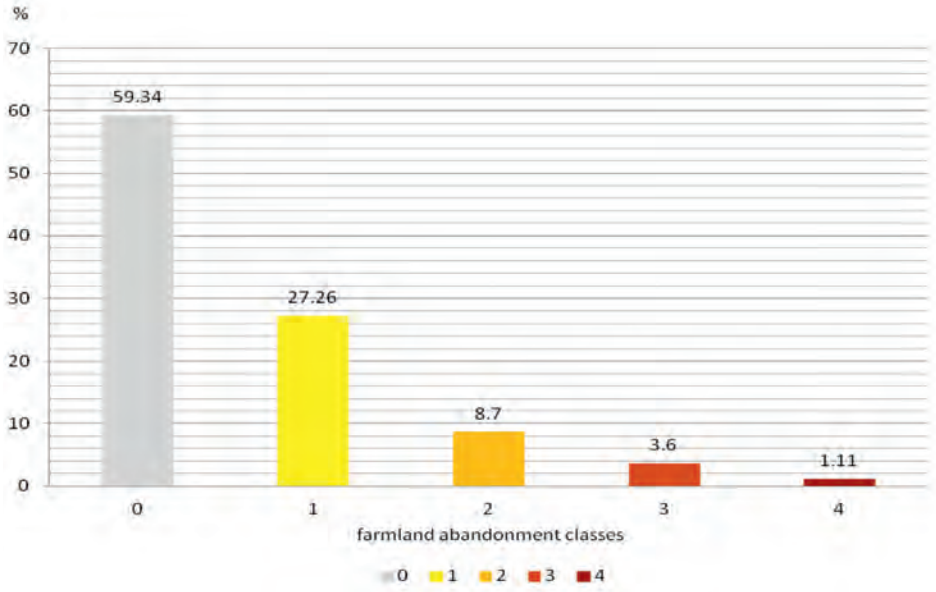


Fig. 4.5. Percentage of area of land abandonment intensity classes in the buffer zone around landscape parks on the Pilica River

Source: own elaboration

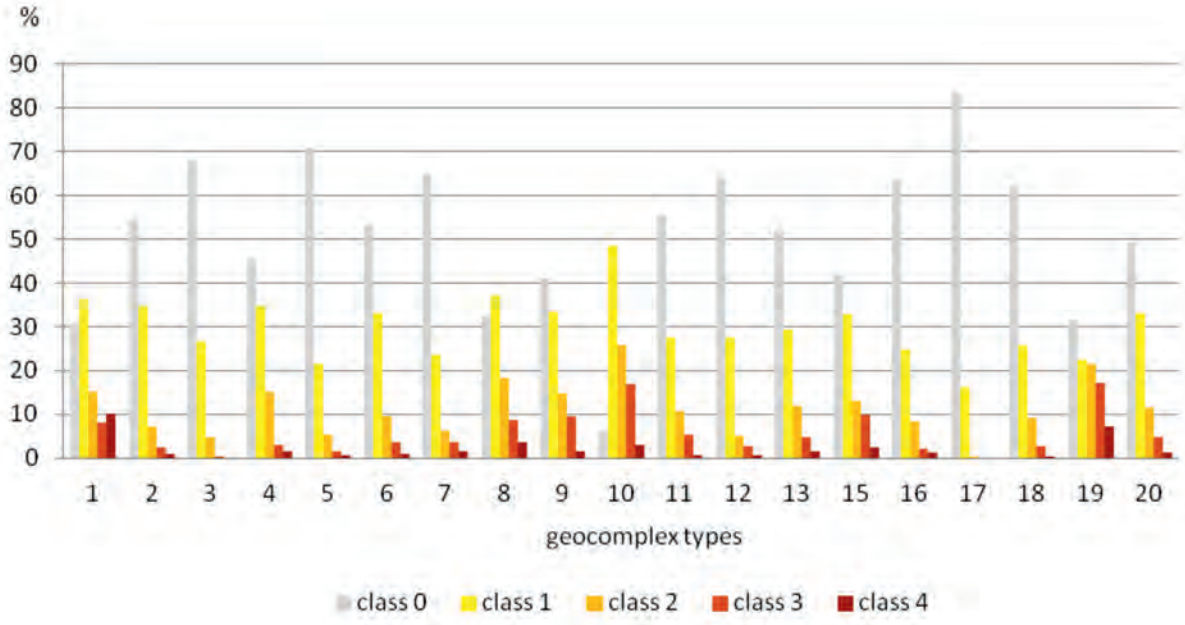


Fig. 4.6. Percentage of areas of land abandonment intensity classes in geocomplex types in the buffer zone around landscape parks on the Pilica River

Source: own elaboration

Tab. 4.1. Percentage of areas of geocomplex types in land abandonment intensity classes in the buffer zone around landscape parks on the Pilica River (sorted by the decreasing share in the area of geocomplex type)

Geocomplex type	% geocomplex type area In abandonment class 0	Geocomplex type	% geocomplex type area In abandonment class 1	Geocomplex type	% geocomplex type area In abandonment class 2	Geocomplex type	% geocomplex type area In abandonment class 3	Geocomplex type	% geocomplex type area In abandonment class 4
5	43.87	5	29.14	5	22.98	6	18.97	5	21.84
6	16.84	6	22.75	6	20.72	5	16.05	6	17.19
18	6.22	20	8.91	20	9.75	9	11.39	1	9.57
20	6.08	11	6.48	11	8.04	20	9.99	20	9.07
11	6.04	18	5.60	9	7.35	11	9.96	15	6.76
16	4.85	9	5.27	18	6.35	15	8.20	9	6.29
9	2.98	16	4.11	15	4.48	18	4.49	19	5.43
13	2.37	15	3.55	16	4.37	19	3.99	16	5.05
12	2.11	13	2.87	13	3.67	13	3.58	11	4.82
15	2.10	12	1.95	8	2.27	16	2.81	8	3.73
3	1.33	8	1.46	19	2.07	8	2.56	13	3.50
7	1.17	1	1.38	4	1.83	1	2.30	7	1.57
2	0.98	2	1.38	1	1.80	12	1.51	4	1.48
4	0.80	4	1.34	12	1.14	10	1.39	12	1.35
17	0.68	3	1.13	2	0.89	7	1.07	2	0.87
8	0.58	19	0.96	10	0.87	4	0.92	10	0.83
1	0.53	7	0.93	7	0.76	2	0.73	18	0.67
19	0.44	10	0.52	3	0.63	3	0.11	3	0.00
10	0.03	17	0.29	17	0.02	17	0.00	17	0.00

Source: own elaboration.

4.2. Abandoned lands around the Sieradz landscape parks (Załęcze Landscape Park, Warta–Widawka Interfluve Landscape Park)

Elżbieta Papińska

The Sieradz landscape parks – the Warta–Widawka Interfluve LP and the Załęcze LP are located relatively close to each other. Because of that, the selected 10-km wide study zones around the parks overlap, forming a vast, longitudinally stretched area, which encompasses both the right and left part of the Warta basin. The buffer zone around the Sieradz landscape parks covers the area of 1 542.27 km². It lies within the following physicogeographical units, according to J. Kondracki's regionalisation (2002): the provinces of Middle European Plain (31) and Polish Uplands (34), subprovinces of the Central Polish Lowland (318) and the Silesia-Cracow Upland (341). The lower order units in the analysed area include: macroregion of the South Greater Poland Lowland (318.1–2) with mesoregions of the Sieradz Basin (318.18), the Łask Plateau (318.19), the Złoczew Plateau (318.22), the Szczerców Basin (318.23), macroregion of the South Mazovian Hills (318.8) with mesoregion of the Bełchatów Plateau (318.81), and in the southern part of the area – macroregion of the Woźniki–Wieluń Upland (341.2) with mesoregion of the Wieluń Upland (341.21). Their spatial relationships are shown in Figure 4.7.

It is noteworthy that the southern part of the analysed area is located in the transitory zone between uplands and lowlands, which is reflected among other things in the presence of Mesozoic sediments on the surface and karst forms (surface and underground karst), so characteristic of the Polish Jurassic. The characteristic curve of the Warta River is found in this zone, which changes its course from latitudinal to longitudinal, forming picturesque gorges (Krzemiński 1965, 1974, 1986, 1988; Krzemiński, Papińska 1993; Laskowski, Papińska, Tołoczko 2001; Papińska 2001ab; Papińska, Tołoczko 2002). The entire analysed area lies within the extent of the Warta Glaciation, which entered the area with its South Greater Poland lobe, reaching as far as the northern fragments of the Woźniki–Wieluń Upland (Lesser Poland). The glaciation left behind an array of glacial and fluvioglacial forms and sediments, which contribute to the fairly diverse character of the area's landscape. Other forms found in the analysed area, which provide evidence for areal deglaciation, include kames and kame terraces, kettle holes or proglacial fragments of valleys. With the retreat of the Warta Glaciation, the local erosional base was lowered and valleys were deepened. According to T. Krzemiński (1988), the Warta River cut in by 15–30 m, and in the plateau areas during the Vistulian, aeolian sands were accumulated in the form of shields and dunes, whose topographic prominence reaches 5–10 m. These opposite processes resulted in an increased amplitude of relative heights, which improves the visual attractiveness of the landscape.

The main axis of the characterised area is the Warta valley. In the southern part of the study area, the Mesozoic substratum influenced the direction of its flow. From Działoszyn, the river flows from east to west, to change the course by 180° in a characteristic bend near Załęcze–Kępowizna, and direct its waters to the north and north-east. In its course, the most prominent features are the gorges near Działoszyn, Załęcze and Krzeczów.

In the study area, the Warta River is supplied by numerous left (e.g. the Oleśnica) and right tributaries (e.g. the Widawka). Undoubtedly, one of the most environmentally attractive fragments of the area is the Warta and Widawka interfluve, with its tributaries: Nieciecz and Grabia.

Valleys of the Widawka and its tributaries (Nieciecz and Grabia) significantly improve the attractiveness of the relief. Each of these rivers has a different valley character. The characteristic feature of the Widawka valley is the presence of peat bogs. They occur in the west slope zone and are supplied with ground water held upon tills and varved clays under a stratum of Vistulian sands of the terraces of the Warta and Widawka interfluve. Peat extraction ponds are left after exploitation of peat, with rich aquatic and rush vegetation, surrounded with nicely formed *Ribeso nigri-Alnetum* forest. The Grabia created a valley with all elements, fairly symmetrical with undercuts of the terraces and oxbow lakes filled with peat. The Nieciecz valley is characterised by clear features of its youth. It has a narrow bottom, which is almost completely filled with the river channel, contrasting with steep slopes. Diversity of the natural environment of the analysed area is illustrated with the map of geocomplexes (Fig. 4.8). The area of geocomplex types was presented in Fig. 4.9.

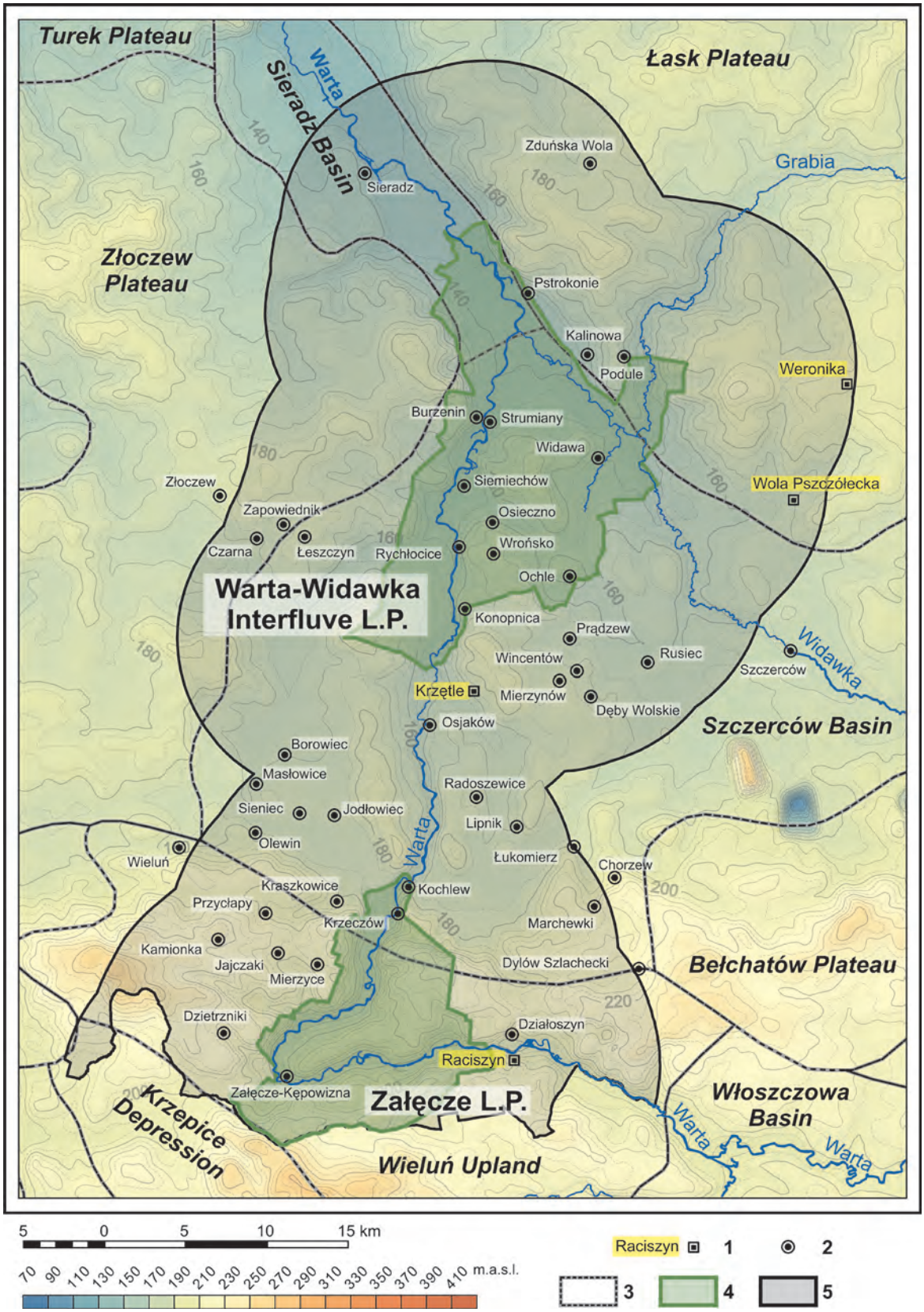


Fig. 4.7. Sieradz landscape parks and their buffer zone against the background of physicogeographical units by J. Kondracki (2002)

1 – location of abandonment study plot groups; 2 – locations mentioned in the text; 3 – boundaries of physicogeographical units; 4 – landscape park areas; 5 – 10-km wide buffer zone around landscape parks

Source: own elaboration based on digital elevation model with grid interval of at least 100 m and other data made available by CODGiK (www.codgik.gov.pl)

The geocomplex map (Fig. 4.8) and data presented in Fig. 4.9 indicate that the largest portion of the spatial structure of the area is occupied by 7 geocomplex types: 5 (24.6%), 6 (23.6%), 16 (13.8%), 11 (11.7%), 8 (6.3%) and 4 (6%). Altogether, these geocomplex types cover 85% of the analysed surface. The spatial image of the areas (Fig. 4.10) without abandoned farmland (class 0) reveals their clear concentration in the zone located to the west and north-west of the borders of the Załęcze Landscape Park. The areas form a broad belt from Masłowice, Sieniec, Jodłowiec toward Wieluń and further to the southern border of the voivodeship. Squares in class 1 of abandonment intensity (0.1–25%) were only recorded in areas which border larger forest complexes, e.g. near Kamionka, Przycłapy, Jajczaki. A similar regularity was observed around the forest complexes near Dzietrzniki and to the south of it, as well as along the longitudinal belt of a forest complex between the borders of the Załęcze Landscape Park and Borowiec.

Larger areas without abandoned lands are found in the eastern and north-eastern side of the Załęcze Landscape Park. The first of such zones lies latitudinally from the park borders towards Pajęczno and is limited in the north and south with larger patches of forest and, in the south, with denser building development of Działoszyn, limestone quarries, and the "Warta" cement plant. Another zone, lying to the north-east of the Załęcze Landscape Park, ranges from Radoszewice through Lipnik, Łukomierz to Chorzew. Here, areas without abandoned lands occur, apart from such geocomplexes as type 5 or 18, also within semihydrogenic geocomplexes – type 13, and hydrogenic complexes – types 11 and 12. Within this zone, both arable lands and permanent grasslands are found, which are maintained in good agricultural condition.

A uniform patch without abandoned lands is located to the south-east of the borders of the Warta–Widawka Interfluve LP, on both sides of the national road 74, near Mierzynów, Wincentów, Rusiec, Prędzew, Dęby Wolskie. In this region, two geocomplexes dominate as regards the area covered: type 5 and 16. Much smaller areas are taken by geocomplex type 18, characterised by slightly worse habitat conditions.

Much smaller concentrations of areas without abandoned lands are observed to the east of the S8 expressway, around the Złoczew junction, near such places as Czarna, Zapowiednik, Łeszczyn and in the Grabia and Widawka interfluve near Kalinowa and Podule. Both areas are dominated by geocomplexes built of glacial till (type 5) and, around the Złoczew junction, some areas built of fluvioglacial sands and gravels upon glacial till (type 16) appear additionally. According to information included in the soil and agricultural map of the Sieradz Voivodeship (Województwo sieradzkie. Mapa glebowo-rolnicza 1977), patches of soils classified as complex 2 (good wheat) of agricultural suitability (2D – loose sands upon loam; 2B – clayey-loamy sands upon loam), and complex 4 and 5 (very good and good rye) occur there. The granulometric composition of sediments which form these soils includes light and heavy loamy sands, which have an important influence on the functioning of soils. In the remaining areas, there are no more such clear concentrations of areas without abandoned lands.

Square plots in class 1 (up to 25% of abandoned lands) dominate in the zone around the Warta–Widawka Interfluve Landscape Park. They often alternate with squares without abandoned lands, forming a kind of mosaic. In many cases, class 1 squares are found near forests. A similar regularity can be observed near anthropogenic areas, mainly the urban fabric of towns and smaller settlements. A good example of this are the surroundings of such towns as Zduńska Wola, Sieradz, Złoczew or Działoszyn.

The recently built S8 expressway runs across the analysed area. Its construction required the exclusion of some land from agricultural use, and resulted in the abandonment of a considerable amount of lands. It is especially visible in the northern part of the characterised area. Near the Sieradz junction, there are basic squares included in class 2 (25.1–50% of abandoned lands) and 3 (50.1–75% of abandoned lands). A similar situation occurs near the Zduńska Wola junction and between the forest complex lying to the south of Zduńska Wola and the city itself. A greater number of squares included in class 2 occur there.

The share of areas in different classes of land abandonment intensity showed (Fig. 4.11) that highest percentage (nearly 50%) is taken by class 1 squares (up to 25% of abandoned lands). Class 0 squares, without abandoned lands, come second with 47.5%. Squares of class 2 (25–50% of abandoned lands) cover only 2.63% of the analysed area. Basic squares in class 3 (50–75% of abandoned lands) and class 4 (75–100% of abandoned lands) have only a minimal share.

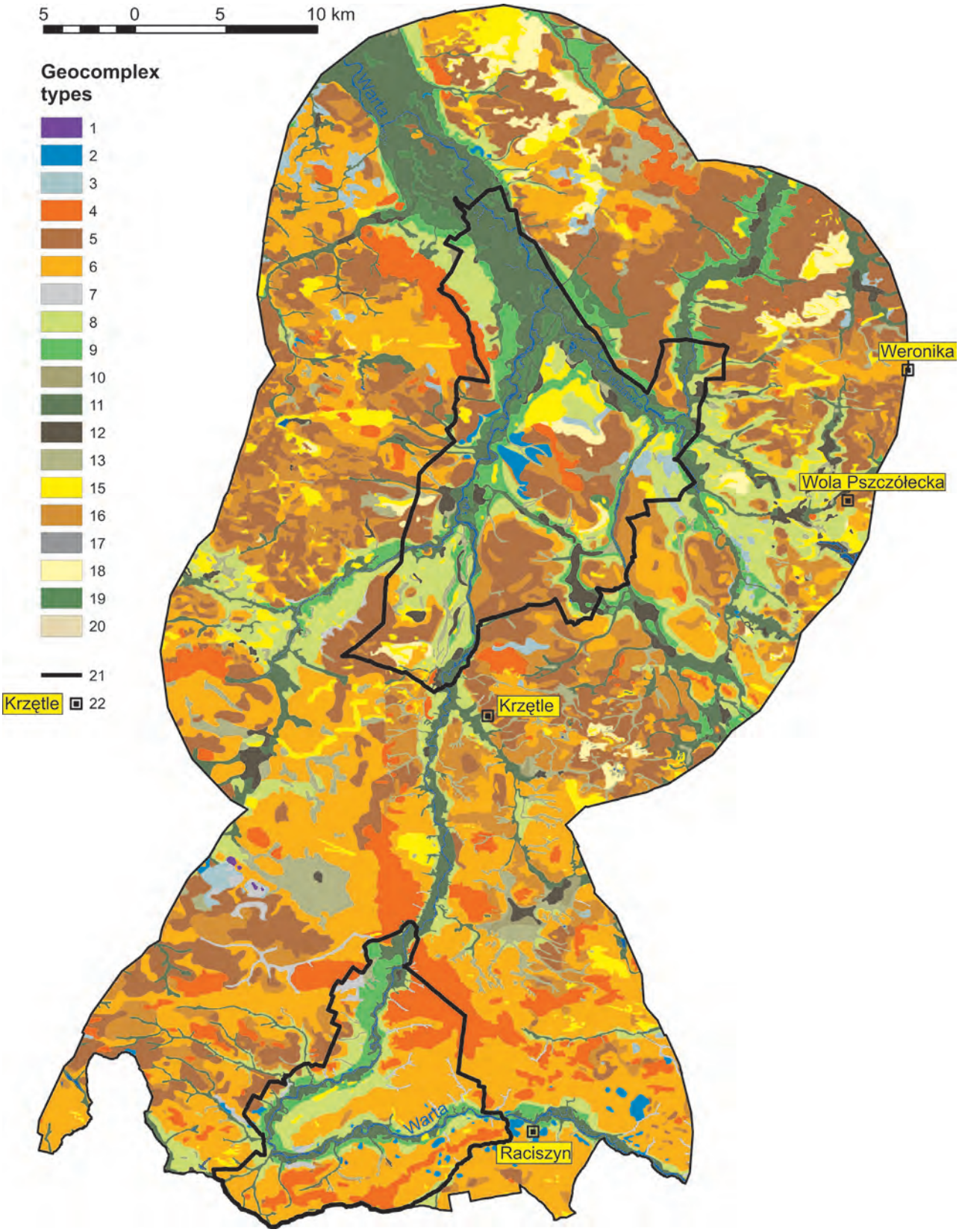


Fig. 4.8. Map of geocomplexes (morpholithohydrotopes) of the Sieradz landscape parks and their buffer zone
1–20 – names of morpholithohydrotopes are listed in Tab. 3.1; 21 – landscape park boundary;
22 – study plot group

Source: own elaboration

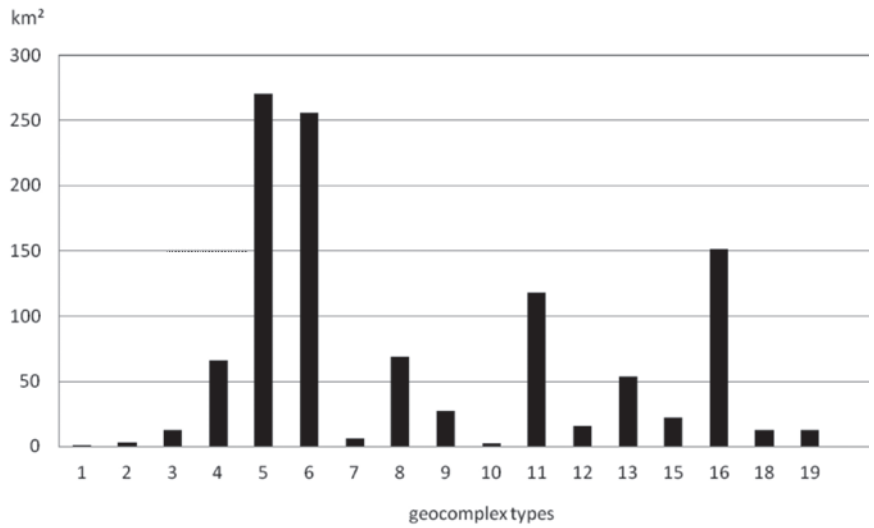


Fig. 4.9. The area of geocomplex types in the structure of the natural environment of the buffer zone around the Sieradz landscape parks

Source: own elaboration

As a result of intersecting the geocomplex map and the map of land abandonment intensity, data was obtained on the percentage of five land abandonment intensity classes in geocomplex types, as well as the percentage of geocomplex types in land abandonment intensity classes. Effects of the procedure in relation to the percentage of land abandonment intensity classes in individual geocomplex types were presented in Figure 4.12. The data shows that the highest percentage of areas without abandoned lands (class 0) is found in the following geocomplex types: 1 – 86%, 7 – 72,5%, 10 – 69%, 13 – 58%, 5 – 55,5%, 16 – 51% and 6 – more than 50%. In the case of the first three geocomplex types (1, 7 and 10) their share in the total area of the study area is extremely low – below 1%, and also the amount of these geocomplexes in class 0 of abandonment intensity is smaller than 1%. A significantly larger area is taken by geocomplexes types 13, 5 and 16. Habitat conditions within these geocomplexes condition their agricultural use. The fact that such a high percentage of their area is without abandoned lands distinctly proves their substantial agricultural usefulness. A perfect example are geocomplexes of type 5, formed of plateau glacial tills. They cover 26.4% of the area of buffer zone and over 55% of this area is characterised by lack of abandoned lands.

The lowest share of areas without abandoned lands is characteristic of geocomplex types 18 – 19.6% and 15 – 25%. In both types, aeolian sands in dunes and shields occur, but in geocomplex 18 they lie upon glacial till. In less than 25% of the area of these geocomplex types, there are no abandoned lands, however the cumulative area percentage of these types is very small (together about 3%), and the amount of geocomplexes in class 0 of abandonment intensity equals 3.8% for type 15, and less than 1% for type 18. About 70% of the area of geocomplexes of both type 18 and type 15 were included in class 1 of land abandonment intensity, which can mean that farmers tend to exclude the least productive areas from cultivation. This process probably progresses since their remaining part is taken by areas characterised by a considerable share of abandoned lands, i.e. those included in class 2 and 3 of land abandonment intensity (Fig. 4.12).

More than 50% of the area taken by class 1 of land abandonment is found in the following geocomplex types: 9, 19, 8, 11, 12 and 3 (Fig. 4.12). These geocomplexes are mostly formed of fluvial sands and muds of terraces and flood plains, which, in slope zones, are frequently characterised by excessive moisture resulting from drainage of underground water caused by the river, which promotes the development of the peat-forming process. Further from the slope, areas of terraces often show excessive dryness, as the drained ground water level lies deeper, reflecting the water level of the river. Neither of these extreme situations favours agricultural use of these geocomplex types, as they can be periodically or

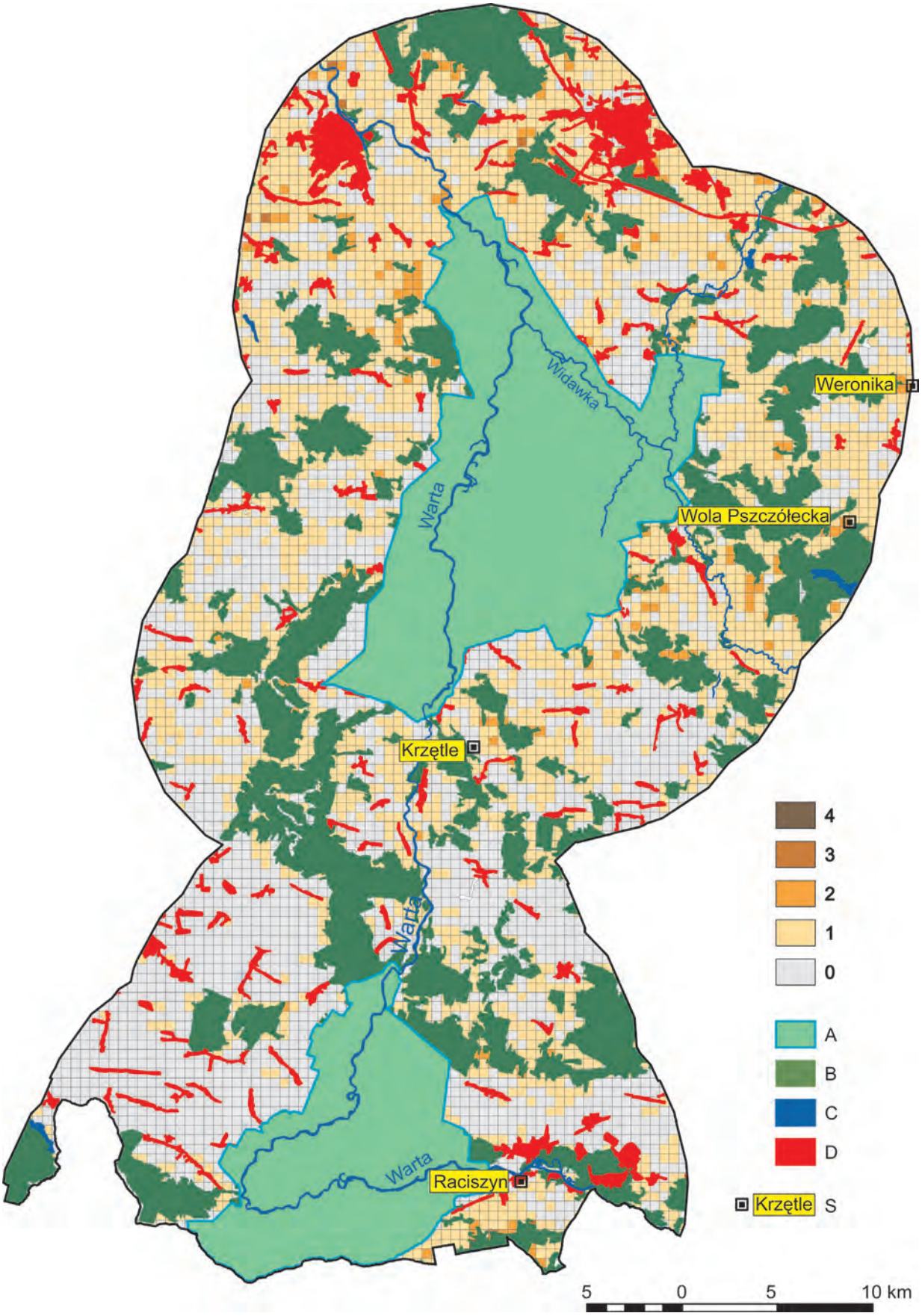


Fig. 4.10. Map of spatial distribution and intensity of land abandonment in the buffer zone around the Sieradz landscape parks. For explanation see Fig. 4.4

Source: own elaboration

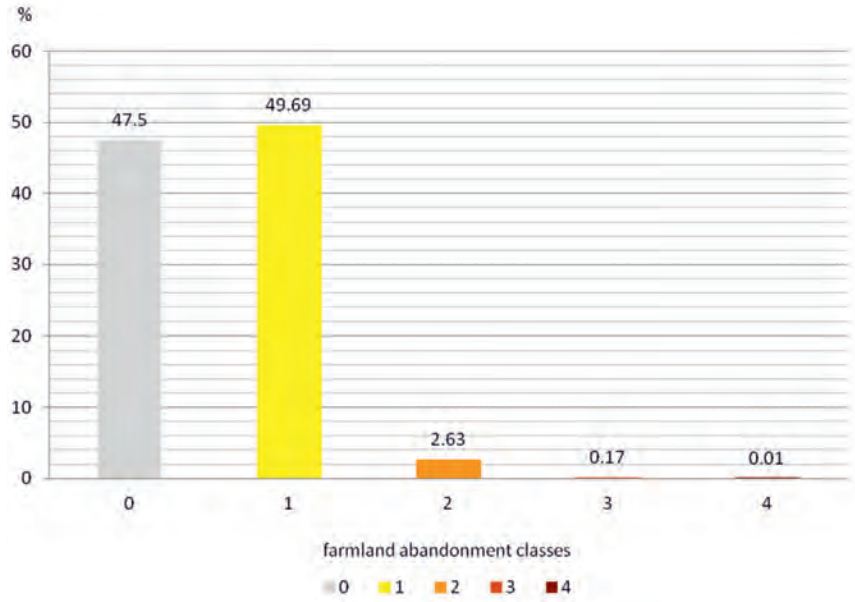


Fig. 4.11. Percentage of area of land abandonment intensity classes in the buffer zone around the Sieradz landscape parks

Source: own elaboration

permanently too moist or too dry. Geocomplex types 12 and 3, due to the occurrence of formations on which their delimitation was based, have properties that can discourage from continuing cultivation in them. In type 12 they are peats and mucks of wetlands, which very often used to undergo drainage which allowed for their agricultural use, mainly as permanent grasslands. With time, when the efficiency of the drainage system deteriorates due to cessation of maintenance, the moisture content in these areas increases, which often renders their usage difficult or impossible. Similar situations concern geocomplex type 3, which was distinguished in areas built of clays, claystones, muds and mudstones of various origin. Low permeability of the substratum creates the possibility for the occurrence of long-term or permanent excessive moisture content if the geocomplex is not properly drained. It is also worth stressing that geocomplex types 3, 12 and 19 take a relatively small portion in the study area – the share of each of them is below 1.5%.

Geocomplexes which were characterised by the highest percentage of area without abandoned lands (class 0), have the lowest share of area included in class 1 of land abandonment intensity – they are the following types: 10, 7 and 1 (Fig. 4.12).

Abandoned lands whose intensity of occurrence allowed them to be included in class 2, clearly mark their share in the above mentioned geocomplex types: 18 – 8.7%, 15 – 5.4% and 4 – 5.8%, 9 – 4.5%, 8 – 4.3%, and 6 – 3.3% (Fig. 4.12). There are eight more geocomplex types with a low share of class 2 of land abandonment, ranging from 0.35% to 2.94% (Fig. 4.12). Three types – 2, 10, 1 – are not represented in this class of land abandonment intensity.

The share of class 3 of abandoned lands in the area of geocomplexes is very low. In one case, of geocomplex type 18, it is a little more than 1%. For seven types, it ranges from 0.02 to 0.64% (Fig. 4.12). In the remaining types, there are no abandoned lands of this intensity class.

The share of class 4 of abandonment intensity is even lower – their minimal share (0.09%) was found in geocomplex type 6.

With the use of computer-assisted spatial analysis, results were obtained which provided information on the percentage share of area of different geocomplex types in individual classes of land abandonment intensity (Tab. 4.2). Also in this case, some regularities may be observed resulting from the predispositions created by certain geocomplex types for the development of agricultural production.

Table 6.1. Percentage share of species of flora and lichens in the abandonment study plots in the Łódź Voivodeship

Site/Species	Glinnik A	Glinnik B	Glinnik C	Celestynów A	Celestynów B	Celestynów C	Sulejów A	Sulejów B	Sulejów C	Krzętle A	Krzętle B	Krzętle C	Raciszyn A	Raciszyn B	Raciszyn C	Weronika A	Weronika B	Weronika C	Wola Pszczółecka A	Wola Pszczółecka B	Wola Pszczółecka C	Piskorzeniec A	Piskorzeniec B	Piskorzeniec C	Wola Życińska A	Wola Życińska B	Wola Życińska C	Wola Makowska A	Wola Makowska B	Wola Makowska C	Polesie A	Polesie B	Polesie C	Szymaniszki A	Szymaniszki B	Szymaniszki C	Łagiewniki A	Łagiewniki B	Łagiewniki C
Achillea millefolium L.	0,5	0,5	0	0	0,5	2	1	0	0,5	0	1	0	0,5	3	5	0,5	3	0	0,5	0	0,5	0	0	0	2	0	0,5	1	0	0	0	3	1	5	0	0	0	0	0
Agrimonia eupatoria L.	0	0	0	0	0	0	0,5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Agrostis capillaris L.	65	30	80	0,5	10	10	0	0	7	0	50	60	10	15	0,5	0	20	20	0	0	15	0	0	1	30	0	10	0	0	5	0	10	10	10	0	0	70	0	15
Agrostis gigantea ROTH	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0,5	0	0	0	0	0	0	0	0	0	0	0	10
Anagallis arvensis L.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Anthoxanthum aristatum BOISS.	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0,5	0	0	0,5	0	0	0	3	0	0	0	0	0	0,5	0	0	0	0	0	0	0	0	0	0
Anthoxanthum odoratum L.	0,5	0	0	0	0,5	0	0,5	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Anthriscus sylvestris (L.) HOFFM.	0	0	0	0	0	0	0,5	0	0,5	0	0	0	0	0	0	0	0	0,5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Apera spica-venti (L.) P. BEAUV.	0,5	0	0,5	0	0	0	0	0	0	0	1	0	0	0	0	0,5	0	0	0	0	0	0	0	2	0	0	0,5	0	0	0	0	0,5	0	0	0	0	0	0	0
Arnoseris minima (L.) SCHWEIGG. & KÖRTE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Arrhenatherum elatius (L.) P. BEAUV. ex J. PRESL & C. PRESL	0,5	0	0	0	0	0	3	0	0	0	0	0	0,5	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Artemisia absinthium L.	0	0	0	0	0	0,5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0,5	0	0	0	0	0
Artemisia campestris L.	0	0,5	0	0	0	15	0	0,5	0	0	0	0	0,5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0,5	0	0	0	0	5
Artemisia vulgaris L.	0	0,5	0	0	0	7	0	0,5	0	0	0	0	0	0,5	0,5	0	0	0	0	0	0	0	0	0	0	0	0,5	0	0	0	0	0	0	0	0	0	0	0	0
Betula pendula ROTH	0,5	0	0,5	0	0	0	0	0	0	0	0	0	0,5	0	0	0	0	0	0	0	0,5	0	0	0	0	0	0	0	0	0,5	0	0	0	0,5	0,5	0	0,5	10	0
Brym sp.	0	0	0	0	0	0	0	0	0	0,5	0	0	0	0	0	0	0	0	0,5	0	0	0	0	0	0	0	0	0	0,5	0	0	0	0	0	0	0	0	0	0
Calamagrostis epigejos (L.) ROTH	0	0	0	0	0	0	0,5	0	0	0	0	0	0,5	0,5	5	0	0	0	0	0	0	0	0	0	0	60	0	0	0	80	0	0	0	25	0	0	0	0	0
Carex hirta L.	0	0	0	0	0	0	0	0	0	0	0	0	0,5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Carex leporina L.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Carlina vulgaris L.	0	0	0	0	0	0	0	0	0	0	0	0	0,5	0,5	0,5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Centaurea cyanus L.	0	0	0	0	0	0,5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0,5	0	0	0	0	0	0	0
Centaurea scabiosa L.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0,5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Centaurea stoebe L.	0	0,5	0	0	0	0	0	0	0	0	0	0	0	0	0,5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cerastium arvense L. s. s.	0	0	0	0	0	0,5	0	0	0	0	0	0	0,5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ceratodon purpureus (Hedw.) Brid.	0	0	0	0	0	0	0	0	0	0,5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Chamaenerion angustifolium (L.) SCOP.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0,5	0	0	0	0	0	0	0	0	0
Chamomilla recutita (L.) RAUSCHERT	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0,5	0	0	0	0	0	0	0
Chenopodium album L.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0,5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cirsium arvense (L.) SCOP.	0	0	0	0	0	0	0,5	0	1	0	0	0	0	0	0	0	0	0,5	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	60	10	0	0	0
Cladonia strepsillis f. coralloides Vain	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	5	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
Cladonia furcata (Huds.) Schrad.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0	0	0,5	0	0	0	0	0	0	0	0	0	10
Cladonia rangiferina (L.) Weber ex F.H. Wigg	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cladonia arbuscula (Wallr.) Flot.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	50	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
Cladonia uncialis Elenkin & Savicz	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
Convolvulus arvensis L.	0	2	0	0	0	0,5	0	0	0	10	0,5	0	0	0,5	0,5	0,5	0,5	0	3	0	0	0	0	0	1	0	0,5	0,5	0,5	0	0	0,5	0	0,5	0	0,5	0	0	0
Conyza canadensis (L.) CRONQUIST	0	0,5	0	0	0	0,5	0	0	0	0	0,5	0	0,5	0	0,5	0	0	5	15	0	0	0	0	0	0	0	0,5	3	0	0	0	1	0,5	0	0	2	0	0	0
Coronilla varia L.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0,5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Corynephorus canescens (L.) P. BEAUV	0	0,5	0	70	0	5	0	0	0	20	0	5	0	0	0	0	0	0	1	0	0	5	0	0	0	0	0	10	45	0	10	3	10	0	0	0	0	0	0
Crataegus monogyna JACQ.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0,5	0	0	0	0	0	0	0	0	0	0	0	0
Crepis biennis L.	0	0	0	0	0	0	0,5	0	0,5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	20	0	0	0
Crepis tectorum L.	0	3	0	0	0	0	0	0,5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Table 6.1. Percentage share of species of flora and lichens in the abandonment study plots in the Łódź Voivodeship (continued)

Site/Species	Glinnik A	Glinnik B	Glinnik C	Celestynów A	Celestynów B	Celestynów C	Sulejów A	Sulejów B	Sulejów C	Krzętle A	Krzętle B	Krzętle C	Raciszyn A	Raciszyn B	Raciszyn C	Weronika A	Weronika B	Weronika C	Wola Pszczółecka A	Wola Pszczółecka B	Wola Pszczółecka C	Piskorzeniec A	Piskorzeniec B	Piskorzeniec C	Wola Życińska A	Wola Życińska B	Wola Życińska C	Wola Makowska A	Wola Makowska B	Wola Makowska C	Polesie A	Polesie B	Polesie C	Szymaniszki A	Szymaniszki B	Szymaniszki C	Łagiewniki A	Łagiewniki B	Łagiewniki C
Dactylis glomerata L.	0	0	0	0	0	0	0,5	0	10	0	0	0	0	0	0	0,5	0,5	7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0,5
Dianthus carthusianorum L.	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0,5	0	0	0	0	0	0	0	0	0	0	0	0,5	0	0	0	0	0	0	0	0	0	0	0	0
Dicranum scoparium (L.) Hedw.	0	0	0,5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Elymus repens (L.) GOULD	0	0	0	0	0	15	20	0	0	0	0	0	0	0	0,5	3	0	0	0	0	0	0	0	0	0	0	0,5	5	0	0	0	2	2	0	0	0	0,5	10	0
Equisetum arvense L.	0	0	0	0	0	0	0	0	0,5	0	0	0,5	0	0	0	0,5	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
Equisetum pratense EHRH.	0	0	0	0	0	0	0,5	0	0	0,5	0	0	0	0	0	0	0	0	0,5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Equisetum sylvaticum L.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0,5	0,5	0,5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Erigeron annuus (L.) PERS.	0	0,5	0	0	0	0	0	0	0	0	0	0	5	0,5	0,5	0,5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Eupatorium cannabinum L.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10	0	0	0	0	0	0	0	0	0	0	0	0	0
Euphorbia cyparissias L.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0,5	0,5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Euphrasia rostkoviana HAYNE	0	0	0	0	0	0	0	0	0	0	0	0	0,5	0,5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Festuca ovina L	0,5	0,5	7	0	0	5	0,5	0	0	0	5	0	0	5	0	0,5	0	0	0,5	0	0,5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Festuca rubra L. s. s.	0	0	0	0	0	5	10	0	1	0	0	0	0	0	5	2	0,5	0	0	0	0	0	0	0	0	0	0,5	0	0	0	0	10	15	0	0	0	0	0	0
Fragaria viridis DUCHESNE	0	0	0	0	0	0	0	0	0	0	0	0	0,5	0,5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Frangula alnus MILL.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0,5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Galeopsis tetrahit L.	0	0	0	0	0	0	0,5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0,5	0	0
Galeopsis ladanum L.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0,5	0	0	0	0	0	0	0
Galium mollugo L.	0	0	0	0	0	0	0	0	0,5	0	0	0	0,5	0,5	0,5	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0,5	0	0,5	0	0	0
Galium verum L.	0	0	0	0	0	0	0,5	0	0	0	0	0	0,5	0,5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Geranium pratense L.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Geum urbanum L.	0	0	0	0	0	0	0	0	0,5	0	0	0	0,5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Gnaphalium sylvaticum L.	0	0	0	0	0	0	0	0	0	0	0	0	0	0,5	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0,5	0	0	0	3	0
Helichrysum arenarium (L.) MOENCH	0	5	0	0	0	0	0	1	0	0	0	0	0	0	0	20	0	0	0	0	0	0	0	0	0	0	0	10	1	0	0	0	0,5	0	0	0	0	0	0
Herniaria glabra L.	0	0,5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hieracium pilosella L.	25	30	3	0,5	50	10	0,5	0	0	30	0	10	50	1	50	60	35	5	40	5	65	0	3	40	10	0	50	40	10	1	0	60	50	5	0	0,5	0,5	0	0
Hieracium umbellatum L.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0,5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	30	0	0	0	0	0
Holcus lanatus L.	0	0	0	0	0	0	0	0	0	0	15	0	0,5	0	0	0	0	0,5	0	0	0	0	0	0	0	0	0,5	0	0	0	0	0	0,5	0	0	0	0	0	0
Holcus mollis L.	0	0	0	0,5	0,5	0	0	0	0	1	0	20	0,5	0,5	0	0,5	0	0	0	0	0	0	0	0	30	0	0	0	0	0	0	0	0	0,5	0	0	0	0	0
Hypericum perforatum L.	0	0	0	0	0	0,5	0	0	0	0,5	0	0	0,5	0,5	0	0,5	4	0	0,5	0,5	0	0	0	0	0	3	0	0	0	0	0	0,5	0	5	0,5	0	0	5	0
Hypochoeris radicata L.	0	0	0	0	0,5	0	0	0	0	0	0	0	0	0	0,5	0	0	0	0	0	0	0	0	0	0	0	0,5	0,5	0	0	0	0	0	0	0	0	0	0	0
Jasione montana L.	0,5	10	0	3	3	2	0	0	0	0,5	1	5	0,5	1	0	0,5	0	0	0,5	0	0,5	0	0	3	0	0	1	2	0	0	0	0,5	0,5	0	0	0	0	15	0
Juncus effusus L.	0,5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0
Juniperus communis L.	0	0	0	0	0,5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Knautia arvensis (L.) J.M. COULT.	0	0	0	0	0	0,5	0	0	0	0	0,5	0	0	0,5	0,5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Leontodon autumnalis L.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Linum catharticum L.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Lupinus polyphyllus LINDL.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0,5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Luzula campestris (L.) DC.	0	0	0	0	0	0	0	0	0	0	0	0	0,5	0	0	0	0	0	0	0	0	0	0	0	0	0	0,5	0	0	0	0	0	0	0	0	0	0	0	0
Lysimachia vulgaris L.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	10	0	0	0	0	0	0	0	0	0	0	0	0	0
Lythrum salicaria L.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0,5	0	0	0	0	0	0	0	0	0	0	0	0
Melandrium album (MILL.) GARCKE	0	0	0	0	0	0,5	0,5	1	1	0	0	0	0,5	0	0	0	0	0	0	0	0	0	0	0	0	0	0,5	0	0	0	0	0,5	0	0	0	0	0	0	0

Table 6.1. Percentage share of species of flora and lichens in the abandonment study plots in the Łódź Voivodeship (continued)

Site/Species	Glinnik A	Glinnik B	Glinnik C	Celestynów A	Celestynów B	Celestynów C	Sulejów A	Sulejów B	Sulejów C	Krzętle A	Krzętle B	Krzętle C	Raciszyn A	Raciszyn B	Raciszyn C	Weronika A	Weronika B	Weronika C	Wola Pszczółecka A	Wola Pszczółecka B	Wola Pszczółecka C	Piskorzeniec A	Piskorzeniec B	Piskorzeniec C	Wola Życińska A	Wola Życińska B	Wola Życińska C	Wola Makowska A	Wola Makowska B	Wola Makowska C	Polesie A	Polesie B	Polesie C	Szymaniszki A	Szymaniszki B	Szymaniszki C	Łagiewniki A	Łagiewniki B	Łagiewniki C
Mentha arvensis L.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
Mentha x verticillata L.	0	0	0	0	0	0	0	0	0,5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Myosotis arvensis (L.) HILL	0	0	0	0	0	0,5	0,5	0	0,5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0,5	0	0	0	0	0	0
Nardus stricta L.	0,5	0,5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Oenothera biennis L. s. s.	0	0	0	0	0	0,5	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0,5	0	0
Padus serotina (EHRH.) BORKH.	0	0	0	0,5	0	0	0	0	0	0	0	0	0	0	0	0	0	0,5	0	0	0	0	0	0	1	0	0,5	0	0	0	0	0	0	0,5	0	20	0,5	10	0
Papaver argemone L.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0,5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Peucedanum oreoselinum (L.) MOENCH	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Phleum pratense L.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0,5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5
Pinus sylvestris L.	0,5	5	3	0,5	0,5	0	0	0	0	0,5	0	0	0,5	0,5	0,5	0,5	0,5	0	0,5	5	0,5	0	0	1	0	0	0	0	0,5	0	0,5	0	0,5	0,5	0	0	0	0	0
Plantago lanceolata L.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0,5	0	0	0	0	0	0	0
Pleurozium schreberi (Brid.) Mitt.	0	0	0,5	0	0	0	0	0	0	0	0,5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Poa compressa L.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5
Poa pratensis L.	0,5	0	0	0	0	0	0,5	0	20	0	0	0	0	0	0	0	0,5	5	0	0	0,5	0	0	0	0,5	0	0	0	0	0	0	2	0	0	0,5	2	0,5	0,5	5
Poa trivialis L.	0	0	0	0	0	0	0,5	0	0,5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10	0
Polygonum aviculare L.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0,5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Polygonym hydropiper L.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Polytrichum formosum (Hedw.) G. Sm.	0	0	0,5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Polytrichum piliferum Hedw.	0	0	0	0,5	70	0	0	0	0	1	0	0,5	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
Potentilla anserina L.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0,5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Potentilla argentea L. s. s.	0	3	0	0	0	0,5	0,5	0	0,5	0	0	0	0,5	0	0,5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pteridium aquilinum (L.) KUHN	0	0	0	0	0	0	0	0	0	0	0	0	0	65	40	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pyrus communis L.	0	0,5	0	0	0	0	0	0	0,5	0	0	0	0,5	0	0	0	0,5	0,5	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Quercus robur L.	0,5	0	0,5	0,5	0	0	0	0	0	0	0,5	0,5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0,5	0	0	0	0	0	0	0	0	0	0,5	0	0
Quercus rubra L.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0,5	0	0	0	0	0	0	0	0	0
Ranunculus repens L.	0	0	0	0	0	0	0	0	0,5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Rosa sp.	0	0	0	0	0	0	0	0	0,5	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Rubus idaeus L.	0	0	0	0	0	0	0	0	0,5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0
Rubus caesius L.	0	0	0	0	0	0	0	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Rubus sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Rumex acetosa L.	0,5	0,5	0	0	0	2	0,5	20	15	0	5	0	0,5	0	5	3	3	15	15	5	0	0	0	0	1	0	0,5	10	0	0	0	0	0,5	0	0	0	0	0	0
Rumex acetosella L.	0,5	0,5	0,5	0,5	0,5	0	0,5	0	0,5	0	0,5	0	0,5	0	0,5	0,5	0	0	0,5	0	0	0	0	0	0	0	0,5	5	0,5	0	0,5	0,5	0,5	0	0	0	20	0	0
Rumex crispus L.	0	0	0	0	0	0	0,5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
Salix caprea L.	0	0	0	0	0	0	0,5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Scleranthus annuus L.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0,5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Danthonia decumbens DC.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0,5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Senecio jacobaea L.	0	0,5	0	0	0	0,5	10	0	1	0	1	0	3	0,5	0,5	0	0,5	0,5	0	0	0,5	0	0	0	0	0	0	0	0	0	0	0	0,5	0	0	0	0	10	0
Senecio vernalis WALDST. & KIT.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Senecio viscosus L.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	30	0	0	0
Setaria viridis (L.) P. BEAUV.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0,5	0	0	0	0	0	0	0	0	0	5	0	0	0,5	0	0	0	0	0	0	0
Solidago virgaurea L.	0	0	0	0	0	0	0	0	0,5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0,5	0	0	0	0	0

Table 6.1. Percentage share of species of flora and lichens in the abandonment study plots in the Łódź Voivodeship (continued)

Site/Species	Glinnik A	Glinnik B	Glinnik C	Celestynów A	Celestynów B	Celestynów C	Sulejów A	Sulejów B	Sulejów C	Krzętle A	Krzętle B	Krzętle C	Raciszyn A	Raciszyn B	Raciszyn C	Weronika A	Weronika B	Weronika C	Wola Pszczółecka A	Wola Pszczółecka B	Wola Pszczółecka C	Piskorzeniec A	Piskorzeniec B	Piskorzeniec C	Wola Życińska A	Wola Życińska B	Wola Życińska C	Wola Makowska A	Wola Makowska B	Wola Makowska C	Polesie A	Polesie B	Polesie C	Szymaniszki A	Szymaniszki B	Szymaniszki C	Łagiewniki A	Łagiewniki B	Łagiewniki C
Solidago canadensis L.	0	0,5	0	0,5	0	0	5	0	0,5	0	0	0	0,5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0,5	30	10	0	0	5
Sonchus arvensis L.	0	0	0	0	0	0	0	5	0,5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sorbus aucuparia L. em. HEDL.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0,5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0,5	0	0	0	0	0	0
Spergula morisonii BOREAU	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0,5	0	0
Spergularia rubra (L.) J. PRESL & C. PRESL	0	0	0	0	0	0	0	0	0	0,5	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Stachys recta L.	0	0	0	0	0	0	0	10	0,5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Stellaria graminea L.	0	0	0	0	0	0	0,5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0,5	0	0	0	0	0	0	0	0	0	0	0	0	0
Tanacetum vulgare L.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Taraxacum officinale F. H. WIGG.	0,5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Thymus pulegioides L.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10	0	0	0	0	0
Tragopogon pratensis L. s. s.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0,5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Trifolium arvense L.	0	0	0	0	0	0,5	0	0	0,5	0	0	0	0	0	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Trifolium repens L.	0	0	0	0	0	0	0,5	0	0,5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Urtica dioica L.	0	0	0	0	0	0	0	0	0,5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0,5	0	0	0	0	0	0	0	0	0
Veronica chamaedrys L.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0,5	0	0	0	0	0	0	0	0	0	0	0	0	0
Veronica officinalis L	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Vicia angustifolia L.	0	0	0	0	0	0,5	0	0	0	0	0,5	0	0,5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Vicia cracca L.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0,5	0	0	0	0	0	0	0
Vicia hirsuta (L.) S. F. GRAY	0	0	0	0	0	0,5	0	0	0,5	0	0,5	0	0	0,5	0	0	0,5	0,5	0	0	0	0	0	0	0	0	0,5	0	0	0	0	0	0	0	0	0	0	0	0
Vicia sativa L.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0,5	0	0,5	0,5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Vicia tenuifolia ROTH	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0,5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Vicia tetrasperma (L.) SCHREB.	0	0	0	0	0	0	0	0	0	0	0,5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5
Viola arvensis MURRAY	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0,5	0	0	0	0	0	0	0	0	0	0	0	0,5	0	0	0	0	0	0,5	0	0	0	0	0	0
Viola reichenbachiana JORD. ex BOREAU	0	0	0	0	0	0	0	0	0	0	0	0	0	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
Viola tricolor L. s. s.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0,5	0	0	0	0,5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Source: own elaboration.

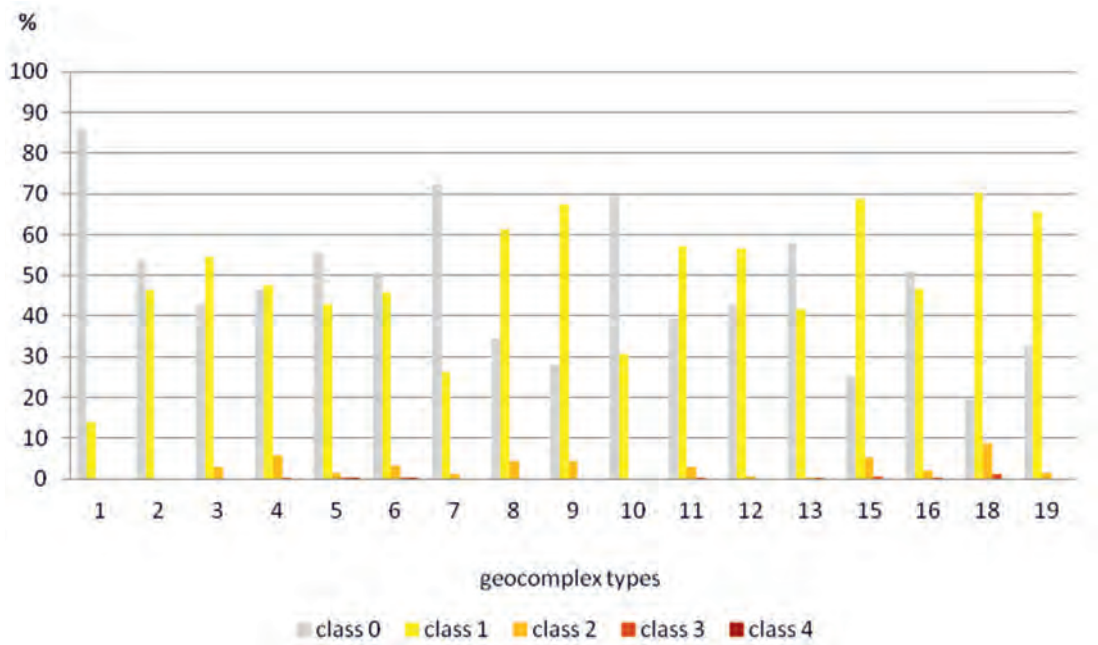


Fig. 4.12. Percentage of areas of land abandonment intensity classes in geocomplex types in the buffer zone around the Sieradz landscape parks

Source: own elaboration

Tab. 4.2. Percentage of areas of geocomplex types in land abandonment intensity classes in the buffer zone around the Sieradz landscape parks (sorted by decreasing share in the area of geocomplex type)

Geocomplex type	% geocomplex type area In abandonment class 0	Geocomplex type	% geocomplex type area In abandonment class 1	Geocomplex type	% geocomplex type area In abandonment class 2	Geocomplex type	% geocomplex type area In abandonment class 3	Geocomplex type	% geocomplex type area In abandonment class 4
5	28.4	6	21.7	6	28.1	6	38.1	6	77.3
6	24.5	5	21.6	4	12.8	11	29.6	5	22.7
16	14.6	16	13.1	5	12.4	18	10.0	1	0.0
11	8.8	11	12.6	11	11.3	15	8.6	2	0.0
13	5.8	8	7.9	16	10.7	13	5.9	3	0.0
4	5.8	4	5.8	8	9.9	5	4.7	4	0.0
8	4.5	13	4.1	9	4.1	16	2.3	7	0.0
9	1.4	9	3.4	15	4.1	4	0.9	8	0.0
12	1.2	15	2.9	18	3.7	1	0.0	9	0.0
15	1.1	18	1.7	3	1.2	2	0.0	10	0.0
3	1.0	12	1.6	13	0.6	3	0.0	11	0.0
7	0.8	19	1.5	19	0.6	7	0.0	12	0.0
19	0.8	3	1.3	12	0.3	8	0.0	13	0.0
18	0.5	2	0.3	7	0.2	9	0.0	15	0.0
2	0.4	7	0.3	1	0.0	10	0.0	16	0.0
10	0.4	10	0.2	2	0.0	12	0.0	18	0.0
1	0.1	1	0.0	10	0.0	19	0.0	19	0.0

Source: own elaboration.

4.3. Abandoned lands around the Łódź Hills Landscape Park and the Bolimów Landscape Park

Anna Majchrowska

The large share of urbanised area, resulting from the location of Łódź and Zgierz, is peculiar to the 10-km wide buffer zone around the Łódź Hills Landscape Park. Research into the ecological role of abandoned farmlands included the area of 557.3 km² in the surroundings of the Łódz Hills Landscape Park and a part of the buffer zone around the Bolimów Landscape Park, 642.2 km² in area, lying within the limits of the Łódź Voivodeship. In all, the study area covers 1 199.5 km² .

The structure of natural environment and the location of abandoned lands within the buffer zone around the Łódź Hills Landscape Park

The buffer zone around the Łódź Hills Landscape Park includes areas of relatively diverse relief, shaped during the Cainozoic by a number of geomorphological processes, with a distinctive role of the Wartanian glacial morphogenesis (Turkowska 2006). Within the zone around the park, elevation decreases radially, most clearly to the north, descending in several characteristic steps, from the central culmination area of 284–260 m a.s.l., located along the south-western segment of the park boundary near Dąbrowa, to about 121–125 m a.s.l. near Wola Mąkolska (Klatkowa 1965, 1972, 1996). The land relief is varied with river valleys, running along the land's surface inclination towards the Warta, Pilica and Bzura rivers (Fig. 4.13), as well as with young erosional valleys and ravines.

Despite the relatively high relief dynamics, the entire buffer zone around the Łódź Hills Landscape Park is included in the subprovince of the Central Polish Lowland (318) and its three macroregions: the South Greater Poland Lowland (318.1-2), the Central Mazovian Lowland (318.7) and the South Mazovian Hills (318.8), represented respectively by the mesoregions of the Łask Plateau (318.19) – in the west, the Łowicz–Błonie Plain (318.72) – in the north, and the Łódź Hills (318.82) – in the remaining area (Fig. 4.13).

The structure of natural environment of the buffer zone around the Łódź Hills Landscape Park (Fig. 4.14) is dominated by two geocomplex types (Fig. 4.15): 6 – glacial and fluvioglacial boulders, cobbles, gravels, sands and muds of plateaus, alluvial fans and erosional-accumulational terraces (36.5% of the area) and 5 – glacial tills of plateaus (30% of the area). Subsequently, with significantly lower shares of 5–6% each, there are geocomplexes of periglacial cover sands of plateaus (type 20) and glacial and fluvioglacial plateau sands and gravels upon glacial tills (type 16). Overall, these four geocomplex types cover about 79% of the area, whose characteristic features include the location at the water divide of the Vistula and Odra basins, and the lack of large rivers. Geocomplex types associated with river valleys: fluvial sands and muds and organic sediments of valley bottoms (type 11), fluvial sands and muds of the lower terrace (type 9) and fluvial sands and muds and organic sediments of terraces (type 10), constitute jointly about 7.5% of the buffer area. Very small areas, below 1% of the buffer area, are taken by geocomplex types 3, 10, 12 and 15.

Within the study area, the area of land abandonment intensity square plots included in class 0, that is without abandonment, and the area of squares with abandoned lands, have similar shares of approximately 50% (Fig. 4.16). The area of squares included in class 1 of land abandonment intensity constitutes about 30.2% of the total study area, class 2 – 14.2%, class 3 – 5.2%, class 4 – 1%.

The spatial distribution of abandoned lands in the study area is irregular (Fig. 4.17) and, in general, higher land abandonment intensity is present in its western half. The largest concentrations of abandoned lands were observed in the area between Łódź, Zgierz and the Łagiewniki Forest, whose edge delimits the northern border of the Łódź Hills Landscape Park, and the line of Klęk – Czaplinek – Glinnik – Maciejów – Dąbrówka – Marianka – Dąbrówka Wielka in the north. This area is dominated by squares in classes 2 and 3 of land abandonment intensity, whereas class 0 and 1 squares are sparse. The limits of dense building development of Zgierz and, to a lesser degree, of Łódź are accompanied by groups of 2–3 squares

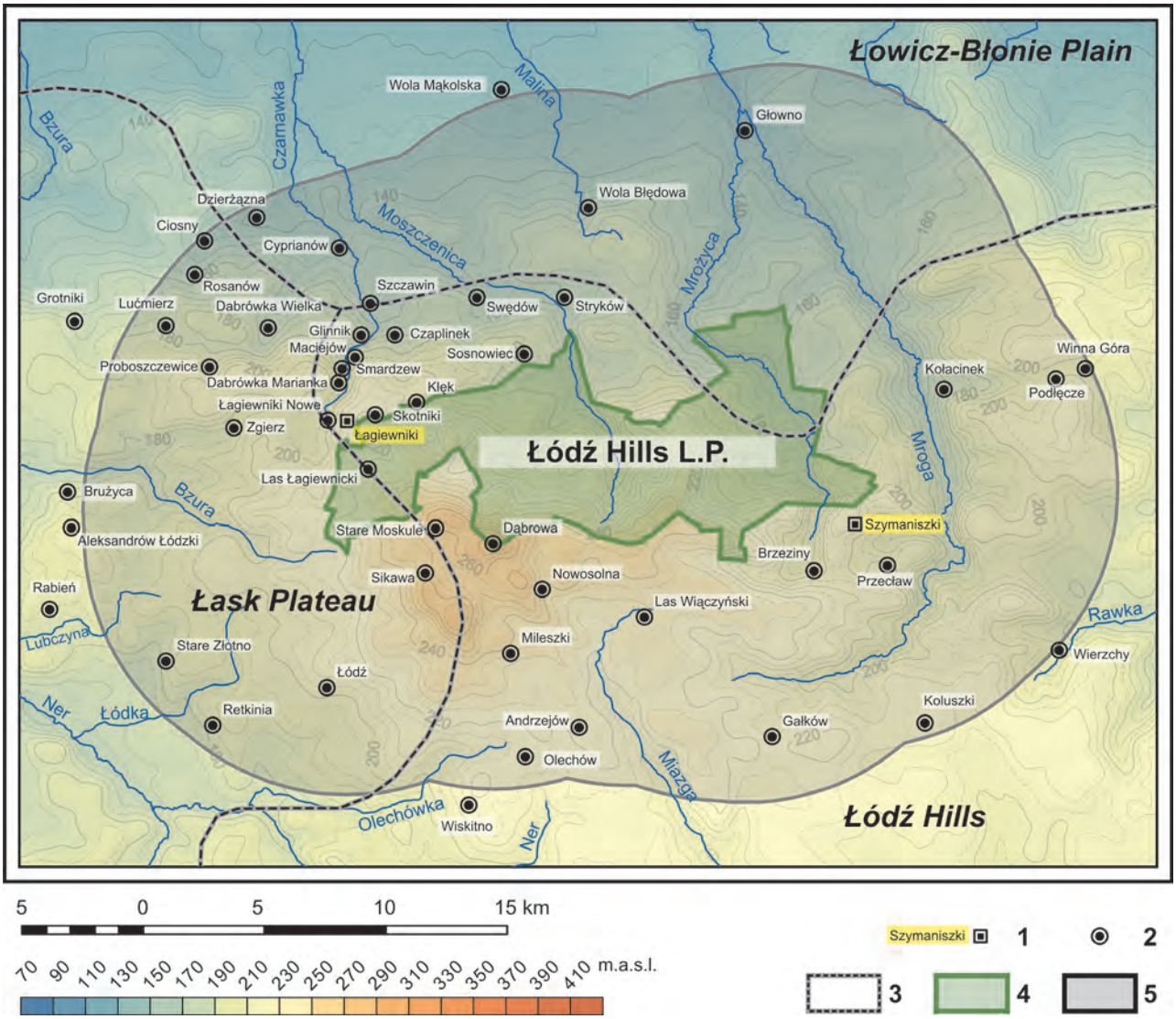


Fig. 4.13. The Łódź Hills Landscape Park and its buffer zone against the background of the physicogeographical units by Kondracki (2002)

1 – location of abandonment study plot groups; 2 – locations mentioned in the text; 3 – boundaries of physicogeographical units; 4 – landscape park area; 5 – 10-km wide buffer zone around landscape park

Source: own elaboration based on digital elevation model with grid interval of at least 100 m and other data made available by CODGiK (www.codgik.gov.pl)

of class 4, in which more than 75% of the area is taken by abandoned lands. Increased land abandonment intensity was also recorded to the west of Zgierz, near Proboszczewice and along the Bzura valley to Brużyca Wielka.

Extensive concentrations of abandoned lands are also found in the eastern part of Łódź, within its administrative borders, in the belt encompassing parts of Stare Moskule in the north, Sikawa and Nowosolna, as well as Mileszki and Andrzejów, and Wiskitno – to the south of the railway and the Łódź Olechów station, to the Olechówka valley. Most of them are villages and their grounds incorporated into Łódź in 1988. In this zone, land abandonment intensity is the highest in the central part – between Sikawa and Nowosolna, where there are several squares of class 4 of land abandonment intensity, i.e. taken almost entirely by abandoned lands. Apart from that, squares included in classes 1, 2 and 3 occur here in similar proportions. Basic squares without abandoned lands occur sporadically. Other clusters of class 4 squares, usually accompanied by class 2 and 3 squares, are found near Stryków, within a triangle marked by Sosnowiec, Wola Błędowa and the junction of A1 and A2 motorways. Smaller

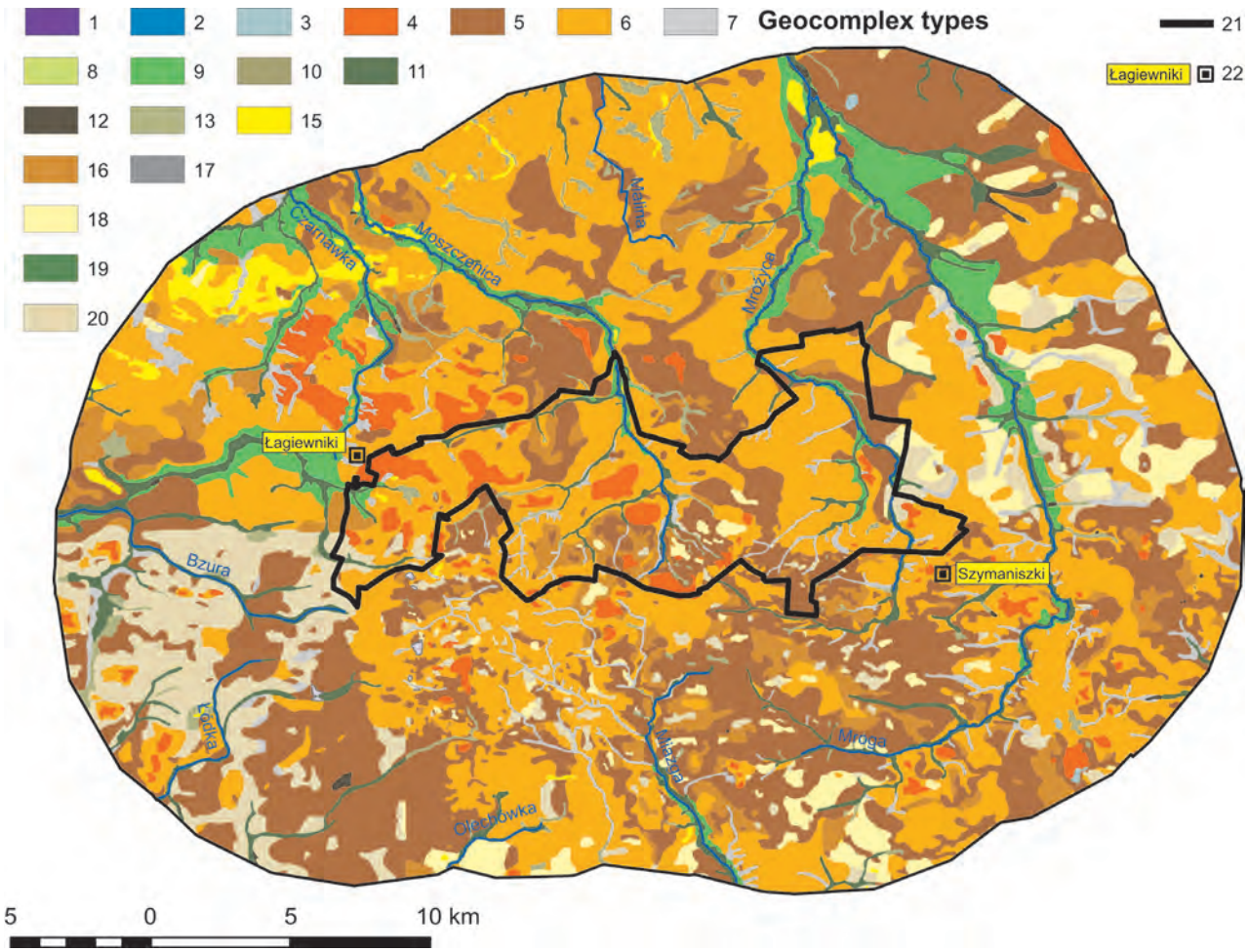


Fig. 4.14. Map of geocomplexes (morpholithohydrotopes) of the Łódź Hills Landscape Park and its buffer zone
1–20 – names of the morpholithohydrotope types listed in Tab. 3.1; 21 – landscape park boundary;
22 – study plot group

Source: own elaboration

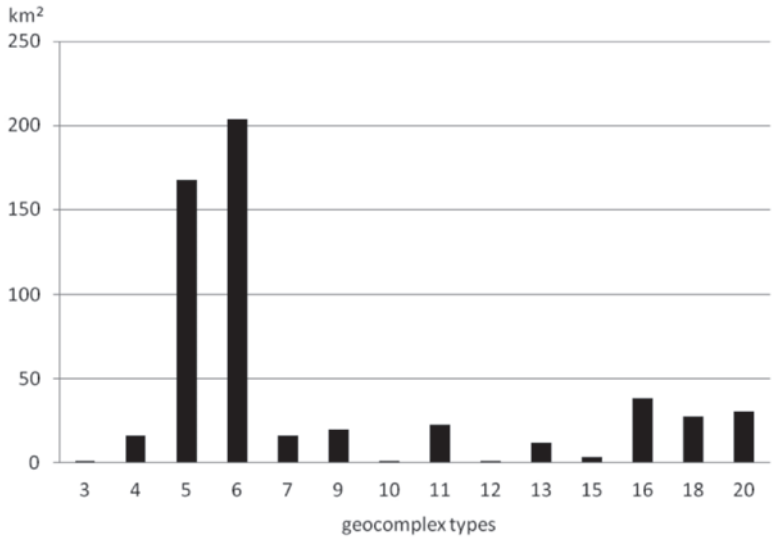


Fig. 4.15. The area of geocomplex type in the structure of the natural environment
of the buffer zone around the Łódź Hills Landscape Park

Source: own elaboration

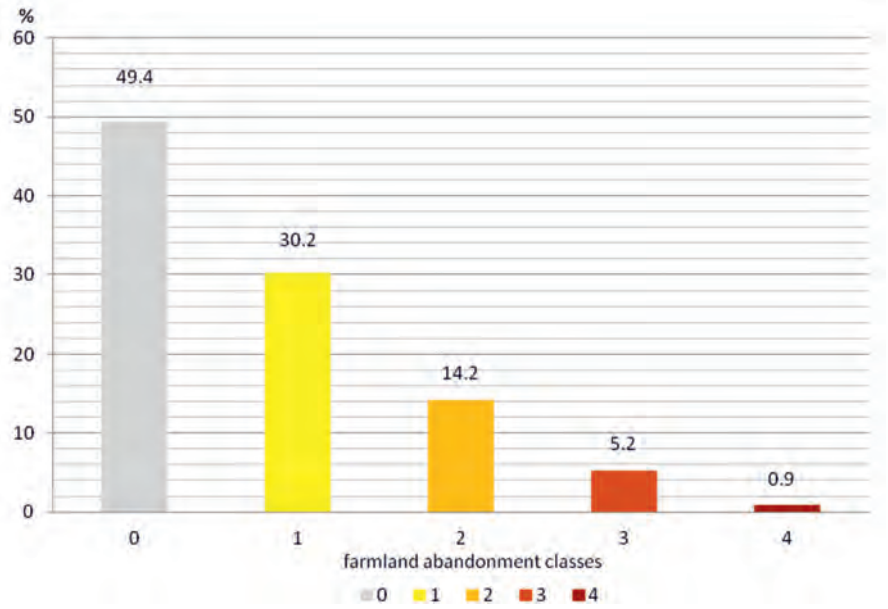


Fig. 4.16. Percentage of the areas of land abandonment intensity classes in the buffer zone around the Łódź Hills Landscape Park

Source: own elaboration

concentrations of abandoned lands in the western part of the described area are marked in the following locations: near Dzierzążna, Ciosny and Rosanów, near Cyprianów, near Rąbień AB, Stare Złotno and Retkinia.

In the eastern half of the buffer zone, the only larger concentration of plots assigned to classes 3 and 4 of abandonment intensity was found between Brzeziny and the southern border of the landscape park, along the Mrożyca valley. Only one concentration of abandonment class 2 and 3 squares is found in the south-eastern part of the analysed area – near Koluszki.

The remaining, usually not numerous, squares of class 4 of abandonment intensity, scattered across the entire study area, encompass forest-field ecotones.

The lowest abandonment intensity in the analysed area occurs in its northern, north-eastern and eastern parts. In these areas, class 0 squares of land abandonment intensity, i.e. those without any abandoned lands, prevail definitely. There are a few class 2 squares, whereas class 1 squares, concentrated in small groups, accompany patches of forest and river valleys. A belt of class 1 and sporadic class 2 squares lies along the Mroga and Mrożyca valleys. Low abandonment rates also characterise the upper part of the Mroga catchment basin, between the Wiączyn Forest, Gałków Duży and Brzeziny and Przecław.

Based on the comparison between the map of geocomplexes and the map of abandoned land distribution, the share of different abandonment intensity classes was determined in individual geocomplex types (Fig. 4.18). The results indicate that farmlands with no abandonment (class 0) have the highest share in the area of lithogenic complexes: type 3 – clays, claystones, muds and mudstones of various origin (a very low share of the geocomplex type in the study area), 18 – plateau periglacial silts and aeolian sands upon glacial till, and 5 – plateau glacial tills and – with hydrologic conditions shaped partially by shallow low permeable formations.

The lowest share of class 0 squares occurs in the geocomplex types with highly permeable soils, vulnerable to drying: aeolian sands of dunes and shields (type 15), boulders, cobbles, gravels, sands and muds of moraine hills and kame hills (type 4), and fluvial sands and muds of the lower terrace (type 9) (Fig. 4.18).

Classes with the highest abandonment intensity: 2, 3 and 4, have the highest share in the following geocomplex types: 4 – boulders, cobbles, gravels, sands and muds of moraine hills and kame hills, 15 – aeolian sands of dunes and shields, type 10 – fluvial sands and muds and organic sediments of the terrace, and 7 – sands, silts and muds in bottoms of dry valleys. The lowest share of intense abandonment classes is characte-

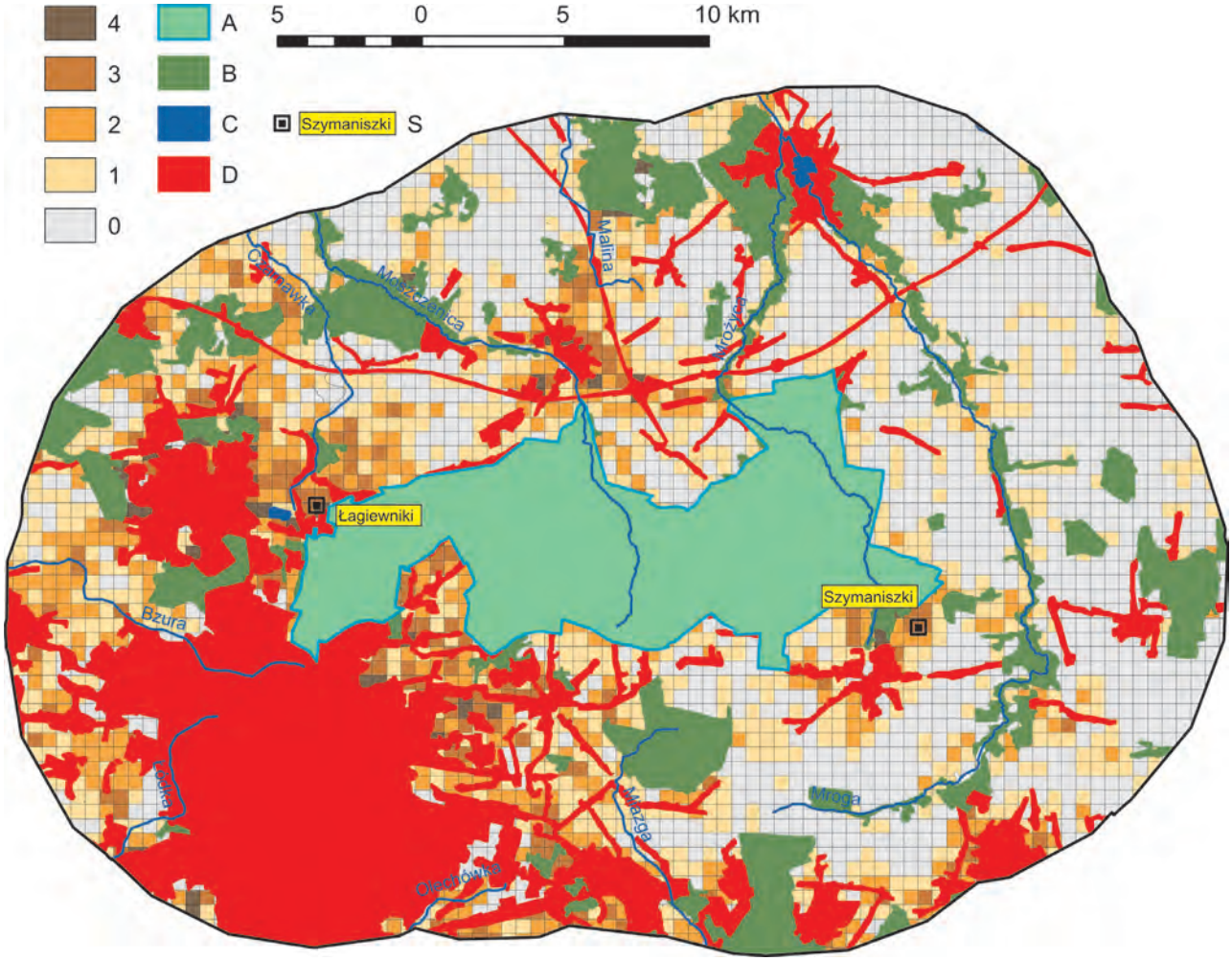


Fig. 4.17. Map of spatial distribution and intensity of land abandonment in the buffer zone around the Łódź Hills Landscape Park. For explanation see Fig. 4.4

Source: own elaboration

ristic of the following geocomplex types: 18 – plateau periglacial silts and aeolian sands upon glacial tills; 13 – mineral and organic formations in depressions of kettle holes, blowouts, spring niches and basin valleys, which is a semihydrogenic geocomplex, with periodically increased moisture content, and 5 – plateau glacial tills. Also geocomplex type 12 – peats and mucks of wetlands, contains little abandoned lands.

The percentage of geocomplex type area in land abandonment intensity classes (Tab. 4.3) indicates an increase of geocomplex type 6 area in higher intensity classes. Type 6 constitutes nearly 50% of the area in classes 3 and 4 of abandonment intensity. The percentage of area of several geocomplex types fluctuates in higher abandonment intensity classes. Generally, the percentage of types 20, 9 and 4 increases when intensity of abandonment grows. The percentage of geocomplex types 5, 16 and 18 decreases with increased abandonment intensity, but even in classes 3 and 4 it remains quite high.

Table 7.1. Frequency of occurrence of macrofungi species in the abandonment study plots in the Łódź Voivodeship

Site/Species	Glinnik A	Glinnik B	Glinnik C	Celestynów A	Celestynów B	Celestynów C	Sulejów A	Sulejów B	Sulejów C	Krzętle A	Krzętle B	Krzętle C	Raciszyn A	Raciszyn B	Raciszyn C	Weronika A	Weronika B	Weronika C	Wola Pszczółecka A	Wola Pszczółecka B	Wola Pszczółecka C	Piskorzeniec A	Piskorzeniec B	Piskorzeniec C	Wola Życińska A	Wola Życińska B	Wola Życińska C	Wola Makowska A	Wola Makowska B	Wola Makowska C	Polesie A	Polesie B	Polesie C	Szymaniszki A	Szymaniszki B	Szymaniszki C	Łagiewniki A	Łagiewniki B	Łagiewniki C
Amanita muscaria (L.: Fr.) Hook.	3	4	2	2	0	0	0	0	0	2	4	4	4	5	1	0	5	3	0	2	6	0	0	1	0	0	1	0	0	0	3	0	2	3	0	2	0	0	0
Arrhenia lobata (Pers.: Fr.) Redhead	2	0	0	0	2	0	2	0	7	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Auriscalpium vulgare Gray	1	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
Boletus edulis Bull.: Fr.	2	0	2	0	0	0	1	0	0	0	5	0	1	0	5	3	3	6	4	2	0	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0
Bovista nigrescens Pers.: Pers.	2	3	3	2	0	0	0	0	1	1	0	0	1	1	1	1	1	0	1	5	1	0	0	1	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0
Bovista plumbea Pers.: Pers.	5	3	0	3	0	0	2	4	3	4	0	2	4	1	5	4	5	5	5	5	8	3	3	40	1	0	0	0	0	0	0	6	5	5	0	0	0	0	0
Calocybe gambosa Fr. Donk	1	0	2	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Calvatia excipuliformis (Scop.: Pers.) Perdeck	2	0	0	0	3	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Calvatia utriformis (Bull.: Pers.) Jaap	1	0	0	3	0	0	0	1	0	1	1	5	1	1	0	1	0	0	1	0	1	0	0	3	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0
Chalciporus piperatus (Bull.: Fr.) Bat.	2	2	3	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Clitocybe vibecina (Fr.) Quél.	1	1	0	0	0	0	2	0	0	0	5	0	0	5	2	1	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Clitopilus prunulus (Scop.: Fr.) P. Kumm	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Conocybe rickeaniana Singer ex P.D. Orton	1	1	0	2	0	0	2	0	2	0	1	0	1	0	1	1	0	0	1	0	0	0	0	0	0	0	0	2	2	0	0	1	1	0	2	0	2	0	1
Conocybe tenera (Schaeff.: Fr.) Fayod	1	0	0	0	0	1	1	0	1	1	1	0	1	3	5	1	3	0	1	0	1	0	0	0	2	1	0	0	0	0	0	3	1	5	0	5	0	0	1
Crinipellis scabella (Alb. & Schwein.: Fr.) Murrill	6	0	4	0	0	0	0	0	8	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	4	0	1	0	0	0	0	0	0	0	0	0	0	0	0
Entoloma chalybaeum (Fr.: Fr.) Noordel.	1	1	0	2	0	1	0	0	0	0	1	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Entoloma conferendum (Britzelm.) Noordel.	0	0	0	0	0	0	3	0	0	0	0	0	1	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hemimycena lactea (Pers.: Fr.) Singer	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hygrocybe conica (Schaeff.: Fr.) P. Kumm.	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
Inocybe asterospora Quél.	1	0	0	0	0	1	4	0	0	1	1	0	3	1	1	0	1	1	0	0	1	0	0	0	1	0	1	0	0	0	2	0	1	0	0	1	0	2	0
Inocybe corydalina Quél.	1	0	0	1	0	0	5	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0
Inocybe maculata Boud.	0	0	0	0	0	1	1	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Inocybe praetervisa Quél.	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Laccaria laccata (Scop.: Fr.) Berck. & Broome	0	0	0	0	0	5	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	1	0	0	0	0	0
Leccinum scabrum (Bull.: Fr.) Gray	0	0	0	0	0	2	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0
Lepiota alba (Bres.) Sacc.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Lycoperdon ericaeum Bonord.	0	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	1	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Lycoperdon nigrescens (Pers.: Pers.) Pers.	0	0	0	4	0	1	0	0	0	2	0	5	0	0	0	0	0	0	1	0	0	5	0	0	0	0	0	0	0	0	0	3	6	0	0	0	0	0	0
Macrolepiota procera (Scop.: Fr.) Singer	0	0	0	0	0	2	0	1	0	0	1	0	1	0	1	0	0	5	5	0	1	0	0	0	0	0	0	0	0	0	0	1	1	0	1	2	1	0	0
Marasmius oreades (Bolt.: Fr.) Fr.	5	0	4	0	0	3	0	5	0	3	2	0	5	1	1	1	0	0	0	0	0	0	0	0	3	0	3	3	2	2	5	0	0	0	4	5	2	4	5
Mycena epipterygia (Scop.: Fr.) Gray	0	2	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Mycena filopes (Bull.: Fr.) P. Kumm.	0	1	0	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Panaeolus foemisecii (Pers.: Fr.) Kühner	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	2	3	2
Panaeolus fimicola (Fr.) Quél.	0	0	0	1	0	0	0	1	0	1	0	4	1	1	0	1	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	1	0	0	0	0	0
Paxillus involutus (Batsch: Fr.) Fr. ss.lato	0	0	3	2	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0
Psilocybe rugosoannulata (Farlow ex Murrill) Noordel.	0	0	0	1	0	0	0	0	0	1	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Psilocybe semiglobata (Batsch.: Fr.) Noordel.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
Psilocybe semilanceata (Fr.) P. Kumm.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	2	0	0	0	0	0	0	0	0	0
Rickenella fibula (Bull.; Fr.) Raith.	0	0	0	0	2	1	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Table 7.1. Frequency of occurrence of macrofungi species in the abandonment study plots in the Łódź Voivodeship (continued)

Site/Species	Glinnik A	Glinnik B	Glinnik C	Celestynów A	Celestynów B	Celestynów C	Sulejów A	Sulejów B	Sulejów C	Krzętle A	Krzętle B	Krzętle C	Raciszyn A	Raciszyn B	Raciszyn C	Weronika A	Weronika B	Weronika C	Wola Pszczółecka A	Wola Pszczółecka B	Wola Pszczółecka C	Piskorzeniec A	Piskorzeniec B	Piskorzeniec C	Wola Życińska A	Wola Życińska B	Wola Życińska C	Wola Makowska A	Wola Makowska B	Wola Makowska C	Polesie A	Polesie B	Polesie C	Szymaniszki A	Szymaniszki B	Szymaniszki C	Łagiewniki A	Łagiewniki B	Łagiewniki C
Schizophyllum commune Fr.: Fr.	0	0	0	0	0	1	0	0	0	1	0	0	1	1	0	1	4	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	5	0	0	0	0	0
Scleroderma citrinum Pers.	0	0	0	0	0	1	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	2	0	0	0	2	1	0	0	0	0	0	0	0
Suillus bovinus (L.: Fr.) Roussel	0	0	0	0	0	2	0	0	0	2	2	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Suillus luteus (L.: Fr.) Roussel	0	0	0	0	3	3	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Trichaptum abietinum (Dick.: Fr.) Ryvarden	0	0	2	0	0	1	0	0	0	0	1	0	0	1	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Xerocomus badius (Fr.: Fr.) Kühner ex Gilbert	0	0	0	0	0	2	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0

Source: own elaboration.

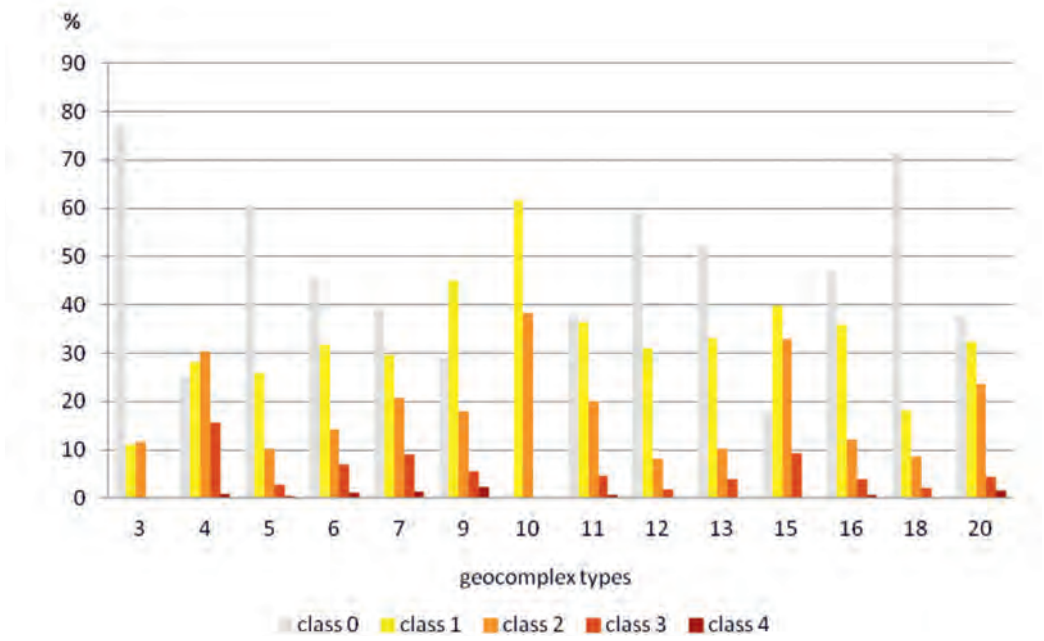


Fig. 4.18. Percentage of the area of land abandonment intensity classes in geocomplex types in the buffer zone around the Łódź Hills Landscape Park

Source: own elaboration

Table 4.3. Percentage of areas of geocomplex types in land abandonment intensity classes in the buffer zone around the Łódź Hills Landscape Park (sorted by decreasing share in geocomplex type area)

Geocomplex type	% geocomplex type area In abandonment class 0	Geocomplex type	% geocomplex type area In abandonment class 1	Geocomplex type	% geocomplex type area In abandonment class 2	Geocomplex type	% geocomplex type area In abandonment class 3	Geocomplex type	% geocomplex type area In abandonment class 4
5	36.87	6	38.32	6	36.85	6	48.94	6	47.45
6	33.74	5	25.66	5	21.66	5	15.51	5	15.58
18	7.01	16	8.09	20	9.14	4	8.47	20	9.30
16	6.49	20	5.90	4	6.04	16	5.24	9	8.68
20	4.19	9	5.21	11	5.82	7	5.01	16	4.52
11	3.15	11	4.94	16	5.80	20	4.71	7	4.45
7	2.30	18	2.91	9	4.42	11	3.73	4	2.87
13	2.18	7	2.83	7	4.22	9	3.71	11	2.45
9	2.06	4	2.65	18	2.94	18	1.89	18	0.56
4	1.44	13	2.26	13	1.48	13	1.57	13	0.39
12	0.25	15	0.76	15	1.34	15	1.02	12	0.00
15	0.21	12	0.22	12	0.12	12	0.07	15	0.00
3	0.07	3	0.02	3	0.04	3	0.00	3	0.00
10	0.00	10	0.01	10	0.01	10	0.00	10	0.00

Source: own elaboration.

The structure of natural environment and the location of abandoned lands around the Bolimów Landscape Park

According to J. Kondracki's regionalisation (2002), the 10-kilometre wide buffer zone around the Bolimów Landscape Park lies in the subprovince of the Central Poland Lowland (318). Lower order units in the characterised area include: the macroregion of the Central Mazovian Lowland (318.7) with mesoregions of the Kutno Plain (318.71) in the north-east and the Łowicz–Błonie Plain (318.72) – in the centre, and the macroregion of the South Mazovian Hills (318.8) with the Rawka Plateau (318.83) in the southern part, as well as a small fragment of the Łódź Hills (318.82) – in the south-west (Fig. 4.19).

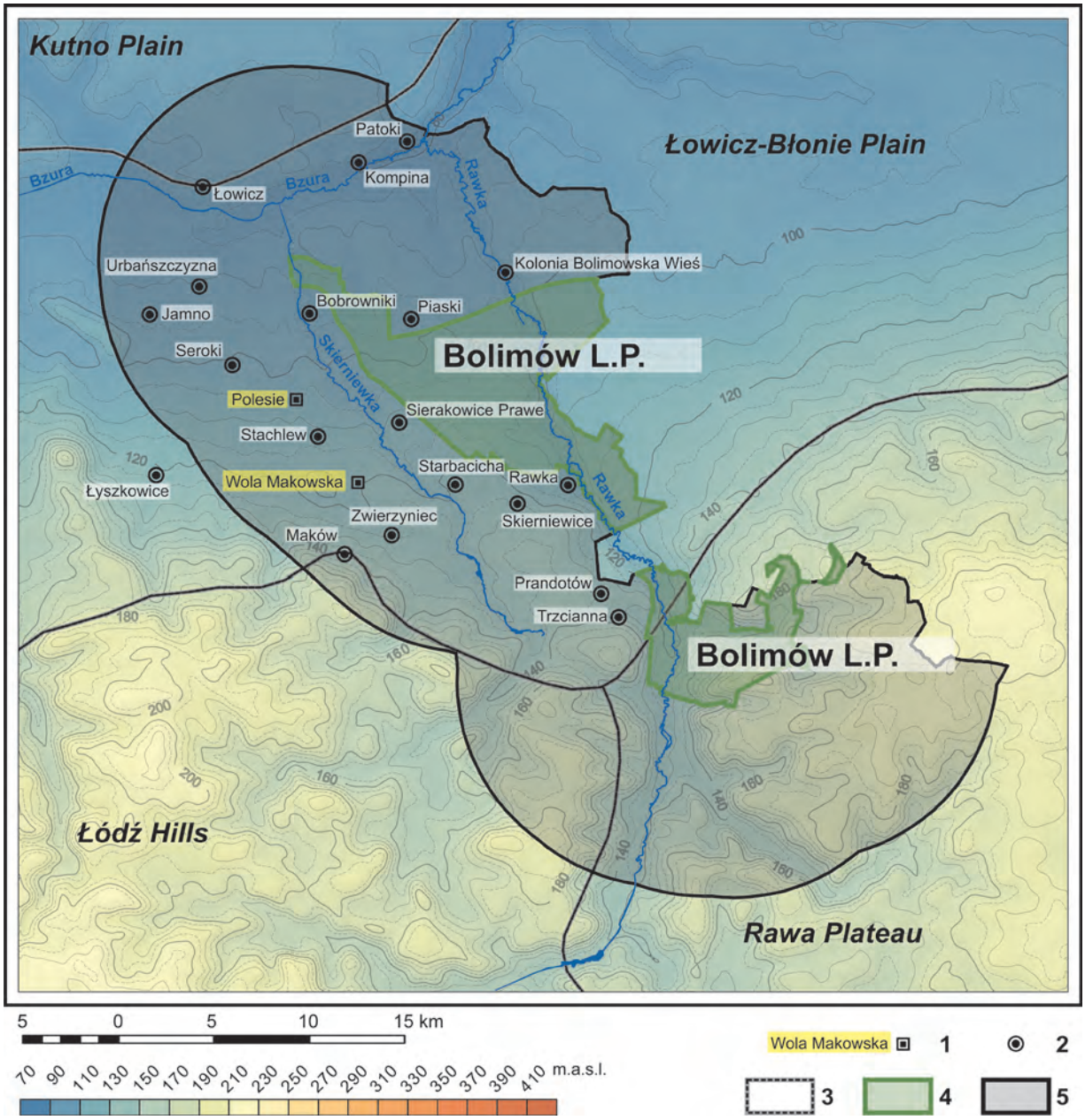


Fig. 4.19. The Bolimów Landscape Park and its buffer zone against the background of the physicogeographical units by J. Kondracki (2002)

1 – location of abandonment study plot groups; 2 – locations mentioned in the text; 3 – boundaries of physicogeographical units; 4 – landscape park area; 5 – 10-km wide buffer zone around the landscape park

Source: own elaboration based on digital elevation model with grid interval of at least 100 m and other data made available by CODGiK (www.codgik.gov.pl)

The surroundings of the Bolimów Landscape Park are dominated by flat or undulated landscapes with a general south-to-north inclination. The elevation difference ranges from about 180 to 82–85 m a.s.l. and begins in the area of a glacial plateau with forms of crevasse accumulation through lower plateau levels – erosional and accumulational – and the terraces of the Warsaw–Berlin ice marginal valley, to the bottom of the valley. At some locations, slopes of the plateau and terraces of the ice marginal valley, cut by the Bzura river tributaries, are covered with patches of sandy-gravelly sediments of alluvial fans or aeolian sands (Rdzany 2014). In this area, segments of the Rawka valley with naturally meandering river are the characteristic features.

The structure of the natural environment of the Bolimów Landscape Park buffer zone (Fig. 4.20, 4.21) is dominated by plateau glacial tills (geocomplex type 5), which cover 40.2%. Then, with a much lower share, there are geocomplex types 6 and 16, which take up respectively 17.7% and 12.2% of the area. The total area of the three geocomplex types associated with river valleys: fluvial sands and muds of lower terraces (type 9), fluvial sands, muds and organic sediments of valley bottoms (type 11), and fluvial sands and gravels of upper terraces (type 8) constitutes almost 15% of the buffer zone area. In all, these six geocomplex types occupy over 85% of the study area.

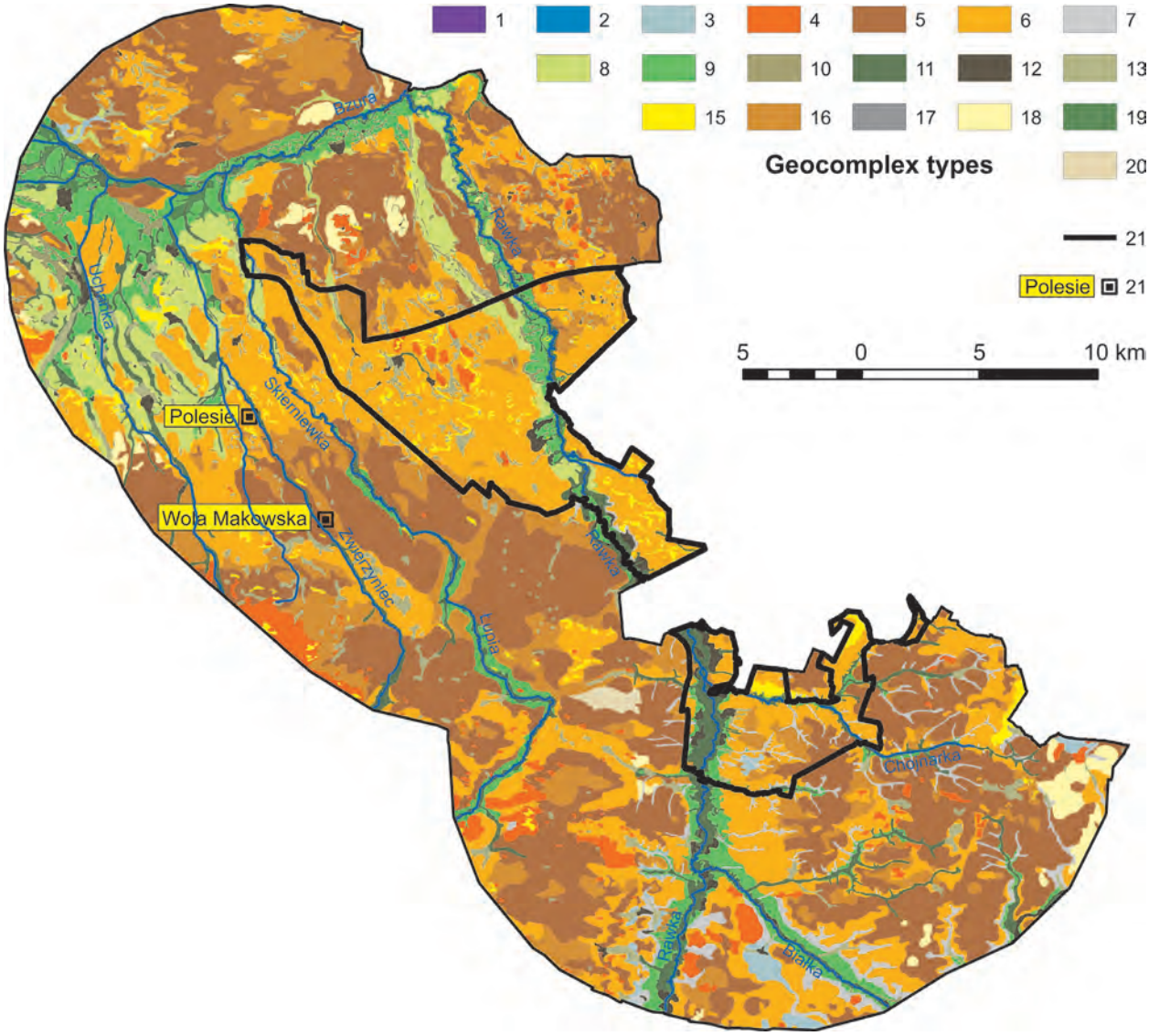


Fig. 4.20. Map of geocomplexes (morpholithohydrotopes) of the Bolimów Landscape Park and its buffer zone
1–20 – names of the morpholithohydrotopes listed in Tab. 3.1; 21 – landscape park boundary;
22 – study plot group

Source: own elaboration

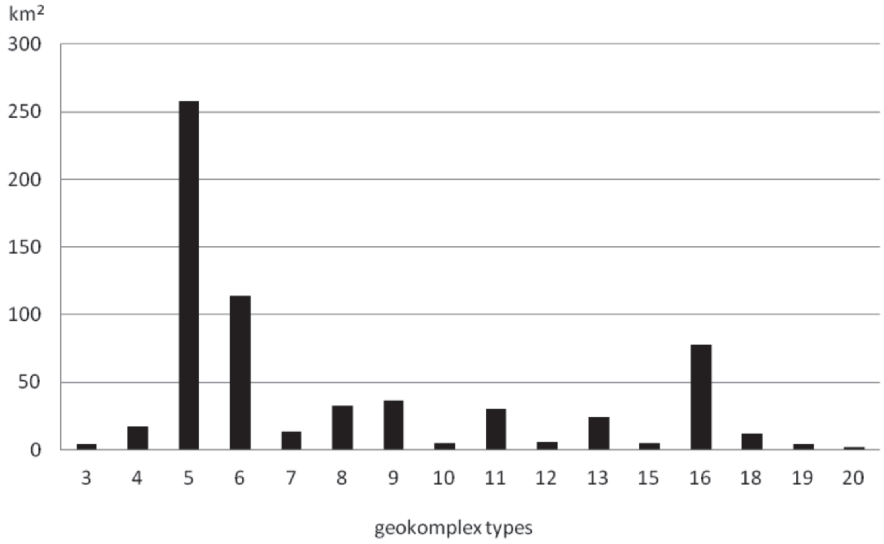


Fig. 4.21. The area of geocomplex types in the structure of the natural environment of the buffer zone around the Bolimów Landscape Park and its surroundings

Source: own elaboration

The 10-kilometre buffer zone of the Bolimów Landscape Park is characterised by lower intensity of land abandonment than the surroundings of the Łódź Hills Landscape Park, since the phenomenon of land abandonment was only found in one third of the analysed squares plots. The squares included in class 1 of land abandonment intensity cover about 26% of the area of the analysed farmlands, class 2 – 6.3%, class 3 – 1.4%, class 4 – less than 0.5% (Fig. 4.22). Areas free from abandonment take up about 66% of the study area.

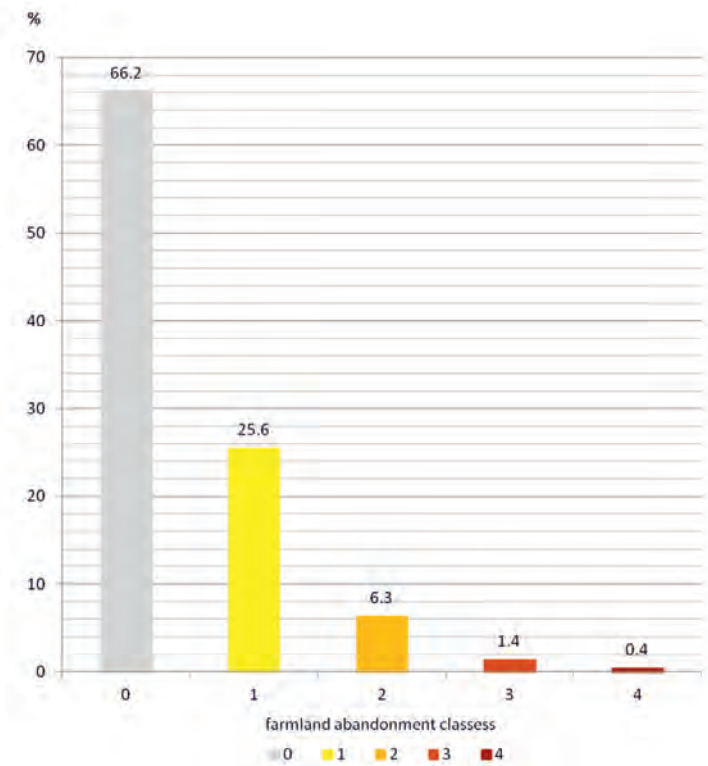


Fig. 4.22. Percentage of areas of land abandonment intensity classes in the buffer zone around the Bolimów Landscape Park

Source: own elaboration

Arable lands without abandonment (class 0 of land abandonment intensity) are concentrated in the northern and south-eastern part of the study area (Fig. 4.23). In the north, the loamy Kutno Plain stands out, clearly dominated by plateau glacial till (geocomplex type 5), where even squares with a low share of abandoned lands (class 1) occur incidentally. Areas without abandoned lands surround Łowicz from the north, forming an arch between Jamno in the west and Kompina and Patoki in the east. Some very extensive areas with very little abandoned lands are also found to the south and south-east of Pradontów and Trzcianna and the Łupia valley in the west, in an arch around the Park borders up to the eastern limit of the study area, across almost the entire width of the buffer zone. In this area, an increased incidence of squares of class 1 and 2 of abandonment intensity is marked along the Rawka and Białka valleys and near forests.

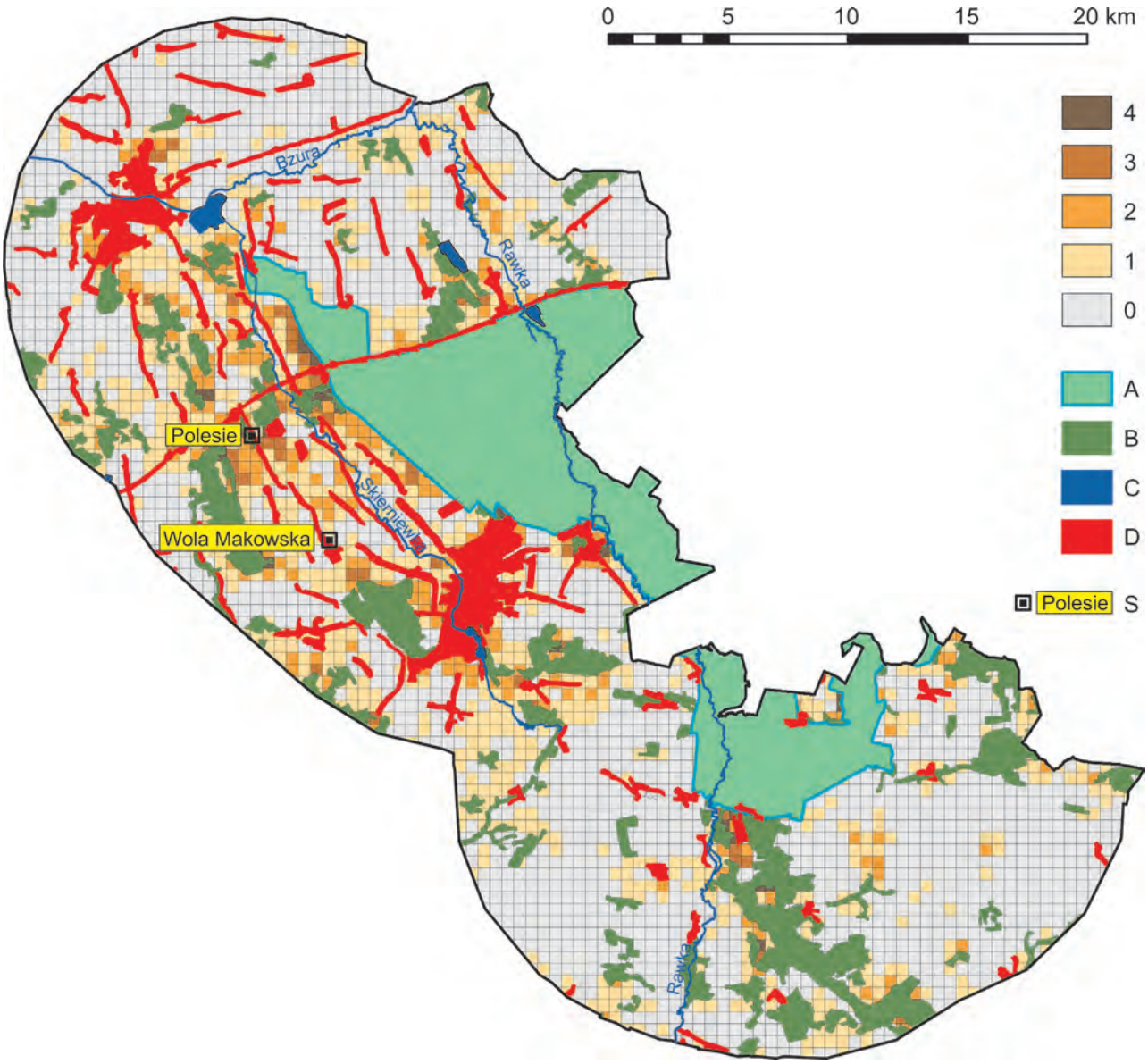


Fig. 4.23. Map of spatial distribution and intensity of land abandonment in the buffer zone around the Bolimów Landscape Park. For explanation see Fig. 4.4

Source: own elaboration

The highest intensity of land abandonment is visible in the central and central-west part of the buffer zone around the park, between Łowicz and Skierniewice, and particularly in the belt stretching from Urbańszczyzna, through Polesie and Stachlew to the Zwierzyniec Forest. In this area, similar proportions of class 1, 2 and 3 squares occur, whereas class 4 squares, which come in groups of two or three, are found near the forests around Wola Makowska, Polesie and Seroki. A very high intensity of abandonment was also recorded in the area stretching between Skierniewice and the Bolimów Landscape Park, in Starbacicha and Rawka quarters, and, also near the border of the park, in the belt between Sierakowice Prawe and Bobrowniki. In these areas, groups of two or three squares of the highest abandonment intensity class occur, as well as numerous class 1, 2 and 3 squares. A grouping of squares with a slightly lower abandonment intensity lies along the northern border of the park and the A2 motorway, between Piaski and Kolonia Bolimowska Wieś. A cluster of abandonment intensity class 1 squares with some class 2 and 3 squares is found here. The above mentioned areas of intensified land abandonment resemble the location of geocomplex types 6, 15 and 8, with low agricultural usability.

A comparison between the geocomplex map and the map of abandonment intensity classes (Fig. 4.24) shows that the highest percentage of areas with no abandonment (class 0) occurs in lithogenic geocomplex types: 20 – periglacial cover sands and silts of plateaus, 18 – periglacial and aeolian sands upon glacial tills of plateaus, and 5 – glacial tills of plateaus. The lowest amount of squares included in class 0 occurs in the types of geocomplexes with highly permeable soils, prone to drying: types 15, 4, as well as 6 and 8. There is a clear decrease in the share of geocomplex type 5, formed of glacial tills of plateaus, with increasing abandonment intensity, accompanied by an increase in the share of geocomplex type 6 (Tab. 4.4).

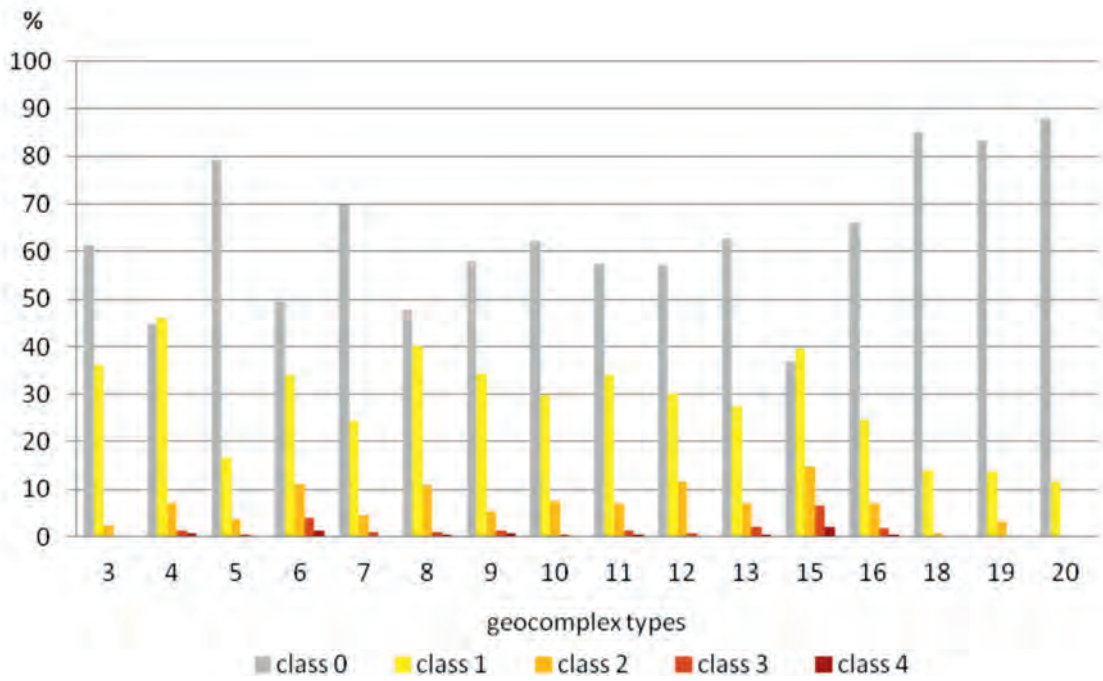


Fig. 4.24. Percentage of the area of land abandonment intensity classes in geocomplex types in the buffer zone around the Bolimów Landscape Park

Source: own elaboration

Table 4.4. Percentage of areas of geocomplex types in land abandonment intensity classes in the buffer zone around the Bolimów Landscape Park (sorted by decreasing share in geocomplex type area)

Geocomplex type	% geocomplex type area In abandonment class 0	Geocomplex type	% geocomplex type area In abandonment class 1	Geocomplex type	% geocomplex type area In abandonment class 2	Geocomplex type	% geocomplex type area In abandonment class 3	Geocomplex type	% geocomplex type area In abandonment class 4
5	48.05	5	26.23	6	30.86	6	49.30	6	52.63
6	13.25	6	23.65	5	23.31	16	14.85	16	12.35
16	12.17	16	11.84	16	13.45	5	10.03	9	10.49
9	4.99	8	7.89	8	8.54	9	5.54	8	5.06
11	4.06	9	7.61	11	5.18	13	5.49	4	5.02
8	3.62	11	6.25	9	4.84	11	3.77	13	4.07
13	3.53	4	4.85	13	4.19	15	3.37	15	3.55
18	2.44	13	4.01	4	2.99	8	3.02	11	3.27
7	2.23	7	2.03	15	1.71	4	2.35	5	3.16
4	1.82	15	1.14	12	1.58	7	1.30	12	0.41
19	0.81	18	1.04	7	1.54	12	0.47	18	0.00
10	0.79	12	1.00	10	1.01	18	0.31	7	0.00
12	0.73	3	1.00	19	0.33	10	0.20	19	0.00
3	0.65	10	0.97	3	0.25	19	0.00	10	0.00
20	0.44	19	0.34	18	0.21	3	0.00	3	0.00
15	0.41	20	0.15	20	0.00	20	0.00	20	0.00

Source: own elaboration

http://dx.doi.org/10.18778/8088-193-8.05

5. Pedological, floristic and mycological characteristics of the study areas

5.1. Abandoned land study plot groups in the buffer zone around landscape parks on the Pilica River

Stanisław Krysiak, Jolanta Adamczyk, Jarosław Sieradzki

GLINNIK STUDY PLOT GROUP

The Glinnik study plot group is located several hundred metres from the borders of the Spała Landscape Park, in Lubochnia Commune. It is surrounded by extensive forest complexes from the east and south. Surface formations include upper fluvioglacial sands and gravels that originated during the cataglacial phase of the Warta Glaciation (Trzmiel 1986). A small addition of silty fraction, found in the uppermost series of the Glinnik A, Glinnik B and Glinnik C study plots is related to aeolian accumulation in the periglacial conditions of the Vistulian. The formations constitute the parent rock for sandy soils of different genetic types (AB), whose agricultural suitability was classified as poor rye complex (6) and very poor rye complex (7) (Województwo piotrkowskie. Mapa glebowo-rolnicza 1979). As regards soil valuation, the productivity of soils at plots Glinnik A and Glinnik C was classified as class VI, whereas plot Glinnik B – as class V of arable lands (http://geoportal.lodzkie.pl/imap/). Photographic documentation and results of laboratory analyses from the Glinnik study plot group are presented in figures 5.1–5.6, and in tables 5.1–5.3.

STUDY PLOT GLINNIK A (51°33'561N, 20°07'135E, elevation: 178 m a.s.l.)

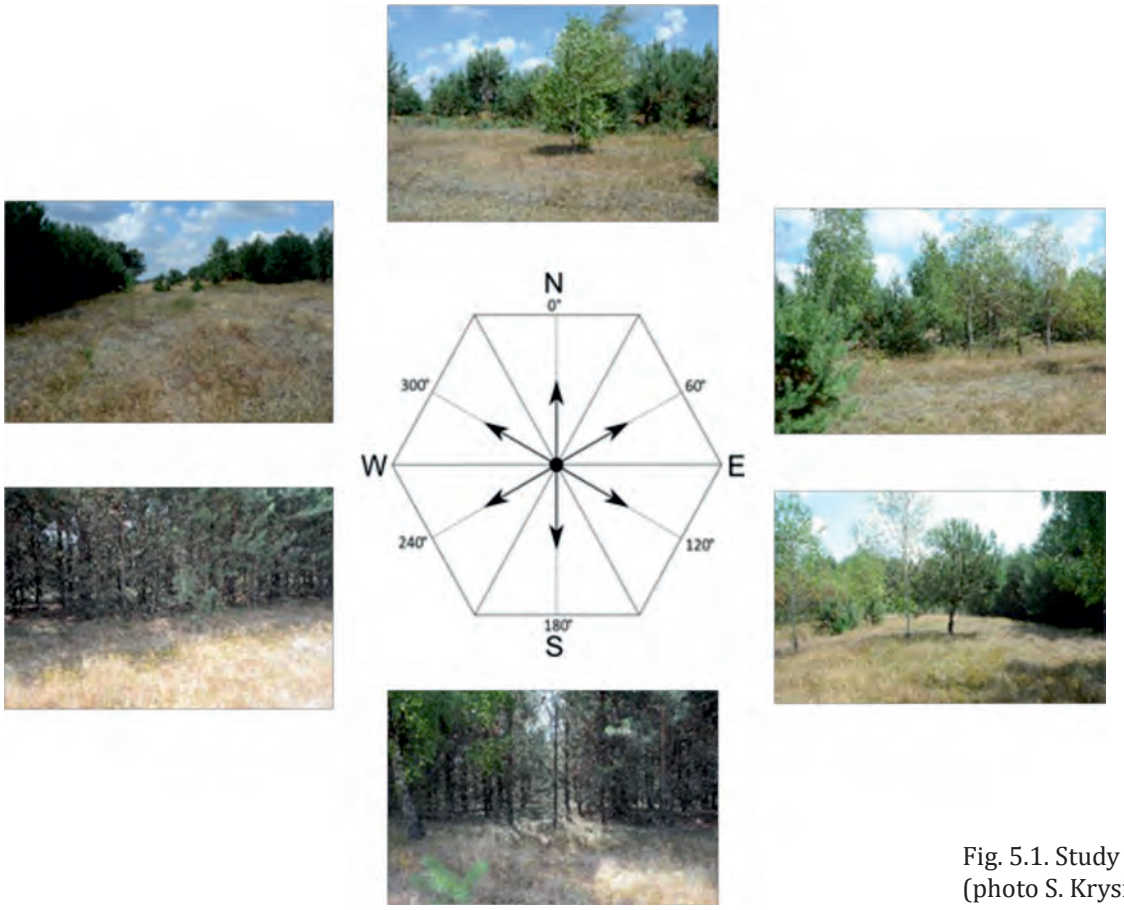


Fig. 5.1. Study plot Glinnik A (photo S. Krysiak, 2012)

Depth		Profile description
0–23 cm	–	humus, fine and silty sand, grey
23–70 cm	–	fine and silty sand, light beige
70–90 cm	–	fine sand with a boulder (20 cm in diameter) and cobbles
90–110 cm	–	medium and fine sand, rusty yellow

Fig. 5.2. Soil pit in study plot Glinnik A (photo S. Krysiak, 2012)

Table 5.1. Study plot Glinnik A. Granulometric and chemical properties of soil

Soil pit	Sampling depth cm	Grain size distribution %									Granulometric sub-group	Specific surface area $m^2 \cdot g^{-1}$
		2.0–1.0 mm	1.0–0.5 mm	0.5–0.25 mm	0.25–0.1 mm	0.1–0.05 mm	0.05–0.02 mm	0.02–0.005 mm	0.005–0.002 mm	<0.002 mm		
Glinnik A	0–20	0.0	20.8	43.0	15.3	5.7	8.5	4.6	1.3	0.8	ps	0.1350
Glinnik A	20–40	0.0	19.7	42.2	17.8	5.6	7.6	4.5	1.4	1.1	ps	0.1550
Glinnik A	90–110	0.0	18.3	72.9	7.2	0.0	0.0	1.0	0.5	0.1	pl	0.0344

Soil pit	Sampling depth cm	Humus %	C total %	N total %	C/N	pH in		Available nutrients mg/100g		
						KCl	H_2O	P_2O_5	K_2O	Mg
Glinnik A	0–20	1.75	1.015	0.069	14.71	4.0	4.8	5.0	2.6	0.4
Glinnik A	20–40	–	–	–	–	4.3	4.9	3.0	1.5	0.2
Glinnik A	90–110	–	–	–	–	4.3	5.2	1.6	1.6	0.4

Soil pit	Sampling depth cm	Hydrolytic acidity mmol/100g	Exchangeable cations me/100 g				Sorption capacity me/100 g			
			Ca^{2+}	Mg^{2+}	Na^{+}	K^{+}	S	T	(T–S)	V, %
Glinnik A	0–20	4.75	0.15	0.020	0.017	0.079	0.266	5.016	4.75	5.5
Glinnik A	20–40	2.27	0.10	0.013	0.009	0.044	0.166	2.436	2.27	6.8
Glinnik A	90–110	1.45	0.10	0.027	0.009	0.031	0.167	1.617	1.45	10.3

Source: own elaboration.

Characteristics of the flora and fungi – Glinnik A

Approximately 100% of the study plot is covered with plants. Most recorded species are grasses. The share of dicotyledons is smaller. Two species dominate among plants: *Agrostis capillaris* (about 65%) and *Hieracium pilosella* (about 25%). The share of other species does not exceed 0.5% of land cover. Identified grass species include: *Poa pratensis*, *Anthoxantum odoratum*, *Festuca ovina*, *Apera spica-venti*, *Nardus stricta*, *Arrenatherum elatius*. Other observed species include e.g.: *Jasio-*

ne montana, *Achillea millefolium* (Tab. 6.1). Sparse saplings of trees are also found in the area: *Betula pendula*, *Pinus sylvestris* and *Quercus robur*.

Fungi of the plot are represented by 17 species of macromycetes. The most frequently found are *Bovista plumbea* and *Crinipellis scabella*, which appear on grasses, mostly on *Agrostis capillaris* and *Festuca ovina*. Among land mycorrhizal fungi, the most abundant species was *Amanita muscaria* (Tab. 7.1).

STUDY PLOT GLINNIK B (51°33'449N, 20°07'114E, elevation 172 m a.s.l.)

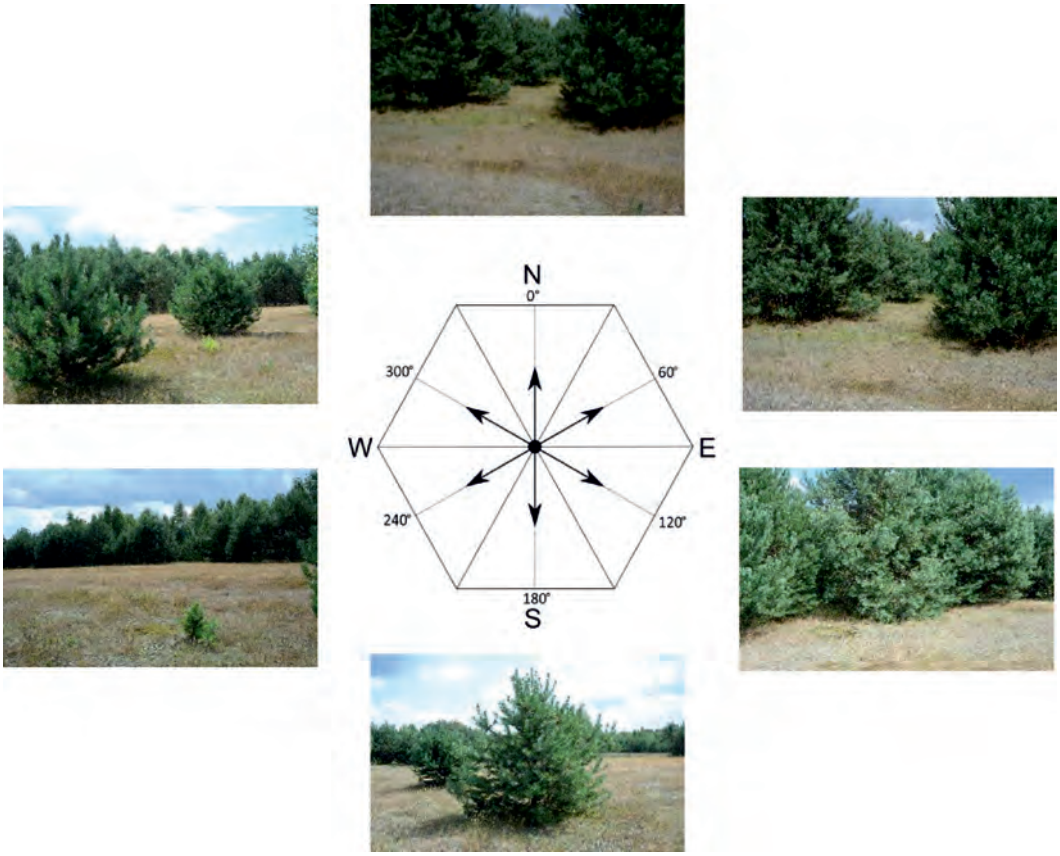
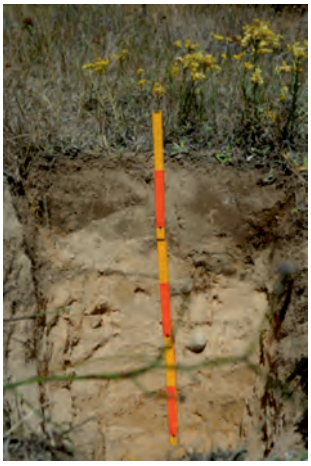


Fig. 5.3. Study plot Glinnik B (photo S. Krysiak, 2012)



Depth		Profile description
0–20 cm	–	humus, fine and silty sand, grey
20–40 cm	–	unsorted sand with single pebbles, yellow
40–70 cm	–	unsorted sand with gravel and cobbles of 3–4 cm in diameter, rusty
70–100 cm	–	fine sand with cobbles, yellow
100–110 cm	–	loamy sand, brown

Fig. 5.4. Soil pit in study plot Glinnik B (photo S. Krysiak, 2012)

Table 5.2. Study plot Glinnik B. Granulometric and chemical properties of soil

Soil pit	Sampling depth cm	Grain size distribution %									Granulometric sub-group	Specific surface area $m^2 \cdot g^{-1}$
		2.0–1.0 mm	1.0–0.5 mm	0.5–0.25 mm	0.25–0.1 mm	0.1–0.05 mm	0.05–0.02 mm	0.02–0.005 mm	0.005–0.002 mm	<0.002 mm		
Glinnik B	0–20	0.0	19.5	42.5	26.1	4.8	3.9	2.3	0.8	0.2	pl	0.0668
Glinnik B	20–40	0.1	19.4	42.6	31.6	4.7	1.6	0.0	0.0	0.0	pl	0.0268
Glinnik B	90–110	0.0	16.5	47.7	33.0	1.7	1.1	0.0	0.0	0.0	pl	0.0245
Glinnik B	120–130	1.3	12.5	23.3	22.2	8.0	8.3	12.0	7.4	5.1	gp	0.5560

Soil pit	Sampling depth cm	Humus %	C total %	N total %	C/N	pH in		Available nutrients mg/100g		
						KCl	H_2O	P_2O_5	K_2O	Mg
Glinnik B	0–20	0.86	0.499	0.036	13.86	4.2	5.0	10.6	1.4	0.4
Glinnik B	20–40	–	–	–	–	4.6	5.5	4.0	0.7	0.3
Glinnik B	90–110	–	–	–	–	4.5	5.4	3.4	1.8	0.4
Glinnik B	120–130	–	–	–	–	4.4	5.7	4.1	9.6	12.6

Soil pit	Sampling depth cm	Hydrolytic acidity mmol/100 g	Exchangeable cations me/100 g				Sorption capacity me/100 g			
			Ca^{2+}	Mg^{2+}	Na^{+}	K^{+}	S	T	(T–S)	V, %
Glinnik B	0–20	2.65	0.15	0.033	0.009	0.044	0.236	2.886	2.65	8.2
Glinnik B	20–40	1.25	0.10	0.020	0.026	0.038	0.184	1.434	1.25	12.8
Glinnik B	90–110	1.16	0.05	0.030	0.009	0.044	0.133	1.297	1.16	10.3
Glinnik B	120–130	1.54	2.80	1.210	0.087	0.246	4.343	5.883	1.54	73.8

Source: own elaboration.

Characteristics of the flora and fungi – Glinnik B

Approximately 90% of the study plot is covered with plants. There are fairly many species of flora (24). Three species dominate: *Agrostis capillaris* (about 30%), *Hieracium pilosella* (about 30%) and *Jasione montana* (10%). The share of other species does not exceed 5–0.5% of the area. Grasses are a quantitatively significant component of the flora, but the number of species is small (4). Apart from *Agrostis capillaris*, they include: *Festuca ovina*, *Nardus stricta* and *Corynephorus canescens*. The observed species of dicotyledons include: *Artemisia campestris*, *Centaurea stoebe jacobea* (Tab. 6.1). The area also features a few saplings of trees: *Pinus sylvestris* and *Quercus robur*.

Fungi of the plot are rather sparse. They are represented by as few as 6 species of macromycetes. The most frequently found species is *Crinipellis scabella*, which occurs on grasses, mainly on *Agrostis capillaris* and *Festuca ovina*. Among land fungi, the most abundant species were *Marasmius oreades* and *Bovista plumbea*. Apart from them, rare fruit bodies of *Conocybe tenera* were found. Numerous fruit bodies of mycorrhizal species were identified: *Suillus bovinus* and *Inocybe maculata*.

STUDY PLOT GLINNIK C (51°33'434N, 20°07'064E, elevation 172 m a.s.l.)

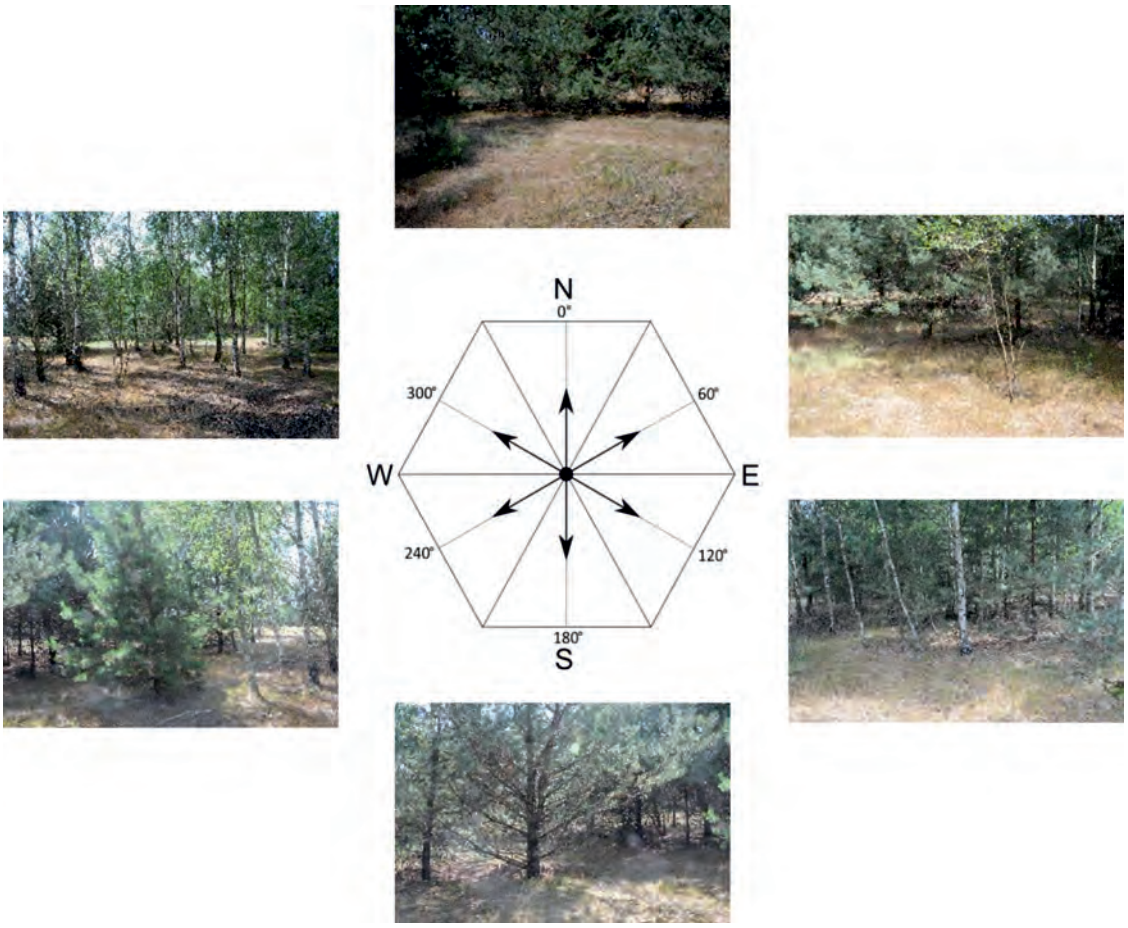


Fig. 5.5. Study plot Glinnik C (photo S. Krysiak, 2012)

Depth		Profile description
0–15 cm	–	humus, medium and silty sand with gravel, grey
15–20 cm	–	medium sand, beige
20–40 cm	–	medium and coarse sands, yellow
40–110 cm	–	medium and coarse sands with single pebbles, yellow

Fig. 5.6. Soil pit in study plot Glinnik C (photo S. Krysiak, 2012)

Table 5.3. Study plot Glinnik C. Granulometric and chemical properties of soil

Soil pit	Sampling depth cm	Grain size distribution %									Granulometric sub-group	Specific surface area $m^2 \cdot g^{-1}$
		2.0–1.0 mm	1.0–0.5 mm	0.5–0.25 mm	0.25–0.1 mm	0.1–0.05 mm	0.05–0.02 mm	0.02–0.005 mm	0.005–0.002 mm	<0.002 mm		
Glinnik C	0–20	6.7	38.7	32.9	7.7	4.5	5.3	3.1	0.8	0.3	pl	0.0734
Glinnik C	20–40	0.0	29.8	57.8	12.4	0.0	0.0	0.0	0.0	0.0	pl	0.0162
Glinnik C	90–110	0.0	5.8	75.7	18.5	0.0	0.0	0.0	0.0	0.0	pl	0.0193

Soil pit	Sampling depth cm	Humus %	C total %	N total %	C/N	pH in		Available nutrients mg/100g		
						KCl	H_2O	P_2O_5	K_2O	Mg
Glinnik C	0–20	1.41	0.818	0.048	17.04	4.0	4.7	10.6	2.3	0.5
Glinnik C	20–40	–	–	–	–	4.5	5.4	2.8	0.3	0.3
Glinnik C	90–110	–	–	–	–	4.7	5.7	1.3	0.3	0.2

Soil pit	Sampling depth cm	Hydrolytic acidity mmol/100 g	Exchangeable cations me/100 g				Sorption capacity me/100 g			
			Ca^{2+}	Mg^{2+}	Na^{+}	K^{+}	S	T	(T–S)	V, %
Glinnik C	0–20	1.48	0.10	0.033	0.009	0.074	0.155	1.635	1.48	9.5
Glinnik C	20–40	1.01	0.05	0.015	0.009	0.013	0.087	1.097	1.01	7.9
Glinnik C	90–110	0.65	ND	0.117	ND	0.005	0.122	0.772	0.65	15.8

Source: own elaboration.

Characteristics of the flora and fungi – Glinnik C

Approximately 100% of the study plot is covered with plants. Poor in species of vascular plants (8). One species dominates: *Agrostis capillaris*, covering about 80% of the area. A much lower share (7–3%) occurs of e.g.: *Apera spica-venti*, *Hieracium pilosella* (Tab. 6.1) and saplings of trees: *Pinus sylvestris*, *Quercus robur* and *Betula pendula*. The occurrence of three species of moss was also identified: *Polytrichum attenuatum*, *Pleurozium schreberii* and *Dicranum scoparium*, which covered a small portion of the area (about 2%).

Fungi of the plot are represented by 9 species of macromycetes. None of the species was abundant. The identified species include: *Bovista nigrescens*, *Calocybe gambosa*, *Marasmius oreades* and others (Tab. 7.1).

Analysis of granulometric composition and chemical properties of soils in the Glinnik study plot group

Granulometric analyses of study plots Glinnik A, B and C (Tab. 5.1–5.3) reveal a slight diversity. The dominating role is played by the sandy fraction. At Glinnik A, about 15% share of the silty fraction allowed the surface series to be qualified as the granulometric subgroup of slightly loamy sands (ps). Underneath them lie loose sands (pl), completely devoid of silts. Also at Glinnik B (sample from the depths: 0–20 and 20–40 cm) and Glinnik C (sample from the depth of 0–20 cm), the content of several percent of silts is present, confirmed with larger values of specific surface area. As regards agronomic classification, the granulometric composition of the analysed sediments qualify them as soils of category I (very light soils). The sandy loam found at Glinnik B is an exception, classified as category III (medium soils).

The pH reaction in KCl for all samples from the three sites is acidic and very acidic. The highest reaction spread was recorded at Glinnik C – from

4.0 to 4.7. The available content of phosphorus (P_2O_5), potassium (K_2O) and magnesium (Mg) at all analysed sites corresponds to very low and low class of availability. The content of alkaline cations Ca^{2+}, Mg^{2+}, Na^{+} and K^{+} is also low, which confirms the low saturation of the sorptive complex (V), ranging from several to about a dozen percent. The sandy loam from Glinnik B is an exception here, with saturation of the above mentioned cations reaching 73.8%.

CELESTYNÓW STUDY PLOT GROUP

The Celestynów study plot group is located 3 km away from the Sulejów Landscape Park and 8 km away from the borders of the Spała Landscape Park, in Sławno Commune. It is a part of a vast stretch of land belonging to the villages of Unewel and Celestynów, where most croplands were excluded from farming and became abandoned, representing various degrees of secondary succession. In the west and south the abandoned lands border directly on woodlands. There are also extensive woodlands not far away to the north and east of the study area. Surface deposits in the Celestynów study plot group include sands and fluvioglacial gravels, which originated in the period of the Odranian Glaciation (Szałamacha 1991). A slight admixture of the silty fraction, found in the uppermost series of plots Celestynów A, B and C, is related to aeolian accumulation in the periglacial conditions of the Wartanian and Vistulian. The deposits constitute the parent rock for sandy soils of different genetic types (AB), whose agricultural suitability was classified as very poor rye complex (7) (Województwo piotrkowskie. Mapa glebowo-rolnicza. 1979). As regards soil valuation, productivity of soils at all plots of the Celestynów group was qualified as class VI (http://geoportal.lodzkie.pl/imap/). Photographic documentation and results of laboratory analyses from the plots of the Celestynów study plot group are presented in figures 5.7–5.12, and in tables 5.4–5.6.

STUDY PLOT CELESTYNÓW A (51°26'175N, 20°04'494E, elevation 205 m a.s.l.)

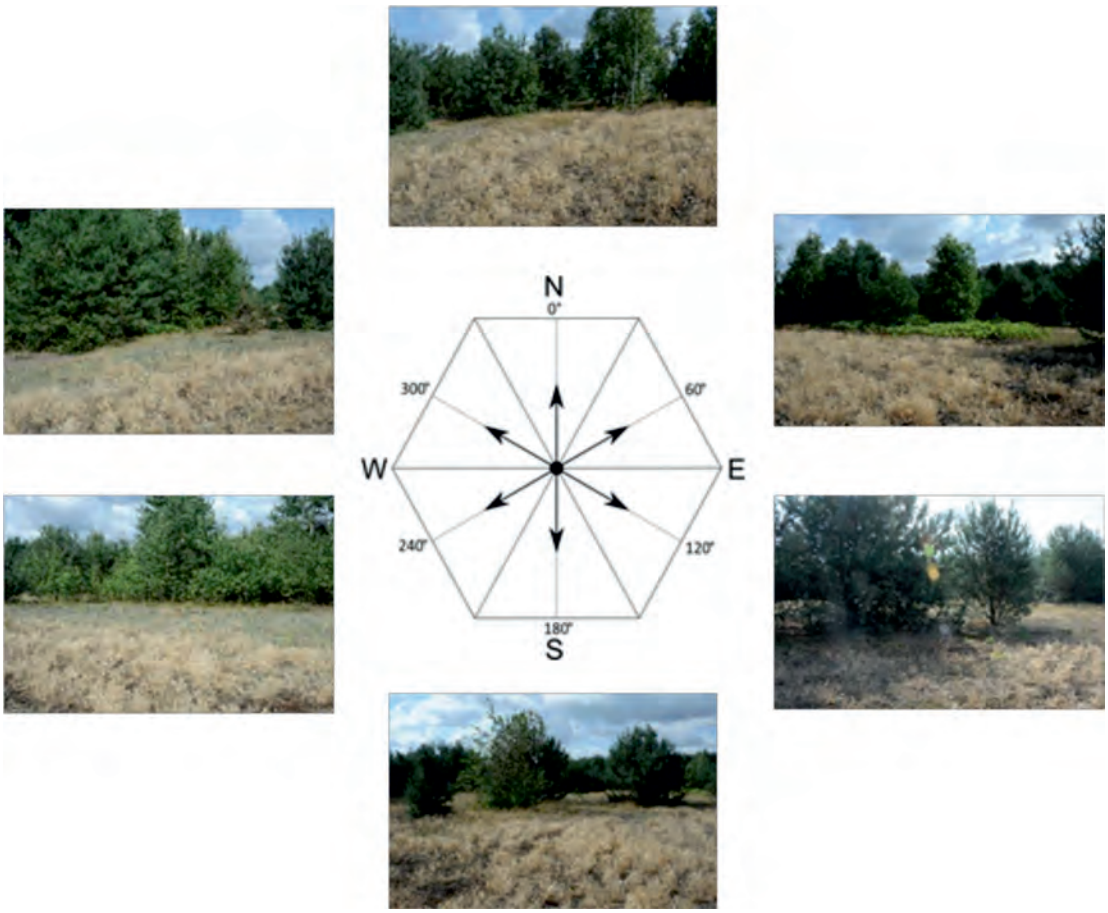


Fig. 5.7. Study plot Celestynów A (photo S. Krysiak, 2012)

Depth		Profile description
0–15 cm	–	humus, fine and medium sand with gravel and cobbles of up to 4 cm in diameter, grey
15–40 cm	–	medium and coarse sand with gravel, rusty yellow
40–60 cm	–	medium and coarse sand with single pebbles, rusty
60–110 cm	–	fine and medium sand with single pebbles, yellow

Fig. 5.8. Soil pit in study plot Celestynów A (photo S. Krysiak, 2012)

Table 5.4. Study plot Celestynów A. Granulometric and chemical properties of soil

Soil pit	Sampling depth cm	Grain size distribution %									Granulometric sub-group	Specific surface area $m^2 \cdot g^{-1}$
		2.0–1.0 mm	1.0–0.5 mm	0.5–0.25 mm	0.25–0.1 mm	0.1–0.05 mm	0.05–0.02 mm	0.02–0.005 mm	0.005–0.002 mm	<0.002 mm		
Celestynów A	0–20	5.2	38.3	37.5	10.4	2.2	2.7	2.7	0.9	0.1	pl	0.0577
Celestynów A	20–40	7.3	40.3	37.9	8.3	0.7	1.6	2.4	1.1	0.4	pl	0.0685
Celestynów A	90–110	4.3	38.1	46.3	11.4	0.0	0.0	0.0	0.0	0.0	pl	0.0148

Soil pit	Sampling depth cm	Humus %	C total %	N total %	C/N	pH in		Available nutrients mg/100g		
						KCl	H_2O	P_2O_5	K_2O	Mg
Celestynów A	0–20	1.37	0.795	0.047	16.91	4.0	4.3	2.6	0.6	0.4
Celestynów A	20–40	–	–	–	–	4.2	4.6	1.5	0.8	0.3
Celestynów A	90–110	–	–	–	–	4.3	5.0	1.2	0.3	0.2

Soil pit	Sampling depth cm	Hydrolytic acidity mmol/100 g	Exchangeable cations me/100 g				Sorption capacity me/100 g			
			Ca^{2+}	Mg^{2+}	Na^{+}	K^{+}	S	T	(T–S)	V, %
Celestynów A	0–20	3.65	ND	0.020	0.009	0.026	0.055	3.705	3.65	1.5
Celestynów A	20–40	2.43	ND	0.020	0.078	0.026	0.124	2.554	2.43	4.9
Celestynów A	90–110	1.14	ND	0.015	0.009	0.005	0.029	1.169	1.14	2.5

Source: own elaboration.

Characteristics of the flora and fungi – Celestynów A

Approximately 100% of the study plot is covered with plants. Poor in species of vascular plants (10). One species dominates: *Corynephorus canescens*, covering about 70% of the area. A much lower share (3–0.5%) occurs of such species as: *Agrostis capillaris*, *Hieracium pilosella*, *Rumex acetosella*, *Solidago canadensis* and saplings of trees: *Pinus sylvestris*, *Quercus robur* and *Padus serotina* (Tab. 6.1). One species of moss was also identified: *Polytrichum piliferum*, which covered a small portion of the area (about 1%).

Fungi of the plot are not numerous. They are represented by 11 species of macromycetes. None of them was abundant. The identified species include: *Amanita muscaria*, *Bovista plumbea*, *Lycoperdon nigrescens* and others (Tab. 7.1).

STUDY PLOT CELESTYNÓW B (51°26'193N, 20°04'463E, elevation 206 m a.s.l.)

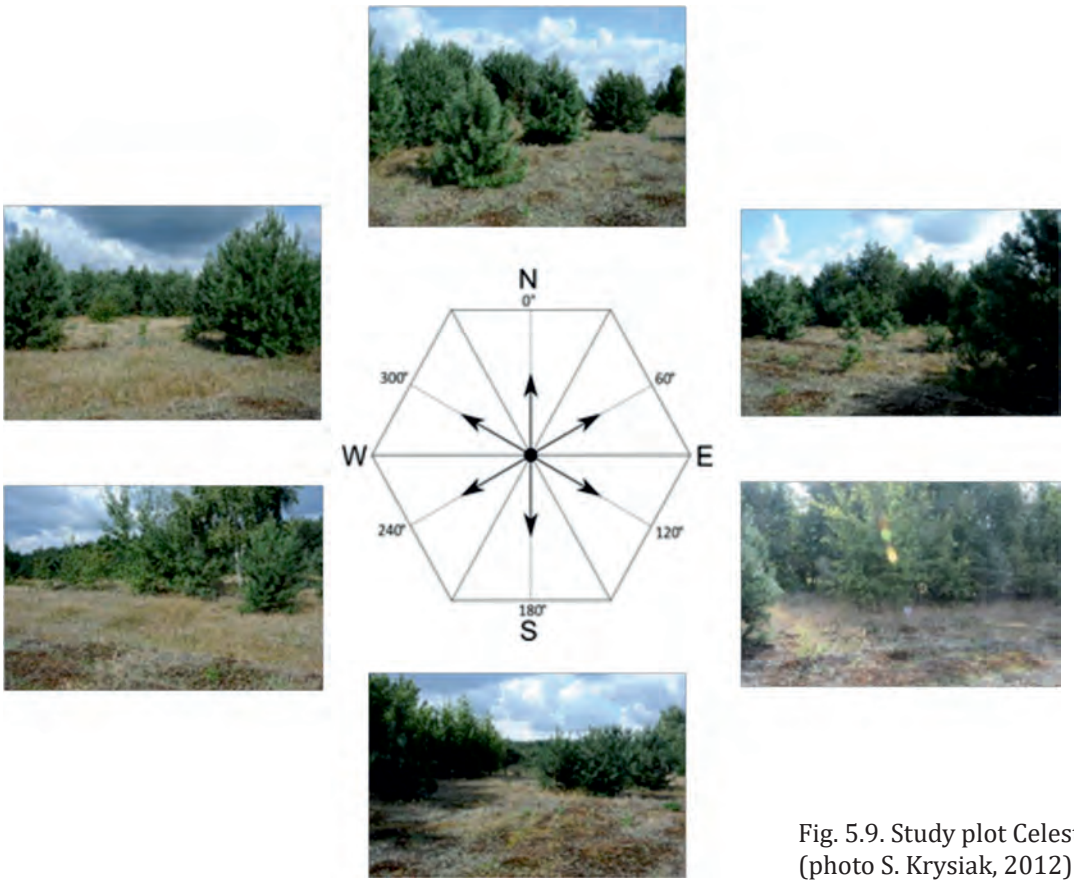


Fig. 5.9. Study plot Celestynów B (photo S. Krysiak, 2012)

Depth		Profile description
0–20 cm	–	humus, fine and silty sand, grey
20–40 cm	–	medium and fine sand with cobbles of Scandinavian origin, grey
40–70 cm	–	medium sand with cobbles on the bottom, yellow
70–110 cm	–	medium sand with gravel, rusty

Fig. 5.10. Soil pit in study plot Celestynów B (photo S. Krysiak, 2012)

Table 5.5. Study plot Celestynów B. Granulometric and chemical properties of soil

Soil pit	Sampling depth cm	Grain size distribution %									Granulometric sub-group	Specific surface area $m^2 \cdot g^{-1}$
		2.0–1.0 mm	1.0–0.5 mm	0.5–0.25 mm	0.25–0.1 mm	0.1–0.05 mm	0.05–0.02 mm	0.02–0.005 mm	0.005–0.002 mm	<0.002 mm		
Celestynów B	0–20	2.3	27.7	37.6	19.0	4.3	4.0	3.4	1.2	0.6	pl	0.1000
Celestynów B	20–40	1.6	27.3	41.7	19.5	2.0	2.3	3.1	1.6	0.9	pl	0.1170
Celestynów B	90–110	0.1	31.7	54.1	9.0	0.5	0.9	1.9	1.2	0.5	pl	0.0763

Soil pit	Sampling depth cm	Humus %	C total %	N total %	C/N	pH in		Available nutrients mg/100g		
						KCl	H_2O	P_2O_5	K_2O	Mg
Celestynów B	0–20	1.42	0.824	0.051	16.16	4.1	4.6	2.2	0.3	0.3
Celestynów B	20–40	–	–	–	–	4.5	4.8	2.7	0.3	0.2
Celestynów B	90–110	–	–	–	–	4.2	4.6	1.0	0.6	0.3

Soil pit	Sampling depth cm	Hydrolytic acidity mmol/100 g	Exchangeable cations me/100 g				Sorption capacity me/100 g			
			Ca^{2+}	Mg^{2+}	Na^{+}	K^{+}	S	T	(T–S)	V, %
Celestynów B	0–20	3.80	0.10	0.018	0.017	0.018	0.153	3.953	3.80	3.9
Celestynów B	20–40	1.52	0.10	0.013	0.009	0.013	0.135	1.655	1.52	8.2
Celestynów B	90–110	1.92	0.10	0.015	0.009	0.013	0.137	2.057	1.92	6.7

Source: own elaboration.

Characteristics of the flora and fungi – Celestynów B

Approximately 70% of the plot area is covered with plants. Poor in species of vascular plants (8). One species dominates: *Hieracium pilosella*, covering about 50% of the area. Species occurring with a lower share: *Agrostis capillaris* (about 10%) and *Jasione montana* (about 3%). They are accompanied in slight quantities by e.g.: *Achillea millefilium*, *Anthoxathum odoratum*, *Holcus mollis* (Tab. 6.1). The occurrence of one species of moss was also identified: *Polytrichum piliferum*, which covered a large portion of the area (about 70%).

Fungi of the plot are sparse. They are represented by 7 species of macromycetes, of which the only abundant species were gasteroid fungi, e.g. *Calvatia excipuliformis*, *Vascellum pratense* (Tab. 7.1).

STUDY PLOT CELESTYNÓW C (51°26'138N, 20°04'547E, elevation 206 m a.s.l.)

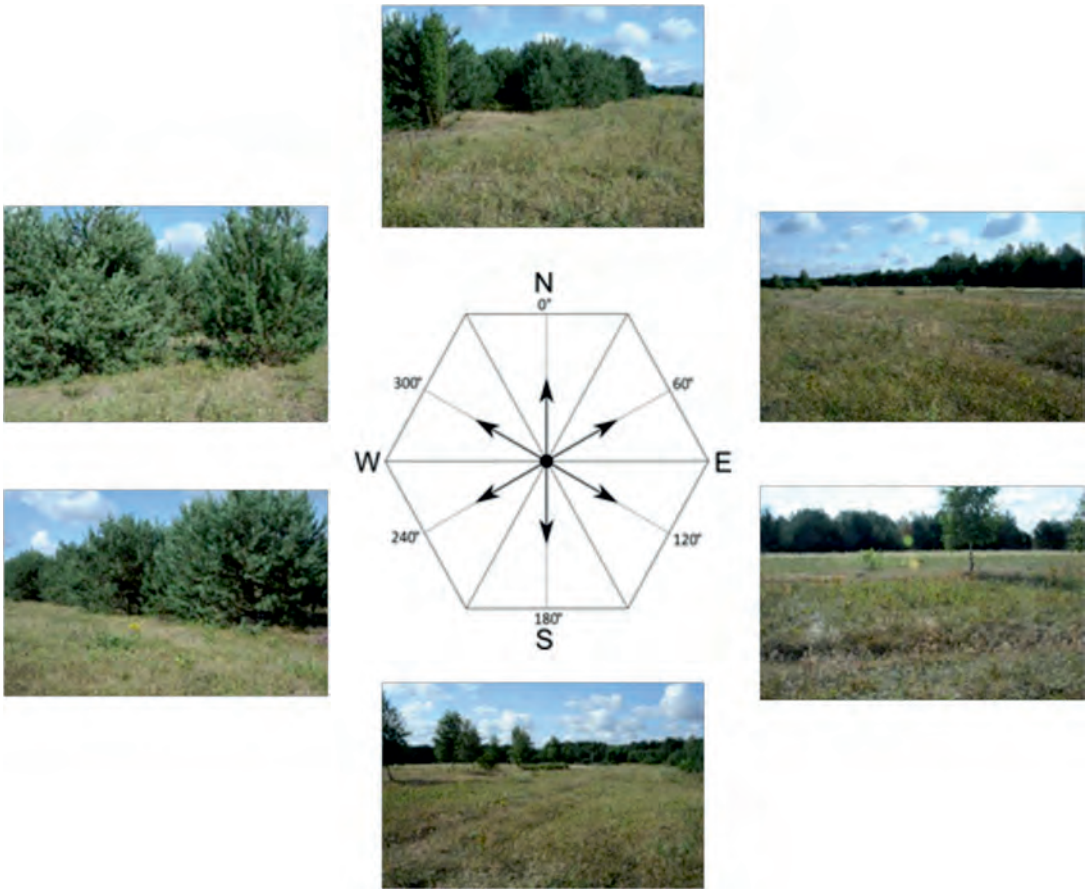


Fig. 5.11. Study plot Celestynów C (photo S. Krysiak, 2012)

Depth		Profile description
0–20 cm	–	humus, fine and silty sand with cobbles, grey
20–45 cm	–	medium and fine sand with numerous cobbles of Scandinavian origin with diameters of up to 10 cm, greyish yellow
45–70 cm	–	medium and fine sands, light beige
70–110 cm	–	fine and medium sands with single pebbles, light beige

Fig. 5.12. Soil pit in study plot Celestynów C (photo S. Krysiak, 2012)

Table 5.6. Study plot Celestynów C. Granulometric and chemical properties of soil

Soil pit	Sampling depth cm	Grain size distribution %									Granulometric subgroup	Specific surface area $m^2 \cdot g^{-1}$
		2.0–1.0 mm	1.0–0.5 mm	0.5–0.25 mm	0.25–0.1 mm	0.1–0.05 mm	0.05–0.02 mm	0.02–0.005 mm	0.005–0.002 mm	<0.002 mm		
Celestynów C	0–20	1.6	25.2	36.6	19.2	6.5	5.9	3.5	1.0	0.5	pl	0.0966
Celestynów C	20–40	2.8	26.2	37.2	21.0	4.0	3.4	3.1	1.3	0.9	pl	0.1200
Celestynów C	90–110	4.4	28.8	42.1	17.6	0.3	1.9	2.5	1.6	0.8	pl	0.1070

Soil pit	Sampling depth cm	Humus %	C total %	N total %	C/N	pH in		Available nutrients mg/100g		
						KCl	H_2O	P_2O_5	K_2O	Mg
Celestynów C	0–20	1.77	1.027	0.076	13.51	5.5	6.3	14.3	1.3	2.2
Celestynów C	20–40	–	–	–	–	5.1	6.3	2.5	2.1	1.5
Celestynów C	90–110	–	–	–	–	4.3	5.3	1.3	1.1	1.8

Soil pit	Sampling depth cm	Hydrolytic acidity mmol/100 g	Exchangeable cations me/100 g				Sorption capacity me/100 g			
			Ca^{2+}	Mg^{2+}	Na^{+}	K^{+}	S	T	(T–S)	V, %
Celestynów C	0–20	1.90	2.60	0.200	0.052	0.044	2.896	4.796	1.90	60.4
Celestynów C	20–40	1.46	1.10	0.123	0.026	0.062	1.311	2.771	1.46	47.3
Celestynów C	90–110	1.18	0.50	0.152	0.009	0.031	0.692	1.872	1.18	37.0

Source: own elaboration.

Characteristics of the flora and fungi – Celestynów C

Approximately 100% of the study plot is covered with plants. A large number of plant species occur here (26). Four species dominate: *Elymus repens* (about 15%), *Artemisia campestris* (about 15%), *Agrostis capillaris* (about 10%) and *Hieracium pilosella* (about 10%). Species with a larger coverage (5–7%) include: *Artemisia vulgaris*, *Corynephorus canescens*, *Festuca ovina*, *F. rubra*. The share of other species does not exceed 2–0.5% of the area coverage (Tab. 6.1).

Fungi of the plot are abundant. 18 species of macromycetes were identified, of which the most frequently fruiting ones were: *Conocybe tenera*, *Leccinum scabrum* and *Suillus bovinus* (Tab. 7.1).

Analysis of granulometric composition and chemical properties of soils in the Celestynów study plot group

The sandy fraction dominates the three analysed plots – Celestynów A, B and C. All the analysed samples were qualified granulometrically with the subgroup of loose sands (pl) with low values of specific surface area, ranging from 0.12 to 0.0148 m^2g^{-1}. At all sites, the 0–20 cm deep series had a slightly larger share of the silty fraction than the lower horizon. The increased share of silt indicates the periglacial origin of the 0–20 cm series. The minimum value of specific surface area – 0.0148 m^2g^{-1}, was found in a sample taken at plot Celestynów A at the depth of 90–110 cm, and was completely devoid of the silty and clayey fractions. Lack of these fractions, or their scantiness at the depth of 90–110 cm at plot Celestynów B confirms the fluvioglacial character of the underlying series. Sediments at plot Celestynów C, despite their qualification as the granulometric subgroup of loose sand, reveal slightly more favourable agrophysical properties due to a larger share of the silty and clayey fractions.

As regards agronomic classification, the granulometric composition of the analysed sediments qualify them as soils of category I (very light soils). The permeable character of fluvioglacial deposits results in the occurrence of the precipitation-retention type of water balance with the possibility of frequent shortages of moisture in the soil.

The pH reaction in KCl and H_2O at sites Celestynów A and B is very acidic. At the same time, sediments from these sites show a very low content of available phosphorus (P_2O_5), potassium (K_2O) and magnesium (Mg) with insignificant presence of alkaline cations. The more favourable agrochemical properties of the sediments at site Celestynów C are confirmed by a higher reaction, a higher content of available phosphorus, potassium and magnesium and a larger share of alkaline cations Ca^{2+}, Mg^{2+}, Na^{+} and K^{+}, expressed by a high degree of saturation of the sorptive complex (V).

SULEJÓW STUDY PLOT GROUP

The Sulejów study plot group is located several hundred metres from the borders of the Sulejów Landscape Park, within the limits of Sulejów. It lies within a belt of land surrounded by forests. Currently, inside areas which were once used agriculturally, there are abandoned lands at different stages of secondary succession and strips of young stands of pine and birch. According to the Detailed Geological Map of Poland, sheet Sulejów (702) (Brzeziński 1990), the surface sediments at site Sulejów A should be aeolian sands upon periglacial sands and muds, whereas at sites Sulejów B and Sulejów C – Vistulian periglacial sands and muds. The conducted field studies allow for a correction to be made for sites Sulejów A and Sulejów C, where glacial till was found underneath the cover of sandy and silty periglacial formations. The till, according to H. Brzeziński (1990), should be related to the Odranian Glaciation, whereas in the light of more recent interpretations by K. Turkowska (2006) – to the Wartanian Glaciation. The formations constitute the parent rock for sandy soils of different genetic types (AB), whose agricultural suitability was classified as poor rye complex (6) and very poor rye complex (7) (Województwo piotrkowskie. Mapa glebowo-rolnicza 1979). As regards soil valuation, the productivity of soils at plots Sulejów A and Sulejów C was qualified as class V, whereas at Sulejów B – as class VI of arable lands (http://geoportal.lodzkie.pl/imap/). Photographic documentation and results of laboratory analyses from the plots of the Sulejów study area are presented in figures 5.13–5.17, and in tables 5.7–5.9.

STUDY PLOT SULEJÓW A (51°21'039N, 19°54'847E, elevation 199 m a.s.l.)

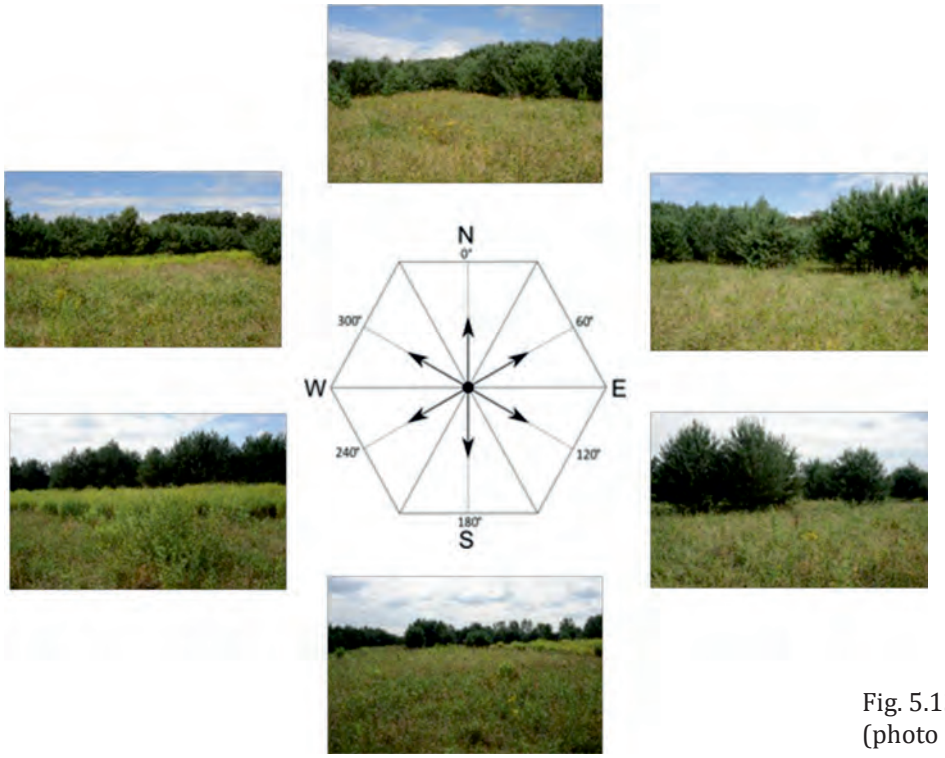


Fig. 5.13. Study plot Sulejów A (photo S. Krysiak, 2012)

Depth		Profile description
0–30 cm	–	humus, silty sand and compact silt, grey
30–60 cm	–	silty sand and silt with some fine sand, light beige
60–90 cm	–	fine and medium sand, beige with rusty stains
90–110 cm	–	medium and coarse sand, rusty
110–140 cm	–	loamy sand turning into sandy loam, rusty brown

Table 5.7. Study plot Sulejów A. Granulometric and chemical properties of soil

Soil pit	Sampling depth cm	Grain size distribution %									Granulometric sub-group	Specific surface area $m^2 \cdot g^{-1}$
		2.0–1.0 mm	1.0–0,5 mm	0.5–0.25 mm	0.25–0.1 mm	0.1–0.05 mm	0.05–0.02 mm	0.02–0.005 mm	0.005–0.002 mm	<0.002 mm		
Sulejów A	0–20	0.1	16.7	32.7	18.3	9.1	13.5	6.9	1.5	1.2	pg	0.1920
Sulejów A	20–40	0.1	17.8	35.7	19.4	6.6	10.0	6.4	2.2	1.7	pg	0.2230
Sulejów A	90–110	5.0	37.4	40.2	12.4	0.7	1.3	1.7	0.9	0.4	pl	0.0647
Sulejów A	130–140	0.4	15.3	25.9	21.8	7.3	6.0	10.6	7.3	5.3	gp	0.5730

Soil pit	Sampling depth cm	Humus %	C total %	N total %	C/N	pH in		Available nutrients mg/100g		
						KCl	H_2O	P_2O_5	K_2O	Mg
Sulejów A	0–20	1.98	1.148	0.092	12.48	5.0	5.8	4.0	4.3	2.2
Sulejów A	20–40	–	–	–	–	4.3	6.3	2.4	1.1	1.3
Sulejów A	90–110	–	–	–	–	5.3	6.4	1.2	2.6	0.8
Sulejów A	130–140	–	–	–	–	5.2	6.6	2.9	2.9	5.9

Soil pit	Sampling depth cm	Hydrolytic acidity mmol/100g	Exchangeable cations me/100 g				Sorption capacity me/100 g			
			Ca^{2+}	Mg^{2+}	Na^{+}	K^{+}	S	T	(T–S)	V, %
Sulejów A	0–20	2.86	2.30	0.187	0.052	0.115	2.654	5.514	2.86	48.1
Sulejów A	20–40	1.29	1.70	0.110	0.345	0.044	2.199	3.489	1.29	63.0
Sulejów A	90–110	0.55	0.80	0.065	0.017	0.062	0.944	1.494	0.55	63.2
Sulejów A	130–140	0.82	4.00	0.568	0.096	0.092	4.756	5.576	0.82	85.3

Source: own elaboration.

Characteristics of the flora and fungi – Sulejów A

Approximately 80% of the study plot is covered with plants. A large number of plant species occur here (29). Three species dominate: *Elymus repens* (about 20%), *Senecio jacobea* (10%) and *Solidago canadensis* (Photo 6.1). The other species, which cover from 3–0.5% include: *Achillea millefolium*, *Agrimonia eupatoria*, *Anthriscus sylvestris*, *Anthoxanthum odoratum*, *Arrthenatherum elatior*, *Calamagrostis epigeios* (Tab. 6.1). One tree species was also identified: *Salix caprea*.

Fungi of the plot consisted of only 3 species of macromycetes. The most frequent one was *Inocybe asterospora* (Tab. 7.1).

STUDY PLOT SULEJÓW B (51°21'054N, 19°54'886E, elevation 198 m a.s.l.)

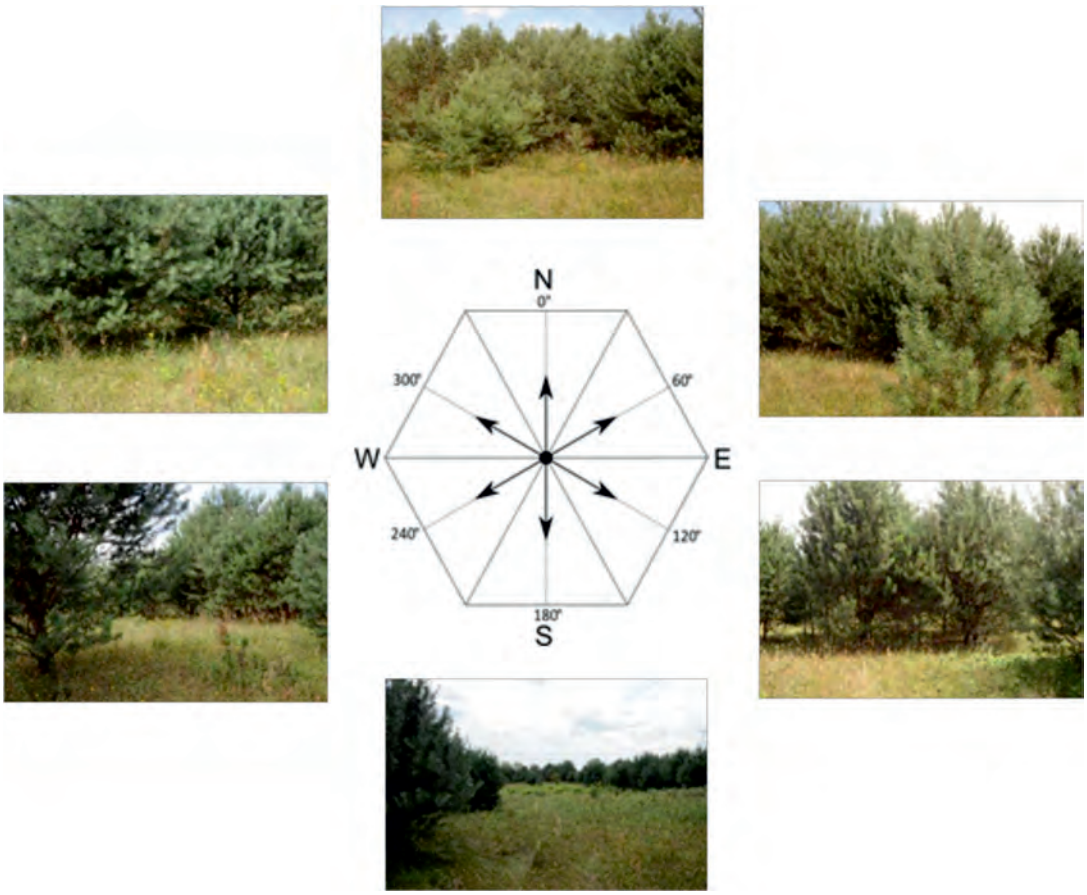


Fig. 5.14. Study plot Sulejów B (photo S. Krysiak, 2012)

Depth		Profile description
0–30 cm	–	humus, fine and silty sand with single cobbles of Scandinavian origin, dark brown and grey
30–60 cm	–	fine and silty sand, beige
60–90 cm	–	fine and medium sand, beige
90–110 cm	–	medium and coarse sand with gravel of 2 to 4 mm in diameter, beige with rusty stains

Fig. 5.15. Soil pit in study plot Sulejów B (photo S. Krysiak, 2012)

Table 5.8. Study plot Sulejów B. Granulometric and chemical properties of soil

Soil pit	Sampling depth cm	Grain size distribution %									Granulometric sub-group	Specific surface area $m^2 \cdot g^{-1}$
		2.0–1.0 mm	1.0–0,5 mm	0.5–0.25 mm	0.25–0.1 mm	0.1–0.05 mm	0.05–0.02 mm	0.02–0.005 mm	0.005–0.002 mm	<0.002 mm		
Sulejów B	0–20	0.1	16.7	36.7	21.3	7.1	9.9	5.5	1.5	1.1	ps	0.1690
Sulejów B	20–40	0.0	13.0	34.1	20.3	7.6	12.4	7.8	2.6	2.2	pg	0.2760
Sulejów B	90–110	0.8	32.1	46.7	16.2	0.7	1.1	1.1	0.9	0.5	pl	0.0629

Soil pit	Sampling depth cm	Humus %	C total %	N total %	C/N	pH in		Available nutrients mg/100g		
						KCl	H_2O	P_2O_5	K_2O	Mg
Sulejów B	0–20	1.49	0.864	0.073	11.84	4.4	5.4	7.6	5.8	1.2
Sulejów B	20–40	–	–	–	–	4.9	6.1	1.2	4.2	0.8
Sulejów B	90–110	–	–	–	–	5.2	6.4	1.0	2.4	0.8

Soil pit	Sampling depth cm	Hydrolytic acidity mmol/100g	Exchangeable cations me/100 g				Sorption capacity me/100 g			
			Ca^{2+}	Mg^{2+}	Na^{+}	K^{+}	S	T	(T–S)	V, %
Sulejów B	0–20	7.25	1.10	0.107	0.026	0.159	1.392	8.642	7.25	16.1
Sulejów B	20–40	1.12	0.80	0.065	0.017	0.120	1.002	2.122	1.12	47.2
Sulejów B	90–110	0.42	0.60	0.057	0.017	0.061	0.735	1.155	0.42	63.6

Source: own elaboration.

Characteristics of the flora and fungi – Sulejów B

Approximately 50% of the study plot is covered with plants. A small number of plant species occur here (9). Three species dominate: *Rumex acetosa* (about 20%), *Stachys arvensis* (10%) and *Rubus sp*. Other species, covering from 1–0.5%, include: *Melandrium album*, *Artemisia campestris*, *Chelichrysum arenaria* (Tab. 6.1).

Fungi of the plot are sparse. Only 6 species of macromycetes were found here, of which the most abundant were *Bovista plumbea* and *Marasmius oreades* (Tab. 7.1).

STUDY PLOT SULEJÓW C (51°21'015N, 19°54'933E, elevation 193 m a.s.l.)

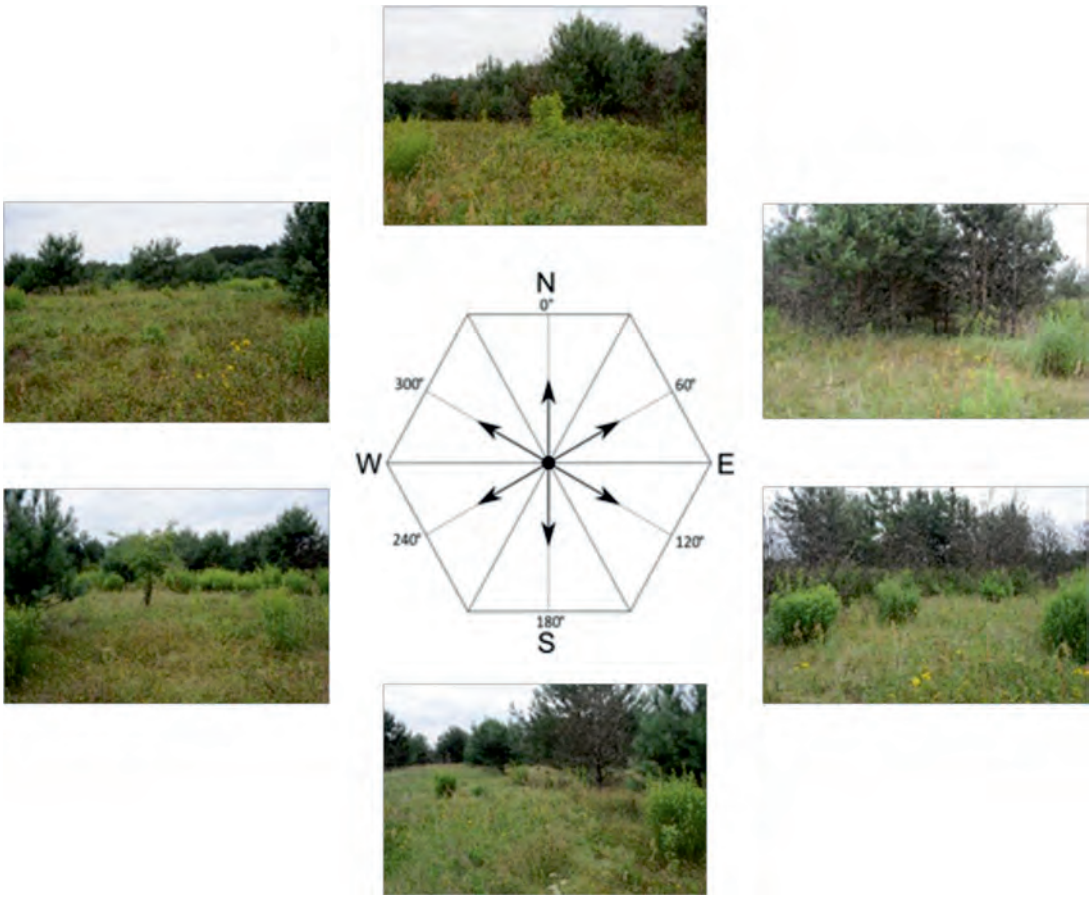


Fig. 5.16. Study plot Sulejów C (photo S. Krysiak, 2012)

Depth		Profile description
0–25 cm	–	humus, fine and silty sand with single cobbles of Scandinavian origin, diameter of up to 10 cm, dark brown
25–60 cm	–	fine and silty sand, beige with dark grey stains
60–70 cm	–	medium sand with cobbles of Scandinavian origin, diameter from 4 to 10 cm (stone pavement horizon)
70–80 cm	–	loamy sand, brown and rusty
80–110 cm	–	sandy loam, light brown

Fig. 5.17. Soil pit in study plot Sulejów C (photo S. Krysiak, 2012)

Table 5.9. Study plot Sulejów C. Granulometric and chemical properties of soil

Soil pit	Sampling depth cm	Grain size distribution %									Granulometric sub-group	Specific surface area $m^2 \cdot g^{-1}$
		2.0–1.0 mm	1.0–0,5 mm	0.5–0.25 mm	0.25–0.1 mm	0.1–0.05 mm	0.05–0.02 mm	0.02–0.005 mm	0.005–0.002 mm	<0.002 mm		
Sulejów C	0–20	0.0	14.3	30.5	18.0	10.1	14.5	8.7	2.2	1.8	pg	0.254
Sulejów C	20–40	0.4	16.3	31.1	18.3	8.7	13.1	7.7	2.4	2.0	pg	0.266
Sulejów C	90–110	1.0	17.0	25.4	20.6	7.0	5.6	10.2	7.4	5.8	gp	0.608

Soil pit	Sampling depth cm	Humus %	C total %	N total %	C/N	pH in		Available nutrients mg/100g		
						KCl	H_2O	P_2O_5	K_2O	Mg
Sulejów C	0–20	1.94	1.125	0.094	11.97	4.6	5.5	3.9	5.5	2.7
Sulejów C	20–40	–	–	–	–	5.1	6.1	2.4	1.1	2.2
Sulejów C	90–110	–	–	–	–	4.9	6.3	2.2	3.4	8.9

Soil pit	Sampling depth cm	Hydrolytic acidity mmol/100g	Exchangeable cations me/100 g				Sorption capacity me/100 g			
			Ca^{2+}	Mg^{2+}	Na^{+}	K^{+}	S	T	(T–S)	V, %
Sulejów C	0–20	3.56	2.10	0.248	0.043	0.159	2.550	6.110	3.56	41.7
Sulejów C	20–40	1.58	1.30	0.205	0.026	0.049	1.580	3.160	1.58	50.0
Sulejów C	90–110	0.98	4.10	0.840	0.087	0.126	5.153	6.133	0.98	84.0

Source: own elaboration.

Characteristics of the flora and fungi – Sulejów C

Approximately 80% of the study plot is covered with plants; rich in plant species (30). Among plants, the largest areas are covered with grasses. Four species dominate: *Poa pratensis* (about 20%), *Rumex acetosa* (about 15%), *Dactylis glomerata* (about 10%) and *Agrostis capillaris* (about 7%). The share of other species does not exceed 1–0.5%. They include: *Achillea millefolium*, *Anthriscus sylvestris*, *Chelichrysum arenaria*, *Vicia hirsuta* (Tab. 6.1). The area also features a few saplings of *Pyrus communis*.

Fungi of the plot are represented by 9 species of macromycetes. The most frequent one is *Crinipellis scabella*, occurring on grasses, mainly on *Agrostis capillaris*, *Arrhenia lobata* and *Vascellum pratense* (Tab. 7.1).

Analysis of granulometric composition and chemical properties of soils in the Sulejów study plot group

At all the plots down to the depth of 40 cm, the content of silty and clayey fractions allowed the analysed sediments to be qualified as the granulometric subgroups of loamy sand (pg) and slightly loamy sand (ps). It is presumed that it is a Vistulian periglacial cover, underlined at plot Sulejów C with a clear stone pavement horizon, found at the depth of 60–70 cm. Additionally, in the case of plots Sulejów A and C, the water balance of the habitats is influenced by sandy loam. At plot Sulejów A, it occurs at the depth of 90 cm, at plot Sulejów C – at 130 cm.

As regards agronomic classification, the granulometric composition of the humus layer at the analysed sites qualify them to soils of category I and II (very light and light soils).

The pH reaction of most analysed series was acidic. At plots Sulejów A and Sulejów B, some individual series showed a very acidic reaction (pH in KCl < 4.5).

At the analysed plots, the content of available phosphorus (P_2O_5), potassium (K_2O) and magnesium (Mg) oscillated at a level corresponding to very low and low class of availability (class V and IV). Only at plot Sulejów C did the content of available magnesium in the series from the depth of 0–20 cm correspond to class III, whereas in loams at the depth of 90–110 cm – to class II. In the analysed series, the degree of saturation of the sorptive complex with alkaline cations Ca^{2+}, Mg^{2+}, Na^{+} and K^{+} was fairly high, ranging from 41.7% to 85.3%. Only in the sample from the depth of 0–20 cm at plot Sulejów B it was significantly lower – 16.1%.

Plots Sulejów A and Sulejów C were characterised by a considerably larger number of plant species (29 and 30) than Sulejów B, where the number was 9.

PISKORZENIEC STUDY PLOT GROUP

The Piskorzeniec study plot group is located about 1 km from the Przedbórz Landscape Park, near the eastern border of the Łódź Voivodeship, in Przedbórz Commune. The surface sediments at all three plots (Piskorzeniec A, Piskorzeniec B and Piskorzeniec C) are cover aeolian sands, deposited upon postglacial sands and gravels from the Warta Glaciation (Jurkiewicz 1962). The deposits constitute the parent rock for sandy soils of different genetic types (AB), whose agricultural suitability was classified as very poor rye complex (7) and poor and very poor grasslands (3z) (Województwo piotrkowskie. Mapa glebowo-rolnicza 1979). As regards soil valuation, the productivity of these soils was qualified as class VI of arable lands and class VI of grasslands (http://geoportal.lodzkie.pl/imap/). The sites of the Piskorzeniec study area represent young abandoned lands, several years old, not taken over by trees and shrubs yet. In their vicinity, there are some older abandoned lands with a large share of pine trees. Photographic documentation and results of laboratory analyses from the Piskorzeniec study plot group are presented in figures 5.18–5.21 and in tables 5.10–5.12.

STUDY PLOT PISKORZENIEC A (51°03’896N, 20°01’720E, elevation 239 m a.s.l.)

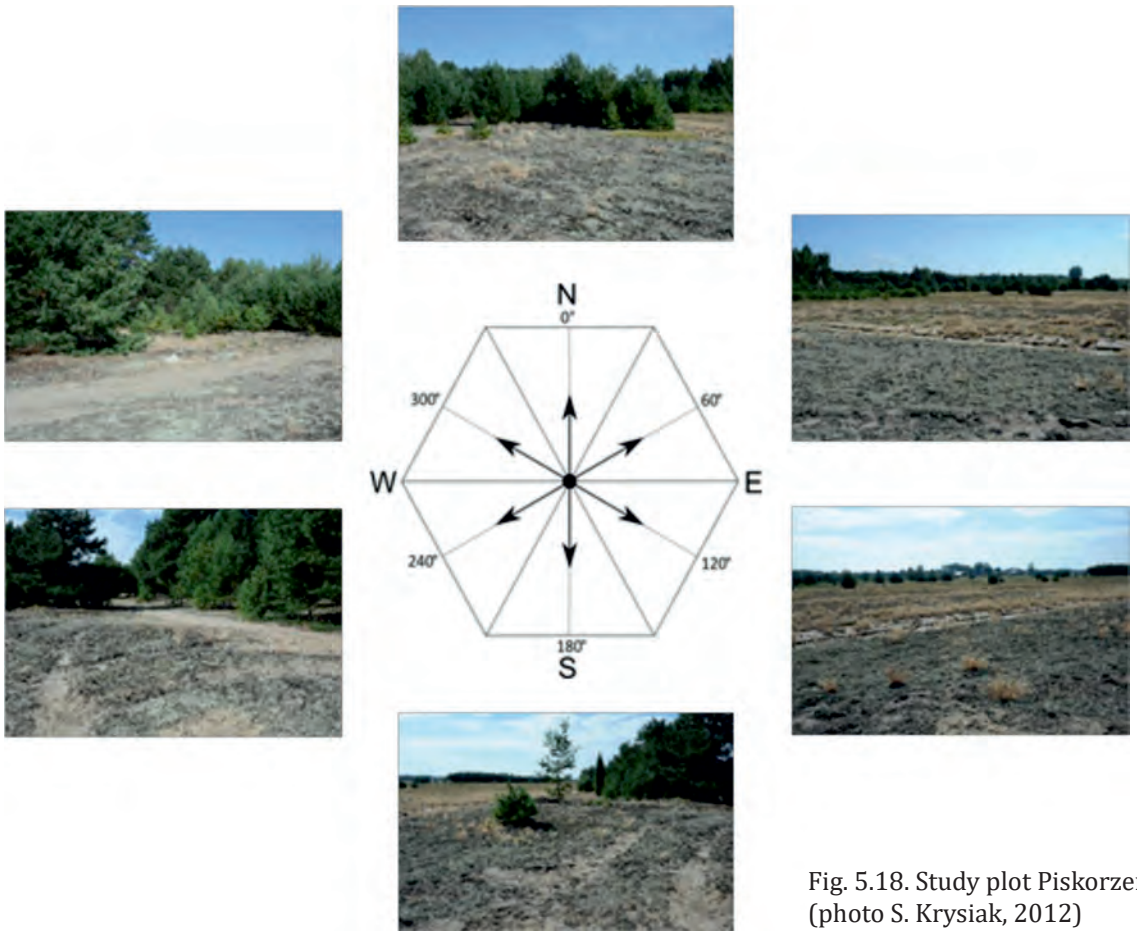


Fig. 5.18. Study plot Piskorzeniec A (photo S. Krysiak, 2012)

Depth		Profile description
0–28 cm	–	humus, fine and medium sand, grey
28–40 cm	–	fine and medium sand, rusty yellow
40–90 cm	–	fine and medium sand, yellow
90–110 cm	–	fine and medium sand, beige

Fig. 5.19. Soil pit in study plot Sulejów C (photo S. Krysiak, 2012)

Table 5.10. Study plot Piskorzeniec A. Granulometric and chemical properties of soil

Soil pit	Sampling depth cm	Grain size distribution %									Granulometric sub-group	Specific surface area $m^2 \cdot g^{-1}$
		2.0–1.0 mm	1.0–0.5 mm	0.5–0.25 mm	0.25–0.1 mm	0.1–0.05 mm	0.05–0.02 mm	0.02–0.005 mm	0.005–0.002 mm	<0.002 mm		
Piskorzeniec A	0–20	0.4	27.4	47.2	19.8	0.9	1.5	1.8	0.8	0.2	pl	0.0542
Piskorzeniec A	20–40	0.3	28.9	46.9	16.9	1.7	2.1	1.9	0.9	0.4	pl	0.0694
Piskorzeniec A	90–110	0.0	20.9	49.0	25.4	1.6	1.9	0.9	0.3	0.0	pl	0.0337

Soil pit	Sampling depth cm	Humus %	C total %	N total %	C/N	pH in		Available nutrients mg/100g		
						KCl	H_2O	P_2O_5	K_2O	Mg
Piskorzeniec A	0–20	0.64	0.371	0.020	18.55	4.2	4.9	5.0	0.5	0.3
Piskorzeniec A	20–40	–	–	–	–	4.5	4.8	2.6	0.5	0.3
Piskorzeniec A	90–110	–	–	–	–	4.6	5.0	1.9	0.4	0.2

Soil pit	Sampling depth cm	Hydrolytic acidity mmol/100g	Exchangeable cations me/100g				Sorption capacity me/100g			
			Ca^{2+}	Mg^{2+}	Na^{+}	K^{+}	S	T	(T–S)	V, %
Piskorzeniec A	0–20	2.13	0.10	0.017	0.017	0.013	0.147	2.277	2.13	6.5
Piskorzeniec A	20–40	1.68	0.05	0.017	0.009	0.013	0.089	1.769	1.68	5.0
Piskorzeniec A	90–110	1.07	ND	0.017	0.017	0.005	0.039	1.109	1.07	3.5

Source: own elaboration.

Characteristics of the flora and fungi – Piskorzeniec A

Approximately 7% of the study plot is covered with plants. Very poor in species of vascular plants (2). The plot is dominated by lichens, of which the most abundant is *Cladonia arbuscula*, which covers about 50%. It is accompanied by *Cladonia rangiferina* and *Cladonia coccifera*, which cover about 20% of the area. Among the lichens, there are small tufts of *Corynephorus canescens* and a few specimens of *Arnoseris minima* (Tab. 6.1).

Fungi of the plot are very sparse. They are represented by only 2 species of macromycetes: *Bovista plumbea* and *Lycoperdon nigrescens*. Several isolated sporocarps of these species occurred in the area (Tab. 7.1).

STUDY PLOT PISKORZENIEC B (51°03'881N, 20°01'729E, elevation 239 m a.s.l.)

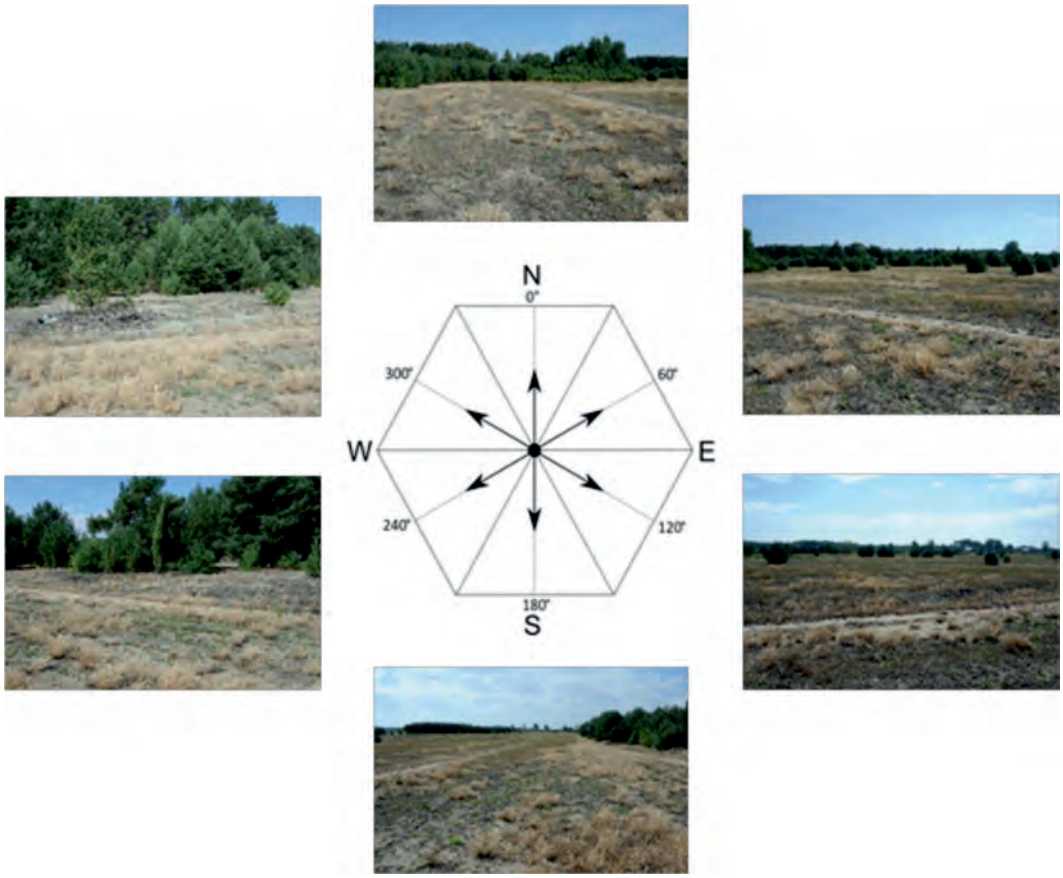


Fig. 5.20. Study plot Piskorzeniec B (photo S. Krysiak, 2012)

Depth		Profile description
0–28 cm	–	humus, fine and medium sand, grey
28–40 cm	–	fine and medium sand, rusty yellow
40–90 cm	–	fine and medium sand, yellow
90–110 cm	–	fine and medium sand, beige

Table 5.11. Study plot Piskorzeniec B. Granulometric and chemical properties of soil

Soil pit	Sampling depth cm	Grain size distribution %									Granulometric sub-group	Specific surface area $m^2 \cdot g^{-1}$
		2.0–1.0 mm	1.0–0.5 mm	0.5–0.25 mm	0.25–0.1 mm	0.1–0.05 mm	0.05–0.02 mm	0.02–0.005 mm	0.005–0.002 mm	<0.002 mm		
Piskorzeniec B	0–20	0.1	22.9	45.9	22.7	2.3	3.2	2.2	0.7	0.0	pl	0.0541
Piskorzeniec B	20–40	0.0	19.9	45.9	26.1	2.2	2.5	2.0	0.9	0.4	pl	0.0747
Piskorzeniec B	90–110	0.0	18.8	52.0	26.7	0.8	1.7	0.0	0.0	0.0	pl	0.0233

Soil pit	Sampling depth cm	Humus %	C total %	N total %	C/N	pH in		Available nutrients mg/100g		
						KCl	H_2O	P_2O_5	K_2O	Mg
Piskorzeniec B	0–20	1.26	0.731	0.048	15.22	3.9	4.4	12.6	0.3	0.2
Piskorzeniec B	20–40	–	–	–	–	4.4	4.7	2.6	0.4	0.3
Piskorzeniec B	90–110	–	–	–	–	4.6	5.0	2.0	0.6	0.2

Soil pit	Sampling depth cm	Hydrolytic acidity mmol/100g	Exchangeable cations me/100g				Sorption capacity me/100g			
			Ca^{2+}	Mg^{2+}	Na^{+}	K^{+}	S	T	(T–S)	V, %
Piskorzeniec B	0–20	3.49	0.10	0.017	0.017	0.013	0.147	3.637	3.49	4.0
Piskorzeniec B	20–40	1.69	ND	0.017	0.017	0.013	0.047	1.737	1.69	2.7
Piskorzeniec B	90–110	0.99	ND	0.017	0.017	0.013	0.047	1.037	0.99	4.5

Source: own elaboration.

Characteristics of the flora and fungi – Piskorzeniec B

Approximately 10% of the study plot is covered with plants. Very poor in species of vascular plants (3). The identified species are: *Hieracium pilosella*, *Anthoxanthum aristatum* and *Spergularia rubra*. Area coverage with specimens of any of the species did not exceed 3% (Tab. 6.1).

Fungi of the plot are exceptionally sparse. They are represented by only 1 species of macromycetes: *Bovista plumbea*. Two sporocarps of this species were found in the area (Tab. 7.1).

STUDY PLOT PISKORZENIEC C (51°03'871N, 20°01'748E, elevation 239 m a.s.l.)

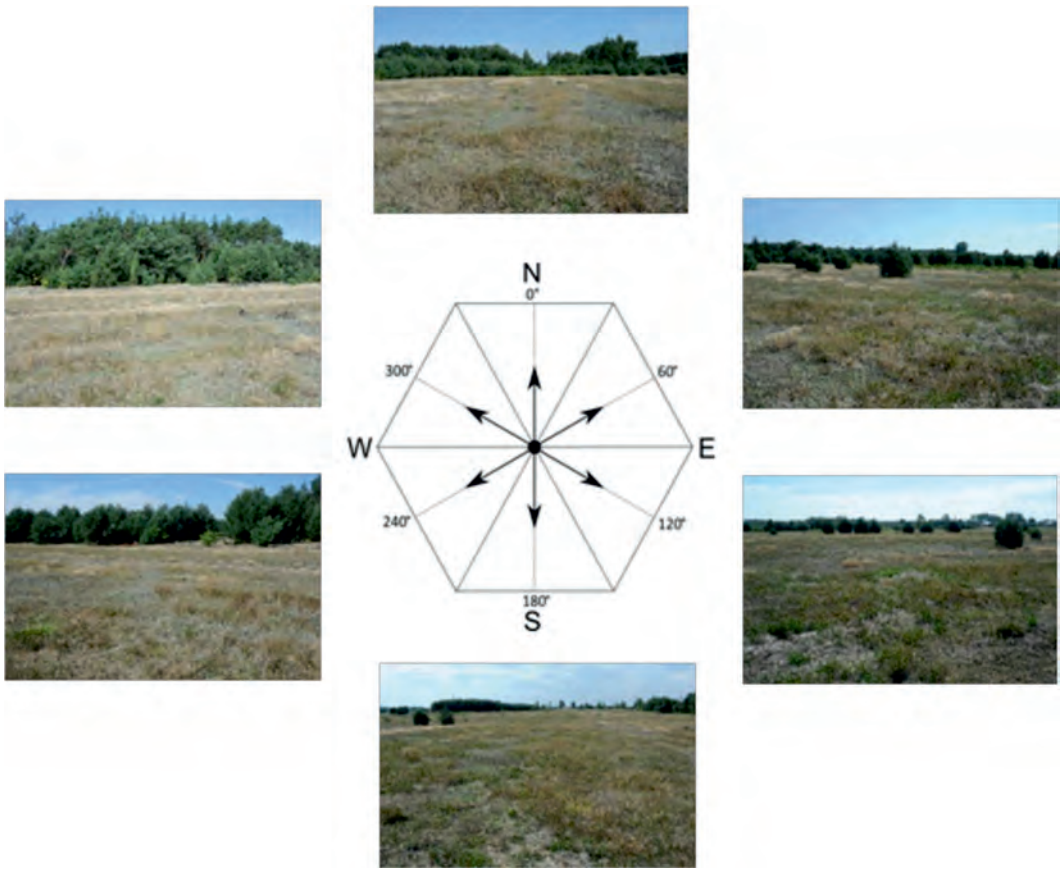


Fig. 5.21. Study plot Piskorzeniec C (photo S. Krysiak, 2012)

Depth		Profile description
0–20 cm	–	humus, fine and medium sand, light grey
20–40 cm	–	fine and medium sand, yellow
40–70 cm	–	fine and medium sand, light yellow
70–110 cm	–	fine and medium sand, rusty with grey stains

Table 5.12. Study plot Piskorzeniec C. Granulometric and chemical properties of soil

Soil pit	Sampling depth cm	Grain size distribution %									Granulometric sub-group	Specific surface area $m^2 \cdot g^{-1}$
		2.0–1.0 mm	1.0–0.5 mm	0.5–0.25 mm	0.25–0.1 mm	0.1–0.05 mm	0.05–0.02 mm	0.02–0.005 mm	0.005–0.002 mm	<0.002 mm		
Piskorzeniec C	0–20	0,0	20,1	43,8	23,3	4,4	5,1	2,6	0,7	0,0	pl	0,0600
Piskorzeniec C	20–40	0,0	20,4	47,9	26,4	1,4	1,7	1,4	0,7	0,2	pl	0,0519
Piskorzeniec C	90–110	0,0	21,4	50,0	28,2	0,4	0,0	0,0	0,0	0,0	pl	0,0204

Table 5.12. Study plot Piskorzeniec C. Granulometric and chemical properties of soil (continued)

Soil pit	Sampling depth cm	Humus %	C total %	N total %	C/N	pH in		Available nutrients mg/100g		
						KCl	H_2O	P_2O_5	K_2O	Mg
Piskorzeniec C	0–20	2.18	1.265	0.085	14.88	3.9	4.3	15.6	0.9	0.3
Piskorzeniec C	20–40	–	–	–	–	4.4	4.7	2.3	0.5	0.2
Piskorzeniec C	90–110	–	–	–	–	4.6	5.3	1.5	0.4	0.2

Soil pit	Sampling depth cm	Hydrolytic acidity mmol/100g	Exchangeable cations me/100g				Sorption capacity me/100g			
			Ca^{2+}	Mg^{2+}	Na^{+}	K^{+}	S	T	(T–S)	V, %
Piskorzeniec C	0–20	5.14	0.10	0.017	0.009	0.038	0.164	5.304	5.14	3.1
Piskorzeniec C	20–40	1.76	ND	0.017	0.009	0.018	0.044	1.804	1.76	2.4
Piskorzeniec C	90–110	0.90	ND	0.017	0.009	0.013	0.039	0.939	0.90	4.2

Source: own elaboration.

Characteristics of the flora and fungi – Piskorzeniec C

Approximately 70% of the study plot is covered with plants. Poor in species of vascular plants (9). The dominating species are: *Hieracium pilosella* (about 40%) and *Poa compressa* (about 20%). Coverage with specimens of other species did not exceed 3%. They included: *Agrostis capillaris*, *Apera spica-venti*, *Arnoseris minima*, *Carex ovalis*, and *Pinus sylvestris* (Tab. 6.1).

Fungi of the plot are sparse. They are represented with only three species of macromycetes: *Amanita muscaria*, *Bovista plumbea* and *Suillus luteus* (Tab. 7.1).

Analysis of granulometric composition and chemical properties of soils in the Piskorzeniec study plot group

The Piskorzeniec study plot group represents very poor, dry habitats related to the occurrence of cover aeolian sands. The percentage share of granulometric fractions indicates a good sorting of the sediments. At all three analysed plots: Piskorzeniec A, B and C, the dominating role is played by the sandy fraction, mainly the subfraction of medium sand, whose share in the analysed horizons ranges from 43 to 50%. Very coarse sands (1 to 2 mm) and the clayey fraction represent an insignificant share (below 0.4%). All the analysed samples were qualified as the granulometric subgroup of loose sands (pl) with low values of specific surface area, ranging from 0.0233 to 0.0747 $m^2 \cdot g^{-1}$.

As regards agronomic classification, the granulometric composition of the analysed sediments qualify them as soils of category I (very light soils).

At all analysed plots – Piskorzeniec A, B and C, samples from the depths of 0–20 cm and 20–40 cm revealed very acidic reaction, whereas below, at the depth of 90–110 cm, the reaction was acidic. At plots B and C, in the sample from the 0–10 cm horizon, medium and high content of available phosphorus (P_2O_5) was recorded, whereas in deeper horizons and along the entire profile at plot A, the content was low and very low. In all horizons at sites Piskorzeniec A, B and C, a very low content of available potassium (K_2O) and magnesium (Mg) was found. An insignificant share of alkaline cations Ca^{2+}, Mg^{2+}, Na^{+} and K^{+}, expressed by very low degree of saturation of the sorptive complex (V), ranging from 2.7 to 6.5%, confirms the low agricultural suitability of the area.

WOLA ŻYCIŃSKA STUDY PLOT GROUP

The Wola Życińska study plot group is located 6 km away from the borders of the Przedbórz Landscape Park, in Wielgomłyny Commune. The surface sediments at plots Wola Życińska A and Wola Życińska C include sands, sands with gravels and boulders, glacial and partially fluvioglacial, not separated, originated during the period of the Odranian Glaciation, whereas at plot Wola Życińska B – Odranian glacial tills (Szajn 1978). The deposits constitute the parent rock for sandy soils of various genetic types (AB), whose agricultural suitability was classified as poor rye complex (6). As regards soil valuation, productivity of soils at plot Wola Życińska A was classified as class IVb, at plots Wola Życińska B and C – as class V of arable lands (http://geoportal.lodzkie.pl/imap/). Photographic documentation and results of laboratory analyses from the plots of the Wola Życińska study area are presented in figures 5.22–5.24 and in tables 5.13–5.15.

STUDY PLOT WOLA ŻYCIŃSKA A (50°57'174N, 19°48'677E, elevation 215 m a.s.l.)

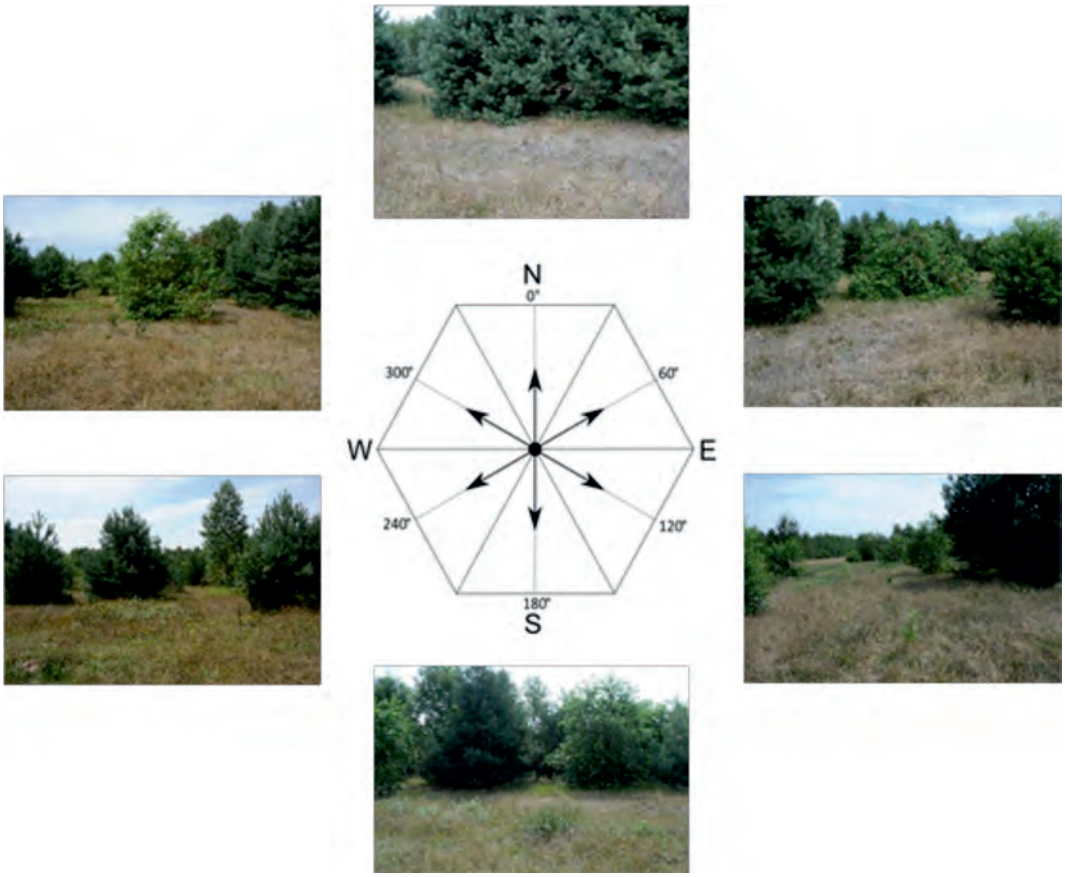


Fig. 5.22. Study plot Wola Życińska A (photo S. Krysiak, 2012)

Depth		Profile description
0–30 cm	–	humus, fine sand and silty sand with single cobbles of Scandinavian origin, light grey
30–50 cm	–	unsorted sand with some silty sand and single granules of gravel, grey and rusty
50–60 cm	–	unsorted sands with cobbles of Scandinavian and local origin with 6 to 7 cm in diameter, beige
60–90 cm	–	unsorted sands with single pebbles, yellow
90–120 cm	–	unsorted sands, rusty
120–165 cm	–	coarse and medium sands with single pebbles, rusty

Table 5.13. Study plot Wola Życińska A. Granulometric and chemical properties of soil

Soil pit	Sampling depth cm	Grain size distribution %									Granulometric sub-group	Specific surface area $m^2 \cdot g^{-1}$
		2.0–1.0 mm	1.0–0.5 mm	0.5–0.25 mm	0.25–0.1 mm	0.1–0.05 mm	0.05–0.02 mm	0.02–0.005 mm	0.005–0.002 mm	<0.002 mm		
W. Życińska A	0–20	0.5	16.7	29.3	23.7	8.4	10.2	7.6	2.1	1.5	pg	0.2150
W. Życińska A	20–40	1.7	20.8	33.3	24.0	5.8	6.3	5.2	1.7	1.2	ps	0.1670
W. Życińska A	90–110	5.1	38.7	37.5	13.9	2.2	0.4	1.2	0.8	0.2	pl	0.0473
W. Życińska A	160–165	3.5	47.3	44.4	4.8	0.0	0.0	0.0	0.0	0.0	pl	0.0130

Soil pit	Sampling depth cm	Humus %	C total %	N total %	C/N	pH in		Available nutrients mg/100g		
						KCl	H_2O	P_2O_5	K_2O	Mg
W. Życińska A	0–20	1.85	1.073	0.082	13.09	3.8	4.5	15.0	1.3	0.5
W. Życińska A	20–40	–	–	–	–	4.4	4.9	1.9	0.4	0.3
W. Życińska A	90–110	–	–	–	–	4.5	5.8	1.2	4.3	1.6
W. Życińska A	160–165	–	–	–	–	4.6	6.0	1.3	3.3	1.2

Soil pit	Sampling depth cm	Hydrolytic acidity mmol/100g	Exchangeable cations me/100g				Sorption capacity me/100g			
			Ca^{2+}	Mg^{2+}	Na^{+}	K^{+}	S	T	(T–S)	V, %
W. Życińska A	0–20	5.48	0.20	0.033	0.035	0.050	0.318	5.798	5.48	5.5
W. Życińska A	20–40	2.21	0.15	0.017	0.017	0.013	0.197	2.407	2.21	8.2
W. Życińska A	90–110	0.73	0.70	0.150	0.026	0.087	0.963	1.693	0.73	57.0
W. Życińska A	160–165	0.43	0.50	0.117	0.026	0.062	0.705	1.135	0.43	62.1

Source: own elaboration.

Characteristics of the flora and fungi – Wola Życińska A

Approximately 80% of the study plot is covered with plants. Among plants, three species dominate: *Agrostis capillaris* (about 30%), *Holcus mollis* (30%) and *Hieracium pilosella* (about 10%). The share of other species does not exceed 2–0.5% of area coverage (Tab. 6.1). The plot also features saplings of trees and shrubs: *Pyrus communis* and *Padus serotina* (Photo 6.2).

Fungi of the plot are represented by 11 species of macromycetes. The most frequently found species is *Crinipellis scabella*, which occurs on grasses, mainly on *Agrostis capillaris*. Among land fungi, the most abundant species was *Marasmius oreades*. Some sporocarps of mycorrhizal fungi were also found in the area: *Scleroderma citrina* and *Inocybe asterospora* (Tab. 7.1).

STUDY PLOT WOLA ŻYCIŃSKA B (50°57'137N, 19°48'715E, elevation 215.5 m a.s.l.)

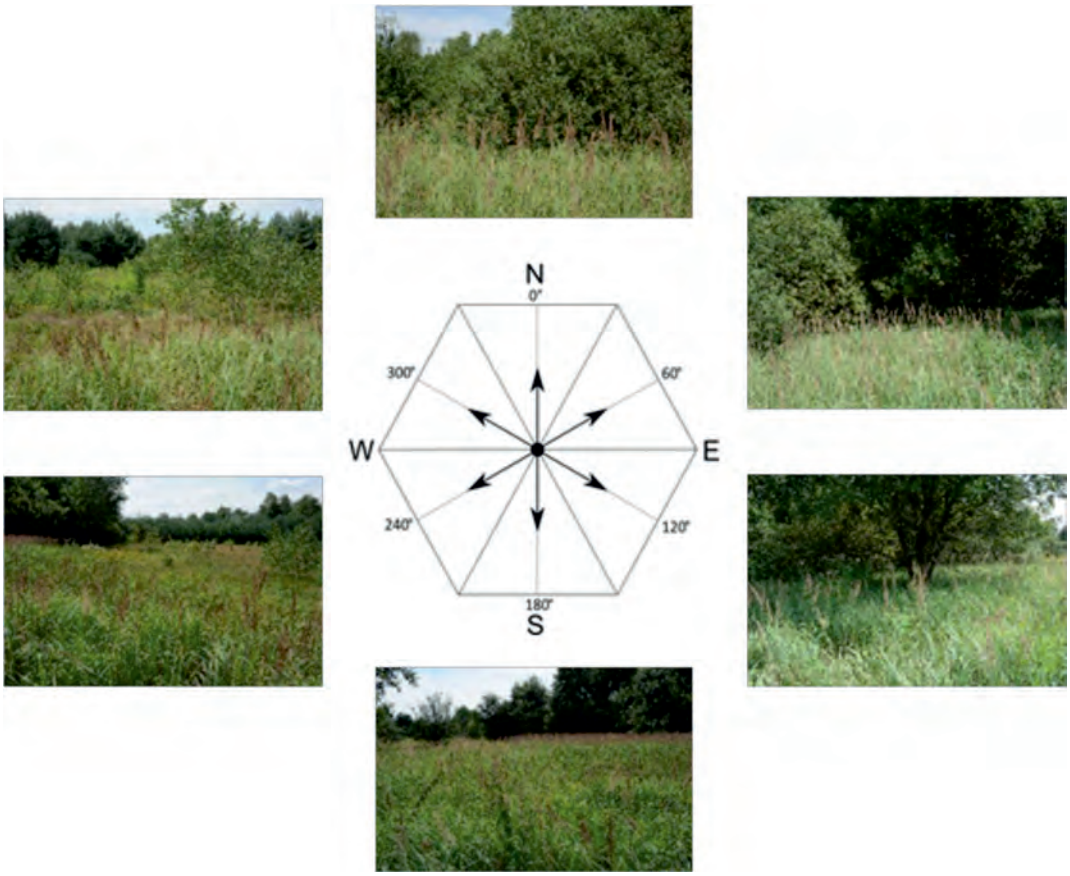


Fig. 5.23. Study plot Wola Życińska B (photo S. Krysiak, 2012)

Depth		Profile description
0–30 cm	–	humus, fine sand with some silty sand, dark brown
30–40 cm	–	sandy loam, brown and yellow
40–110 cm	–	glacial till, brown and grey

Table 5.14. Study plot Wola Życińska B. Granulometric and chemical properties of soil

Soil pit	Sampling depth cm	Grain size distribution %									Granulometric sub-group	Specific surface area $m^2 \cdot g^{-1}$
		2.0–1.0 mm	1.0–0.5 mm	0.5–0.25 mm	0.25–0.1 mm	0.1–0.05 mm	0.05–0.02 mm	0.02–0.005 mm	0.005–0.002 mm	<0.002 mm		
W. Życińska B	0–20	1.4	16.6	28.2	17.2	9.3	13.9	9.3	2.4	1.8	pg	0.258
W. Życińska B	20–40	0.0	9.8	23.2	16.8	9.8	17.9	14.5	4.7	3.3	gp	0.441
W. Życińska B	90–110	0.0	4.9	16.7	20.9	8.1	11.7	18.5	11.4	7.8	gz	0.850

Table 5.14. Study plot Wola Życińska B. Granulometric and chemical properties of soil (continued)

Soil pit	Sampling depth cm	Humus %	C total %	N total %	C/N	pH in		Available nutrients mg/100g		
						KCl	H_2O	P_2O_5	K_2O	Mg
W. Życińska B	0–20	3.15	1.827	0.162	11.28	4.6	5.4	0.2	5.4	3.2
W. Życińska B	20–40	–	–	–	–	4.6	5.5	0.2	2.9	3.0
W. Życińska B	90–110	–	–	–	–	4.0	4.9	0.7	5.1	6.2

Soil pit	Sampling depth cm	Hydrolytic acidity mmol/100g	Exchangeable cations me/100g				Sorption capacity me/100g			
			Ca^{2+}	Mg^{2+}	Na^{+}	K^{+}	S	T	(T–S)	V, %
W. Życińska B	0–20	5.10	2.80	0.300	0.070	0.164	3.334	8.434	5.10	39.5
W. Życińska B	20–40	3.30	2.10	0.283	0.070	0.102	2.555	5.555	3.30	46.0
W. Życińska B	90–110	5.61	3.30	0.633	0.087	0.164	4.184	9.794	5.61	42.7

Source: own elaboration.

Characteristics of the flora and fungi – Wola Życińska B

Approximately 100% of the study plot is covered with plants. Among plants, the dominating species is definitely *Calamagrostis epigeois*, which covers about 60% of the area. It is accompanied by the less abundant *Eupatorium cannabinum* (about 10%) and *Lysimachia vulgaris* (10%). The share of other species does not exceed 3%. They include: *Cirsium arvense*, *Hypericum perforatum*, *Equisetum arvense* (Tab. 6.1).

Fungi of the plot are sparse. Only 3 species of macromycetes were observed. Among grasses, some sporocarps of *Conocybe tenera*, *Psilocybe semiglobata* and *Psilocybe semilanceata* (Tab. 7.1) were identified.

STUDY PLOT WOLA ŻYCIŃSKA C (50°57'153N, 19°48'658E, elevation 215,5 m a.s.l.)

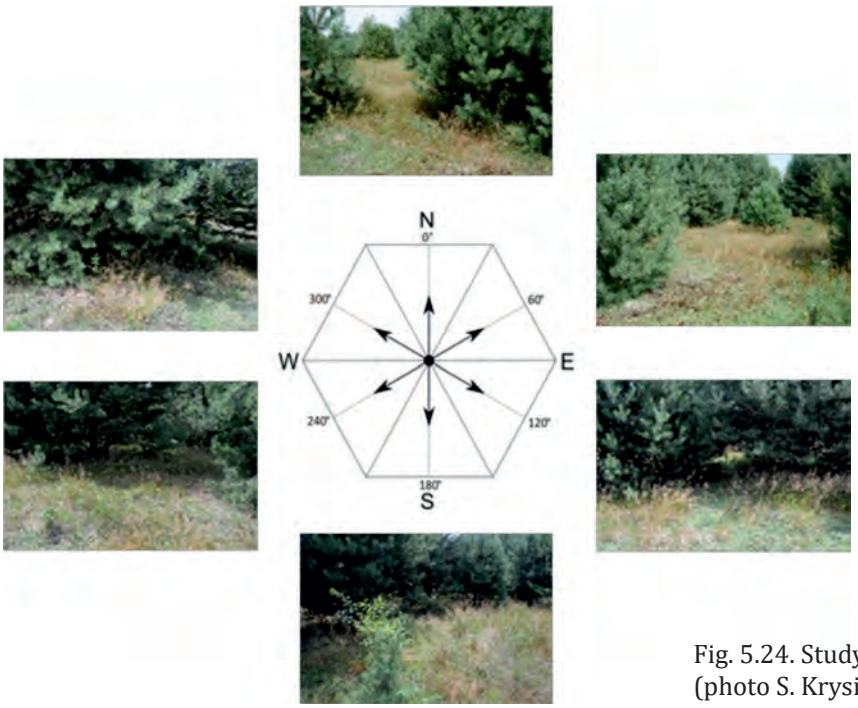


Fig. 5.24. Study plot Wola Życińska C (photo S. Krysiak, 2012)

Depth		Profile description
0–30 cm	–	humus, fine silty sand, grey and beige
30–40 cm	–	fine silty sand, yellow and beige
40–70 cm	–	fine silty sand with numerous cobbles of Scandinavian and local origin
70–90 cm	–	fine and medium sand, yellow and brown
90–110 cm	–	fine sand and silty sand with gravel of local origin, yellow

Table 5.15. Study plot Wola Życińska C. Granulometric and chemical properties of soil

Soil pit	Sampling depth cm	Grain size distribution %									Granulometric sub-group	Specific surface area $m^2 \cdot g^{-1}$
		2.0–1.0 mm	1.0–0.5 mm	0.5–0.25 mm	0.25–0.1 mm	0.1–0.05 mm	0.05–0.02 mm	0.02–0.005 mm	0.005–0.002 mm	<0.002 mm		
W. Życińska C	0–20	0.1	15.0	32.9	27.6	7.9	8.0	5.9	1.6	1.1	ps	0.168
W. Życińska C	20–40	0.4	18.9	32.5	24.6	6.4	7.1	6.3	2.2	1.5	ps	0.202
W. Życińska C	90–110	0.1	14.3	34.7	41.5	6.4	0.4	1.4	0.9	0.2	pl	0.0622
W. Życińska C	130–135	0.0	0.0	13.1	74.7	7.4	0.6	1.9	1.6	0.7	pl	0.1150

Soil pit	Sampling depth cm	Humus %	C total %	N total %	C/N	pH in		Available nutrients mg/100g		
						KCl	H_2O	P_2O_5	K_2O	Mg
W. Życińska C	0–20	1.58	0.916	0.075	12.21	4.8	5.8	9.3	2.6	0.6
W. Życińska C	20–40	–	–	–	–	4.8	5.9	1.6	1.0	0.3
W. Życińska C	90–110	–	–	–	–	4.3	5.1	1.0	0.6	0.3
W. Życińska C	130–135	–	–	–	–	4.4	5.5	1.2	1.7	1.7

Soil pit	Sampling depth cm	Hydrolytic acidity mmol/100g	Exchangeable cations me/100g				Sorption capacity me/100g			
			Ca^{2+}	Mg^{2+}	Na^{+}	K^{+}	S	T	(T–S)	V, %
W. Życińska C	0–20	2.89	2.10	0.067	0.052	0.090	2.309	5.199	2.89	44.4
W. Życińska C	20–40	1.18	0.80	0.018	0.026	0.038	0.882	2.062	1.18	42.8
W. Życińska C	90–110	1.12	0.15	0.025	0.009	0.031	0.215	1.335	1.12	16.1
W. Życińska C	130–135	0.90	0.90	0.155	0.026	0.044	1.125	2.025	0.90	55.5

Source: own elaboration.

Characteristics of the flora and fungi – Wola Życińska C

Approximately 80% of the study plot is covered with plants. Rich in species (26). Two species clearly dominate: *Hieracium pilosella* (about 50%) and *Agrostis capillaris* (about 10%). The share of other species does not exceed 1% of the area coverage. Other identified plant species include: *Achillea millefolium*, *Elymus repens*, *Agrostis gigantea*, *Apera spica-venti*, *Artemisia vulgaris*, *Convolvulus arvensis*, *Dianthus carthusiana*, *Conyza*, *Hypochoeris radicata* (Tab. 6.1). A few saplings of trees and shrubs also occur in the plot: *Quercus robur*, *Crataegus monogyna* and *Padus serotina*.

Fungi of the plot are sparse. They are represented by 7 species of macromycetes. The most frequently found one is *Crinipellis scabella*, which occurs on grasses, mainly on *Agrostis capillaris* and *Festuca rubra*. Among land fungi, the most abundant species was *Marasmius oreades*. A small number of sporocarps of mycorrhizal fungi were also found in the area: *Scleroderma citrina*, *Amanita muscaria*, *Inocybe asterospora*, *I. corydalina* and *Laccaria laccata* (Tab. 7.1).

Analysis of granulometric composition and chemical properties of soils in the Wola Życińska study plot group

At plots Wola Życińska A and Wola Życińska C a clear duality of sediments is visible. The upper part of the profile is formed by a periglacial cover series with 10–20% share of the silty fraction, thanks to which the sediments may be classified as the granulometric subgroups of loamy sand (pg) or slightly loamy sand (ps). The cover series are divided from the lower, more granulometrically diverse loose sands (pl), with a clear horizon of stone pavement with numerous cobbles of Scandinavian and local origin. At plot Wola Życińska B, the share of silty and clayey fraction increases with depth, which reveals a transition from the granulometric subgroup of loamy sand (pg) through sandy loam (gp) to loam (gz).

As regards agronomic classification, the granulometric composition of the humus layers at plots Wola Życińska A and B classify them with the category of light soils (category II). Slightly loamy sands in the humus layer of the plot Wola Życińska C classify the soil with the category of very light soils.

At all analysed plots of the Wola Życińska study plot group, the reaction was acidic or strongly acidic. A higher content of available phosphorus (P_2O_5), which corresponds to medium availability, was only found at plot Wola Życińska A. At all plots, the content of available potassium (K_2O) was at a very low or low level. As regards the content of available magnesium, the loamy sediments of plot Wola Życińska B were above the average, reaching class II in the sample from the depth of 90–110 cm, which corresponds to high availability.

In most analysed sediments, the saturation degree of the sorptive complex with alkaline cations Ca^{2+}, Mg^{2+}, Na^{+} and K^{+} oscillated around several dozen percent. Only in the cover sediments at plot Wola Życińska A did it not exceed 10%.

5.2. Abandoned land study plot groups in the buffer zone around the Sieradz landscape parks

Elżbieta Papińska, Jolanta Adamczyk, Jarosław Sieradzki

WERONIKA STUDY PLOT GROUP

The described study plot group is located about 10 km to the east of the border of the Warta–Widawka Interfluve Landscape Park. As regards administration, the described area lies in the northern part of Zelów Commune (Bełchatów District), at the border with Buczek Commune. According to the physicogeographical division by J. Kondracki (2002), the study plot group is located within the macroregion of the South Greater Poland Lowland, in the Szczerców Basin mesoregion.

Surface sediments occurring in the Weronika study plot group include upper fluvioglacial sands deposited upon Wartanian glacial till (Baliński, Gawlik 1983). They became the parent rock for the leeched brown soils, which originated here (Województwo miejskie łódzkie. Mapa glebowo-rolnicza 1986). At plot Weronika A, the thickness of sands is the highest, which was of importance for classifying the soils originated here as complex 7 of agricultural suitability (very poor rye) and valuation class VI. At plots Weronika B and C, the thickness of sandy formations is lower, which resulted in classifying them as complex 6 of agricultural suitability (poor rye) and valuation class IVb (http://geoportal.lodzkie.pl/imap/). The current usage status of the study area is abandoned land, whose "age" was estimated at 4 to 8 years (Figures 5.25, 5.27, 5.29). All plots are located within a type 16 geocomplex, formed by plateau glacial sands and gravels upon glacial till. It belongs to the group of lithogenic geocomplexes, shaped under hydrogenic conditions associated with shallow low permeable formations. In order to document individual sites of the Weronika study plot group, photographs of soil pits were taken (Figures 5.26, 5.28, 5.30), which present the diversity of soil environment, and the results of laboratory analyses were presented in tables 5.16–5.18.

STUDY PLOT WERONIKA A (51°28'5''N, 19°09'44''E, elevation 187 m a.s.l.)

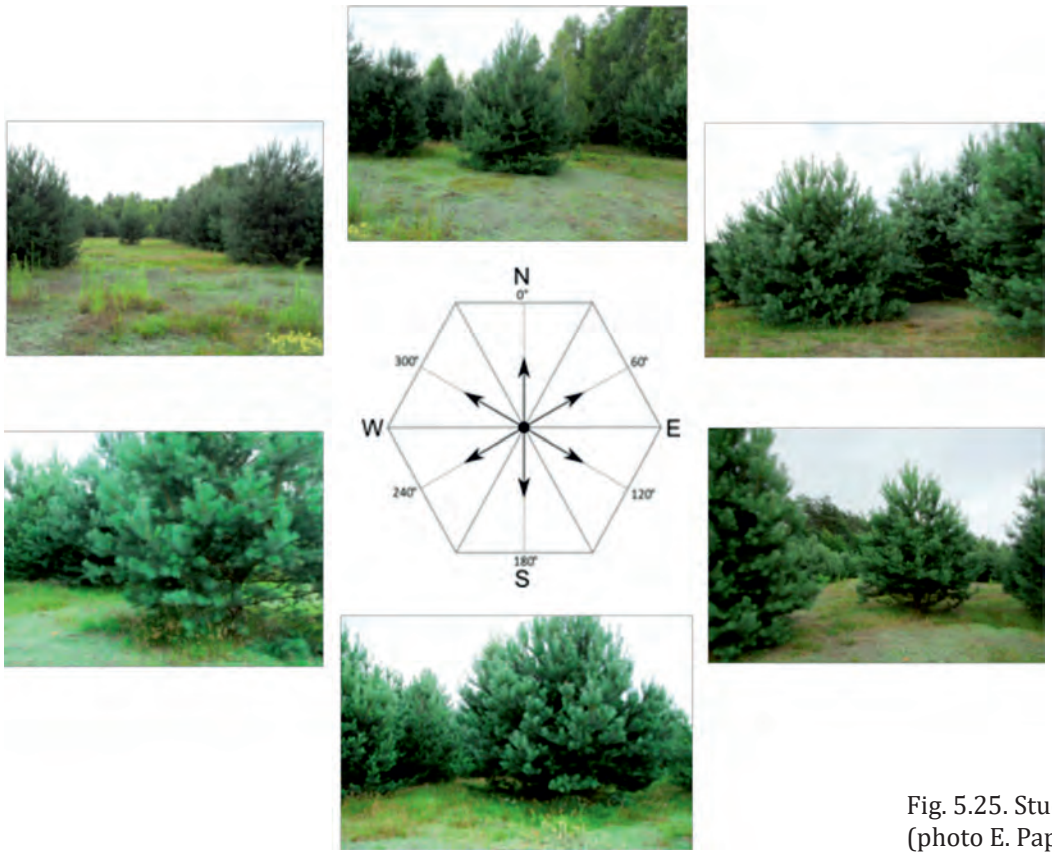


Fig. 5.25. Study plot Weronika A (photo E. Papińska, 2012)

Depth		Profile description
0,5–0 cm	–	organic horizon
0–25 cm	–	humus, coarse and medium sand, yellow
25–90 cm	–	horizon dominated by medium sand
90–100 cm	–	horizon with fine stones, rusty unsorted sand (mostly medium) with cobbles of up to 10 cm in diameter
100–110 cm	–	horizon of parent rock, unsorted sand with rusty and brown stains

Fig. 5.26. Soil pit at study plot Weronika A (photo E. Papińska 2012)

Table 5.16. Study plot Weronika A. Granulometric and chemical properties of soil

Soil pit	Sampling depth cm	Grain size distribution %									Granulometric sub-group	Specific surface area $m^2 \cdot g^{-1}$
		2.0–1.0 mm	1.0–0.5 mm	0.5–0.25 mm	0.25–0.1 mm	0.1–0.05 mm	0.05–0.02 mm	0.02–0.005 mm	0.005–0.002 mm	<0.002 mm		
Weronika A	0–20	0.2	23.2	43.0	20.6	3.4	4.3	3.4	1.2	0.6	pl	0.1020
Weronika A	20–40	0.0	21.0	48.6	27.2	1.9	1.3	0.0	0.0	0.0	pl	0.0233
Weronika A	90–110	0.3	22.9	41.5	23.2	4.1	2.7	2.8	1.5	1.0	pl	0.1270

Soil pit	Sampling depth cm	Humus %	C total %	N total %	C/N	pH in		Available nutrients mg/100g		
						KCl	H_2O	P_2O_5	K_2O	Mg
Weronika A	0–20	1.73	1.003	0.062	12.865	4.2	5.0	5.8	1.5	0.5
Weronika A	20–40	–	–	–	–	4.7	5.5	2.5	0.8	0.4
Weronika A	90–110	–	–	–	–	4.5	5.4	1.4	0.7	0.9

Soil pit	Sampling depth cm	Hydrolytic acidity mmol/100g	Exchangeable cations me/100g				Sorption capacity me/100g			
			Ca^{2+}	Mg^{2+}	Na^{+}	K^{+}	S	T	(T–S)	V, %
Weronika A	0–20	2.84	0.20	0.042	0.035	0.056	0.333	3.173	2.84	10.495
Weronika A	20–40	1.22	0.15	0.025	0.026	0.026	0.227	1.447	1.22	15.688
Weronika A	90–110	1.08	0.35	0.072	0.017	0.031	0.470	1.550	1.08	30.323

Source: own elaboration.

Characteristics of the flora and fungi – Weronika A

Approximately 100% of the study plot is covered with plants. Fairly rich in species (20). Two species dominate: *Hieracium pilosella* (about 60%) and *Chelichrysum arenaria* (about 20%) (Photo 6.3). The share of other species ranges from 3% to 0.5% of area coverage. They include: *Achillea millefolium*, *Anthoxathum aristatum*, *Apera spica-venti*, *Convolvulus arvensis*, *Dactylis glomerata*, *Elymus repens*, *Erigeron annuus*, *Euphorbia cyparissias*. The area also features some specimens of *Pinus sylvestris* (Tab. 6.1).

Fungi of the plot are represented by 13 species of macromycetes. The most frequently found ones are saprobionts: *Marasmius oreades* and *Bovista plumbea*. Mycorrhizal fungi are represented by: *Boletus edulis* and *Chalciporus piperatus* (Tab. 7.1).

STUDY PLOT WERONIKA B (51°28'36''N, 19°09'42''E, elevation 190 m a.s.l.

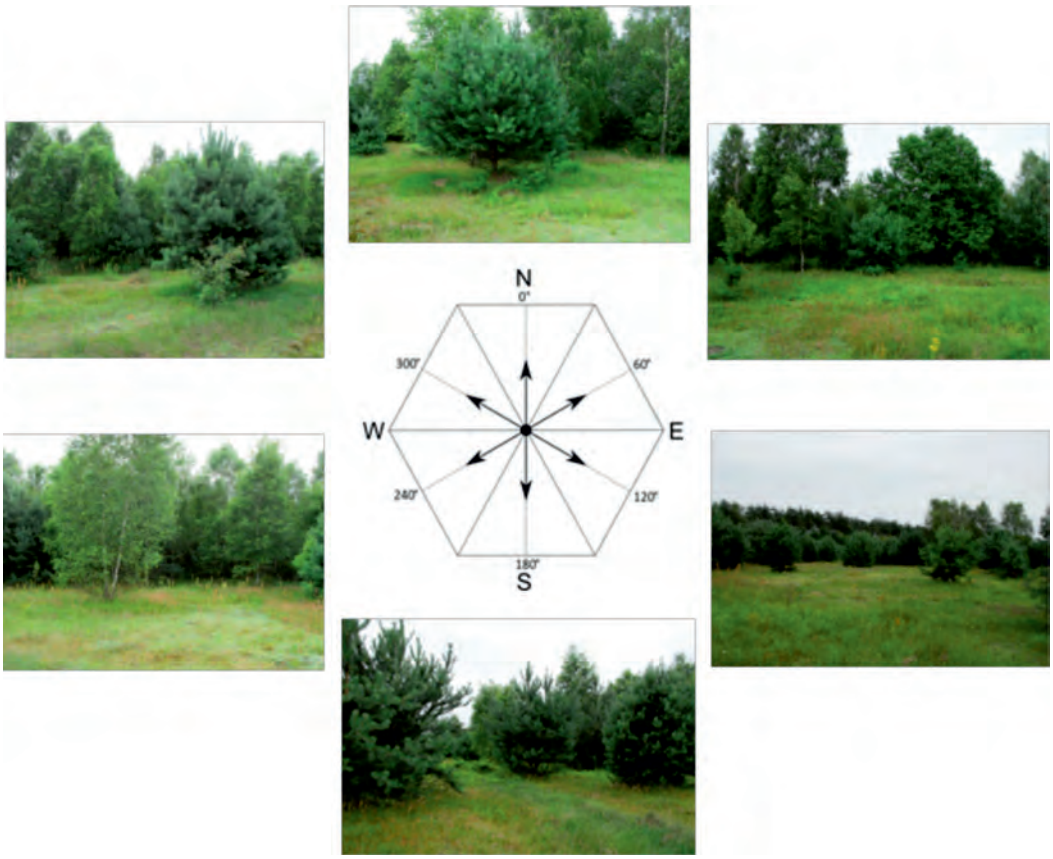


Fig. 5.27. Study plot Weronika B (photo E. Papińska, 2012)

Depth		Profile description
0,5–0 cm	–	organic horizon
0–28 cm	–	humus, transformed, deepened by agricultural use (ploughing) coarse and medium sand, rusty
28–90 cm	–	horizon with dominating medium sand and single pebbles,
90–110 cm	–	loamy sand turning into grey loam

Fig. 5.28. Soil pit in study plot Weronika B (photo. E. Papińska, 2012)

Table 5.17. Study plot Weronika B. Granulometric and chemical properties of soil

Soil pit	Sampling depth cm	Grain size distribution %									Granulometric sub-group	Specific surface area $m^2 \cdot g^{-1}$
		2.0–1.0 mm	1.0–0.5 mm	0.5–0.25 mm	0.25–0.1 mm	0.1–0.05 mm	0.05–0.02 mm	0.02–0.005 mm	0.005–0.002 mm	<0.002 mm		
Weronika B	0–20	0.2	22.4	42.1	21.0	3.6	4.5	3.9	1.4	0.9	pl	0.1280
Weronika B	20–40	0.0	19.7	48.1	28.4	2.7	1.2	0.0	0.0	0.0	pl	0.0239
Weronika B	90–110	0.3	19.0	33.2	20.9	5.0	4.3	8.0	5.4	4.0	pg	0.4280

Table 5.17. Study plot Weronika B. Granulometric and chemical properties of soil (continued)

Soil pit	Sampling depth cm	Humus %	C total %	N total %	C/N	pH in		Available nutrients mg/100g		
						KCl	H_2O	P_2O_5	K_2O	Mg
Weronika B	0–20	1.33	0.771	0.051	15.127	4.1	4.9	8.0	3.2	0.6
Weronika B	20–40	–	–	–	–	4.6	4.9	3.4	0.6	0.3
Weronika B	90–110	–	–	–	–	4.3	5.2	1.5	2.2	3.0

Soil pit	Sampling depth cm	Hydrolytic acidity mmol/100g	Exchangeable cations me/100g				Sorption capacity me/100g			
			Ca^{2+}	Mg^{2+}	Na^{+}	K^{+}	S	T	(T–S)	V, %
Weronika B	0–20	3.23	0.15	0.052	0.026	0.102	0.330	3.560	3.23	9.270
Weronika B	20–40	1.38	0.10	0.015	0.009	0.026	0.150	1.530	1.38	9.804
Weronika B	90–110	1.75	1.00	0.280	0.043	0.079	1.402	3.152	1.75	44.480

Source: own elaboration.

Characteristics of the flora and fungi – Weronika B

Approximately 80% of the study plot is covered with plants. Fairly rich in species (21). Two species dominate: *Hieracium pilosella* (about 35%) and *Agrostis capillaris* (about 20%). The share of other species ranges from 5% to 0.5% of area coverage. Other identified plant species include: *Achillea millefolium*, *Chenopodium album*, *Convolvulus arvensis*, *Dactylis glomerata*, *Euphorbia cyparissias*, *Equisetum arvense*, *Equisetum sylvaticum*. The area also features specimens of trees: *Pinus sylvesris*, *Pyrus communis*, *Sorbus aucuparia* (Tab. 6.1).

Fungi of the plot include 11 species of macromycetes. Frequently found ones include: *Bovista pumbea*, *Amanita muscaria*, *Boletus edulis*. Dead pine wood is inhabited by *Schizophyllum commune*.

STUDY PLOT WERONIKA C (51°28'34''N, 19°09'38''E, elevation 188 m a.s.l.)

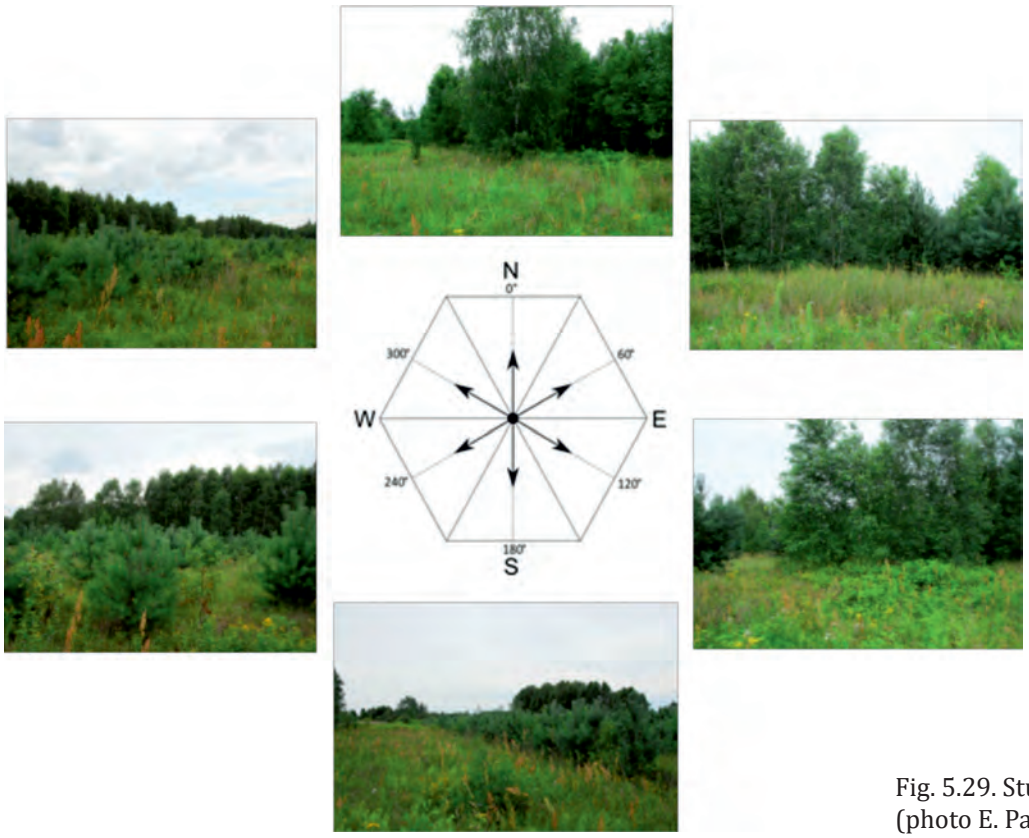


Fig. 5.29. Study plot Weronika C (photo E. Papińska, 2012)

Depth		Profile description
1–0 cm	–	organic horizon
0–37 cm	–	humus, transformed and deepened by agricultural use (ploughing)
37–75 cm	–	coarse and medium sand with dominating light grey sand
75–110 cm	–	grey loam

Fig. 5.30. Soil pit in study plot Weronika C (photo. E. Papińska, 2012)

Table 5.18. Study plot Weronika C. Granulometric and chemical properties of soil

Soil pit	Sampling depth cm	Grain size distribution %									Granulometric sub-group	Specific surface area $m^2 \cdot g^{-1}$
		2.0–1.0 mm	1.0–0.5 mm	0.5–0.25 mm	0.25–0.1 mm	0.1–0.05 mm	0.05–0.02 mm	0.02–0.005 mm	0.005–0.002 mm	<0.002 mm		
Weronika C	0–20	0.9	26.0	40.9	18.4	3.6	4.6	3.8	1.1	0.6	pl	0.103
Weronika C	20–40	1.1	24.7	40.8	21.5	2.8	2.8	3.5	1.8	1.1	pl	0.138
Weronika C	90–110	1.8	12.8	16.8	15.3	6.1	8.4	17.9	12.0	8.8	gl	0.915

Soil pit	Sampling depth cm	Humus %	C total %	N total %	C/N	pH in		Available nutrients mg/100g		
						KCl	H_2O	P_2O_5	K_2O	Mg
Weronika C	0–20	1.02	0.592	0.058	10.201	4.5	5.5	5.2	3.8	0.7
Weronika C	20–40	–	–	–	–	4.8	6.0	1.9	1.3	1.1
Weronika C	90–110	–	–	–	–	4.1	5.4	3.0	5.8	20.0

Soil pit	Sampling depth cm	Hydrolytic acidity mmol/100g	Exchangeable cations me/100g				Sorption capacity me/100g			
			Ca^{2+}	Mg^{2+}	Na^{+}	K^{+}	S	T	(T–S)	V, %
Weronika C	0–20	2.37	1.05	0.053	0.043	0.120	1.266	3.636	2.37	34.818
Weronika C	20–40	0.84	0.65	0.092	0.035	0.044	0.821	1.661	0.84	49.428
Weronika C	90–110	2.68	6.20	2.220	0.209	0.208	8.837	11.517	2.68	76.730

Source: own elaboration.

Characteristics of the flora and fungi – Weronika C

Approximately 80% of the study plot is covered with plants. Fairly rich in species (25). Two species dominate: *Agrostis capillaris* (about 20%) and *Rumex acetosa* (10%). The share of other species ranges from 7% to 0.5% of area coverage. They include: *Arrthenatherum elatius*, *Conyza canadensis*, *Dactylis glomerata*, *Cirsium arvense*, *Equisetum sylvaticum*, *Hieracium pilosella*, *Hieracium umbellatum*, *Holcus lanatus*, *Juncus effusus*. The area also features specimens of trees and shrubs: *Pinus sylvestris*, *Pyrus communis*, *Padus serotina* and *Frangula alnus* (Tab. 6.1).

Fungi of the plot are not too abundant. They are represented by 10 species of macromycetes (Photo 7.1). The frequently found species include: *Entoloma conferendum*, *Macrolepiota procera* and mycorrhizal species: *Amanita muscaria* and *Boletus edulis* (Tab. 7.1).

Analysis of granulometric composition and chemical properties of soils in the Weronika Study Plot Group

A comparison of grain size distribution results for individual plots of the Weronika study group (Tab. 5.16–5.18) clearly indicates the dominance of the sandy fraction (Polskie Towarzystwo Gleboznawcze 2009) in all horizons at plot Weronika A and in two horizons (0–20 cm and 20–40 cm) at plots B and C. The share of this fraction in these horizons ranges from 90 to 99%. The medium sand fraction dominates, reaching 40–48% in samples from the depth of 20–40 cm at all sites. The share of coarse and fine sands is similar and oscillates around 18–26% in two horizons (0–20 cm and 20–40 cm) at all sites. The situation begins to change at the deepest analysed depth at plots B and C. At plot B, the share of total sandy fraction in horizon 90–100 cm is below 80%, and it is still lower at plot C, where it drops to about 53%. Simultaneously, the share of silty fraction in this horizon at both plots increases to 17.7% at plot B and up to 38.3% at plot C. There is a clearly increased share of clay in this horizon – up to 4% at plot B and 8.8% at plot C. The results of granulometric analyses of samples from individual horizons indicate fairly subtle differences between plots. At plot Weronika A, the granulometric subgroup of loose sand (pl) was determined for all horizons. At plot Weronika B, samples from two horizons (0–20 cm and 20–40 cm) were classified as loose sands (pl), whereas the sample from the depth of 90–100cm – as loamy sand (pg). At plot Weronika C, the situation is similar, except that the deepest sample exhibits the properties of sandy loam (gp).

All analysed soils in the Weronika study plot group were categorised agronomically. Samples classified as loose sands on the basis of their grain size distribution are classified as agronomic category I (very light soils). Another parameter which characterises the properties of soils at the described sites – specific surface area – is dependent on grain size distribution. Data included in tables 5.16–5.18 clearly shows that it is at its lowest in these horizons, where the share of the sandy fraction is close to 100%. Such a situation occurs at plots Weronika A and B in samples from the depth of 20–40 cm, whereas the specific surface area value is 0.0233 $m^2 \cdot g^{-1}$ (Weronika A) and 0.0239 $m^2 \cdot g^{-1}$ (Weronika B). The value of this parameter increases with the increase of the percentage of silts and clays in the sample, which can be observed at plot Weronika C in the sample from the depth 90–100 cm, where it reaches the maximum of 0.915 $m^2 \cdot g^{-1}$, with the content of both mentioned fractions at nearly 40%.

The pH reaction in KCl in all samples from all three plots is acidic and very acidic and ranges from 4.1 (Weronika B, sample 0–20 cm) to 4.8 (Weronika C, sample 20–40 cm). The highest values are recorded in samples taken from the depth of 20–40 cm. The pH reaction in H_2O ranges from 4.9 to 6. The highest pH value of 6 was found in the sample from the depth of 20–40 cm at plot Weronika C, which is also reflected in the high level of saturation with alkaline cations (V), which is 76.73%. The lowest pH value was found at plot Weronika B in samples from the depth of 0–20 cm and 20–40 cm, where the saturation with alkaline cations is the lowest and is 9.27% and 9.804%, respectively. Low values of this parameter make the soil susceptible to fluctuations of the reaction and chemical degradation caused by acidic substances. In such events, the buffering capacity of the soil is low. Assessing the content of individual nutrients available for plants, it may be stated that for phosphorus (P_2O_5) it changes from low in the 0–20 cm horizon at all sites, to very low in the other two samples for all horizons. The content of potassium (K_2O) is very low and low (only in 2 samples), and the content of magnesium (Mg) in most horizons is very low and low. Only the content in the sample from the depth of 90–100 cm at plot Weronika C falls within the very high availability class.

The content of humus in the 0–20 cm horizon is the lowest at plot Weronika A – 0.95%, and the highest at plot Weronika B – 1.33%. The content of organic carbon (C) is fairly high at plot Weronika B – 0.771%. At the two other plots, the content is lower and falls below 0.6%.

WOLA PSZCZÓŁECKA STUDY PLOT GROUP

The described study plot group is located at the elevation of 165–170 m a.s.l., on the border between the Łask Plateau and the Szczerców Basin (Kondracki 2002), about 8.5 km to the east of the border of the Warta–Widawka Interfluve Landscape Park, in Zelów Commune. The study plot group lies within the terrace of the Chrzęstawka, a right tributary of Widawka. According to the Detailed Geological Map of Poland, scale 1:50 000, sheet Zelów (Baliński, Gawlik 1983), Vistulian fluvial sands of terraces upon Wartanian loams occur here. On the 1:5 000 soil and agricultural map, within the analysed area there are leeched brown soils (Bw), agricultural suitability class 7 (very poor rye), developed upon loose sands (pl) at plots Wola Pszczółecka A and B. The soils were qualified as valuation class VI (http://geoportal.lodzkie.pl/imap/). At plot Wola Pszczółecka C, the map shows podzolic soils (A), of agricultural suitability class 5 (good rye), developed upon slightly loamy sands (psg) upon sandy loams (gp). The soils were qualified as valuation class IVb (http://geoportal.lodzkie.pl/imap/). The current usage – abandoned land, whose "age" is estimated at a minimum of 5–6 years. The physiognomy of individual study plots within the analysed group is presented in photographs (Figures 5.31, 5.33, 5.35). The study plot group is located within a type 8 geocomplex, which is formed by fluvial sands and gravels of upper terraces. Similarly to the previous case, soil pits were excavated (Figures 5.32, 5.34, 5.36) from which samples were taken for laboratory studies, and their results are presented in tables 5.19–5.21.

STUDY PLOT WOLA PSZCZÓŁECKA A (51°24'31''N, 19°06'27''E; elevation 168 m a.s.l.)

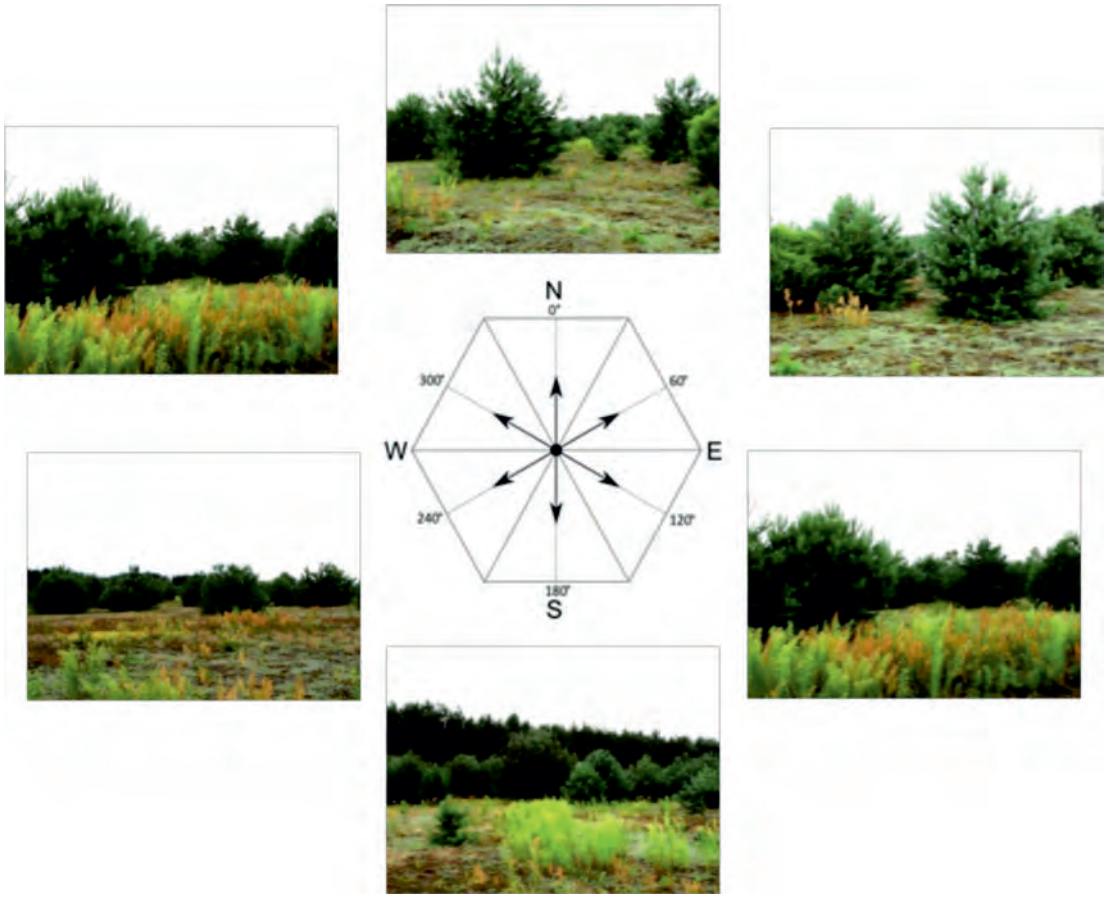


Fig. 5.31. Study plot Wola Pszczółecka A (photo E. Papińska, 2012)

Depth		Profile description
1–0 cm	–	organic horizon
0–25 cm	–	humus, transformed, deepened by agricultural use (ploughing) coarse and medium sand, grey and brown
25–30 cm	–	depletion layer, reduced thickness probably due to deep ploughing with dominating medium sand
30–85 cm	–	enrichment horizon, unsorted sand (mostly medium) light yellow
85–110 cm	–	horizon of parent rock, unsorted sand, rusty wit pebbles and cobbles of 8 cm in diameter

Fig. 5.32. Soil pit in study plot Wola Pszczółecka A (photo. E. Papińska, 2012)

Table 5.19. Study plot Wola Pszczółecka A. Granulometric and chemical properties of soil

Soil pit	Sampling depth cm	Grain size distribution %									Granulometric subgroup	Specific surface area $m^2 \cdot g^{-1}$
		2.0–1.0 mm	1.0–0.5 mm	0.5–0.25 mm	0.25–0.1 mm	0.1–0.05 mm	0.05–0.02 mm	0.02–0.005 mm	0.005–0.002 mm	<0.002 mm		
Wola Pszczółecka A	0–20	0.4	26.1	45.5	21.6	1.9	2	1.9	0.6	0.0	pl gr	0.0462
Wola Pszczółecka A	20–40	0.0	22.6	51.7	25.6	0.1	0	0.0	0.0	0.0	pl sr	0.0195
Wola Pszczółecka A	90–110	1.1	26.2	40.5	23.4	4.2	2	1.5	0.8	0.3	pl gr	0.0617

Soil pit	Sampling depth cm	Humus %	C total %	N total %	C/N	pH in		Available nutrients mg/100g		
						KCl	H_2O	P_2O_5	K_2O	Mg
Wola Pszczółecka A	0–20	1.29	0.748	0.057	13.127	4.3	5.2	12.0	2.8	1.0
Wola Pszczółecka A	20–40	–	–	–	–	4.8	5.0	5.1	0.5	0.3
Wola Pszczółecka A	90–110	–	–	–	–	4.5	4.8	1.9	1.0	0.4

Soil pit	Sampling depth cm	Hydrolytic acidity mmol/100g	Exchangeable cations me/100g				Sorption capacity me/100g			
			Ca^{2+}	Mg^{2+}	Na^{+}	K^{+}	S	T	(T–S)	V, %
Wola Pszczółecka A	0–20	2.92	0.5	0.033	0.026	0.079	0.638	3.558	2.92	17.93
Wola Pszczółecka A	20–40	1.54	0.1	0.013	0.009	0.018	0.140	1.680	1.54	8.333
Wola Pszczółecka A	90–110	1.53	0.1	0.018	0.009	0.031	0.158	1.688	1.53	9.360

Source: own elaboration.

Characteristics of the flora and fungi – Wola Pszczółecka A

Approximately 90% of the study plot is covered with plants. Fairly rich in species (22). Three species dominate: *Hieracium pilosella* (40%), *Conyza canadensis* (15%) and *Rumex acetosa* (15%). The share of other species ranges from 5% to 0.5% of area coverage. They include: *Achillea millefolium*, *Anthoxanthum aristatum*, *Convolvulus arvensis*, *Corynephorus canescens*, *Equisetum pratense*, *Festuca ovina viridis*, *Viola tricolor*. Two species of moss were also identified: *Bryum sp*. and *Polytrichum piliferum*. Specimens of trees occur in the area – *Pinus sylvesris* (Tab. 6.1).

Fungi of the plot are represented by 13 species of macromycetes. The frequently found species include: *Bovista plumbea*, *Macrolepiota procera*, *Lepiota alba*, *Rickenella fibula* (Photo 7.2) occurs abundantly on mosses (Tab. 7.1).

STUDY PLOT WOLA PSZCZÓŁECKA B (51°24'37''N, 19°06'30''E; elevation 165 m a.s.l.)

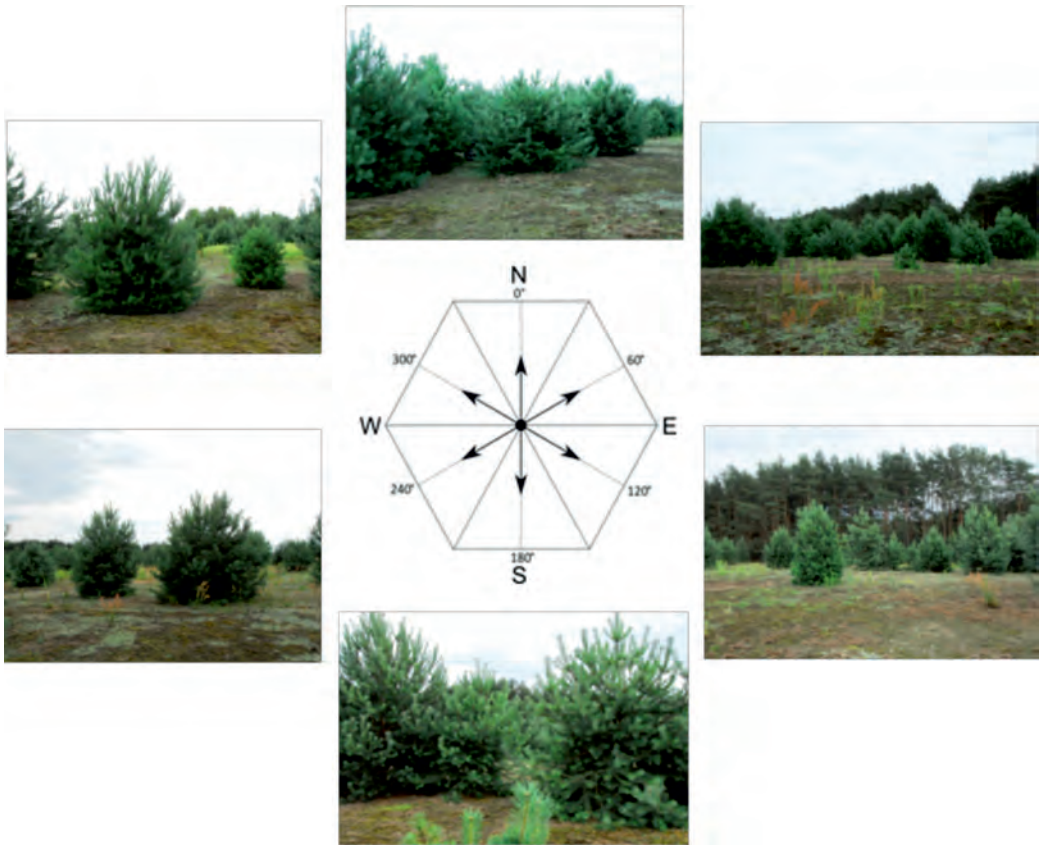


Fig. 5.33. Study plot Wola Pszczółecka B (photo E. Papińska, 2012)

Depth		Profile description
0–30 cm	–	humus, transformed, deepened by agricultural use (ploughing), coarse and medium sand, grey and dark brown
30–90 cm	–	horizon with dominating fine and medium sand
90–110 cm	–	horizon of stone pavement, turning into sand

Fig. 5.34. Soil pit in study plot Wola Pszczółecka B (photo. E. Papińska, 2012)

Table 5.20. Study plot Wola Pszczółecka B. Granulometric and chemical properties of soil

Soil pit	Sampling depth cm	Grain size distribution %									Granulometric sub-group	Specific surface area $m^2 \cdot g^{-1}$
		2.0–1.0 mm	1.0–0.5 mm	0.5–0.25 mm	0.25–0.1 mm	0.1–0.05 mm	0.05–0.02 mm	0.02–0.005 mm	0.005–0.002 mm	<0.002 mm		
Wola Pszczółecka B	0–20	0	22.7	48.7	26.3	1.9	0.5	0	0	0	pl	0.0217
Wola Pszczółecka B	20–40	0	19.5	43.6	31.7	4.1	1.1	0	0	0	pl	0.0257
Wola Pszczółecka B	90–100	0	20.7	45.4	29.5	3.4	1.0	0	0	0	pl	0.0243

Soil pit	Sampling depth cm	Humus %	C total %	N total %	C/N	pH in		Available nutrients mg/100g		
						KCl	H_2O	P_2O_5	K_2O	Mg
Wola Pszczółecka B	0–20	1.55	0.899	0.06	14.985	3.9	4.3	18.9	0.4	0.2
Wola Pszczółecka B	20–40	–	–	–	–	4.7	5.1	1.6	0.3	0.3
Wola Pszczółecka B	90–100	–	–	–	–	4.7	4.9	1.2	0.4	0.3

Soil pit	Sampling depth cm	Hydrolytic acidity mmol/100g	Exchangeable cations me/100g				Sorption capacity me/100g			
			Ca^{2+}	Mg^{2+}	Na^{+}	K^{+}	S	T	(T–S)	V, %
Wola Pszczółecka B	0–20	4.27	0.1	0.017	0.017	0.018	0.152	4.422	4.27	3.437
Wola Pszczółecka B	20–40	0.9	0.05	0.012	0.017	0.013	0.092	0.992	0.9	9.274
Wola Pszczółecka B	90–100	0.98	0.05	0.01	0.087	0.018	0.165	1.145	0.98	14.410

Source: own elaboration.

Characteristics of the flora and fungi – Wola Pszczółecka B

Approximately 20% of the study plot is covered with plants and approximately 20% with lichens. Poor in species of plants (5). Three species dominate: *Hieracium pilosella*, *Rumex acetosa* and *Pinus sylvesris*, with each covering about 5% of the area. The other two species: *Hypericum perforatum* and *Lupinus perennis* exhibit a low coverage (about 5%). Three species of lichens occur in the plot: *Cladonia uncialis*, *Cladonia coccifera* and *Cladonia furcata* (Tab. 6.1).

Fungi of the plot are sparse. They are represented by only 4 species of macromycetes, such as *Bovista plumbea* and *B. nigrescens* (Tab. 7.1).

STUDY PLOT WOLA PSZCZÓŁECKA C (51°24'37''N, 19°06'30''E; elevation 166 m a.s.l.)

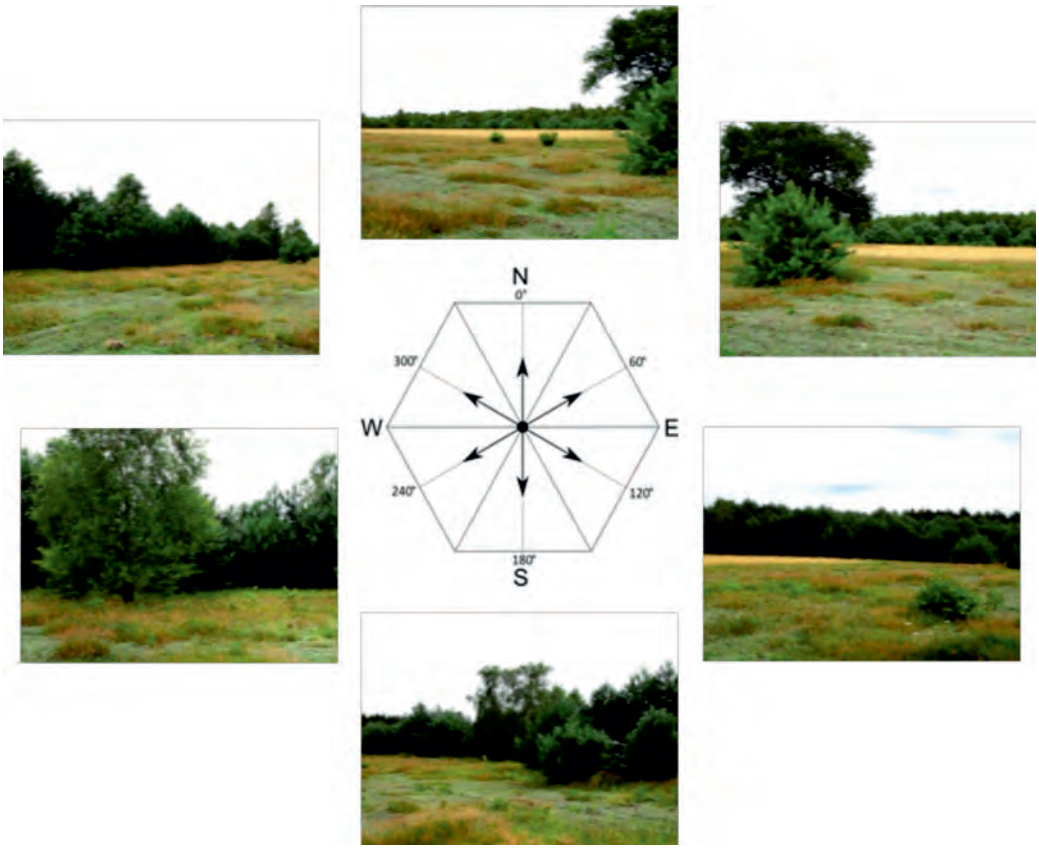
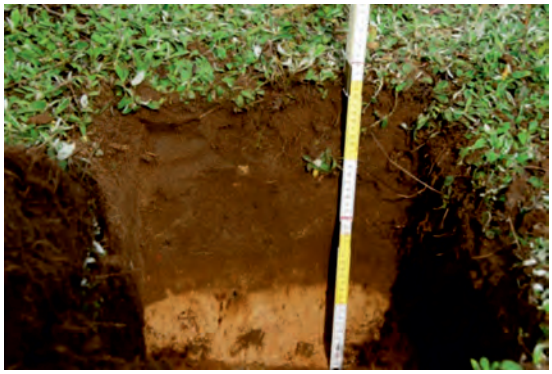


Fig. 5.35. Study plot Wola Pszczółecka C (photo E. Papińska, 2012)



Depth		Profile description
1–0 cm	–	organic horizon
0–30 cm	–	humus, transformed, deepened by agricultural use (ploughing), medium
30–40 cm	–	sand, dark brown
40–110 cm	–	loamy sand, beige sandy loam, beige

Fig. 5.36. Soil pit in study plot Wola Pszczółecka C (photo. E. Papińska, 2012)

Table 5.21. Study plot Wola Pszczółecka C. Granulometric and chemical properties of soil

Soil pit	Sampling depth cm	Grain size distribution %									Granulometric sub-group	Specific surface area $m^2 \cdot g^{-1}$
		2.0–1.0 mm	1.0–0.5 mm	0.5–0.25 mm	0.25–0.1 mm	0.1–0.05 mm	0.05–0.02 mm	0.02–0.005 mm	0.005–0.002 mm	<0.002 mm		
Wola Pszczółecka C	0–20	1.2	23.4	35.1	20.3	5.4	5.3	5.8	2.1	1.3	ps	0.180
Wola Pszczółecka C	20–40	1.5	20.4	28.1	19.2	6.0	5.3	9.7	5.8	4.0	pg	0.441
Wola Pszczółecka C	50–60	0.1	13.3	24.0	17.3	5.9	7.8	15.0	9.6	7.0	gp	0.743
Wola Pszczółecka C	90–100	0.3	14.6	24.3	16.7	5.8	7.2	14.6	9.6	7.0	gp	0.745

Soil pit	Sampling depth cm	Humus %	C total %	N total %	C/N	pH in		Available nutrients mg/100g		
						KCl	H_2O	P_2O_5	K_2O	Mg
Wola Pszczółecka C	0–20	1.42	0.824	0.072	11.440	3.9	4.4	6.4	1.5	0.4
Wola Pszczółecka C	20–40	–	–	–	–	4.1	4.9	1.2	1.5	0.9
Wola Pszczółecka C	50–60	–	–	–	–	3.9	5.2	0.9	3.3	6.5
Wola Pszczółecka C	90–100	–	–	–	–	4.6	6.3	0.9	3.2	8.0

Soil pit	Sampling depth cm	Hydrolytic acidity mmol/100g	Exchangeable cations me/100g				Sorption capacity me/100g			
			Ca^{2+}	Mg^{2+}	Na^{+}	K^{+}	S	T	(T–S)	V, %
Wola Pszczółecka C	0–20	4.46	0.15	0.027	0.026	0.062	0.265	4.725	4.46	5.608
Wola Pszczółecka C	20–40	3.13	0.45	0.068	0.035	0.056	0.609	3.739	3.13	16.288
Wola Pszczółecka C	50–60	3.42	4.00	0.678	0.122	0.138	4.938	8.358	3.42	59.081
Wola Pszczółecka C	90–100	1.05	6.35	0.867	0.174	0.126	7.517	8.567	1.05	87.744

Source: own elaboration.

Characteristics of the flora and fungi – Wola Pszczółecka C

Approximately 90% of the plot is covered with plants. Poor in species of plants (9). Two species dominate: *Hieracium pilosella* (65%) and *Agrostis capillaris* (15%). The other species do not cover more than 0.5% of the area each. They include: *Achillea millefolium*, *Festuca*, *Jasione montana*. There are some specimens of trees in the plot: *Pinus sylvestris* and *Betula pendula* (Tab. 6.1).

Fungi of the plot are represented by 10 species of macromycetes. The most frequently found ones include: *Marasmius oreades*, *Bovista plumbea*. In the undergrowth, the following species were also found: *Lepiota alba* and *Macrolepiota procera*. Mycorrhizal species were represented by: *Amanita muscaria*, *Boletus edulis*, *Inocybe asterospora* and *Suillus luteus* (Tab. 7.1).

Analysis of granulometric composition and chemical properties of soils in the Wola Pszczółecka study plot group

Data included in tables 5.19–5.21 indicate that the grain size distribution for two of three plots (A and B) is very similar, but it clearly differs for plot C. The dominating fraction in all horizons of plots Wola Pszczółecka A and B is the sandy fraction (95.4–100%), the share of silt is very small (the maximum of 4.5%). The content of particles <0.002 mm (clays) is insignificant and its maximum value is 0.3%. In all horizons, the dominating fraction is medium sand, whose content ranges from 40.5 to 51.7%. The share of coarse and fine sands is similar and ranges from 20.3 to 31.7% each. Thus, they are fractions of loose medium and coarse sand. Such a high content of the sandy fraction results in classifying the soils as the agronomic category of very light soils (I).

The granulometric composition at plot Wola Pszczółecka C is different than that observed at sites A and B (hence the decision to take samples from an additional depth range of 50–60 cm) and reflects the information given on the soil and agricultural map. Based on fraction analysis, the sample from the 0–20 cm depth was determined as the granulometric subgroup of slightly loamy sands (psg); then it turns into loamy sand (pg), to become sandy loam (gp) at the depth of 50–60 cm. The share of silts and clays clearly increases with profile depth, from 9.2% in the sample from 0–20 cm to more than 31% in samples taken below 50 cm. The granulometric composition allows to qualify the soil as very light (I).

The value of specific surface area in samples from plots Wola Pszczółecka A and B is very low. It reaches 0.0195 $m^2 . g^{-1}$ in samples taken at the depth of 20–40 cm, where the share of the sandy fraction was 100%. In other horizons, where some content of the silty and clayey fractions was present, the specific surface area value is higher, with the maximum value of 0.0617 $m^2 \cdot g^{-1}$. The situation is different at plot C, where the grain size distribution reveals a high content of silts and clays. The value of specific surface area ranges from 0.18 $m^2 \cdot g^{-1}$ in the sample taken at the depth of 0–20 cm to 0.745 $m^2 \cdot g^{-1}$ in the sample from the depth of 90–100 cm.

The reaction in KCl in all horizons of the analysed plots is very acidic or acidic. The pH value in H_2O at plot Wola Pszczółecka A decreases with depth, which is also reflected in a lower level of saturation with alkaline cations (V), which drops from nearly 18% in the sample from the 0–20 cm horizon to as little as 8–9% in lower horizons. In samples from plot B, the pH value is at its highest in the 20–40 cm horizon (pH 5.1), and at plot C, the value of this parameter increases with depth, from pH 4.4 in the surface horizon to pH 6.3 in the 90–100 cm horizon.

Low values of this parameter at plots A and B make the soils susceptible to fluctuation of the pH reaction and chemical degradation from acidic substances. Saturation with alkaline cations (V) in these soils is low and ranges from 3.4% to nearly 18%. Regrettably, the content of available nutrients in the case of potassium (K_2O) and magnesium (Mg) in all horizons of plots A and B is very low and low. At plot C, the level of saturation with alkaline cations increases noticeably, from 5.6% (depth: 0–20 cm) to nearly 88% (depth: 90–100 cm), which means the base saturation is high. The fact is primarily influenced by the content of calcium cations (Ca^{2+}), which increases with depth. The content of magnesium reflects this rising trend with depth, from very low in the two upper horizons, through medium in the 50–60 cm horizon, to very high in the deepest sample. The content of phosphorus (P_2O_5) in samples from all horizons of plots A and C is very low and low. Only at plot Wola Pszczółecka B, in the sample from the 0–20 cm horizon, was its high content recorded at 18.9%.

The presence of humus compounds shapes the soil absorbing capacity. The content of organic carbon is high at all plots and ranges from 0.748% (A) to 0.899% (B). The content of humus is the lowest at plot Wola Pszczółecka A – 1.29%, and the highest at plot Wola Pszczółecka B – 1.55%, despite the fact that the vegetation occurring in the analysed area does not form a dense cover.

KRZĘTLE STUDY PLOT GROUP

Krzętle study plot group lies at the elevation of 183–188 m a.s.l., in the Szczerców Basin (Kondracki 2002), about 1 km to the south-east of the border of the Warta–Widawka Interfluve Landscape Park, and about 10 km to the north-east of the border of the Załęcze Landscape Park. In administrative terms, the analysed group is located in Osjaków Commune, Wieluń District. The group is within a local kame hill. According to a geomorphological sketch by A. Dura-Gędek (2012), the kame hills border (mainly in the east) fluvioglacial plains, and to the west of them, there are undulating morainic plateaus. The 1:5 000 soil and agricultural map of the area, shows the occurrence of leeched brown soils (Bw), of class 7 agricultural suitability (very poor rye), developed upon loose sands (pl). The soils were qualified as valuation class VI (http://geoportal.lodzkie.pl/imap/). Current usage – abandoned farmland. Characteristic scenery of the study plots is shown in photographs taken from the centre of the plot selected for the phytosociological inventory (Figures 5.37, 5.39, 5.41). All the plots in the analysed group belong to a type 4 geocomplex. Also in this case, soil pits were excavated (Figures 5.38, 5.40, 5.42), from which samples were taken for laboratory studies, and their results were presented in tables 5.22–5.24.

STUDY PLOT KRZĘTLE A (51°18'44''N, 18°50'52''E; elevation 183 m a.s.l.)

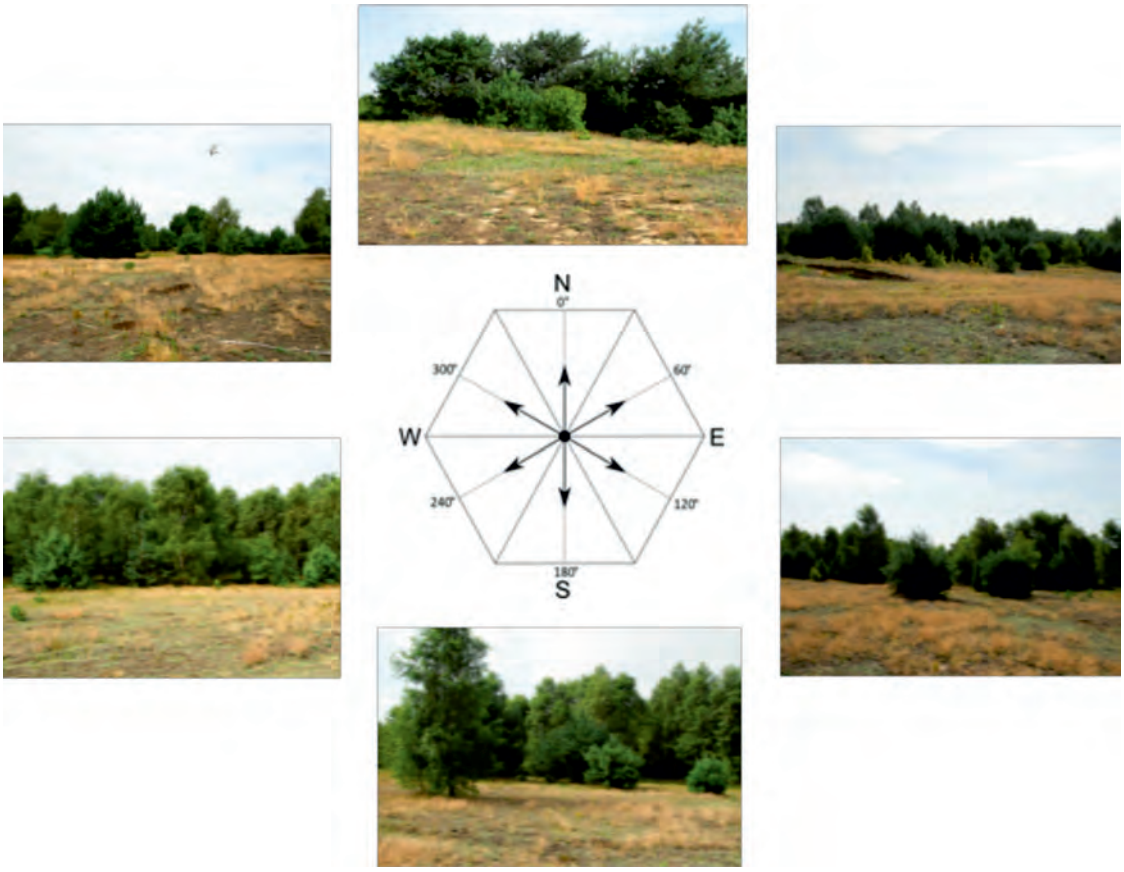


Fig. 5.37. Study plot Krzętle A (photo E. Papińska, 2012)

Depth		Profile description
1–0 cm	–	organic horizon
0–5 cm	–	windrow, loose sand, rusty
5–30 cm	–	humus, transformed, deepened by agricultural use (ploughing), coarse and medium sand, grey and dark brown
30–90 cm	–	rusty horizon with dominating medium sand
90–110 cm	–	horizon of parent rock, unsorted sand, rusty, with cobbles and stones of 10–20 cm in diameter

Fig. 5.38. Soil pit in study plot Krzętle A (photo. E. Papińska, 2012)

Table 5.22. Study plot Krzętle A. Granulometric and chemical properties of soil

Soil pit	Sampling depth cm	Grain size distribution %									Granulometric sub-group	Specific surface area $m^2 \cdot g^{-1}$
		2.0–1.0 mm	1.0–0.5 mm	0.5–0.25 mm	0.25–0.1 mm	0.1–0.05 mm	0.05–0.02 mm	0.02–0.005 mm	0.005–0.002 mm	<0.002 mm		
Krzętle A	0–20	1.8	32.0	41.0	14.9	3.0	3.0	2.9	1.0	0.3	pl śr	0.0737
Krzętle A	20–40	2.7	37.9	41.7	11.7	1.7	1.2	1.9	0.9	0.3	pl gr	0.0617
Krzętle A	90–110	1.2	36.3	47.6	13.3	1.2	0.4	0.0	0.0	0.0	pl gr	0.0172

Soil pit	Sampling depth cm	Humus %	C total %	N total %	C/N	pH in		Available nutrients mg/100g		
						KCl	H_2O	P_2O_5	K_2O	Mg
Krzętle A	0–20	0.86	0.499	0.038	13.127	3.9	4.5	15.9	0.5	0.3
Krzętle A	20–40	–	–	–	–	4.6	5.0	4.8	0.3	0.3
Krzętle A	90–110	–	–	–	–	4.5	5.0	1.4	0.4	0.3

Soil pit	Sampling depth cm	Hydrolytic acidity mmol/100g	Exchangeable cations me/100g				Sorption capacity me/100g			
			Ca^{2+}	Mg^{2+}	Na^{+}	K^{+}	S	T	(T–S)	V, %
Krzętle A	0–20	3.23	0.20	0.017	0.009	0.028	0.254	3.484	3.23	7.290
Krzętle A	20–40	1.40	0.15	0.013	0.004	0.013	0.180	1.580	1.40	11.392
Krzętle A	90–110	1.12	0.10	0.018	0.009	0.013	0.140	1.260	1.12	11.111

Source: own elaboration.

Characteristics of the flora and fungi – Krzętle A

Approximately 80% of the plot is covered with plants. Poor in herbaceous plant species (10). Three species dominate among plants: *Hieracium pilosella* (about 30%), *Corynephorus canescens* (about 20%) (Photo 6.4) and *Convolvulus arvensis* (about 10%). The share of other species does not exceed 1% of area coverage. The other identified species include: *Anthoxantum aristatum*, *Equisetum pratense*, *Holcus mollis* (Tab. 6.1). There are some saplings of *Pinus sylvestris* in the plot. A moss layer is also formed and covers about 5% of the area. It consists of the following species: *Brym sp.*, *Ceratodon purpureus*, *Polytrichum piliferum*.

Fungi of the plot are represented by 12 species of macromycetes. The most frequently found species include: *Marasmius oreades* and *Bovista plumbea*. Less frequent species: *Conocybe tenera*, *Panaeolus fimicola*. There are also a small number of sporocarps of mycorrhizal fungi in the plot: *Amanita muscaria* (Photo 7.3), *Inocybe asterospora*, *Suillus bovinus* and others (Tab. 7.1).

STUDY PLOT KRZĘTLE B (51°18'43''N, 18°50'45''E; elevation 185 m a.s.l.)

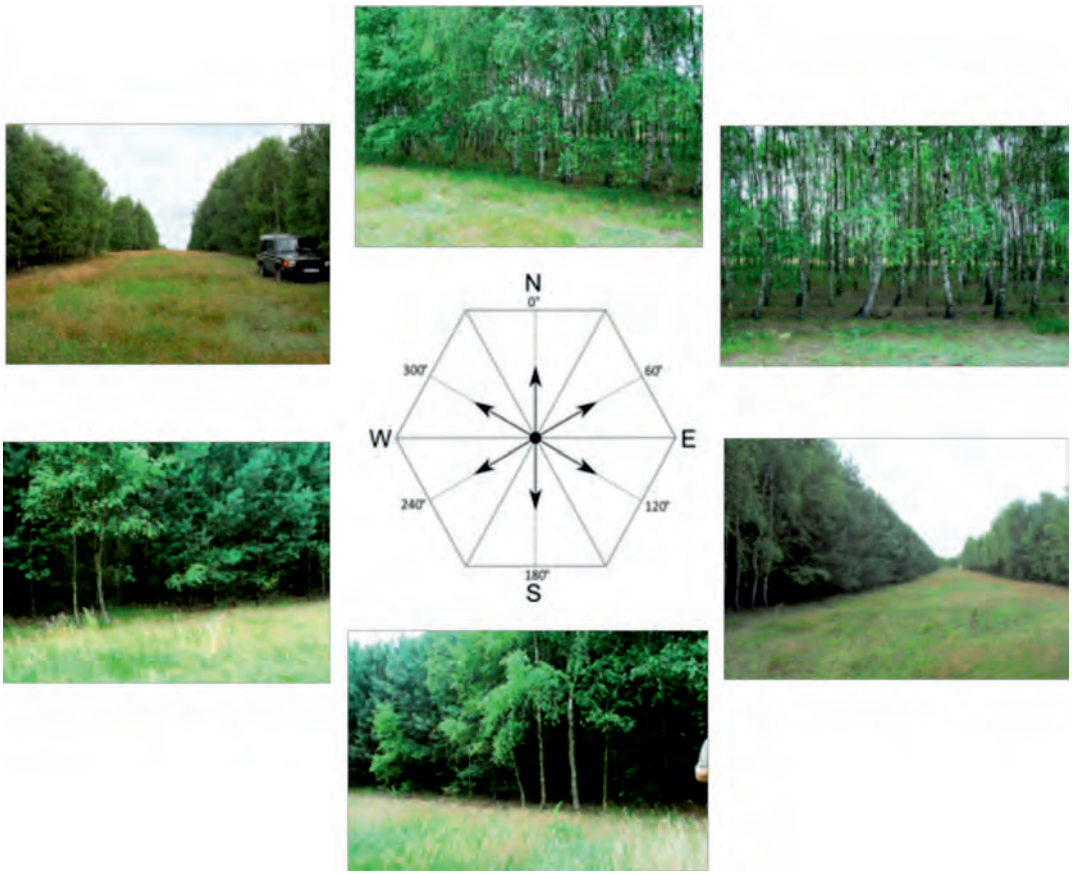


Fig. 5.39. Study plot Krzętle B (photo E. Papińska, 2012)

Depth		Profile description
1–0 cm	–	organic horizon
0–30 cm	–	humus, grey and dark brown medium sand with local material (flint)
30–90 cm	–	rusty horizon with dominating medium sand with loamy inclusions
90–110 cm	–	horizon of parent rock, fine sand

Fig. 5.40. Soil pit in study plot Krzętle B (photo. E. Papińska, 2012)

Table 5.23. Study plot Krzętle B. Granulometric and chemical properties of soil

Soil pit	Sampling depth cm	Grain size distribution %									Granulometric sub-group	Specific surface area $m^2 \cdot g^{-1}$
		2.0–1.0 mm	1.0–0.5 mm	0.5–0.25 mm	0.25–0.1 mm	0.1–0.05 mm	0.05–0.02 mm	0.02–0.005 mm	0.005–0.002 mm	<0.002 mm		
Krzętle B	0–20	2.2	29.1	38.2	17.2	4.7	4.2	3.2	0.9	0.4	pl	0.0807
Krzętle B	20–40	1.3	28.8	42.6	16.9	2.0	2.7	3.0	1.6	1.0	pl	0.1270
Krzętle B	90–110	0.4	27.3	46.6	18.6	1.0	1.3	2.5	1.7	0.6	pl	0.0975

Soil pit	Sampling depth cm	Humus %	C total %	N total %	C/N	pH in		Available nutrients mg/100g		
						KCl	H_2O	P_2O_5	K_2O	Mg
Krzętle B	0–20	1.3	0.754	0.06	12.568	4.1	5.0	10.8	2.7	0.8
Krzętle B	20–40	–	–	–	–	4.3	5.1	2.1	1.6	0.8
Krzętle B	90–110	–	–	–	–	4.4	5.5	1.0	3.8	2.4

Soil pit	Sampling depth cm	Hydrolytic acidity mmol/100g	Exchangeable cations me/100g				Sorption capacity me/100g			
			Ca^{2+}	Mg^{2+}	Na^{+}	K^{+}	S	T	(T–S)	V, %
Krzętle B	0–20	3.37	0.45	0.070	0.017	0.092	0.629	3.999	3.37	15.729
Krzętle B	20–40	1.82	0.30	0.067	0.026	0.049	0.442	2.262	1.82	19.540
Krzętle B	90–110	0.98	0.50	0.210	0.017	0.072	0.799	1.779	0.98	44.913

Source: own elaboration.

Characteristics of the flora and fungi – Krzętle B

Approximately 90% of the study plot is covered with plants. Not very rich in plant species (15). One species dominates: *Agrostis capillaris* (about 50%). The share of other species ranges from 5% to 0.5%. The identified species include: *Achillea millefolium*, *Apera spica-venti*, *Convolvulus arvensis*, *Conyza canadensis*, *Festuca ovina* (Tab. 6.1). There are also several saplings of trees: *Quercus robur*. A moss layer is also formed and it covers about 25% of the plot. It consists of two species: *Ceratodon purpurea* and *Pleurozium schreberii*.

Fungi of the plot are abundant. It is represented by 14 species of macromycetes. The most frequently found species is *Marasmius oreades*. Numerous sporocarps of mycorrhizal fungi were also found in the area, such as: *Scleroderma citrina*, *Amanita muscaria*, *Suillus bovinus*. Numerous sporocarps of *Trichaptum abietinum* were identified on pine branches (Tab. 7.1).

STUDY PLOT KRZĘTLE C (51°19'41''N, 18°50'37''E; elevation 186 m a.s.l.)

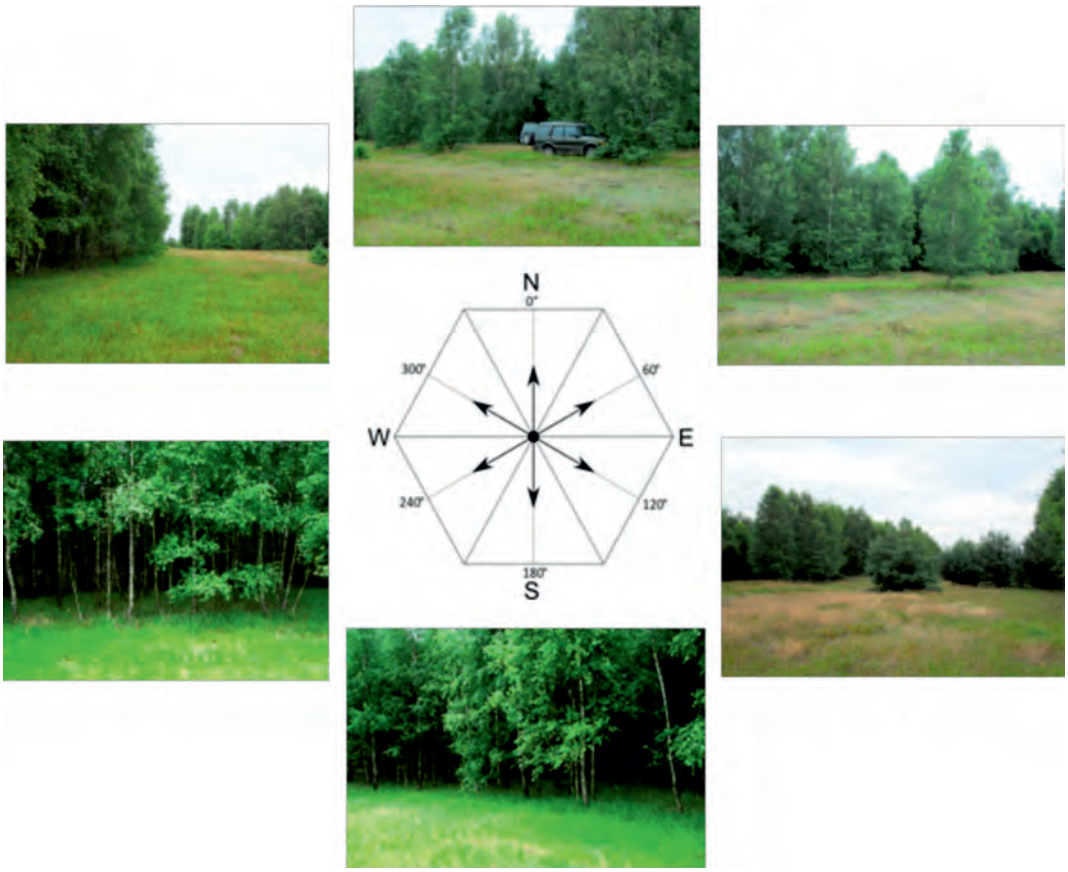


Fig. 5.41. Study plot Krzętle B (photo E. Papińska, 2012)

Depth		Profile description
1–0 cm	–	organic horizon
0–20 cm	–	humus, grey and dark brown medium sand with local material (flint)
20–40 cm	–	rusty horizon with dominating medium sand
40–110 cm	–	horizon of parent rock, medium sand, light yellow

Fig. 5.42. Soil pit in study plot Krzętle C (photo. E. Papińska, 2012)

Table 5.24. Krzętle C. Granulometric and chemical properties of soil

Sampling depth cm	Soil pit	Grain size distribution %									Granulometric sub-group	Specific surface area $m^2 \cdot g^{-1}$
		2.0–1.0 mm	1.0–0.5 mm	0.5–0.25 mm	0.25–0.1 mm	0.1–0.05 mm	0.05–0.02 mm	0.02–0.005 mm	0.005–0.002 mm	<0.002 mm		
Krzętle C	0–20	1.3	23.1	33.2	22.3	7.9	5.1	4.4	1.6	1.0	pl	0.1470
Krzętle C	20–40	0.4	27.9	46.1	19.9	2.6	1.1	1.2	0.6	0.1	pl	0.0442
Krzętle C	90–110	0.0	31.1	54.2	10.8	0.0	0.0	2.0	1.3	0.4	pl	0.0716

Soil pit	Sampling depth cm	Humus %	C total %	N total %	C/N	pH in		Available nutrients mg/100g		
						KCl	H_2O	P_2O_5	K_2O	Mg
Krzętle C	0–20	1.22	0.708	0.06	11.794	3.8	4.4	14.2	1.1	0.3
Krzętle C	20–40	–	–	–	–	4.5	4.9	5.3	0.3	0.2
Krzętle C	90–110	–	–	–	–	4.3	5.4	2.4	2.1	1.3

Soil pit	Sampling depth cm	Hydrolytic acidity mmol/100g	Exchangeable cations me/100g				Sorption capacity me/100g			
			Ca^{2+}	Mg^{2+}	Na^{+}	K^{+}	S	T	(T–S)	V, %
Krzętle C	0–20	3.94	0.10	0.020	0.009	0.049	0.178	4.118	3.94	4.322
Krzętle C	20–40	1.22	0.10	0.015	0.009	0.013	0.137	1.357	1.22	10.096
Krzętle C	90–110	1.03	0.45	0.098	0.017	0.056	0.621	1.651	1.03	37.614

Source: own elaboration.

Characteristics of the flora and fungi – Krzętle C

Approximately 100% of the study plot is covered with plants. Poor in vascular plants (8). The flora is dominated by one species: *Agrostis capillaris* (about 60%). Other species with a significant share include *Holcus mollis* (about 20%), *Hieracium pilosella* (about 10%). The share of other species ranges from 5% to 0.5%. They include: *Anthoxanthum odoratum*, *Corynephorus canescens* (Tab. 6.1). The plot also features a few saplings of *Quercus robur*. The moss layer is formed scantily and is represented by one species: *Polytrichum piliferum*.

Fungi of the plot are sparse. They are represented by 8 species of macromycetes. The frequently found species is *Crinipellis scabella*, occurring on grasses, mainly on *Agrostis capillaris*. Among land fungi, the abundantly fruiting species were: *Bovista pumbea* and Calvatias: *Calvatia utriformis* and *C. excipuliformis*. There were a small number of sporocarps of the mycorrhizal *Amanita muscaria* (Tab. 7.1).

Analysis of granulometric composition and chemical properties of soils in the Krzętle study plot group

The results of granulometric analysis presented in tables 5.22–5.24, indicate the domination of the sandy fraction at all plots and in all horizons from which samples were taken (Figures 5.38, 5.40 and 5.42). The share of this fraction ranges from 87.8% to 99.6% in the sample from the depth of 90–110 cm. The share of the silty fraction exceeds 10% in just one sample (Krzętle C,

horizon 0–20 cm). Its lowest content was found at plot Krzętle A – 0.4% – at the depth of 90–100 cm. The clayey fraction is insignificant and amounts to a maximum of 1% in samples from the depth of 0–20 cm (plot C) and 20–40 cm (plot B). The high content of material in granulometric groups of coarse (20–32%) and medium sands (40% and above) is worth noticing. The presented grain size distribution of the analysed soils provides a basis for classifying them as very light soils (I) in the agronomic category.

A derivative of grain size distribution is the value of specific surface area. It is the highest for the sample taken from the smallest depth at plot Krzętle C – 0.147 $m^2 \cdot g^{-1}$. This is due to the highest recorded share of silts (11.1%) and clays (1%) of all the profile. Also at this plot, the lowest value of this parameter of 0.0172 $m^2 \cdot g^{-1}$ was recorded at the depth of 20–40 cm.

Analysis of pH reaction indicates high soil acidification, the pH value in KCl for the surface horizon at plot Krzętle C was as low as 3.8 (very acidic). Only one sample from the depth of 20–40 cm at plot Krzętle A reveals a slight increase of the pH value to 4.6 (acidic). In all other samples at the analysed group, the pH value was very acidic. It influences the saturation degree with alkaline cations (V), which is only 7.29% at plot Krzętle A in the near-surface horizon and gradually increases to more than 11% in the remaining samples. At plot Krzętle B, the parameter changes with depth from 15.729% (0–20 cm) to 44.913% (90–100 cm), and at plot Krzętle C from 4.322% (0–20 cm) to 37.614% (90–100 cm). The assessment of plant nutrient availability indicates very low availability of magnesium (Mg) and potassium (K_2O) in all samples from plot Krzętle A. At plots B and C both parameters are within very low and low availability classes, except for the sample taken from the depth of 90–100cm at plot Krzętle B, which is found in the medium magnesium availability class. The content of phosphorus (P_2O_5) indicates a higher diversity, from high availability (Krzętle A, 0–20cm), through medium (Krzętle B and C, 0–20 cm), to low and very low in the remaining cases.

Similarly to other analysed study plot groups, the content of humus was determined in the 0–20 cm horizon, and it ranges from 0.86% at plot Krzętle A to 1.3% at plot Krzętle B.

RACISZYN STUDY PLOT GROUP

The Raciszyn study plot group is located in Działoszyn Commune, Pajęczno District. It lies at the elevation of 210–220 m a.s.l., in the Wieluń Upland (Kondracki 2002), about 800–1 200 m to the east of the border of the Załęcze Landscape Park. In geomorphological terms, it is a fluvioglacial plain, formed of fluvioglacial sands of the Odra Glaciation (Haisig, Wilanowski 2000). In the close vicinity, there are some outcrops of Upper Jurassic limestone, which were excavated in numerous quarries. They form some clearly dominating surfaces in the landscape – island hills. At numerous spots, the Mesozoic substratum lies close to the land surface, covered with a thin layer of fluvioglacial deposits (Laskowski, Papińska, Tołoczko 2001; Papińska 2001a, 2001b; Papińska, Tołoczko 2002). At plots Raciszyn A and B, the 1:5 000 soil and agricultural map shows leeched brown soils (Bw), belonging to class 6 of agricultural suitability (poor rye). They were formed on slightly loamy sands (psg) lying upon limestone (w). The soils were qualified as valuation class V (http://geoportal.lodzkie.pl/imap/). At plot Raciszyn C, the leeched brown soils were classified as agricultural suitability class 7 (very poor rye) and valuation class VI, and they are formed on loose sands (pl). The study plot group is located in a type 6 geocomplex, and its characteristics are presented in photographs (Figures 5.43, 5.45, 5.47). Soil pits were excavated in order to document the plots (Figures 5.44, 5.46, 5.48), from which samples were taken for laboratory analyses, and their results were presented in tables 5.25–5.27.

STUDY PLOT RACISZYN A (51°05'26''N, 18°51'13''E; elevation 220 m a.s.l.)

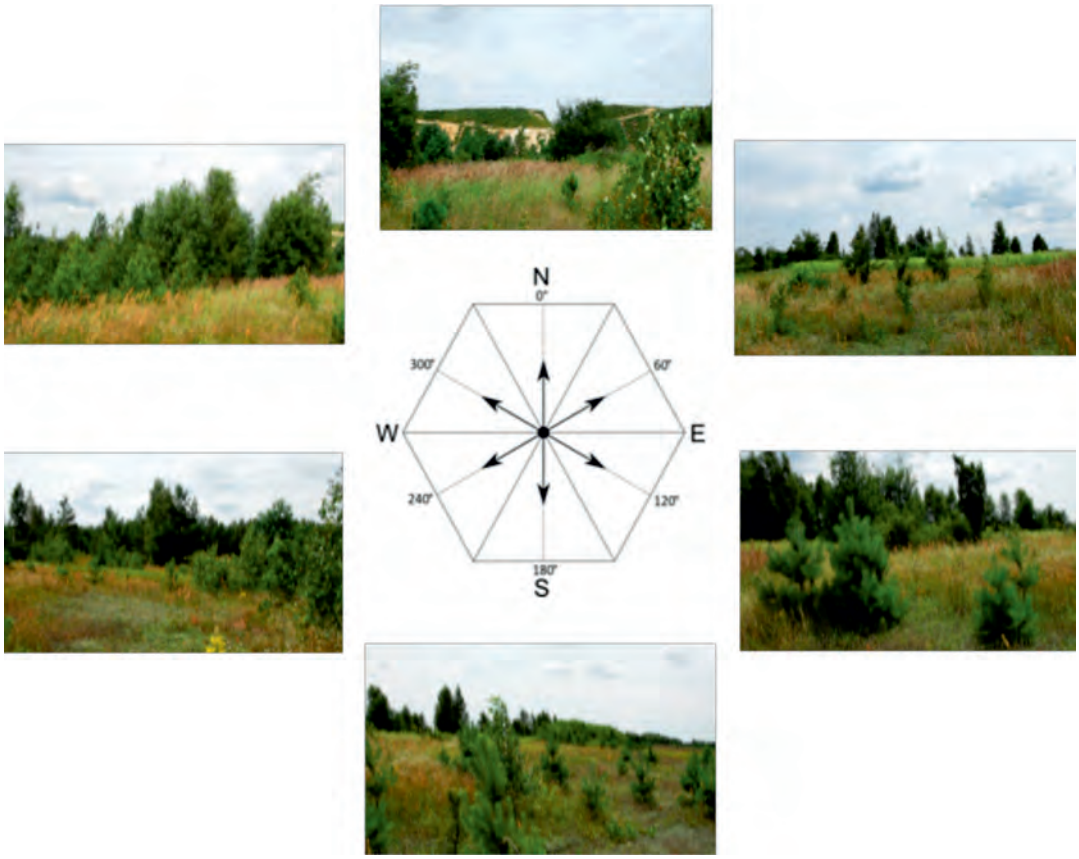


Fig. 5.43. Study plot Raciszyn A (photo E. Papińska, 2012)

Depth		Profile description
1–0 cm	–	organic horizon
0–16 cm	–	humus, medium sand, grey and dark brown
16–90 cm	–	rusty sand with single cobbles and stones of local and northern material, with dominating medium sand
90–110 cm	–	loamy sand, light yellow with rusty (hardpan) stains

Fig. 5.44. Soil pit in study plot Raciszyn A (photo. E. Papińska, 2012)

Table 5.25. Study plot Raciszyn A. Granulometric and chemical properties of soil

Soil pit	Sampling depth cm	Grain size distribution %									Granulometric sub-group	Specific surface area $m^2 \cdot g^{-1}$
		2.0–1.0 mm	1.0–0.5 mm	0.5–0.25 mm	0.25–0.1 mm	0.1–0.05 mm	0.05–0.02 mm	0.02–0.005 mm	0.005–0.002 mm	<0.002 mm		
Raciszyn A	0–20	2.1	32.0	36.3	10.2	5.0	7.0	4.9	1.5	1.0	ps	0.150
Raciszyn A	20–40	0.7	28.3	38.4	12.6	5.1	7.0	4.8	1.7	1.4	ps	0.176
Raciszyn A	90–110	2.6	20.2	25.4	16.9	8.0	10.8	9.0	4.1	3.1	pg	0.363

Soil pit	Sampling depth cm	Humus %	C total %	N total %	C/N	pH in		Available nutrients mg/100g		
						KCl	H_2O	P_2O_5	K_2O	Mg
Raciszyn A	0–20	0.94	0.545	0.05	10.905	4.2	4.8	3.0	1.9	0.3
Raciszyn A	20–40	–	–	–	–	4.3	5.2	0.5	2.2	0.4
Raciszyn A	90–110	–	–	–	–	4.1	5.3	1.0	8.0	3.2

Soil pit	Sampling depth cm	Hydrolytic acidity mmol/100g	Exchangeable cations me/100g				Sorption capacity me/100g			
			Ca^{2+}	Mg^{2+}	Na^{+}	K^{+}	S	T	(T–S)	V, %
Raciszyn A	0–20	3.21	0.15	0.023	0.017	0.062	0.252	3.462	3.21	7.279
Raciszyn A	20–40	1.70	0.20	0.032	0.017	0.067	0.316	2.016	1.70	15.675
Raciszyn A	90–110	2.12	2.05	0.270	0.061	0.213	2.594	4.714	2.12	55.028

Source: own elaboration.

Characteristics of the flora and fungi – Raciszyn A

Approximately 100% of the study plot is covered with plants. Rich in species (31). Two species clearly dominate: *Hieracium pilosella* (about 50%) and *Agrostis capillaris* (about 10%). The share of other species ranges from 3% to 0.5% of area coverage. They include: *Achillea millefolium*, *Arrthenatherum elatior*, *Artemisia campestris*, *Calamagrostis epigeios*, *Carex hirta*, *Carlina vulgaris*, *Cerastium arvense*, *Conyza canadensis*, *Fragaria viridis*, *Galium mollugo*, *Galium verum*, *Geum urbanum*, *Vicia angustifolia*, *Senecio jacobea* (Photo 6.5). There are a small number of saplings of trees and shrubs: *Pinus sylvestris*, *Betula pendula* and *Pyrus communis* (Tab. 6.1).

Fungi of the plot are abundant. They are represented by 19 species of macromycetes. The most frequently found species is *Crinipellis scabella*, which occurs on grasses, mainly on *Agrostis capillaris*. Among land fungi, the most abundant was *Marasmius oreades*. There were numerous sporocarps of mycorrhizal fungi in the plot: *Scleroderma citrina*, *Amanita muscaria*, *Inocybe asterospora* and *Laccaria laccata* (Photo 7.4) and others (Tab. 7.1).

STUDY PLOT RACISZYN B (51°05'26''N, 18°51'11''E; elevation 214 m a.s.l.)

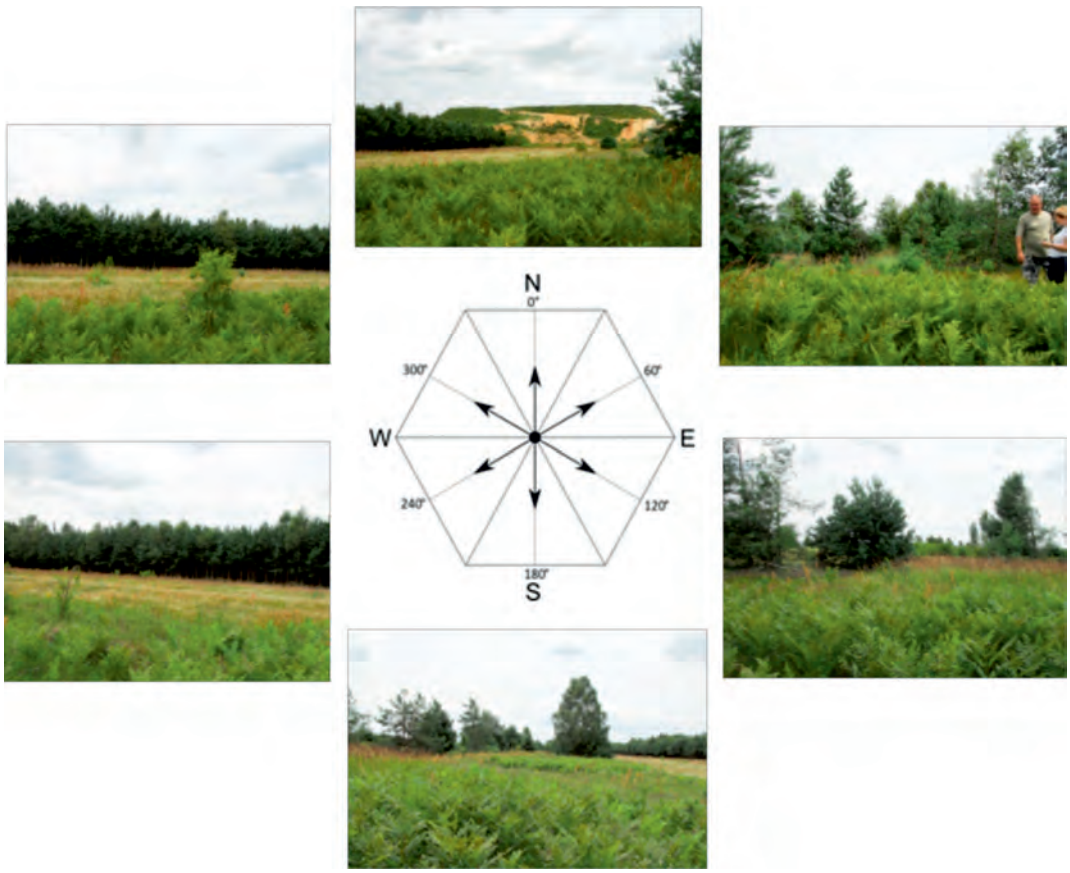


Fig. 5.45. Study plot Raciszyn B (photo E. Papińska, 2012)

Depth		Profile description
1–0 cm	–	organic horizon
0–20 cm	–	humus, medium sand, grey and dark brown
20–90 cm	–	rusty sand with single cobbles and stones of local and northern material, with dominating medium sand
90–110 cm	–	coarse sand, rusty

Fig. 5.46. Soil pit in study plot Raciszyn B (photo. E. Papińska, 2012)

Table 5.26. Raciszyn B. Granulometric and chemical properties of soil

Soil pit	Sampling depth cm	Grain size distribution %									Granulometric sub-group	Specific surface area $m^2 \cdot g^{-1}$
		2.0–1.0 mm	1.0–0.5 mm	0.5–0.25 mm	0.25–0.1 mm	0.1–0.05 mm	0.05–0.02 mm	0.02–0.005 mm	0.005–0.002 mm	<0.002 mm		
Raciszyn B	0–20	2.3	33.1	37.5	9.6	4.9	6.1	4.4	1.2	0.8	pl	0.1230
Raciszyn B	20–40	3.5	37.4	40.3	6.7	1.4	2.8	4.3	2.1	1.4	pl	0.1680
Raciszyn B	90–110	2.4	31.7	45.4	14.4	0.4	1.3	2.4	1.4	0.6	pl	0.0887

Soil pit	Sampling depth cm	Humus %	C total %	N total %	C/N	pH in		Available nutrients mg/100g		
						KCl	H_2O	P_2O_5	K_2O	Mg
Raciszyn B	0–20	1.13	0.655	0.05	13.109	4.4	5.5	1.1	3.1	0.6
Raciszyn B	20–40	–	–	–	–	4.4	5.4	0.7	3.2	1.0
Raciszyn B	90–110	–	–	–	–	4.5	5.7	1.0	2.5	2.4

Soil pit	Sampling depth cm	Hydrolytic acidity mmol/100g	Exchangeable cations me/100g				Sorption capacity me/100g			
			Ca^{2+}	Mg^{2+}	Na^{+}	K^{+}	S	T	(T–S)	V, %
Raciszyn B	0–20	2.51	0.8	0.048	0.035	0.102	0.985	3.495	2.51	28.183
Raciszyn B	20–40	1.27	1.2	0.078	0.043	0.097	1.418	2.688	1.27	52.753
Raciszyn B	90–110	0.73	1.1	0.190	0.043	0.067	1.400	2.130	0.73	65.728

Source: own elaboration.

Characteristics of the flora and fungi – Raciszyn B

Approximately 100% of the study plot is covered with plants. Rich in species (31). Two species clearly dominate: *Hieracium pilosella* (about 50%) and *Agrostis capillaris* (about 10%). The share of other species ranges from 3% to 0.5% of area coverage. The other identified species of plants include: *Achillea millefolium*, *Arrthenatherum elatius*, *Artemisia campestris*, *Calamagrostis epigeios*, *Carex hirta*, *Carlina vulgaris*, *Cerastium arvense*, *Conyza canadensis*, *Fragaria viridis*, *Galium mollugo*, *Galium verum*. The plot also features a few saplings of trees and shrubs: *Pinus sylvestris*, *Betula pendula* and *Pyrus communis* (Tab. 6.1).

Fungi of the plot are abundant. They are represented by 14 species of macromycetes. Among land fungi, the most frequently found was *Marasmius oreades*. Some sparse sporocarps of mycorrhizal fungi were also found in the area: *Scleroderma citrina*, *Amanita muscaria*, *Inocybe asterospora*, *Xerocomus badius*. On dead pine trees, sporocarps of *Schizophyllum commune* and *Trichaptum abietinum* were observed (Tab. 7.1).

STUDY PLOT RACISZYN C (51°05'27''N, 18°51'10''E; elevation 210 m a.s.l.)

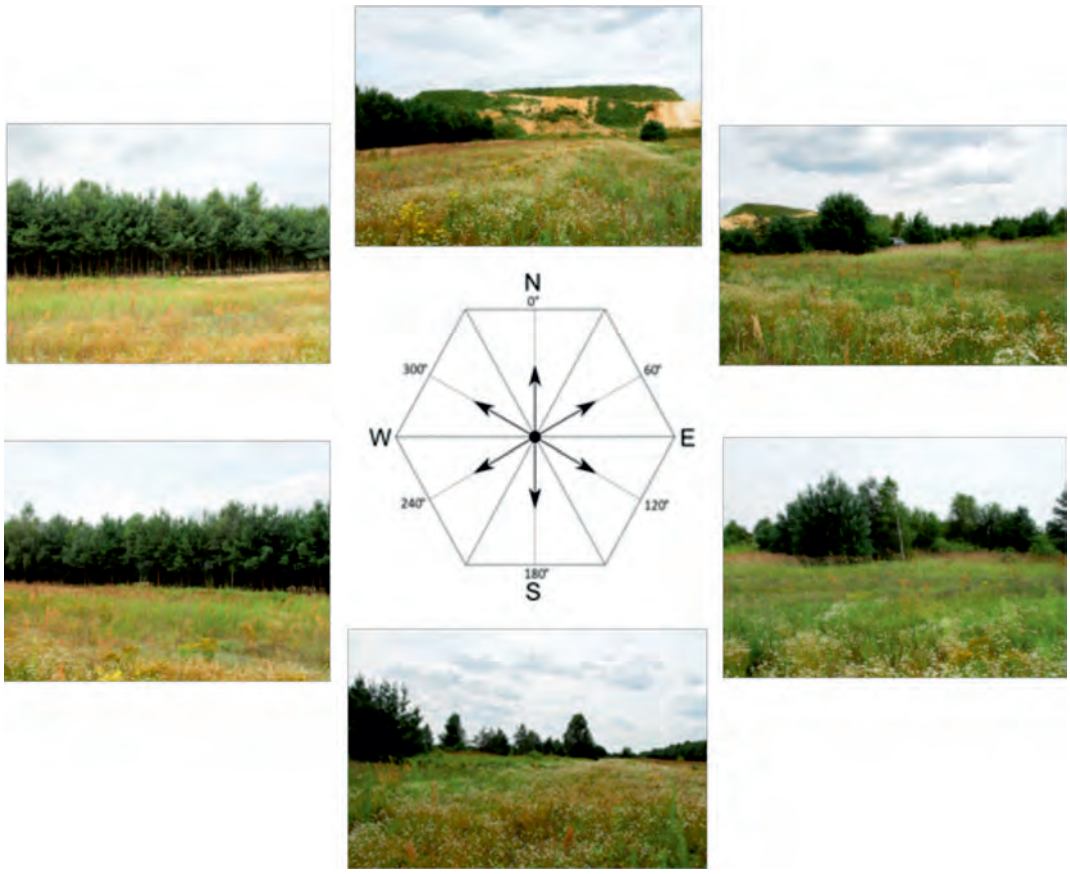


Fig. 5.47. Study plot Raciszyn C (photo E. Papińska, 2012)

Depth		Profile description
1–0 cm	–	organic horizon
0–20 cm	–	humus, medium sand, grey and dark brown
20–100 cm	–	medium sand, rusty, moisture content increases with depth

Fig. 5.48. Soil pit in study plot Raciszyn C (photo. E. Papińska, 2012)

Table 5.27. Raciszyn C. Granulometric and chemical properties of soil

Soil pit	Sampling depth cm	Grain size distribution %									Granulometric subgroup	Specific surface area $m^2 \cdot g^{-1}$
		2.0–1.0 mm	1.0–0.5 mm	0.5–0.25 mm	0.25–0.1 mm	0.1–0.05 mm	0.05–0.02 mm	0.02–0.005 mm	0.005–0.002 mm	<0.002 mm		
Raciszyn C	0–20	3.5	36.3	35.0	6.9	4.9	6.4	4.7	1.3	0.9	ps	0.131
Raciszyn C	20–40	2.6	43.4	43.4	6.1	1.4	1.0	1.4	0.6	0.1	pl	0.0401
Raciszyn C	90–110	1.7	37.1	41.8	8.5	3.2	3.3	2.5	1.1	0.7	pl	0.0952

Soil pit	Sampling depth cm	Humus %	C total %	N total %	C/N	pH in		Available nutrients mg/100g		
						KCl	H_2O	P_2O_5	K_2O	Mg
Raciszyn C	0–20	1.73	1.003	0.078	12.865	4.2	4.9	2.5	1.7	0.3
Raciszyn C	20–40	–	–	–	–	4.6	5.4	1.6	0.2	0.4
Raciszyn C	90–110	–	–	–	–	4.8	5.9	1.2	1.9	0.6

Soil pit	Sampling depth cm	Hydrolytic acidity mmol/100g	Exchangeable cations me/100g				Sorption capacity me/100g			
			Ca^{2+}	Mg^{2+}	Na^{+}	K^{+}	S	T	(T–S)	V, %
Raciszyn C	0–20	3.89	0.40	0.025	0.026	0.062	0.513	4.403	3.89	11.651
Raciszyn C	20–40	1.09	0.15	0.028	0.017	0.026	0.221	1.311	1.09	16.857
Raciszyn C	90–110	0.62	0.50	0.047	0.035	0.049	0.631	1.251	0.62	50.440

Source: own elaboration.

Characteristics of the flora and fungi – Raciszyn C

Approximately 100% of the study plot is covered with plants. Rich in species (31). Two species dominate: *Hieracium pilosella* (about 40%) and *Pteridium aquilinum* (30%). About 5% of the area is covered by the following species: *Achillea millefolium*, *Festuca rubra* and *Calamagrostis epigeios*. The share of other species does not exceed 0.5% of area coverage (Photo 6.6). Other identified species of plants include: *Agrostis capillaris*, *Artemisia vulgaris*, *Carlina vulgaris*, *Centaurea stoebe*, *C. scabiosa*, *Conyza canadensis*, *Convolvulus arvensis*, *Coronilla varia*, *Dianthus carthusiana*. There are also some trees and shrubs in the area: *Pinus sylvestris* and *Rosa sp*.

Fungi of the plot include 18 species of macromycetes (Photo 7.5). The most frequently found species is *Marasmius oreades*. In the lush undergrowth, the following species were also found: *Clitopilus prunulus*, *Clitocybe vibecina*, *Conocybe tenera*. Mycorrhizal fungi were represented by: *Amanita muscaria* and *Boletus edulis*. *Hemimycena lactea* was found fruiting on pine needles (Tab. 7.1).

Analysis of granulometric composition and chemical properties of soils in the Raciszyn study plot group

The analysis results presented in tables 5.25–5.27 indicate that grain size distribution at individual plots of the study plot group is diverse. At plot Raciszyn A, the granulometric composition of all samples is dominated by the fraction of sands, whose share decreases with depth, from 85.6% in the sample from 0–20 cm to 73.1% at the depth of 90–110 cm. On the other hand, there is an increasing share of silts (from 13.4% to 23.9%) and clays (from 1% to 3.1%). Content analysis of the

fractions <0.02 mm, which is the basis for assigning the agronomic category of soils, ranges from 7.4% in the sample from 0–20 cm to 16.2% at the depth of 90–110 cm. The soil was classified as category I – very light soils.

The high content of the finest fractions (silts and clays) in all samples, influences another parameter of the analysed soil – its specific surface area. The value of this parameter increases with depth, from 0.15 $m^2 \cdot g^{-1}$ (sample from the depth of 0–20 cm) to 0.363 $m^2 \cdot g^{-1}$ (sample from the depth of 90–110 cm).

At plot Raciszyn B, the granulometric composition in all horizons is similar – the granulometric subgroup of loose sand (pl). In this case, the share of the sandy fraction increases with depth from 87.4 (0–20 cm) to 94.3 (90–100 cm of depth). The share of silts is the highest in the uppermost sample and reaches nearly 12%, to decrease to the value of 5.1% in the deepest sample. The share of the clayey fraction at this site is the highest at the depth of 20–40 cm: 1.4%. Dominance of the sandy fraction in the grain size distribution resulted in classifying them as agronomic category I – very light soils. The specific surface area is the lowest at the depth of 90–100 cm with the value of 0.0887 $m^2 \cdot g^{-1}$, and the highest at 0.176 $m^2 \cdot g^{-1}$ in the sample from the depth of 20–40 cm, where the share of the finest fraction (clays) is the highest of the entire profile.

The grain size distribution results for plot Raciszyn C are different. The occurrence of slightly loamy sand (ps) was identified the closest to the surface, and in other horizons – loose sands (pl). The content of sands is the lowest in the sample from the depth of 20–40 cm is nearly 97%, which leaves very little room for other granulometric groups – 3% of silts and 0.1% of clays. Specific surface reached the lowest value in this horizon: 0.0401 $m^2 \cdot g^{-1}$. More favourable parameters of grain size distribution, and thus also of specific surface, were found in the sample from the 0–20 cm horizon. The share of the sandy fraction of 87.4% is the lowest of the entire profile, whereas it is the highest for silts (12.4%) and clays (0.9%). In this horizon, the value of specific surface was estimated at 0.131 $m^2 \cdot g^{-1}$.

The pH reaction of the soil in KCl in all horizons of plots Raciszyn A and B is very acidic and changes with depth within a very narrow range. It is similar in the 0–20 cm horizon at Raciszyn C, but it increases slightly to acidic in the subsequent two horizons. The same parameter analysed in H_2O indicates a slight increase into the depth of the profile, e.g.: from pH 4.8 to 5.3 at site A, or from pH 4.9 to 5.9 at site C. The degree of saturation with alkaline cations (V) also corresponds to this tendency, increasing in samples from Raciszyn A from 7.279% in the upper horizon to 55.028% in the deepest horizon. This is due to the content of calcium cations (Ca^{2+}), which increases with depth. However, the highest saturation with alkaline cations occurs in samples from Raciszyn B. This parameter changes with depth from 28.183% (0–20 cm) to 65.728% (90–100 cm).

The content of nutrients available to plants is not sufficient. For phosphorus (P_2O_5), the value is low in only one sample (the first sample from Raciszyn A), and very low in all the remaining samples. Potassium (K_2O) also shows low or very low content. The values were a bit better for magnesium (Mg), from very low to medium availability (samples from the depth of 90–110 cm at sites Raciszyn A and B).

The humus content in the uppermost horizon ranges from 0.94% (at Raciszyn A) to 1.73% (at Raciszyn C). It is the highest content of all the analysed study plots. The content of organic carbon ranges from 0.545% (at Raciszyn A) to 1.003%.

5.3. Abandoned land study plot groups in the buffer zones around the Bolimów Landscape Park and the Łódź Hills Landscape Park

Anna Majchrowska, Jolanta Adamczyk, Jarosław Sieradzki

POLESIE STUDY PLOT GROUP

The Polesie study plot group lies about 5 km to the west of the Bolimów Landscape Park, in Łyszkowice Commune, Łowicz District. According to the physicogeographical regionalisation of Poland (Kondracki 2002), it is located in the central part of the mesoregion of the Łowicz–Błonie Plain, in the macroregion of the Central Mazovian Lowland. The Polesie group lies in one of the southern branches of the North-Central Ecological Corridor (Jędrzejewski et al. 2011).

The area has the structure of a mosaic of abandoned lands at various ages and planted forests, mostly pine ones. In the west, it borders a vast forest complex, whereas on the other sides, it is surrounded with areas of alternating farmlands, abandoned lands and forests, which are mostly artificially planted. The share of farmlands clearly increases towards the north-east and east.

The geological substratum of the study plot group was presented at the junction of two sheets of the Detailed Geological Map of Poland (Brzeziński 1990, 1995), as fluvioglacial and fluvial sands and gravels of the North-Mazovian stage of the Central Polish Glaciation, and upper fluvioglacial sands and gravels of the Warta Glaciation, respectively. The grade of soils was described in soil and agricultural maps (http://geoportal.lodzkie.pl/imap/) as loose sands, of which leached brown soils originated. The soils were classified as very poor rye complex (7) of agricultural suitability and class VI of soil valuation (http://geoportal.lodzkie.pl/imap/).

All plots of the described group: Polesie A, B and C are found in a type 6 geocomplex – glacial and fluvioglacial boulders, cobbles, gravels, sands and muds of plateaus, alluvial fans and erosional-accumulational terraces. It is included in the group of lithogenic geocomplexes, which normally do not undergo excessive moisturising, associated with permeable Quaternary formations.

The physiognomy of the study plot group and soil profiles is illustrated with figures 5.49–5.54. The results of laboratory analyses of soils were presented in tables 5.28–5.30.

STUDY PLOT POLESIE A (50°00’799N, 19°59’941E, elevation 112 m a.s.l.)

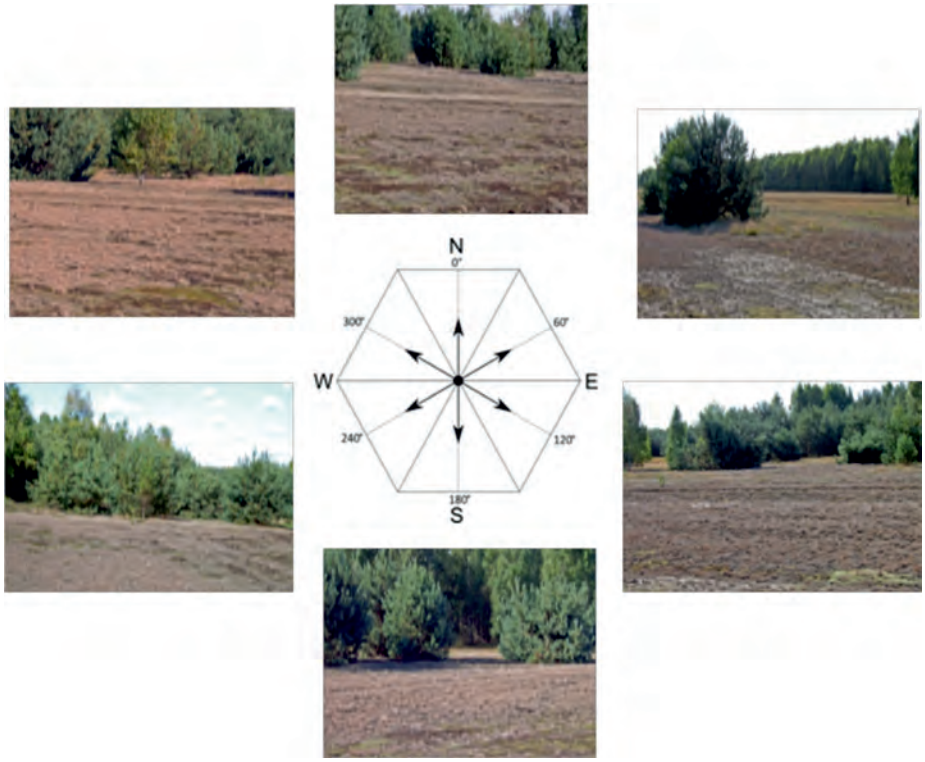


Fig. 5.49. Study plot Polesie A (photo A. Majchrowska, 2013)

Depth		Profile description
0–20 cm	–	humus, fine silty sand, dark brown
0–100 cm	–	fine and medium sand, yellow
100–140cm	–	fine and medium sand, light yellow and grey
140–150cm	–	medium and fine sand, light yellow and grey, with some single cobbles of 1–1.5 cm in diameter

Fig. 5.50. Soil pit in study plot Polesie A (photo A. Majchrowska, 2013)

Table 5.28. Study plot Polesie A. Granulometric and chemical properties of the soil

Soil pit	Sampling depth cm	Grain size distribution %									Granulometric sub-group	Specific surface area $m^2 \cdot g^{-1}$
		2.0–1.0 mm	1.0–0.5 mm	0.5–0.25 mm	0.25–0.1 mm	0.1–0.05 mm	0.05–0.02 mm	0.02–0.005 mm	0.005–0.002 mm	<0.002 mm		
Polesie A	0–20	1.3	20.7	30.4	15.5	2.9	5.2	11.7	7.5	4.8	gp	0.532
Polesie A	20–40	1.7	24.2	41.6	27.2	3.2	1.1	0.7	0.2	0.0	p	0.0313
Polesie A	90–110	1.0	21.7	42.4	30.8	3.0	1.1	0.0	0.0	0.0	p	0.0244

Soil pit	Sampling depth cm	Humus %	C total %	N total %	C/N	pH in		Available nutrients mg/100g		
						KCl	H_2O	P_2O_5	K_2O	Mg
Polesie A	0–20	1.42	0.824	0.053	15.54	4.0	4.4	9.8	0.4	0.3
Polesie A	20–40	–	–	–	–	4.5	4.7	2.5	0.3	0.2
Polesie A	90–110	–	–	–	–	4.6	4.9	1.4	0.3	0.3

Soil pit	Sampling depth cm	Hydrolytic acidity mmol/100g	Exchangeable cations me/100g				Sorption capacity me/100g			
			Ca^{2+}	Mg^{2+}	Na^{+}	K^{+}	S	T	(T–S)	V, %
Polesie A	0–20	3.62	0.15	0.017	0.026	0.026	0.219	3.839	3.62	5.7
Polesie A	20–40	1.39	0.15	0.013	0.017	0.018	0.198	1.588	1.39	12.5
Polesie A	90–110	1.00	0.10	0.013	0.017	0.018	0.148	1.148	1.00	12.9

Source: own elaboration.

Characteristics of the flora and fungi – Polesie A

The study plot is floristically poor, only about 15% is covered with plants. Only three species of vascular plants were found: *Corynephorus canescens*, which covered about 10% of the area, *Rumex acetosella* and *Pinus sylvestris* in small amounts. The layer of lichens (about 3%) and mosses (about 1%) was not very abundant (Photo 7.6). The following species of lichens were found: *Cladonia arbuscula*, *Cladonia coccifera*, *Cladonia uncialis*. Among the lichens there was one species of moss – *Polytrichum piliferum* (Tab. 6.1).

Fungi of the plot are sparse. They are represented by only 4 species of macromycetes. The most frequently occurring was *Marasmius oreades*. Several sporocarps of mycorrhizal fungi were also observed: *Scleroderma citrina*, *Amanita muscaria*, *Inocybe asterospora* (Tab. 7.1).

STUDY PLOT POLESIE B (52°00'857N, 19°59'921E, elevation 103 m a.s.l.)

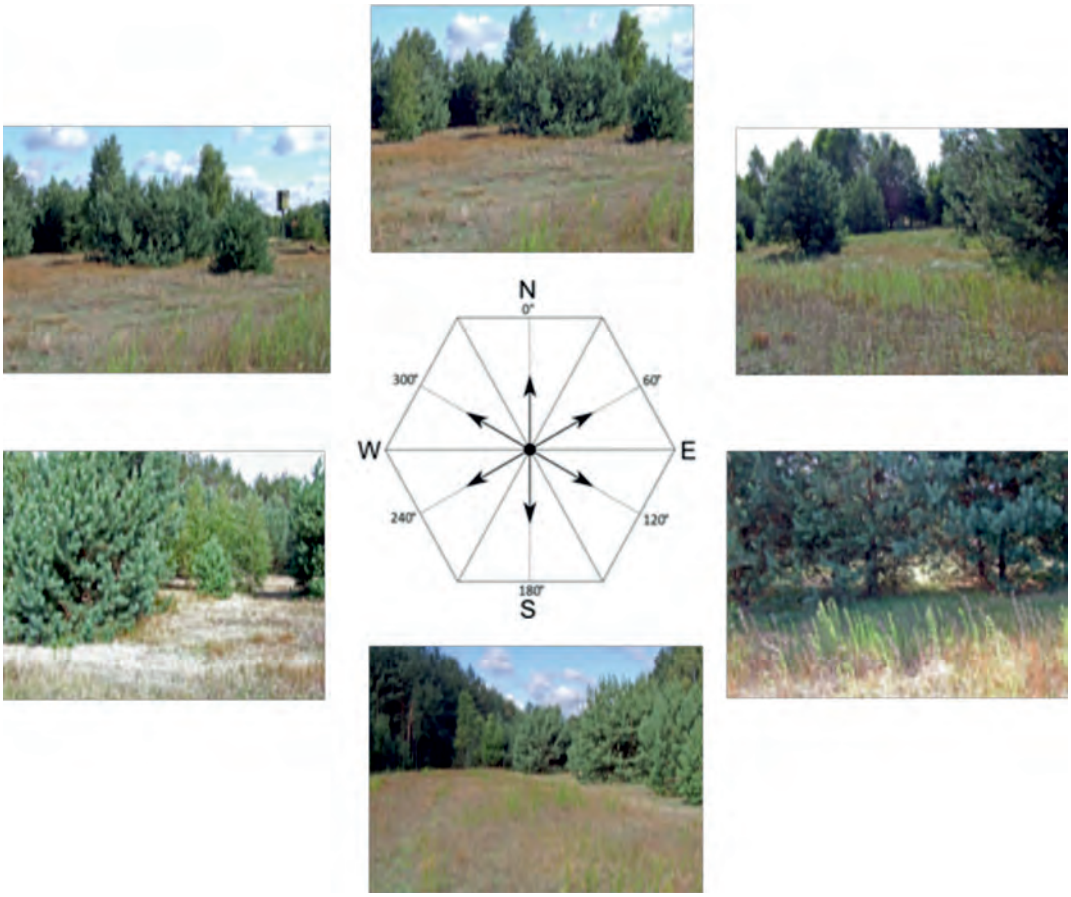


Fig. 5.51. Study plot Polesie B (photo A. Majchrowska, 2013)

Depth		Profile description
0–25 cm	–	humus, medium and fine sand, dark grey
25–50 cm	–	medium and fine sand, golden, with gravel
50–100 cm	–	medium sand, light yellow, with more gravel
100–140 cm	–	medium sand, light beige, with gravel

Fig. 5.52. Soil pit in study plot Polesie B (photo A. Majchrowska, 2013)

Table 5.29. Study plot Polesie B. Granulometric and chemical properties of soil

Soil pit	Sampling depth cm	Grain size distribution %									Granulometric sub-group	Specific surface area $m^2 \cdot g^{-1}$
		2.0–1.0 mm	1.0–0.5 mm	0.5–0.25 mm	0.25–0.1 mm	0.1–0.05 mm	0.05–0.02 mm	0.02–0.005 mm	0.005–0.002 mm	<0.002 mm		
Polesie B	0–20	0.6	21.5	39.6	25	4.9	4.7	2.8	0.8	0.1	p	0.0645
Polesie B	20–40	0.5	20.6	40.9	28.8	3.4	2.7	2.0	0.8	0.3	p	0.0697
Polesie B	90–110	2.1	30.7	42.8	20.3	1.0	0.8	1.3	0.8	0.2	p	0.0515

Soil pit	Sampling depth cm	Humus %	C total %	N total %	C/N	pH in		Available nutrients mg/100g		
						KCl	H_2O	P_2O_5	K_2O	Mg
Polesie B	0–20	2.24	1.3	0.092	14.12	4.0	4.6	10.3	1.1	0.6
Polesie B	20–40	–	–	–	–	4.5	5.0	1.7	0.8	0.4
Polesie B	90–110	–	–	–	–	4.6	4.9	1.5	1.0	0.4

Soil pit	Sampling depth cm	Hydrolytic acidity mmol/100g	Exchangeable cations me/100g				Sorption capacity me/100g			
			Ca^{2+}	Mg^{2+}	Na^{+}	K^{+}	S	T	(T–S)	V, %
Polesie B	0–20	4.90	0.35	0.045	0.026	0.044	0.465	5.365	4.90	11.5
Polesie B	20–40	2.00	0.15	0.030	0.017	0.038	0.235	2.235	2.00	9.5
Polesie B	90–110	1.27	0.15	0.018	0.017	0.044	0.229	1.499	1.27	15.3

Source: own elaboration.

Characteristics of the flora and fungi – Polesie B

Approximately 90% of the study plot is covered with plants. Three species dominate among plants: *Agrostis capillaris* (about 10%), *Hieracium pilosella* (about 60%) and *Festuca rubra* (about 10%). The share of other species does not exceed 3% of area coverage. Other identified species include: *Apera spica-venti*, *Jasione montana*, *Centaurea cyanus*, *Conyza canadensis*, *Elymus repens*, *Galeopsis ladanum* (Tab. 6.1).

Fungi of the plot are sparse. They are represented by only 9 species of macromycetes. The most frequently found species is *Crinipellis scabella*, which occurs on grasses. Among land fungi, the most abundant species were *Marasmius oreades* and *Bovista plumbea* (Tab. 7.1).

STUDY PLOT POLESIE C (52°00'893N, 19°59'895E, elevation 106 m a.s.l.)

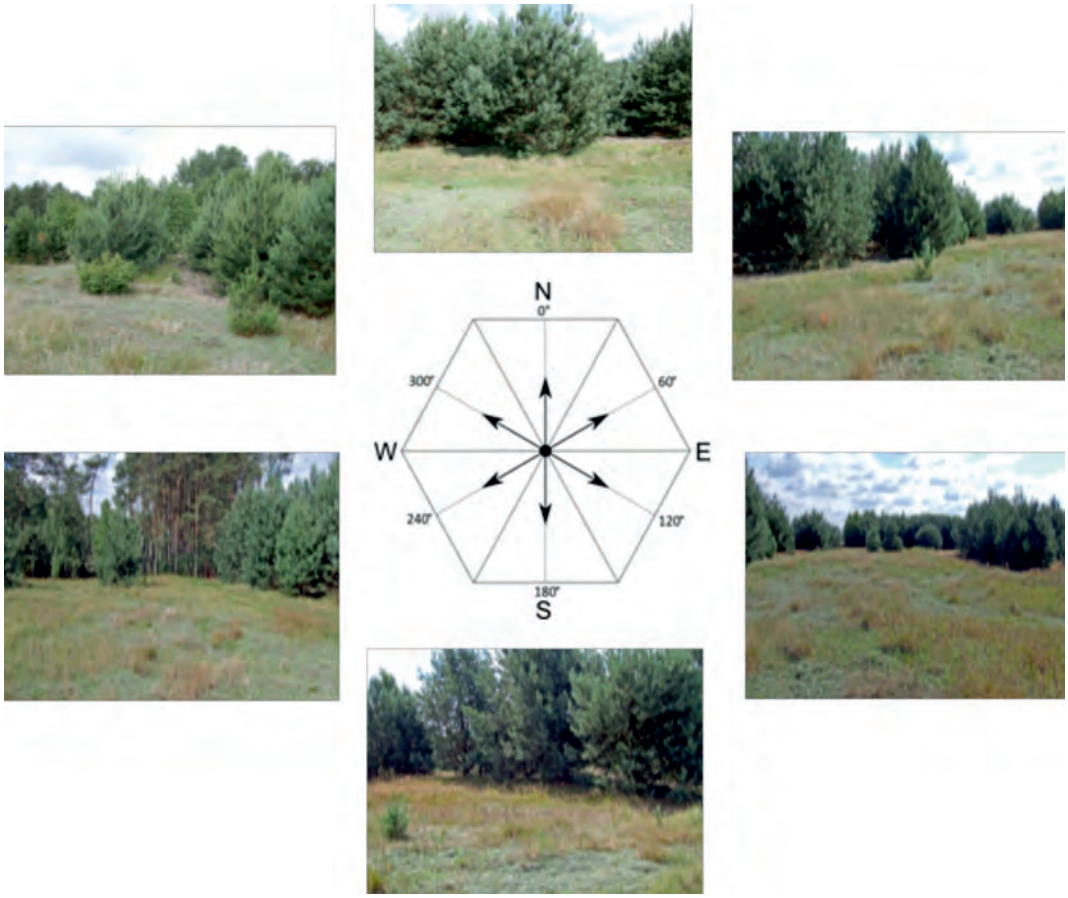


Fig. 5.53. Study plot Polesie C (photo A. Majchrowska, 2013)

Depth		Profile description
0–26 cm	–	humus, medium and fine sand, dark brown
26–40 cm	–	fine sand, yellow and golden, with a single cobble of 8 cm in diameter
40–90 cm	–	fine and medium sand, yellow and golden
90–140 cm	–	medium and coarse sand, light yellow, with gravel

Fig. 5.54. Soil pit in study plot Polesie C (photo A. Majchrowska, 2013)

Table 5.30. Study plot Polesie C. Granulometric and chemical properties of soil

Soil pit	Sampling depth cm	Grain size distribution %									Granulometric sub-group	Specific surface area $m^2 \cdot g^{-1}$
		2.0–1.0 mm	1.0–0.5 mm	0.5–0.25 mm	0.25–0.1 mm	0.1–0.05 mm	0.05–0.02 mm	0.02–0.005 mm	0.005–0.002 mm	<0.002 mm		
Polesie C	0–20	1.5	23.9	37.3	20.7	5.6	5.9	3.7	1.0	0.5	p	0.0954
Polesie C	20–40	0.6	25.1	43.2	19.9	2.6	3.3	3.0	1.4	0.9	p	0.1190
Polesie C	90–110	11.0	51.1	34.6	3.3	0.0	0.0	0.0	0.0	0.0	p	0.0116

Soil pit	Sampling depth cm	Humus %	C total %	N total %	C/N	pH in		Available nutrients mg/100g		
						KCl	H_2O	P_2O_5	K_2O	Mg
Polesie C	0–20	2.23	1.29	0.093	13.91	4.6	5.5	5.2	1.1	0.8
Polesie C	20–40	–	–	–	–	4.7	5.7	1.6	0.8	0.4
Polesie C	90–110	–	–	–	–	4.7	5.6	2.0	0.6	0.2

Soil pit	Sampling depth cm	Hydrolytic acidity mmol/100g	Exchangeable cations me/100g				Sorption capacity me/100g			
			Ca^{2+}	Mg^{2+}	Na^{+}	K^{+}	S	T	(T–S)	V, %
Polesie C	0–20	3.49	1.80	0.060	0.043	0.044	1.947	5.437	3.49	35.80
Polesie C	20–40	1.90	0.50	0.028	0.026	0.044	0.598	2.498	1.90	23.94
Polesie C	90–110	0.90	0.10	0.015	0.035	0.026	0.176	1.076	0.90	16.36

Source: own elaboration.

Characteristics of the flora and fungi – Polesie C

Approximately 90% of the study plot is covered with plants. Three species dominate among plants: *Hieracium pilosella* (about 50%), *Agrostis capillaris* (about 10%) and *Corynephorus canescens* (about 10%). The share of other species does not exceed 2% of area coverage. Other identified species include: *Helichrysum arenaria*, *Conyza canadensis*, *Elymus repens*, *Festuca rubra*, *Holcus lanatus*, *Viola arvensis*. Species found in the young tree layer include: *Pinus sylvestris* and *Sorbus aucuparia* (Tab. 6.1).

Fungi of the area are poor. They are represented by only 6 species of macromycetes. The most frequently occurring species is *Crinipellis scabella*, which occurs on grasses, mainly on *Agrostis capillaris* and *Festuca rubra*. Among terrestrial fungi, the most abundant species was *Marasmius oreades*. Fairly numerous sporocarps of mycorrhizal fungi were found in the area: *Amanita muscaria*, *Xerocomus badius* (Tab. 7.1).

Analysis of granulometric composition and chemical properties of soils in the Polesie study plot group

On the basis of the results of grain size analyses (Tab. 5.28–5.30), soils of the abandoned lands in the Polesie study plot group were classified as the granulometric group of sand (p) (Polskie Towarzystwo Gleboznawcze 2009). The surface horizon (0–20 cm) of soil at plot Polesie A was an exception, with an increased content of the silty and clayey fractions (up to 29.2%), which was classified as sandy loam (gp). At all plots, the content of this fraction decreased with depth. The grain size

distribution of soil at plot Polesie A allowed for classifying it as the medium category of agrotechnical heaviness, and the soils at the other plots were classified as very light soils.

The value of specific surface area shows a relation with the granulometric composition and was at its highest where the content of fine fractions was high, in the surface horizon of plot Polesie A.

The content of humus, ranging from 1.42 to 2.24% in the analysed soils, was defined as medium and high. The poorest in humus was the soil at plot Polesie A. The C/N ratio oscillated around 15:1–13:1. The pH reaction of the analysed soils at plots Polesie A and B was very acidic, and at site Polesie C – acidic.

The surface horizon of soils in the Polesie study plot group was characterised by low and medium content of easily available phosphorus, whereas in the lower horizons, the content of phosphorus decreased to very low. The content of available potassium and magnesium was very low for all the analysed soil horizons.

The soils revealed varied hydrolytic acidity, with values ranging from 0.9–4.9 mmol/100g. The total capacity for cation exchange was very low: the maximum value was 5.437 mmol/100g. Saturation of the sorptive complex with alkaline ions was very low at plots Polesie A and B (5.7%–15.3%). The degree of saturation with alkalis at plot Polesie C in the 0–20 cm horizon was the highest, though it was low in general, as it was 35.8% and decreased into the depth of the soil profile to 16%. The highest values of acidity, total alkaline cations and the values of total absorbing capacity were found in humus horizons.

WOLA MAKOWSKA STUDY PLOT GROUP

The Wola Makowska study plot group is located about 7 km west of the Bolimów Landscape Park, in Maków Commune, Skierniewice District. According to the physicogeographical regionalisation (Kondracki 2002), it is located in the southern part of the mesoregion of the Łowicz–Błonie Plain, in the macroregion of the Central Mazovian Lowland. Elevation of the analysed area is about 110–120 m a.s.l.

In the west, the study plot group borders on an extensive forest complex. In the north and east, it borders on belts of farmlands and meadows, dissected by a stream called Ruczaj. In the south, the area neighbours arable lands with a small share of abandoned fields, and with several strips of planted woodland.

According to the Detailed Geological Map of Poland, the substratum of the analysed area is formed by Quaternary sands of alluvial fans and Holocene aeolian sands (Balińska-Wuttke 1958). On the basis of a soil and agricultural map (http://geoportal.lodzkie.pl/imap/), the soils were qualified as leeched brown soils, formed upon loose sand and were classified as very poor rye complex (7) of agricultural suitability. The plot Makowska Wola C lies in direct neighbourhood of the border between leeched brown soils and muck soils, classified as very poor grassland (3z). Soils of the plots Wola Makowska A and B were qualified as valuation class VIRz, and soils of the plot Wola Makowska C – as class VI of arable lands (http://geoportal.lodzkie.pl/imap/).

Plot Wola Makowska A is located within a type 15 geocomplex – aeolian sands of dunes and shields, plot B – on the border between geocomplexes 15 and 6 – geocomplex of glacial and fluvioglacial boulders, cobbles, gravels, sands and muds of plateaus, alluvial fans and erosional-accumulational terraces, and plot Wola Makowska C – in a type 6 geocomplex. Type 6 and 15 geocomplexes are included in the group of lithogenic units, which normally do not undergo excessive moisturising, associated with permeable Quaternary deposits.

Photographical documentation of the Wola Makowska study plot group and soil profiles consists of a set of figures 5.55–5.60. The results of detailed laboratory analyses are presented in tables 5.31–5.33.

STUDY PLOT WOLA MAKOWSKA A (51°58'309N, 20°01'664E, elevation 109 m a.s.l.)

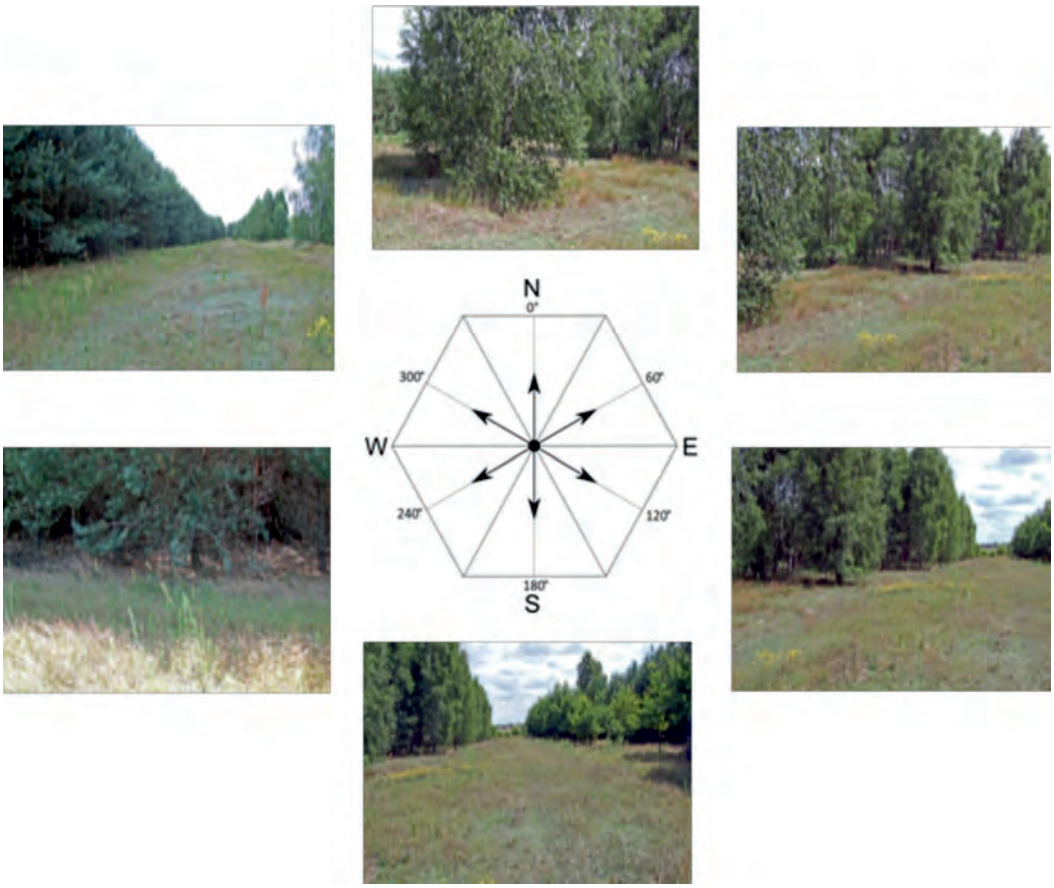


Fig. 5.55. Study plot Wola Makowska A (photo A. Majchrowska, 2013)

Depth		Profile description
0–20 cm	–	humus; unsorted sand, silty, light brown
20–60 cm	–	fine and silty sand, yellow and beige
60–110 cm	–	silty sand and fine sand, light beige
110–150 cm	–	silty sand, light grey and white

Fig. 5.56. Soil pit in study plot Wola Makowska A (photo A. Majchrowska, 2013)

Table 5.31. Study plot Wola Makowska A. Granulometric and chemical properties of soil

Soil pit	Sampling depth cm	Grain size distribution %									Granulometric sub-group	Specific surface area $m^2 \cdot g^{-1}$
		2.0–1.0 mm	1.0–0.5 mm	0.5–0.25 mm	0.25–0.1 mm	0.1–0.05 mm	0.05–0.02 mm	0.02–0.005 mm	0.005–0.002 mm	<0.002 mm		
Wola Makowska A	0–20	0.1	14.7	41.6	32.6	4.9	2.8	2.0	0.9	0.4	p	0.0794
Wola Makowska A	20–40	0.0	12.4	39.4	34.4	7.1	3.5	2.0	0.8	0.5	p	0.0826
Wola Makowska A	90–110	0.0	10.0	37.7	38.3	8.7	3.2	1.4	0.6	0.1	p	0.0562

Soil pit	Sampling depth cm	Humus %	C total %	N total %	C/N	pH in		Available nutrients mg/100g		
						KCl	H_2O	P_2O_5	K_2O	Mg
Wola Makowska A	0–20	0.63	0.365	0.033	11.07	4.3	5.3	10.1	2.0	0.4
Wola Makowska A	20–40	–	–	–	–	4.5	5.1	17.2	0.7	0.3
Wola Makowska A	90–110	–	–	–	–	4.5	5.6	6.6	1.1	0.7

Soil pit	Sampling depth cm	Hydrolytic acidity mmol/100g	Exchangeable cations me/100g				Sorption capacity me/100g			
			Ca^{2+}	Mg^{2+}	Na^{+}	K^{+}	S	T	(T–S)	V, %
Wola Makowska A	0–20	2.20	0.50	0.025	0.026	0.074	0.625	2.825	2.20	22.12
Wola Makowska A	20–40	2.00	0.20	0.015	0.026	0.031	0.272	2.272	2.00	11.97
Wola Makowska A	90–110	1.00	0.30	0.048	0.009	0.038	0.395	1.395	1.00	28.32

Source: own elaboration.

Characteristics of the flora and fungi – Wola Makowska A

Approximately 90% of the study plot is covered with plants. Poor in species (11). Four species dominate: *Hieracium pilosella* (40%), *Rumex acetosa* (10%), *Corynephorus canescens* (10%) and *Chelichrysum arenaria* (10%). The share of other species ranges between 5% and 0.5% of area coverage. They include: *Achillea millefolium*, *Convolvulus arvensis*, *Conyza canadensis* (Tab. 6.1).

Fungi of the plot are sparse. They are represented by only 3 species of macromycetes. They are: *Marasmius oreades*, *Conocybe rickeaniana* and *Panaeolus foenisecii* (Tab. 7.1).

STUDY PLOT WOLA MAKOWSKA B (51°58'436N, 20°01'479E, elevation 112 m a.s.l.)

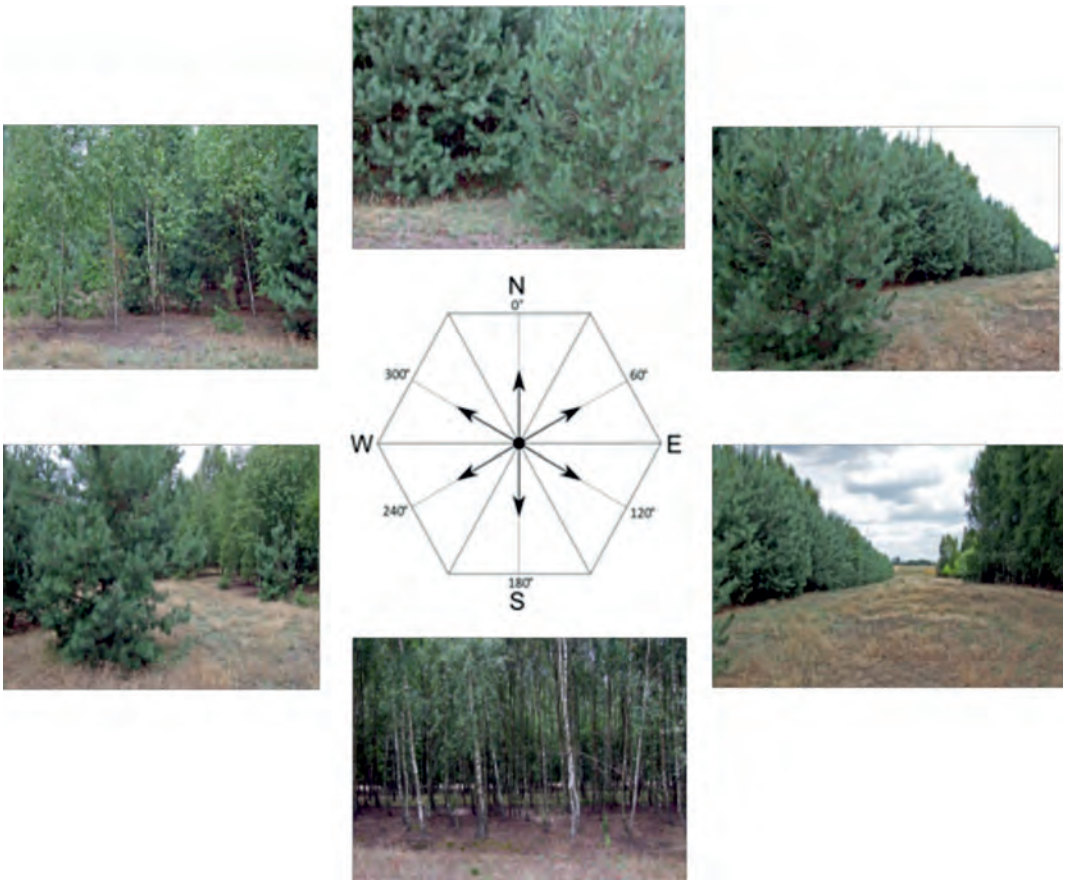


Fig. 5.57. Study plot Wola Makowska B (photo A. Majchrowska, 2013)

Depth		Profile description
0–20 cm	–	humus, fine sand, brown and grey
20–70 cm	–	medium and fine sand, yellow
70–110 cm	–	fine sand, silty, light yellow

Fig. 5.58. Soil pit in study plot Wola Makowska B (photo A. Majchrowska, 2013)

Table 5.32. Study plot Wola Makowska B. Granulometric and chemical properties of soil

Soil pit	Sampling depth cm	Grain size distribution %									Granulometric sub-group	Specific surface area $m^2 \cdot g^{-1}$
		2.0–1.0 mm	1.0–0.5 mm	0.5–0.25 mm	0.25–0.1 mm	0.1–0.05 mm	0.05–0.02 mm	0.02–0.005 mm	0.005–0.002 mm	<0.002 mm		
Wola Makowska B	0–20	0.2	19.4	43.4	29.3	2.9	2.3	1.7	0.8	0.1	p	0.0543
Wola Makowska B	20–40	0.0	18.5	45.6	32.5	2.3	1.1	0.0	0.0	0.0	p	0.0245
Wola Makowska B	90–110	0.0	9.7	38.4	38.9	6.4	3.1	2.0	0.9	0.6	p	0.0948

Soil pit	Sampling depth cm	Humus %	C total %	N total %	C/N	pH in		Available nutrients mg/100g		
						KCl	H_2O	P_2O_5	K_2O	Mg
Wola Makowska B	0–20	0.85	0.493	0.041	12.02	4.2	4.6	12.4	0.3	0.3
Wola Makowska B	20–40	–	–	–	–	4.6	4.8	7.1	0.3	0.3
Wola Makowska B	90–110	–	–	–	–	4.4	4.7	3.0	0.6	0.3

Soil pit	Sampling depth cm	Hydrolytic acidity mmol/100g	Exchangeable cations me/100g				Sorption capacity me/100g			
			Ca^{2+}	Mg^{2+}	Na^{+}	K^{+}	S	T	(T–S)	V, %
Wola Makowska B	0–20	2.70	0.10	0.017	0.017	0.031	0.165	2.865	2.70	5.76
Wola Makowska B	20–40	1.48	0.15	0.017	0.009	0.026	0.202	1.682	1.48	12.01
Wola Makowska B	90–110	1.30	0.10	0.015	0.009	0.026	0.150	1.450	1.30	10.34

Source: own elaboration.

Characteristics of the flora and fungi – Wola Makowska B

Approximately 70% of the study plot is covered with plants. Poor in plant species (8). Two species dominate: *Corynephorus canescens* (45%) and *Hieracium pilosella* (10%). The share of other species oscillates between 5% and 0.5% of area coverage. The other identified plant species include: *Anthoxanthum aristatum*. Scarce specimens of *Pinus sylvestris* are found in the plot. Among herbaceous plants, there are patches of moss – *Bryum sp*. and lichens – *Cladonia furcata* (Tab. 6.1).

Fungi of the plot are very sparse. They are represented by only 2 species of macromycetes. They are: *Marasmius oreades* and *Conocybe rickeaniana* (Tab. 7.1).

STUDY PLOT WOLA MAKOWSKA C (51°58'534N, 20°01'394E, elevation 118 m a.s.l.)

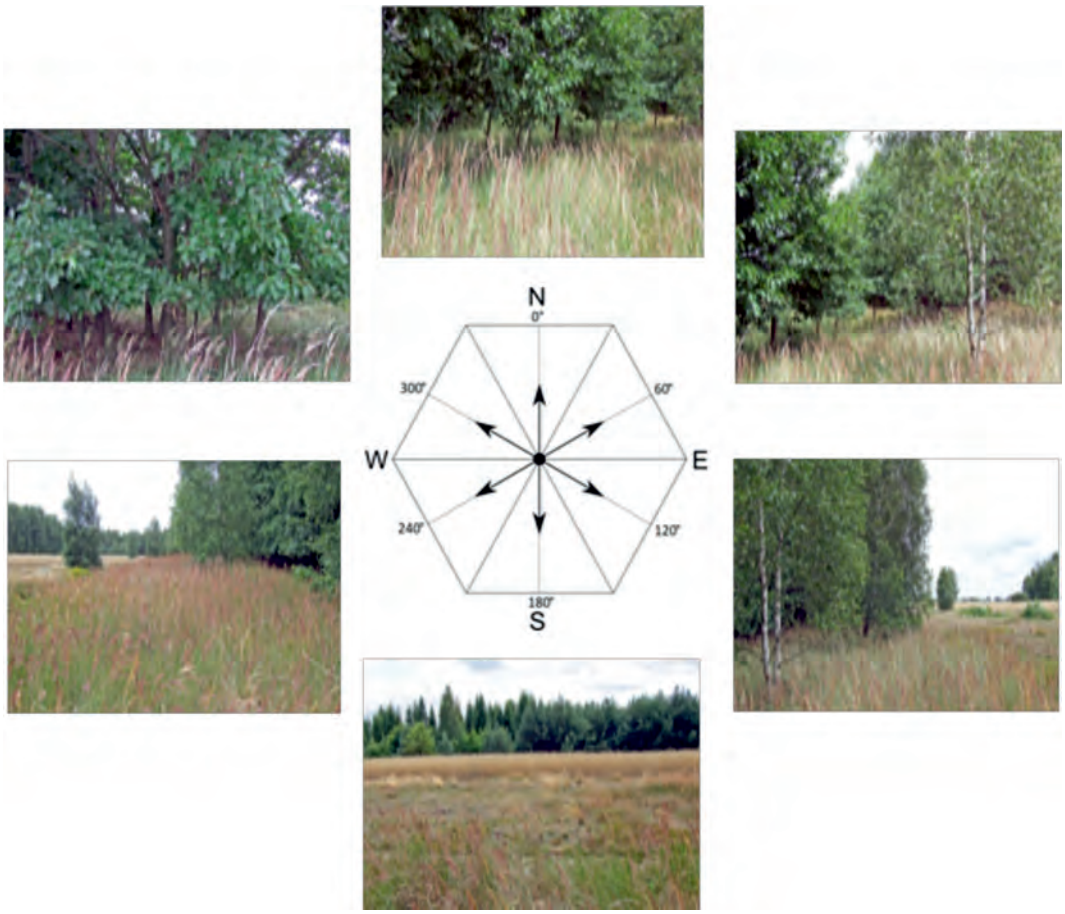


Fig. 5.59. Study plot Wola Makowska C (photo A. Majchrowska, 2013)

Depth		Profile description
0–24 cm	–	humus, numerous grass roots, sandy, brown and grey
24–32 cm	–	humus, fine sand, silty, light brown and grey
32–60 cm	–	fine sand, dark grey
60–90 cm	–	fine sand, yellow and grey
90–120 cm	–	medium sand, grey, yellow and beige

Fig. 5.60. Soil pit in study plot Wola Makowska C (photo A. Majchrowska, 2013)

Table 5.33. Study plot Wola Makowska C. Granulometric and chemical properties of soil

Soil pit	Sampling depth cm	Grain size distribution %									Granulometric sub-group	Specific surface area $m^2 \cdot g^{-1}$
		2.0–1.0 mm	1.0–0.5 mm	0.5–0.25 mm	0.25–0.1 mm	0.1–0.05 mm	0.05–0.02 mm	0.02–0.005 mm	0.005–0.002 mm	<0.002 mm		
Wola Makowska C	0–20	0	12.8	37.8	31.6	7.8	6.1	2.9	0.8	0.2	p	0.0747
Wola Makowska C	20–40	0	13.0	38.5	29.8	6.0	6.0	4.6	1.3	0.7	p	0.1230
Wola Makowska C	90–110	0	14.6	53.5	31.9	0.0	0.0	0.0	0.0	0.0	p	0.0213

Soil pit	Sampling depth cm	Humus %	C total %	N total %	C/N	pH in		Available nutrients mg/100g		
						KCl	H_2O	P_2O_5	K_2O	Mg
Wola Makowska C	0–20	1.70	0.986	0.078	12.64	4.1	4.5	5.0	0.6	0.4
Wola Makowska C	20–40	–	–	–	–	4.3	4.8	1.7	0.4	0.3
Wola Makowska C	90–110	–	–	–	–	4.6	5.2	0.9	0.4	0.3

Soil pit	Sampling depth cm	Hydrolytic acidity mmol/100g	Exchangeable cations me/100g				Sorption capacity me/100g			
			Ca^{2+}	Mg^{2+}	Na^{+}	K^{+}	S	T	(T–S)	V, %
Wola Makowska C	0–20	4.72	0.15	0.027	0.004	0.031	0.212	4.932	4.72	4.30
Wola Makowska C	20–40	4.88	0.15	0.020	0.017	0.026	0.213	5.093	4.88	4.18
Wola Makowska C	90–110	0.94	0.10	0.018	0.009	0.018	0.145	1.085	0.94	13.36

Source: own elaboration.

Characteristics of the flora and fungi – Wola Makowska C

Approximately 90% of the study plot is covered with plants. Very poor in plant species (7). One species dominates: *Calamagrostis epigeios* (85%). Other plants include only *Agrostos capillaris*, which covers about 5% of the area. The other species show only a slight coverage. They include: *Hieracium pilosella*, *Betula pendula*, *Epilobium angustifolium* and *Quercus rubra* (Tab. 6.1).

Fungi of the plot are very sparse. They are represented by only 2 species of macromycetes. They are: *Marasmius oreades* and *Psilocybe semilanceata* (Tab. 7.1).

Analysis of granulometric composition and chemical properties of soils in the Wola Makowska study plot group

On the basis of the results of grain size distribution analyses (Tab. 5.31–5.33) at all study plots and soil horizons, the granulometric group of sand (p) was identified (Polskie Towarzystwo Gleboznawcze 2009). The share of sandy fraction ranged from 87.3% to 100%, and the total content of the fraction below 0.02 mm fell within the range 0–6.6% and was at its highest in the horizon of 20–40 cm, at plot Wola Makowska C. On the basis of the granulometric composition, the soils

in the Wola Makowska study plot group were classified as very light in the category of agrotechnical heaviness.

At plot Wola Makowska C, in the horizon of 20–40 cm, the specific surface area reached the maximum value of only 0.123 $m^2 \cdot g^{-1}$, and in general this index was very low at all analysed soil horizons, due to the low content of the clayey and silty fractions.

The humus content ranged from 0.63% at plot A to 1.70% at plot C. The lowest value occurred in leeched brown soil, formed upon aeolian sands, and the highest – at the plot located on the border between the leeched brown and mucky soil types. The C/N ration was narrow and amounted to about 12:1–11:1.

The pH in 1 M KCl in all soil horizons indicated very acidic reaction and only in horizons 20–40 cm at plot Wola Makowska B and 90–110 cm at plot Wola Makowska C, the reaction was acidic.

The surface horizon of soils at plots Wola Makowska A and B was characterised by medium content of available phosphorus, whereas deeper horizons showed medium, low or very low content of this element. The soil at plot C was very poor in available forms of phosphorus along the entire profile. The content of available potassium and magnesium in all analysed soil horizons was very low.

The soils were characterised by varied hydrolytic acidity, with values within the range from 0.94 to 4.88 mmol/100g. The total content of exchangeable alkaline cations was low, as it was ranging from 0.145 mmol/100g to 0.625 mmol/100g, and its most important component was calcium. Total cation exchange capacity was very low: the maximum value was 5.093 mmol/100g. Saturation of the sorptive complex with alkaline ions (V) was very low (4.18%–13.36%) at plots Wola Makowska B and C. At plot Wola Makowska A, in the horizon of 90–110 cm, the degree of saturation with alkalis was the highest, though it was low in general, amounting to 28.32%.

SZYMANISZKI STUDY PLOT GROUP

The Szymaniszki study plot group is located about 750 m from the borders of the Łódź Hills Landscape Park, on the north-eastern outskirts of Brzeziny. According to the physicogeographical regionalisation of Poland (Kondracki 2002), it lies in the mesoregion of the Łódź Hills, within the macroregion of the South Mazovian Hills.

The analysed area encompasses alternating belts of farmlands, abandoned fields and narrow strips of woodland. In the south, it is restricted by buildings of Szymaniszki. In the east, it borders arable lands, with single strips of abandoned lands and a group of farm buildings and several recreational lots. To the south, there are mainly arable lands. To the west, about 200 metres away, there is a developing pit of a sand mine.

The geological substratum of the area consists of deposits from the Warta Glaciation, diversified genetically and lithologically (Trzmiel 1990). In the south-western part (study plot Szymaniszki A), there are sands and gravels with pebbles of end moraines as well as glacial sands and gravels; in the northern part (study plot Szymaniszki B) – glacial tills, whereas in the remaining area (study plot Szymaniszki C) – fluvioglacial sands.

On the basis of a soil and agricultural map (http://geoportal.lodzkie.pl/imap/), at plot Szymaniszki A leeched brown soil was identified, formed from loamy and silty sand, underneath which lies slightly loamy sand and loose sand. The soil was classified as complex 6 of agricultural suitability – poor rye and class V of arable land valuation. At plots Szymaniszki B and C, there are leeched brown soils, formed from silts, lying over loamy sands. The soils were classified as complex 5 of agricultural suitability – good rye and valuation class IVb. The soil and agricultural map shows the presence of silty and sandy deposits which, due to their low thickness – about 0.5 m – were omitted in the geological map.

The diverse geological substratum is reflected in the complex structure of natural environment of the Szymaniszki group, as each of the three study plots was classified as a different type of morpholithohydrotope: Szymaniszki A – lies in a type 4 geocomplex – boulders, cobbles, gravels, sands and muds of moraine hills, kame hills and esker ridges; Szymaniszki B – in a type 5 geocomplex – glacial tills of plateaus; Szymaniszki C – in a type 6 geocomplex – glacial and fluvioglacial boulders, cobbles, gravels, sands and muds of plateaus, alluvial fans and erosional-accumulational terraces.

Photographic documentation of the Szymaniszki study plot group and analysis results of granulometric composition and chemical properties of soils are presented in figures 5.61–5.66 and in tables 5.34–5.36.

STUDY PLOT SZYMANISZKI A (51°48'944N, 19°46'556E, elevation 229 m a.s.l.)

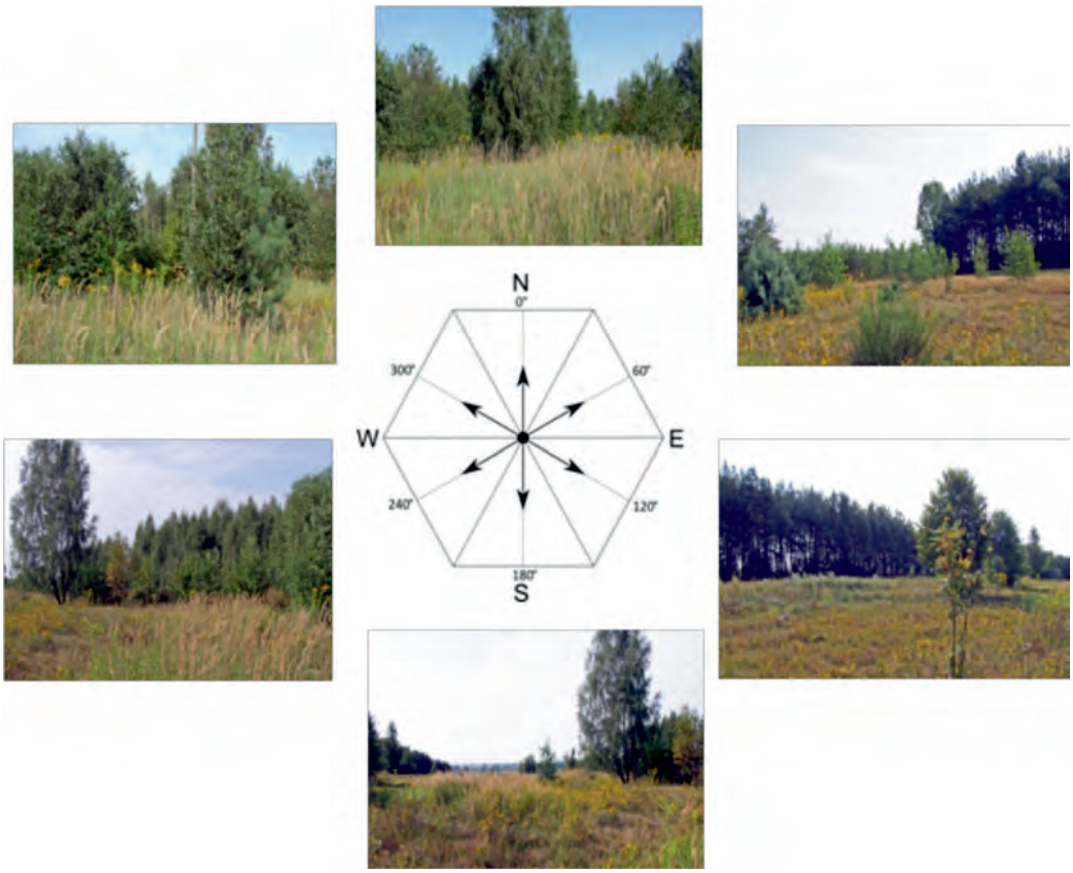


Fig. 5.61. Study plot Szymaniszki A (photo A. Majchrowska, 2013)

Depth		Profile description
0–30 cm	–	humus, sandy and silty, grey and beige
30–45 cm	–	sand with gravel and silt, grey, beige and yellow
45–70 cm	–	unsorted and coarse sand, with gravel and cobbles, rusty
70–110 cm	–	coarse sand, yellow and rusty; with layers of gravel
110–150 cm	–	coarse sand, with increasing content of gravel, yellow and rusty, moist

Fig. 5.62. Soil pit in study plot Szymaniszki A (photo. A. Majchrowska, 2013)

Table 5.34. Study plot Szymaniszki A. Granulometric and chemical properties of soil

Soil pit	Sampling depth cm	Grain size distribution %									Granulometric subgroup	Specific surface area $m^2 \cdot g^{-1}$
		2.0–1.0 mm	1.0–0.5 mm	0.5–0.25 mm	0.25–0.1 mm	0.1–0.05 mm	0.05–0.02 mm	0.02–0.005 mm	0.005–0.002 mm	<0.002 mm		
Szymaniszki A	0–20	5.5	29.9	24.6	6.6	9.5	14.0	6.7	1.7	1.5	pg	0.2110
Szymaniszki A	20–40	6.0	38.2	33.0	5.3	3.9	6.5	4.6	1.4	1.1	ps	0.1460
Szymaniszki A	90–110	6.7	49.8	39.3	4.2	0.0	0.0	0.0	0.0	0.0	p	0.0124

Soil pit	Sampling depth cm	Humus %	C total %	N total %	C/N	pH in		Available nutrients mg/100g		
						KCl	H_2O	P_2O_5	K_2O	Mg
Szymaniszki A	0–20	1.24	0.719	0.069	10.42	4.3	5.1	6.2	5.6	0.6
Szymaniszki A	20–40	–	–	–	–	4.4	5.2	2.9	3.4	0.7
Szymaniszki A	90–110	–	–	–	–	4.8	6.1	2.1	2.1	1.0

Soil pit	Sampling depth cm	Hydrolytic acidity mmol/100g	Exchangeable cations me/100g				Sorption capacity me/100g			
			Ca^{2+}	Mg^{2+}	Na^{+}	K^{+}	S	T	(T–S)	V, %
Szymaniszki A	0–20	3.94	0.70	0.050	0.017	0.143	0.910	4.850	3.94	18.76
Szymaniszki A	20–40	1.80	0.80	0.053	0.017	0.072	0.942	2.742	1.80	34.35
Szymaniszki A	90–110	0.49	0.70	0.078	0.017	0.036	0.831	1.321	0.49	62.91

Source: own elaboration.

Characteristics of the flora and fungi – Szymaniszki A

Approximately 100% of the study plot is covered with plants. Fairly rich in plant species (17). Four species dominate: *Hieracium umbellatum* (30%), *Calamagrostis epigeios* (25%), *Agrostis capillaris* (15%) and *Thymus pulegioides* (10%). The share of other species ranges from 5% to 0.5% of area coverage. The other identified species of plants include: *Convolvulus arvensis*, *Holcus mollis*, *Hypericum perforatum*, *Gnaphalium sylvaticum* (Tab. 6.1).

The plot features specimens of trees and shrubs: *Pinus sylvestris*, *Betula pendula* and *Padus serotina*.

Fungi of the plot are not abundant. They are represented by 8 species of macromycetes. The most frequently found species include: *Bovista plumbea* and *Amanita muscaria* (Tab. 7.1).

STUDY PLOT SZYMANISZKI B (51°49'089N, 19°46'598E, elevation 214 m a.s.l.)

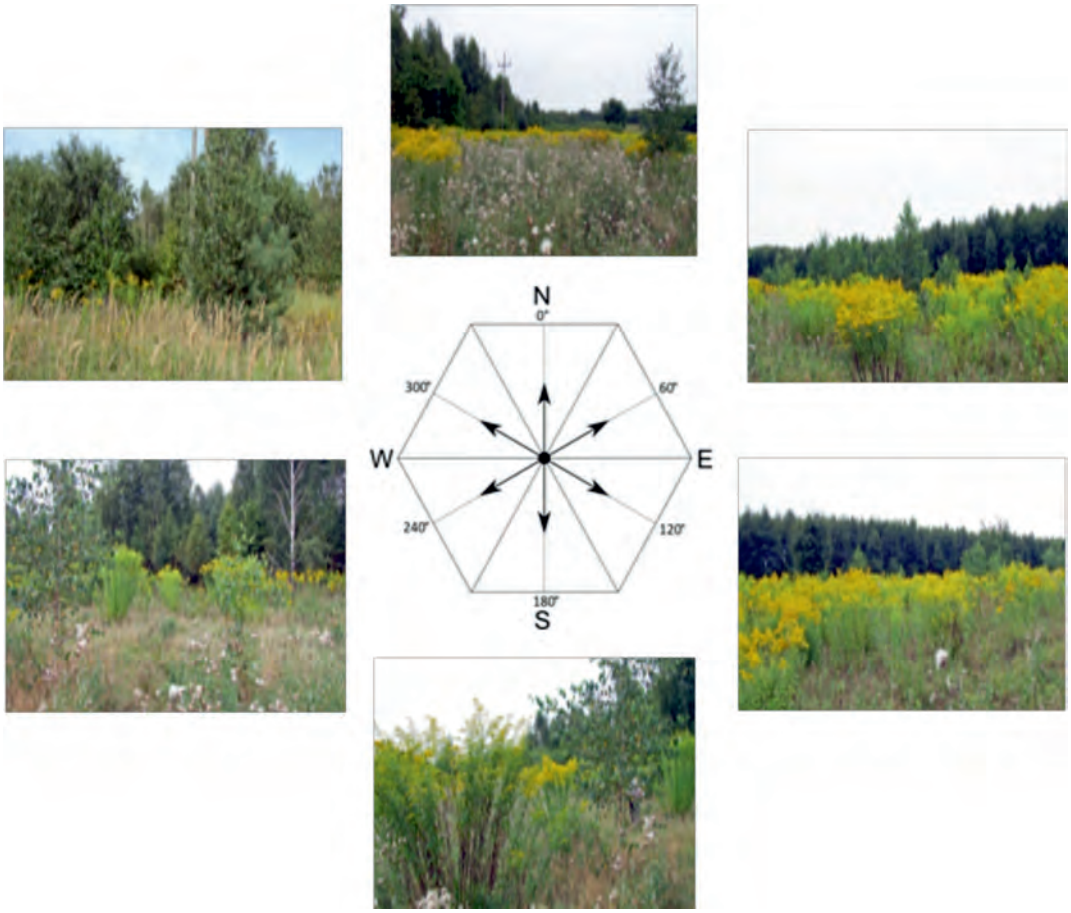


Fig. 5.63. Study plot Szymaniszki B (photo A. Majchrowska, 2013)

Depth		Profile description
0–32 cm	–	humus, silty and clayey, grey and brown
32–70 cm	–	yellow and beige silt, with single cobbles of 5 cm in diameter
70–80 cm	–	yellow and beige fine sand, with gravel and cobbles
80–130 cm	–	light beige silty sand, alternating with strata of coarse sand, red, with gravel
130–140 cm	–	coarse sand, with gravel, somewhat loamy, rusty

Fig. 5.64. Soil pit in study plot Szymaniszki B (photo. A. Majchrowska, 2013)

Table 5.35. Study plot Szymaniszki B. Granulometric and chemical properties of soil

Soil pit	Sampling depth cm	Grain size distribution %									Granulometric subgroup	Specific surface area $m^2 \cdot g^{-1}$
		2.0–1.0 mm	1.0–0.5 mm	0.5–0.25 mm	0.25–0.1 mm	0.1–0.05 mm	0.05–0.02 mm	0.02–0.005 mm	0.005–0.002 mm	<0.002 mm		
Szymaniszki B	0–20	0.5	11.6	19.4	13.0	16.7	23.2	10.9	2.4	2.3	gp	0.323
Szymaniszki B	20–40	1.3	10.6	16.0	10.3	16.6	25.7	13.2	3.3	3.0	gp	0.402
Szymaniszki B	90–110	2.6	32.2	42.4	16.0	1.20	1.90	2.40	1.0	0.3	p	0.065

Soil pit	Sampling depth cm	Humus %	C total %	N total %	C/N	pH in		Available nutrients mg/100g		
						KCl	H_2O	P_2O_5	K_2O	Mg
Szymaniszki B	0–20	1.86	1.079	0.100	10.788	4.4	5.1	5.3	3.8	1.6
Szymaniszki B	20–40	–	–	–	–	4.6	5.4	4.5	2.3	1.1
Szymaniszki B	90–110	–	–	–	–	5.1	6.5	3.5	1.7	2.8

Soil pit	Sampling depth cm	Hydrolytic acidity mmol/100g	Exchangeable cations me/100g				Sorption capacity me/100g			
			Ca^{2+}	Mg^{2+}	Na^{+}	K^{+}	S	T	(T–S)	V, %
Szymaniszki B	0–20	4.39	1.80	0.145	0.043	0.108	2.096	6.486	4.39	32.32
Szymaniszki B	20–40	3.14	1.20	0.088	0.035	0.072	1.395	4.535	3.14	30.76
Szymaniszki B	90–110	0.60	1.55	0.268	0.039	0.036	1.893	2.493	0.60	75.93

Source: own elaboration.

Characteristics of the flora and fungi – Szymaniszki B

Approximately 100% of the study plot is covered with plants. Poor in species of plants (5). Two species dominate: *Cirsium arvense* (60%), *Solidago canadensis* (30%). The share of other species is about 0.5% of area coverage each. The other identified species of plants include: *Hypericum perforatum*, *Poa pratensis* and *Betula pendula*.

Fungi of the plot are sparse. They are represented by 3 species of macromycetes. The most frequently found species is *Marasmius oreades*. The undergrowth also features the following: *Conocybe rickeaniana* and *Macrolepiota procera* (Tab. 7.1).

STUDY PLOT SZYMANISZKI C (51°49'047N, 19°46'804E, elevation 220 m a.s.l.)

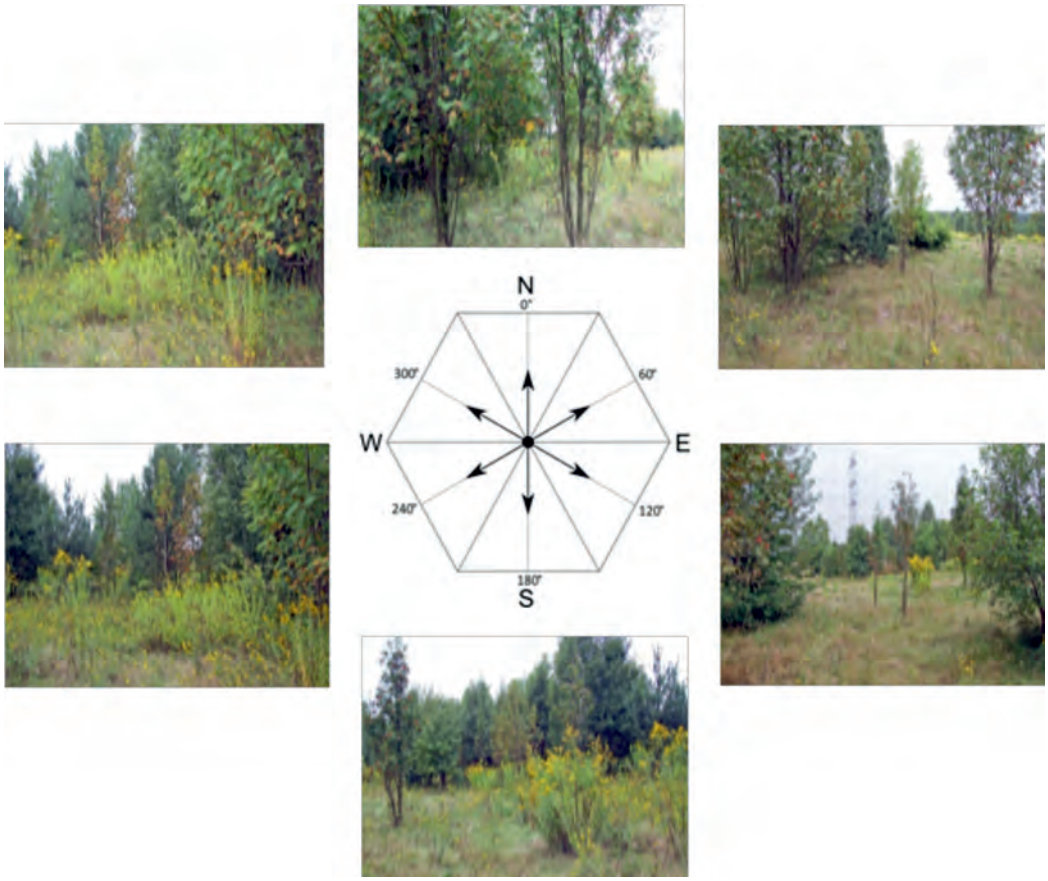


Fig. 5.65. Study plot Szymaniszki C (photo A. Majchrowska, 2013)

Depth		Profile description
0–25 cm	–	humus, silty, dark brown and grey
25–40 cm	–	fine silty sand, golden
40–90 cm	–	fine and medium sand, silty, golden and rusty with rusty smudges
90–140 cm	–	medium and fine sand, silty, yellow

Fig. 5.66. Soil pit in study plot Szymaniszki C (photo. A. Majchrowska, 2013)

Table 5.36. Study plot Szymaniszki C. Granulometric and chemical properties of soil

Soil pit	Sampling depth cm	Grain size distribution %									Granulometric subgroup	Specific surface area $m^2 \cdot g^{-1}$
		2.0–1.0 mm	1.0–0.5 mm	0.5–0.25 mm	0.25–0.1 mm	0.1–0.05 mm	0.05–0.02 mm	0.02–0.005 mm	0.005–0.002 mm	<0.002 mm		
Szymaniszki C	0–20	0.1	7.4	17.6	17.7	18.3	23.5	10.7	2.5	2.3	gp	0.331
Szymaniszki C	20–40	0.0	2.5	19.0	46.7	17.6	6.2	4.8	1.8	1.3	ps	0.187
Szymaniszki C	90–110	0.0	7.1	27.7	44.3	14.5	3.1	1.8	0.9	0.6	p	0.101

Soil pit	Sampling depth cm	Humus %	C total %	N total %	C/N	pH in		Available nutrients mg/100g		
						KCl	H_2O	P_2O_5	K_2O	Mg
Szymaniszki C	0–20	1.34	0.77	0.068	11.43	4.1	4.4	7.1	2.4	0.4
Szymaniszki C	20–40	–	–	–	–	4.2	4.7	2.8	1.7	1.0
Szymaniszki C	90–110	–	–	–	–	4.7	6.0	1.9	1.0	1.8

Soil pit	Sampling depth cm	Hydrolytic acidity mmol/100g	Exchangeable cations me/100g				Sorption capacity me/100g			
			Ca^{2+}	Mg^{2+}	Na^{+}	K^{+}	S	T	(T–S)	V, %
Szymaniszki C	0–20	5.42	0.20	0.033	0.017	0.072	0.322	5.742	5.42	5.61
Szymaniszki C	20–40	3.21	0.65	0.077	0.017	0.051	0.795	4.005	3.21	19.85
Szymaniszki C	90–110	1.49	1.00	0.155	0.026	0.020	1.201	2.691	1.49	44.63

Source: own elaboration.

Characteristics of the flora and fungi – Szymaniszki C

Approximately 100% of the study plot is covered with plants. Fairly rich in species of plants (10). Five species dominate: *Senecio viscosus* (30%), *Crepis biennis* (20%), *Padus serotina* (20%), *Solidago canadensis* (10%) and *Cirsium arvense* (10%). The share of other species is low (Tab. 6.1). The area also features specimens of trees and shrubs: *Pinus sylvestris*, *Betula pendula* and *Padus serotina*.

Fungi of the plot are not abundant. They are represented by 6 species of macromycetes. The most frequently found species include: *Marasmius oreades* and *Conocybe tenera*. The undergrowth also features: *Macrolepiota procera* and *Panaeolus foenisecii*. The mycorrhizal fungi were represented by: *Inocybe asterospora* and *Amanita muscaria* (Tab. 7.1).

Analysis of granulometric composition and chemical properties of soils in the Szymaniszki study plot group

On the basis of the results of grain size distribution analyses (Tab. 5.34–5.36), the soils of abandoned lands in the Szymaniszki study plot group were classified as two granulometric groups of sands and loams (Polskie Towarzystwo Gleboznawcze 2009). At plot Szymaniszki A, the subsequent soil horizons, starting from the surface, were classified as subgroups of loamy sand, sand and loose sand. As regards agrotechnical heaviness, the soil was classified as very light. At plot Szymaniszki B, in the two shallower soil horizons the silty fraction constituted 36.5% and 42.7%, the deepest horizon was dominated with sand – 94.3%, which provided the base to include them in subgroups of sandy loam and loose sand, respectively. The soil was classified as the

agronomical category of light soils. At plot Szymaniszki C, the soil texture was similar to that of plot B, but the content of silts decreased faster with the depth and the subsequent horizons were classified into subgroups of sandy loam, slightly loamy sand and loose sand, respectively. The soil's agrotechnical heaviness was classified as light soils.

At plot Szymaniszki B, in the 20–40 cm horizon, the index of specific surface area, dependent on the content of the silty and clayey fraction, reached its highest value of 0.402 m^2/g.

The content of humus was medium and ranged from 1.24% at plot A to 1.86% at plot C. The lowest value was recorded in the soil formed on loamy sand, and the highest – on sandy loam. The C/N ratio was narrow: 12.6:1–10.4:1.

The pH value in 1 M KCl in all surface horizons of the soils indicated very acidic reaction and acidic reaction in deeper horizons.

The surface horizon of soils of the Szymaniszki study plot group was characterised by low content of available phosphorus, whereas deeper horizons had very low content of this element. The soil in the surface horizon at plot Szymaniszki C was characterised by low content of potassium, and the remaining analysed horizons – by very low content. The content of magnesium at all plots and soil horizons increased with the depth of the profile from very low to medium at plot B and low at plot C.

The level of hydrolytic acidity clearly decreased with depth, whereas total alkaline cations, generally low, revealed fluctuations in various directions within the range from 0.322 to 2.096 mmol/100g. Among alkaline cations, the most important at all plots was calcium. Total sorptive capacity of the soils was very low: it reached the maximum of 6.486 mmol/100g at plot Szymaniszki B, in the humus horizon. The degree of soil saturation with alkaline cations was different at different sites and horizons, but generally increased with depth and pH value to reach the highest values at plots B – 75.9% and A – 62.9%. At plot C, the saturation of alkaline cations was clearly the lowest and ranged from 5.61% to 44.6%.

ŁAGIEWNIKI STUDY PLOT GROUP

The Łagiewniki study plot group is located about 450 m to the north of the border of the Łódź Hills Landscape Park, in Zgierz District, Rural Commune of Zgierz, on its border with Łódź. According to the physicogeographical regionalisation (Kondracki 2002), it is located in the north-western part of the mesoregion of the Łódź Hills, within the macroregion of Southern Mazovian Hills.

The analysed area lies in the suburban zone of Łódź and Zgierz. It contains alternating strips of arable lands, abandoned farmlands and narrow strips of shrubs and forests, which are perpendicular to the dirt road running across the area. The southern border of the area is the voivodeship road 71. On the other sides, it is limited by developing suburban villages: Skotniki, Smardzew and Łagiewniki Nowe.

The analysed area lies at the elevation of approximately 200–222 m a.s.l. in the extreme north-western part of the highest marginal level of the Łódź Upland (Klatkowa 1972). According to the Detailed Geological Map of Poland, its geological substratum is constituted by upper fluvioglacial sands and sands with gravels of the Warta Glaciation (Klatkowa et al. 1991). On the basis of soil and agricultural maps (http://geoportal.lodzkie.pl/imap/), the soils are identified as leeched brown. In study plots Łagiewniki A and B, the soils were formed from loose sands and were classified as very poor rye complex (7) of agricultural suitability. Study plot Łagiewniki C is located on the border of loamy silty sands upon slightly loamy sands and loam, and loamy silty sands upon loose sand. Respectively, leeched brown soils at this plot, classified as good rye complex (5), turn into poor rye complex (6). Soils of plot A and B are qualified as valuation class VI, and soils at plot Łagiewniki C – as valuation class V of arable lands. The soil and agricultural map shows the presence of a stratum with features of periglacial cover sands and silts (Krysiak 2006b).

All the study plots: Łagiewniki A, B and C are within a type 6 geocomplex – glacial and fluvioglacial boulders, cobbles, gravels, sands and muds of plateaus, alluvial fans and erosional-accumulational terraces. It belongs to the group of lithogenic geocomplexes, which normally do not undergo excessive moisturising, associated with permeable Quaternary deposits.

The physiognomy of the study plot group and soil profiles are illustrated with figures 5.67–5.72. Results of laboratory soil analyses are presented in tables 5.37–5.39.

STUDY PLOT ŁAGIEWNIKI A (51°51'360N, 19°28'343E, elevation 222 m a.s.l.)

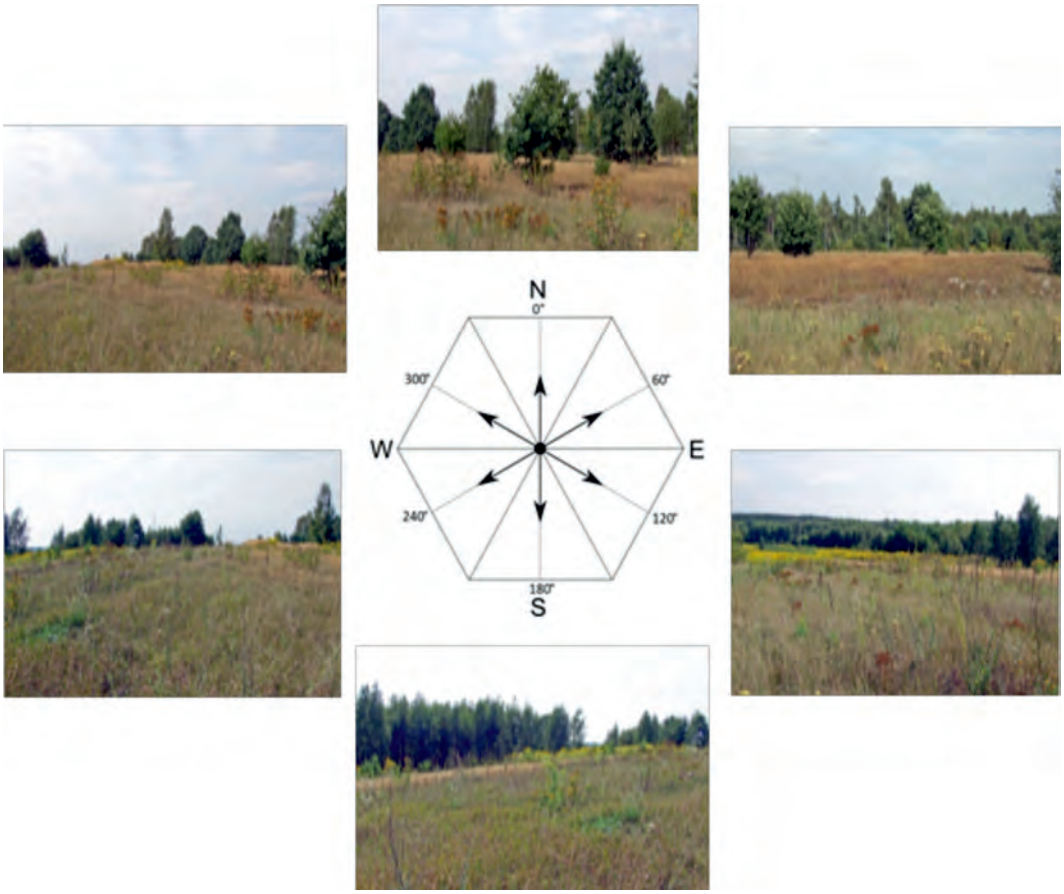


Fig. 5.67. Study plot Łagiewniki A (photo A. Majchrowska, 2013)

Depth		Profile description
0–29 cm	–	humus, unsorted sand, silty with cobbles, dark brown and grey
29–60 cm	–	coarse and medium sand with gravel and cobbles, silty, grey and dark brown
60–100 cm	–	coarse sand with gravel and cobbles, grey, dark brown and yellow
100–150 cm	–	medium sand with gravel, yellowish
150–160 cm	–	medium and unsorted sand, yellowish

Fig. 5.68. Soil pit in study plot Łagiewniki A (photo A. Majchrowska, 2013)

Table 5.37. Study plot Łagiewniki A. Granulometric and chemical properties of soil

Soil pit	Sampling depth cm	Grain size distribution %									Granulometric subgroup	Specific surface area $m^2 \cdot g^{-1}$
		2.0–1.0 mm	1.0–0.5 mm	0.5–0.25 mm	0.25–0.1 mm	0.1–0.05 mm	0.05–0.02 mm	0.02–0.005 mm	0.005–0.002 mm	<0.002 mm		
Łagiewniki A	0–20	4.3	30.5	35.0	16.9	4.3	4.5	3.2	1.0	0.4	p	0.0835
Łagiewniki A	20–40	6.5	44.6	37.5	7.9	1.1	0.7	1.2	0.5	0.0	p	0.0313
Łagiewniki A	90–110	9.7	49.2	33.5	2.7	1.3	1.0	1.8	0.7	0.1	p	0.0420

Soil pit	Sampling depth cm	Humus %	C total %	N total %	C/N	pH in		Available nutrients mg/100g		
						KCl	H_2O	P_2O_5	K_2O	Mg
Łagiewniki A	0–20	0.88	0.5104	0.043	11.87	5.4	6.4	9.2	4.2	4.8
Łagiewniki A	20–40	–	–	–	–	5.3	6.5	4.6	2.8	2.9
Łagiewniki A	90–110	–	–	–	–	4.8	5.9	3.2	1.6	2.3

Soil pit	Sampling depth cm	Hydrolytic acidity mmol/100g	Exchangeable cations me/100g				Sorption capacity me/100g			
			Ca^{2+}	Mg^{2+}	Na^{+}	K^{+}	S	T	(T–S)	V, %
Łagiewniki A	0–20	1.76	1.70	0.410	0.035	0.100	2.245	4.005	1.76	43.95
Łagiewniki A	20–40	0.94	0.65	0.255	0.009	0.062	0.976	1.916	0.94	50.94
Łagiewniki A	90–110	0.71	1.15	0.193	0.017	0.028	1.388	2.098	0.71	66.16

Source: own elaboration.

Characteristics of the flora and fungi – Łagiewniki A

Approximately 100% of the study plot is covered with plants. Medium abundance of plant species (11). Two species dominate: *Agrostis capillaris* (70%) and *Rumex acetosella* (20%). The share of other species is low and does not exceed 0.5% of area coverage. Other identified species of plants include: *Hieracium pilosella*, *Poa pratensis*, *Elymus repens*, *Spergula arvensis* (Tab. 6.1).

The plot features specimens of trees and shrubs: *Betula pendula*, *Quercus robur* and *Padus serotina*.

Fungi of the plot are sparse. They are represented by 4 species of macromycetes. The most frequently found species is *Marasmius oreades*. The undergrowth also features: *Conocybe rickeaniana*, *Macrolepiota procera* and *Panaeolus foenisecii* (Tab. 7.1).

STUDY PLOT ŁAGIEWNIKI B (51°51'371N, 19°28'343E, elevation 220 m a.s.l.)

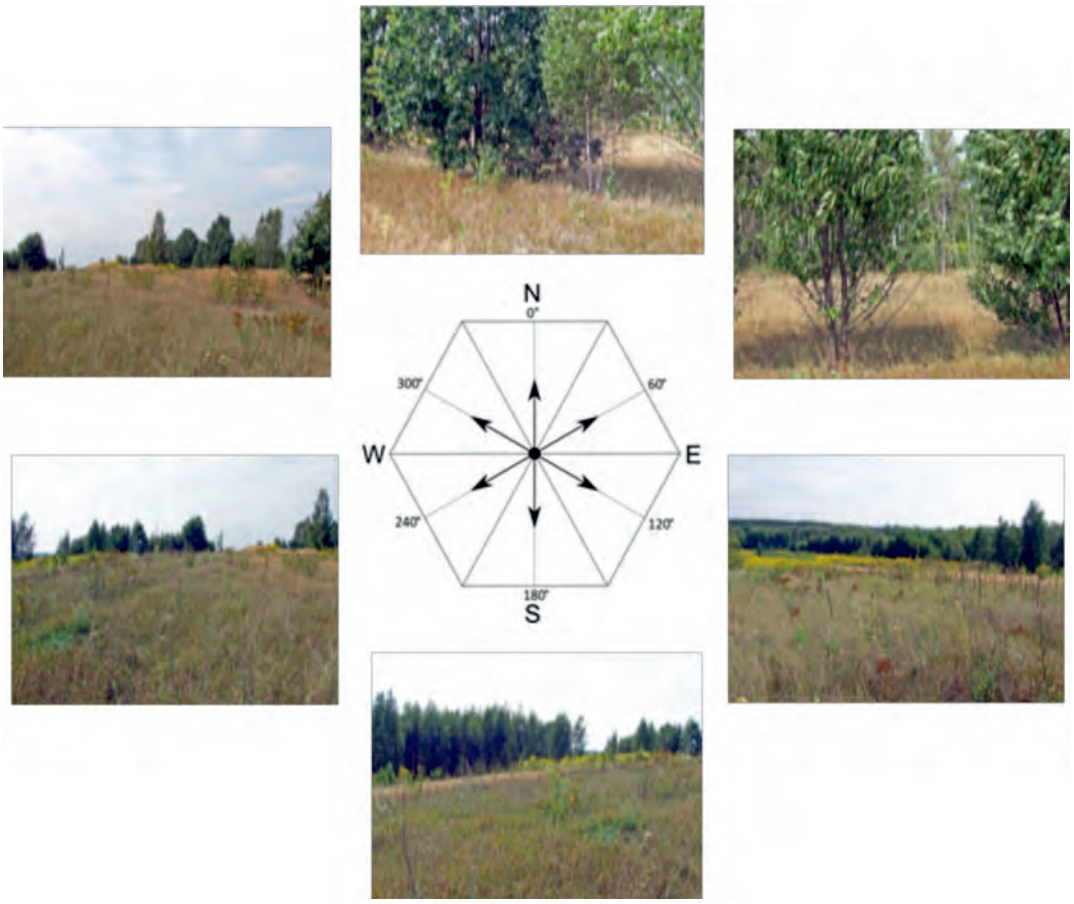


Fig. 5.69. Study plot Łagiewniki B (photo A. Majchrowska, 2013)

Depth		Profile description
0–23 cm	–	humus, silty sand, brown and grey
23–40 cm	–	silty sand, beige, with single cobbles of up to 3 cm in diameter at the bottom
40–45 cm	–	cobbles of over 3 cm in diameter
45–60 cm	–	silty sand, beige and golden
60–120 cm	–	fine and silty sand, light beige and golden, with single cobbles
120–150 cm	–	medium and fine sand, silty, light beige and golden

Fig. 5.70. Soil pit in study plot Łagiewniki B (photo A. Majchrowska, 2013)

Table 5.38. Study plot Łagiewniki B. Granulometric and chemical properties of soil

Soil pit	Sampling depth cm	Grain size distribution %									Granulometric subgroup	Specific surface area $m^2 \cdot g^{-1}$
		2.0–1.0 mm	1.0–0.5 mm	0.5–0.25 mm	0.25–0.1 mm	0.1–0.05 mm	0.05–0.02 mm	0.02–0.005 mm	0.005–0.002 mm	<0.002 mm		
Łagiewniki B	0–20	0.1	13.4	27.9	17.7	11.9	16.9	8.2	2.1	1.8	gp	0.258
Łagiewniki B	20–40	0.1	12.2	22.1	12.6	14.0	20.3	11.6	3.7	3.3	gp	0.412
Łagiewniki B	90–110	0.0	11.3	53.3	28.5	0.4	2.8	2.1	1.0	0.4	p	0.076

Soil pit	Sampling depth cm	Humus %	C total %	N total %	C/N	pH in		Available nutrients mg/100g		
						KCl	H_2O	P_2O_5	K_2O	Mg
Łagiewniki B	0–20	1.35	0.783	0.072	10.88	4.1	4.4	3.2	0.9	0.4
Łagiewniki B	20–40	–	–	–	–	4.3	4.5	1.8	0.6	0.3
Łagiewniki B	90–110	–	–	–	–	4.4	5.1	1.7	0.5	0.6

Soil pit	Sampling depth cm	Hydrolytic acidity mmol/100g	Exchangeable cations me/100g				Sorption capacity me/100g			
			Ca^{2+}	Mg^{2+}	Na^{+}	K^{+}	S	T	(T–S)	V, %
Łagiewniki B	0–20	6.24	0.15	0.027	0.013	0.036	0.226	6.466	6.24	3.495
Łagiewniki B	20–40	4.54	0.15	0.020	0.009	0.026	0.205	4.745	4.54	4.320
Łagiewniki B	90–110	1.57	0.30	0.053	0.070	0.015	0.438	2.008	1.57	21.810

Source: own elaboration.

Characteristics of the flora and fungi – Łagiewniki B

Approximately 70% of the study plot is covered with plants. Poor in species of plants (9). 6 species occur with similar area coverage (about 10%–15%): *Betula pendula*, *Elymus repens*, *Jasione montana*, *Poa trivialis*, *Padus serotina* and *Senecio jacobea*. Specimens of other species occur in small quantities (Tab. 6.1).

Fungi of the study plot are not abundant. They are represented by 4 species of macromycetes. The most frequently found species include: *Marasmius oreades* and *Panaeolus foenisecii*. Mycorrhizal fungi are represented by: *Inocybe asterospora* and *Leccinum scabrum* (Tab. 7.1).

STUDY PLOT ŁAGIEWNIKI C (51°51'496N, 19°28'400E, elevation 214 m a.s.l.)

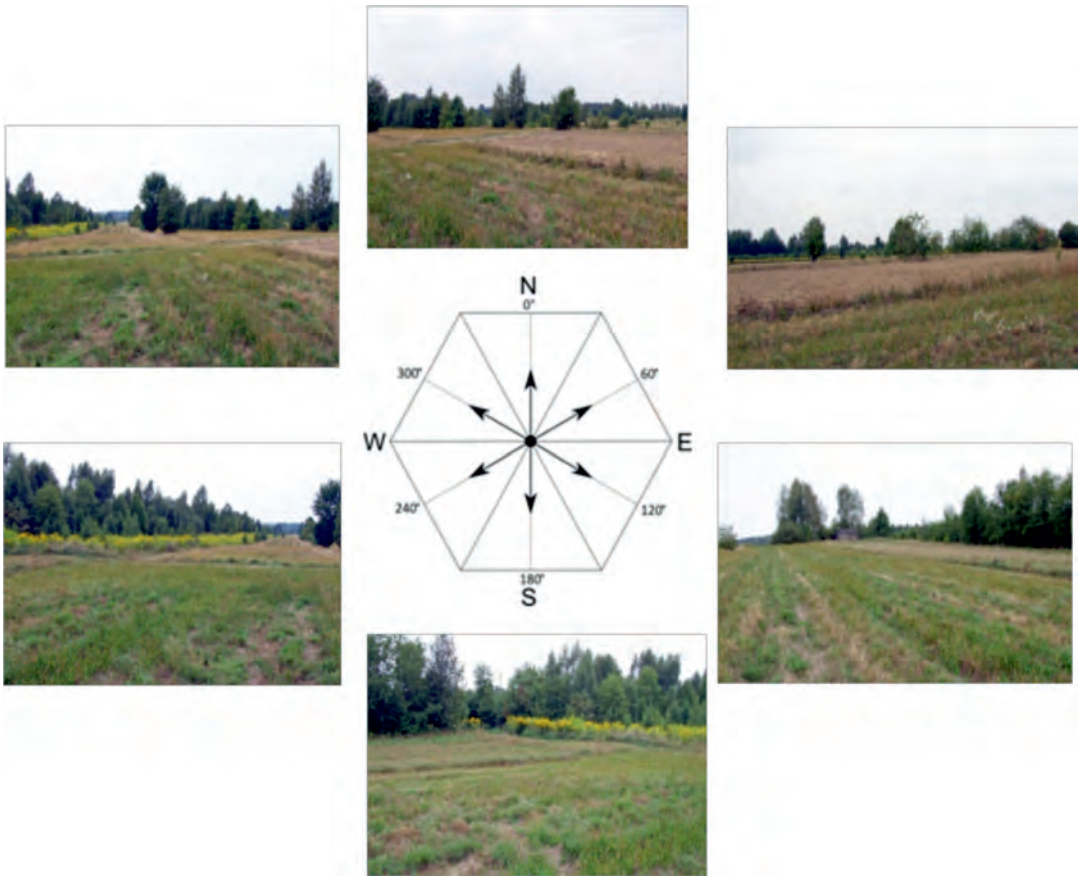


Fig. 5.71. Study plot Łagiewniki C (photo A. Majchrowska, 2013)

Depth		Profile description
0–21 cm	–	humus, silty sand, dark brown
21–40 cm	–	unsorted silty sand, yellow
40–45 cm	–	fine sand, silty, golden
45–110 cm	–	unsorted sand, slightly loamy, rusty and golden
110–150 cm	–	fine and medium sand, silty, golden

Fig. 5.72. Soil pit in study plot Łagiewniki C (photo A. Majchrowska, 2013)

Table 5.39. Study plot Łagiewniki C. Granulometric and chemical properties of soil

Soil pit	Sampling depth cm	Grain size distribution %									Granulometric subgroup	Specific surface area $m^2 \cdot g^{-1}$
		2.0–1.0 mm	1.0–0.5 mm	0.5–0.25 mm	0.25–0.1 mm	0.1–0.05 mm	0.05–0.02 mm	0.02–0.005 mm	0.005–0.002 mm	<0.002 mm		
Łagiewniki C	0–20	4.8	27.8	23.9	7.6	9.7	13.6	8.3	2.5	2.0	pg	0.266
Łagiewniki C	20–40	0.7	26.0	39.3	15.7	5.7	5.9	4.3	1.4	0.9	p	0.136
Łagiewniki C	90–110	3.4	22.7	28.4	26.9	7.5	3.5	4.4	2.1	1.1	p	0.159
Łagiewniki C	150–160	0.7	14.3	26.7	33.1	12.7	5.2	4.3	1.8	1.2	ps	0.172

Soil pit	Sampling depth cm	Humus %	C total %	N total %	C/N	pH in		Available nutrients mg/100g		
						KCl	H_2O	P_2O_5	K_2O	Mg
Łagiewniki C	0–20	1.38	0.8004	0.068	11.77	4.2	4.6	4.5	2.5	1.0
Łagiewniki C	20–40	–	–	–	–	4.4	5.0	3.1	1.6	0.8
Łagiewniki C	90–110	–	–	–	–	4.2	5.3	3.1	1.6	2.8
Łagiewniki C	150–160	–	–	–	–	4.2	4.9	4.1	1.3	2.5

Soil pit	Sampling depth cm	Hydrolytic acidity mmol/100g	Exchangeable cations me/100g				Sorption capacity me/100g			
			Ca^{2+}	Mg^{2+}	Na^{+}	K^{+}	S	T	(T–S)	V, %
Łagiewniki C	0–20	4.66	0.35	0.082	0.009	0.072	0.513	5.173	4.66	9.92
Łagiewniki C	20–40	2.14	0.35	0.078	0.009	0.072	0.509	2.649	2.14	19.22
Łagiewniki C	90–110	1.69	1.40	0.262	0.030	0.041	1.733	3.423	1.69	50.63
Łagiewniki C	150–160	1.42	1.30	0.233	0.026	0.036	2.020	3.440	1.42	58.72

Source: own elaboration.

Characteristics of the flora and fungi – Łagiewniki C

Approximately 100% of the study plot is covered with plants. Medium abundance of species of plants (13). Five species dominate: *Betula pendula* (15%), *Conyza canadensis* (10%), *Elymus repens* (10%), *Rumex acetosa* (10%). Other species cover about 5% of the area each. They include: *Anagalis arvensis*, *Geranium pratense*, *Gnaphalium sylvaticum*, *Hypericum perforatum*, *Matricaria chamomilla*, *Padus serotina* (Tab. 6.1).

Fungi of the plot are not abundant. They are represented by 4 species of macromycetes. The most frequently found species was *Marasmius oreades*. The undergrowth also features *Conocybe rickeaniana* (Tab. 7.1).

Analysis of granulometric composition and chemical properties of soils in the Łagiewniki study plot group

On the basis of the results of grain size distribution analyses, soils of the Łagiewniki study plot group were classified as two granulometric groups of sands and loams (Polskie Towarzystwo Gleboznawcze 2009). At plot Łagiewniki A, there is a clear domination of the sandy fraction (90.9–97.7%), and within it – of coarse and medium sand, allowed for the soil to be classified as the agronomic category of very light, well-aerated and permeable soils. At plot Łagiewniki B, a discrepancy was noticed between the analysis results and the state presented on the soil and

agricultural map (http://geoportal.lodzkie.pl/imap/). Instead of loose sand, in the 0–20 cm and 20–40 cm horizons, an increase of the content of the silty fraction to 27.3–35.7% was detected, which provided a basis for classifying the soil with the subgroup of sandy loam. At plot Łagiewniki C, the content of silt was 24.3% in the surface horizon and it remained at the level of 10–11% in the deeper horizons, which allowed for the soil to be classified with the subgroup of loamy sand, and deeper – loose and slightly loamy sand. Soils of plots B and C were classified with the agronomic category of light soils.

Specific surface area, low in study plot A, reached its maximum value of 0.412 $m^2 \cdot g^{-1}$ in the horizon of 20–40 cm at plot Łagiewniki B, where the presence of silty-sandy cover was recorded. The content of humus was low at plot A – 0.88% and medium (1.35–1.38%) at the other plots. The C/N ratio was about 11:1–10:1.

The pH value at plot A indicated acidic reaction in 1 M KCl, and slightly acidic in H_20 and decreased with the depth of the profile. At the other plots, the reaction was very acidic.

Soils of the Łagiewniki study plot group were characterised by a very low content of available phosphorus, except for the humus horizon at plot A, where the level was low. All soils were characterised by very low and low content of potassium. The content of available magnesium at plot A was high and decreased with the depth of the profile to medium. At plot B – it was very low, at plot C – very low near the surface and increased to medium values in deeper horizons.

The level of hydrolytic acidity clearly decreased with the depth of the profile, whereas total alkaline cations, generally low, revealed a growing tendency with the depth within the range from 0.205 to 2.245 mmol/100g. Among alkaline cations, the most important at all plots was calcium, and then magnesium. Total sorptive capacity of the soils was very low: it reached the maximum value of 6.466 mmol/100g at plot Łagiewniki B, in the humus horizon. The saturation degree of soils with alkaline cations was different at different sites and horizons, but it generally clearly increased with depth. The saturation degree of soils with alkaline cations was the highest at plot A – 43.95–66.16%, and the lowest – at plot B – 3.495–21.81%.

Characteristics of exchangeable sorption and other physical and chemical parameters of the soils indicate diversified, though generally low habitat value of the Łagiewniki study plot group. Despite its less favourable, very light granulometric composition, the soil at plot A was characterised by the relatively highest pH level, content of alkaline cations and saturation degree of alkaline ions.

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6. Diversity of the flora and vegetation of abandoned farmlands

6.1. Diversity of species and habitat groups of the flora

Jolanta Adamczyk

One hundred and thirty-nine taxa of vascular plants and four taxa of mosses were recorded in the analysed abandoned lands (Tab. 6.1).

In the flora inhabiting abandoned farmlands, there are taxa which prefer various habitat types. The majority of identified species are associated with habitats of dry grasslands or they grow there frequently (24 species). They include *Carlina vulgaris*, *Carex leporina*, *Centaurea scabiosa*, *C. stoebe* and *Thymus pulegioides*. Almost equally numerous were groups of species associated with or preferring farmland habitats (22 species), such as *Apera spica-venti*, *Arnoseris minima*, *Centaurea cyanus*, *Papaver argemone* and species which mostly inhabit ruderal locations, including species of the *Rudero-Secalietea* class (20 species), e.g. *Cirsium arvense*, *Convolvulus arvensis*, *Elymus repens* and *Rumex crispus*. The group associated with meadow habitats of the *Molinio-Arrhenatheretea* class (19 species) is also numerously represented. They include: *Achillea millefolium*, *Anthoxanthum odoratum*, *Crepis biennis*, *Galium mollugo*, *Rumex acetosa*, *Stellaria graminea*, *Trifolium repens* and *Vicia cracca*. Fewer species are found in the group of plants which occur predominantly in forest communities (13 species). They mainly include trees: *Pinus sylvestris*, *Betula pendula*, *Quercus robur* and a few species of herbaceous plants, such as *Anthriscus sylvestris* and *Pteridium aquilinum* (Tab. 6.1).

Invasive species of non-native origin should be treated as a separate group. There are 7 of them, which is about 5% of all the identified plant taxa. They include three species of high invasiveness category (Tab. 6.2). The remaining 34 taxa are cosmopolitan plants, which occur in various types of plant communities.

Table 6.2. Invasive alien plant species recorded on abandoned farmlands of the Łódź Voivodeship

Latin name	Life form	Origin	Category of invasiveness
Anthoxanthum aristatum Boiss.	annual plant	South Europe	I
Conyza canadensis (L.) Cronquist	annual plant	North America	I
Galinsoga parviflora Cav.	annual plant	North and Central America	I
Padus serotina (Ehrh.) Borkh.	tree	North and Central America	IV
Quercus rubra L.	tree	North America	IV
Setaria viridis (L.) P. Beauv.	annual plant	South Europe, South-West Asia, North Africa	I
Solidago canadensis L.	perennial	North America	IV

Categories of invasiveness according to Tokarska-Guzik et al. 2012:
Category I – segetal and ruderal weeds that show high relative abundance, or potentially invasive species that currently occupy a small area;
Category II – species that already show invasive behaviour in some regions, and are increasing the occupied area or the number of localities;
Category III – species occurring at a few localities with high relative abundance or found scattered around many localities;
Category IV – species whose occurrence is very important in Poland – a large number of localities and large populations in patches are known.

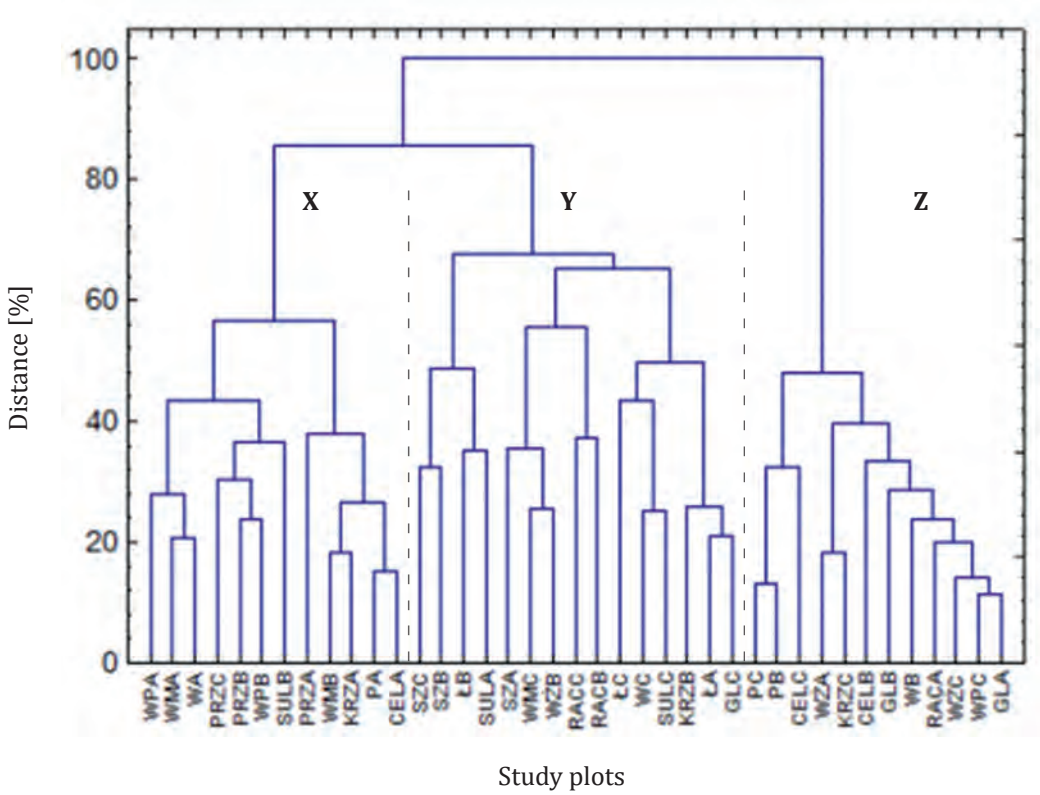
Source: own elaboration.

Apart from *Helichrysum arenaria*, no protected species or species that are endangered in Poland or the Łódź region were found in the flora of the analysed abandoned lands. Despite that, some of the identified species are not common in the Łódź Voivodeship, due to their occurrence in rare or endangered phytocoenoses. Such species as *Dianthus carthusianorum*, *Knautia arvensis* and *Thymus pulegioides* are worth mentioning here.

6.2. Vegetation structure

Jolanta Adamczyk

In the analysed abandoned lands, three main structural groups of plant communities (Fig. 6.1) were distinguished using Ward's method of hierarchical cluster analysis. In addition, the use of the IndVal index made it possible to determine the preferences of plant species for individual community group (Tab. 6.3). Each community group represents a particular development stage but sometimes, in the same cluster, there are communities typical of the given development stage and communities which are a transition to another stage or community with a different structure. The isolated clusters and analysis of similarities between the plots they were assigned, allowed to identify 8 plant communities with different structures.



Abbreviations: **CELA, CELB, CELC** – Celestynów A, Celestynów B, Celestynów C; **GLA, GLB, GLC** – Glinnik A, Glinnik B, Glinnik C; **KRZA, KRZB, KRZC** – Krzętle A, Krzętle B, Krzętle C; **ŁA, ŁB, ŁC** – Łagiewniki A, Łagiewniki B, Łagiewniki C; **PA, PB, PC** – Polesie A, Polesie B, Polesie C; **PRZA, PRZB, PRZC** – Piskorzeniec A, Piskorzeniec B, Piskorzeniec C; **RACA, RACB, RACC** – Raciszyn A, Raciszyn B, Raciszyn C; **SULA, SULB, SULC** – Sulejów A, Sulejów B, Sulejów C; **SZA, SZB, SZC** – Szymaniszki A, Szymaniszki B, Szymaniszki C; **WA, WB, WC** – Weronika A, Weronika B, Weronika C; **WMA, WMB, WMC** – Wola Makowska A, Wola Makowska B, Wola Makowska C; **WPA, WPB, WPC** – Wola Pszczółecka A, Wola Pszczółecka B, Wola Pszczółecka C; **WŻA, WŻB, WŻC** – Wola Życińska A, Wola Życińska B, Wola Życińska C

Fig. 6.1. Classification of study plots (hierarchical cluster analysis, Euclidean distance, Ward's method)

Source: own elaboration

The most uniform was cluster Z, which grouped study plots representing the same community type, with *Agrostis capillaris*, *Hieracium pilosella* and *Achillea millefolium*. Less uniform is cluster X, which groups patches of a poor community with *Anthoxanthum aristatum* and *Corynephorus canescens* and patches similar to the more diverse community with *Agrostis capillaris*, *Hieracium pilosella* and *Achillea millefolium*.

The most heterogeneous is cluster Y. It groups patches of the floristically poor community with *Calamgrostis epigejos*; patches of a community rich in plant species, with *Cirsium arvense*, *Galium mollugo* and *Gnaphalium sylcaticum*; the few patches of phytocoenoses with *Cirsium arvense* and *Solidago canadensis*; a community of grasses and perennial plants with *Betula pendula* and a community with lichens of the *Cladonia* genus.

Table 6.3. Relative cover (P), relative frequency (F) and IndVal indicator value (I) (all in %) in individual clusters (for species associated with any cluster at p < 0.1). The significantly (at p ≤ 0.05) highest IndVals are in bold

Cluster		*Ahtoxantum aristatum*	*Corynephorus canescens*	*Bryum sp.*	*Gnaphalium sylvaticum*	*Cirsium arvense*	*Galium mollugo*	*Carex leporina*	*Betula pendula*	*Poa pratensis*	*Senecio jacobea*	*Solidago canadensis*	*Hieracium pilosella*	*Agrostis capillaris*	*Achillea millefolium*	*Festuca rubra*	*Jasione montana*
p		0.0028	0.0055	0.0482	0.0008	0.0094	0.0104	0.0166	0.0334	0.0896	0.0945	0.0964	0.0011	0.0046	0.0268	0.0869	0.0982
X	P	100	87	100	0	0	0	0	0	0	0	1	31	0	7	4	20
	F	42	58	25	0	0	0	0	0	0	0	8	75	17	25	8	50
	I	**42**	**51**	**25**	0	0	0	0	0	0	0	0	23	0	2	0	10
Y	P	0	0	0	100	100	85	100	94	85	77	96	7	42	44	28	29
	F	0	0	0	33	40	40	40	47	47	47	33	60	60	40	20	20
	I	0	0	0	**33**	**40**	**34**	**40**	**44**	40	36	32	4	25	17	6	6
Z	P	0	13	0	0	0	15	0	6	15	23	3	61	57	49	68	50
	F	0	42	0	0	0	8	8	25	42	50	17	100	100	92	42	83
	I	0	5	0	0	0	1	0	2	6	11	0	**61**	**57**	**45**	28	42

Source: own elaboration.

Community with *Anthoxanthum aristatum* and *Corynephorus canescens*

It is a floristically poor community of grasses. The highest IndVal value was obtained by two species here: *Anthoxanthum aristatum* and *Corynephorus canescens* (cluster X). Some study plots were overgrown only with *Corynephorus canescens* (e.g. Celestynów A). The two species dominate as regards land cover and shape the physiognomy of this community. The share of other species is insignificant (Tab. 6.1). The most typical patches include: Celestynów A, Krzętle A (Photo 6.4), Wola Makowska A, Wola Makowska B, Polesie C. The physiognomically similar patches of study plots Polesie B and Polesie C, which are very poor floristically, and their dominating species are grasses *Anthoxanthum aristatum* or *Poa compressa*, can also be included in this community.

Community with *Agrostis capillaris*, *Hieracium pilosella* and *Achillea millefolium*

These are floristically poor phytocoenoses, in which the species with significant values of IndVal were: *Agrostis capillaris*, *Hieracium pilosella* and *Achillea millefolium* (cluster Z). All patches of phytocoenoses that are included in cluster Z constitute the typical form of this community (Fig. 6.1). Only study plots Piskorzeniec C and Wola Życińska A are characterised by a high share of *Holcus mollis*, higher than that of *Hieracium pilosella*. In some plots, there are small numbers of tree saplings (*Betula pendula*, *Pinus sylvestris*).

This community is represented by study plots Wola Pszczółecka A, Weronika A and Piskorzeniec C, included in cluster X. These patches are richer in plant species, with a large share of *Hieracium pilosella*. They probably constitute a transitory link from poor communities of grasses with a small share of perennial plants, to the floristically richer phytocoenoses of meadow character. Study plots Glinnik C, Celestynów C and Krzętle B, included in cluster Y, are also physiognomically similar to this community, because their dominating species is *Agrostis capillaris*, accompanied by a significant share of *Hieracium pilosella* or *Elymus repens*.

Community with *Calamgrostis epigejos*

The physiognomy of this community is shaped by dense occurrence of *Calamgrostis epigejos*, assisted by a small addition of *Agrostis capillaris*, *Hieracium pilosella*, *Eupatorium cannabinum*, *Cirsium arvense* and *Equisetum arvense*. Among the analysed abandoned lands, only three patches dominated by *Calamgrostis epigejos* were found. They were: Wola Życińska B, Wola Makowska C and Szymaniszki A (Tab. 6.1). The study plots were included in cluster Y (Fig. 6.3). The least typical is plot Szymaniszki A, which differs from the others by the much greater number of species (17), a smaller share of *Calamgrostis epigejos* and a high share of perennial plants, such as *Hieracium umbellatum*.

Community with *Cladonia*

Patches of this phytocoenosis are characterised by a very small share of vascular plants, mainly: *Corynephorus canescens* and *Arnoseris minima*. The plants cover an insignificant percentage of the plot. The patches are dominated by lichens of the *Cladonia* genus, mostly *Cladonia arbuscula* and *Cl. rangiferina*. They are accompanied by *Cladonia strepsillis f. coralloides* (Photo 7.6), *Cl. uncialis* and *Cl. furcata*. Patches of this community were recorded at study plots: Piskorzeniec A, Polesie A and Wola Pszczółecka B, included in cluster X.

Community with *Cirsium arvense*, *Galium mollugo* and *Gnaphalium sylcaticum*

It is a floristically rich community, with multi-species flora (Tab. 6.1). A significant value of IndVal was reached by 5 species: *Cirsium arvense*, *Galium mollugo*, *Gnaphalium sylcaticum* and *Betula pendula*. This phytocoenosis is represented by two study plots: Raciszyn C and Weronika C (cluster Y). Several meadow species were identified here, such as *Galium mollugo*, *Stellaria graminea*, *Viccia cracca*, *Trifolium repens*; species of xerothermic grasslands, e.g. *Dianthus carthusiana*, and a few forest species, e.g. *Gnaphalium sylcaticum*.

Community with *Elymus repens* or *Poa pratensis*

This phytocoenosis is dominated by grasses – *Elymus repens* or *Poa pratensis*. In patches of this community, a high share of *Senecio jacobea* or *Rumex acetosa* is also noticeable. The community is very abundant floristically (Tab. 6.1). Forest species, meadow species, and species of dry grasslands occur here. Typical patches of this community – Sulejów A and Sulejów C were included in cluster Y.

Community with *Cirsium arvense* and *Solidago canadensis*

The phytocoenosis is represented in the analysed area by only one study plot – Szymaniszki B, included in cluster Y. Floristically, it is a very poor community. Two species dominate here: *Cirsium arvense* and *Solidago canadensis*. The share of three other species is insignificant (Tab. 6.1).

Community with *Betula pendula*

This type of community was identified at two study plots only: Łagiewniki B and Łagiewniki C, included in cluster Y. The physiognomy of this phytocoenosis is shaped by a considerable share of *Betula pendula*. There are not many herbaceous plants there (8–12). The dominating ones are: *Elymus repens*, *Conyza canadensis*, *Senecio jacobea*, *Jasione montana* and *Rumex acetosa* (Tab. 6.1).

Photo 6.1. *Solidago canadensis* in Sulejów A (S. Krysiak)

Photo 6.2. *Padus serotina* in Wola Życińska A (S. Krysiak)

Photo 6.3. *Helichrysum arenaria* in Weronika A (E. Papińska)

Photo 6.4. *Corynephorus canescens* in Krzętle A (E. Papińska)

Photo 6.5. *Senecio jacobaea* in Raciszyn A (E. Papińska)

Photo 6.6. *Viola tricolor* in Raciszyn C (E. Papińska)

http://dx.doi.org/10.18778/8088-193-8.07

7. Diversity of macromycete communities

Jolanta Adamczyk

Forty-six species of macromycetes were identified in the analysed abandoned lands. Communities of macromycetes show a diversity related to the development stage of the communities in the abandoned lands.

The community with lichen and the community with *Anthoxanthum aristatum* and *Corynephorus canescens* are the poorest in macrofungi species. There, mostly saprotrophic species of the *Bovista*, *Conocybe*, *Lycoperdon*, *Marasmius*, *Panaeolus*, and *Psilocybe* genera occur, individually or in small groups (Tab. 7.1). In study plots with trees, some mycorrhizal species appear, e.g. *Amanita muscaria* (Photo 7.3), *Inocybe corydalina*, and *Paxillus involutus* (Photo 7.1).

Equally poor in macromycete species are the few communities with *Calamagrostis epigejos*. Sporocarps of saprotrophic species were found there, e.g. *Conocybe tenera*, *Psilocybe semiglobata*, and *P. semilanceata*.

In patches of the phytocoenosis with *Agrostis capillaris*, *Hieracium pilosella*, and *Achillea millefolium*, macrofungi form larger and more abundant communities (7–19 species). In study plots where trees grow, there are some mycorrhizal species, which often produce numerous sporocarps. In patches, where the moss layer is present, species associated with mosses were observed, such as *Arrhenia lobata*, *Rickenella fibula* (Photo 7.2). In the community with *Agrostis capillaris*, *Hieracium pilosella*, and *Achillea millefolium*, the Glinnik A plot was the most abundant with macrofungi species.

The floristically abundant community with *Cirsium arvense*, *Galium mollugo*, and *Gnaphalium sylcaticum*, features fungi which are richer in macromycete species (10–19 species). It is characterised by fairly numerous saprotrophic species, e.g. *Clitocybe vibecina*, *Conocybe tenera*, *Macrolepiota procera* and a large share of mycorrhizal species, e.g. *Amanita muscaria*, *Boletus edulis*, *Inocybe maculata*, *Suillus bovinus* and *Xerocomus badius*. Only in this community, the occurrence of fruiting bodies of *Hemimycena lactea* on pine needles was observed.

Patches of the community with *Elymus repens* or *Poa pratensis*, which occurred at study plots Sulejów A and Sulejów C, feature a quite rich and diverse composition of macrofungi species. Among saprotrophic fungi, species of gasteroid fungi prevail, such as *Calvatia excipuliformis*, *Scleroderma citrina*, and *Vascellum pratense*. Mycorrhizal species also grow here, e.g. *Amanita muscaria*, *Inocybe asterospora*, and *I. maculata*. There are many fungi growing on special substrates – *Arrhenia lobata* on mosses and *Crinipellis scabella* on grasses.

One patch included in the community with *Cirsium arvense* and *Solidago canadensis* is very poor in macromycete species (3). Only *Marasmius oreades* occurs here frequently and abundantly.

The community with *Betula pendula* also has poor fungi (Tab. 7.1). Only saprotrophic species which form small sporocarps, such as *Panaeolus foemisecii*, occur here, infrequently.

The vast majority of macromycetes identified in the abandoned lands are saprotrophic terrestrial and mycorrhizal fungi. There is a small group of species which grow on grasses, mosses, pine needles and cones. Only two species of lignicolous fungi were observed in several study plots: *Schizophyllum commune* and *Trichaptum abietinum*, which grew on branches or twigs of *Pinus sylvestris* (Tab. 7.1).

Photo 7.1. *Paxillus involutus* in Weronika C (E. Papińska)

Photo 7.2. *Rickenella fibula* in Wola Pszczółecka A (E. Papińska)

Photo 7.3. *Amanita muscaria* in Krzętle A (E. Papińska)

Photo 7.4. *Laccaria laccata* in Raciszyn A (E. Papińska)

Photo 7.5. *Suillus luteus* in Raciszyn C (E. Papińska)

Photo 7.6. *Cladonia strepsillis f. coralloides* in Polesie A (A. Majchrowska)

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8. Discussion

8.1. Abandoned lands in the buffer zones around landscape parks in the Łódź Voivodeship

Stanisław Krysiak, Anna Majchrowska, Elżbieta Papińska

The spatial distribution of abandoned land, presented in chapters 4.1–4.3, shows the regional intensity variations of the phenomenon of land abandonment and different reasons for discontinuing cultivation in individual areas. Abandoning the agricultural use is a social phenomenon, which results from economic reasons, sometimes demographic ones (ageing of the farmers, no interest among the youth in farming the land, marginalisation and social exclusion, etc.), advancing urbanisation of the suburban zones, exclusion of lands for commercial and industrial investments, road construction, mineral extraction, etc. Thus, land abandonment results from farmers' decisions to discontinue the former agricultural usage. Examples include areas around the Sieradz landscape parks, with the lowest rate of land abandonment, caused by advanced agriculture, characteristic of the eastern part of Greater Poland (Fig. 8.1). Arable land in classes 0 and 1 of abandonment intensity constitute as much as 97.2%. Even areas with poor habitat potential (e.g. geocomplex types 15, 6, 4 or 7) are cultivated and have a low percentage of abandoned lands.

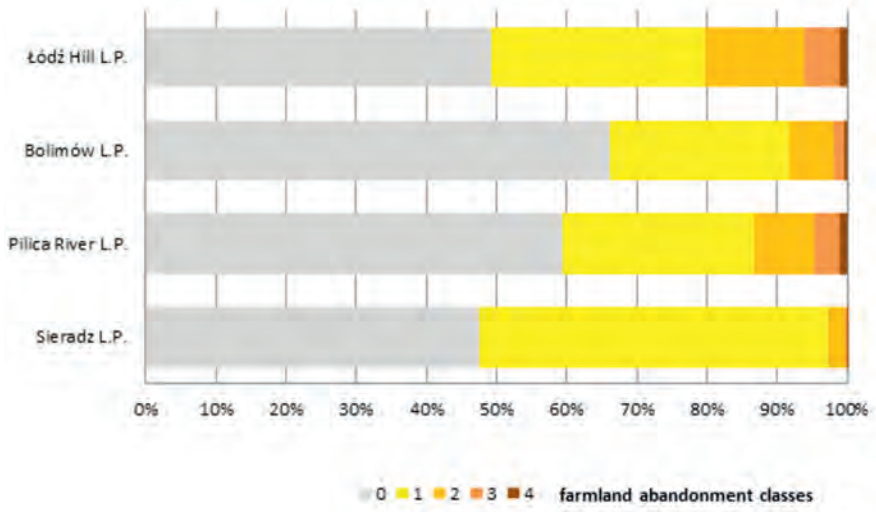

Fig. 8.1. Percentage of areas in land abandonment intensity classes in the buffer zones around landscape parks of the Łódź Voivodeship

Source: own elaboration.

Among driving forces of farmland abandonment in the Łódź Voivodeship, natural conditions play a major role. In a significant part of cases, land abandonment results from decreased profitability of agricultural production. Here, environmental conditions make it ineffective to cultivate habitats with a medium or poor biological productivity potential (sometimes, the poorest habitats have never been cultivated or have been afforested before). Such a situation occurs around the Pilica landscape parks and near the Bolimów Landscape Park. In these zones, a higher share of lands in abandonment classes 2, 3 and 4 is observed (Fig. 8.1).

This applies particularly to areas on the Pilica River and on the Warta River within the Szczerców Basin. The above observation complies with the results of J. Bański's research (1999) into problem areas in the Polish agriculture. On the map which shows "areas backward in their development" (Fig. 18, p. 61), J. Bański indicated many communes located in the southern and eastern part of the Łódź Voivodeship. Some of these communes were categorized as "critical areas", in which agriculture is doomed to failure without external help, and the condition for their development can be the introduction of other economic functions such as tourism and recreation or forestry (p. 62). Low agricultural value of soils of areas on the Pilica River resulted in high forest cover, unseen in other parts of the Łódź Voivodeship. The phenomenon is reflected in statistical data on forest cover in communes, according to which the Inowłódz commune is characterised by 58.3% of forest cover, the Przedbórz commune – 54.2%, and the Sulejów commune – 42.5% (http://lodz.stat.gov.pl/vademecum/vademecum_lodzkie/portrety_gmin). Within the buffer zone around the Pilica landscape parks, nearly 647 km² of forest were excluded from further analyses. A similar situation, but on a smaller scale, concerns areas around the Sieradz landscape parks. In some communes, the forest cover reaches up to 40%, for example in the Wierzchlas commune it is 37.8%, in the Osjaków commune – 36.3% (http://lodz.stat.gov.pl/vademecum/vademecum_lodzkie/portrety_gmin). In this case, almost 367 km² within the buffer was covered by forest and excluded from further analyses.

The buffer zones around landscape parks established in the southern part of the Łódź Voivodeship are characterised by the occurrence of large forest complexes, diverse land relief of the border between lowlands and uplands, and mosaic landscape. Crucial are large river valleys of the Pilica (along with the Sulejów Reservoir) and Warta, which make the described area also an important European ecological corridor of animal migrations (Paturalska-Nowak, Szymańska 2009). The vicinity of Przedbórz, the Wieluń Upland and the Bolimów Forest are regarded as nodes of national importance within the national ecological network ECONET-Poland, whereas the river valleys of Warta, Pilica, Rawka and Bzura have the status of national ecological corridors (Bernatek 2011).

Around forest areas, on larger rivers and in areas of favourable microclimate the replacement of agricultural functions with touristic ones is another frequent reason for land abandonment. The scale of this phenomenon is so large that, in relation to the areas on the Pilica River, it was called "touristic colonisation" (Wojciechowska 1998). It is particularly well visible around the Sulejów Reservoir in places like Smardzewice, Zarzęcin, Karolinów, Tresta, Twarda, Borki, Nagórzyce, Swolszewice, Bronisławów, Barkowice Mokre, Włodzimierzów. In the Spała Landscape Park, the above situation concerns Glinnik, Królowa Wola, Ciebłowice, Inowłódz, Żądłowice. In the Przedbórz Landscape Park, the abandoned lands are a part of the physiognomy of Miejskie Pola, Wygwizdów, Jabłonna, Wojciechów, Piskorzeniec, Wymysłów, Borowa, Stanisławów, Łączkowice, Wola Życińska, Chałupy, Dobromierz, Stara Wieś, Mojżeszów (Krysiak 2012).

The concentration of abandoned lands between Maluszyn and Skotniki (Fig. 4.4) indicates that the problem of low profitability of agricultural use concerns the Pilica river valley, where the decreased importance of cattle breeding resulted in discontinued grazing and mowing in large areas of grasslands.

The unique location of the Łódź Hills Landscape Park within the zone of the Łódź agglomeration induces strong urbanisation pressure on its surroundings (Jakóbczyk-Gryszkiewicz 2011). Suburbanisation shows in massive exclusion of lands from agricultural use, which results in a considerable percentage of abandoned lands of class 2 and 3 – about 20% (Fig. 8.1). Similar situations are observed near Piotrków Trybunalski, Tomaszów Mazowiecki and Sulejów (around the Pilica Landscape Parks), and Skierniewice (the buffer zone around the Bolimów Landscape Park).

The large concentrations of abandoned lands are related to suburban areas or peripheral areas, often lying within the administrative borders of towns. They are areas with the usually chaotic development of permanent housing by individual investors and, to a lesser degree, by real estate developers. A typical component of the landscape are abandoned lands on derelict farmlands, which await sale or commencement of building works, and areas at different stages of secondary succession alternating with plots with houses which have been or are being built and single cultivated fields. At many locations, recreational development is sometimes introduced as

the initial stage of building development in post-agricultural lands. The marginal zone of the Łódź Hills, e.g. near Rosanów, Smardzew, Szczawin or Swędów, has been one of the most important areas of seasonal summertime housing in the Łódź Voivodeship for several decades (Włodarczyk 1999). The increase of recreational development around large agglomerations in Poland is a typical phenomenon, presented in many scientific publications (Matczak 1986; Kowalczyk 1994; Matuszyńska 2001; Szkup 2003; Łowicki 2008; Myga-Piątek 2012).

Around cities, abandoned lands sometimes occur in more fertile habitats, and their presence can be explained with the cessation of agricultural functions in suburban zones. In places, the distribution of abandoned lands is to some extent related to the suitability of the lands for agricultural production and usually a minimal protection level is preserved for arable lands of high quality, e.g. near Lućmierz, where the soil and agricultural map (Województwo miejskie łódzkie. Mapa glebowo-rolnicza 1986) shows a patch of leeched brown soils, developed on silts lying upon loose sand, classified as the very good rye (4) complex of agricultural suitability.

In recent years, the factor that promoted land abandonment in the analysed areas were the road investments. An example is the S8 expressway, which runs across the northern part of the buffer zone around the Sieradz landscape parks. A concentration of abandoned lands included in class 2 and 3 is visible for instance near the Sieradz, Zduńska Wola or Złoczew junctions. The area to the north of the Warta–Widawka Interfluve Landscape Park, located within its buffer zone, was qualified as colliding with protected areas (http://www.wios.lodz.pl/files/docs/r11xviiix-przyroda.pdf).

Also the A1 and A2 motorways, which run near the Łódź Hills Landscape Park and the Bolimów Landscape Park, are accompanied by areas of intensified land abandonment. Such a situation occurs near Stryków, within a triangle marked by Sosnowiec, Wola Błędowa and the junction of A1 and A2 motorways (Fig. 4.17). Here, concentrations of class 4 of abandonment intensity are found, accompanied mainly by class 2 and 3 squares, which clearly reflect the location of investment areas around the town, and the course of motorways, whose construction might have made it difficult to access some agricultural plots. The issue of farmland abandonment does not appear in scientific literature dealing with spatial influence of roads and motorways construction, but the studies usually stress its negative impact on organising production in farms, breaking connections in the local road network used by agricultural transport and hampering the access to fields, disadvantageous changes in field layout and the resulting decrease in production potential (Dzikowska 2006).

Within the buffer zones around all landscape parks in the Łódź Voivodeship, considerable similarities occur in the structure of the natural environment, expressed in the share of individual geocomplex types (Fig. 8.2). The highest percentage in the analysed zones is taken by areas of plateau glacial tills (from 24.6 to 40.2%), which belong to geocomplex type 5, and a slightly lower share is taken by the sandy and gravelly areas of glacial and fluvioglacial accumulation (from 17.7 to 36.6%), which belong to geocomplex type 6. Among the other geocomplex types, areas of glacial and fluvioglacial accumulation lying upon glacial tills (type 16) and fluvial sediments of hydrogenic sections of valley bottoms (type 11) are also notable. Some geocomplex types occur sporadically and not in all analysed areas. Examples include areas built of siliceous rocks (type 1), carbonate and marl rocks (type 2), cover silts upon glacial tills (type 17) found in the Pilica and Warta landscape parks.

Abandoned lands are present in all geocomplex types, but their share usually corresponds to the habitat potential. In arable lands, which are located outside cities and suburban zones, the lack of abandoned lands results from favourable agricultural conditions. Such conditions are provided first of all by places where the parent rocks are silts upon till (geocomplex of type 17), glacial tills (type 5), clays, muds and mudstones (type 3) and other geocomplex types, where trophic and moisture conditions are shaped by the presence of glacial till in the lower parts of the soil profile. Shallow glacial tills make them the horizon which shapes the water balance of the geocomplex. By hampering the infiltration of precipitation water, tills improve the water balance of the habitat, contributing to periodical increases of moisture in the plant root zone.

In places there are no abandoned farmlands in areas classified as lithogenic geocomplexes related to permeable Quaternary deposits, in particular as geocomplex of type 6. It might seem that the less favourable abiotic conditions could

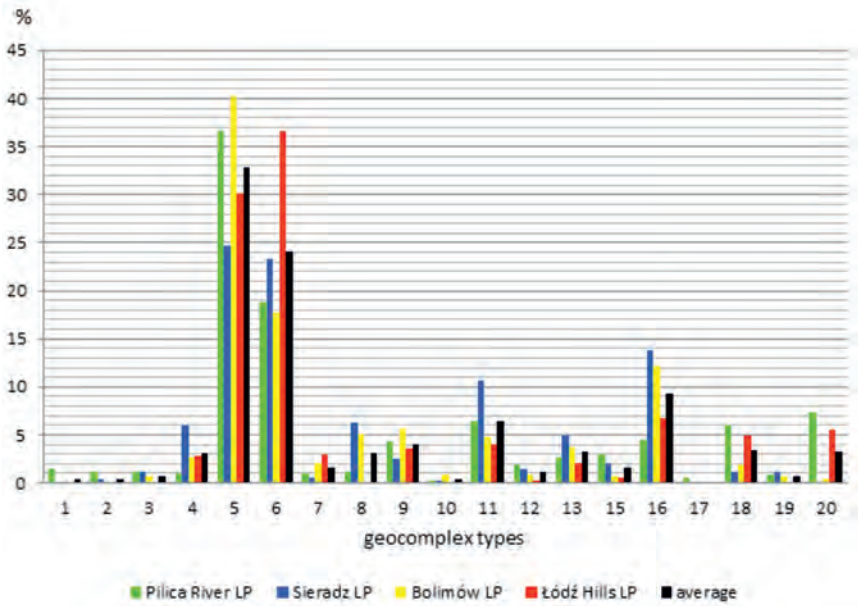

Fig. 8.2. Percentage areas of geocomplex types in the buffer zones around landscape parks of the Łódź Voivodeship

Source: own elaboration

predispose them for discontinuing their use as arable lands and for introducing abandoned lands among them. The soil and agricultural map can help explain this situation (http://geoportal.lodzkie.pl/imap/), as it shows some soils classified as complex 4 and 5 of agricultural suitability, which results from a considerable content of silts. Their thickness is not high enough to be marked on geological maps, yet their contribution to the improvement of the practical value of the soils is significant (Krysiak 1999ab, 2005ab, 2006ab, 2008ab; Papińska 2014). Silts change the infiltration conditions, by retaining water and making it available for plants. At locations where thickness of silts is the highest, there even appear soils classified as complex 2 of agricultural suitability of arable lands and 2z of permanent grasslands.

In all the analysed areas, an intensification of the phenomenon of land abandonment around forest complexes can be noticed (Fig. 4.4, 4.10, 4.23). This applies to both forests which lie outside the landscape parks and those which constitute their borders.

The borderlines of landscape parks in the Łódź Voivodeship are complex. Except for the Sieradz landscape parks, which have a compact shape, the others have very well-developed boundary lengths in relation to their area. Landscape parks on the Pilica River are characterised by particularly well-developed boundary lengths, especially the Sulejów Landscape Park, which consists of two parts, connected by a narrow section of the Pilica valley near Sulejów. In addition, the boundary development degree is influenced by enclaves of farmlands which have not been included in the parks when they were established. Examples of such locations are the vicinities of Zarzęcin and Karolinów in the Sulejów Landscape Park, areas around Królowa Wola and Inowłódz, Żądłowice and Liciążna in the Spała Landscape Park, the vicinities of Policzek, Gaj and Góry Mokre in the Przedbórz Landscape Park. At present, these enclaves have mostly lost their agricultural character, which is confirmed by the considerable share of abandoned lands there (Fig. 4.4). The increased naturalness of landscape there, provides a basis for the possible correction of the course of the boundaries, which might consist in integrating these areas into the parks. The presented suggestion relates to the practice of protecting entire environmental structures and not only their fragments (Żarska 2006).

In the authors' opinion, the recommendation for correcting the park boundaries may be applied to such sections, along which the phenomenon of land abandonment is intensified. It is compatible with the principle of "friendly" utilisation of neighbourhoods of environmentally valuable areas, proposed by B. Żarska (2006). Even if the boundaries are not corrected, the abandoned areas actually do provide a kind of buffer zone, which decreases the degree of isolation of protected areas and minimizes the negative impact of the surroundings.

8.2. Abiotic properties of the abandoned land study plots in the Łódź Voivodeship

Stanisław Krysiak, Anna Majchrowska, Elżbieta Papińska

Research conducted in 39 farmland abandonment study plots showed that the majority of the plots were located within the geocomplex type 6 (Fig. 8.3). Geocomplex types 4 and 15 were in the second place, with the percentage of study plots exceeding 10%. A slightly smaller share (nearly 8%) of the study plots were identified in geocomplex types: 8, 16 and 18. Little more than 5% were found in the geocomplex type 5.

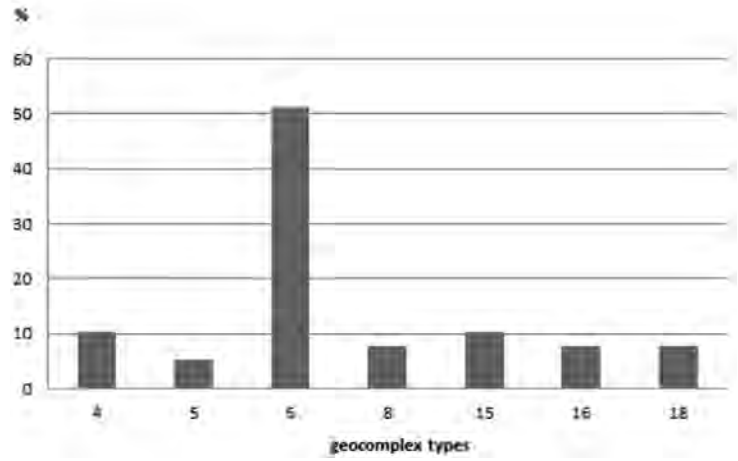

Fig. 8.3. Percentage of the abandonment study plots in individual geocomplex types

Source: own elaboration

One of the basic characteristics of the analysed soils is the grain size distribution, which is primarily dependant on the type of parent rocks. This parameter determines many soil properties, of which the most important include the capacity to retain water available and necessary for vegetation growth, or absorption or depletion of nutrients.

Most of the above mentioned geocomplex types, within which the study plots were delimited, are characterised by the occurrence of sands of various origin (see Tab. 3.1) and were included in the group of lithogenic geocomplexes with permeable Quaternary deposits. Only geocomplex types 5 and 18 were included in the group of lithogenic geocomplexes with hydrologic conditions shaped partially by shallow low-permeable deposits (Tab. 3.1).

The results of grain size distribution from all study plot groups in the soil horizon 0–20 cm indicate the dominance of the sand fraction (85.5%), and in it, the subfraction of medium sand (Fig. 8.4). It ranges from 17.6% (Szymaniszki C) to 48.6% (Wola Pszczółecka B). Due to such a large share of the sand fraction, the soils are characterised by excessive aeration and high permeability and a precipitation-retention type of water balance with the possibility of frequent shortages of soil moisture (e.g. Wola Pszczółecka A and B, Piskorzeniec A, B, C).

An important role in shaping the aeration and moisture properties is played by the silt fraction, whose presence influences the volume of mesopores, which retain capillary water available for plants (Krysiak 1996, 2006b). The average content of the silt fraction in this horizon exceeds 13%. An increased admixture of silt fraction is characteristic of the study plots in which periglacial cover formation occurs (e.g. Glinnik A, Sulejów A, B, C; Łagiewniki B, C; Szymaniszki A, B, C; Polesie A).

A similar situation occurs in the 20–40 cm horizon, which is the optimal one for the development of the root system of herbaceous plants and most trees. The sand fraction shows the highest content – 83.6% (Fig. 8.5). The content of medium sands in this fraction reaches 45%, coarse – 27%, and fine – 24%. The dominance of the sand fraction has a significant influence on the value of specific surface area, which averages in the 0–20 cm horizon at

0.14 $m^2 \cdot g^{-1}$ (median: 0.103 $m^2 \cdot g^{-1}$), and in the 20–40 cm horizon – 0.136 $m^2 \cdot g^{-1}$ (median: 0.119 $m^2 \cdot g^{-1}$). The results of grain size distribution analyses allow to conclude that soils of the abandonment study plots are characterised by excessive aeration and high permeability. Also the water and absorbing capacity of such soils is relatively low, as is the availability of nutrients for plants.

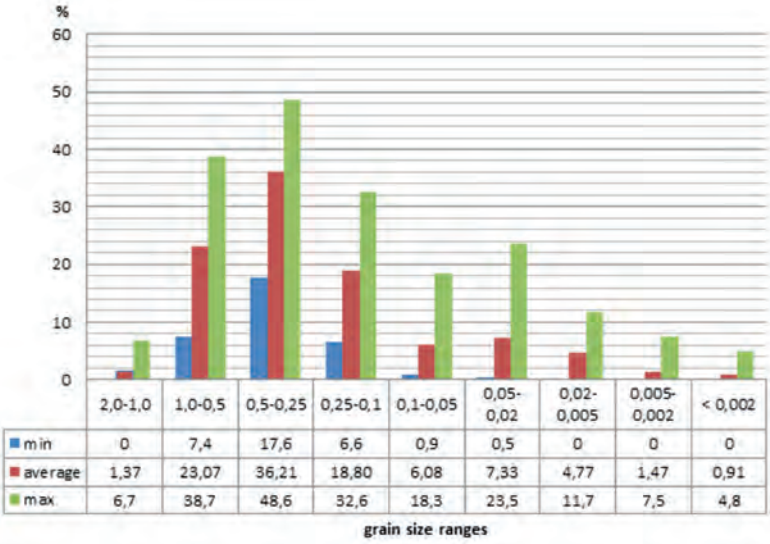

Fig. 8.4. The minimum, arithmetic mean and maximum percentage of granulometric fractions and subfractions of soils sampled from the study plots, in the 0–20 cm horizon

Source: own elaboration

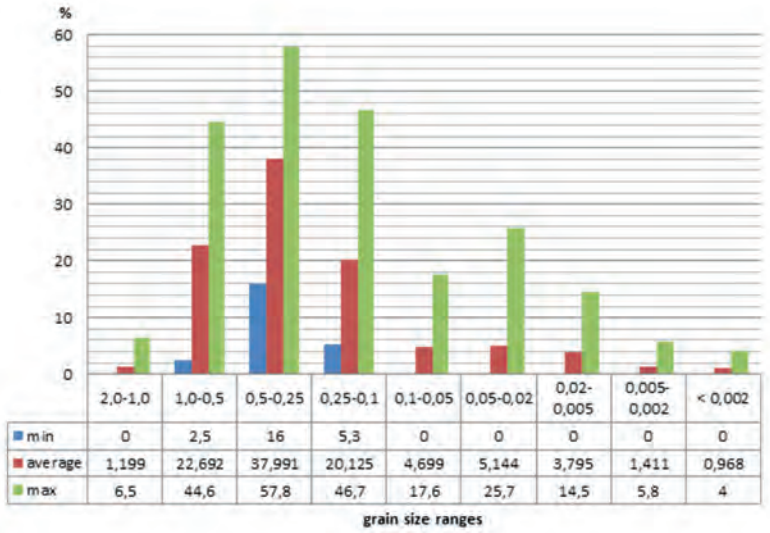

Fig. 8.5. The minimum, arithmetic mean and maximum percentage of granulometric fractions and subfractions of soils sampled from the study plots, in the 20–40 cm horizon

Source: own elaboration

A significant role in shaping the water conditions of some plots is played by glacial tills, which are characterised by a higher content of the clay fraction in the lower parts of the soil profile. These deposits hamper the infiltration of precipitation water, contributing to periodical occurrence of perched water tables available for plant roots. Examples of such study plots include: Glinnik B, Sulejów A and C, Wola Życińska B, Weronika B and C, Wola Pszczółecka C.

Laboratory analyses showed that in all analysed soil profiles, the pH_{KCl} value in the 0–20 cm

horizon was very acidic and acidic (Fig. 8.6) and ranged from 3.8 to 5.5. Nearly 80% of the samples were characterised by very acidic reaction, which reached its lowest value of 3.8 in 5% of the samples. The median for this distribution equals 4.2, which indicates a clear share of samples with very acidic reaction (Fig. 8.6).

The distribution of pH_{H2O} in the same horizon is slightly different (Fig. 8.7). The results of reaction analyses are contained in three classes of acidity: very acidic (56.4% of samples), acidic (33.3%) and slightly acidic (10.3%) (Bednarek et. al 2004). The pH values range from 4.3 to 6.4. Despite a greater spread of pH values, the samples classified as very acidic constitute the highest percentage.

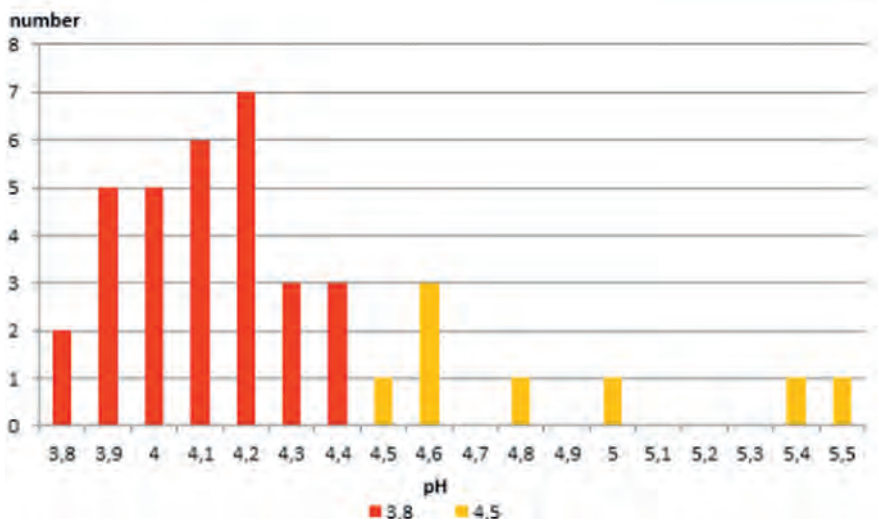

Fig. 8.6. Number of soil samples in pH_{KCl} acidity classes, in the 0–20cm horizon

Source: own elaboration

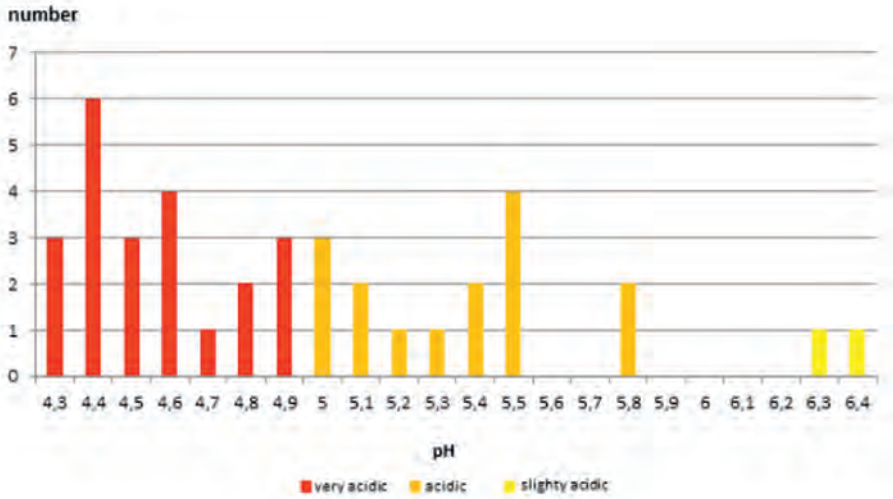

Fig. 8.7. Number of soil samples in pH_{H2O} acidity classes, in the 0–20 cm horizon

Source: own elaboration

Analogous juxtapositions of the pH value were performed for samples taken from the depth of 20–40 cm (Fig. 8.8 and 8.9), that is of great importance for the development of the root system of herbaceous plants and most trees. Also in this case, all samples were characterised by very acidic and acidic pH_{KCl}, although the extreme values exhibited a smaller spread – from 4.1 to 5.3. The percentage of samples classified as very acidic is also lower – they constitute 38% in this horizon.

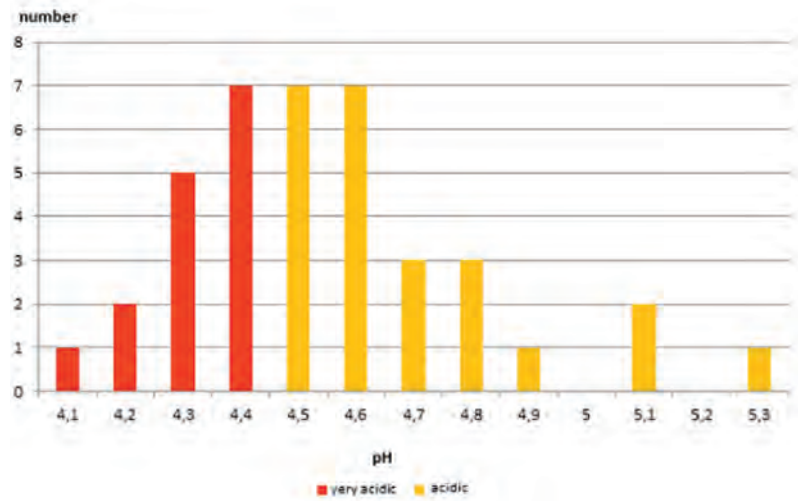

Fig. 8.8. Number of soil samples in pH_{KCl} acidity classes, in the 20–40 cm horizon

Source: own elaboration

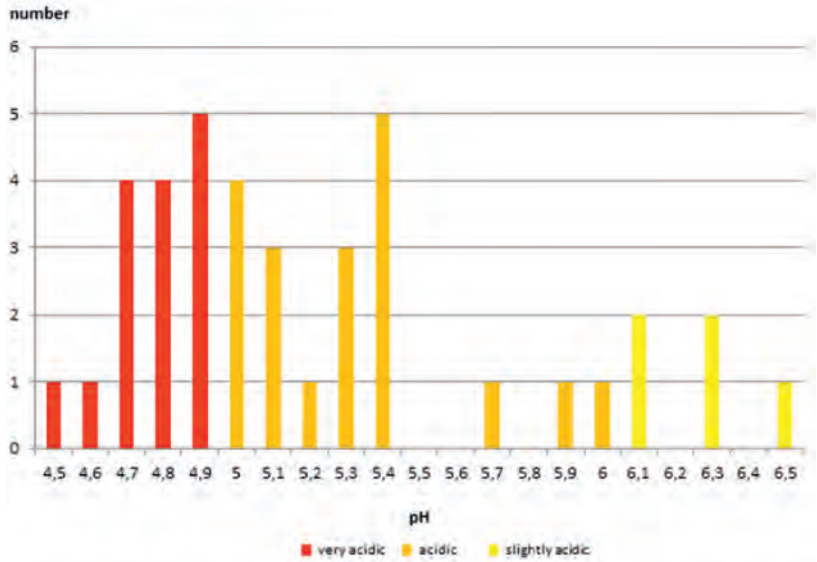

Fig. 8.9. Number of soil samples in pH_{H2O} acidity classes, in the 20–40 cm horizon

Source: own elaboration

The pH value of samples taken from the 20–40 cm horizon, marked in H_2O, is contained in three classes. Very acidic samples make up about 38%, acidic – about 49% and slightly acidic – nearly 13%. Extreme pH values in this case range from 4.5 to 6.5. The presented data indicate that there is a clear shift towards lower acidity.

The analysis of pH is important because "a lot of soil properties are the function of their pH value" (Bednarek et al. 2004, p. 198). It influences, among other things, the composition of exchangeable cations, availability of nutrients for plants, or release of elements which are potentially toxic to plants. In Table 8.1, the selected chemical properties of soils for two horizons: 0–20 cm and 20–40 cm are juxtaposed in order to show their extreme values (min and max) and average values (median and arithmetic mean).

Many abandonment study plots, presented in chapters 5.1–5.3, have a very low saturation degree of the sorptive complex with alkaline cations, not exceeding 20% (Glinnik A, B, C; Celestynów A, B; Piskorzeniec A, B, C; Weronika A, Wola Pszczółecka A, B; Polesie A, B; Wola Makowska B, C). The above parameter was regarded by A. Harasimiuk (2013) as one of the quantitative indicators for delimiting oligotrophic landscapes, which represent the class of landscapes poor in nutrients for

Tab. 8.1. Selected measurements which characterise the chemical properties of soils of the abandonment study plots.

Selected measurements	Available nutrients %			Exchangeable cations me/100g				Hydrolytic acidity mmol/100g	Humus %
	P_2O_5	K_2O	Mg	Ca^{2+}	Mg^{2+}	Na^{+}	K^{+}		
Level 0–20 cm									
Min.	1.1	0.3	0.2	0.1	0.017	0.004	0.013	1.48	0.63
Average	8.0	2.2	0.8	0.7	0.100	0.000	0.100	3.70	1.40
Median	7.1	1.7	0.5	0.2	0.030	0.030	0.060	3.56	1.38
Max.	18.9	5.8	4.8	2.8	0.410	0.070	0.164	7.25	3.15
Level 20–40 cm									
Min.	0.7	0.20	0.20	0.05	0.010	0.000	0.01	0.84	–
Average	3.0	1.21	0.70	0.50	0.060	0.030	0.04	1.86	–
Median	2.5	0.80	0.30	0.17	0.020	0.020	0.04	1.54	–
Max.	17.2	4.20	3.00	2.10	0.283	0.345	0.12	4.88	–

Source: own elaboration.

living organisms (p. 24). According to A. Harasimiuk, oligotrophic agricultural landscapes, in the conditions of social and economic changes in agriculture, are subject to various scenarios of transformations. For soils of the lowest productivity, the scenario is usually abandonment.

The phenomenon of abandonment causes changes in the soil environment, influencing e.g. the course of physicochemical processes. The changes are difficult to unequivocally define as positive or negative, as the rich literature of this issue often reveals opposing opinions. Some authors point out the decreased fertility of abandoned soils, and even their permanent degradation (Krężel, Miklaszewski 1987; Kutyna, Niedźwiecki 1996; after Zawieja 2013). However, many authors also emphasize the increased content of organic carbon (Tomaszewicz, Chudecka 2010; Włodek et al. 2014) or the higher pH value and saturation degree of the sorptive complex with bases (Chudecka, Tomaszewicz 2004). Some contrasting opinions on the rising trends concerning the organic carbon content were presented in the publications by such authors as T. Wojnowska et al. (2003) and G. Żukowska et al. (2007), and on the impoverishment of the sorptive complex – S. Sienkiewicz et al. (2003) or S. Strączyńska and S. Strączyński (2003).

The results of laboratory studies presented in chapters 5.1–5.3 may constitute the starting point for future research projects, which may be aimed at demonstrating changes taking place in the soil environment after a given period of abandonment. Then, the authors can join the discussion of the directions of transformations which occur in the pedosphere as a result of farmland abandonment.

8.3. Plant cover and fungi of the abandoned lands in the Łódź Voivodeship in comparison with abandoned land habitats in different regions of Poland

Jolanta Adamczyk

There is a high degree of interest in vegetation which encroaches upon the post-cultivation lands. Most studies which were published in this area focus on observing subsequent stages of plant succession, during a shorter or longer period of time. In Poland, the most well-documented in this respect is the Jelonka reserve, on which continuous observations have been conducted for over 40 years (Faliński 1986). Similar research projects were also conducted in other regions of the country (e.g. Wójcik 1996; Balcerkiewicz, Pawlak 1997; Sławski 2002). Shorter time studies of abandoned lands in Poland concerned the area in the Wierzbówka Valley, to the south of Skawina, just behind the edge of the Carpathian Foothills (Dubiel 1984) and the Przemyśl Foothills (Barabasz-Krasny 2002).

In this work, which deals with abandoned lands of the Łódź Voivodeship, it was not one of the aims to study plant succession in these habitats. The short period of research (2 years) and lack of information on the age and previous usage of the abandoned farmland allowed the authors only to evaluate the vegetation which grew there during a given time, with an emphasis on its biocoenotic role in the analysed area. For this reason, a comparison of the abandoned land vegetation in the Łódź Voivodeship was made only with studies of the Wierzbówka Valley and the Przemyśl Foothills. In the Wierzbówka Valley, three development stages were distinguished in the abandoned land vegetation, which differed with respect to the dominating species, physiognomy and age: the *Cirsium arvense – Agropyron repens* stage, the *Agrostis vulgaris – Holcus mollis* stage and the *Solidago virgaurea – Hieracium umbellatum* stage (Dubiel 1984). As regards abandoned lands in the Przemyśl Foothills, the occurrence of three communities was identified: the community with *Hypericum perforatum* and *Torilis japonica*, the community with *Calamagrostis epigejos* and the community with *Vicia tetrasperma* (Barabasz-Krasny 2002). No clear similarity was found between plant communities distinguished in the abandoned lands of the Łódź Voivodeship and those identified in the two above mentioned works. Only the *Calamagrostis epigejos* community, identified in the Przemyśl Foothills (Barabasz-Krasny 2002) also occurred in the area of the Łódź Voivodeship. This confirms the observation that communities which develop in post-agricultural lands are very diverse floristically, devoid of balance and open to alien species from various habitats (Dubiel 1984). Their floristic composition is certainly shaped by numerous biotic and abiotic factors. Most dominating species in the communities of the Carpathian and Przemyśl Foothills also occur in the phytocoenoses of the Łódź Voivodeship abandoned lands, but in different quantities and species compositions. When comparing the studies, one must take into account significant differences in the geologic structure, soil types and climate between the areas of the Carpathian and Przemyśl Foothills and the analysed area of the Łódź Voivodeship. Obviously, they have an impact on the shaping of phytocoenoses in the abandoned lands.

Mycological research in abandoned farmland habitats is not rich. So far, it has been conducted in Białowieża (Kałucka 1999, 2009) and the Chłapowski Landscape Park in central Greater Poland (Kujawa 2007, 2008ab, Kujawa and Kujawa 2008). Recently, preliminary results of studies of abandoned lands in the Łódź Voivodeship have been published (Adamczyk 2014). A reliable comparison of mycological analyses results from Białowieża and Greater Poland with abandoned land research results from the Łódź Voivodeship is impossible. This results from the specificity of the former research, which concerned more diverse habitats than abandoned lands of the Łódź region, as well as from the length of the research period, which was much shorter for the latter research. Two-year mycological studies, conducted in permanent study plots, allow to capture only a few development trends of the macromycete communities. In addition, precipitation during the years when research in the Łódź Voivodeship was conducted (2012–2013) was exceptionally low, which might have had a significant impact on the results of mycological observations.

8.4. Evaluation of the phenomena and processes which influence the plant cover and fungi of the analysed abandoned lands

Jolanta Adamczyk

The shaping of plant cover and fungi of abandoned lands may be influenced by many different abiotic and biotic factors. They may include: the geological substratum, soils, the most recently cultivated crops and the neighbouring communities (Dubiel 1984). On the basis of research conducted in the Łódź Voivodeship, it is possible to attempt at evaluating most of these factors. It is difficult to determine the most recently cultivated crops, as it was impossible to reliably verify the age and previous usage of the abandoned lands.

Soil studies indicate considerable acidification of most analysed abandoned lands. In the communities: *Anthoxanthum aristatum* and *Corynephorus canescens*, as well as *Agrostis capillaris*, *Hieracium pilosella* and *Achillea millefolium*, the pH value in H_2O is 4.2–5.5. The soils in patches of phytocoenoses with *Cladonia* and patches with *Calamgrostis epigejos* have similar pH values. Habitats of communities with *Cirsium arvense*, *Galium mollugo* and *Gnaphalium sylcaticum*, as well as *Elymus repens* or *Poa pratensis* have neutral pH of 5.4–6.3 (Tab. 8.2). The pH value is related to the content of calcium in the soil. It increases with the increasing pH value. The highest calcium content occurs at study plots Sulejów A, Sulejów C and Wola Życińska B. The content of potassium ions is very low compared with the average content for medium agricultural soils. It is the lowest in habitats of the floristically poor communities, and increases in habitats with richer flora.

The content of nitrogen in soils of the analysed abandoned lands is very low. On average, it is about 10 times lower than the nitrogen content in the soils of abandoned lands analysed in the Carpathian Foothills (Dubiel 1984). The highest amount of nitrogen was recorded in soils of the study plots Wola Życińska B and Szymaniszki B (Tab. 8.2). The humus horizon is of considerable thickness in most analysed patches in all observed plant communities. However, it does not prove their fertility, as – according to some authors – during the initial stages of phytocoenoses which are formed in abandoned farmland habitats, the production of biomass is higher than its decomposition (Chudecka, Tomaszewicz 2004; Tomaszewicz, Chudecka 2010).

The results of soil analyses confirm the view of some authors (Dubiel 1984) that during the first development stages of abandoned land vegetation, the soil of these habitats is highly depleted. Insufficient amount of nutrients restricts the possibilities for plants to inhabit the abandoned lands. Poor abandoned lands are first colonised by lichens and grasses with lower nutritional requirements, e.g. the community with *Cladonia*, the community with *Anthoxanthum aristatum* and *Corynephorus canescens*. Richer soils are inhabited by grasses and perennial plants with higher soil fertility requirements, e.g. the community with *Cirsium arvense*, *Galium mollugo* and *Gnaphalium sylcaticum*.

It remains difficult to explain whether abandoned lands with rich flora constitute the stage which occurs after the poorer stages, or they are rather the initial stages in the more fertile abandoned lands. Some studies of abandoned lands found that agricultural soils, characterised by a high nitrogen content, remain rich in this element from the moment of abandoning cultivation until the pole wood forest phase (Sławski 2002). All the abandoned lands in the Łódź Voivodeship showed a very low nitrogen content. Due to missing data concerning their age and previous usage, it is difficult to draw conclusions about their initial nitrogen content.

Macromycetes also reveal a dependency on the fertility of abandoned land habitats. The least fertile patches, overgrown with *Cladonia* or grasses, are characterised by a very small number of macromycete species. Mainly small sporocarps of gasteroid fungi and fungi of the *Conocybe* and *Panaeolus genera* occur there. It is only in several study plots, where trees grow, that mycorrhizal fungi occur. Diversity of macromycete communities increases with soil fertility. In more fertile patches, there are a lot more species, both saprotrophic and mycorrhizal ones. Tree species of fungi occur hardly anywhere, which is probably related to the fact that trees in the abandoned lands are young and produce little substrate in the form of fallen branches, logs and stumps.

Table 8.2. Chemical properties of soils of abandoned land plant communities (at the 20–40 cm horizon)

Plan community	Study plots	pH in H_2O	Ca^{2+} me/100g	K^+ me/100g	P_2O_5 mg/100g	N %	Humus %
Anthoxanthum, Corynephorus	Celestynów A	4.2	N.D.	0.026	1.5	0.047	1.37
	Krzętle A	4.6	0.15	0.013	4.8	0.038	0.86
	Wola Makowska A	5.1	0.20	0.031	17.2	0.033	0.63
	Wola Makowska B	4.8	0.15	0.026	7.1	0.041	0.85
	Polesie C	4.7	0.15	0.018	2.5	0.053	1.42
Agrostis – Hieracium – Achillea	Glinnik A	4.9	0.10	0.044	3.0	0.069	1.75
	Glinnik B	5.5	0.10	0.038	4.0	0.036	0.86
	Wola Życińska A	4.9	0.15	0.013	1.9	0.082	1.85
	Wola Życińska C	5.9	0.80	0.038	1.6	0.075	1.58
	Raciszyn A	5.2	0.20	0.067	0.5	0.050	0.94
	Celestynów B	4.8	0.10	0.013	2.7	0.051	1.42
	Krzętle C	4.9	0.10	0.013	5.3	0.060	1.22
	Weronika B	4.9	0.10	0.026	3.4	0.051	1.33
	Wola Pszczółecka C	4.9	0.45	0.056	1.2	0.072	1.42
Calamagrostis	Wola Życińska B	5.5	2.10	0.102	0.2	0.162	3.15
	Wola Makowska C	4.8	0.15	0.026	1.7	0.078	1.70
	Szymaniszki A	5.2	0.70	0.072	2.9	0.069	1.24
Cladonia	Piskorzeniec A	4.8	0.05	0.013	2.6	0.020	0.64
	Polesie A	4.7	0.15	0.018	2.5	0.053	1.42
	Wola Pszczółecka B	5.1	0.05	0.013	1.6	0.060	1.55
Cirsium Galium Gnaphalium	Raciszyn C	5.4	0.15	0.026	1.6	0.078	1.73
	Weronika C	6.0	0.65	0.044	1.9	0.058	1.02
Elumus Poa	Sulejów A	6.3	1.70	0.062	2.4	0.092	1.98
	Sulejów C	6.1	1.30	0.049	2.4	0.094	1.94
Cirsium Solidago	Szymaniszki B	5.4	1.20	0.072	4.5	0.100	1.86
Betula	Łagiewniki B	4.5	0.15	0.026	1.8	0.072	1.35
	Łagiewniki C	5.0	0.35	0.072	3.1	0.068	1.38

Abbreviations: ***Anthoxanthum-Corynephorus*** – community with *Anthoxanthum aristatum* and *Corynephorus canescens*; ***Agrostis – Hieracium – Achillea*** – community with *Agrostis capillaris*, *Hieracium pilosella* and *Achillea millefolium*; ***Calamagrostis*** – community with *Calamagrostis epigejos*; ***Cladonia*** – community with *Cladonia*; ***Cirsium – Gallium-Gnaphalium*** – community with *Cirsium arvense*, *Galium mollugo* and *Gnaphalium sylvaticum*; ***Elymus-Poa*** – community with *Elymus repens* or *Poa pratensis*; ***Cirsium-Solidago*** – community with *Cirsium arvense* and *Solidago Canadensis*; ***Betula*** – community with *Betula pendula*.

Source: own elaboration.

Another factor of importance in the shaping of vegetation and fungi communities in the abandoned lands is their neighbourhood. In the analysed area, the vast majority of abandoned lands is found near smaller or larger areas overgrown with trees. Only the plots Glinnik A, Polesie A and C, Wola Makowska A are not located near woodlands. The neighbourhood of forests of various origin and species composition favours the rapid occurrence of trees in abandoned lands, especially pine *Pinus sylvestris*, birch *Betula pendula*, less frequently oak *Quercus robur* and rowan *Sorbus aucuparia*. In each isolated type of community, there are patches inhabited by trees. They are young trees of different ages, and sometimes only seedlings. Frequent presence of trees in various types and ages of abandoned lands indicates a clear influence of the nearby woodlands on their flora and vegetation. It may be assumed that many of the analysed patches of abandoned lands overgrown with trees, will – under favourable conditions – develop towards forest communities. In our climate, it is the natural direction of succession in abandoned land habitats (Dubiel 1984; Faliński 1986). Owing to the short period of research, it is impossible to determine what factors

influence the fact that in some abandoned lands trees do not appear, despite close neighbourhood of woodlands.

Another factor which influences the phytocoenoses of abandoned lands is the occurrence of expansive species, including invasive species of non-native origin. In the analysed area, the occurrence of 7 such species was recorded (Tab. 6.2). Invasive species of foreign origin quickly colonise new areas and habitats, causing negative effects in ecosystems (Bomanowska et al. 2014). Currently, it is the invasion of species of foreign origin, resulting from human activity, that is considered, apart from habitat fragmentation, to be one of the most serious threats for biodiversity (CBD 1992). In the analysed abandoned lands of the Łódź Voivodeship, the occurrence of two invasive species can be considered as the most dangerous: *Solidago canadensis* and *Padus serotina*. In Poland, *Solidago canadensis* reproduce both sexually and asexually, but it is characterised by rapid clonal proliferation (Sudnik-Wójcikowska 2011). The quick spreading of this species is favoured by longevity of the clones and considerable allocation of biomass (Adamowski et al. 2014). *Solidago canadensis* exhibits high plasticity and easy adaptation to different habitat conditions (Weber and Jacobs 2005). Due to these features, the appearance of this species in abandoned lands may hamper the growth of other plant species and modify the succession direction of abandoned land phytocoenoses. The other dangerous invasive species is *Padus serotina*. This species grows on soils with a wide spectrum of moisture and trophicity, although it is mainly associated with sandy and poor soils, with acidic pH reaction (Closset-Kopp et al. 2010; Halarewicz 2012). *Padus serotina* quickly takes over open habitats: abandoned fields, meadows and pastures (Deckers et al. 2005; Adamczak 2007). *Padus serotina* produces compounds that act allelopathically (prunasin, amygdalin), which can inhibit growth of other plants (Csiszár 2009; Robakowski et al. 2012). Dense undergrowth of *Prunus serotina* restricts the regeneration and growth of indigenous tree species, particularly those that require high amount of daylight, as oak or pine (Starfinger et al. 2003).

The occurrence of *Solidago canadensis* was recorded in 7 study plots of analysed abandoned lands, but it only obtains high cover at plot Szymaniszki B. In other areas, *Solidago canadensis* occurred only as an addition. The presence of *Padus serotina* was recorded in 8 abandoned land areas. It reached the highest cover at plot Szymaniszki C. In other patches it was sparse. Despite the low share of *Solidago canadensis* and *Padus serotina* in most of the analysed abandoned land patches, their presence should be admitted as undesirable and potentially threatening to proper succession in the abandoned lands, owing to the biological properties of these species, as discussed above.

8.5. The importance of abandoned lands for sustaining the ecological processes in areas surrounding the landscape parks of the Łódź Voivodeship

Jolanta Adamczyk

In evaluating the ecological importance of abandoned land habitats, their role in sustaining the biodiversity of the region, the capability to restore forest phytocoenoses or to impede the invasion of non-native plant and animal species must be taken into consideration. The ecological importance of the analysed abandoned lands may result from the type of vegetation, the presence of plant or fungi species that are legally protected, endangered or rare at the scale of the country or region, and their location in relation to other phytocoenoses.

Despite the proximity of landscape parks, in which rare and protected species of flora occur, no legally protected or endangered species were found in the abandoned lands. Only *Helichrysum arenaria* and *Cladonia rangiferina* are partially protected species. However, the significance of abandoned lands as potential refugia for flora and fungi species that are valuable from the point of view of nature conservation cannot be ruled out. It happens that rare species of plants which occur in protected areas leave them for various environmental reasons and look for convenient habitats at other locations. The neighbouring phytocoenoses of abandoned lands may easily become their new sites. Besides, some species identified in the analysed abandoned lands are not frequent in the Łódź region. Such species include *Dianthus cartusianorum* and *Thymus pulegioides*. Their occurrence in abandoned lands is a favourable phenomenon for sustaining the biodiversity of the region. Moreover, the forest phytocoenoses which originated as a result of secondary succession in post-agricultural areas are richer in plant species than abandoned lands that are afforested, and they foster sustained biotic diversity. Artificial afforestation in such habitats are usually shrubs and trees, which are even-aged and lack the zonality of groundcover. Diversity of species is based almost exclusively on the planted target species of forest plant communities (Matysiak 2007). On the other hand, natural succession leads to the formation of forest phytocoenoses with a diverse structure and a greater variety of species. It is very important for the development and life of numerous species of different organisms.

High plant diversity of the analysed abandoned lands may be regarded as a favourable phenomenon. It creates different habitat conditions, which foster the appearance of numerous organisms. For example, even very poor habitats are colonized by several species of *Cladonia*, which enriches the species diversity of the region. Each identified type of abandoned land vegetation is of biocoenotic significance, by creating unique conditions of life for various organisms. The few patches of abandoned lands which were dominated by invasive species of non-native origin – *Solidago canadensis* and *Padus serotina*, must be treated as an exception. They are also the place for various organisms to live but they pose a threat for other plant communities of abandoned lands and natural phytocoenoses, which are protected in the nearby landscape parks. The phenomenon of invasive species of foreign origin occurring in protected areas is currently a worldwide problem (e.g. de Poorter 2007; Foxcroft et al. 2013).

The location of the analysed abandoned lands near afforested areas is very advantageous for the formation of natural ecological corridors (Fig. 4.4, 4.23). Agricultural usage of the land always results in fragmentation of habitats. Secondary succession which occurs in the abandoned lands helps reverse the process (Faliński 1986). Abandoned land phytocoenoses are places where species of various organisms may live or through which they can reach forest phytocoenoses that exist nearby more easily. In a spatially diverse agricultural landscape, in which small areas favourable for the life of individual species are separated with unfavourable areas (fields), corridor connections play an important role. They influence the dynamics of populations of organisms, by limiting their extinction and enabling proper shaping of their communities by decreasing the degree of isolation (Kijowska, Zajadacz 2004). All landscapes are related thanks to corridors, which play an important role in the ecological, visual and economic dimensions. A corridor is a relatively narrow belt of land, different than the surrounding background. It tends to be either isolated or connected with a given area, which is characterised by unique ecological conditions. Abandoned lands may

function as belt corridors, as they are wide enough to shape specific habitat conditions inside them. Such corridors can also act as habitats, filters (barrier), guide, source and receiver, but usually they are the main migration paths for substances, energy and organisms in the landscape (Forman 1995).

While analysing the ecological role of the analysed abandoned lands, it is worth pointing to another factor. Abandoned lands are habitats, where the composition of the occurring species, both cultivated and wild, changes many times. Thus, they form a sort of "container" of different diaspores, from crop weeds to species found in meadows, forests and other habitats. They probably also contain spores of various fungi or dormant forms of plant and animal microorganisms. From the environmental point of view, such habitats are very valuable, as a unique, natural gene bank of various organisms.

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9. Conclusions

1. Abandoned lands in the buffer zones around landscape parks of the Łódź Voivodeship are found most frequently in lithogenic habitats characterised by high water permeability, conditioned by the dominance of the sandy fractions.
2. The phenomenon of land abandonment occurs in all geocomplex types because it is influenced not only by environmental conditions, but also by economic and social factors.
3. The soil conditions of abandoned lands, and particularly their pH reaction and content of certain elements, mainly nitrogen, phosphorus and potassium, influence the structure of vegetation which grows as a result of secondary succession of the abandoned lands.
4. The analysed abandoned lands are characterised by high diversity of their vegetation, flora and macromycetes. Phytocoenoses which occur in the abandoned lands exhibit low stability and are open to impact from the neighbouring habitats.
5. Abandoned lands which lie in direct neighbourhood of landscape parks and forest complexes function as a buffer, which provides protection from negative environmental impact.
6. A considerable portion of the analysed abandoned lands is of great ecological significance for the agricultural areas where they occur, by providing refugia for species and genes which enrich the biodiversity, or by forming natural ecological corridors.
7. Abandoned lands inhabited by invasive plant species of foreign origin, can pose a threat to other habitats, in particular to the natural phytocoenoses of protected areas.
8. Abandoned lands in the agricultural landscape are interesting, though insufficiently recognised natural habitats. Due to their important biocoenotic role, they should become the subject of more detailed ecological research.

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11. Ekologiczna rola odłogów stref otaczających parki krajobrazowe w województwie łódzkim

Streszczenie

Przemiany ustrojowe zapoczątkowane w Polsce na przełomie lat 80. i 90. XX wieku sprawiły, że obszary wiejskie objęły przekształcenia strukturalne i funkcjonalne, które spowodowały wyłączanie z użytkowania części gruntów należących do rolników indywidualnych. W krajobrazie rolniczym pojawiły się znaczne powierzchnie ziem leżących odłogiem. Problem odłogowania gruntów przedstawiany był w licznych pracach (np. Bański 1998, 2006, 2007; Krysiak 2010, 2011, 2012; Łowicki 2008; Majchrowska 2013, 2014), które pokazały jedynie skalę odłogowania w jednostkach administracyjnych, nie dając informacji o rozmieszczeniu tego zjawiska w granicach jednostek krajobrazowych i jego uwarunkowaniach siedliskowych. W niniejszej pracy rozmieszczenie odłogów w strefach otaczających parki krajobrazowe województwa łódzkiego przedstawiono na tle naturalnych jednostek krajobrazowych – geokompleksów reprezentujących określony potencjał siedliskowy.

Celem pracy było:

1. Poznanie rozmieszczenia odłogów na badanych terenach.
2. Sporządzenie listy gatunków roślin naczyniowych oraz grzybów wielkoowocnikowych wybranych odłogów.
3. Opisanie roślinności występującej na badanych odłogach.
4. Ocena związku rozmieszczenia odłogów z abiotycznymi cechami środowiska przyrodniczego.
5. Określenie związku roślinności odłogów z cechami abiotycznymi siedliska
6. Ocena ekologicznej roli odłogów w krajobrazie rolniczym woj. łódzkiego, uwzględniając ich warunki abiotyczne oraz specyfikę roślinności i macromycetes.

Badania prowadzono na obszarze 7 205 km², w strefach otaczających wszystkie parki krajobrazowe woj. łódzkiego. Powierzchnie odłogów zostały wybrane po wstępnej analizie ortofotomap, na które naniesiono siatkę o kwadratach równych 25 ha. Pozwoliło to wytypować regiony o największej koncentracji odłogów. W celu uzyskania informacji o naturalnych czynnikach wpływających na rozmieszczenie odłogów wykonano mapy geokompleksów-morfolitohydrotypów. Prace terenowe obejmowały wyznaczenie 39 powierzchni obserwacyjnych. Z badanych powierzchni pobrano próby glebowe do analizy cech fizycznych i chemicznych gleb. Na każdej powierzchni wykonano obserwacje flory i macromycetes. Oceniono pokrycie każdego gatunku rośliny na powierzchni w procentach oraz liczbę wystąpień każdego gatunku grzyba. Uzyskane dane przyrodnicze przeanalizowano wykorzystując hierarchiczną analizę zgrupowań Warda oraz indeks IndVal.

Wszystkie powierzchnie obserwacyjne zostały scharakteryzowane pod kątem typu siedliska, flory, roślinności oraz fungi.

Rozmieszczenie odłogów ukazuje regionalne zróżnicowanie intensywności zjawiska odłogowania oraz różne przyczyny zaprzestania użytkowania rolniczego. Wśród przyczyn odłogowania w otoczeniu parków krajobrazowych województwa łódzkiego podstawowe znaczenie mają warunki przyrodnicze. Przesądzają one o braku efektywności użytkowania siedlisk o średnim i słabym potencjale produktywności biologicznej. Z taką sytuacją mamy przede wszystkim do czynienia wokół nadpilicznych i sieradzkich parków krajobrazowych oraz w otoczeniu Bolimowskiego Parku Krajobrazowego. We wszystkich analizowanych obszarach można zauważyć nasilenie zjawiska odłogowania w otoczeniu kompleksów leśnych, co szczególnie zaznacza się wokół parków nadpilicznych.

W sąsiedztwie lasów, większych rzek, na obszarach o korzystnym mikroklimacie częstą przyczyną odłogowania jest ustępowanie funkcji rolniczych na rzecz funkcji turystycznych. Skala tego zjawiska jest tak duża, że w odniesieniu do

terenów nadpilicznych została określona mianem „kolonizacji turystycznej" (Wojciechowska 1998).

Skupiska odłogów związane są często z obszarami podmiejskimi oraz terenami peryferyjnymi miast, objętymi chaotycznym rozwojem budownictwa mieszkaniowego. Silna presja urbanizacyjna szczególnie widoczna jest w otoczeniu Parku Krajobrazowego Wzniesień Łódzkich, znajdującego w strefie aglomeracji łódzkiej. Podobna sytuacja występuje ponadto w rejonie Piotrkowa Trybunalskiego, Tomaszowa Mazowieckiego i Sulejowa (otoczenie nadpilicznych PK), Skierniewic (otoczenie Bolimowskiego PK) oraz Zduńskiej Woli, Sieradza i Złoczewa w otoczeniu sieradzkich parków krajobrazowych.

W ostatnich latach czynnikiem sprzyjającym powstawaniu odłogów na badanych obszarach były inwestycje drogowe. Przykładem jest droga ekspresowa S-8, przecinająca północną część strefy otaczającej sieradzkie parki krajobrazowe oraz autostrady A1 i A2, przebiegające w sąsiedztwie Parku Krajobrazowego Wzniesień Łódzkich i Bolimowskiego Parku Krajobrazowego, w sąsiedztwie których stwierdzono nasilenie zjawiska odłogowania.

Badania przeprowadzone na 39 powierzchniach obserwacyjnych wykazały, że większość powierzchni odłogowanych wytypowanych do szczegółowych analiz związana była z występowaniem geokompleksów litogenicznych utworzonych z przepuszczalnych utworów czwartorzędowych. Wyniki uziarnienia ze wszystkich powierzchni badawczych, w poziomie 0–20 cm oraz 20–40 cm, wskazują na dominację frakcji piaskowej, a wśród niej podfrakcji piasków średnich. Duży udział frakcji piaskowej sprawia, że gleby cechują się nadmierną przewiewnością i przepuszczalnością oraz opadowo-retencyjnym typem gospodarki wodnej, skutkującym możliwością występowania częstych niedoborów wilgoci (np. Wola Pszczółecka A i B, Piskorzeniec A, B, C). W profilach glebowych wszystkich badanych powierzchni obserwacyjnych, na głębokości 0–20 cm i 20–40 cm, występował odczyn bardzo kwaśny i kwaśny. Wpływa on niekorzystnie na skład kationów wymiennych, a także dostępność pierwiastków pokarmowych dla roślin. Wiele powierzchni obserwacyjnych posiada bardzo niski stopień wysycenia kompleksu sorpcyjnego kationami zasadowymi, nie przekraczający 20% (Glinnik A, B, C, Celestynów A, B, Piskorzeniec A, B, C, Weronika A, Wola Pszczółecka A, B, Polesie A, B, Wola Makowska B, C). Powyższa wielkość oznacza, że miejsca te reprezentują ubogie w składniki pokarmowe krajobrazy oligotroficzne (Harasimiuk 2013).

Na badanych odłogach zanotowano 139 taksonów roślin naczyniowych oraz 4 taksony mchów. We florze zasiedlającej odłogi występują taksony preferujące różne typy siedlisk. Najwięcej zanotowano gatunków związanych z siedliskami suchych muraw lub często na nich rosnących (24 gatunki). Są to np. *Carlina vulgaris*, *Carex leporina* i inne. Zbliżone liczbą grupy stanowiły gatunki związane z siedliskami polnymi lub je preferujące (22 gatunki), takie jak, np. *Apera spica-venti*, *Centaurea cyanus*, *Papaver argemone* oraz gatunki zasiedlające głównie miejsca ruderalne, w tym gatunki z klasy *Rudero-Secalietea* (20 gatunków), np. *Cirsium arvense*, *Convolvulus arvensis*, *Elymus repens*, *Rumex crispus*. Licznie reprezentowana jest także grupa związana z siedliskami łąk z klasy *Molinio-Arrhenatheretea* (19 gatunków). Są to np. *Achillea millefolium*, *Anthoxanthum odoratum*, *Crepis biennis*, *Galium mollugo*, *Rumex acetosa*, *Stellaria graminea*. Mniej gatunków jest w grupie roślin, które najczęściej występują w zbiorowiskach leśnych (13 gatunków). Tworzą ją głównie drzewa: *Pinus sylvestris*, *Betula pendula*, *Quercus robur* i nieliczne gatunki roślin zielnych, np. *Anthriscus sylvestris*, *Pteridium aquilinum*. Odrębną grupę stanowią inwazyjne gatunki obcego pochodzenia. Zanotowano ich 7, co stanowi około 5% wszystkich zanotowanych taksonów roślin. Są wśród nich trzy gatunki o wysokiej kategorii inwazyjności: *Padus serotina*, *Solidago canadensis* i *Quercus rubra*. Pozostałe 34 taksony to rośliny kosmopolityczne, występujące w różnych typach zbiorowisk roślinnych. We florze badanych odłogów poza *Helichrysum arenaria*, nie zanotowano gatunków chronionych ani zagrożonych w Polsce lub regionie łódzkim.

Na badanych odłogach, stosując hierarchiczną analizę zgrupowań metodą Warda, wyodrębniono trzy główne grupy strukturalne zbiorowisk roślinnych. Dodatkowo zastosowany indeks IndVal, pozwolił na określenie preferencji gatunków roślin dla określonej grupy zbiorowisk. Każda grupa zbiorowisk reprezentuje określone stadium rozwojowe, jednak w tym samym klasterze niekiedy znajdują się zbiorowiska typowe dla danego stadium rozwojowego oraz zbiorowiska stanowiące przejście do innego stadium. Wyodrębnione klastery oraz analiza podobieństw do nich przyporządkowanych stanowisk, pozwoliły zidentyfikować 8 zbiorowisk roślinnych o różnej strukturze:

zbiorowisko z *Anthoxanthum aristatum* i *Corynephorus canescens*; zbiorowisko z *Agrostis capillaris*, *Hieracium pilosella* i *Achillea millefolium*; zbiorowisko z *Calamgrostis epigejos*; zbiorowisko *Cladonia*; zbiorowisko z *Cirsium arvense*, *Galium mollugo* i *Gnaphalium sylcaticum*; zbiorowisko traw i bylin z dominacją *Elymus repens* lub *Poa pratensis*; zbiorowisko z *Cirsium arvense* i *Solidago canadensis* oraz zbiorowisko traw i bylin z *Betula pendula*.

Badane odłogi nie były bogate w macromycetes. Zanotowano jedynie 46 gatunków grzybów wielkoowocnikowych. Zbiorowiska macromycetes wykazują zróżnicowanie związane ze stadium rozwojowym zbiorowisk na odłogach. Najuboższa w gatunki jest funga zbiorowiska porostów oraz zbiorowiska z *Anthoxanthum aristatum* i *Corynephorus canescens*. Występują tam przeważnie saprotroficzne gatunki z rodzajów *Bovista*, *Conocybe*, *Lycoperdon*, *Marasmius*, *Panaeolus*, *Psilocybe*. Na powierzchniach, gdzie występowały drzewa pojawiają się gatunki mykoryzowe, np. *Amanita muscaria*, *Inocybe corydalina*, *Paxillus involutus*, zaś w płatach, gdzie występuje warstwa mchów zanotowano gatunki z nimi związane, np. *Arrhenia lobata*, *Rickenella fibula*. Większość zanotowanych na odłogach macromycetes to saprotroficzne grzyby naziemne oraz grzyby mykoryzowe. Niewielką grupę stanowią gatunki występujące na trawach, mchach, igłach lub szyszkach sosny. Z grupy grzybów nadrzewnych zaobserwowano tylko dwa gatunki: *Schizophyllum commune* i *Trichaptum abietinum*.

Większość prac przyrodniczych, poświęconych odłogom koncentruje się na problemie sukcesji roślinności na tych siedliskach. Z tego powodu wyniki badań botanicznych na odłogach w woj. łódzkim porównano jedynie z pracami z Pogórza Karpackiego (Dubiel 1984) i Pogórza Przemyskiego. Nie stwierdzono wyraźnego podobieństwa zbiorowisk roślinnych wyodrębnionych na badanych odłogach do tych opisywanych w wymienionych wyżej dwóch pracach. Jedynie zbiorowisko *Calamagrostis epigejos* zanotowane na Pogórzu Przemyskim (Barabasz-Krasny 2002) występowało również na obszarze woj. łódzkiego. Potwierdza to spostrzeżenie, że zbiorowiska rozwijające się na odłogach są bardzo zróżnicowane florystycznie, pozbawione równowagi i otwarte dla przybyszów z różnorodnych siedlisk.

Badania mykologiczne siedlisk odłogowanych nie są bogate. Do tej pory prowadzono je w Białowieży (Kałucka 1999, 2009) oraz Parku Krajobrazowym Dezyderego Chłapowskiego w środkowej Wielkopolsce (Kujawa 2007, 2008; Kujawa i Kujawa 2008). Niedawno opublikowane zostały wstępne wyniki badań odłogów w woj. łódzkim (Adamczyk 2014). Wiarygodne porównywanie wyników badań mykologicznych z Białowieży i Wielkopolski z wynikami badań odłogów w woj. łódzkim jest niemożliwe. Wynika to ze specyfiki poprzednich badań, które obejmowały siedliska bardziej zróżnicowane niż odłogi regionu łódzkiego oraz z czasu badań, który w przypadku tych ostatnich, był dużo krótszy.

Znaczenie ekologiczne badanych odłogów może wynikać z typu roślinności, obecności chronionych prawnie, zagrożonych i rzadkich w skali kraju lub regionu gatunków roślin lub grzybów oraz położenia w stosunku do innych fitocenoz. Pomimo bliskości parków krajobrazowych, w których występują rzadkie i chronione gatunki flory, na odłogach nie zanotowano gatunków roślin lub grzybów prawnie chronionych, bądź zagrożonych. Jedynie *Helichrysum arenaria* oraz *Cladonia rangiferina* i *Cl. arbuscula* są gatunkami częściowo chronionymi. Mimo to, nie można wykluczyć znaczenia odłogów jako potencjalnych refugiów, dla cennych z punktu widzenia ochrony przyrody gatunków flory i fungi. Duże zróżnicowanie roślinności badanych odłogów można uznać za zjawisko korzystne. Każdy zanotowany typ roślinności odłogów ma znaczenie biocenotyczne, stwarzając specyficzne warunki życia dla różnych organizmów.

Położenie badanych odłogów w pobliżu terenów zalesionych jest bardzo korzystne dla powstawania naturalnych korytarzy ekologicznych. Fitocenozy odłogów stanowią miejsca, gdzie gatunki różnych organizmów mogą żyć lub przez które mogą łatwiej przedostać się do fitocenoz leśnych istniejących w pobliżu. W zróżnicowanym przestrzennie krajobrazie rolniczym, w którym niewielkie obszary korzystne dla bytowania poszczególnych gatunków są oddzielone od siebie powierzchniami niesprzyjającymi (polami), istotną rolę odgrywają połączenia korytarzowe (Forman 1995).

Analizując rolę ekologiczną badanych odłogów warto zwrócić uwagę na fakt, że są to siedliska, na których wielokrotnie zmienia się kompozycja występujących gatunków uprawianych i dziko rosnących. Stanowią zatem „zbiornik" różnych diaspor, począwszy od chwastów uprawowych do gatunków łąkowych, leśnych i innych siedlisk. Z przyrodniczego punktu widzenia, takie siedli-

ska są bardzo cenne, jako swoisty, naturalny bank genów różnych organizmów.

Prowadzone badania pozwoliły stwierdzić, że rozmieszczenie i struktura roślinności oraz macromycetes odłogów związana jest z licznymi czynnikami abiotycznymi i biotycznymi. Do zaobserwowanych, najważniejszych czynników można zaliczyć: właściwości fizyczno-chemiczne gleb, otoczenie odłogów w terenie oraz występowanie gatunków inwazyjnych. Badane odłogi charakteryzują się kwaśnym odczynem gleb oraz niską zawartością w nich azotu. Wpływa to na występujące na odłogach zbiorowiska roślinne. Na najuboższych glebach zanotowano najuboższe gatunkowo fitocenozy. Wraz ze wzrostem żyzności gleb, bogactwo gatunkowe fitocenoz i zbiorowisk macromycetes wzrastało. Zbiorowiska roślinne na odłogach sąsiadujących z terenami zadrzewionymi charakteryzowały się udziałem kilku gatunków drzew oraz występowaniem grzybów mykoryzowych. Wśród gatunków inwazyjnych, które zasiedlały niektóre płaty odłogów, najgroźniejsze dla innych fitocenoz są: *Padus serotina* i *Solidago canadensis*. Gatunki te szybko się rozprzestrzeniają, co stwarza realne niebezpieczeństwo dla pobliskich zbiorowisk roślinnych, zwłaszcza cennych fitocenoz chronionych w parkach krajobrazowych.

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