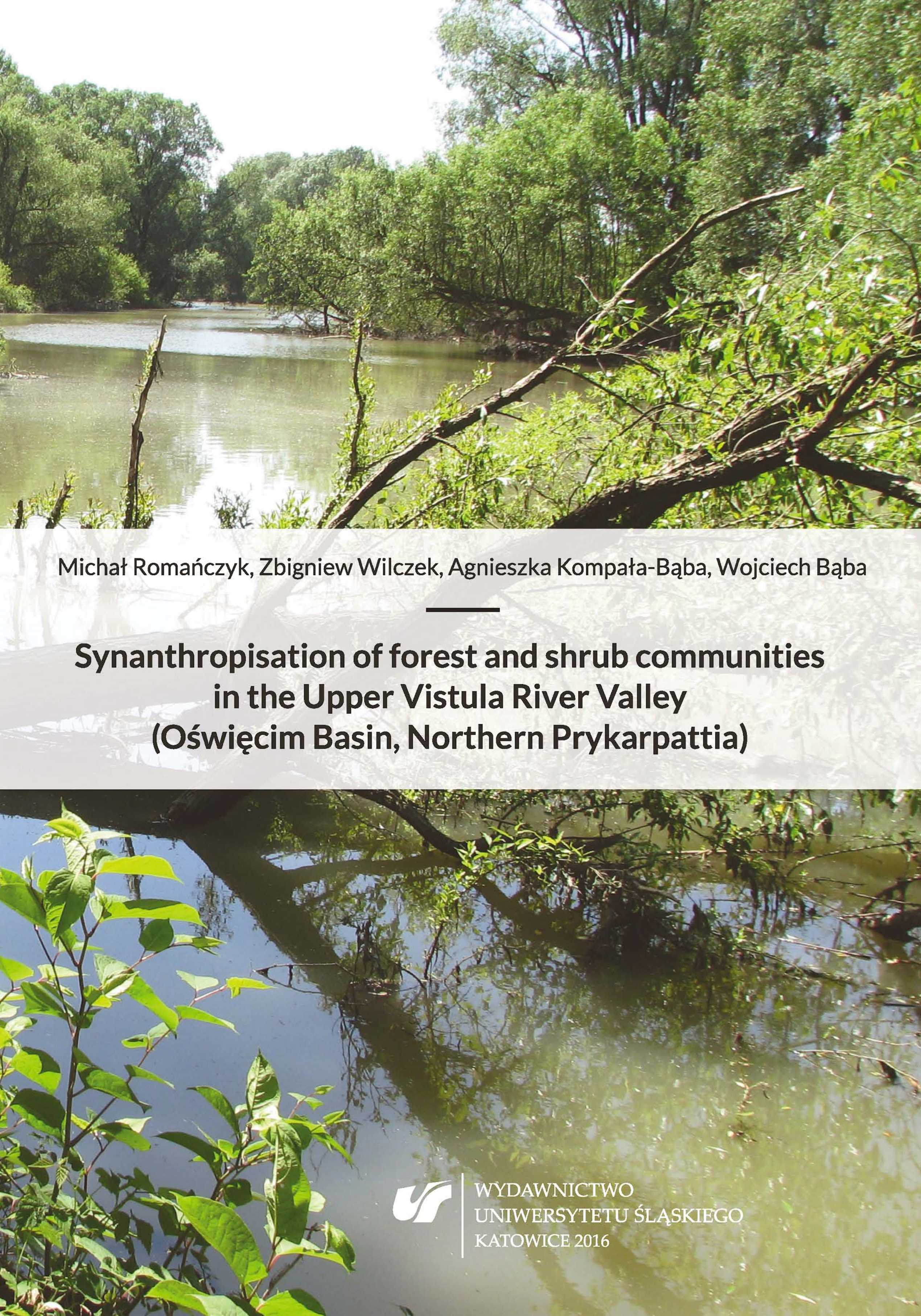

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Contents

Introduction

The Upper Vistula Valley is an area of particular interest from a scientific point of view. Due to its favourable location, arising out of the course and the role of the Vistula River, this area was subject to severe and long-term anthropopressure, which led to a significant transformation of the natural environment. The development of agriculture, the formation of towns and villages and the fish farming economy, which play an important role in the history of the region, have contributed to a significant reduction of the area that is occupied by forest communities, which originally dominated the landscape. Such landscape changes have not only brought negative effects. The increase in surface water bodies at the expense of forests is now seen as almost a natural advantage that enables a richness of the avifauna to exist on the present territory, including many rare and valuable species. This became the basis for the establishment of four Special Protection Areas in the Upper Vistula River Valley within the scope of Natura 2000. In contrast, the remaining forest fragments were gradually subjected to further human pressure, the most important of which were the influences that resulted from forest management. An initial query of the cartographic materials of this area showed a broad convergence of existing complexes and forest islands with their historical distribution. This proves that they belong to the category of ancient woodlands, including some remnants of primeval forests or that they had been created before a certain date (Europe adopted a date from the 18th and 19th centuries) (Dzwonko 2007). An extremely interesting question remains: how strong was the influence of humans on the diversity and conservation status of forest and thicket communities that are typical of the valleys of large rivers.

Polish researchers had taken an interest in the naturalness and degree of the transformations of plant communities from around the second half of the 20th century. The origins of this line of research, however, date back much further. Floristic studies, which eventually joined the study of synanthropic vegetation – segetal and ruderal, dominated in the first period of research. The same transformations of natural communities, of both their character and intensity, have drawn the attention of geobotanists relatively recently (Olaczek 1972). The synanthropisation and degeneration of forest vegetation was the subject of interest of such researchers as Faliński et al. (1963), Faliński (1966a, 1966b, 1966c, 1972, 1975), Kostrowicki (1972), Olaczek (1972, 1974a, 1974b), Olaczek and Sowa (1972), Olaczek and Piotrowska (1986), Czerwiński (1988, 1995), Jakubowska-Gabara (1989, 1992, 1994), Jackowiak (1990), Krotoska (1991), Piotrowska and Olaczek (1991), Balcerkiewicz (1991, 2001), Łaska (1997, 2004, 2006), Matuszkiewicz ((ed.) 2007) and many others.

Despite the considerable amount of interest in the phenomenon of forest synanthropisation and interesting research material about the vegetation of the Upper Vistula Valley, the area studied has not been covered by this type of studies to date. The earliest, mainly botanical, studies date back to the second half of the 20th century (Zając 1990a). Contemporary publications concerning the flora, as well as the vegetation of the area (Żarnowiec 1986, 1988, 1996a, 1996b, 1996c; Żarnowiec et al. 1991, 1997, 2010, 2012; Cabała 1989b; Zając 1990a, 1990b, 1992a, 1992b; Toma 1995, 1996; Czylok et al. 1997; Wilczek et al. 2005, 2008, 2011; Węglarz-Wieszołek, Wika 2010; Betleja et al. 2013), often serve to popularise the knowledge about the most valuable parts of the natural environment (Herczek et al. 1995; Gorczyca et al. 1998; Żarnowiec, Herczek 1999; Ledwoń et al. 2004). However, no study has been conducted to date that comprehensively shows how the synanthropisation of the forest and scrub of the entire mesoregion has been subjected to strong anthropogenic pressure for centuries. This is the main reason why the presented research has been undertaken. The aim of the study was to assess the conservation status of forest and scrub vegetation (naturalness, degree of transformation), including the forms of degeneration and the participation of different groups of indicator species, which allowed the intensity of synanthropisation to be assessed.

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1. The characteristics of the study area

The study area includes the valley of the Upper Vistula, which is the central part of the Oświęcim Basin (Kondracki 2001). It stretches along the river in a narrow belt (about 8 km wide) from Skoczów in the south-west to Zator (around Mirów and Spytkowice) in the north-east. The Upper Vistula Valley is about 70 km long and its area is estimated to be 530 km^2. It is adjacent to the Rybnik Plateau, the Pszczyńska Plain, the Pagóry Jaworznickie Horst Hills and the Tenczyn Hummock to the north; the Ditch Skawina (Cracow Gate) to the east; the Wilamowicki Foothills and the Silesia Foothills to the south; and the Kończysta High Plain (Ostrava Basin) to the west. According to the physico-geographical regionalisation of Poland (Kondracki 2001), the study area belongs to following physico-geographical units of the Carpathian Region (Fig. 1):

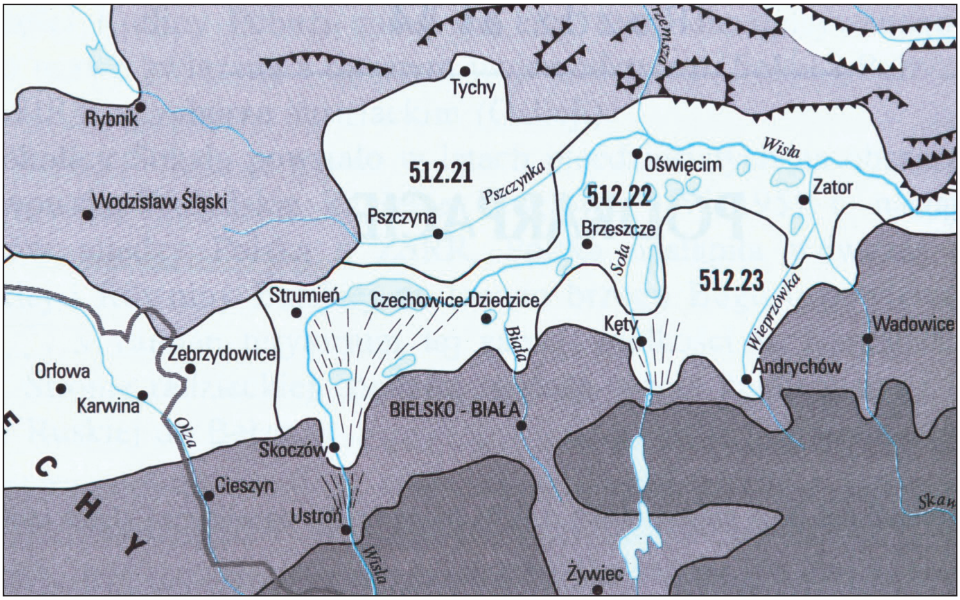

Fig. 1. The location and boundaries of the Upper Vistula Valley (Dolina Górnej Wisły) in relation to the other mesoregions of the Oświęcim Basin (Kotlina Oświęcimska) (Kondracki 2001, changed): 512.21. Pszczynska Plain (Równina Pszczyńska); 512.22. Upper Vistula Valley (Dolina Górnej Wisły); 512.23. Wilamowickie Foothills (Podgórze Wilamowickie)

Province 51. Western Carpathians with Western and Northern Subcarpathia (Karpaty Zachodnie z Podkarpaciem Zachodnim i Północnym)
  Subprovince 512. Northern Prykarpattia (Podkarpacie Północne)
    Macroregion 512.2. Oświęcim Basin (Kotlina Oświęcimska)
      Mesoregion 512.22. Upper Vistula Valley (Dolina Górnej Wisły)

From the administrative point of view, the south-western part of the area is a part of the Silesian province (Cieszyn, Pszczyna, Bielsko and Bieruń-Lędziny counties) and a part of the north-eastern province of Małopolska (Oświęcim and Chrzanów counties).

According to the geobotanical regionalisation Szafer (1972a), the study area was sectioned off as the Oświęcim District and included into the Sandomierz Basin to the east, into one geobotanical land, also called the Sandomierz Basin. The increasing influence of the continental climate was detected eastward. In contrast, the Oświęcim District has the most oceanic type of climate, similar to the Silesian Basin (Szafer 1972b). According to the geobotanical regionalisation, the Oświęcim District should be assigned to the following units within the Euro-Siberian Area:

Province: Middle-European Lowland-Upland Province
(Niżowo-Wyżynna, Środkowoeuropejska)
  A. Divide: Baltic (Bałtycki)
    $A_{3.}$ Subdivide: Belt of Submontane Basins (Pas Kotlin Podgórskich)
      12. Syntaxonomical region: Sandomierz Basin (Kotlina Sandomierska)
        a. Landscape region: Oświęcimski

Taking into account the limits of the geobotanical regionalisation of Poland, the south-western part of the study area should be included into the Geobotanical Divide Karpaty Zachodnie (Western Carpathians) (more precisely into the Beskidy landscape region), which is a part of the Mountain, Central European Province. However, due to the scale of the cartographic approach to the issue and the generalised delimitation of boundaries, this affiliation can be omitted.

The geobotanical regionalisation of Poland has a different character (Matuszkiewicz 1993, 2008). In contrast to the deductive division that was proposed by Szafer (1972a), this division is inductive and was formed through the merger of smaller regions into larger ones. The basic units are landscape subregions, which are isolated on the basis of the diversity of potential natural vegetation and some habitat factors such as areas with a homogeneous vegetation landscape. Higher units were separated by grouping basic units that were based on the different criteria that resulted from the landscape, syntaxonomic and biogeographical characteristics (Matuszkiewicz

1993, 2008). According to this regionalisation, almost the entire study area belongs to the Oświęcim Landscape Subregion (also known as the Vistula Valley “Ustroń-Skawa mouth”), which is placed in the following hierarchical units (Fig. 2):

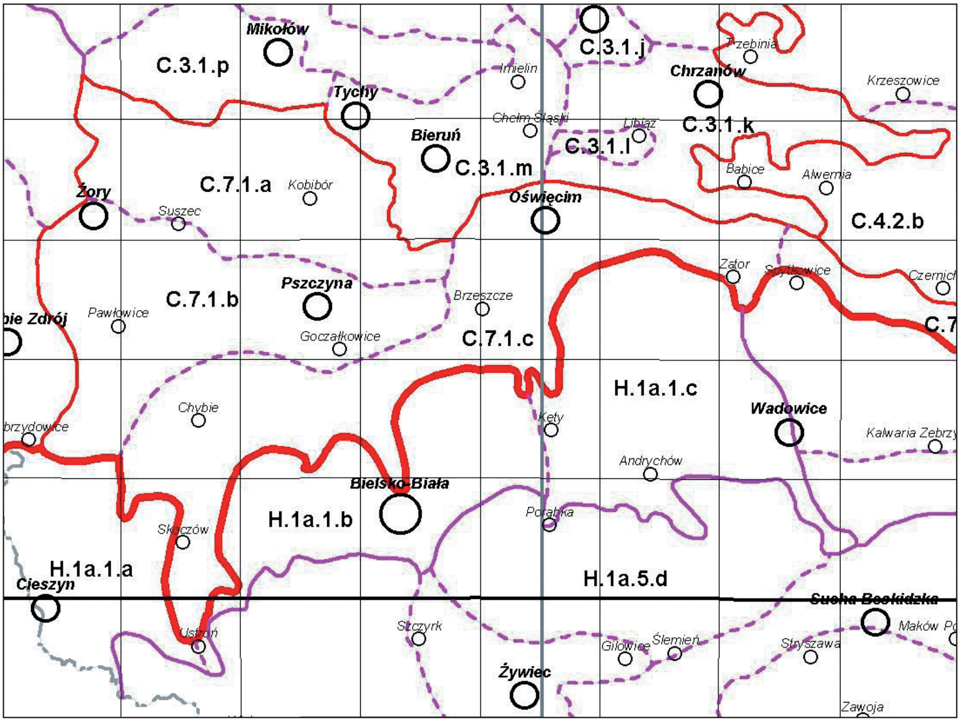

Fig. 2. Location and borders of Podokręg Oświęcimski (Oświęcim Landscape Subregion) (C.7.1.c) according to the geobotanical regionalisation by Matuszkiewicz J.M. (2008)
Explanations: thick red line – geobotanical divide, thin red line – syntaxonomical region, violet line – landscape region, violet dashed line – landscape subregion

European Region of broad-leaved deciduous and mixed forests
(Obszar Europejskich Lasów Liściastych i Mieszanych)
Central European Province (Prowincja Środkowoeuropejska)
Proper Central European Subprovince
(Podprowincja Środkowoeuropejska Właściwa)
South-Polish Uplands Divide (Dział Wyżyn Południowopolskich)
C.7. Oświęcim Basin Syntaxonomical Region
(C.7. Kraina Kotliny Oświęcimskiej)
C.7.1. Oświęcim Landscape Region
(C.7.1. Okręg Oświęcimski)
C.7.1.c. Oświęcim Landscape Subregion
(C.7.1.c. Podokręg Oświęcimski)

The nature and forest regionalisation constitutes a geographical diversification of natural conditions of silviculture which is expressed as different roles of various species of trees in a forest structure (Trampler et al. 1990). The regionalisation that was proposed by these authors has ecological and physiographic features and combines elements of nature and forest division. Moreover, according to the proposal of Trampler et al. (1990), the study area was classified into the following mesoregions: Wodzisławsko-Wilamowicki and Lasy Raciborskie (more precisely a separate unit – the Wysoczyzna Tyska) within the Kędzierzyn-Rybnik District and the Oświęcim Basin District mesoregion within the Dzielnica Wyżyny (Highlands) and Pogórze Śląskie (the Silesian Foothills). The analysed area is situated in two Nature-Forestry Counties: Silesia and Małopolska. The fact that the Wodzisławsko-Wilamowicki mesoregion and Oświęcim Basin mesoregion have been characterised as agricultural units with a very low degree of forestation should also be noted.

The Upper Vistula Valley area is, according to Kondracki (2001), located almost exclusively in the basin of the Vistula River. Only a small north-west part of this mesoregion is drained by the Pielgrzymówka River and its tributaries, which flow into the Oder through Piotrówka and Olza.

The Vistula River is the central element in the river network. The length of this segment in the Oświęcim Basin is approximately 70 km, but due to the development of around 180%, the actual length of the river reaches 109 km. Two separate sections can be distinguished within the aforementioned section of the Vistula River:

- from Skoczów (71 km) to the mouth of the Przemsza around Oświęcim (0 km), a fragment of the so-called Little Vistula;
- from the mouth of Przemsza (from the point marked as 0 km, the number of kms of the watercourse is counted up and down to show the distinct nature of this section of the river) to the Cracow Gate (Brama Krakowska) around Mirów (38 km).

The Little Vistula was separated from the source of the river to the mouth of the Przemsza River in order to show the different nature of this section of the river. It can be considered as a separate tributary of the Vistula. From the mouth of the Przemsza, the Vistula River is a navigable river, which is associated with the issue of the location and maintenance of the signs of shipping (Chełmicki 1991; Soja 1992; Starkel 2001).

After it flows out of the Carpathians, the Vistula River (the Carpathian part of the river is less than 4% of its entire length) flows inside the boundaries of the Oświęcim Basin, which is actually its transit area. In this area, it assumes a character of an allochthonous river, which is characterised by a decrease at the low troughs – 0.36‰ (with an average value of 1.04‰ and the lowering of plain along with the passage of the river). The surface area of the basin is also the mouth of the rivers and streams that are formed in the Carpathian Mountains and Uplands (Chełmicki 1991; Starkel 2001). In the study area, the most important tributaries on the left bank of the Vistula River are: Knajka, Pszczynka, Korzenica, Gostynia, Przemsza and Chechło, while on the right bank: Bajerka, Iłownica (with Jasienica and Wapienica), Biała, Łękawka, Soła, Bachórz and Skawa. The upper part of the Vistula, as is the case of the entire river basin, is dominated by right-bank tributaries, which determine the asymmetric shape of the catchment.

Bodies of water are also included in the surface water network of the study area. The Goczałkowice Reservoir is the largest reservoir of the Upper Vistula Valley. It was built on the Little Vistula (43.1 km of its course) in the years 1950–1955. The total capacity of the reservoir is 165.6 km^3, the maximum water level – 14 m (the dam is made of fluvioglacial sands interspersed with screen and screen with reinforced concrete that is less than 3 km long) and the maximum area 32 km^2 (2–6 km wide and 12 km long, the average depth at the normal level of damming is 255.50 m above sea level – about 5.3 m). This reservoir serves a number of functions – supplying the Silesian agglomeration (Katowice and Rybnik) with water (water is supplied to 66 municipalities in the province of Silesia and 3 in the province of Małopolska), flood and drought protection (reducing the culmination of flood waves and conserving the underlying container and leveling low flows in the river), and supporting fisheries and recreation (having areas of shores for fishing). The aligned outflow from the reservoir is Qgw = 4.80 m^3/s (Hennig et al. 1991; Operat wodno-prawny…, 2001 cited by Ruman, Rzętała 2006; Bilnik et al. 2004). Regardless of the documented positive role of Goczałkowice Reservoir, it should also be mentioned that it has a deforming effect on the regime of the Vistula River. This adverse impact can also be observed in the Przemsza and Soła Rivers, whose regimes have also been disturbed by human activities (Dobija 1983). The large number of complexes of ponds also play an important role in the Oświęcim Basin (Fig. 3). The origins of fish farming, which is located in the

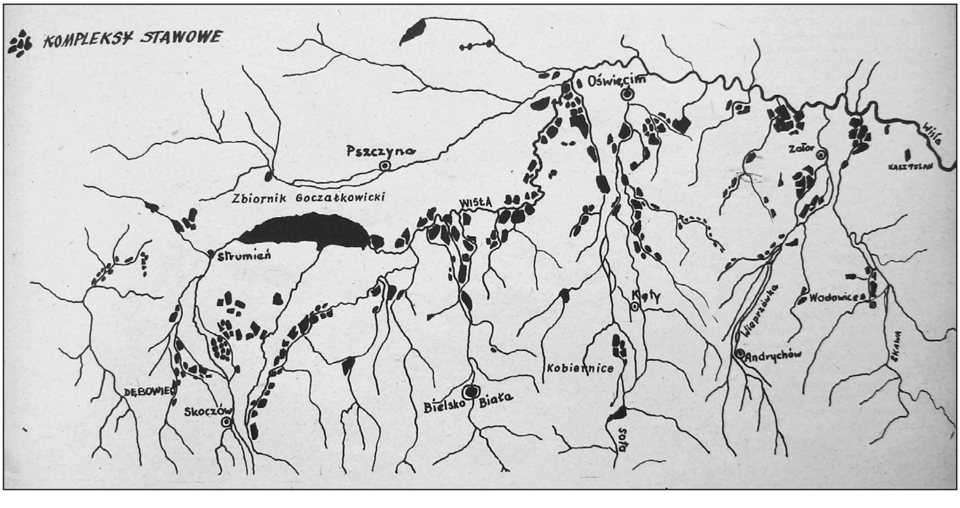

Fig. 3. Fish farming in the upper basin of the Vistula River in the mid-20th century (Włodek 1957)

Upper Vistula and the Soła and Skawa valleys, dates back to the turn of the 12th and 13th centuries. According to estimates, anthropogenic water reservoirs overran approximately 12% of the Oświęcim Basin in the 4th–10th centuries. Adding the area that is occupied by the Goczałkowice Reservoir (at maximum flood) totals about 17% (WŁODEK 1957; WRÓBEL, WŁODEK 1991). This accumulation of ponds along the Vistula, Soła and Skawa called "Land of Lakes" is mainly used today for the production of fish. It has a major impact on the water balance in the study area because it is a significant emitter of organic pollutants (WŁODEK, WRÓBEL 1991).

Dams are other objects of anthropogenic origin occurring in the area. These facilities have been built to improve the favourable conditions for shipping. Two water rapids are situated within the study area – Dwory (4 km of the Vistula) and Smolice (21 km of the Vistula) (HENNIG 1991). Along with four other facilities, they provide the navigation conditions that allow water transport barges with a capacity of up to 1,000 tonnes to ply the stretch between Oświęcim (from the mouth of the Przemsza) and Kraków. Upper Vistula waterway was built in the years 1949–2002 (www.krakow.rzgw.gov.pl).

2. The anthropogenic changes of natural environment

The natural environment of the Upper Vistula Valley has been significantly transformed as a result of human activity. Arable land, buildings and industrial areas are located in the vast majority of the study area. Ponds and other bodies of water also play an important role. Only 8% of the Upper Vistula Valley is covered by forests (Ledwoń et al. 2004). In order to fully understand this state of affairs and to properly assess the diversity and the degree of the preservation of the studied vegetation, the anthropogenic impacts that have occurred in this part of the Oświęcim Basin should be briefly described.

The beginning of the anthropopressure in this area cannot be determined precisely. Initially, the intensity of anthropogenic impact was not significant. Humans have lived in the Oświęcim Basin (Polish name: Kotlina Oświęcimska) since ancient times. The Małopolska Upland, which is nearby, was a place where people lived and human activity occurred during the period of climate change from the end of the Middle Poland glaciation. Although the oldest areas of settlements included the last wooded areas and most fertile loess (e.g., the Nida Basin (Kotlina Nidy), the left bank of the Vistula and the Sandomierska Upland), the riverside silt, and the comfort of inhabiting the vicinity of rivers and lakes prompted settlers to colonise less populated areas (Arnold 1951; Dobrowolska 1961). One of the oldest pieces of evidence of the settlement, which was found on the border of the units that were analysed (Spytkowice east of Zator), comes from the late Paleolithic period (about 8000 BCE) (Koźbiał 2000). Prior to the formation of the Polish state the Upper Vistula Valley was within the boundaries of the state of the Vistulans, which stretched between the sources of the Vistula River and the East River and its focal point was in Kraków (Hensel 1967). Although the population of the area was still sparse, its size gradually increased, which inevitably increased its impact on the environment (as Hensel 1967 reported) largely due to arable farming. A large amount of arable land was taken over and used for permanent cultivation since the 6th century. It is hardly surprising that many authors emphasise the fundamental differences in the geographical image of the so-called primeval landscape of areas of Poland in the early medieval period. At that time, the landscape was the result of the influence of natural forces and human activities, which had been managed by people for thousands of years (Buczek 1960; Dobrowolska 1961).

From the point of view of the present research, the intensity of the human impact on the environment, including forest vegetation, seems particularly important because it increased over time due to constant abuse and the progressive subduing of nature. Forest areas were transformed into buildings, farmlands and grasslands. Wood was commonly used as a building material. It is estimated that by the second half of the 13th century, larger population centres had taken over the river valleys (especially Vistula River) and from the end of the century, there was an increase in the development of settlements and locations of villages and towns in this area (Kożbiał 2000). The development of fish farming in the Upper Vistula Valley can be considered to be a more significant interference with the natural system. The Cistercians are considered to be the forerunners of such activity because at the turn of the 12th and 13th centuries they brought the carp to the monastery ponds and later to the ponds that were established in the outskirts of oxbows lakes and in river valleys. The Bugaj complex of ponds near Zator is considered to be the oldest centre in this region. During the period of the most intensive development of fish farming in the Oświęcim Basin (the 16th century and the beginning of the 17th century), the artificially flooded area was 2–3 times greater than that of the current area. Presumably, ponds covered 25–35% of the surface area of the unit described in this work. The area situated between Wisła, Soła and Skawa rivers was called the “Land of Ponds.” Although their number was lower, the size of the water bodies significantly exceeded what can be observed today. The fish farming area in the Upper Vistula Valley played an important part in the economy of Poland during those times. It began to decline in the mid-17th century, only to be revived in the second half of the 19th century. However, it had a huge impact on the natural environment of the area that was much greater than that of agriculture because of the complete conversion of the existing habitat (Włodek 1957, Wróbel, Włodek 1991; Ledwoń et al. 2004).

The history of fish farming in the area is one of the elements that have an indirect effect on the state of our knowledge about the degree of the transformation of the vegetation in the Oświęcim Basin. A second important element is population density. In the second half of 14th century, it was 11–15 individuals/km^2 near Oświęcim and near Zator it was 21–30 people/km^2. These values should be considered to be high because they exceed the average population density for the region of Małopolska as well as that of other geographical regions (during the same time Upper Silesia was inhabited by an average of 8 people/km^2 and Lower Silesia had 12 people/km^2) (Dobrowolska 1961). The larger population had a greater impact on the environment (due to e.g., an increased demand for food, raw materials, living space and stronger economic development). Between the 14th and the mid-16th century the development of Oświęcim was also observed and a gradual loss of importance of Zator was estimated based on the population (Kożbiał 2000).

Maps are a reliable source of information that permits the evaluation of how much of the surface of the Upper Vistula basin was covered by forests. One of the oldest cartographic works which faithfully depicts the river network and forest areas of area that is described in this work is a map of the Oświęcim and Zator principality from 1563 *DVCATVS OSWIECZENSIS ET ZATORIENSIS DESCRIPTIO*, which was prepared by Stanisław Porębski (Fig. 4) (Krassowski et al. 1977). Comparing it with contemporary maps leads to the conclusion that in the mid-16th century, the forest vegetation occupied only a small area. Moreover, the distribution of forest patches was similar to that observed today. Additionaly, the map prepared by Porębski was of significant geographical value because of the compatibility of the content with reality (Alexandrowicz 1984), we can be assured of the reliability of the source.

Fig. 4. Map of the Duchy of Oświęcim-Zator in the development of Abraham Ortelius based on the maps of Stanisław Porębski, 1579

A similar picture of the distribution of forests was also shown in maps that were developed and published much later (Fig. 5) (e.g., *Administrativ Karte von den Königreichen Galicia und Lodomerien…* 1:115,000, 1855; *Spezialkarte der österreichisch-ungarischen Monarchie* 1:75,000, 1905–1914; *Generalkarte von Mitteleuropa* 1:200,000, the beginning of the 20th century). Although most areas of this part of the Oświęcim Basin have undergone anthropogenic changes, it can be assumed that the forests that were preserved have been occupied habitats for centuries. It is interesting to examine the extent to which they have retained their natural character.

Another example of the human impact on the natural environment are the changes of the hydrological network, which affect riparian forests (the *Alno-Ulmion* alliance), alder fen forests and thickets that occur in the immediate vicinity. Initially, hydrographic relations were only transformed indirectly through the removal of substantial portions of the forest. This led to changes in climate (temperature rise), lowering the groundwater level or the gradual drying out of marshy valleys (Dobrowolska 1961). Direct human intervention in the fluvial system, which was designed to regulate the rivers and were associated with flood protection, took place in the Upper Vistula until the first half of the 19th century. Regulatory works conducted in the first segment, which extends east from Niepołomice, were associated with large floods in 1813, in the 1840s and in 1884. Those activities consisted mainly of narrowing troughs, digging bends (to increase the fall and reduce the water course) and housing the banks of the river. Fascine, stone and fascine-stone constructions were used to consolidate the banks in the upper basin of the Vistula River. As a result of the regulatory works that took place in between 1855 and 1977, the Vistula riverbed between Zawadka and the mouth of the Skawa was shortened by about 12 km (due to the increased drop from 0.33 to 0.4‰), the typical braided Soła riverbed between Kęty and Oświęcim was shortened by 3 km and its mouth was moved approximately 700 m to the west (Galarowski, Klimek 1991; Hennig 1991; Trafas 1992; Starkel 2001). All of these changes, which were gradually supplemented by new flood protection measures (the Goczałkowice water reservoir was built in 1950–1955), influenced the vegetation that grows in the habitats that are associated with the watercourses. Embankments have the biggest impact on the distribution of riparian communities because they limit the flow of water to a narrow zone of inter-annually and prevent the flooding of the floodplain; therefore they are one of the least used flood control facilities today (Roszkowski, Hennig 1991). Other regulatory methods (regardless of their utilitarian nature) have also contributed to the standardisation of the conditions in the river and its vicinity and therefore to the depletion of vegetation and fauna in the area.

The history of human pressure in the Upper Vistula is completed by contemporary human activities such as: changes in the water (in addition to the already described issues, there also should be mentioned, among others, the

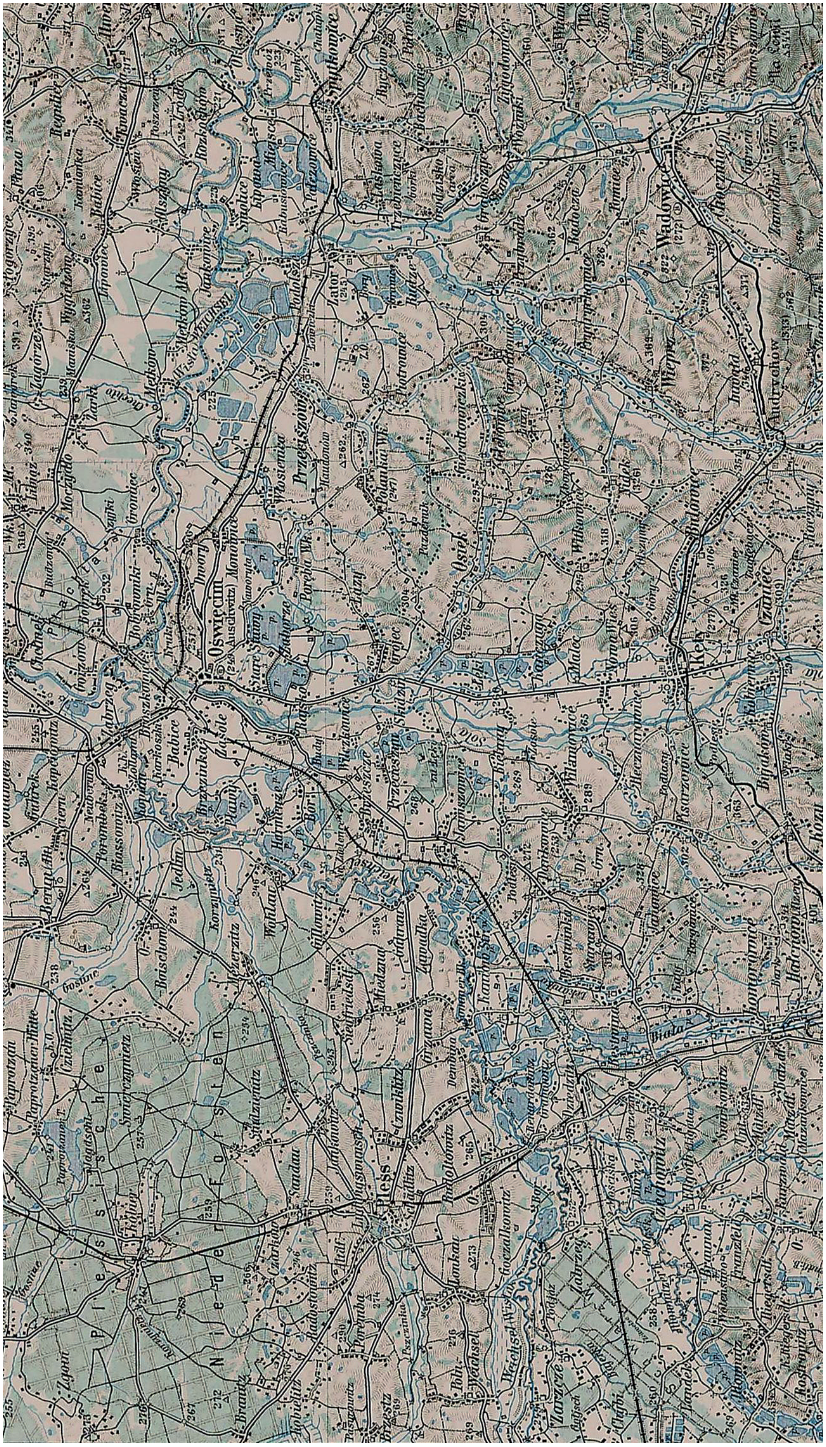

Fig. 5. Austro-Hungarian Military Map of Central Europe *Generalkarte von Mitteleuropa*, original scale 1:200,000, map sheet 37–50, Oświęcim 1905

regime change of river courses, changes in groundwater resources, the pollution of groundwater and surface water, agricultural drainage); the increasing degree of urbanisation (buildings that are mainly of a diffuse character, “wild” landfill sites, which increase the deterioration of the water quality, an increase in air pollution from low emissions, changing the character of the landscape and the fragmentation of valuable natural area); agriculture (the influence of mineral fertilizers and chemical pesticides, the removal of woodlots); industry (the exploitation of mineral resources, among others the coal mine “Silesia” in Czechowice-Dziedzice, natural gas, peat and medicinal waters, the functioning of industrial factories, among others the chemical plant in Oświęcim, the refinery in Czechowice-Dziedzice) and even tourism (the potential risks that are associated with the increasing management that is required for tourism and recreation) (JOSEPH-TOMASZEWSKA 2006; RUMAN, RZĘTAŁA 2006).

3. Nature protection in the Upper Vistula Valley in the face of anthropopressure

3.1. Existing forms of nature protection

Despite many centuries of human impact on the environment, fragments of high natural value have been preserved in the area of the Upper Vistula Valley. In addition to the residues of the valuable natural systems, a significant portion of these "biocenotic oases" are semi-natural areas that have resulted from human interaction with the forces of nature, which has been taking place because of the economy of fishing ponds. According to the Nature Conservation Act of 16 April 2004 (Journal of Laws No. 92, item 880, Ustawa z dn. 16 kwietnia 2004 r. o ochronie przyrody, t.j. Dz.U. nr 92, poz. 880), there are five forms of protection that enable to protect the forest and scrub communities. Nineteen of such objects occurring in the area of our research is under one of these form of protection. Their brief characteristics are given below.

Nature reserves:

1. "Rotuz" – this reserve has an area of 40.63 ha and was established in 1966 (M.P. 1967 nr 10 poz. 59) for the protection of a mid-forest poor fen (transitional mire) (on the borders of Chybie and Czechowice-Dziedzice municipality), which is accompanied by a continental bog pine forest *Vaccinio uliginosi-Pinetum* and a moist coniferous forest *Molinio-Pinetum* and *Calamagrostio villosae-Pinetum*. The most valuable plant communities are the disturbance-tolerant vegetation of moderately rich fens – *Rhynhosporetum albae*, which are dominated by *Rhynchospora alba* and *Sphagnum* species; a quaking bog *Eriophoro angustifolii-Sphagnetum recurvi* and a hummock community *Sphagnetum magellanici* whose patches are found in the western and north-eastern part of the reserve. Some rare plant species grow in those phytocoenoses, for instance, the common sundew *Drosera rotundifolia*, the bog rosemary *Andromeda polifolia*, the cotton-grass *Eriophorum vaginatum*, the bog cranberry *Oxycoccus palustris*, the white beak-sedge *Rhynhospora alba* (Żarnowiec et al. 1991; Wilczek 1998; Rąkowski (ed.) 2007).

2. “Przeciszów” – this is a forest reserve that was founded in 1996 that has an area of 85.13 hectares that is located near the town of Przeciszów, which is adjacent to the Nawiga channel. This reserve, which was only created in 1996 (M.P. 1996 nr 5 poz. 52), is a forest enclave that includes: a moist mixed broadleaved forest *Tilio-Carpinetum* (a wet and dry subassociation), an ash-alder riparian forest *Fraxino-Alnetum* and a fresh mixed coniferous forest *Querco roboris-Pinetum*, which occupies a dune in the south-western part of the reserve. The multispecies, moist mixed broadleaved forest is dominant among these communities (Wilczek 1998; Rąkowski (ed.) 2007). According to the current classification of nature reserves (Regulation of the Minister of Environment dated 30 March 2005 on the kind, types and subtypes of nature reserves, Rozporządzenie Ministra Środowiska z dn. 30 marca 2005 r. w sprawie rodzajów, typów i podtypów rezerwatów przyrody), this reserve was classified as forests L, the biocoenosis of natural and seminatural biocoenoses Pbfbp and forest and pine forests of lowlands ELlni.

3. “Żaki” – this reserve is located near the town of Żaki in the immediate vicinity of the “Przeciszów” reserve. It was created in 1959 (M.P. 1959 nr 23, poz. 104). It is also a forest enclave. However, it has only 11.84 hectares. This is due to, inter alia, the construction of the shipping channel Naviga. Almost the entire surface of the reserve is covered by a subcontinental lime-hornbeam forest *Tilio-Carpinetum* with an imposing old growth that consists of lime trees (Wilczek 1998, Rąkowski (ed.) 2007; Wilczek et al. 2008). The property has been designated as a landscape reserve. According to the current classification, it represents the following type and the types and subtypes: forest L, phytocoenotic of forest communities PFizl and forest and pine forests of lowlands ELlni.

Landscape park:

1. Rudno Landscape Park (Rudniański Park Krajobrazowy) – this property has an area of 5813.9 hectares and was established in 1981 (Dz.U. R.N.M.K. 31.12.1981 nr 14, poz. 76) for the conservation of the precious natural resources, geological, historical, cultural and the landscape of the Tenczyn Hummock and a part of the Upper Vistula Valley. Among other natural and cultural values, the park includes several forest complexes, which cover about half of its surface and two nature reserves, including the “Valley of the Rudno Stream,” which was created for the protection of riparian communities – an ash-alder *Fraxino-Alnetum* and an alder fen forest *Ribeso nigri-Alnetum*. The two areas are, however, outside the study area. The Upper Vistula Valley area is mainly in the buffer zone of the Rudniański Landscape Park. The object extends up to the Vistula River, although it was established primarily for the protection of the southern part of the Tenczyn Hummock (Rąkowski (ed.) 2002; Zalewski (ed.) 2008).

Natura 2000 sites

Sites of Community Importance:

1. Pierściec (PLH240022) – this area was established for the protection of a breeding colony of the little horseshoe bat *Rhinolophus hipposideros* along with the feeding area of bats. The boundaries of the area, of which a third is covered with forest communities, includes the Pierściec, Roztropice, Iłownica, Zaborze and the Vistula River.

2. Goczałkowice Reservoir – the Mouth of Vistula and Bajerka (Zbiornik Goczałkowicki – Ujście Wisły i Bajerki) (PLH240039) – this refuge covers the south-western fragment of Goczałkowice Reservoir into which the Vistula River flows and the shore of a body in the estuarine part of the Bajerka River. Fragments of alder, willow thickets, damp forests and rushes and meadows are found there. The presence of valuable animal species that are associated with aquatic and semi-aquatic environments determine the conservation value of this area (especially numerous amphibians, wetland birds, otters) and communities with *Salvinia natans* and frogbit *Hydrocharis morsus-ranae*, which are rare in Poland.

3. The Lower Soła (Dolna Soła) (PLH120083) – this area covers part of the Soła River Valley from the road bridge on the bottom of the Kęty–Harszówki route and ending at the southern boundary of a nature-landscape complex – the Valley of the Soła River. Riparian willow and poplar cars dominate along the Soła, which is a natural mountainous river with a wide stony bottom in this section. In addition to riverine and other habitats of Annex I of the Habitat Directive, seven species that are listed in Annex II of the Directive are found in the area, including an exceptionally high location of the fire-bellied toad *Bombina bombina*.

4. Wiśliska (PLH120084) – a system of three floodplains of Vistula River, which in Polish are collectively called *wiśliska* – Krajskie, Miejsce and Oko. These floodplains are situated near Spytkowice and Okleśna and are partly joined with each other and the Vistula River. This area mainly protects water vegetation. Moreover, it is valuable as a place where many water birds and amphibians are protected.

Special Protection Areas:

1. The Upper Vistula Valley (Dolina Górnej Wisły) (PLB240001) – it is the earliest Natura 2000 site that was founded in the Upper Vistula River and constitutes a bird sanctuary of the European rank. It comprises the Goczałkowicki Reservoir and adjacent ponds and has a total area of 24,740.2 hectares. Its special natural value is determined by the species richness of avifauna, of which species (29) of the Bird Directive (Annex I) and species from *The Polish Red Data Book of Animals* (Głowaciński (ed.) 2001), such as the night heron *Nycticorax nycticorax*, the little bittern *Ixobrychus minu-*

tus, the bittern *Botaurus stellaris*, the whiskered tern *Chlidonias hybrida*, the common tern *Sterna hirundo*, the common redshank *Tringa totanus* and others deserve special attention.

2. Ponds in Brzeszcze (Stawy w Brzeszczach) (PLB120009) – is an area of 3,065.9 hectares comprising complexes of ponds on both sides of the Vistula River that extends from Kaniów and Dankowice to Brzezinka and Jedlina, and that is accompanied by river oxbows. It was established for the protection of rare species of birds, including at least 14 of Annex I to the Birds Directive and 5 from *The Polish Red Data Book of Animals* (Głowaciński (ed.) 2001), for instance, the little bittern *Ixobrychus minutus*, the purple heron *Ardea purpurea*, the whiskered tern *Chlidonias hybrida*, the night heron *Nycticorax nycticorax* and others.

3. Lower Soła Valley (Dolina Dolnej Soły) (PLB120004) – the area includes a fragment of the Soła Valley that has breeding ponds that are located east of the Soła and that has a gravel terrain, which is operated for recreational purposes. The current object has been designated to protect at least 13 bird species of the Bird Directive (Annex I) and 4 bird species of *The Polish Red Data Book of Animals* (Głowaciński (ed.) 2001), for example, the little bittern *Ixobrychus minutus*, the whiskered tern *Chlidonias hybrida*, the night heron *Nycticorax nycticorax* and others. This area includes the entirety of the Lower Soła.

4. Lower Skawa Valley (Dolina Dolnej Skawy) (PLB120005) – the surface area covers 7,081.7 ha. Extensive complexes of ponds that are located along the river from the Monowskie Ponds to Okleśna and that extend south along Skawa and Wieprzówka are located within its borders. This continuously operated fishing and habitat area is a good habitat for many bird species of the Bird Directive (Annex I) (min. 16) and of *The Polish Red Data Book of Animals* (Głowaciński (ed.) 2001) (min. 6), among which the little bittern *Ixobrychus minutus*, the Mediterranean gull *Larus melanocephalus*, the ferruginous duck *Aythya nyroca*, the night heron *Nycticorax nycticorax*, the common tern *Sterna hirundo* and others can be mentioned.

Nature and landscape complex (Polish *zespół przyrodniczo-krajobrazowy*):

1. The Soła River Valley (Dolina Rzeki Soły) – an area of 143 hectares, which includes a fragment of the Soła Valley within the city of Oświęcim that runs from Broszkowice to Rajsko, has been protected as a nature-landscape complex pursuant to resolution of the Oświęcim City Council (Uchwała nr LVIII/513/98 Rady Miejskiej w Oświęcimiu z dnia 16 czerwca 1998 roku). The main reason for the establishment of this form of conservation was the complex of riparian forests and non-forest communities that is located in the inter Soła and in order to attain the goal of "protection of its biodiversity, preservation of ‘a corridor’ for the migration of valuable plant and animal species as well as to meet the current and future needs in the field of ecological education, leisure and recreation of the people living in Oświęcim and the surrounding area.”

Protected landscape area (Polish *obszar chronionego krajobrazu*):

1. “Podkępie” – it was established by the Resolution of the Commune Council in Bestwina (Uchwała nr XII/68/95 Rady Gminy w Bestwinie z dnia 29 czerwca 1995 roku), and concerned the designation of protected landscape areas covering a specific complex of land that extends from the border of Bielsko-Biała to Kaniowo, between Biała River and the Młynówka Stream. The main goal of the protection is to preserve the river and the surrounding vegetation and the large complex of fish ponds as a “relic” of the centuries-old fisheries in the area of the Upper Vistula River Valley. At the same time, the entire complex is an ecological corridor that links the commune of Bestwina with the valley of Vistula River (WILCZEK, MAŚKA 2010).

Ecological sites (Polish *użytki ekologiczne*):

1. “Łęg Stare Stawy” – area 4.45 ha.
2. “Łęg Kamieniec” – area 23.84 ha.
3. “Łęg Błonie” – area 6.00 ha.
4. “Łęg Za torami” – area 15.00 ha.

The ecological sites that are mentioned in points 1–4 are surrounded by a nature-landscape complex of the Soła River Valley, with which they have been designated by the city council in Oświęcim (16 June 1998). The purpose of the protection is the “preservation of the natural fragments of a poplar-willow riparian forest and the flora and fauna that exists in this area for scientific, educational and natural value.”

5. “Zapadź” – area amounting to 22.86 ha. This object in the municipality of Miedźna on the left bank of the Vistula was designated by the voivode of Silesia (rozporządzenie wojewody śląskiego nr 58/04 z dn. 8 września 2004 roku, Dz. Urz. Nr 90/04 z 16.09.04, poz. 2528). The stated aim is “the preservation of scientific, educational, scenic considerations bog ecosystem with localities of regionally rare and outgoing plant species.”

6. Jedlina ponds (Stawy Jedlina) – this ecological site (surface 42.18 ha) in the Bojszowy municipality on the right bank of Gostynia River just before it reaches the Vistula River was designated by the voivode of Silesia (rozporządzenie wojewody śląskiego nr 60/04 z dn. 8 września 2004 r., Dz. Urz. Nr 90/04 z 16.09.04 poz. 2530). The objects under protection are the ecosystems of ponds and wet meadows that are breeding sites for regionally rare species and the declining population of birds.

3.2. The proposed forms of nature protection

Research on the shrub and forest vegetation in the valley of the Upper Vistula, on the one hand, showed the significant transformations in the natural environment of the area that have been caused by humans, but on the other hand, it showed quite a variety of plant communities that exist there, including the occurrence of rare phytocoenoses that are valuable from the conservation point of view. This phytocenotic characteristic of the mesoregion that was analysed, combined with the small area that is occupied by forests, is the most important argument in favour of expanding the existing network of protected areas. The fact is that at the beginning of the 21st century, the small surface area that is occupied by the different forms of nature protection, was significantly enlarged as a result of the emergence and development of the Natura 2000 network. However, it should be emphasised that forests, which constitute an important element of the nature of the Upper Vistula Valley, are not abundantly represented in the entire system of nature protection of the mesoregion.

To sum up, objects that significantly contribute to the conservation of forest communities include: all of the existing nature reserves, the Special Area of Conservation (in fact one of the Sites of Community Importance) “The Lower Soła” and the ecological sites that were established on the territory of Oświęcim and the nature and landscape complex of the “The Soła River Valley.” These provide protection for communities comprised primarily of the *Salicetea purpureae* willow thicket communities and lowland willow-poplar floodplain forest, which are regularly flooded. By contrast, the previously established forms of nature protection, lime, hornbeam forest *Tilio-Carpinetum* and continental bog pine forest *Vaccinio uliginosi-Pinetum* were insufficient. Therefore, it is necessary to consider broadening the functioning network of protected areas for further objects, primarily for the maintenance of the valuable forest communities of the mesoregion.

It is proposed that the following forms of nature protection be created in the areas that are described below:

1. “Kopaniny” Nature Reserve – it is a small forest enclave that occupies just over 28 ha that is situated near the village of Kopaniny. It is separated from the highest forest complex in the Upper Vistula Valley by a narrow 70–200 m strip of non-forest areas. Only the northern part of the object is connected with that complex over a short distance by a local asphalt road. The vast natural value of forest Kopaniny is due to the presence on its territory of relatively well-preserved phytocoenoses of the *Vaccinio uliginosi-Pinetum* as well as somewhat more numerous patches of the moist island pine forest *Molinio-Pinetum.* A continental bog pine forest is a rare community, particularly in the area of Upper Vistula Valley. Apart from the Gołysz forest, it is was situated near the "Rotuz" reserve. The natural value of this community is confirmed by its presence on the list of natural habitats that are under protection (Regulation of the Minister of Environment dated 14 August 2001 on types of habitats, Rozporządzenie Min. Środ. z dn. 14 sierpnia 2001 r. w sprawie określenia rodzajów siedlisk…) and the list of habitats of interest to the community as a priority habitat 91D0 (Regulation of the Minister of Environment dated 13 April 2010 on types of habitats, Rozporządzenie Min. Środ. z dn. 13 kwietnia 2010 r. w sprawie siedlisk…). The patches that occur in the area that is proposed for protection bear the marks of the forest management that has been carried out so far. Although they can be distinguished, the occurrence of: the bog bilberry *Vaccinium uliginosum*, the wild rosemary *Ledum palustre*, the bog cranberry *Oxycoccus palustris*, the hare's-tail cottongrass *Eriophorum vaginatum*, *Sphagnum fallax*, the common sundew *Drosera rotundifolia*, their abundance is not high. Apart from species mentioned, a significant role in the herb layer is also played by the bilberry *Vaccinium myrtillus* and the blue moor grass *Molinia caerulea.* This fact, together with the dominance of the moist pine forest in the area of the enclave, is caused by a disturbance of the water conditions and changes in the light conditions. Therefore, the protection of one of the most valuable pine phytocoenose of the investigated mesoregion should be based on maintaining or even improving the existing water conditions and the cessation of further harmful interference. This seems to be possible after the establishment of the proposed form of conservation. The need to protect the complex was already highlighted earlier when the assessment of the natural environment of "Upper Vistula Valley" – a Natura 2000 site – was made (Betleja et al. 2006).

2. "Lasy nad Rudką" Nature Reserve – a fragment of a larger forest island that is situated between Olszyny and Rozkochów (south of the interconnecting road), which contains the Rudka River together with the surrounding areas. The most important natural values of this area to be considered are the mentioned stream, the accompanying riparian communities from the *Alno-Ulmion* alliance, and the surrounding pine forests, which are the main component of the studied area. The Rudka River along the section that is proposed for protection (and above) is characterised by a high degree of naturalness – a curving, meandering course; an abundance of silt and meander scroll ridges in the trough, both marginal and inter-trough; the diversity of shore slopes that creates a wealth of habitats for living organisms and ensures the formation of wash-aways and landslides. In the bottom of the watercourse are branches that slow down the outflow of the water and modify the habitat conditions, and what is of utmost importance, the whole area is surrounded by a floodplain forest. This community, notwithstanding its affinity to a lowland ash-elm floodplain forest *Ficario-Ulmetum minoris*, in connection with a dominance of *Ulmus glabra* in the tree layer, was described as an *Ulmus glabra* community. The same valley together with floodplain forests do not cover a large area. They are surrounded by a well-preserved fresh pine forest *Leucobryo-Pinetum* with *Chimaphila umbellata* in terms of floristic composition, which occurs in the herb layer. A large part of the observed patches represents the driest and most well-lit variant of association with *Veronica officinalis*, where a subvariant with *Chamaecytisus ratisbonensis* was delimited, which approximates a lichen-Scotch pine forest (*Cladonio-Pinetum*).

3. "Stare Wiślisko" protected landscape area – a small area (approx. 50 ha), which is located in the municipality of Oświęcim in the vicinity of Brzezinka and Babice, and in the immediate vicinity of the Vistula River and its right tributary Pławianki. A rich mosaic of habitats occurs in this area, which includes: water and reed communities that are associated with oxbows; non-forest communities, including scrubs, as well as floristically interesting oak-hornbeam forest *Tilio-Carpinetum*, which represents a wet and typical type of community. The tree layer mainly consists of the pedunculate oak *Quercus robur*, the European hornbeam *Carpinus betulus* and the small-leaved lime *Tilia cordata.* The herb layer is rich in species. The most interesting species that are worth mentioning are, among others, the common snowdrop *Galanthus nivalis*, the hellebore *Veratrum lobelianum*, the mixed-flower *Phyteuma spicatum*, *Isopyrum thalictroides*, *Corydalis cava*, *Corydalis solida*, the oxlip *Primula elatior*, the buttercup *Ranunculus cassubicus* – recorded by Żarnowiec (1983, 1986, 1988) and Żarnowiec et al. (2012), the common twayblade *Listera ovata* and the broad-leaved helleborine *Epipactis helleborine.* The value of a natural area that is located so close to Oświęcim has been known for a long time. Żarnowiec (2012) first proposed that a floristic reserve be created to protect the location of hellebore in the oak-hornbeam forest and then to set up a reserve of well-fitting, very floristically valuable oxbow lakes. It is worth noting that currently the subcontinental oak-hornbeam forest is a habitat that is protected under law (Rozporządzenie Min. Środ. z dn. 14 sierpnia 2001 r. w sprawie określenia rodzajów siedlisk…) as is a habitat that is of interest to the community (code 9170) (Rozporządzenie Min. Środ. z dn. 13 kwietnia 2010 r. w sprawie siedlisk…). The oxbow lakes and other natural eutrophic waters have the same status. Despite this, "Stare Wiślisko," has only been recognised as an area of the special protection of natural values (*Strategia rozwoju gminy Oświęcim 2007–2013*), which is, however, insufficient. The observations that were made in the field during this investigation clearly show the gradual loss of value of the object (for example in timber harvesting). Żarnowiec et al. (2012) also pointed to the risks that arise from the location of the "wild" landfills, sand and rubble in forest and riparian areas that contribute to the spread of anthropophytes.

4. "Olsy w Brzeszczach" protected landscape area – the area proposed for protection is located in the Brzeszcze municipality in the vicinity of Bor settlements. It is a physiocenotic complex of a middle-European alder fen forest, willow communities and ponds. The habitat mosaic and current use of fishing ponds is the reason for the proposal as was the case of the “Old Wiśliska,” a recently protected landscape area. The main reason for including this area into objects that are worth protecting are the well-preserved patches of alder fen forest *Ribeso nigri-Alnetum*, whose phytocoenoses are not very frequent in the Upper Vistula Valley. They create dynamic systems with willow communities that represent the *Salicetum pentandro-cinereae* association. Alders in the study area are characterised by a well-developed system of hollows and hummocks. The bittersweet nightshade *Solanum dulcamara*, the marsh violet *Viola palustris*, the water horsetail *Equisetum fluviatile*, the marsh marigold *Caltha palustris*, the milk measure *Peucedanum palustre*, the yellow iris *Iris pseudacorus* and the loosestrife *Lysimachia vulgaris*, among others, grow in the undergrowth. Some patches represent the *Ribeso nigri-Alnetum comaretosum* subassociation.

In order to briefly describe the proposals to create new forms of nature protection, it should be stressed once again that there has been a significant degree of transformation of the contemporary vegetation of the Upper Vistula Valley and only a small percentage of the surface coverage of the mesoregion by forests. Such environmental conditions mean that all of the relatively natural forest systems, few of which have survived until today, should be protected from any further potential loss of value. Legal protection provides for the possibility of excluding them from direct anthropogenic pressure and thus to allow spontaneous regenerative processes to occur.

4. Methods

Field studies were conducted during the growing seasons in 2007–2010. They mainly comprised the forest and thicket communities of the Upper Vistula Valley. Research also included an important element of the landscape of the Upper Vistula Valley – patches with *Reynoutria japonica*. It is a herbaceous plant that reaches a height of 3 m and its phytocoenoses are physiognomically similar to thicket communities. Phytosociological relevés were made in the study area according to the rules of Braun-Blanquet (1964), Fukarek (1967) and Dzwonko (2007) in order to illustrate the diversity of the vegetation. The sample plot was chosen on the basis of uniformity and homogeneity of phytocoenoses. Size of the reléve was adjusted to the type of vegetation: 100–200 m^2 for forest vegetation and 25–100 m^2 for thicket vegetation (in the case of some thickets, single phytosociological relevés are just 20 m^2 due to the small size of patches that were studied). Distribution of the sample plots in the field, in turn, was based on a subjective approach, without any preliminary assumptions. This combines the advantages of the lack of full recognition of the diversity of the vegetation with a non-random collection of sample plots. This method permits the diversity of plant communities to be fully recognised, taking into account any phytocoenoses with a distinct, unusual floristic composition. However, as a result of the analyses, some relevés that were not sufficiently uniform or that were only fragments of communities can be excluded from further analyses (Dzwonko 2007). This necessity also occurred during the preparation of the material that was gathered in the course of the research. As many as 414 phytosociological relevés were arranged into 24 phytosociological tables of syntaxons, which were attached in electronic form onto CD (Appendix 1). In the present work, synoptic tables of the plant communities that were distinguished are presented.

Phytosociological relevés were collected in Turboveg for Windows 2.98, which is widely used in Europe for storing and processing data sets (Hennekens, Schaminée 2001). The relevés were then exported from the database to the Juice 7.0.60 software (Tichy, Holt 2006), where a number of analyses were performed. These comprised calculations of the number, frequency and average coverage of species and their groups in the phytosociological relevés. Phytosociological tables were arranged using TWINSPAN (Hill 1979) with the modifications proposed by Roleček et al. (2009) and MULVA (Wildi, Orlòci 1996) software programs.

For statistical purposes, the values of the cover-abundance Braun-Blanquet scale were transformed in the following way: r = 1%; + = 2%; 1 = 3%; 2 = 13%; 3 = 38%; 4 = 68%, 5 = 88%. Higher values were particularly given to 'r' and '+' in comparison to other amongst these transformations (Pawłowski 1977, Dzwonko 2007). In a sense, it is possible to explain this method for calculating the group coverage, which is not a simple sum of the component cover of species, but rather the sum that takes into account the reciprocal partial overlapping of the coverage area of different species and different layers. Such a method of calculation may lead to an underestimation of the actual coverage of a group. Conversion of coefficients 'r' and '+' to the values which constitute only a fraction of a per cent, deprives them of any influence on the final value of group coverage (Tichý, Holt 2006). In some situations, especially in the case of the self-formation of groups by the species with the lowest levels of abundance-coverage, there is nevertheless a slight overestimation of their role in a phytocoenose. However, the uniformity of the methodology that was used for all of the data does provide an assurance of the comparability of results.

The syntaxonomical status of a species, the names of phytosociological units that are used in a monograph (including their identification) and syntaxonomical classification were applied according to the "Guide for recognition of plant communities of Poland" (Matuszkiewicz W. 2002). Some exceptions are: *Calamagrostio villosae-Pinetum*, included into the *Vaccinio-Piceetalia* order and the *Piceion abietis* alliance as well as some communities that were not included in the "Guide…" such as: *Chelidonio-Robinietum*, *Reynoutria japonica* community, *Ulmus glabra* community and some units that have no defined phytosociological affinity. The classification system of Matuszkiewicz W. (2002) was applied including some remarks by Brzeg and Wojterska (2001) in the case of the non-compliance of certain phytosociological names that are used in the "Guide for recognition of plant community names" according to the code for phytosociological nomenclature (Barkman et al. 1995; Weber et al. 2000). However, this phytosociological system is commonly used by many Polish phytosociologists.

In the plant communities that were recognized, units of a lower rank were distinguished, such as: subassociations, variants and subvariants according to the basic hierarchical system that was proposed by Braun-Blanquet and supplemented by Tüxen (Dzwonko 2007). In a case in which the collected phytosociological material or differences in its floristic composition did not permit subassociations to be distinguished, only the variants were delimited. They are treated as variants of the typical subassociations. According to Wilczek (2006), such an approach is frequently used in phytosociological papers (e.g., Matuszkiewicz J.M. 1976, 2002; Dzwonko 1986; Kasprowicz 1996; Dubiel et al. 1999).

The names of vascular plants follow the "Flowering plants and pteridophytes of Poland. A checklist" (Mirek et al. 2002). The nomenclature of mosses is according to the “Census catalogue of Polish mosses” (Ochyra et al. 2003) and liverworts according to “An annotated checklist of Polish liverworts” (Szweykowski 2006).

The naturalness of forest and scrub vegetation in the Upper Vistula Valley was determined on the basis of a modified system of forms and phases of degeneration (Olaczek 1972, 1974a). This approach also stems from a critical look at some forms of degeneration that were proposed later (Brzeg, Krotoska 1984; Krotoska et al. 1985; Balcerkiewicz 1991; Czerwinski 1995; Kasprowicz 1996; Łaska 1997, 2006). A perfect example is, among others, impoverishment, which seems to be a sign of many degenerative forms, and therefore distinguishing it as a separate form of degeneration appears to be unjustified. The foundation of the calculation of the intensity of transformation is the division of species in each of the phytosociological relevés into two groups: euphytes (Polish *eufity*) (E), a species that is specific for a given plant community in the study area and allophytes (Polish *allofity*) (A), the remaining group of species. Euphytes are a character species for the class that a given plant community belongs to (including the character species of phytosociological units within a class) and differentials of a plant association, subassociations and variants. Some units have no distinct groups of diagnostic species and their floristic composition comprises species from different classes. In such case, the range of species that are considered to be euphytes, was extended to species of those classes and other constant components of a community. When the affiliation to a one of groups was determined, in addition to the syntaxonomical position given by Matuszkiewicz W. (2002), other papers were taken into account, first of all papers such as: “Forest communities of Poland” (Matuszkiewicz J.M. 2002) as well as the guides for habitat protection Natura 2000 (Herbich ed. 2004). An assessment of the conservation status was performed for plant communities that were distinguished during research, excluding communities that were composed of alien species (*Reynoutria japonica* community and *Chelidonio-Robinietum*) and communities whose affiliation into the existing Braun-Blanquet system was difficult to determine (*Alnus glutinosa* community, *Querco roboris-Carex brizoides* community, *Pinus sylvestris-Carex brizoides* community), for which such calculations caused difficulties or made no sense as well as for thicket communities such as *Rubo fruticosi-Prunetum spinosae* and *Sambucetum nigrae*, whose floristic composition significantly depends on their regenerative and substitute role in the dynamic circle of forest vegetation and the plant communities that occur in the vicinity. Such phytocoenoses were taken into account in the analysis of the share of anthropophytes in plant community and partly in different landscape categories of the vegetation that was studied. After the division of the floristic list into euphytes and allophytes, the number of species that represented each of those group was calculated followed by the percentage ratio (E):(A). The same calculations were performed for the sum of the average percentage cover for the euphytes and allophytes in a reléve. The method for the calculations of group coverage includes all of the layers of a community, hence the results exceed 100% in most cases. Therefore, the sum was taken as 100 and divided in proportion to the sum of the average coverage of any of the groups. Such a recalculation was made after Olaczek (1972). The factors that were used permitted an inference about the state of the preservation of the plant communities, based on the values of the parameters without taking into account the degeneration phases.

The next step in the evaluation of the synanthropisation of the vegetation that was studied was the share of anthropophytes in plant communities, considering the number of species and their total cover in a given phytosociological reléve. The group of anthropophytes includes: unnaturalised diaphytes and established metaphytes. The second group can be further divided into archeophytes and kenophytes. According to Zając (1983), archeophytes are taxa that are "alien" to the native flora of Poland that had come onto the area of Poland before the 15th century. This "alienness" means not only coming into the country from another area, but also a survival from the earlier formation that was caused by humans or a rise in the evolution from its native taxa under the influence of a human activity. The list of archaeophytes was adopted in accordance with protocol made by Zając (1987a, 1987b, 1988). Kenophytes, which came into the territory of Poland after the year 1500, are species that are alien to Polish flora (Zając et al. 1998; Tokarska-Guzik 2005; Tokarska-Guzik et al. 2012). In addition to the number and coverage of anthropophytes, the value of a systematic group of those species was also calculated (Pawłowski 1977).

In order to assess the naturalness and above all to verify the hypothesis of the occupancy of old, historical locations by the forests that occur in the Upper Vistula Valley, a group of old deciduous forest species was analysed in the terms of Dzwonko and Loster (2001), and Dzwonko (2007). The calculation took into account both the number of species as well as their overall coverage in a phytosociological reléve. Due to the specify of this group of plants, the calculations were made exclusively for the communities of the *Querco-Fagetea* class.

In addition to the comparison of the individual phytocoenoses of plant communities and plant communities within groups that comprised similar plant associations, the share of anthrophytes and species of ancient woodlands in the categories that were distinguished (called landscape categories of vegetation): forest complexes (more or less compact forests and forest islands with areas exceeding 150 ha); forest islands, which were divided into four categories in terms of the space that is occupied in ha (I – 0.5–5.0 ha, II – 5.5–25.0 ha, III – 25.5–50.0 ha, IV – 50.5–150.0 ha) and scrubs (thicket communities) are summarised.

Statistical analyses were performed in STATISTICA version 9.1. The non-parametric tests (ANOVA Kruskal-Wallis rank test including multiple comparisons of the average ranks for all of the samples and the U Mann-Whitney test) were used in case of lack of normal distribution in the data set (in single cases lack of homogeneity of variance) that eliminates applying of parametric counterparts. The Pearson linear correlation coefficient and the coefficient of determination, which indicates how well data fit a statistical model and the Spearman's rank correlation coefficient, due to the sensitivity of the former one to the lack of normality, were applied in order to determine the significant relations between chosen variables. Detailed descriptions of particular tests and the conditions under which they were applied can be found in STANISZ (2005, 2006).

To increase the readability of work, a more detailed explanation of the specific methodological issues and of the most important information, were also included into the results.

Additionally, the monograph contains photographic documentation (18 photographs), which includes the selected plant species, plant communities, landscapes that are co-created by shrub and forest vegetation and examples of the synanthropisation of the vegetation under study.

Abbreviations used in the monograph

Locations of phytosociological relevés:

BA – Bąków
BB – Babice
BCZ – Brzeszcze
BJ – Bijasowice
BO – Bobrek
BR – Broszkowice
BRZ – Brzezinka
CD – Czechowice-Dziedzice
CH – Chybie
GL – Gołysz
GO – Goczałkowice
GR – Grzawa
GRA – Graboszyce
GRO – Gromiec
GRZ – Gorzów
GZ – Goczałkowice-Zdrój
JE – Jedlina
JW – Jawiszowice
KN – Kaniów
KW – Kwaczała
LI – Ligota
ŁE – Łęki
ŁK – Łowiczki Książęce
ŁO – Łowiczki
ŁP – Łowiczki Pańskie
OCH – Ochaby
OK – Okleśna
OL – Olszyny
OS – Oświęcim
OS/KA – Oświęcim Kamieniec
P – Palczowice
PI – Pierściec
PO – Podolsze
PR – Przeciszów
PW – Poręba Wielka
RD – Rudołtowice
RO – Rozkochów
RT – Rotuz
RU – Rudawki
S – Smolice
SM – Stawy Monowskie
ST – Strumień
U – Uchylany
WŁ – Włosienica
WM – Wisła Mała
Z – Zabrzeg
ZA – Zator
ZAB – Zasole Bielańskie
ZB – Zaborze
ZC – Zabrzeg Czarnolesie
ZG – vicinity of the Goczałkowice Reservoir
ZI – Żarki
ZK – Żaki
ZR – Zarzecze
ZS – Zasole
ZZ – vicinity of forester's lodge Zalew (Goczałkowice Reservoir)

Indices used to describe the preservation status of phytocoenoses:

1. E/A number – percentage ratio of the number of euphytes to allophytes in a phytosociological reléve.
2. E/A cover – percent coverage ratio of euphytes to allophytes in a phytosociological reléve.
3. No. of anthropophytes – number of anthropophytes in a phytosociological reléve.
4. Cover of anthropophytes – percentage cover of anthropophytes in a phytosociological reléve.
5. No. of woodland species – number of old woodland species in a phytosociological reléve.

6. Cover of woodland species – percentage cover of old woodland species in a phytosociological relevé.
7. Syst. val. grp. antrop. – systematic value of a group of anthrophytes.

Structure-landscape categories that are distinguished:

C – forest complexes,
I – forest islands:
  I1 – forest islands with an area of 0.5–5.0 ha,
  I2 – forest islands with an area of 5.5–25.0 ha,
  I3 – forest islands with an area of 25.5–50.0 ha,
  I4 – forest islands with an area of 50.5–150.0 ha,
B – bushes, scrub communities.

5. Theoretical bases for the evaluation of the degeneration of forest communities

The concept of the degeneration of phytocoenoses was introduced by Faliński et al. (1963) and Faliński (1966b, 1966c). It defines the distortion of natural and semi-natural plant communities, whose aim is to “change the floristic composition and disturbance of the vertical and horizontal structure of phytocoenoses under the influence of some external factors, which may be called degeneration factors.” The nature of the degeneration factors can be both anthropogenic and natural. Terminological clarification was then made by Olaczek (1972, 1974a), who distinguished the degeneration of vegetation, the degeneration of plant associations and the degeneration of the vegetation landscape. The degeneration of a plant association involves a deviation of the internal structure and its floristic composition within a certain degree of variation. The distortion is so small that phytocoenosis still represents the same association, even though the elements that characterise it are not typical for a given plant association. When the size of transformations is so large that it should be classified into another plant association, alliance or a class, we have to deal with the degeneration of vegetation. As a result, new semi-natural or anthropogenic plant associations are created. The sum of the degeneration of plant communities and the vegetation of a given area is defined as the degeneration of the vegetation landscape. It is worth emphasising that degeneration – regardless of its pejorative meaning – is not used in this book as an evaluative term. The concept only indicates the deviation of a plant association from the full compliance with the habitat (Olaczek 1972). Faliński (1966b) drew attention to the difference in meaning between the terms degeneration and degradation. It is degradation, not degeneration, that has a value that is associated with evaluating the deterioration of the quality or value of a habitat.

The findings of Olaczek (1972), who described the process of the degeneration of a plant community’s qualitative changes as a form of degeneration, should be distinguished from the quantitative transformations that were called the phases of degeneration by Faliński (1966b). While the phases primarily describe the intensity of transformation, the forms describe a different character, state or direction of transformations in a community structure. Olaczek (1972, 1974a) defines a form of degeneration as a “temporary form of a plant association with specific features of the structure, floristic composition and species vitality, which express the reaction of a natural plant association to certain factors of degeneration.” The degeneration phase was defined as “a period of changes (or a temporary condition) in the floristic composition and structure of communities […], which can be defined floristically, distinguish and interpret” by Faliński (1966b). Olaczek (1972, 1974a) distinguished six forms of degeneration on the basis of studies that were conducted in central Poland. They express the changes in the structure of phytocoenoses, their floristic composition, habitat as well as changes in the stages of development. Forms of degeneration include:

1. Monotypisation – this change involves a unification of species composition and stand age, a simplification of its layered structure and a kind of species impoverishment, which occurs in the course of forest management that is based on clear-cuttings or selective felling, even under partly natural regeneration. The result of monotypisation is a woodland with a tree layer that consists of 1–2 tree species that have adapted to a given habitat and demand by the forest economy.
2. Fruticetisation (development of shrubs) – is revealed as an excessively (even abnormally strong) developed understorey. It is a response to the stand thinning caused by selective felling or the encroachment of light-demanding tree species into the tree layer. A particular form of fruticetisation is the massive development of blackberries that was observed in pine monocultures on habitats of rich oak or hornbeam forests or Euro-Siberian steppe woods with *Quercus* spp.
3. Cespitisation (sodding) – this form manifests the strong development of a grassy undergrowth in the forest along with a simultaneous reduction in the number of species, especially the cover of dicotyledones. One or two grass species often dominate (e.g., *Festuca ovina*, *Deschampsia flexuosa*, *D. caespitosa*, *Calamagrostis epigejos*), although a similar effect can also be connected with an abundant occurrence of sedge species (e.g., *Carex brizoides*). This type of reaction may be a response to community grazing, a thinning stand or the destruction of undergrowth. The strong development of a grassy undergrowth is also observed in forests that are planted on former agricultural soils or in clearings that had been used for agricultural purposes for some time.
4. Juvenilisation – through cyclical clear-cuts a community is held at an early stage of development, which results in a quite a young stand that is connected with the renewal of a natural or artificial community that is consistent with the habitat.
5. Neophytisation – this process facilitates the penetration of alien species (neo-phytes) into the species composition of communities or the artificial introduction of alien species. Kenophytes can often cause significant changes in the structure, floristic composition and even in the ecology of a community.

6. Pinetisation – is associated with the introduction of conifers (most often those from the *Pinaceae* family) into deciduous stands or the removal of deciduous trees from mixed stands. Clear cuttings and the artificial restocking of forest stands, which are not adapted to the habitat, are the main causes of this common form of degeneration that greatly alters the habitat (e.g., microflora, reaction and soil chemistry). The result of the changes described in the oak, hornbeam forests, acidophilus oak woods, Euro-Siberian steppe woods with *Quercus* sp. and mixed forests is an example of such a transformation of communities and habitats, which does not allow the diagnosis and classification of a given phytocoenose into a phytosociological system.

Unfortunately, the forms of degeneration that were highlighted by Olaczek do not cover all of the responses of communities to the factors that cause them to degenerate that have been observed and described in scientific papers regarding the subject in question. Brzeg and Krotoska (1984), Krotoska et al. (1985), Balcerkiewicz (1991), Czerwiński (1995), Kasprowicz (1996), Łaska (1997, 2006) completed the list above with other additional forms of degeneration:

7. Geranietisation – this form of degeneration, which involves the abundant presence of different meso- and nitrophilous terophytes and biennials, for example, *Geranium robertianum*, *Galeopsis pubescens*, *Chaerophyllum temulum*, *Impatiens parviflora*, *Moehringia trinervia*, was originally distinguished by Brzeg and Krotoska (1984) as a specific form of the pinetisation of a habitat, in which a massive occurrence of species that are typical of pine forest did not take place, although an abundant occurrence of species from the *Artemisietea* class, particularly species from the *Lapsano-Geranion robertiani* alliance occur.

8. Bryofitisation – is a form of degeneration that involves the absolute dominance of the moss layer in the bottom of the community, especially a strong growth of heath moss that replaces species that are typical of pine-forests. It is sometimes also broadly defined as any form of degeneration that results from the excessive growth of the moss layer. It is one of the causes of the impoverishment of the herb layer species.

9. Apophytisation – this phenomenon facilitates the penetration of apophytes into the floristic composition of communities.

10. Epilobietisation – this form of degeneration involves the increased occurrence and significant participation in phytocoenoses species of clearings (the *Epilobietea angustifolii* class), for example, *Sambucus nigra*, *Rubus idaeus*, *Calamagrostis epigejos*.

11. Impoverishment of the floristic composition of a community occurs through the reduction of the number of species comprising its structure, which is often coupled with a decrease in the abundance and vitality of the species that remain in a phytocoenose. This process mainly influences the floristic

composition of the herb layer and frequently is connected with other forms of degeneration. It should be noted, however, that the forms of degeneration that are characterised above are not mutually exclusive. A plant association may in fact be subject to the simultaneous interaction of several of them (“multidirectional degeneration”), although in many cases this is marked by the dominance of one of the forms, which masks and sometimes excludes the others, such as fruticetisation and cespitisation, which are reactions to overexposure (Balcerkiewicz 1991). When Olaczek (1972) defined the form of degeneration, he did not mean it as only a state, but also as the whole process of more or less intense degenerative changes which leads in a certain direction. This issue should be treated in such a way. The form of degeneration reflects the nature of the transformations, as opposed to a phase that describes their intensity.

The six-step system of degeneration phases that was presented by Faliński (1966b) is based on the assumption that the impact of degenerative factors leads to the progressive replacement of floristic composition. Species with narrow ecological amplitude and wild, primary components of the local flora, are replaced by ubiquitous, cosmopolitan, cultivated or foreign ones. The result of this type of transformation is, therefore, a decrease in the abundance, that is the lowering of number, and sometimes the total disappearance of the character species of an association and an alliance, which then become character for the order and the class and finally accompanying species and a change of formation in accordance with the six phases of degeneration.

1. A decrease in the abundance and number of the character species of the association and the alliance.
2. The disappearance of the character species of the plant association and the alliance and a decrease in the abundance and number of the character species of the order.
3. The disappearance of the character species of the order and a decrease in the abundance and the number of character species of the class.
4. The disappearance of the character species of the class.
5. The disappearance of the most enduring species, which constitute a given plant community.
6. The change of formation.

Such a sequence of degenerative phases faces several problems that result from the use of the position and status of the species in a phytosociological system of communities rather than the actual ecological amplitude of species in the assessment of transformations of a plant community. In many cases, this does not provide a basis for inferences about the actual response of the species to the specific ecological factors. Another difficulty is the frequent inadequacy of taxonomic and ecological units, of which the former ones are in the field of phytosociology (Mirek 1974; Łaska 2006). Olaczek (1972, 1974a) proposed a different approach, due to the need for applying of objective measures to the quantitative assessment of degeneration phenomena. The syngenetic groups that often bear signs of regionality are difficult to be treated as objective measurements. The extraction of the degenerative phases is based on the quotient of the number of two groups of species occurring within each relevé: euphytes – species that are appropriate for the natural form of an association in the study area and aphytes (afity, also called allophytes), which include alien, accompanying and occasional species. In this way, the evaluation of the degenerative phase is still based on the disappearance of species that are relevant to a given community (without any internal evaluation), taking into account the occurrence of ecologically alien species in the calculation. Euphytes according to Olaczek (1972) are a group character species of a class (or two classes) and differentials of subassociations, variants and geographic varieties, which determine the distinctiveness of a given phytocoenosis. He accepted the principle of the recognition of species with higher trophic requirements as the primary element of a community, whereas those less demanding in terms of trophic requirements and more light-demanding species were treated as a secondary elements, indicating the degeneration of the association.

It should be emphasised that in the present system phases of degeneration have been extracted separately for each association in a relative way (with respect to the least degenerated form of a given community, defined as phase 0 and in relation to the limit values of E/A – in an arbitrary way). Olaczek (1972) based calculations on the number of species and not on the transformed sum of their average total cover. The calculations made for thermophilous oak forest showed a significant similarity of the results obtained using these two methods.

The systems for the evaluation of degeneration of plant communities that are presented here are not the only ones that were used and proposed during the study on transformation of vegetation in Poland. However, they can be described as classical or even model ones for many later concepts. The other proposals for the measurements that are used to assess the degree of the transformation of phytocoenoses should also be mentioned:

(a) the hemeroby concept (Jalas 1955) and its development by Sukopp (1972);

(b) the eight-step scale that was proposed by Olaczek and Sowa (1972), which uses the system of the degeneration phases of vegetation (Faliński 1966b);

(c) the concept of ecological efficiency; the coefficient of the resistance of a habitat and the value of the coefficient of variability and multiformity of the vegetation in particular areas (Kostrowicki 1972);

(d) the six-point scale that uses the compatibility of patches with typical phytocoenoses diagnosing their phytosociological affiliation (Olaczek, Piotrowska 1986; Piotrowska, Olaczek 1991);

(e) the indicators of anthropogenic changes of vegetation that were proposed by Jackowiak (1990); the ratio of the total synanthropisation of vegetation (Wcsr) and the share of anthropogenic communities in it (War) for the assessment of landscape transformation rather than individual patches;

(f) scale of distortion of oak, hornbeam forests based on an assessment of the number and percentage of vascular plant species of the *Querco-Fagetea* class by Krotoska (1991);

(g) proposal to assess the degree of synanthropisation of a submontane moist spruce-pine forest based on the number and percentage occurrence of non-forest species of a native origin and anthropophytes in relation to the total number of occurrences of all species (Cabała 1992);

(h) the four-step descriptive scale of the naturalness of forest phytocoenoses that was proposed by Pawlaczyk (1996), which is based on the concept of potential vegetation;

(i) the quantitative characteristics of the degeneration of substitute plant communities, which is based on the concept of Faliński (1966b) and Olaczek (1972, 1974a) and followed by Łaska (2006);

(j) the Disturbance Index that was proposed by Kącki and Michalska-Hejduk (2010), whose value depends on the overall number and cover of incidental, non-specific or alien to the ecosystem species.

6. Results

6.1. A systematic review of the distinguished plant communities

Seventeen plant associations and five communities were distinguished as a result of the analyses of the phytosociological material that was collected during the study conducted within the Upper Vistula Valley mesoregion. Their syntaxonomy is the following:

Class: *Epilobietea angustifolii* R.Tx. et Prsg 1950
    Order: *Atropetalia* Vlieg. 1937
        Alliance: *Sambuco-Salicion* R.Tx. et Neum. 1950
            Association: *Sambucetum nigrae* Oberd. 1957

Class: *Artemisietea vulgaris* Lohm., Prsg et R.Tx. in R.Tx. 1950
            Association: *Chelidonio-Robinietum* Jurko 1963
  Subclass: *Galio-Urticenea* (Pass. 1967)
    Order: *Glechometalia hederaceae* R.Tx. in R.Tx. et Brun-Hool 1975
            Reynoutria japonica community

Class: *Rhamno-Prunetea* Rivas Goday et Garb. 1961
    Order: *Prunetalia spinosae* R.Tx. 1952
        Alliance: *Pruno-Rubion fruticosi* R.Tx. 1952 corr. Doing 1962
            Association: *Rubo fruticosi-Prunetum spinosae* Web. 1974 n.inv. Wittig 1976

Class: *Salicetea purpureae* Moor 1958
    Order: *Salicetalia purpureaea* Moor 1958
        Alliance: *Salicion albae* R.Tx. 1955
            Association: *Salicetum triandro-viminalis* Lohm. 1952
            Association: *Salicetum albo-fragilis* R.Tx. 1955
            Association: *Populetum albae* Br.-Bl. 1931

Class: *Alnetea glutinosae* Br.-Bl. et R.Tx. 1943
- Order: *Alnetalia glutinosae* R.Tx. 1937
  - Alliance: *Alnion glutinosae* (Malc. 1929) Meijer Dress 1936
    - Association: *Salicetum pentandro-cinereae* (Almq. 1929) Pass. 1961
    - Association: *Ribeso nigri-Alnetum* Sol.-Górn. (1975) 1987

Class: *Vaccinio-Piceetea* Br.-Bl. 1939
- Order: *Cladonio-Vaccinietalia* Kiell.-Lund 1967
  - Alliance: *Dicrano-Pinion* Libb. 1933
  - Suballiance: *Dicrano-Pinenion* Seibert in Oberd. (ed.) 1992
    - Association: *Leucobryo-Pinetum* W.Mat. (1962) 1973
    - Association: *Molinio (caeruleae)-Pinetum* W.Mat. et J.Mat. 1973
    - Association: *Querco roboris-Pinetum* (W.Mat. 1981) J.Mat. 1988
  - Suballiance: *Piceo-Vaccinienion uliginosi* Seibert in Oberd. (ed.) 1992
    - Association: *Vaccinio uliginosi-Pinetum* Kleist 1929
- Order: *Vaccinio-Piceetalia* Br.-Bl. 1939
  - Alliance: *Piceion abietis* Pawł. et al. 1928
    - Association: *Calamagrostio villosae-Pinetum* Staszk. 1958

Class: *Quercetea robori-petraeae* Br.-Bl. et R.Tx. 1943
- Order: *Quercetalia roboris* R.Tx. 1931
  - Alliance: *Quercion robori-petraeae* Br.-Bl. 1932
    - Association: *Calamagrostio arundinaceae-Quercetum petraeae* (Hartm. 1934) Scam. et Pass. 1959

Class: *Querco-Fagetea* Br.-Bl. et Vlieg 1937
- Order: *Fagetalia sylvaticae* Pawł. in Pawł., Sokoł. et Wall. 1928
  - Alliance: *Alno-Ulmion* Br.-Bl. et R.Tx. 1943
    - *Ulmus glabra* community
  - Suballiance: *Alnenion glutinoso-incanae* Oberd. 1953
    - Association: *Fraxino-Alnetum* W.Mat. 1952
  - Alliance: *Carpinion betuli* Issl. 1931 em. Oberd. 1953
    - Association: *Tilio cordatae-Carpinetum betuli* Tracz. 1962
  - Alliance: *Fagion sylvaticae* R.Tx. et Diem. 1936
  - Suballiance: *Luzulo-Fagenion* (Lohm. ex R.Tx. 1954) Oberd. 1957
    - Association: *Luzulo pilosae-Fagetum* (Du Rietz 1923) Markgr. 1932 em. Meusel 1937

Units with a phytosociological affinity that is difficult to determine:
- *Alnus glutinosa* community
- *Pinus sylvestris-Carex brizoides* community
- *Quercus robur-Carex brizoides* community

The floristic and phytosociological characteristics of the plant communities that were included in the systematic list of plant communities are presented in 24 phytosociological tables whose electronic versions were recorded on the CD that the present book is supplemented with.

6.2. Forms of degeneration

Cespitisation, which is connected with luxuriant growth of a sedge *Carex brizoides* in the herb layer, is the most frequently observed form of degeneration in the Upper Vistula Valley. It was found in many plant communities such as lime-oak-hornbeam forests *Tilio-Carpinetum* (the *Tilio-Carpinetum caricetosum brizoides* subassociation), a submontane moist spruce-pine forest *Calamagrostio villosae-Pinetum,* a lowland acidophilus beech forest *Luzulo pilosae-Fagetum* (or plantings of beech with a similar structure), a lowland alder and ash-alder forest on the periodically swamped ground-water soils *Fraxino-Alnetum* and, to a lesser extent, even in a humid pine forest *Molinio-Pinetum,* a suboceanic Middle-European pine forest *Leucobryo-Pinetum*, a Middle-European lowland acidophilus oak forest *Calamagrostio arundinaceae-Quercetum. Carex brizoides* is a sedge expansive to such a degree that it can occur abundantly on the forest floor (and frequently occupies large areas) and gives patches a specific physiognomy, and has even been the main component of the phytocoenoses that were distinguished. Such a phenomenon was observed in the case of many patches which, due to changes and floristic impoverishment, could not be classified into any association that has been described in the phytosociological literature. Some separate units such as the *Pinus sylvestris-Carex brizoides* community, the *Quercus robur-Carex brizoides* community and the *Alnus glutinosa* community were delimited.

The specific biology of the growth of *Carex bryzoides* provides an effective, often complete, overgrowing of the understorey of forest phytocoenoses. The species forms long and thin rhizomes that grow on the soil surface under a layer of litter from which the air shoots grow. The overgrowing of older rhizomes by younger rhizomes (at a growth rate of the underground parts up to 40 cm per year), leads to a rapid and significant crowding of belowground parts. Its impact on the other components of the herb layer is strengthen by the well-developed aboveground organs that are creeping the forest floor. An important aspect of a given habitat during the first period of colonisation is also minimising any contact with individuals of its own clone and maximising interclonal and interspecies interactions (sometimes called “phalanx growth”) (Sierka, Chmura 2004). The effect of mass vegetative propagation and forming synusiae by a sedge is to reduce the vitality, decrease species richness and ultimately exclude the species that originally constituted a community beginning with species that are characterised by a narrow ecological amplitude (Harper 1980; Faliński 1998; Stachurska 1998; Sierka, Orczewska 2001, 2004; Chmura, Sierka 2007; Janukowicz 2008).

Thinning has been discussed by a number of authors (i.a., Medwecka-Kornaś et al., 1988, Orczewska, Sierka 2002, Sierka, Chmura 2004, Janukowicz 2008) as an important factor in the encroachment of *Carex brizoides* into forest communities. It also stimulates the development of other plant species, thereby causing the cespitisation of phytocoenoses (e.g., *Calamagrostis epigejos*). Any disruption of the structure of a stand by forest management is a disturbance that continuously affects smaller or larger areas of a forest. Moreover, areas of clear-cuttings as well as even-aged greenwood and heavily overexposed stands were observed in the Upper Vistula Valley. Such open spaces are rapidly colonised by *Carex brizoides*. Conversely, excessive shading of the herb layer contributes to the weaker development and lower cover of *Carex brizoides* (Medwecka-Kornaś et al. 1988, Orczewska, Sierka 2002).

The cespitisation process of oak-hornbeam phytocoenoses with *Carex brizoides* has frequently been described in papers (i.a., Kuczyńska 1973; Celiński et al. 1978; Medwecka-Kornaś et al. 1988; Cabała 1990; Anioł-Kwiatkowska, Dajdok 1993; Hereźniak 1993; Orczewska, Sierka 2002). According to Sierka (2003) and Sierka and Chmura (2004), despite a significantly higher commitment to fertile deciduous forests (particularly *Tilio-Carpinetum* and *Fraxino-Alnetum*) in the Silesian Uplands, this species was also found in many other habitats. Among the syntaxa that involves *Carex brizoides*, which were mentioned by previously mentioned authors, there are also many in the area of the Upper Vistula Valley, such as *Querco roboris-Pinetum*, *Populetum albae*, *Ribeso nigri-Alnetum*, *Molinio-Pinetum*, *Calamagrostio villosae-Pinetum*, *Calamagrostio arundinaceae-Quercetum petraeae*, *Luzulo pilosae-Fagetum* and *Pinus sylvestris-Carex brizoides* communities. Similar results were obtained by Stachurska (1998), who distinguished a unit in almost every plant association described in the Wieliczka Foothills that physiognomy is determined by *Carex bryzoides*: *Tilio-Carpinetum* form with *Carex brizoides*, *Querco roboris-Pinetum* form with *Carex brizoides*, *Alnus glutinosa-Carex brizoides* com., *Fagus sylvatica-Carex brizoides* com., *Abies alba-Carex brizoides* com. The diversity of habitats that are available for *Carex brizoides* indicates the huge expansiveness of this species on the one hand, but its negative influence on the floristic diversity and structure of many communities on the other. This threat was also found in the Upper Vistula Valley where *Carex brizoides* occurs in forests in large numbers. The common view, especially in commercial forests, is that all of the forest intersections that are degenerated by *Carex brizoides* cover the forest floor sedge.

In addition to *Carex brizoides*, cespitisation was also caused by grass species such as *Deschampsia flexuosa* in the *Leucobryo-Pinetum* or *Phalaris arundinacea* in the *Populetum albae* or in the *Salicetum albo-fragilis* in the plant communities that were examined. It should be emphasised that their role is hardly significant in comparison with *Carex brizoides*.

Fruticetisation is another commonly occurring form of degeneration. Excessive growth of the shrub layer – similar to cespitisation – is the result of a change in light conditions in phytocoenosis caused by the overexposure of a given forest stand or transformations that are made on the adjacent surfaces, which laterally expose a community, devoid, as a result of intensive disturbance, of outer strip of thickets naturally occurring at the edge of the forest.

In the Upper Vistula Valley, fruticetisation was observed with varying degrees of frequency in patches of *Tilio-Carpinetum* (all subassociations), *Fraxino-Alnetum*, *Salicetum albo-fragilis*, *Populetum albae*, *Querco roboris-Pinetum*, *Leucobryo-Pinetum*, *Molinio-Pinetum*, *Calamagrostio villosae-Pinetum*, *Pinus sylvestris-Carex brizoides* and *Alnus glutinosa* communities. This form of degeneration was most often caused by species such as *Corylus avellana* and *Padus avium* (plant communities of the *Querco-Fagetea* class), invasive kenophyte *Reynoutria japonica* (in the patches of the *Salicetum albo-fragilis*) or *Frangula alnus* (in coniferous and mixed forests). In addition, a quite common type of fruticetisation involves the strong development of the species of the genus *Rubus sp.* (the most frequent being *Rubus hirtus* and *Rubus idaeus*). This was found primarily in patches of degraded *Tilio-Carpinetum*, *Leucobryo-Pinetum* (which may suggest an anthropogenic character of coniferous phytocoenoses that are created on more fertile habitats), an *Alnus glutinosa* community, rarely or with less intensity also in patches of the *Fraxino-Alnetum*, *Calamagrostio arundinaceae-Quercetum*, *Querco roboris-Pinetum* and *Quercus robur-Carex brizoides*. Not always in a overgrowth of a given patch was involved only one species of blackberry. Sometimes, a share of other species of *Rubus* genus was observed that form a dense cover in phytocoenoses.

Fruticetisation is a common form of degeneration (including the expansion of *Rubus hirtus* and *Rubus idaeus*) that is a response of plant communities to the sudden exposure of the forest floor through the increased lighting that is associated with the thinning of tree stands or the eutrophication of habitats. Its effects are now commonly known (e.g., Balcerkiewicz 1991; Anioł-Kwiatkowska et al. 1998; Macicka-Pawlik, Wilczyńska 1998; Stachurska 1998; Macicka-Pawlik 2000). The threat of the decreasing floristic diversity of communities and the naturalness of their structure that is associated with this phenomenon, however, is still important and relevant to the protection of the forests that are characteristic of this mesoregion.

Pinetisation, which is related to the increasing share of coniferous species in different habitats (especially mixed forests, acidophilus oak forests, acid beech forests and poor oak-hornbeam forests but also rich habitats of deciduous forests), also appears to be a significant threat to the vegetation of the Upper Vistula Valley. The severity of this type of degeneration is considerable due to several factors. Pinetisation does not have a local or regional character, but generally affects the whole area of Poland, even some areas that are under protection in the national parks or nature reserves (e.g., Olaczek, Sowa 1972; Olaczek 1974a, 1974b; Olaczek, Piotrowska 1986; Pawlaczyk 1993, 1997; Krotoska 1991; Hereźniak 1993; Jakubowska-Gabara 1994; Bernadzki, Zajączkowski 1995; Załuski et al. 1997; Stachurska 1998; Balcerkiewicz 2001; Kurowski 2004; Miś, Rączka 2004; Łaska 2006). It is a consequence of forest management, which according to Olaczek (1974b), has been for at least 200–300 years aimed at forming single-species stands, and prefers pine stands, which caused the transformation of deciduous forests into mixed forests. A significant risk that is associated with pinetisation is habitat transformation, which occurs along with the transformation of stands and which is manifested by changes in the soil flora, pH and soil chemistry, the rate of the decomposition of organic matter or even in the dominant process of soil formation. The duration of the successive generations of the coniferous stands that are planted causes continuous changes and transformations of the soil subtype (Biały 1997). This process, which has been often described, results in such a degeneration of a community that it leads to drastic species impoverishment and a habitat that is impossible to be correctly evaluated (Kurowski 1979, 2004; Macicka 1984; Hereźniak 1993; Stachurska 1998; Grzyb 1999; Danielewicz, Pawlaczyk 2004). Moreover, studies that were carried out by Kurowski (2004) in the nature reserve "Jaksonek" showed that plant communities that had formerly been classified as dry or fresh pine forests appeared to be anthropogenic substitutive communities in more fertile and wetter habitats (mixed-forest/oak-hornbeam forest), which due to their established protection as nature reserves, were relieved of anthropogenic pressures and had begun the process of regeneration. Similar studies that were conducted by Sowa et al. (1993) in the "Jamno" reserve showed a regeneration of a dry oak-hornbeam forest that had been diagnosed as a mixed pine forest, the *Pino-Quercetum abietetosum.* The most considerable diagnostic doubts were emphasised by the characteristics of phytocoenoses that were found in the Upper Vistula Valley, and they refer to the poor oak-hornbeam forests, an acidophilus oak forest, mixed pine forests and pine forests, which as a result of the introduction of pine trees, lose their characteristic features and undergo convergence. Opinions about the reversibility of the transformations of habitats that occur under the influence of coniferous species are divided. Some authors stress the stability of emerging alternative systems, while others (e.g., Markowski 1974; Olaczek, Piotrowska 1986; Danielewicz 1991b; Biały 1997; Danielewicz, Pawlaczyk 2004; Balcerkiewicz 1991, 2001; and Matuszkiewicz J.M. 2007a) argue the more or less regenerative capacity of degenerated phytocoenoses, which is primarily dependent on the type, duration and intensity of the anthropogenic impact and the intrinsic properties of the communities.

What serves as the confirmation of the presence of pinetisation within the characterised mesoregion is a map of potential natural vegetation of Poland (Matuszkiewicz W. et al. 1995). For the vast surface of the studied area (outside the complex to the east of Gromiec), it shows presence of lowland ash-elm floodplain forest, occasionally flooded – *Ficario-Ulmetum* and partly also a subcontinental submontane lime-oak-hornbeam forest − *Tilio-Carpinetum* (in Lesser-Poland-vicariant, upland form, eutrophic ("rich") or oligotrophic ("poor") communities), lowland alder and ash-alder forest on the periodically swamped ground-water soils – *Fraxino-Alnetum* (Fig. 6).

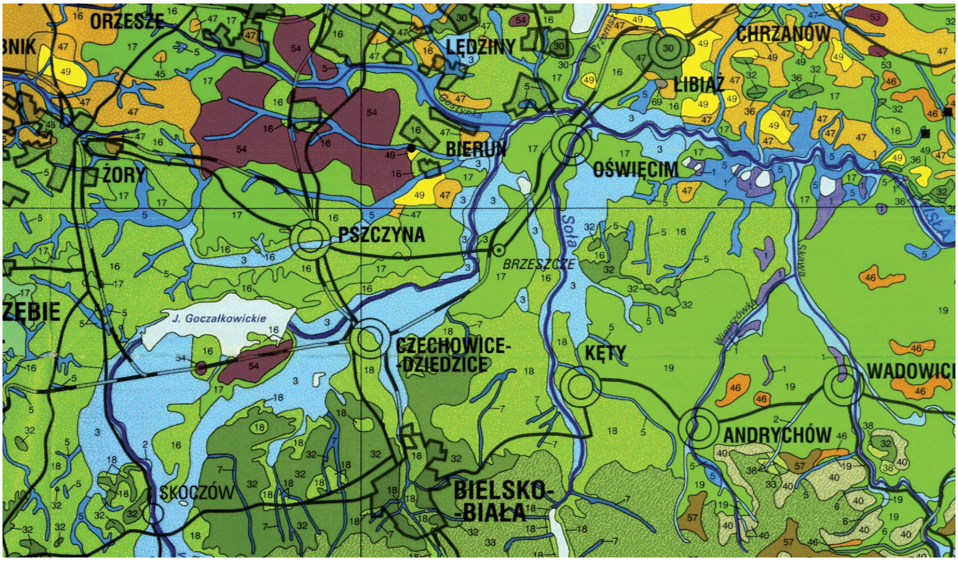

Fig. 6. A map of the potential natural vegetation of the Upper Vistula Valley (Matuszkiewicz W. et al. 1995, changed). The map with comprehensive explanations is available at: http://wydawnictwo.us.edu.pl/sites/wydawnictwo.us.edu.pl/files/synanthropisation_of_forest_map.pdf

This description is far from what was observed during field studies. A substantial surface area was covered by pine stands (communities of the *Dicrano-Pinion* alliance) or patches with a greater or lesser share of pine trees, including communities that had been strongly modified or degraded, often with a syntaxonomical affinity that was difficult to determine (degenerated *Tilio-Carpinetum*, *Pinus sylvestris-Carex brizoides* com., *Quercus robur-Carex brizoides* com.). Moreover, some patches do not have a well-developed undergrowth, which is typical for pine phytocoenoses. In some cases, for example, a significant share of blackberries was observed, thus suggesting at least a mesotrophic character of the habitat. It indicates the probability of human involvement in their genesis and thus their unnatural character (Izdebski 1962; Macicka 1984; Krotoska et al. 1985; Balcerkiewicz 1991; Anioł-Kwiatkowska, Dajdok 1993; Pawlaczyk 1993; Jakubowska-Gabara 1994 and others).

The above-described pinetisation is closely related to two other forms of degeneration – monotypisation and juvenilisation. Monotypisation like pinetisation is connected with the type of forest management that is used, which through the clear-cutting combined with a simultaneous artificial renewal has led to the development of communities of a uniform age, species composition and structure. In the area that was studied (especially in the forest complex that is located south of the Goczałkowice Reservoir) such systems have been observed quite often, especially in the pine communities. Deforested areas, highly dense greenwoods or fenced forest crops were also found frequently.

Juvenilisation takes place as a result of cuttings that are carried out cyclically in a relatively young stand, which keeps a community at an early stage of development. It is impossible, however, to clearly determine whether the "juvenile phytocoenoses" that were observed during this short-term research are maintained at this stage through clear cuttings or whether they are simply not very mature stands after a previous felling. An assessment of the actual intensity of juvenilisation (according to Olaczek 1972, 1974a) is not possible until the end of the study.

Neophytisation is a form of degeneration that results from either direct human impact through the deliberate introduction of species that are alien to Polish flora or due to a variety of distortions or intereferences in existing phytocoenoses, which greatly facilitates the penetration of kenophytes into their structure (Faliński 1966c). According to Danielewicz (1991a), neophytisation can be seen as a "self-perpetuating" process. The introduction of alien species into phytocoenoses facilitates the establishment of other alien species.

Small balsam *Impatiens parviflora* occurred in 25% of all phytosociological relevés, while Himalayan balsam *Impatiens glandulifera* was confined to thickets. Red oak *Quercus rubra*, Japanese knotweed *Reynoutria japonica*, black cherry *Padus serotina* and common beggar ticks *Bidens frondosa* were most frequently found in the forest and thicket plant communities in the Upper Vistula Valley. Among them *Reynoutria japonica* and *Robinia pseudacaccia*, which had not previously been listed, created distinct plant communities and gave them a specific physiognomy. However, the *Quercus rubra* community recorded in other regions of Poland has not been observed. Red oak was not the main constituent of the tree layer but it accounted for an admixture with other species. The other kenophytes that were most frequently recorded included: the cutleaf coneflower *Rudbeckia laciniata*, the giant goldenrod *Solidago gigantea* and the Canadian goldenrod *Solidago canadensis*. It is worth mentioning that neophytisation that was connected with the intentional plantings of exotic species also affected the protected areas. Weymouth pine (*Pinus

Tab. 1. The share of kenophytes in the plant communities that were recorded in the area of the Upper Vistula Valley

Plant community (phytocoenose)	***Salicetum albo-fragilis***	***Salicetum triandro-viminalis***	***Populetum albae***	***Chelidonio-Robinietum***	***Tilio-Carpinetum typicum***	***Tilio-Carpinetum degenerated***	***Reynoutria japonica com.***	***Querco roboris-Pinetum***	***Fraxino-Alnetum***	***Rubo fruticosi-Prunetum spinosae***	***Alnus glutinosa com.***	***Calamagrostio villosae-Pinetum***	***Calamagrostio-Quercetum***	***Leucobryo-Pinetum***	***Ribeso nigri-Alnetum***	***Tilio-Carpinetum calamagrostietosum***	***Quercus robur-Carex brizoides com.***	***Luzulo pilosae-Fagetum***	***Molinio-Pinetum***	***Salicetum pentandro-cinereae***	***Pinus sylvestris-Carex brizoides com.***	***Ulmus glabra com.***	***Sambucetum nigrae***	***Vaccinio uliginosi-Pinetum***	***Tilio-Carpinetum corydaletosum***	**The number of communities with occurrence of alien species**
Number of relevés	35	40	16	5	34	17	12	10	16	16	14	18	16	29	16	8	16	6	22	26	12	3	2	8	17	
Impatiens parviflora	II$^{8.4}$	I$^{5.8}$	II$^{2.2}$	II$^{2.5}$	II$^{9.7}$	III$^{3.9}$	I$^{2.0}$	II$^{5.3}$	V$^{17.3}$	II$^{10.0}$	II$^{9.4}$	I$^{1.7}$	I$^{18.0}$	I$^{2.0}$	II$^{2.0}$	II$^{2.0}$	II$^{4.2}$	–	I$^{2.0}$	–	I$^{2.0}$	V$^{6.3}$	V$^{2.5}$	–	–	**21**
Quercus rubra	I$^{6.0}$	–	I$^{1.0}$	–	II$^{9.6}$	II$^{16.2}$	I$^{1.0}$	II$^{1.3}$	–	–	I$^{18.0}$	II$^{1.8}$	III$^{10.0}$	IV$^{2.9}$	–	I$^{1.0}$	I$^{2.0}$	III$^{2.3}$	I$^{2.3}$	–	–	II$^{2.0}$	–	I$^{1.0}$	–	**16**
Bidens frondosa	I$^{2.0}$	I$^{10.2}$	I$^{2.0}$	–	–	I$^{2.0}$	I$^{2.0}$	I$^{2.0}$	I$^{2.0}$	–	–	I$^{2.0}$	–	I$^{1.0}$	III$^{7.6}$	–	–	–	–	III$^{2.6}$	–	–	–	–	–	**11**
Prunus serotina	I$^{24.0}$	–	–	–	I$^{10.0}$	II$^{5.0}$	–	III$^{4.5}$	–	–	I$^{2.0}$	–	II$^{3.0}$	III$^{8.4}$	–	III$^{5.3}$	I$^{2.0}$	II$^{1.5}$	I$^{2.5}$	–	–	–	–	–	–	**11**
Impatiens glandulifera	III$^{7.8}$	IV$^{8.0}$	II$^{2.8}$	III$^{1.7}$	–	I$^{13.0}$	III$^{5.6}$	–	II$^{14.0}$	I$^{1.0}$	–	I$^{1.0}$	–	–	I$^{2.0}$	–	–	–	–	–	–	–	–	–	–	**10**
Solidago canadensis	I$^{2.3}$	I$^{2.0}$	I$^{2.0}$	III$^{6.3}$	I$^{2.0}$	–	I$^{2.0}$	–	I$^{3.0}$	II$^{2.0}$	I$^{3.0}$	–	–	–	I$^{2.0}$	–	–	–	–	–	–	–	–	–	–	**10**
Amelanchier spicata	–	–	–	–	I$^{2.0}$	II$^{11.8}$	–	I$^{9.0}$	–	–	–	–	–	–	–	–	I$^{15.0}$	–	–	I$^{15.0}$	I$^{13.0}$	–	–	–	–	**6**
Rudbeckia laciniata	II$^{19.0}$	II$^{5.7}$	I$^{2.0}$	I$^{1.0}$	–	–	–	–	I$^{68.0}$	–	–	–	–	–	–	–	–	–	–	I$^{1.0}$	–	–	–	–	–	**6**
Solidago gigantea	I$^{2.0}$	II$^{3.3}$	I$^{2.5}$	I$^{13.0}$	–	–	–	–	–	I$^{2.0}$	I$^{2.0}$	–	–	–	–	–	–	–	–	–	–	–	–	–	–	**6**
Echinocystis lobata	I$^{2.0}$	II$^{2.5}$	I$^{2.0}$	–	–	–	I$^{3.0}$	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	**4**
Pyrus communis	–	–	–	–	I$^{2.5}$	II$^{5.0}$	–	I$^{2.0}$	–	–	–	–	–	–	–	II$^{2.5}$	–	–	–	–	–	–	–	–	–	**4**
Reynoutria japonica	III$^{18.3}$	III$^{3.9}$	III$^{19.6}$	–	–	–	V$^{88.7}$	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	**4**
Robinia pseudoacacia	–	I$^{13.0}$	–	V$^{76.8}$	I$^{15.0}$	I$^{2.0}$	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	**4**
Erigeron annuus	–	I$^{2.0}$	–	I$^{13.0}$	–	–	–	–	–	I$^{2.0}$	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	**3**
Galinsoga ciliata	I$^{1.0}$	I$^{2.0}$	–	–	–	–	I$^{1.0}$	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	**3**
Populus berolinensis	I$^{25.5}$	I$^{16.3}$	I$^{25.5}$	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	**3**
Cerasus vulgaris	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	I$^{2.0}$	–	–	–	–	–	–	–	**1**
Acer negundo	I$^{2.0}$	–	–	II$^{2.0}$	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	**2**
Chenopodium aristatum	I$^{2.0}$	I$^{2.0}$	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	**2**
Hesperis matronalis	I$^{38.0}$	–	I$^{2.0}$	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	**2**
Oxalis fontana	–	–	–	II$^{1.5}$	–	–	–	–	–	I$^{1.0}$	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	**2**
Pinus strobus	–	–	–	–	–	–	–	I$^{3.0}$	–	–	–	–	I$^{15.0}$	–	–	–	–	–	–	–	–	–	–	–	–	**2**
Aesculus hippocastanum	–	–	–	–	I$^{14.5}$	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	**1**
Aster novi-belgii	–	I$^{2.0}$	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	**1**
Erigeron ramosus	I$^{2.0}$	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	**1**
Malus domestica	–	–	–	–	I$^{2.0}$	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	**1**
Ribes rubrum	–	–	–	–	–	–	–	–	I$^{2.0}$	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	**1**
Symphoricarpos albus	–	I$^{3.0}$	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	**1**
The number of kenophytes in a given community	16	15	11	9	9	8	8	7	6	6	5	4	4	4	4	4	4	3	3	3	2	2	1	1	0	

strobus) was found in a degenerated subcontinental lime-oak-hornbeam forest in the “Żaki” Nature Reserve. This does not indicate a very unfavourable state of the vegetation of the Upper Vistula Valley, but is rather a manifestation of the dynamic neophytisation process of plant communities, which is occurring throughout Poland, including the areas that are covered by the highest forms of conservation.

This synoptic table was created in order to show the share of kenophytes in the plant communities that were distinguished. The values of constancy degree and mean non-zero cover are given for the species (Tab. 1).

The analysis of the qualitative and quantitative share of kenophytes in the plant communities of the study area revealed that they play the most important part in the structure of plant communities such as: *Salicetum albo-fragilis*, *Salicetum triandro-viminalis*, *Populetum albae*, *Chelidonio-Robinietum* and *Reynoutria japonica* communities. In the case of the latter two communities, this is connected with a great abundance of differential species.

6.3. The intensity of anthropopressure

In this study, the assessment of the degree of the naturalness of vegetation, which is the opposite of the degree of deformation, was calculated using the share of groups of species that are characterised by an uneven response to the impact of anthropogenic pressure in phytocoenoses (Roo-Zielińska 2004). The concept of the participation of foreign species in a given phytocoenosis while on the other hand participation of anthropophytes in a vegetation patch as elements pointing to synanthropisation, which was presented by Roo-Zielińska (2004), is based directly on the system of degenerative phases that was proposed by Faliński (1966b) and Olaczek (1972, 1974a). These systems were not used in connection with any problems or doubts that emerged during the analysis of the results. In this work, due to the combination of research on the diversity and internal variability of forest and shrub plant communities and the state of their conservation, it was impossible to meet the requirements of the methodology in accordance with which it is necessary to use the Faliński system (1966b) or the Olaczek system (1972, 1974a). Faliński (1966) claims that the former requires knowledge of the plant associations that are represented by phytocenoses which had been studied before the start of degenerative changes as well as investigations that are repeated over a long period of time (preferably on permanent study plots) in order to guarantee compliance with the predicted changes by the system of degeneration, which was also emphasised by Dzwonko (2007). The latter (Olaczek 1972, 1974a), due to the need to carry out specific calibrations for different phases of the degeneration of plant communities, which is necessary in order to determine the intervals of values that represent the ratio of euphytes to allophytes for the next stages of degeneration, requires an adequate methodology for data collection. An analysis of the so-called degeneration series is required for the proper separation of the phases of degeneration. According to Olaczek (1972), this is a group of patches of the same plant association that are situated close to each other and that occur in the same topographic and habitat conditions that represent the different forms and phases of degeneration. An analysis of such a series cannot only determine the rank of degeneration for each value of the coefficients, but also makes it easier to distinguish the natural diversity of the habitat conditions from the variability that is caused by external factors. Therefore, only a general concept of the assessment of the state of the preservation of phytocoenoses that was based on the percentage ratio of the number of species and the coverage of euphytes to allophytes without the separation and identification of the exact degenerative phases was applied. The degree of the transformation of individual patches was determined using the uncategorised values of the coefficients. In addition, a comparison was made between the plant communities within the groups of similar communities.

Moreover, in the case of forest communities which represent the *Querco-Fagetea* class as a measure of their naturalness (including the persistence of their occurrence on current localities), the share of species that represent old deciduous forests was applied (Dzwonko, Loster 2001; Dzwonko 2007). This parameter is based on research that has shown a much greater species richness of this group within the old woodlands compared to young forests, which have formed naturally as a result of succession or artificially as a result of plantings. The explanation for such a pattern is the poor ability of old forest species to spread, which results in their difficulty in colonising new, spatially isolated forest systems as well as the low durability of the soil seed bank of this group of plants. The rate of the colonisation of new forests that are adjacent to an old system of forests is also slow. This means that the presence of a large group of old deciduous forest species can be considered to be an indicator of the long and continuous existence of a forest habitat and often also of its primary origin (Dzwonko 2007).

To sum up, these indices were used as a measure of the naturalness-degeneration of plant communities:

- the percentage ratio of the number of euphytes to allophytes (E/A number) and the percentage ratio of the abundance (cover) of euphytes to allophytes (E/A cover) according to the system of degenerative phases that was proposed by Olaczek (1972, 1974a);
- the number and percentage cover of anthropophytes and the systematic value of the group of anthropophytes;

- the number and percentage cover of species of old deciduous woodlands that were calculated for the plant communities of the *Querco-Fagetea* class.

The analysis of the degree of transformation of the plant communities that were recorded in the Upper Vistula Valley was performed within separate groups that comprised similar phytocoenoses. This approach permitted the comparison of communities which were similar to each other in terms of the coefficients that were used and allowed conclusions to be drawn about the state of their conservation. In turn, the evaluation of individual phytosociological relevés, on which the degree of naturalness often deviates from the average that is calculated for the whole association, is possible due to tables that contain raw data and mean value, median and standard deviation for a given plant community. The order of the phytosociological relevés in the tables is the same as in the tables of plant communities, which allows the values of the individual coefficients to be related to the composition and structure of communities. In addition, the tables have been supplemented with information about the landscape structure of the vegetation under study. The patches were divided into groups representing: forest complexes (“C”), forest islands (“I”) and thickets “bushes” (“B”). Additionally, forests islands were divided into four categories: I – 0.5–5.0 ha (“I1”), II – 5.5–25.0 ha (“I2”), III – 25.5–50.0 ha (“I3”) and IV – 50.5–150.0 ha (“I4”).

Oak-hornbeam forest – the *Carpinion betuli* alliance

Different subassociations of the *Tilio-Carpinetum* were investigated within the *Carpinion betuli* alliance. They were divided into typical, dry, wet and degenerated groups. The analysis of the data (Tables 2–5) shows a considerable range of the calculated values of the coefficients and in particular the percentage ratio of the number of euphytes to allophytes and their coverage ratio. Both of these values reached the absolute maximum (E/A number = 750; E/A cover = 2012.5) in one of patches of wet oak-hornbeam forest, which exceeded the highest values that were observed in the dry oak-hornbeam forests or degenerated oak-hornbeam forests. Such statistically significant higher values of E/A cover and E/A number coefficients that were observed in wet oak-hornbeam forests in comparison to dry and degenerated oak-hornbeam forests was confirmed using the ANOVA Kruskal-Wallis test and the test of multiple comparisons of the average ranks for all of the samples. The tests also indicated higher values of the coefficients in the typical oak-hornbeam forests in comparison with the degenerated oak-hornbeam forest (Fig. 7). It is worth emphasising that both of the indices that are mentioned demonstrate a statistically significant high linear correlation ($r = 0.84$, $r^2 = 0.70$; $R = 0.86$). Such a correlation was also found between the

E/A number and E/A cover indices and the cover of species of old woodlands. Its values do not show such a strong linear relationship as the one between the indices that used euphytes and allophytes (r = 0.34–0.49, r^2 = 0.12–0.25; R = 0.55–0.60).

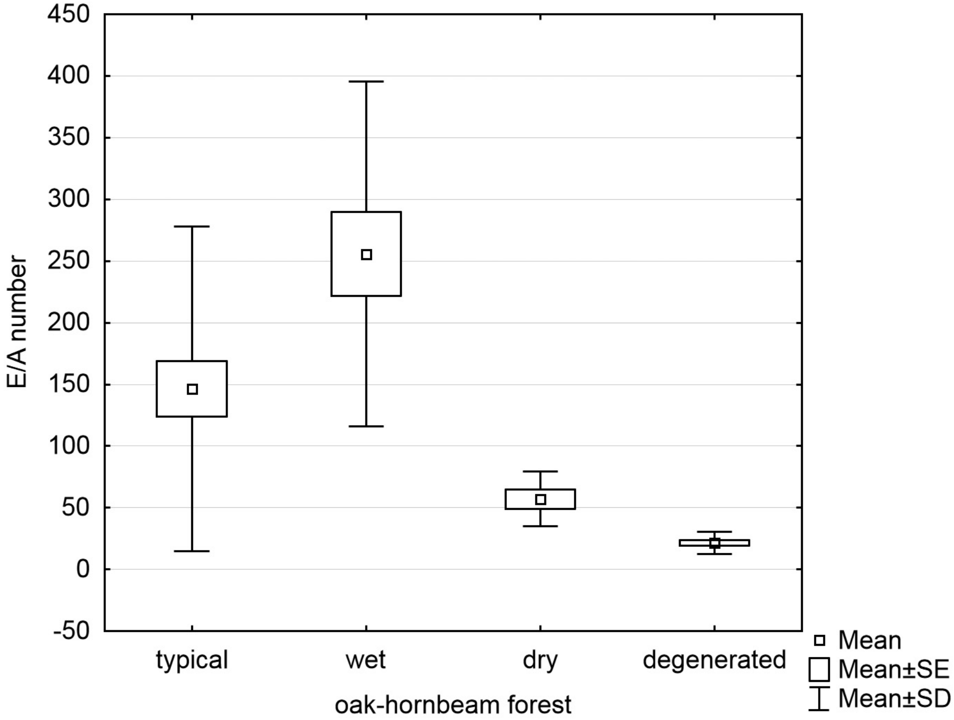

Fig. 7. The value of the E/A number coefficient in the groups of the *Tilio-Carpinetum* subassociations

Moreover, wet oak-hornbeam forests are strongly distinguished from the rest of the subassociations by other parameters – it is the only subassociation in which anthropophytes were not recorded in documented patches and the mean cover of species of old deciduous woodlands significantly exceeded the values that were obtained for the other groups (Fig. 8). This can be considered to be the least transformed oak-hornbeam community in the Upper Vistula Valley. The opposite situation was observed in the case of the degenerated oak-hornbeam forests; the results that were obtained suggest the validity of such an approach, especially in comparison to typical and wet oak-hornbeam forests, which are characterised by a significantly higher naturalness that is manifested primarily by higher values of the ratio of euphytes to apophytes. It should be emphasised that only 4 of the 76 phytocoenoses of oak-hornbeam forest that were studied were related to forest complexes (of which 3 represented the degenerated

Tab. 2. Coefficients that describe the state of the preservation of phytocoenoses that represent the typical subassociation of the *Tilio-Carpinetum* phytocoenoses

No. of relevés in the table	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	Mean	Median	Standard deviation
No. of species	15	21	13	15	15	17	19	26	18	19	15	11	26	10	18	21	16	22	16	17	47	16	13	23	36	26	22	24	24	34	24	30	27	32			
Structure	W2	L	W2	W4	W2	W4	W2	W2	W4	W2	W1	W4	W1	W2	W2	W1	W1	W1	W1	W1	W1	W2	W4	W4	W3	W4	W1	W1	W2	W4	W1	W2	W3	W1			
E/A number	66.7	50.0	116.7	150.0	150.0	142.9	375.0	420.0	260.0	375.0	200.0	266.7	116.7	400.0	500.0	61.5	45.5	57.1	77.8	70.0	34.3	166.7	225.0	27.8	24.1	30.0	144.4	84.6	71.4	36.0	84.6	76.5	28.6	39.1	146.31	84.62	131.40
E/A cover	62.1	82.1	119.0	212.7	191.6	169.7	315.9	496.0	1035.6	767.7	1139.7	1288.2	292.5	546.2	1394.9	156.6	154.7	209.1	114.3	458.8	68.5	405.9	234.6	136.2	125.2	94.8	132.5	162.8	108.0	184.8	77.9	191.5	147.1	195.2	337.43	188.15	362.49
No. of anthropophytes	2	1	0	0	0	0	0	0	0	0	1	0	0	2	0	2	1	1	0	1	3	1	0	2	0	2	2	2	4	3	2	1	1	2	1.06	1.00	1.10
Cover of anthropophytes	42.2	2.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	15.6	0.0	25.8	1.0	3.0	0.0	2.0	36.1	13.0	0.0	4.0	0.0	15.6	3.0	18.1	32.3	4.9	68.6	2.0	1.0	6.8	8.76	1.50	15.56
No. of woodland species	2	4	5	5	6	6	12	15	10	11	6	5	13	6	11	9	6	8	4	5	11	4	8	6	7	5	10	9	7	7	3	10	7	5	7.30	6.50	3.00
Cover of woodland species	4.9	10.6	50.3	42.8	50.3	23.0	78.2	77.6	74.7	81.5	50.8	42.8	52.8	50.8	30.4	49.3	31.6	48.9	19.0	88.9	22.4	18.1	90.8	22.2	14.1	30.2	44.0	27.5	25.3	15.0	5.9	36.9	15.8	9.6	39.30	34.30	24.70
Cover of woodland species/anthropophytes	0.1	10.6	50.3	42.8	50.3	23.0	78.2	77.6	74.7	81.5	50.8	42.8	52.8	3.1	30.4	1.8	15.8	12.2	19.0	29.6	0.6	1.3	90.8	4.4	14.1	1.8	11.0	1.4	0.8	2.5	0.1	12.3	7.9	1.2	26.41	13.20	28.48

Tab. 3. Coefficients that describe the state of the preservation of the phytocoenoses that represent the wet subassociation of the *Tilio-Carpinetum* phytocoenoses

No. of relevés in the table	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	Mean	Median	Standard deviation
No. of species	21	17	24	20	24	19	21	24	21	28	28	21	24	28	14	15	18			
Structure	W4	W2	W4	W2	W2	W2	W2	W2	W4	W4	W4	W2	W4	W4	W2	W2	W4			
E/A number	250.0	750.0	166.7	233.3	166.7	171.4	250.0	200.0	250.0	180.0	154.5	320.0	200.0	211.1	366.7	275.0	200.0	255.61	211.11	139.63
E/A cover	274.7	2012.5	389.2	222.7	278.3	253.7	410.0	542.5	692.9	239.3	169.3	403.8	577.2	561.7	1271.8	548.1	445.9	546.68	410.00	457.22
No. of anthropophytes	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00	0.00	0.00
Cover of anthropophytes	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.00	0.00	0.00
No. of woodland species	12	10	13	14	10	11	13	15	12	13	14	13	11	17	10	9	6	11.94	12.00	2.56
Cover of woodland species	69.5	36.3	70.7	83.7	64.6	57.7	83.6	68.6	86.2	83.3	93.9	83.6	89.9	92.7	92.4	92	93.9	78.98	83.60	15.78
Cover of woodland species/anthropophytes	69.5	36.3	70.7	83.7	64.6	57.7	83.6	68.6	86.2	83.3	93.9	83.6	89.9	92.7	92.4	92	93.9	78.98	83.60	15.78

Tab. 4. Coefficients that describe the state of the preservation of the phytocoenoses that represent the dry subassociation of the *Tilio-Carpinetum* phytocoenoses

No. of relevés in the table	1	2	3	4	5	6	7	8	Mean	Median	Standard deviation
No. of species	23	32	36	27	32	18	21	17			
Structure	W1	W2	W2	W1	W2	W2	W4	W4			
E/A number	64.3	100.0	44.4	39.3	56.3	43.5	75.0	33.3	57.01	50.35	22.17
E/A cover	74.5	98.8	50.2	97.5	114.6	319.8	187.8	229.0	146.52	106.70	91.56
No. of anthropophytes	0	2	3	1	0	0	1	2	1.13	1.00	1.13
Cover of anthropophytes	0.0	4.0	19.0	1.0	0.0	0.0	2.0	4.0	3.75	1.50	6.39
No. of woodland species	9	11	7	11	9	7	7	4	8.13	8.00	2.36
Cover of woodland species	54.1	74.7	24.5	74.1	35.6	32.3	21.4	9.6	40.79	33.95	24.35
Cover of woodland species/anthropophytes	54.1	14.9	1.2	37.1	35.6	32.3	7.1	1.9	23.03	23.62	19.44

Tab. 5. Coefficients that describe the state of the preservation of the phytocoenoses that represent the degenerated subassociation of the *Tilio-Carpinetum* phytocoenoses

No. of relevés in the table	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	Mean	Median	Standard deviation
No. of species	30	13	30	23	45	21	24	26	22	15	15	11	27	21	22	20	20			
Structure	L	W2	W2	W2	W2	W2	W4	L	W4	W4	W4	W4	L	W4	W4	W4	W2			
E/A number	30.4	18.2	36.4	27.8	22.2	40.0	26.3	13.0	22.2	15.4	15.4	22.2	12.5	16.7	10.0	11.1	25.0	21.46	22.22	8.74
E/A cover	101.3	20.0	73.7	65.2	41.2	124.7	27.4	20.0	78.3	17.7	44.4	5.0	18.9	77.5	21.4	20.1	109.4	50.96	41.18	37.29
No. of anthropophytes	3	3	2	2	2	0	1	2	0	0	0	0	2	0	2	1	1	1.24	1.00	1.09
Cover of anthropophytes	9.6	74.1	4.9	15.6	4.0	0.0	13.0	15.6	0.0	0.0	0.0	0.0	3.0	0.0	4.0	2.0	2.0	8.69	3.00	17.72
No. of woodland species	6	2	5	0	10	6	9	6	7	6	6	5	9	7	5	7	9	6.18	6.00	2.51
Cover of woodland species	11.4	4.9	10.5	0.0	23.2	23.0	60.1	32.3	40.5	23.0	32.3	20.6	35.6	61.6	50.3	33.7	36.3	29.37	32.30	17.69
Cover of woodland species/anthropophytes	1.1	0.1	1.8	0.0	4.6	23.0	4.3	1.9	40.5	23.0	32.3	20.6	8.9	61.6	10.1	11.2	12.1	15.12	10.06	16.91

Tilio-Carpinetum). The others occurred in the area of forest islands (size II and IV categories). This indicates the strong synanthropisation of the space and a reduction in the area that is occupied by the communities of oak-hornbeam to enclaves in the transformed landscape. In spite of such a structure of the landscape, the mean cover and the number of anthropophytes was not very high in the following subassociations and there were quite a large number of species of old deciduous forests, which indicates the primary nature of most of the patches that were studied.

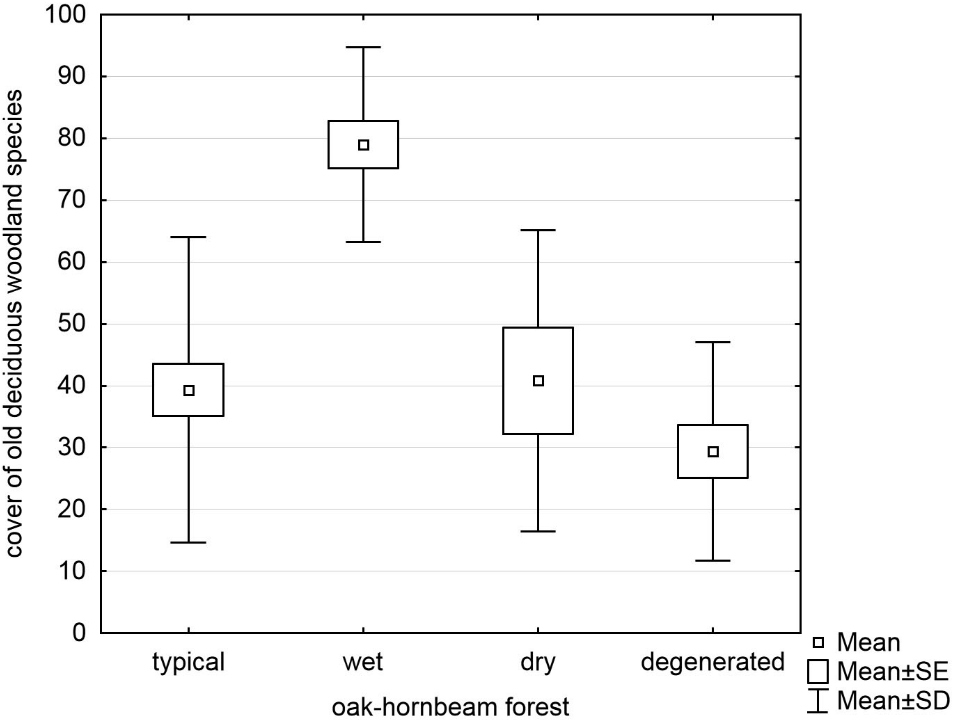

Fig. 8. The value of the cover of old woodland species in the groups of the *Tilio-Carpinetum* subassociations

Lowland alder, ash-alder and elm-ash forests on the periodically swamped ground-water soils of the *Alno-Ulmion*

In the study area, riparian plant communities of the *Querco-Fagetea* class comprise the *Fraxino-Alnetum* and *Ulmus gabra* communities. Due to the small number of phytosociological relevés in both units (16 and 3, respectively) and their different phytosociological representations, no statistical comparisons of these syntaxa were performed. The indices that were calculated for the relevés and averaged for a plant community are difficult to relate to the values that were obtained for the submontane lime-oak-hornbeam forest or the lowland willow-poplar floodplain forest.

The habitats that were occupied by the lowland alder and ash-alder forests of the *Alno-Ulmion* alliance are different from each other and from other groups. When analysing the results that were obtained for the ash-alder forests (Tab. 6), attention should be paid to the moderate mean value of the E/A number and E/A cover and the simultaneous small range in the values of these coefficients across the table. The average is also the number and cover of species of old deciduous woodlands. This can be explained by the abundant occurrence of nitrophilous species of the *Artemisietea vulgaris* class, which is typical for the *Fraxino-Alnetum*, although it cannot be considered to be an index of the degeneration of a community. Transformation can be revealed by quite high cover of anthropophytes (22.1%) in the community, among which *Impatiens parviflora* plays the most important part and has the highest constancy. In the *Ulmus glabra* community (Tab. 7), all of the parameters that were calculated reached values that indicated a relatively higher naturalness of patches that were studied; however, the sample size was very low. The cover of anthropophytes was also lower and species of old deciduous forests and euphytes play a more important role. The characterised communities were observed in both complexes as well as in the forest islands of different sizes.

Acid beech forest – the *Fagion sylvaticae* alliance

The beech forests in the study area are represented by phytocoenoses that belong to the *Luzulo pilosae-Fagetum* association. They are characterised by a low value of the E/A number and, at the same time, a quite high average value of the parameter of E/A cover (Tab. 8). The reason for this is the very low species richness of the communities (the maximum number of species that were recorded in the relevé was only 19) and the negligible cover of the herb layer along with a strong density of a mainly beech stand. The beech tree (classified as an euphyte) has the considerable influence just on the value of the ratio E/A cover. The lower value of this parameter in the phytosociological relevés in which beech trees (*Fagus sylvatica*) co-occur with Scots pine (*Pinus sylvestris*) trees is definitely a confirmation of this fact. There can be found relations between the small role of the herb layer in all of the phytocoenoses and extremely low value of the coverage of the species of old deciduous woodlands (and also their number) and ratio of the cover of this group to anthropophytes. Anthropophytes also appear alone and do not significantly affect the structure of the communities. Documented patches of acidic beech forests have been also described in the area of forest complexes.

Tab. 6. Coefficients that describe the state of the preservation of the *Fraxino-Alnetum* phytocoenoses

No. of relevés in the table	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	Mean	Median	Standard deviation
No. of species	45	43	22	26	28	44	29	31	37	39	34	33	34	21	30	16			
Structure	W3	W1	L	W1	L	L	W1	W1	L	L	L	L	L	W2	W3	W2			
E/A number	45.2	48.3	37.5	36.8	47.4	46.7	31.8	72.2	37.0	39.3	30.8	37.5	47.8	110.0	42.9	100.0	50.70	44.01	23.32
E/A cover	133.6	95.2	83.2	108.4	50.4	75.7	68.4	103.6	59.8	49.7	17.7	29.2	59.4	123.7	27.3	128.5	75.86	72.05	36.95
No. of anthropophytes	1	5	1	1	1	1	1	1	1	2	2	1	1	0	2	1	1.38	1.00	1.09
Cover of anthropophytes	13.0	49.8	13.0	13.0	3.0	38.0	3.0	3.0	13.0	39.9	39.9	38.0	13.0	0.0	72.2	2.0	22.11	13.00	21.32
No. of woodland species	9	9	5	6	11	14	8	9	11	12	9	9	10	3	5	1	8.19	9.00	3.41
Cover of woodland species	35.6	36.3	29.5	14.1	29.6	41.8	35.0	49.8	50.9	36.9	19.2	27.5	60.1	5.9	19.8	13.0	31.56	32.30	14.90
Cover of woodland species/anthropophytes	2.5	0.7	2.1	1.0	7.4	1.1	8.8	12.5	3.6	0.9	0.5	0.7	4.3	5.9	0.3	4.3	3.53	2.33	3.53

Tab. 7. Coefficients that describe the state of the preservation of the *Ulmus glabra* community phytocoenoses

No. of relevés in the table	1	2	3	Mean	Median	Standard deviation
No. of species	22	42	28			
Structure	W1	L	L			
E/A number	83.3	100.0	100.0	94.44	100.00	9.62
E/A cover	197.9	138.5	273.5	203.29	197.89	67.64
No. of anthropophytes	1	2	1	1.33	1.00	0.58
Cover of anthropophytes	3.0	4.9	13.0	6.97	4.90	5.31
No. of woodland species	8	18	14	13.33	14.00	5.03
Cover of woodland species	25.3	87.9	76.9	63.37	76.90	33.42
Cover of woodland species/anthropophytes	6.3	14.9	5.5	8.91	6.33	5.21

Tab. 8. Coefficients that describe the state of the preservation of the *Luzulo pilosae-Fagetum* phytocoenoses

No. of relevés in the table	1	2	3	4	5	6	Mean	Median	Standard deviation
No. of species	15	19	7	10	16	15			
Structure	L	L	L	L	L	L			
E/A number	36.4	90.0	16.7	66.7	77.8	66.7	59.02	66.67	27.33
E/A cover	146.3	185.0	210.0	202.3	437.5	308.6	248.28	206.11	107.17
No. of anthropophytes	0	1	1	1	1	1	0.83	1.00	0.41
Cover of anthropophytes	0.0	2.0	1.0	2.0	3.0	2.0	1.67	2.00	1.03
No. of woodland species	3	4	1	3	4	3	3.00	3.00	1.10
Cover of woodland species	6.8	8.7	2	5.9	7.8	5.9	6.18	6.35	2.32
Cover of woodland species/anthropophytes	6.8	2.9	1.0	2.0	2.0	2.0	2.76	1.97	2.07

Mixed forests and an acidophilus oak forest – *Querco roboris-Pinetum* and *Calamagrostio arundinaceae-Quercetum petraeae*

These communities represent different classes, but are close to each other in terms of habitat. In addition the economic use of this type of phytocoenoses often leads to a blurring of differences between them. For these reasons and because of the fairly large floristic similarity, those communities were included into one group. It should be emphasised that there is a great deal of similarity between the two associations in terms of the values of the coefficients that were calculated (Tables 9 and 10) – the percentage ratios of the number and cover of euphytes to allophytes reached similar mean values and only had a slightly different span. The average number and cover of anthropophytes in the relevé had a similar shape with a slightly higher value observed in *Calamagrostio arundinaceae-Quercetum petraeae.* The mixed forests and acidophilus oak forest in the study area occur mainly in the complexes and larger forest islands (size IV category).

Pine forests – the *Vaccinio-Piceetea* class (excluding the *Querco roboris-Pinetum*)

This group comprises the pine phytocoenoses that were classified as: *Leucobryo-Pinetum*, *Molinio-Pinetum*, *Calamagrostio villosae-Pinetum* and *Vaccinio uliginosi-Pinetum* associations. The values of the coefficients for particular relevés and the basic statistics for associations are presented in Tables 11–14. Taking into account the coefficients of the E/A number and E/A cover, it is worth noting that they are less than in the case of the range of the data for the oak-hornbeam forests. The same means are also lower compared with the wet and typical oak-hornbeam forests, but this may be explained by the specificity of

Tab. 9. Coefficients that describe the state of the preservation of the *Querco roboris-Pinetum* phytocoenoses

No. of relevés in the table	1	2	3	4	5	6	7	8	9	10	Mean	Median	Standard deviation
No. of species	29	41	24	31	24	24	29	18	21	16			
Structure	L	L	L	L	W2	W4	W3	L	W4	W4			
E/A number	52.6	41.4	60.0	93.8	118.2	71.4	52.6	100.0	61.5	33.3	68.49	60.77	27.29
E/A cover	80.0	89.9	131.8	166.2	146.5	81.0	153.7	278.8	90.6	123.5	134.20	127.69	59.83
No. of anthropophytes	0	3	2	1	2	2	3	1	2	1	1.70	2.00	0.95
Cover of anthropophytes	0.0	19.0	4.0	2.0	3.0	14.7	5.9	2.0	14.7	4.9	7.02	4.45	6.60

Tab. 10. Coefficients that describe the state of the preservation of the *Calamagrostio arundinaceae-Quercetum petraeae* phytocoenoses

No. of relevés in the table	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	Mean	Median	Standard deviation
No. of species	25	22	20	28	25	23	20	25	23	25	20	27	20	17	26	26			
Structure	L	L	L	L	W4	W4	L	L	L	W4	L	L	W2	L	W4	L			
E/A number	78.6	120.0	42.9	47.4	31.6	21.1	53.8	25.0	43.8	31.6	33.3	50.0	33.3	112.5	73.3	73.3	54.46	45.56	29.67
E/A cover	177.2	263.6	113.6	71.6	41.0	53.6	123.0	96.7	107.8	68.7	86.7	199.6	85.6	280.1	118.5	138.3	126.60	110.71	70.30
No. of anthropophytes	2	2	2	2	2	2	0	1	0	2	0	0	1	2	0	0	1.13	1.50	0.96
Cover of anthropophytes	4.0	5.9	8.7	48.7	5.9	19.8	0.0	2.0	0.0	14.7	0.0	0.0	38.0	10.6	0.0	0.0	9.89	4.95	14.46

the plant communities that were compared, which are more similar to the mixed forests and acidophilus oak forests. Moreover, this is also manifested by the coefficients that were calculated. The highest mean E/A number value occurred in the *Vaccinio uliginosi-Pinetum* association and the E/A cover in the *Molinio-Pinetum* association. However, the analysis of variance of coefficients based on the share of euphytes and allophytes in the patches did not show any statistically significant differences between particular plant communities. In contrast, such differences were observed in the number and cover of anthropophytes that play a significantly greater role in the fresh pine forest *Leucobryo-Pinetum* than in the *Molinio-Pinetum* or *Vaccinio uliginosi-Pinetum* forests (Fig. 9). It is interesting that the specific distribution of pine forests in comparison to oak-hornbeam forests is almost completely different. The collected data show a very strong "attachment" to the forest complexes and in the case of forest islands, there was a more frequent occurrence in larger objects (size III and IV categories).

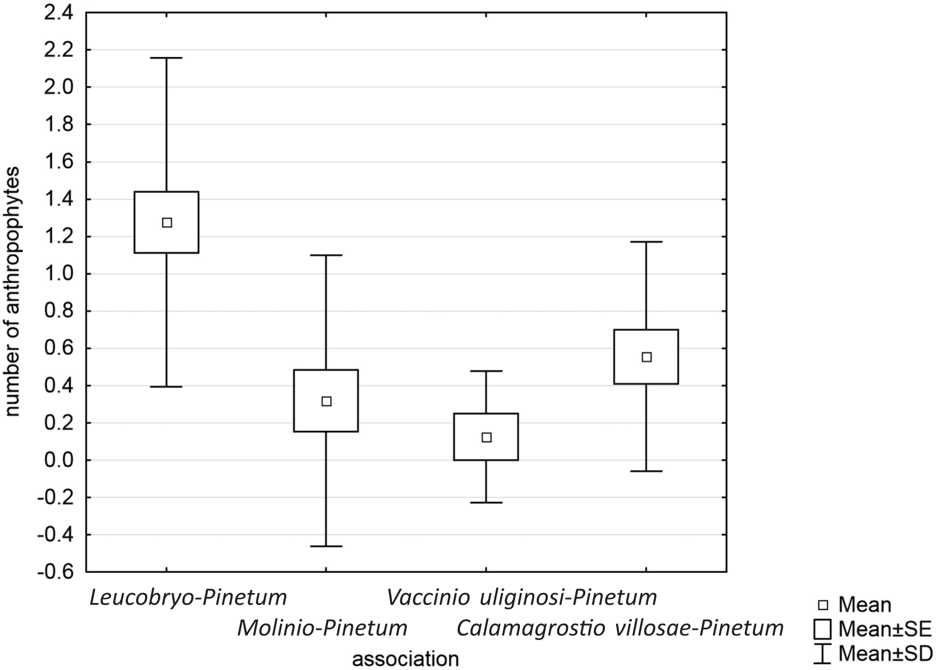

Fig. 9. Number of anthropophytes in the plant communities of pine forests of the *Dicrano-Pinion* phytocoenoses

Lowland willow-poplar riparian forest and riverine scrub, regularly flooded – *Salicetea purpureae* class

This group comprises two communities: the *Salicetum albo-fragilis* and the *Populetum albae* and a dynamic willow community *Salicetum triandro-viminalis*

Tab. 11. Coefficients that describe the state of the preservation of the *Leucobryo-Pinetum* phytocoenoses

No. of relevés in the table	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	Mean	Median	Standard deviation
No. of species	20	24	20	27	22	13	20	19	18	24	13	17	26	22	21	20	17	26	19	23	22	17	14	25	18	26	21	23	16			
Structure	L	L	L	L	L	L	L	L	L	L	L	W2	L	L	L	L	W4	L	L	L	W4	L	L	L	L	L	L	L	L			
E/A number	100.0	118.2	100.0	68.8	83.3	116.7	42.9	46.2	63.6	26.3	62.5	21.4	31.6	37.5	16.7	25.0	30.8	30.0	18.8	27.8	22.2	30.8	100.0	31.6	125.0	23.8	50.0	43.8	60.0	53.62	42.86	33.73
E/A cover	190.7	236.7	301.0	221.6	187.1	415.3	221.2	259.0	258.1	174.3	634.2	85.4	100.9	41.9	58.6	109.8	76.6	48.6	87.8	161.4	59.9	68.4	508.7	159.4	269.2	58.2	45.6	170.9	69.9	182.09	161.44	143.24
No. of anthropophytes	1	1	2	2	0	2	2	2	2	1	1	3	0	0	1	1	0	2	2	2	2	0	1	2	2	0	0	2	1	1.28	1.00	0.88
Cover of anthropophytes	2.0	2.0	4.0	4.0	0.0	4.0	16.4	4.9	8.7	2.0	2.0	73.5	0.0	0.0	2.0	1.0	0.0	8.7	4.0	19.8	3.0	0.0	1.0	5.9	4.9	0.0	0.0	4.0	2.0	6.20	2.00	13.76

Tab. 12. Coefficients that describe the state of the preservation of the *Molinio-Pinetum* phytocoenoses

No. of relevés in the table	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	Mean	Median	Standard deviation
No. of species	14	26	14	15	13	25	15	25	17	17	18	25	13	17	19	14	19	21	14	21	15	20			
Structure	L	L	W3	W3	L	L	L	L	L	L	L	W4	W3	L	L	W3	L	L	W3	L	W3	L			
E/A number	27.3	30.0	75.0	87.5	116.7	47.1	50.0	31.6	54.5	88.9	38.5	31.6	85.7	54.5	35.7	75.0	46.2	31.3	75.0	40.0	87.5	66.7	58.00	52.27	25.11
E/A cover	190.6	145.1	286.8	227.7	430.4	123.5	125.5	109.4	87.1	287.1	295.2	149.3	232.2	187.4	122.6	126.5	123.2	181.3	190.2	107.6	290.0	129.4	188.55	165.31	85.55
No. of anthropophytes	0	0	0	0	0	0	0	3	0	0	0	2	0	0	1	0	0	0	0	1	0	0	0.32	0.00	0.78
Cover of anthropophytes	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5.9	0.0	0.0	0.0	4.0	0.0	0.0	2.0	0.0	0.0	0.0	0.0	2.0	0.0	0.0	0.63	0.00	1.54

Tab. 13. Coefficients that describe the state of the preservation of the *Calamagrostio villosae-Pinetum* phytocoenoses

No. of relevés in the table	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	Mean	Median	Standard deviation
No. of species	15	19	19	16	19	18	28	13	20	24	20	28	20	17	17	21	20	13			
Structure	L	L	L	L	L	L	L	L	L	W4	L	L	L	L	L	L	L	L			
E/A number	50.0	26.7	35.7	45.5	46.2	50.0	27.3	44.4	42.9	26.3	33.3	27.3	66.7	54.5	54.5	50.0	66.7	62.5	45.02	45.80	13.38
E/A cover	65.8	66.0	60.3	138.1	94.4	85.0	88.7	318.7	107.6	120.9	116.7	84.9	140.0	81.6	248.1	110.5	134.2	289.6	130.61	109.04	76.24
No. of anthropophytes	0	0	0	0	0	1	1	1	0	1	1	2	1	0	0	1	0	1	0.56	0.50	0.62
Cover of anthropophytes	0.0	0.0	0.0	0.0	0.0	2.0	1.0	1.0	0.0	2.0	2.0	4.0	1.0	0.0	0.0	3.0	0.0	1.0	0.94	0.50	1.21

Tab. 14. Coefficients that describe the state of the preservation of the *Vaccinio uliginosi-Pinetum* phytocoenoses

No. of relevés in the table	1	2	3	4	5	6	7	8	Mean	Median	Standard deviation
No. of species	21	19	16	13	20	12	13	9			
Structure	L	L	L	W3	L	W3	L	L			
E/A number	162.5	90.0	45.5	85.7	53.8	200.0	44.4	50.0	91.49	69.78	58.95
E/A cover	100.0	82.6	42.2	154.3	66.3	265.4	137.8	126.6	121.90	113.31	69.05
No. of anthropophytes	1	0	0	0	0	0	0	0	0.13	0.00	0.35
Cover of anthropophytes	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.13	0.00	0.35

that is connected with them. The values of the coefficients that were calculated based on the division of species into euphytes and allophytes for each plant community (Tables 15–17), particularly *Salicetum albo-fragilis* and *Salicetum triandro-viminalis*, are quite similar in size, which can be seen in the statistically significant difference between the arithmetic mean of the parameter E/A number, for which the *Populetum albae* community has the highest value and the mean that was calculated for the other associations (using the Kruskal-Wallis test for significance level $p < 0.05$) (Fig. 10). The *Populetum albae* association also had the highest mean value of the E/A cover coefficient. However, this difference was not statistically significant. The statistically significant difference was confirmed by the analysis of variance for the *Salicetum albo-fragilis*, in which this parameter reached the lowest value (Fig. 11). Particular attention should be paid to the number and cover of anthropophytes, the average values of which reached 1.94–2.65 number of species and 12.7–20.7% of cover, respectively, in the phytosociological relevé for the communities of the *Salicetea purpureae* class that were studied. Although these values were overestimated by single patches with a higher share of anthropophytes, this does not disprove the fact that this group of species has a significant negative effect on the state of riverine communities. It should be emphasised that such a significant share of anthropophytes, among which kenophytes play a dominant role, was observed only in the ash-alder riparian forest (excluding the plant communities that were formed by anthropophytes).

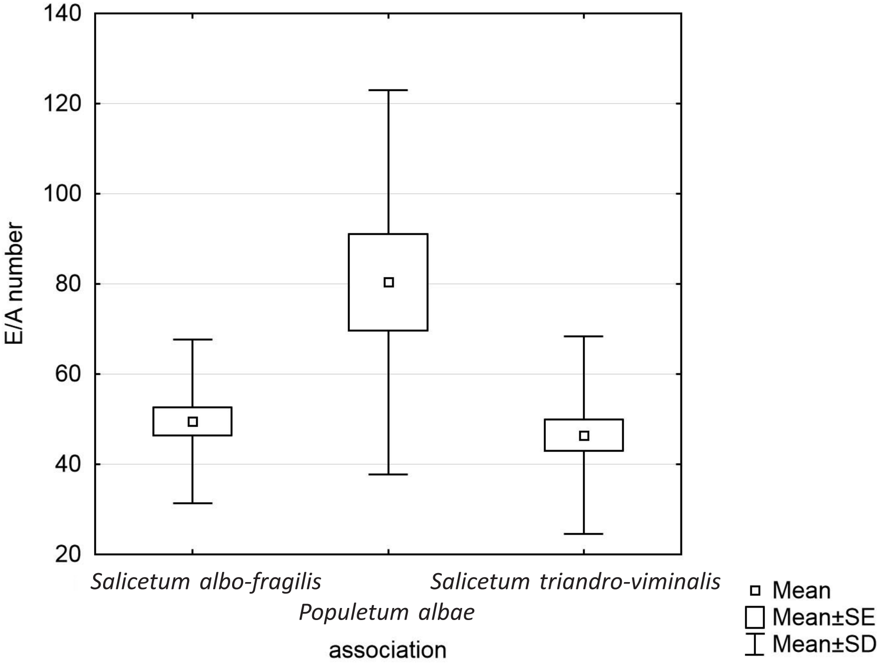

Fig. 10. Values of the E/A number coefficient in the plant communities of the *Salicetea purpureae* class

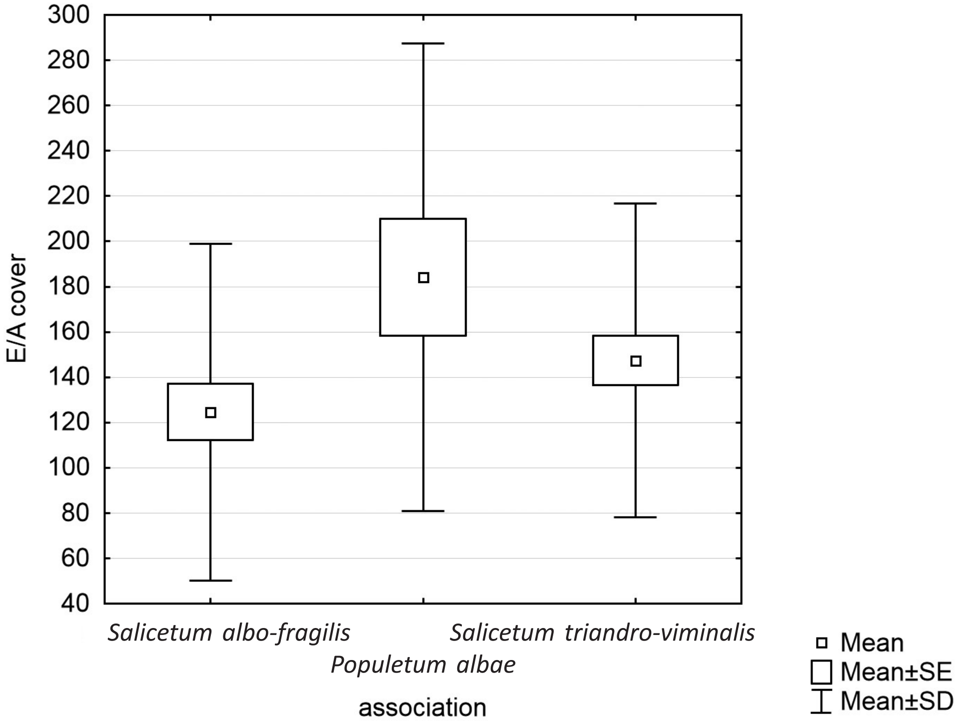

Fig. 11. Value of the E/A cover coefficient in plant communities of the *Salicetea purpureae* class

Middle-European alder fen forests and willow communities – the *Alnetea glutinosae* class

This group comprises middle-European alder fen forest of the *Ribeso nigri-Alnetum* association and a *Salicetum pentandro-cinereae* willow community. An analysis of the values of individual indicators (Tables 18 and 19) showed a higher mean value of the E/A number and E/A cover in the willow community. The statistical significance of the difference in the second coefficient was tested using the U Mann-Whitney test, which showed differences between the medians of both units. The low share of anthropophytes in the studied patches is worth emphasising – the mean number of species from this group in the phytosociological relevé was 0.7–1.0 and the mean cover was about 5% in the middle-European alder fen forest (*Ribeso nigri-Alnetum*) and about 2% in the willow thickets (*Salicetum pentandro-cinereae*). As to their locations, the alder fen forests are concentrated in the forest complexes and the largest forest islands (mainly size IV category) in the Upper Vistula Valley.

Tab. 15. Coefficients that describe the state of the preservation of the *Salicetum triandro-viminalis* phytocoenoses

No. of relevés in the table	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	Mean	Median	Standard deviation
No. of species	10	18	29	26	39	39	32	28	25	27	13	23	20	20	28	19	19	30	20	18	42	37	30	29	25	29	20	29	20	24	15	27	22	21	27	35	27	30	27	21			
Structure	K	K	K	K	K	K	K	K	K	K	K	K	K	K	K	K	K	K	K	K	K	K	K	K	K	K	K	K	K	K	K	K	K	K	K	K	K	K	K	K			
E/A number	66.7	80.0	93.3	85.7	30.0	50.0	24.0	22.7	26.3	42.1	62.5	35.3	42.9	66.7	33.3	58.3	35.7	50.0	81.8	20.0	40.0	27.6	25.0	20.8	66.7	45.0	33.3	38.1	53.8	41.2	114.3	35.0	37.5	50.0	28.6	16.7	42.1	50.0	35.0	50.0	46.45	41.64	21.90
E/A cover	140.5	164.9	229.4	138.9	124.9	105.2	192.0	142.7	204.9	122.1	484.8	147.7	207.7	119.3	178.3	249.5	123.7	121.5	125.8	92.5	80.3	104.7	104.8	132.5	200.0	159.6	185.2	98.9	172.1	89.6	176.4	97.3	108.8	142.5	96.5	71.1	99.0	139.2	105.1	117.1	147.43	129.10	69.27
No. of anthropophytes	1	0	3	3	6	3	6	4	6	6	0	4	1	3	5	2	0	2	1	1	4	3	4	3	2	3	1	2	4	2	1	1	2	2	2	2	4	4	2	1	2.65	2.00	1.69
Cover of anthropophytes	3.0	0.0	5.9	39.8	56.3	25.8	13.2	9.6	15.0	30.9	0.0	19.8	2.0	41.7	13.2	7.8	0.0	4.0	3.0	3.0	18.1	5.9	48.7	17.3	5.9	8.7	2.0	14.7	8.7	24.3	2.0	3.0	15.6	4.9	4.9	4.0	9.6	9.6	4.0	2.0	12.70	8.25	13.79

Tab. 16. Coefficients that describe the state of the preservation of the *Salicetum albo-fragilis* phytocoenoses

No. of relevés in the table	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	Mean	Median	Standard deviation
No. of species	25	27	23	32	35	38	30	27	22	28	20	20	27	24	19	24	18	28	28	30	26	22	19	34	25	23	24	23	24	21	38	26	31	40	30			
Structure	W2	W1	W2	W1	W2	W3	W2	W3	W3	W3	W2	W2	W1	W3	W2	W3	W1	W3	W3	W1	W3	W3	W3	W3	W3	W1	W3	W1	W1	W2	W1	W1	W1	W1	W1			
E/A number	66.7	58.8	109.1	52.4	45.8	26.7	57.9	42.1	83.3	40.0	53.8	53.8	50.0	60.0	58.3	50.0	50.0	55.6	47.4	36.4	52.9	57.1	58.3	36.0	47.1	27.8	71.4	64.3	60.0	40.0	26.7	23.8	29.2	21.2	20.0	49.54	50.00	18.19
E/A cover	235.0	236.3	434.9	111.1	99.4	108.4	81.7	95.3	93.5	82.0	83.7	75.3	96.5	252.8	66.4	241.1	152.4	84.5	135.3	105.3	110.8	87.6	101.6	110.5	95.3	125.6	103.8	124.3	137.6	81.6	36.3	96.7	129.8	83.7	67.3	124.66	101.55	74.33
No. of anthropophytes	0	2	0	4	5	6	3	2	2	3	3	0	4	1	2	1	2	3	2	1	3	1	1	5	4	1	3	0	1	1	2	1	1	2	2	2.11	2.00	1.51
Cover of anthropophytes	0.0	14.7	0.0	28.0	64.2	24.5	19.0	38.6	14.7	47.1	8.7	0.0	73.8	3.0	88.2	13.0	4.0	19.8	7.8	13.0	47.1	2.0	2.0	22.2	43.4	2.0	48.2	0.0	2.0	2.0	4.0	2.0	13.0	26.6	26.6	20.72	13.00	22.78

Tab. 17. Coefficients that describe the state of the preservation of the *Populetum albae* phytocoenoses

No. of relevés in the table	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	Mean	Median	Standard deviation
No. of species	17	24	19	26	23	25	22	22	29	17	32	15	27	25	29	30			
Structure	W1	W1	W3	W3	W1	W1	W2	W3	W2	W3	W1	W2	W3	W3	W3	W3			
E/A number	41.7	76.9	90.0	44.4	69.2	100.0	100.0	69.2	70.6	142.9	28.0	200.0	68.8	66.7	81.3	36.4	80.37	69.91	42.60
E/A cover	345.9	178.6	143.2	104.3	175.7	100.5	284.6	93.1	306.9	414.0	92.1	89.9	140.6	231.0	162.9	83.9	184.20	153.04	103.12
No. of anthropophytes	3	2	1	3	2	2	4	3	0	1	3	3	2	1	1	0	1.94	2.00	1.18
Cover of anthropophytes	6.8	4.9	3.0	17.3	4.0	5.9	8.7	47.7	0.0	13.0	4.9	90.0	4.9	2.0	3.0	0.0	13.51	4.90	23.37

Tab. 18. Coefficients that describe the state of the preservation of the *Ribeso nigri-Alnetum* phytocoenoses

No. of relevés in the table	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	Mean	Median	Standard deviation
No. of species	22	24	31	37	29	26	35	24	22	31	37	43	35	41	33	19			
Structure	L	W4	L	L	L	W4	W4	L	L	L	L	W4	W4	W4	W4	W3			
E/A number	29.4	140.0	63.2	42.3	70.6	85.7	94.4	71.4	100.0	72.2	60.9	79.2	150.0	127.8	73.7	35.7	81.03	72.95	34.89
E/A cover	129.0	106.8	275.0	93.0	68.6	199.8	210.7	323.8	345.0	194.7	156.9	128.9	236.9	189.6	124.7	139.7	182.69	173.24	80.61
No. of anthropophytes	0	1	1	1	3	1	1	2	1	1	1	1	1	1	1	0	1.10	1.00	0.70
Cover of anthropophytes	0.0	2.0	3.0	2.0	5.9	2.0	1.0	4.0	2.0	2.0	1.0	38.0	2.0	13.0	1.0	0.0	4.90	2.00	9.30

Tab. 19. Coefficients that describe the state of the preservation of the *Salicetum pentandro-cinereae* phytocoenoses

No. of relevés in the table	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	Mean	Median	Standard deviation
No. of species	17	19	18	13	26	26	21	25	28	28	17	44	30	28	18	12	15	17	14	7	28	11	14	16	15	17			
Structure	K	K	K	K	K	K	K	K	K	K	K	K	K	K	K	K	K	K	K	K	K	K	K	K	K	K			
E/A number	183.3	111.1	157.1	333.3	116.7	85.7	75.0	108.3	75.0	75.0	183.3	69.2	114.3	75.0	157.1	300.0	114.3	54.5	100.0	75.0	33.3	120.0	55.6	60.0	114.3	41.7	114.93	104.17	71.64
E/A cover	744.7	459.4	404.4	191.4	383.5	217.2	240.8	314.9	141.0	131.6	888.6	183.6	136.8	236.3	361.2	562.2	257.9	138.4	225.1	126.9	89.5	172.0	268.6	332.6	529.1	212.6	305.78	238.56	196.54
No. of anthropophytes	1	1	0	1	1	1	1	1	1	1	0	3	1	2	1	0	0	1	1	0	2	0	0	1	0	0	0.80	1.00	0.70
Cover of anthropophytes	1.0	2.0	0.0	2.0	2.0	2.0	1.0	2.0	1.0	2.0	0.0	3.0	0.0	2.0	3.0	0.0	0.0	13.0	2.0	0.0	14.7	0.0	0.0	2.0	0.0	0.0	2.10	1.50	3.60

Tab. 20. Mean number, mean cover and the systematic value of the group of anthropophytes in particular plant communities

Community	*Tilio-Carpinetum typicum.*	*Tilio-Carpinetum wet*	*Tilio-Carpinetum dry*	*Tilio-Carpinetum degenerated*	*Fraxino-Alnetum*	*Ulmus glabra*	*Luzulo pilosae-Fagetum*	*Querco roboris-Pinetum*	*Calamagrostio-Quercetum*	*Leucobryo-Pinetum*	*Molinio-Pinetum*	*Calamagrostio villosae-Pinetum*	*Vaccinio uliginosi-Pinetum*	*Salicetum albo-fragilis*	*Populetum albae*	*Salicetum triandro-viminalis*	*Ribeso nigri-Alnetum*	*Salicetum pentandro-cinereae*	*Pinus-Carex*	*Quercus-Carex*	*Sambucetum nigrae*	*Rubo-Prunetum*	*Chelidonio-Robinietum*	*Reynoutria japonica*
No. of anthropophytes	1.1	0.0	1.1	1.2	1.4	1.3	0.8	1.7	1.1	1.3	0.3	0.6	0.1	2.1	1.9	2.7	1.1	0.8	0.2	0.6	1.0	1.0	5.2	2.3
Cover of anthropophytes	8.8	0.0	3.8	8.7	22.1	7.0	1.7	7.0	9.9	6.2	0.6	0.9	0.1	20.7	13.5	12.7	4.9	2.1	1.3	3.4	2.5	4.3	80.1	89.3
Syst. value group anthropophytes	0.58	0.0	1.23	1.13	0.98	2.9	2.54	1.61	1.36	1.4	0.14	0.4	0.08	1.05	1.32	1.45	0.92	0.71	0.11	0.59	5.71	0.6	5.18	7.12

6.4. The participation of anthropophytes in the following associations and different landscape categories of the vegetation that was investigated

A comparison of all of the plant communities that were recorded in the Upper Vistula Valley in terms of the occurrence of anthropophytes in their patches (including the number of recorded species, the cover of the group of anthropophytes and the systematic value of a group), gave interesting results (Tab. 20, Figs. 12 and 13). The lowest values of these parameters were found in the following phytocoenoses: *Tilio-Carpinetum corydaletosum*, *Vaccinio uliginosi-Pinetum*, *Molinio-Pinetum*, *Pinus sylvestris-Carex brizoides* and *Calamagrostio villosae-Pinetum*. The highest values (in the case of a coefficient that was based on cover of anthropophytes) were found in plant communities whose structure is determined by the kenophytes *Reynoutria japonica* in the *Reynoutria japonica* community and *Robinia pseudacaccia* in the *Chelidonio-Robinietum* community. It should be emphasised that other parameters such as the number of anthropophytes and their systematic value reached quite high values in these phytocoenoses. This indicates, among others, the ease of penetration of alien species into habitats that have already been transformed and that are covered by vegetation with a modified structure. In addition to these units, the significant role of anthropophytes is primarily reflected in the willow-poplar floodplain forests and lowland alder and ash-alder forests on the periodically swamped ground-water soils – the *Salicetum albo-fragilis*, the *Populetum albae*, the *Salicetum triandro-viminalis* and the *Fraxino-Alnetum.* This is influenced to a great extent by such factors as a significant increase in the anthropogenic pressure that is exerted on the riverine communities; the fragmentary degree of the preservation of the phytocoenoses that are being discussed; the disruptive role of flooding, which facilitates the penetration of anthropophytes into the patches of vegetation and the function of river valleys as corridors, which support the spread of alien species. Among the kenophytes that occur in the area of Upper Vistula Valley, whose migration pattern along rivers is commonly known and widely documented (Dajdok et al. 2003, Kucharczyk, Krawczyk 2004, Tokarska-Guzik 2005), *Impatiens glandulifera*, *Bidens frondosa*, *Echinocystis lobata* or *Rudbeckia laciniata* can be mentioned. It is worth emphasising that the differences between the communities that are listed in both groups, which are characterised by the lowest and highest value, respectively, are in the overwhelming majority of cases (taking into account the factor of the number of anthropophytes and the cover of anthropophytes or at least one of them) statistically significant. This was shown by the non-parametric analysis of variance of the Kruskal-Wallis test of the multiple comparisons of the average ranks for all of the samples at the significance level $p = 0.05$.

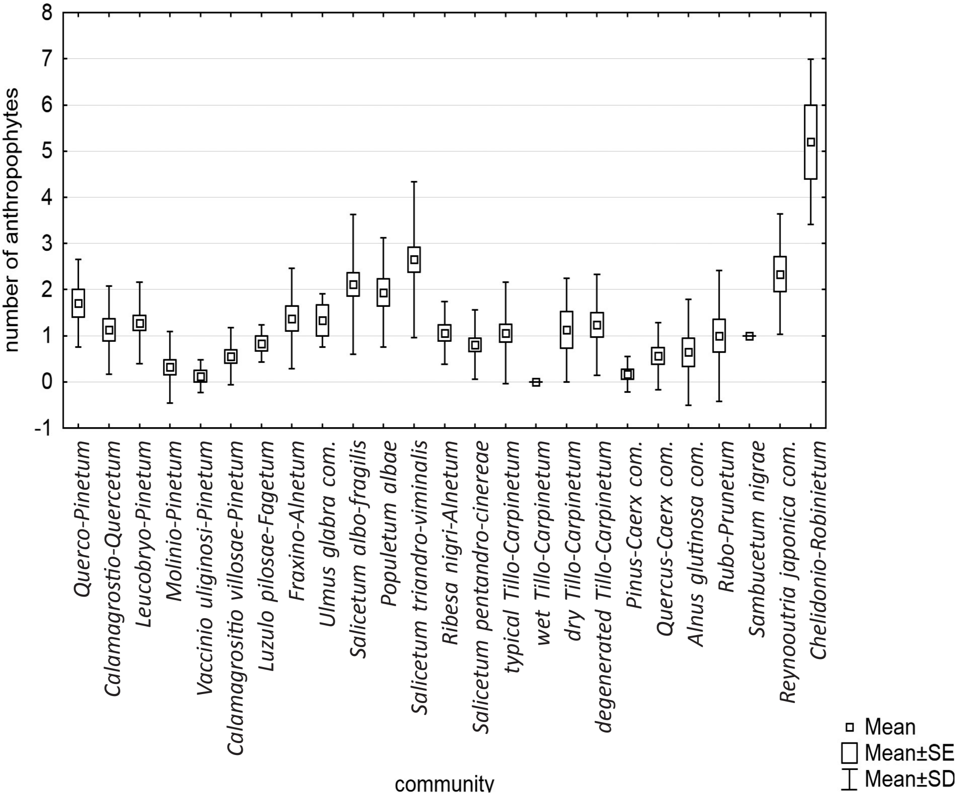

Fig. 12. Mean number of anthropophytes in the plant communities that were recorded in the area of the Upper Vistula Valley

A surprisingly high value of a systematic group of anthropophytes was calculated for the *Sambucetum nigrae* and the *Luzulo pilosae-Fagetum.* It should be stated clearly that this does not provide proof of an absolute significant share of anthropophytes in the structure of these communities, but is rather connected with the specificity of the calculation of a given parameter. Both associations had a low number of phytosociological relevés and are characterised by a low species diversity. Those elements, which are connected with the constant presence of one or two species of anthropophytes in the relevés, gives high values of a systematic group despite their relatively small role, which can be explained by the low mean value of the number and cover of anthropophytes in a relevé.

The phytosociological data that were collected during the field research were additionally analysed in terms of the share of anthropophytes in the three categories that were distinguished:

1. Thicket communities (“bushes”).

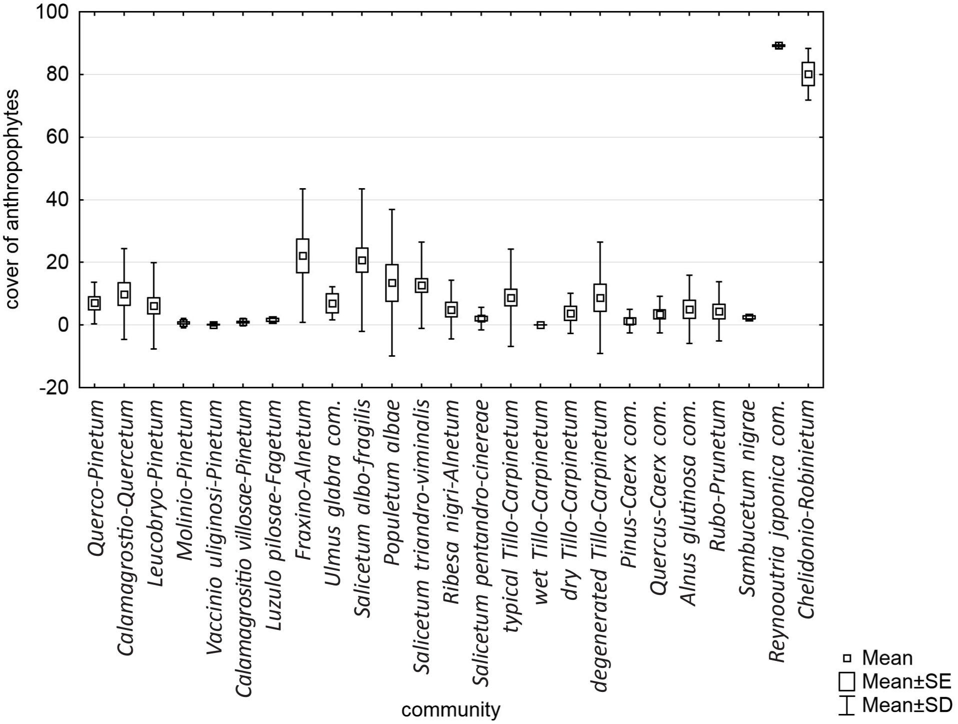

Fig. 13. Mean cover of anthropophytes in the plant communities that were recorded in the area of the Upper Vistula River

2. Forest communities that form environmental islands and that are surrounded by a different type of landscape covering an area that does not exceed 150 hectares (“forest islands”).
3. Forest communities that are a part of forest complexes or that form environmental islands covering an area that exceeds 150 hectares (“forest complexes”).

The aim of the analysis was to assess the naturalness as well as the susceptibility to the transformation of these types of vegetation landscape, without taking into account the syntaxonomical diversity of the plant communities that were formed.

The basic statistics that were calculated for the data on the participation of anthropophytes (the number of recorded species and their total cover in a phytosociological relevé) in the categories that were distinguished are presented in Table 21. The lowest value, which in the case of both of the coefficients that were studied was reached by the group that includes forest complexes and the highest, which was recorded in thicket communities. The Kruskal–Wallis non-parametric analysis of variance (ANOVA) and post-hoc multiple comparison test indicated significant difference between the number of anthropophytes that occurred in complexes and forest islands and the number of anthrophytes that were recorded in the thicket communities. This difference is clearly visible especially in the case of a pair complexes-thickets – in 75% of the phytosociological relevés of the first group only no or one species of anthropophytes were found and in 75% of the second group one or more species were found, respectively. Similar results were obtained in the case of the cover of anthropophytes; however, in this case the difference was statistically significant for all of the comparable pairs. A graphic illustration of the results is presented in Figs. 14 and 15. It should be emphasised that such results are determined by the significant influence of the two communities that are dominated by anthropophytes, which were grouped in the thicket category such as *Reynoutria japonica* com. and *Chelidonio-Robinietum.* When the anthropophytes were excluded from the analyses, statistically significant differences were only found between the complexes and thickets (for the number) and between the complexes and islands and thickets (for the cover). Moreover, the highest value of the cover of anthropophytes was no longer associated with the thickets but with the forest islands. Regardless of the conditions that were described, it is clear that taking into account the presence of alien species, forests complexes should be considered to be the least synanthropic category.

Tab. 21. The basic statistics related to the number and cover of anthropophytes in the landscape categories that were distinguished

Category	N	Mean	Median	Minimum	Maximum	Standard deviation
Forest complexes (number)	134	0.83	1.00	0.0	4.00	0.91
Forest islands (number)	179	1.22	1.00	0.0	6.00	1.26
Thickets (number)	101	1.97	1.00	0.0	7.00	1.76
Forest complexes (cover)	134	4.18	1.00	0.0	48.70	8.53
Forest islands (cover)	179	10.62	2.00	0.0	90.00	18.41
Thickets (cover)	101	20.88	4.00	0.0	90.90	31.61

Because the group that comprises environmental forest islands is quite heterogeneous (it contains objects with areas that ranged from 0.5 to 150.0 ha), we decided to determine whether it was possible to separate the subgroups within it (0.5–5.0 ha, 5.5–25.0 ha, 25.5–50.0 ha, 50.5–150.0 ha) that are characterised by a similar or different participation of anthropophytes (Tab. 22). The results that were obtained, after rerunning the previously mentioned tests, showed the presence of a statistically significant difference between the medians of the first (0.5–5.0 ha) and the last group (50.5–150.0 ha) in both of the cases that were analysed (the number and the cover of anthropophytes). This demonstrates the stronger synanthropisation of small patches relative to the forest islands that cover the largest area. The latter, moreover, are also characterised by the lowest

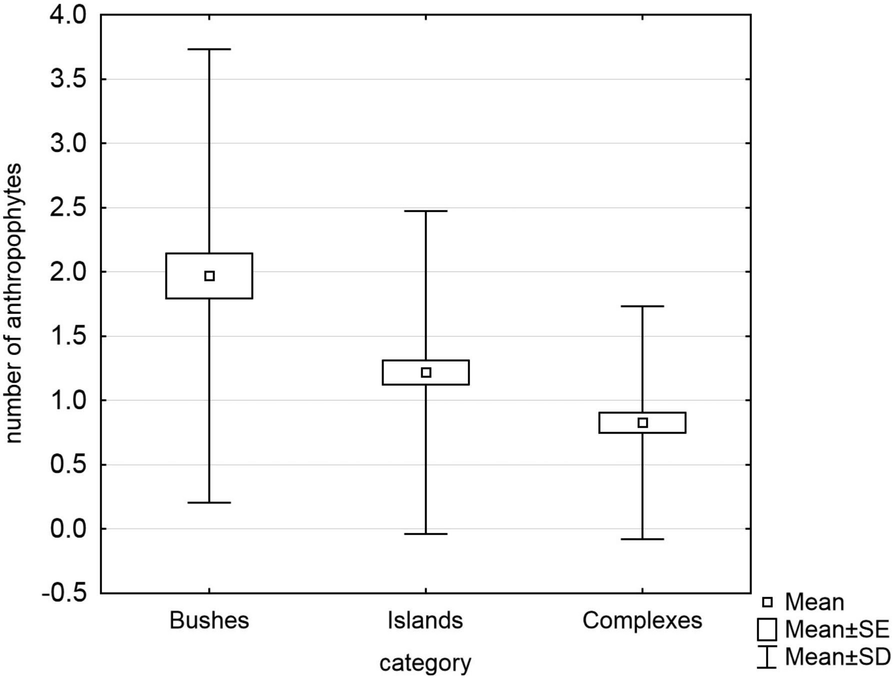

Fig. 14. Mean number of anthropophytes in the landscape categories that were distinguished

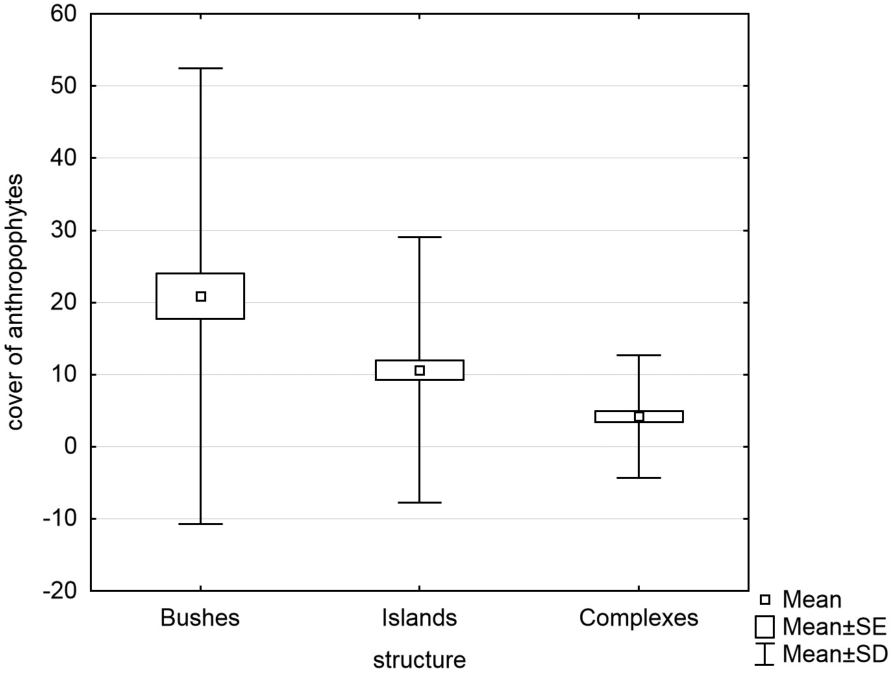

Fig. 15. Mean cover of anthropophytes in the landscapes categories that were distinguished

values of the average number and cover of anthropophytes of all four categories. They relate much more to the forest complexes than the islands in which they were classified according to the parameters discussed here. It is worth noting that the assessment of the relationship between the number and cover of anthropophytes for the entire data set, which was estimated using the Spearman's rank correlation coefficient, revealed a correlation between these parameters at the level of $R_S = 0.91$. Similar results were obtained using Pearson's linear correlation coefficient – $r = 0.56$ and $r^2 = 0.31$. Such a linear correlation is considered to be a high correlation, although the not very high coefficient of determination indicates that only part of the variation in one trait is explained by one regression relative to the other (Stanisz 2005, 2006). The analyses that were performed within individual groups (complexes-islands-bushes and islands that were divided into the size categories) showed a similar, but in some cases an even greater, relationship between the coefficients – $R_S = 0.81–0.95$, $r = 0.45–0.66$ and $r^2 = 0.20–0.43$.

Tab. 22. Basic statistics related to the number and cover of anthropophytes in forest islands that have different surface areas

Subgroups	N	Mean	Median	Minimum	Maximum	Standard deviation
I. 0.5-5 ha (number)	39	1.64	2.00	0.0	5.00	1.14
II. 5.5-25 ha (number)	50	1.10	0.50	0.0	5.00	1.36
III. 25.5-50 ha (number)	39	1.49	1.00	0.0	6.00	1.50
IV. 50.5-150 ha (number)	51	0.80	1.00	0.0	3.00	0.85
I. 0.5-5 ha (cover)	39	12.29	4.00	0.0	73.80	17.97
II. 5.5-25 ha (cover)	50	13.57	1.00	0.0	90.00	24.42
III. 25.5-50 ha (cover)	39	13.60	3.00	0.0	72.20	18.67
IV. 50.5-150 ha (cover)	51	4.16	1.00	0.0	38.00	7.15

6.5. The share of old woodland species in the different landscape categories of the vegetation that was studied

Assumptions were made on the multi-year persistence of the forests that occur on their historical locations in the Upper Vistula Valley based on archival cartographic materials. In order to confirm this hypothesis, the total cover and number of species that represent a group of old deciduous woodland species (Dzwonko, Loster 2001; Dzwonko 2007), which were recorded in the phytosociological relevés that had been divided into the previously mentioned landscape categories of vegetation, were compared. The analysis described herein was performed only for the communities whose affiliation to the *Querco-Fagetea* class did not raise any doubts. These phytocoenoses were classified into the *Tilio-Carpinetum* (including a group of degenerated oak-hornbeam forests), *Fraxino-Alnetum*, *Luzulo pilosae-Fagetum* and *Ulmus-glabra* communities. The data set that was analysed comprises 101 phytosociological relevés in total (of which 76 are oak-hornbeam forests), among which only the W3 group (forest islands of 25.5–50.0 ha) has a very low representation of data (only four cases).

The Kruskal–Wallis one-way analysis of variance by rank showed no statistically significant differences between the groups due to the number of old woodlands species – the mean ranged from 7 to 8.25 (Fig. 16). This value must be considered quite high. The cover of these species showed a statistically significant difference for a pair forests complexes – a forest island in an occupied area 50.5–150.0 ha (with a value that was about 20% higher in the second group). However, this parameter is not as important as the number of taxa. The significant cover that was recorded indicates favourable conditions that enable the strong development of one or more species of old deciduous forests. The large species diversity, in turn, gives evidence of the stability of

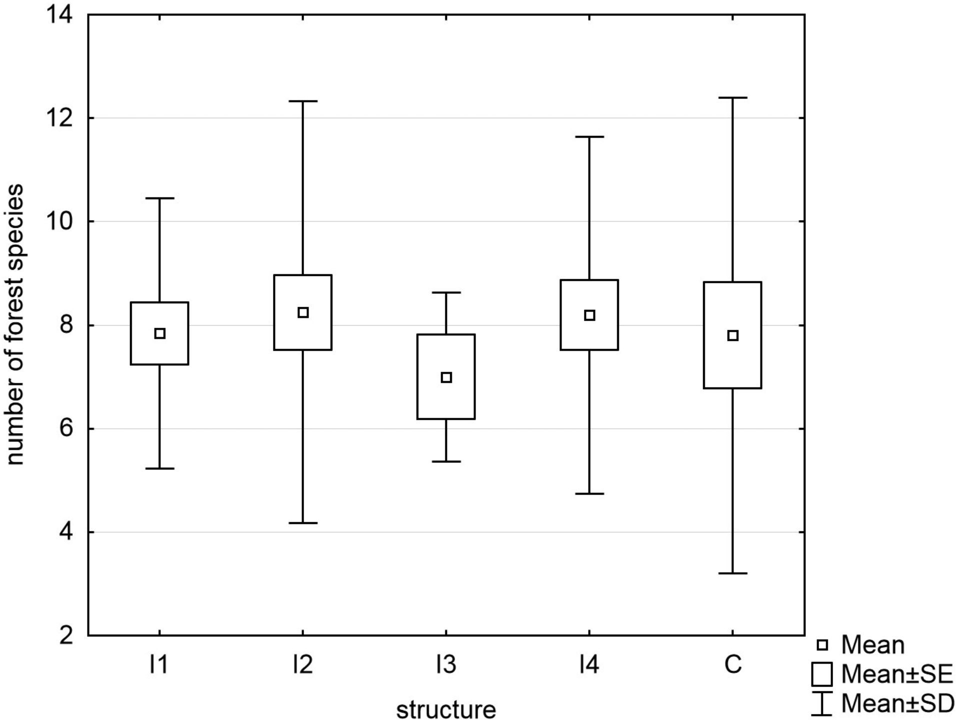

Fig. 16. Mean number of species of old deciduous forests in the particular landscape categories of forest vegetation of the *Querco-Fagetea* class

a forest community in the area that was studied and allows it to be included into a group of old woodlands. While such forests can be considered in the patches that were studied, it should be noted that a significant linear correlation ($R_S = 0.73$; $r = 0.72$, $r^2 = 0.52$) was noted regardless of the interpretation of the two coefficients. Unfortunately, in many cases, an evaluation of existing forest islands using the described method could not be performed. Numerous objects did not contain deciduous forest communities or could not be classified unambiguously.

7. Discussion

The first issue that was found after analysing the test results, is the higher number of forest and scrub communities distinguished during research in contrast to results obtained from the map of potential natural vegetation of Poland, is worth discussing (Matuszkiewicz W. et al. 1995). The dominant communities in the Upper Vistula Valley included: a lowland ash-elm floodplain forest *Ficario-Ulmetum*, a subcontinental submontane lime-oak-hornbeam forest *Tilio-Carpinetum* and a lowland alder and ash-alder forest *Fraxino-Alnetum*. Only two fragments of the area were marked as a potential place for the occurrence of pine associations – a submontane moist spruce-pine forest *Calamagrostio villosae-Pinetum* south of Goczałkowickie Lake and dry, fresh, wet and mixed pine forests (*Cladonio-Pinetum*, *Leucobryo-Pinetum*, *Molinio-Pinetum* and *Querco roboris-Pinetum*) east of Gromiec in the northern part of the region (Fig. 6). However, the actual vegetation differs significantly from the theoretical model. These differences apply not only to the areas in which the vegetation has been completely transformed, thereby losing its forest character, but also to small areas that are characterised by different habitat conditions on the local scale. These phenomena were not, in fact, the object of the study or are the most typical and thus do not require any further explanation. However, the differences in the spread of pine forest communities and the presence of communities with degenerated structure, the classification of which is sometimes impossible, as well as the plant communities that are formed by anthropophytes is worth noting. The presence of these anthropogenic systems is the first clear evidence of the significant progress of the synanthropisation process, which includes the forest and scrub vegetation of the Upper Vistula Valley.

Other elements that indicate anthropopressure are the coefficients that were analysed in the previous chapter, namely, the ratio of euphytes to allophytes and the share of anthropophytes as well as the forms of anthropopressure that were discussed earlier. It is worth noting that the most complete image of the conservation status of these communities can only be seen after considering all of the these elements. Each element is a slightly different aspect of the response of phytocoenoses to anthropressure, which in specific cases when other factors are neglected, may give inaccurate or even erroneous results. The ratio of the number of euphytes to allophytes is substantially quite strongly linearly correlated with the corresponding parameter using the cover of these groups (this correlation was found in individual communities as well as in the entire data set). In particular cases, these parameters may, however, fail or may even give the opposite results. The E/A number often shows no negative changes in species in the case of the impoverishment of a patch. The E/A cover becomes a completely worthless indicator, when a species that is classified as an euphyte, spreads widely in a patch (considered as a degeneration). An example is the fruticetisation process caused by bird cherry *Padus avium* in lowland alder and ash-alder forest *Fraxino-Alnetum.* Moreover, the participation of anthropophytes cannot be regarded as a universal diagnostic parameter of anthropressure. It usually indicates disturbances in a patch that enable or facilitate encroachment and expansion of anthropophytes into natural systems. In the Upper Vistula Valley, the patches that had been transformed by humans were observed very frequently. The share of anthropophytes within them was extremely low, but their degeneration was caused by the abundant occurrence of *Carex brizoides* in the undergrowth, which had an influence on the impoverishment of species composition (*Pinus sylvestris-Carex brizoides* com.*, Quercus robur-Carex brizoides* com.). Thus, only consideration of all of the elements can give a reliable assessment of the conservation status of communities.

The serious methodological problems that are encountered when using the system of degeneration phases (Olaczek 1972, 1974a), which uses the division of all species in a phytosociological relevé into euphytes and allophytes, also requires some discussion. Crucial for the results are not only arbitrary boundaries separating the various phases of degeneration (therefore deliberately give them up) but even the division of species in the two previously mentioned groups. The guidelines for such a classification of the groups of species have been clearly established by the author of the system. In the first approach (Olaczek 1972), euphytes are defined as "plants appropriate for the natural form of the association, usually character species of the class sometimes two classes (e.g., alluvial forests of the *Querco-Fagetea* and *Artemisietea*)" and "species with higher trophic demands were regarded as a primary component, typical of natural phytocoenoses." In another publication (Olaczek 1974a), "all character species of a class and differentials of subassociation, variants and geographical varieties and accompanying constant species" were added to euphytes. This definition is very similar to the concept of the characteristic combination of the species of a plant association. Roo-Zielinska (2004) refers to it, similar to Olaczek (1974a), as the ability to assess the degree and direction of the deformation of a patch of vegetation from a defined syntaxonomical pattern that is based on the character species of other syntaxons and accidental species with ecological preferences that deviate from a given type of a community. The problem with the first definition of euphytes is connected with the phytosociological characteristics of some syntaxa or their complex structure and heterogeneity of habitats, which are not quite clear or distinct. Character species of different classes constitute the typical species composition of these patches. A perfect example, the *Ribeso nigri-Alnetum* association that was observed in the study area, in which in addition to the character species of the *Alnetea glutinosae* class, naturally occurring species of the *Phragmitetea*, *Molinio-Arrhenatheretea*, *Scheuchzerio-Caricetea nigrae* and *Querco-Fagetea* classes (particularly of the *Alno-Ulmion* alliance) or even of *Vaccinio-Piceetea* class had also penetrated (Matuszkiewicz J.W. 2002; Matuszkiewicz W. 2002). Identifying all of them as allophytes would result in a lower assessment of natural, well-developed patches; however, including them into the group of euphytes – according to a later proposal – would make it impossible to diagnose the most common forms of degeneration processes or any forms that deviated from the syntaxonomial standard, such as patches that are dominated by rush species as a result of constantly high water levels or patches that had been converted into riparian ash-alder forest, which is connected with the horizontal movement of the water. Other "critical" units that would be affected by the separation of euphytes from allophytes also include: a continental mesotrophic oak-pine mixed forest *Querco roboris-Pinetum*, a middle-European lowland acidophilus oak forest *Calamagrostio arundinaceae-Quercetum petraeae* (for which Olaczek (1972) did not make any separation) or blackthorn thickets *Rubo fruticosi-Prunetum spinosae.* Another problem of system of degeneration phases that is equally as important is the matter of the whole group of woodland species. These plants, because they are a constant component of many plant communities, can be classified as allophytes according to first approach (unless we treat them as "species with higher trophic demands," which in the case of some of them would be untrue) or as euphytes according to the second approach. However, one must be aware of their very narrow ecological tolerance and thus their increased sensitivity to some changes in the phytocoenosis. Considering them to be allophytes would mean that many components that are typical of a given community would be treated as alien, thereby lowering the evaluation of relatively natural systems, while increasing the sensitivity of the E/A coefficient for various disturbances. Alternatively, to classify them as euphytes reduces the usefulness of this parameter (including its sensitivity), for which a higher value will be determined by species that are moderately sensitive and quite common, which do not react to some forms of degeneration at all.

The last problem that emerged during the analysis of the system of degeneration phases and the attempt to apply it to the data that was collected was the presence of units with a phytosociological affiliation that was difficult to determine or communities with a doubtful phytosociological diagnosis. In their case (especially with no historical data regarding the type of communities that had originally covered an area), an accurate division of species into euphytes and allophytes that was based on the known syntaxonomical pattern meets with significant difficulties or even does not make sense at all. In the event of an incorrect diagnosis of a patch (this can happen especially when considering the degeneration within a group of communities – dry oak-hornbeam forests, acidophilus oak forests, mixed forests), we can evaluate the preservation of the unit, which is just an anthropogenic form of the degeneration of other community. In the case of phytocoenoses that have an unknown phytosociological affiliation, separating the typical species from foreign species is basically impossible. This was the reason for the exclusion of some communities from the analyses.

Analysis of the results that were obtained, together with the observations that were made in the field, clearly indicate a high degree of the transformation of the majority of forest communities as well as of some scrub communities that is occurring in the Upper Vistula Valley. The causes of the synanthropisation of phytocoenoses that were studied do not differ significantly from those that have been observed in other parts of the Poland. Forestry, due to the strength of its interaction and spread, is considered to be the most important transforming factor. According to Łaska (2006), the most common form of forest management is the clear-cutting. In accordance with the rules of silviculture (Rozwałka 2003), there are presently distinguished two types of clear-cutting: complete and complex ones. The latter group of clear-cutting may be divided into: group felling, shelterwood felling, partial harvesting, nest harvesting, progressive harvesting, selective felling, and 13 of their forms. It should be emphasised that such a continuous use of forest stands, especially when using complete clear-cutting, causes major changes of not only the biotic elements, but also of the abiotic environment. Eliminating tree layers that create the habitat conditions of forest communities will change the light, thermal, moisture and, in addition to the climate, will also trigger changes in the soil (its chemical composition, structure, and soil forming processes) as well as the cycling of organic matter (Biały 1997; Puchalski 2000; Łaska 2006). All of this, therefore, results in habitat transformation, which can be described as degradation. In the first stage, the reaction of the vegetation involves drastic changes in the participation and role of synecological groups of species, which then results in the formation of clearings. Over a longer period of time, especially in the case of restockings that are inconsistent with the habitat, more or less permanent forms of degeneration of forest communities occur, that are characterised by the reduction in species composition and the simplification of their structure. These disturbances facilitate the penetration of invasive and expansive species. It should be noted, however, that the final form of substitute communities is highly dependent on degeneration factor – its strength, intensity, duration and the resistance of the same phytocenose. These briefly described effects of forest management, along with the mechanisms that underlie the processes that cause them, are fully understood today (i.a., Sokołowski 1972; Olaczek 1974b; Markowski 1974; Berdowski, Kwiatkowski 1992; Medwecka-Kornaś 1994; Bobiec 1996, 1998; Łaska 1996, 1997, 2006; Pawlaczyk 1997; Stachurska 1998).

Unfortunately, forest management continues to contribute to the degeneration of forest phytocoenoses and to the emergence of substitute communities, as is evidenced by the vegetation of the Upper Vistula Valley. The negative impact of forestry, despite the changes in the rules of silviculture and the reconstruction of pine stands, on systems that are adapted to the habitat in terms of species composition, is not likely to change in the near future. As was already noted by ŁASKA (2006), many habitats have been incorrectly identified (based on the stand) and will continue to be subject to the pressures of forest management. Changes in water conditions are also an issue with the economic use of forests. All types of drainage, which is common in the area of the mesoregion that was studied, also contribute to the strong transformation of forest communities and the progressive processes of degeneration (KUROWSKI 1993, 2007; CZERWIŃSKI 1995). Changes in the water conditions may, however, be caused not only by drainage treatments, but also by works that are carried out within the "traditional" flood protection systems that are based on the hydrotechnical constructions of banks or the construction of flood embankments, which result in a gradual reduction of the area that can be occupied by forests and riparian thickets and thus their gradual fragmentation and degeneration takes place. In addition to the most important factors of synanthropisation, determining the status of forest and scrub communities in the Upper Vistula Valley, the factors of lesser importance, or factors that play a significant role, but only locally, that is tourism and recreation, and the trampling as well as the creation of "wild" landfills accompanying them, should also be taken into account.

The last topic to discuss are the results of the analysis of the participation of anthropophytes in the three landscape categories. It proves the smallest degree of synanthropisation of forest complexes and, the largest islands of forest in comparison to all distinguished groups. These conclusions, however, are merely a simplification of the reality that was observed. Although there was actually a smaller share of anthropophytes in the phytocoenoses among the above groups, they are characterised by quite a considerable degree of transformation. Another issue is the character and at the same time a manifestation of these transformations. The complexes that form forests and forest islands (not only the ones belonging to the largest surface area category) are subject to very strong pressure or forest management, which cause different forms of degeneration such as pinetisation, monotypisation, and above all, cespitisation. The last enumerated form of degeneration, which includes a massive presence of *Carex brizoides* sedge, constrains the growth and development of other plants, possibly including some anthropophytes. In addition, there should be no doubt that the treatment of forest complexes as "compact, continuous systems" and placing them in opposition to forest islands that are "exposed to synanthropisation in the border zone" is a model, which in the case of economic forests, is completely erroneous. In fact, the forest complexes that were examined within the Upper Vistula Valley are a mosaic of the different stages of forest development, clearings and thickets, which were cut in order to create a network of roads and paths. All these factors increase the susceptibility of the phytocoenoses of complexes to some type of degeneration, including neophytisation. It may, therefore, not be the "landscape category" that has the greatest significance when comparing the conservation status of forest complexes and islands, but rather the form of use or the variety of temporary and local conditions. The unequal resistance of different communities to penetration by alien species also has an impact on results. In the area that was studied, pine communities primarily occur in forest complexes and oak-hornbeam forests while lowland willow-poplar floodplain forests are found almost exclusively in the form of patches that are treated as forest islands. It turns out that the results that were obtained are affected by many factors and therefore cannot directly determine the diversity of forest complexes and islands. The lack of statistically significant differences between the islands in different size categories (except those shown for the largest and smallest objects), can be explained by the significant influence of other factors, which have been indicated in the literature as the factors that determine the resistance of forest islands to the synanthropisation process, which includes their shape, origin, the time that has elapsed since the division of a large forest complex, the degree of isolation from other similar environments, the type and intensity of human economic activity, the type of plant community that surrounds the island, the presence of shrubs at the edge of forests and even the location of an island in relation to the cardinal direction (Dzwonko, Loster 1988a, 1988b; Wójcik, Wasiłowska 1994; Ratyńska, Szwed 1998; Wasiłowska 1998; Ratyńska 2003; Petit et al. 2004). The state of the preservation of plant communities cannot be identified by the participation of anthropophytes and the degree of synanthropisation cannot be a simple function of the size of an object.

In addition to the degree of the naturalness of the individual islands of the forest and woodlots that are found in the Upper Vistula Valley, one should definitely highlight the important and varied role that they play in the environment, especially ones that have been transformed as strongly as in the mesoregion that was studied. Forest islands are important elements of the landscape. They have an impact on the increased heterogeneity of the land, they increase the diversity of flora and fauna, they have a favourable impact on the local climate, they affect the cycle of water and the elements and they also become refuge for many plant communities (Ratyńska 2003). The proof of this is the distribution of subcontinental oak-hornbeam forests and riverine riparian willow and poplar forests in the study area, which is limited almost exclusively to the smaller or larger enclaves, which have not been transformed as a result of forest management. Thus, the protection of environmental islands, especially forest ones, is a crucial issue for the conservation of the biodiversity of the Upper Vistula Valley.

8. Summary of results and conclusions

The conclusions of our study are the following:

1. The phytosociological research that was conducted in the Upper Vistula Valley permitted 12 plant associations, 3 forest communities and 1 thicket community to be identified. In total they represent 8 classes, 9 orders and 10 alliances. It was impossible to determine the syntaxonomical affiliation of three forest communities.

2. The actual vegetation of the study area deviates significantly from its potential natural vegetation. The greater diversity that was found within the forest phytocoenoses, including the presence of communities with a syntaxonomical affiliation that was difficult to determine and communities that had been created by anthropophytes, is a proof that the vegetation underwent anthropogenic transformation.

3. In the case of a significant part of the units that were identified, the analysis of the floristic composition of the communities showed their impoverishment in species richness compared to the corresponding syntaxa that have been reported from other areas of Poland. This phenomenon is manifested primarily by a lack of the character species of plant associations and higher phytosociological units.

4. The forest communities underwent all of the degeneration forms that were distinguished by Olaczek (1972, 1974a). Among them, cespitisation and pinetisation are the greatest threat to the preservation of the plant associations in the Upper Vistula Valley.

5. *Carex brizoides* is the most important species that causes the cespitisation of plant communities. The widespread and abundant occurrence of this species is the cause of transformations of phytocoenoses that prevent their syntaxonomical classification (*Pinus sylvestris-Carex brizoides* com.*, Quercus robur-Carex brizoides* com., partly *Alnus glutinosa* com).

6. Significant methodological problems associated with the use of system of degeneration phases proposed by Olaczek (1972, 1974a) were noticed during the data analysis. This system has been modified and the results that were obtained enabled the state of the preservation of patches within individual plant communities and groups of similar plant communities to be determined.

7. The anthropophytes play the most important role in xenospontaneous communities. Among the natural phytocoenoses, alien species have the highest

participation in riparian communities such as *Salicetum albo-fragilis*, *Populetum albae*, *Salicetum triandro-viminalis* and *Fraxino-Alnetum*. This is due to the substantial fragmentation, the impact of increased human pressure and natural disturbances, which facilitate the penetration of anthropophytes.

8. Taking into account the landscape diversity of the vegetation into forest complexes, forest islands and bushes, the smallest share of anthropophytes was found in the patches that formed complexes. The results obtained for the different size categories of forest islands proved stronger similarities of the enclaves with the largest area (50.5–150.0 ha) to complexes than to other forest islands. The explanation of such results has more complex character.

9. The analysis of the share of species of old deciduous forests in the communities of the *Querco-Fagetea* class showed no significant differences between the phytocoenoses of the complexes and the forest islands that represented the different size categories. The average number of species of this group in the studied patch was about 8, which, together with the conclusions that were drawn from the cartographic analyses, proved the persistence of the forests that were studied in the occupied areas, which allows them to be identified as old forests.

10. The economic use of forests and treatments that cause a change in water relations (associated either with forest or water management) are the main factors that are causing the transformation of the forest and scrub vegetation of the Upper Vistula Valley.

11. Forest islands of various sizes fulfil very important functions in the landscape that was strongly transformed by humans. Some communities, which primarily occurred in the area of the Upper Vistula Valley, have been largely limited to the area of forest islands (e.g., the subcontinental submontane lime-oak-hornbeam forest *Tilio-Carpinetum*) or very narrow belt system (e.g., the lowland willow-poplar floodplain forests *Salicetum albo-fragilis* and *Populetum albae*). Protection of the remaining forest enclaves is, therefore, a particularly important issue.

12. The existing forms of nature protection, due to the degree of synanthropisation affecting the vegetation of the studied mesoregion, are insufficient in case of the forest communities and do not shield them from the potential loss of their most natural values.

13. It is advisable that new protected areas should be established, in which environmental monitoring should be conducted which will be aimed at identifying current threats, improving the natural environment and preventing any further synanthropisation of the vegetation.

References

Alexandrowicz S. 1984. Najstarsza mapa szczegółowa ziem polskich Stanisława Porębskiego – mapa Księstwa Oświęcimskiego i Zatorskiego z 1563 roku. Wątpliwości w sprawie genezy i autorstwa. In: Mente el litteris: o kulturze i społeczeństwie wieków średnich. Eds. H. Chłopocka et al. Poznań, UAM: 357–372.

Anioł-Kwiatkowska J., Dajdok Z., Kącki Z. 1998. Walory przyrodnicze projektowanego parku krajobrazowego „Dolina Odry II." Acta Univ. Wrat., Prace Botaniczne 74: 201–233.

Anioł-Kwiatkowska J., Dajdok Z. 1993. Roślinność wschodniego krańca Równiny Oleśnickiej. Cz. I. Zbiorowiska naturalne, półnaturalne i antropogeniczne. Acta Univ. Wrat., Prace Botaniczne 55: 5–100.

Arnold S. 1951. Geografia historyczna Polski. Warszawa, PWN, 112 pp.

Balcerkiewicz S. 1991. Wybrane problemy ochrony rezerwatowej na tle degeneracji fitocenoz leśnych w Wielkopolskim Parku Narodowym. Prądnik. Prace Muz. Szafera 4: 113–123.

Balcerkiewicz S. 2001. Degeneracja fitocenoz leśnych w Wielkopolskim Parku Narodowym – wybrane zagadnienia. In: Szata roślinna Wielkopolski i Pojezierza południowopomorskiego: przewodnik sesji terenowych 52. Zjazdu Polskiego Towarzystwa Botanicznego, 24–28 września 2001. Ed. M. Wojterska. Poznań: 261–264.

Barkman J. J., Moravec J., Rauschert S. 1995. Kodeks Nomenklatury Fitosocjologicznej. Polish Bot. Stud. Guidebook Ser. 16: 3–58.

Berdowski W., Kwiatkowski P. 1992. Roślinność rezerwatów „Dalkowskie Jary" i „Uroczysko Obiszów" w zachodniej części Wału Trzebnickiego. Acta Univ. Wrat., Prace Botaniczne 48: 151–202.

Bernadzki E., Zajączkowski J. 1995. Monokultury iglaste w Polsce – stan i tendencje. Sylwan 139(10): 5–12.

Betleja J., Fajer M., Ruman M., Rzętała M., Waga J., Wilczek Z., Chylarecki P., Gwiazda R., Profus P., Joseph-Tomaszewska E. 2006. Waloryzacja przyrodnicza obszaru Natura 2000 „Dolina Górnej Wisły." Bytom–Katowice, OTOP, 277 pp.

Betleja J., Waga J. M., Wilczek Z., Fajer M., Rzętała M. 2013. The "Upper Vistula Valley" NATURA 2000 Area – a key element of the most important ecological corridor in central Europe. 13th SGEM GeoConference on Ecology, Economics, Education and Legislation, www.sgem.org, SGEM2013 Conference Proceedings, 1: 1085–1092.

Biały K. 1997. Problem zniekształcenia i degradacji gleb na przykładzie ekosystemów leśnych w Drawieńskim Parku Narodowym. In: Gleby i roślinność ekosystemów leśnych w Drawieńskim Parku Narodowym. Ed. P. Pawlaczyk. Idee Ekologiczne 11(5): 25–42.

Bilnik A., Świercz T., Siudy A. 2004. Zbiornik Goczałkowicki wczoraj i dziś. Górnośląskie Przedsiębiorstwo Wodociągów w Katowicach, Goczałkowice, 19 pp.

Bobiec A. 1996. Gospodarka leśna jako źródło zagrożenia naturalnych zbiorowisk Puszczy Białowieskiej. I. Bór trzcinnikowo-świerkowy *Calamagrostio arundinaceae-Piceetum*. Chrońmy Przyrodę Ojczystą 52(6): 58–65.

Bobiec A. 1998. Gospodarka leśna jako źródło zagrożenia naturalnych zbiorowisk Puszczy Białowieskiej. II. Grądy *Tilio-Carpinetum*. Chrońmy Przyrodę Ojczystą 54(6): 18–31.

Braun-Blanquet J. 1964. Pflanzensoziologie, Grundzuge der Vegetationskunde. 3 Aufl. (Phytosociology, the basis of vegetation science, Vol. 3). Wien–New York, Springer Verl., 865 pp.

Brzeg A., Krotoska T. 1984. Zbiorowisko *Pinus-Geranium robertianum* – forma zniekształcenia grądu. Bad. Fizjogr. Pol. Zach. Ser. B. 35: 53–66.

Brzeg A., Wojterska M. 2001. Zespoły roślinne Wielkopolski, ich stan i zagrożenie. In: Szata roślinna Wielkopolski i Pojezierza południowopomorskiego: przewodnik sesji terenowych 52. Zjazdu Polskiego Towarzystwa Botanicznego, 24–28 września 2001. Ed. M. Wojterska. Poznań: 39–110.

Buczek K. 1960. Ziemie polskie przed tysiącem lat: zarys geograficzno-historyczny. Prace Komisji Nauk Historycznych Nr 5. Wrocław, Kraków, Zakład Narodowy im. Ossolińskich, 99 pp.

Cabała S. 1989b. Rozmieszczenie i zmienność geograficzna boru trzcinnikowego (*Calamagrostio villosae-Pinetum* Staszk., 1958) w Polsce. Acta Biol. Sil. 12(29): 45–59.

Cabała S. 1990. Zróżnicowanie i rozmieszczenie zbiorowisk leśnych na Wyżynie Śląskiej. Prace Naukowe Uniwersytetu Śląskiego w Katowicach nr 1068, 144 pp.

Cabała S. 1992. Stan synantropizacji boru trzcinnikowego (*Calamagrostio villosae-Pinetum* Staszk., 1958) w Polsce. Acta Biologica Silesiana 21(38): 30–38.

Celiński F., Sendek A., Wika S. 1978. Zbiorowiska leśne bogatszych siedlisk Katowickiego Okręgu Przemysłowego. UŚ, Acta Biol. 5: 123–168.

Chełmicki W. 1991. Położenie, podział i cechy dorzecza. In: Dorzecze górnej Wisły. Część I. Eds. I. Dynowska, M. Maciejewski. Warszawa–Kraków, PWN: 15–29.

Chmura D., Sierka E. 2007. The invasibility of deciduous forest communities after disturbance: A case study of *Carex brizoides* and *Impatiens parviflora* invasion. Forest Ecology and Management 242: 487–495.

Czerwiński A. (ed.) 1988. Zmiany antropogeniczne wybranych ekosystemów Puszczy Knyszyńskiej. Białystok, Wyd. Polit. Białost., 367 pp.

Czerwiński A. 1995. Geobotanika w ochronie środowiska lasów Podlasia i Mazur. Białystok, Wyd. Politechn. Białost., 345 pp.

Czylok A., Szczypek T., Wika S. 1997. Zasoby przyrody żywej w dolinie Wisły między Mętkowem a Rozkochowem (Kotlina Oświęcimska) jako tło dla eksploatacji kruszywa. Sosnowiec–Dąbrowa Górnicza, Zarząd Zespołu Jurajskich Parków Krajobrazowych Woj. Katowickiego i UŚ WNoZ, 67 pp.

Dajdok Z., Anioł-Kwiatkowska J., Kącki Z. 2003. Distribution of *Impatiens glandulifera* Royle along Odra river. In: Phytogeographical Problems of Synanthropic Plants, Instit. of Botany Jagiellonian University. Eds. A. Zając, M. Zając, B. Zemanek. Cracow: 131–136.

Danielewicz W. 1991a. Tendencje dynamiczne gatunków drzew w zniekształconych fitocenozach grądu na terenie Wielkopolskiego Parku Narodowego. PTPN, Prace Kom. Nauk Roln. Leśn. 72: 13–18.

Danielewicz W. 1991b. Znaczenie badań nad dynamiką populacji drzew w kształtowaniu biocenoz uwolnionych spod presji gospodarki lesnej w Wielkopolskim Parku Narodowym. Prądnik. Prace Muz. Szafera 4: 201–204.

Danielewicz W., Pawlaczyk P. 2004. Grąd środkowoeuropejski i subkontynentalny (*Galio-Carpinetum, Tilio-Carinetum*). In: Poradniki ochrony siedlisk i gatunków Natura 2000 – podręcznik metodyczny. Lasy i bory. T. 5. Ed. J. Herbich. Warszawa, Ministerstwo Środowiska, pp. 113–137.

Dobija A. 1983. Stosunki wodne województwa bielskiego. Folia Geog., Seria Geog.-Phys. 15: 49–66.

Dobrowolska M. 1961. Przemiany środowiska geograficznego Polski do XV w. Warszawa, PWN, 172 pp.

Dubiel E., Stachurska A., Gawroński S. 1999. Nieleśne zbiorowiska roślinne Magurskiego Parku Narodowego (Beskid Niski). Prace Bot. 33: 1–60.

Dzwonko Z. 1986. Klasyfikacja numeryczna zbiorowisk leśnych polskich Karpat. Fragm. Flor. Geobot. 30(2): 93–167.

Dzwonko Z. 2007. Przewodnik do badań fitosocjologicznych. Vademecum Geobotanicum. Poznań–Kraków, Sorus, 304 pp.

Dzwonko Z., Loster S. 1988a. Species richness of small woodlands on the western Carpathian foothills. Vegetatio 76: 15–27.

Dzwonko Z., Loster S. 1988b. The number and distribution of vascular plant species in island forest communities in the northern part of West Carpathian foothills. Folia Geobot. Phytotax. 23: 1–16.

Dzwonko Z., Loster S. 2001. Wskaźnikowe gatunki roślin starych lasów i ich znaczenie dla ochrony przyrody i kartografii roślinności. IGiPZ PAN, Prace Geograficzne 178: 120–132.

Faliński J. B. 1966a. Antropogeniczna roślinność Puszczy Białowieskiej jako wynik synantropizacji naturalnego kompleksu leśnego. Rozprawy Uniwersytetu Warszawskiego 13: 1–256.

Faliński J. B. 1966b. Próba określenia zniekształceń fitocenozy. System faz degeneracyjnych zbiorowisk roślinnych. Ekologia Polska, series B 12(1): 31–42.

Faliński J. B. 1966c. Degeneracja zbiorowisk roślinnych lasu miejskiego w Iławie. Materiały Zakładu Fitosocjologii Stosowanej UW 13: 1–13.

Faliński J. B. 1972. Synantropizacja szaty roślinnej – próba określenia istoty procesu i głównych kierunków badań. Phytocoenosis 1(3): 157–170.

Faliński J. B. 1975. Anthropogenic changes of the vegetation of Poland. Comment to map. Phytocenosis 4(2): 97–115.

Faliński J. B. 1998. Invasive alien plants, vegetation dynamics ane neophytism. Phytocoenosis 10 (N.S.) Supplementum Cartographiae Geobotanicae 9: 163–187.

Faliński J. B., Hrynkiewicz-Sudnik J., Fabiszewski J. 1963. Śródpolne zarośla z rzędu *Prunetalia* (czyżnie) Równiny Kutnowskiej jako wskaźnik dzisiejszej potencjalnej roślinności naturalnej. Acta Soc. Bot. Pol. 32(4): 693–714.

Fukarek F. 1967. Fitosocjologia. Warszawa, PWRiL, 218 pp.

Galarowski T., Klimek K., 1991. Funkcjonowanie koryt rzecznych w warunkach zagospodarowania. Dorzecze górnej Wisły, cz. I. Eds. I. Synowska, M. Maciejewski. Warszawa–Kraków, PWN: 235–259.

Głowaciński Z. (ed.) 2001. Polska czerwona księga zwierząt. Kręgowce. Warszawa, PWRiL, 452 pp.

Gorczyca J., Herczek A., Rostański A., Tokarska-Guzik B. 1998. Ścieżka przyrodnicza w Dolinie Wisły Czechowice-Dziedzice. Sosnowiec, Progres, 71 pp.

Grzyb M. 1999. Aktualne problemy typologii leśnej. Sylwan 143(11): 79–87.

Harper J. L. 1980. Plant demography and ecological theory. Oikos 35: 244–254.

Hennekens S. M., Schaminée J. H. J. 2001. TURBOVEG, a comprehensive data base management system for vegetation data. J. Veg. Sci. 12: 589–591.

Hennig J. 1991. Drogi wodne. In: Dorzecze górnej Wisły. Część II. Eds. I. Dynowska, M. Maciejewski. Warszawa–Kraków, PWN: 162–178.

Hennig J., Hennig I., Roszkowski A. 1991. Zbiorniki retencyjne. In: Dorzecze górnej Wisły. Część II. Eds. I. Dynowska, M. Maciejewski. Warszawa–Kraków, PWN: 121–143.

Hensel W. 1967. Polska przed tysiącem lat. Zakład Narodowy imienia Ossolińskich Wydawn. Polskiej Akademii Nauk, 287 pp.

Herbich J. (ed.) 2004. Lasy i Bory. Poradniki ochrony siedlisk i gatunków Natura 2000 – podręcznik metodyczny. T. 5. Warszawa, Ministerstwo Środowiska, 344 pp.

Herczek A., Gorczyca J., Rostański A. 1995. Ścieżka dydaktyczna w Goczałkowicach Zdroju. Katowice, Fundacja Ekologiczna “Silesia”, 76 pp.

Hereźniak J. 1993. Stosunki geobotaniczno-leśne północnej części Wyżyny Śląsko-Krakowskiej na tle zróżnicowania i przemian środowiska. Monografie Botaniczne 75: 1–343.

Hill M. O. 1979. TWINSPAN – A FORTRAN program for arranging multivariate data in an ordered two-way table by classification of the individuals and attributes. Ithaca, NY, Cornell University, 90 pp.

Izdebski K. 1962. Grądy na Roztoczu Środkowym. Ekol. Pol. Ser. A. 10(18): 523–584.

Jackowiak B. 1990. Antropogeniczne przemiany flory roślin naczyniowych Poznania. UAM. Seria Biologia: 1–232.

Jakubowska-Gabara J. 1989. Leśne zbiorowiska zastępcze. Wiadomości Botaniczne 33, 1: 9–18.

Jakubowska-Gabara J. 1992. Naturalne i antropogeniczne zróżnicowanie zbiorowisk leśnych południowo-wschodniej części Niziny Południowowielkopolskiej. Cz. I. *Ribo nigri-Alnetum, Circaeo-Alnetum, Tilio-Carpinetum.* Bad. Fizj. Pol. Zach., Seria B, 41: 175–198.

Jakubowska-Gabara J. 1994. Naturalne i antropogeniczne zróżnicowanie zbiorowisk leśnych południowo-wschodniej części Niziny Południowowielkopolskiej. Cz. II. *Potentillo albae-Quercetum, Querco-Pinetum, Leucobryo-Pinetum, Molinio-Pinetum* Bad. Fizj. Pol. Zach., Ser. B, 43: 85–103.

Jalas J. 1955. Hemerobe und hemerochore Pflanzenarten, ein terminologischer Reformversuch. Acta. Soc. Fauna Flora Fenn. 72: 1–15.

Janukowicz H. 2008. Zdegenerowane grądy i łęgi z *Carex brizoides* L. w wybranych zbiorowiskach leśnych Pomorza Zachodniego. Klasyfikacja krajobrazu. Teoria i praktyka. Problemy Ekologii Krajobrazu 20: 251–256.

Joseph-Tomaszewska E. 2006. Waloryzacja obszaru Natura 2000 „Dolina Górnej Wisły" z pozycji zagospodarowania przestrzennego. In: Waloryzacja przyrodnicza obszaru Natura 2000 „Dolina Górnej Wisły." Eds. J. Betleja, M. Fajer, M. Ruman, M. Rzętała, J. Waga, Z. Wilczek, P. Chylarecki, R. Gwiazda, P. Profus, E. Joseph-Tomaszewska. Bytom–Katowice: 194–263.

Kącki Z., Michalska-Hejduk D. 2010. Assessment of Biodiversity in Molinia Meadows in Kampinoski National Park based on Biocenotic Indicators. Polish J. of Environ. Stud. 19(2): 351–362.

Kasprowicz M. 1996. Zróżnicowanie i przekształcenia roślinności pięter reglowych masywu Babiej Góry (Karpaty Zachodnie). Idee Ekologiczne 9(3): 1–214.

Kondracki J. 2001. Geografia regionalna Polski. Warszawa, PWN, 440 pp.

Kostrowicki A.S. 1972. Zagadnienia teoretyczne i metodyczne oceny synantropizacji szaty roślinnej. Phytocoenosis 1(3): 171–191.

Koźbiał K. 2000. Starostwo zatorskie. Zarys dziejów do 1772 roku. Kraków, Wydawnictwo Promocji Powiatu, Miasta i Gminy "Promo", 83 pp.

Krassowski B., Kublin L., Madej J., Szaniawska L. 1977. Polska na starych mapach: katalog wystawy. Warszawa, 74 pp.

Krotoska T. 1991. Grądy i dąbrowy okolic Konina oraz ich formy zniekształcone. In: Zbiorowiska roślin naczyniowych Konińskiego Zagłębia Węglowego i jego obrzeży. Ed. T. Krotoska. PTPN, Prace Kom. Biol. 70: 165–210.

Krotoska T., Ratyńska-Nowak H., Szwed W. 1985. Formy zniekształcenia lasu z udziałem gatunków porębowych w okolicach Konina. Bad. Fizj. Pol. Zach., Seria B, 36: 93–103.

Kucharczyk M., Krawczyk R. 2004. Kenophytes as river corridor plants in the Vistula and the San river valleys. Teka Kom. Ochr. Kszt. Środ. Przyr. 1: 110–115.

Kuczyńska I. 1973. Stosunki geobotaniczne Opolszczyzny. Cz. I. Zbiorowiska leśne. Acta Univ. Wrat., Prace Botaniczne 15: 1–91.

Kurowski J. 1979. Bory i lasy z antropogenicznie wprowadzoną sosną w dorzeczach środkowej Pilicy i Warty. Acta Univ. Lodz., Folia Botanica, Seria II, 29: 1–158.

Kurowski J. 1993. Dynamika fitocenoz leśnych w rejonie kopalni odkrywkowej Bełchatów. Łódź, Wyd. Uniwersytetu Łódzkiego, 173 pp.

Kurowski J. 2004. The problem of the naturalness of pine forests – case study Jaksonek nature reserve on the Pilica river. In: Coniferous forest vegetation – differentiation, dynamics and transformations. Eds. A. Brzeg, M. Wojterska. Wydawnictwo Naukowe UAM, Seria Biologia 69: 171–177.

Kurowski J. 2007. Procesy syndynamiczne w zbiorowiskach leśnych wywołane odwodnieniem siedlisk. Leśne Prace Badawcze 2: 27–44.

Ledwoń M., Śmieja A., Żyła W., Betleja J., Krzanowski Z. 2004. Przyroda kompleksu leśno-stawowego w Brzeszczach-Nazieleńcach. Przewodnik po ścieżce dydaktycznej. Towarzystwo na rzecz Ziemi, Ornitologiczna Grupa Robocza Doliny Górnej Wisły CZAPLON, 50 pp.

Łaska G. 1996. Tendencje dynamiczne roślinności Puszczy Knyszyńskiej – kierunki degeneracji i regeneracji fitocenoz leśnych w świetle badań eksperymentalnych. Przegl. Przyrodn. 7(3–4): 41–51.

Łaska G. 1997. Degenerative forms and phases of secondary hornbeam communities. Ekol. Pol. 45(2): 461–493.

Łaska G. 2004. Transformations of coniferous forest vegetation as a result of forest management. In: Coniferous forest vegetation – differnetiation, dynamics and transformations. Eds. A. Brzeg, M. Wojterska. Wydawnictwo Naukowe UAM, Seria Biologia 69: 293–298.

Łaska G. 2006. Tendencje dynamiczne zbiorowisk zastępczych w Puszczy Knyszyńskiej. Bogucki Wydawnictwo Naukowe, Białystok–Poznań, 503 pp.

Macicka T. 1984. Zbiorowiska leśne południowo-zachodniej części Kotliny Milickiej i Wzgórz Krośnickich. Acta Univ. Wrat., Prace Botaniczne 29: 3–57.

Macicka-Pawlik T. 2000. Stosunki florystyczno-fitosocjologiczne rezerwatu „Radziądz" na tle zachodzących zmian antropogenicznych. Acta Univ. Wrat., Prace Botaniczne 78: 51–74.

Macicka-Pawlik T., Wilczyńska W. 1998. Wartości przyrodnicze projektowanego parku krajobrazowego „Dolina Odry I." Acta Univ. Wrat., Prace Botaniczne 74, 165–200.

Markowski R. 1974. Zręby zupełne jako czynnik degeneracji niektórych fitocenoz leśnych. Phytocoenosis 3(3/4): 215–226.

Matuszkiewicz J. M. (ed.). 2007. Geobotaniczne rozpoznanie tendencji rozwojowych zbiorowisk leśnych w wybranych regionach Polski. IGiPZ PAN, Monografie 8: 1–976.

Matuszkiewicz J. M. 1976. Przegląd fitosocjologiczny zbiorowisk leśnych Polski. Cz. 3. Lasy i zarośla łęgowe. Phytocoenosis 5(1): 3–66.

Matuszkiewicz J. M. 1993. Krajobrazy roślinne i regiony geobotaniczne Polski. IGiPZ PAN, Prace Geograficzne 158: 1–108.

Matuszkiewicz J. M. 2002. Zespoły leśne Polski. Warszawa, Wydawnictwo Naukowe PWN, 358 pp.

Matuszkiewicz J. M. (ed.). 2007a. Geobotaniczne rozpoznanie tendencji rozwojowych zbiorowisk leśnych w wybranych regionach Polski. IGiPZ PAN, Monografie 8: 1–976.

Matuszkiewicz J. M. 2008. Regionalizacja geobotaniczna Polski. Warszawa, IGiPZ PAN.

Matuszkiewicz W. 2002. Przewodnik do oznaczania zbiorowisk roślinnych Polski. Warszawa, Wydawnictwo Naukowe PWN, 537 pp.

Matuszkiewicz W., Faliński J. B., Kostrowicki A., Matuszkiewicz J., Olaczek R., Wojterski T. 1995. Potencjalna roślinność naturalna Polski. Mapa przeglądowa 1:300 000, Arkusz 11. Wyżyna Śląska, Beskidy Zachodnie i Tatry. PAN IGiPZ, Warszawa.

Medwecka-Kornaś A. 1994. Ochrona flory i roślinności na obszarach leśnych: stan i zadania. Ochr. Przyr. 51: 3–21.

Medwecka-Kornaś A., Towpasz K., Gawroński S. 1988. Dolina Wierzbanówki: 17. Zespoły leśne. Zesz. Nauk. Uniw. Jagiell., Prace Bot. 17: 99–123.

Mirek Z. 1974. Głos w dyskusji na temat „systemu faz degeneracyjnych." Phytocoenosis 3(3/4): 191–200.

Mirek Z., Piękoś-Mirkowa H., Zając A., Zając M. 2002. Flowering plants and pteridophytes of Poland. A checklist. Krytyczna lista roślin kwiatowych i paprotnikowych Polski. Biodiversity of Poland 1: 1–442.

Miś R., Rączka G. 2004. Przebudowa lasów nizinnych w Polsce. Sylwan 1: 19–32.

Ochyra R., Żarnowiec J., Bednarek-Ochyra H. 2003. Census catalogue of Polish mosses. Katalog mchów Polski. Biodiversity of Poland 3: 1–372.

Olaczek R. 1972. Formy antropogenicznej degeneracji leśnych zbiorowisk roślinnych w krajobrazie rolniczym Polski niżowej. Łódź, Uniwersytet Łódzki, 170 pp.

Olaczek R. 1974a. Kierunki degeneracji fitocenoz leśnych i metody ich badania. Phytocoenosis 3(3–4): 179–190.

Olaczek R. 1974b. Etapy pinetyzacji grądu. Phytocoenosis, 3(3/4): 201–214.

Olaczek R., Piotrowska H. 1986. Lasy Wolińskiego Parku Narodowego w świetle teorii faz i form degeneracji fitocenoz. Parki Narod. Rezerw. Przyr. 7(2): 5–14.

Olaczek R., Sowa R. 1972. Antropogeniczne zniekształcenia naturalnych zespołów leśnych rezerwatu „Dębowiec" w powiecie radomszczańskim. Phytocoenosis 1(4): 267–272.

Operat wodno-prawny na piętrzenie i pobór wody ze zbiornika Goczałkowice. Kraków, Hydroprojekt, 2001.

Orczewska A., Sierka E. 2002. Charakterystyka fitosocjologiczna grądów *Tilio cordatae-Carpinetum betuli* w wariancie z *Carex brizoides* występujących na Płaskowyżu Głubczyckim i Wyżynie Śląskiej. Acta Biologica Silesiana 36(53): 95–104.

Pawlaczyk P. 1993. Możliwości hamowania synantropizacji fitocenoz leśnych. Przegl. Przyr. 4(3): 3–32.

Pawlaczyk P. 1996. Naturalność lasu: w poszukiwaniu kryterium celu unaturalniania fitocenoz leśnych. Przegląd Przyrodniczy 7(3–4): 11–28.

Pawlaczyk P. 1997. Roślinność leśna Drawieńskiego Parku Narodowego, jej antropogeniczne przekształcenia i aktualne tendencje dynamiczne. In: Gleby i roślinność ekosystemów leśnych w Drawieńskim Parku Narodowym. Ed. P. Pawlaczyk. Idee Ekologiczne 11(5): 43–70.

Pawłowski B. 1977. Skład i budowa zbiorowisk roślinnych oraz metody ich badania. In: Szata roślinna Polski. T. I. Eds. W. Szafer, K. Zarzycki. Warszawa, PWN: 237–269.

Petit S., Griffiths L., Smart S. S., Smith G. M., Stuart R. C., Wright S. M. 2004. Effects of area and isolation of woodland patches on herbaceous plant species richness across Great Britain. Landscape Ecology 19: 463–471.

Piotrowska H., Olaczek R. 1991. The real vegetation map of the Woliński National Park as a source of information about the anthropogenic changes of forest communities. Phytocoenosis 3 (N.S.), Semin. Geobot 2: 287–294.

Puchalski T. 2000. Rębnie w gospodarstwie leśnym. Poradnik leśniczego. Warszawa, PWRiL, 290 pp.

Ratyńska H. 2003. Szata roślinna jako wyraz antropogenicznych przekształceń krajobrazu na przykładzie zlewni rzeki Głównej (środkowa Wielkopolska). Bydgoszcz, Wydawnictwo Akademii Bydgoskiej, 381 pp.

Ratyńska H., Szwed W. 1998. Wyspy leśne i zadrzewienia jako refugia. Flora i zbiorowiska roślinne. In: Ekologia wysp leśnych. Ed. J. Banaszak J. Wyd. WSP w Bydgoszczy: 227–229.

Rąkowski G. (ed.). 2002. Parki krajobrazowe w Polsce. Warszawa, Instytut Ochrony Środowiska, 719 pp.

Rąkowski G. (ed.). 2007. Rezerwaty przyrody w Polsce Południowej. Warszawa, Instytut Ochrony Środowiska, 439 pp.

Roleček J., Tichý L., Zelený D., Chytrý M. 2009. Modified TWINSPAN classification in which the hierarchy respects cluster heterogeneity. Journal of Vegetation Science 20: 596–602.

Roo-Zielińska E. 2004. Fitoindykacja jako narzędzie oceny środowiska fizycznogeograficznego. Podstawy teoretyczne i analiza porównawcza stosowanych metod. PAN IGiPZ, Prace Geograficzne 199: 1–258.

Roszkowski A., Hennig J. 1991. Ochrona przed powodzią. In: Dorzecze górnej Wisły. Część II. Eds. M. Dynowska, M. Maciejewski. Warszawa–Kraków, PWN: 147–153.

Rozporządzenie Ministra Środowiska z dn. 30 marca 2005 r. w sprawie rodzajów, typów i podtypów rezerwatów przyrody (Dz.U. 2005 nr 60, poz. 533).

Rozporządzenie Ministra Środowiska z dn. 13 kwietnia 2010 r. w sprawie siedlisk przyrodniczych oraz gatunków będących przedmiotem zainteresowania Wspólnoty, a także kryteriów wyboru obszarów kwalifikujących się do uznania lub wyznaczenia jako obszary Natura 2000 (t.j. Dz.U. 2014, poz. 1713).

Rozporządzenie Ministra Środowiska z dn. 14 sierpnia 2001 r. w sprawie określenia rodzajów siedlisk przyrodniczych podlegających ochronie (Dz. U. 2001 nr 92, poz. 1029).

Rozporządzenie wojewody śląskiego nr 58/04 z dn. 8 września 2004 r. Dz. Urz. Nr 90/04 z 16.09.04, poz. 2528.

Rozporządzenie wojewody śląskiego nr 60/04 z dn. 8 września 2004 r., Dz. Urz. Nr 90/04 z 16.09.04 poz. 2530.

Rozwałka Z. 2003. Zasady hodowli lasu. Warszawa, DGLP, 159 pp.

Ruman M., Rzętała M. 2006. Wody powierzchniowe i podziemne obszaru Natura 2000 „Dolina Górnej Wisły". In: Waloryzacja przyrodnicza obszaru Natura 2000 „Dolina Górnej Wisły". Eds. J. Betleja, M. Fajer, M. Ruman, M. Rzętała, J. Waga, Z. Wilczek, P. Chylarecki, R. Gwiazda, P. Profus, E. Joseph-Tomaszewska. Bytom–Katowice: 33–40.

Sierka E. 2003. The role of grass species in forest communities with *Carex brizoides* of the Silesian Upland. In: Problems of Grass Biology. Eds. L. Frey. W. Szafer Inst. of Bot. PAN, Kraków: 503–512.

Sierka E., Chmura D. 2004. Morska trawka i natrętny Azjata – dwa „chwasty" leśne. Problemy ekologii 5: 250–256.

Sierka E., Orczewska A. 2001. Zdegenerowane grądy z *Carex brizoides* L. wybranych obszarów Wyżyny Śląskiej i Płaskowyżu Głubczyckiego. In: Przemiany środowiska przyrodniczego Polski a jego funkcjonowanie. Eds. K. German, J. Balon. Problemy Ekologii Krajobrazu 10: 474–480.

Soja R. 1992. Charakterystyka hydrologiczna Wisły od Przemszy do Sandomierza. In: Zmiany biegu górnej Wisły i ich skutki. Eds. K. German, J. Balon. Warszawa, Wydaw. Uniw. Warszawskiego: 9–29.

Sokołowski A.W. 1972. Gospodarcze użytkowanie lasu jako główny czynnik synantropizacji zbiorowisk leśnych. Phytocoenosis 1(3): 211–216.

Sowa R., Filipiak E., Andrzejewski H. 1993. Regeneracja grądu jodłowego w rezerwacie „Jamno." Acta Univ. Lodz., Folia Bot. 10: 3–21.

Stachurska A. 1998. Zbiorowiska leśne północno-wschodniej części Pogórza Wielickiego (Karpaty Zachodnie). Zeszyty Naukowe UJ, Prace Botaniczne 30: 1–78.

Stanisz A. (ed.) 2005. Biostatystyka. Kraków, Wydawnictwo Uniwersytetu Jagiellońskiego, 410 pp.

Stanisz A. 2006. Przystępny kurs statystyki z zastosowaniem STATISTICA PL na przykładach z medycyny. Tom 1. Statystyki podstawowe. Kraków, STATSOFT, 529 pp.

Starkel L. 2001. Historia doliny Wisły od ostatniego zlodowacenia do dziś. PAN, Instytut Geografii i Przestrzennego Zagospodarowania im. S. Leszczyckiego, Monografie 2: 1–263.

Strategia rozwoju gminy Oświęcim 2007–2013. Załącznik nr 1 do uchwały nr V/29/07 z dn. 28 lutego 2007 r. Gmina Oświęcim, 164 pp.

Sukopp H. 1972. Wandel von Flora und Vegetation in Mitteleuropa unter dem Einfluss des Menschen. Der Landwirtsch 50: 112–139.

Szafer W. 1972a. Podstawy geobotanicznego podziału Polski. In: Szata roślinna Polski. Tom II. Eds. W. Szafer, K. Zarzycki. Warszawa, PWN: 9–15.

Szafer W. 1972b. Szata roślinna Polski niżowej. In: Szata roślinna Polski. Tom II. In: W. Szafer, K. Zarzycki. Warszawa, PWN: 17–188.

Szweykowski J. 2006. An annotated checklist of Polish liverworts. Krytyczna lista wątrobowców Polski. Biodiversity of Poland 4: 1–114.

Tichý L., Holt J. 2006. Juice. Program for management, analysis and classification of ecological data. Vegetatio Science Group, Masaryk University Brno, 98 pp.

Tokarska-Guzik B. 2005. The Establishment and Spread of Alien Plant Species (Kenophytes) in the Flora of Poland. Prace Naukowe Uniwersytetu Śląskiego w Katowicach nr 2372. Katowice, Wydawnictwo Uniwersytetu Śląskiego, 192 pp.

Tokarska-Guzik B., Dajdok Z., Zając M., Zając A., Urbisz A., Danielewicz W., Hołdyński C. 2012. Rośliny obcego pochodzenia w Polsce ze szczególnym uwzględnieniem gatunków inwazyjnych (Alien plants in Poland with particular reference to invasive species). Warszawa, GDOŚ, 197 pp.

Toma C. 1995. Stanowisko jezierzy morskiej *Najas marina* w Kotlinie Oświęcimskiej. Chrońmy Przyrodę Ojczystą 51(4): 84–86.

Toma C. 1996. Aktualne rozmieszczenie kotewki orzecha wodnego *Trapa natans* w Kotlinie Oświęcimskiej. Chrońmy Przyrodę Ojczystą 52(3): 107–110.

Trafas K. 1992. Zmiany biegu Wisły pomiędzy ujściem Przemszy a Sandomierzem. In: Wisła w dziejach i kulturze Poslki. Zmiany biegu górnej Wisły i ich skutki. Ed. K. Trafas. Warszawa, Wydawnictwa Uniwersytetu Warszawskiego: 31–61.

Trampler T., Kliczkowska A., Dmyterko E., Sierpińska A. 1990. Regionalizacja przyrodniczo-leśna Polski na podstawach ekologiczno-fizjograficznych. Warszawa, PWRiL, 159 pp.

Uchwała Nr 65 Rady Narodowej M. Krakowa z 2.12.1981 r. (Dz.u.R.N.M.K. z 31.12.1981 r. Nr 14 poz 76).

Uchwała nr LVIII/513/98 Rady Miejskiej w Oświęcimiu z dnia 16 czerwca 1998 roku.

Uchwała nr XII/68/95 Rady Gminy w Bestwinie z dnia 29 czerwca 1995 roku.

Ustawa z dn. 16 kwietnia 2004 r. o ochronie przyrody (t.j. Dz.U. 2013, poz. 627).

Wasiłowska A. 1998. Problemy synantropizacji wysp leśnych w krajobrazie rolniczym. In: Ekologia wysp leśnych. Ed. J. Banaszak. Wyd. WSP w Bydgoszczy: 279–292.

Weber H.E. 1999. Synopsis der Pflanzengesellschaften Deutschlands. Heft 5. *Rhamno-Prunetea* (H2A). Schlehen- und Traubenholunder-Gebüsche, Göttingen, 108 pp.

Węglarz-Wieszołek J., Wika S. 2010. Zróżnicowanie roślinności wodnej, nadwodnej i bagiennej w zbiornikach wód stojących Doliny Górnej Wisły oraz jej znaczenie dla obszarów Natura 2000. Sosnowiec–Katowice, Uniwersytet Śląski, Wydział Nauk o Ziemi–Wydział Biologii i Ochrony Środowiska, 97 pp.

WILCZEK Z. 1998. Roślinność rezerwatów przyrody województwa bielskiego. In: Osobliwości szaty roślinnej województwa bielskiego. Eds. L. BERNACKI, A. BLAROWSKI, Z. WILCZEK. Poznań, Colgraf-Press: 92–105.

WILCZEK Z. 2006. Fitosocjologiczne uwarunkowania ochrony przyrody Beskidu Śląskiego (Karpaty Zachodnie). Katowice, Wydawnictwo Uniwersytetu Śląskiego, 224 pp.

WILCZEK Z., HOLEKSA J., ROMAŃCZYK M. 2008. Szata roślinna rezerwatu „Żaki" w Kotlinie Oświęcimskiej – zagrożenia i perspektywy ochrony. Chrońmy Przyrodę Ojczystą 64(2): 93–99.

WILCZEK Z., HOLEKSA J., SIERKA E. 2005. Projekt poszerzenia rezerwatu „Rotuz" w Kotlinie Oświęcimskiej. Chrońmy Przyrodę Ojczystą 61(1): 75–79.

WILCZEK Z., MAŚKA M. 2010. Conservation of water and swamp vegetation in the Biała River Valley (Silesian Foothills, Oświęcim Basin). Teka Kom. Ochr. Kszt. Środ. Przyr. – OL PAN 7: 457–465

WILCZEK Z., ROMAŃCZYK M., BARĆ A. 2011. Ancient woodlands and synanthropic plants as indicators of maintenance of the forest communities in the nature reserves of the Oświęcim Basin. Acta Universitatis Lodziensis. Folia Biologica et Oecologica 7: 111–123.

WILDI O., ORLÒCI L. 1996. Numerical exploration of community patterns. A guide to the use of MULVA-5. SPB Academic Publ., Amsterdam, 171 pp.

WŁODEK J. 1957. Kraina Stawów. Ziemia, 6(8): 6–8.

WÓJCIK Z., WASIŁOWSKA A. 1994. Synantropizacja wysp leśnych w krajobrazie rolniczym. Wiad. Ekol. 40: 77–85.

WRÓBEL S., WŁODEK J. 1991. Gospodarka stawowa w dorzeczu górnej Wisły. In: Dorzecze górnej Wisły. Część II. Eds. I. DYNOWSKA, M. MACIEJEWSKI. Warszawa–Kraków, PWN: 96–105.

ZAJĄC A. 1983. Studies on the origin of archaeophytes in Poland. Part I. Methodical consideration. Zesz. Nauk. Uniw. Jagiell., Prace Bot. 11: 87–107.

ZAJĄC A. 1987a. Studies on the origin of archaeophytes in Poland. Part II. Taxa of Mediterranean and Atlantic-Mediterranean origin. Zesz. Nauk. Uniw. Jagiell., Prace Bot. 14: 7–50.

ZAJĄC A. 1987b. Studies on the origin of archaeophytes in Poland. Part III. Taxa of Irano-Turanian, Euro-Siberian-Irano-Turanian and Meidterranean-Irano-Turanian origin. Zesz. Nauk. Uniw. Jagiell., Prace Bot. 15: 93–129.

ZAJĄC A. 1988. Studies on the origin of archaeophytes in Poland. Part IV. Taxa of Pontic-Pannonian, Mediterraneo-South Asiatic, South Asiatic and Middle European origin. Archaeophyta anthropogena. Archaeophyta resistentia. Archaeophtyes of unknown origin. Zesz. Nauk. Uniw. Jagiell., Prace Bot. 17: 23–51.

ZAJĄC A., ZAJĄC M., TOKARSKA-GUZIK B. 1998. Kenophtyes in the flora of Poland: list, status and origin. Phytocoenosis 9(10): 107–116.

ZAJĄC M. 1990a. Stosunki geobotaniczne południowej części Kotliny Oświęcimskiej i zachodniej części Pogórza Śląskiego. Część I. Historia badań, charakterystyka terenu i występowanie gatunków górskich. Zeszyty Naukowe UJ, Prace Botaniczne 21: 75–106.

ZAJĄC M. 1990b. Stosunki geobotaniczne południowej części Kotliny Oświęcimskiej i zachodniej części Pogórza Śląskiego. Część II. Porównanie flory Kotliny Oświęcimskiej i Pogórza Śląskiego w grupach siedliskowych. Zeszyty Naukowe UJ, Prace Botaniczne 21: 106–139.

Zając M. 1992a. Stosunki geobotaniczne południowej części Kotliny Oświęcimskiej i zachodniej części Pogórza Śląskiego. Część III. Historia roślinności i przynależność geobotaniczna badanego terenu. Zeszyty Naukowe UJ, Prace Botaniczne 24: 25–55.

Zając M. 1992b. Stosunki geobotaniczne południowej części Kotliny Oświęcimskiej i zachodniej części Pogórza Śląskiego. Część IV. Antropogeniczne przemiany flory. Zeszyty Naukowe UJ, Prace Botaniczne 24: 57–70.

Załuski T., Biały K., Kosakowski A., Gracjasz M. 1997. Roślinność dna lasu jako wskaźnik zniekształcenia ekosystemów leśnych w Drawieńskim Parku Narodowym. In: Gleby i roślinność ekosystemów leśnych w Drawieńskim Parku Narodowym. Ed. P. Pawlaczyk. Idee Ekologiczne 11(5): 83–97.

Zarządzenie Ministra Ochrony Środowiska, Zasobów Naturalnych i Leśnictwa z dnia 11 grudnia 1995 r. w sprawie uznania za rezerwat przyrody (M.P. 1996 nr 5, poz. 52).

Zarządzenie Ministra Leśnictwa i Przemysłu Drzewnego z dnia 28 stycznia 1959 r. w sprawie uznania za rezerwat przyrody (M.P. 1959 nr 23, poz. 104).

Zarządzenie Ministra Leśnictwa i Przemysłu Drzewnego z dnia 30 grudnia 1966 r. w sprawie uznania za rezerwat przyrody (M.P. 1967 nr 10, poz. 59).

Żarnowiec J. 1983. Flora naczyniowa terenów nadbrzeżnych Wisły w okolicach Oświęcimia. Acta Biologica 12: 65–78.

Żarnowiec J. 1986. Godne ochrony stanowisko ciemiężycy zielonej *Veratrum lobelianum* w Kotlinie Oświęcimskiej. Chrońmy Przyrodę Ojczystą 42(1): 65–69.

Żarnowiec J. 1988. O ochronę stanowiska śnieżyczki przebiśniegu *Galanthus nivalis* w okolicy Oświęcimia. Chrońmy Przyrodę Ojczystą 44(1): 94–95.

Żarnowiec J. 1996a. Łęgi topolowo-wierzbowe *Salici-Populetum* (R.Tx. 1931) Meijer Drees 1936 w Oświęcimiu – stan zachowania, zagrożenia i problemy ochrony. In: Przyroda województwa bielskiego – stan poznania, zagrożenia i ochrona. In: H. Klama, A. Włochowicz, J. Żarnowiec. Zeszyty Naukowe Polit. Łódz. Inżynieria Włókiennicza i Ochrona Środowiska 40(12): 211–218.

Żarnowiec J. 1996b. Walory szaty roślinnej terenów nadbrzeżnych rzeki Soły w Oświęcimiu. [IN:] Wawręty R., Rymarowicz P. (ed.). Spór o Sołę. Federacja Zielonych. Oświęcim: 24–40.

Żarnowiec J. 1996c. Zbiorowiska mszaków Oświęcimia. Archiwum Ochrony Środowiska 3(4): 145–164.

Żarnowiec J., Herczek A. 1999. Zespół przyrodniczo-krajobrazowy Dolina rzeki Soły. Przewodnik po ścieżce dydaktycznej. Oświęcim, Towarzystwo na rzecz Ziemi, 126 pp.

Żarnowiec J., Jędrzejko K., Klama H. 1991. Charakterystyka fitosocjologiczna roślinności torfowiskowej rezerwatu przyrody Rotuz w Kotlinie Oświęcimskiej. Ochrona Przyrody 48: 135–159.

Żarnowiec J., Jędrzejko K., Klama H. 1997. Rośliny naczyniowe istniejących i proponowanych rezerwatów przyrody Makroregionu Południowego Polski, ze szczególnym uwzględnieniem naturalnych zasobów roślin leczniczych. Katowice, ŚlAM, 103 pp.

Żarnowiec J., Klama H., Chmura D. 2012. Szata roślinna projektowanego zespołu przyrodniczo-krajobrazowego Stare Wiślisko w Kotlinie Oświęcimskiej. Wydawnictwo Akademii Techniczno-Humanistycznej w Bielsku-Białej, 106 pp.

Żarnowiec J., Klama H., Nejfeld P. 2010. Szata roślinna doliny dolnej Soły. Wydawnictwo Akademii Techniczno-Humanistycznej w Bielsku-Białej, 133 pp.

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Synantropizacja roślinności leśnej i zaroślowej Doliny Górnej Wisły (Kotlina Oświęcimska, Podkarpacie Północne)

Streszczenie

Wstęp

Dolina Górnej Wisły − środkowa część Kotliny Oświęcimskiej (Fig. 1) − jest obszarem niezwykle interesującym z przyrodniczego punktu widzenia. Podlegała ona nasilonej i długotrwałej antropopresji, która doprowadziła do znacznego przekształcenia środowiska przyrodniczego, polegającego na wyraźnym zmniejszeniu powierzchni zajmowanej przez dominujące pierwotnie w krajobrazie zbiorowiska leśne na rzecz użytków rolnych, zbiorników wodnych, terenów przemysłowych czy zabudowy. Ocalałe fragmenty lasów – zajmujące swe historyczne lokalizacje, zasługujące na miano starych lasów – były natomiast poddane dalszej antropopresji, w tym przede wszystkim wpływom wynikającym z gospodarki leśnej. W związku z tym podjęto badania zmierzające do oceny stanu zachowania roślinności leśnej i zaroślowej tego terenu (jej naturalności, stopnia przekształcenia) z uwzględnieniem występujących form degeneracji oraz udziału różnych grup gatunków wskaźnikowych, umożliwiających określenie stanu zaawansowania synantropizacji.

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Metodyka

Badania terenowe prowadzono w sezonie wegetacyjnym w latach 2007–2010. W terenie wykonywano zdjęcia fitosocjologiczne, stosując metodę Braun-Blanqueta. Poza zbiorowiskami leśnymi i zaroślowymi badaniami objęto również płaty zbiorowiska *Reynoutria japonica*. Gatunek ten jest wprawdzie rośliną zielną, ale jego fitocenozy, stanowiące istotny element krajobrazu Doliny Górnej Wisły, pod względem fizjonomicznym bardzo przypominają zbiorowiska krzewiaste. Zdjęcia fitosocjologiczne (w liczbie 414) wprowadzono do programu Turboveg, a tak powstałą bazę poddano analizie przy użyciu programu Juice. Przeliczenie wartości ilościowości-pokrycia ze skali Braun-Blanqueta na wartości procentowe dla wszelkich obliczeń, zostało wykonane zgodnie z predefiniowanymi w programie Juice wartościami: ‘r’ – 1%, ‘+’ – 2%, ‘1’ – 3%, ‘2’ – 13%, ‘3’ – 38%, ‘4’ – 68%, ‘5’ – 88%. Naturalność roślinności leśnej i zaroślowej została określona na podstawie zmodyfikowanego systemu form i faz degeneracji Olaczka (1972, 1974a). U podstawy obliczeń natężenia przekształceń spoczywa podział gatunków na dwie grupy: eufity (E), czyli gatunki właściwe dla zespołu roślinnego na danym terenie, oraz allofity (A) – pozostałą grupę gatunków. Do eufitów zaliczono zasadniczo gatunki: charakterystyczne dla klasy, do której należy dane zbiorowisko (w tym charakterystyczne dla niższych jednostek w obrębie klasy), wyróżniające zespół, podzespoły i warianty. Oceny synantropizacji badanej roślinności dokonano na podstawie: 1) stosunku (E):(A) pod względem liczby gatunków (wyrażonego w %) oraz pod względem sumy ich przeciętnego procentowego pokrycia; 2) udziału antropofitów przy uwzględnieniu liczby gatunków oraz ich łącznego pokrycia w zdjęciu. Określenie stanu zachowania przeprowadzono dla wyróżnionych w wyniku badań zbiorowisk, z wyłączeniem: jednostek tworzonych przez gatunki obce, układów o trudnej do ustalenia przynależności syntaksonomicznej oraz dwóch zespołów zaroślowych, dla których to wyjątkowo oceniono jedynie udział antropofitów. W celu oceny naturalności, a przede wszystkim weryfikacji hipotezy o zajmowaniu przez lasy występujące w Dolinie Górnej Wisły dawnych, historycznych już lokalizacji, grupę roślin starych lasów liściastych (Dzwonko i Loster 2001, Dzwonko 2007) poddano analizie pod względem liczby stwierdzonych gatunków i ich łącznego grupowego pokrycia. Obliczenia, ze względu na specyfikę tej grupy roślin, wykonano wyłącznie dla zbiorowisk z klasy *Querco-Fagetea*.

Poza porównywaniem fitocenoz w obrębie zbiorowisk oraz samych zbiorowisk w ramach grup podobnych asocjacji roślinnych, zestawiono również wyniki dotyczące udziału antropofitów oraz gatunków starych lasów w wyróżnionych kategoriach, nazwanych kategoriami krajobrazowymi roślinności: kompleksach leśnych (mniej lub bardziej zwartych układach leśnych oraz wyspach leśnych o powierzchni przekraczającej 150 ha), wyspach leśnych z podziałem na 4 grupy wielkościowe (I – 0,5–5 ha, II – 5,5–25 ha, III – 25,5–50 ha, IV – 50,5–150 ha) i zakrzewieniach (zbiorowiskach zaroślowych).

Obliczenia statystyczne wykonano przy użyciu programu STATISTICA. Wybór testów nieparametrycznych (testu ANOVA rang Kruskala-Wallisa wraz z testem wielokrotnych porównań średnich rang dla wszystkich prób oraz testu U Manna-Whitneya) wynika zasadniczo z braku normalności rozkładu analizowanych danych. Dla określenia związku statystycznego pomiędzy wybranymi parametrami obliczono współczynnik korelacji liniowej Pearsona oraz współczynnik determinacji, obrazujący miarę dopasowania linii regresji do wartości obserwowanych, a także współczynnik korelacji rang Spearmana, ze względu na wrażliwość współczynnika Pearsona na brak normalności.

Współczynniki opisujące stan zachowania fitocenoz:

1. Procentowy stosunek liczbowy eufitów do allofitów w zdjęciu fitosoc. (E/A liczba) – *E/A number*.
2. Procentowy stosunek pokrycia eufitów do allofitów w zdjęciu fitosoc. (E/A pokrycie) – *E/A cover*.
3. Liczba gatunków z grupy antropofitów w zdjęciu fitosoc. – *no. of anthropophytes*.
4. Procentowe pokrycie grupy antropofitów w zdjęciu fitosoc. – *cover of anthropophytes*.
5. Liczba gatunków starych lasów liściastych w zdjęciu fitosoc. – *no. of woodland species*.
6. Procentowe pokrycie grupy gatunków starych lasów liściastych w zdjęciu fitosoc. – *cover of woodland species*.
7. Wartość systematyczna grupy gatunków antropofitów – *syst. val. grp. antrop.*

Struktura – wyróżnione kategorie krajobrazowe:
C – kompleksy leśne,
I – wyspy leśne:
    I1 – wyspy leśne o powierzchni 0,5–5,0 ha,
    I2 – wyspy leśne o powierzchni 5,5–25,0 ha,
    I3 – wyspy leśne o powierzchni 25,5–50,0 ha,
    I4 – wyspy leśne o powierzchni 50,5–150,0 ha,
B – zakrzewienia, zbiorowiska zaroślowe.

Wyniki

Przegląd systematyczny wyróżnionych zbiorowisk roślinnych

W wyniku analizy fitosocjologicznej materiałów zgromadzonych w trakcie badań przeprowadzonych w obrębie mezoregionu Doliny Górnej Wisły wyodrębniono 17 zespołów i 5 zbiorowisk roślinnych, reprezentujących 8 klas. Trzy zbiorowiska uznano za jednostki o trudnej do określenia przynależności syntaksonomicznej. Charakterystykę florystyczno-fitosocjologiczną uwzględnionych w wykazie systematycznym zbiorowisk roślinnych przedstawiono w formie 24 tabel fitosocjologicznych, zamieszczonych w wersji elektronicznej na płycie CD stanowiącej załącznik do niniejszego opracowania.

Formy degeneracji

Najczęściej obserwowaną w Dolinie Górnej Wisły formę degeneracji stanowi **cespityzacja**, która objawia się w przeważającej większości wypadków nadmiernym rozwojem w warstwie zielnej turzycy drżączkowatej *Carex brizoides*. Formę tę obserwowano w wielu typach zbiorowisk. Płatów z *Carex brizoides* występującym łanowo w dnie lasu z powodu zmian i zubożenia florystycznego nie zaklasyfikowano do utrwalonych w literaturze zespołów, lecz wydzielono jako oddzielne jednostki syntaksonomiczne w randze zbiorowisk: zbiorowisko *Pinus sylvestris-Carex brizoides*, zbiorowisko *Quercus robur-Carex brizoides* i zbiorowisko *Alnus glutinosa.* Stan roślinności leśnej Doliny Górnej Wisły pod względem cespityzacji jest szczególnie zły. Częstym zjawiskiem – zwłaszcza w obrębie lasów użytkowanych gospodarczo – są całe pododdziały leśne zdegenerowane przez zaścielającą łanowo dno lasu turzycę drżączkowatą. Poza wspomnianym gatunkiem cespityzacja bywa również wywoływana przez niektóre trawy, m.in. mozgę trzcinowatą czy śmiałka pogiętego.

Fruticetyzacja – polegająca na nadmiernym rozwoju warstwy krzewów – na omawianym obszarze najczęściej powodowana była przez: *Corylus avellana* i *Padus avium* (w zbiorowiskach z klasy *Querco-Fagetea*), inwazyjny kenofit *Reynoutria japonica* (w łęgach wierzbowo-topolowych) oraz *Frangula alnus* (w zbiorowiskach borów i borów mieszanych). Ponadto dość powszechnie występowała specyficzna odmiana fruticetyzacji, polegająca na silnym rozwoju gatunków z rodzaju *Rubus sp.* (najczęściej *Rubus hirtus* i *Rubus idaeus*).

Istotnym problemem roślinności mezoregionu jest również **pinetyzacja**, związana ze zwiększaniem udziału gatunków iglastych na różnych siedliskach − zwłaszcza borów mieszanych, acydofilnych dąbrów, kwaśnych buczyn i ubogich grądów, a także na bogatych siedliskach lasów liściastych. Opisana forma degeneracji jest problemem o charakterze ponadregionalnym, będącym skutkiem gospodarki leśnej przez wiele lat protegującej sosnę i zmierzającej do ujednolicenia drzewostanów. Z prowadzoną gospodarką leśną związana jest również **monotypizacja** oraz **juwenalizacja.** Rębne użytkowanie drzewostanów, połączone z jednoczesnym sztucznym odnawianiem, doprowadziło do wykształcenia się zbiorowisk ujednoliconych wiekowo, gatunkowo i strukturalnie, w niektórych przypadkach utrzymywanych na wczesnym etapie rozwoju (czego ocena w krótkim cyklu badawczym nie jest do końca możliwa).

Neofityzacja na omawianym terenie była związana najczęściej z następującymi kenofitami: *Impatiens parviflora* (obecny w 25% wykonanych zdjęć fitosocjologicznych), *Impatiens glandulifera*, *Quercus rubra*, *Reynoutria japonica*, *Padus serotina* oraz *Bidens frondosa*. Na podstawie analizy jakościowego i ilościowego udziału kenofitów (stopień stałości oraz średnie niezerowe pokrycie) można stwierdzić, że zbiorowiskami, w strukturze których kenofity odgrywają największą rolę, są występujące w sąsiedztwie rzek: *Salicetum albo-fragilis*, *Salicetum triandro-viminalis*, *Populetum albae*, a także *Chelidonio-Robinietum* i zb. *Reynoutria japonica* (w przypadku dwóch ostatnich wynika to z wysokiej ilościowości gatunków wyróżniających zbiorowisko). (Tab. 1).

Natężenie stopnia synantropizacji

Natężenie stopnia synantropizacji oceniono, wykorzystując udział w fitocenozach grup gatunków, które cechują się niejednakową reakcją na oddziaływanie presji antropogenicznej.

Grądy – związek *Carpinion betuli*

Istotną statystycznie wyższą wartość współczynników E/A pokrycie oraz E/A liczba stwierdzono w grądach niskich w porównaniu do grądów wysokich i zdegenerowanych oraz w grądach typowych w porównaniu z grądami zdegenerowanymi (Tables 2–5, Figs. 7 i 8). Grądy niskie bardzo silnie wyróżniają się na tle reszty podzespołów także przy uwzględnieniu pozostałych parametrów – tylko w ich płatach, udokumentowanych zdjęciami fitosocjologicznymi, nie stwierdzono obecności antropofitów, a średnie pokrycie gatunków starych lasów liściastych znacznie przekracza wartości w pozostałych grupach. Można więc uznać je za najmniej przekształcone zbiorowisko grądowe na terenie Doliny Górnej Wisły. Odwrotną sytuację obserwujemy w wypadku grupy grądów zdegenerowanych (uzyskane wyniki sugerują zasadność takiego właśnie ujęcia). Przywiązanie płatów grądów zdegenerowanych do wysp leśnych (kategoria wielkościowa II i IV) wskazuje na znaczne przekształcenie krajobrazu przejawiające się aktualnie ograniczeniem powierzchni zajmowanej przez zbiorowiska grądów do enklaw w krajobrazie rolniczym. Całkiem znaczna liczba gatunków starych lasów liściastych wskazuje jednak na naturalny charakter większości przebadanych płatów.

Olszowe, olszowo-jesionowe i wiązowo-jesionowe zbiorowiska łęgowe – związek *Alno-Ulmion*

Wyniki analizy fitocenoz *Fraxino-Alnetum* wskazują na niewysoką średnią wartość E/A liczba i E/A pokrycie oraz na przeciętną liczbę i pokrycie gatunków starych lasów liściastych (Tab. 6). Można to jednak wyjaśnić typowym dla tej grupy zbiorowisk obfitym występowaniem gatunków nitrofilnych z klasy *Artemisietea vulgaris*, co nie jest przejawem ich degeneracji. Wskaźnikiem przekształcenia jest jednak całkiem wysokie pokrycie, jakie w zbiorowisku uzyskują antropofity (22,1%), spośród których *Impatiens parviflora* odgrywa największą rolę i cechuje się najwyższą stałością. W zbiorowisku *Ulmus glabra* wszystkie obliczone parametry osiągają wartości wskazujące na względnie wyższą naturalność przebadanych płatów (Tab. 7). Fitocenozy ze związku *Alno-Ulmion* zlokalizowane były zarówno w kompleksach, jak i wyspach leśnych, cechujących się zróżnicowaną wielkością.

Kwaśne buczyny – związek *Fagion sylvaticae*

Buczyny reprezentujące zespół *Luzulo pilosae-Fagetum* cechują się niewielką wartością E/A liczba przy jednocześnie całkiem wysokiej średniej wartości parametru E/A pokrycie (Tab. 8). Przyczyną takiego stanu rzeczy jest bardzo niskie bogactwo gatunkowe zbiorowiska oraz znikome pokrycie warstwy zielnej przy silnym zwarciu głównie bukowego drzewostanu. W związku z niewielkim udziałem runa we wszystkich fitocenozach pozostaje niska wartość pokrycia gatunków starych lasów liściastych (a także ich liczba) oraz nieznaczny udział antropofitów w strukturze zbiorowiska. Udokumentowane płaty kwaśnej buczyny opisane zostały z terenu kompleksów leśnych.

Bory mieszane i dąbrowy acydofilne – *Querco roboris-Pinetum* i *Calamagrostio arundinaceae-Quercetum*

Wspólna analiza borów mieszanych i dąbrów acydofilnych należących do różnych klas roślinności wynika z ich podobieństwa pod względem struktury i składu florystycznego spowodowanego gospodarką leśną. Oba zespoły cechuje znaczne podobieństwo pod względem wartości wyliczonych współczynników: stosunku procentowego liczby i pokrycia eufitów do allofitów, średniej liczby i pokrycia antropofitów w zdjęciach fitosocjologicznych (nieznacznie wyższą wartość obserwowano w przypadku *Calamagrostio arundinaceae-Quercetum petraeae*) (Tables 9 i 10). Bory mieszane i dąbrowy acydofilne na badanym obszarze występują głównie w kompleksach i większych wyspach leśnych (kategoria wielkościowa IV).

Bory – klasa *Vaccinio-Piceetea* (z wyłączeniem *Querco roboris-Pinetum*)

Analiza parametrów E/A liczba oraz E/A pokrycie dla grupy zespołów borowych wykazała najwyższą średnią wartość pierwszego ze wskaźników w zespole *Vaccinio uliginosi-Pinetum,* a drugiego – w *Molinio-Pinetum.* Istotne statystycznie różnice pomiędzy poszczególnymi zbiorowiskami stwierdzono w wypadku liczby oraz pokrycia antropofitów odgrywających większą rolę w zespole *Leucobryo-Pinetum* niż w *Molinio-Pinetum* czy *Vaccinio uliginosi-Pinetum* (Tables 11–14, Fig. 9). Interesująca jest odmienna w stosunku do grądów specyfika rozmieszczenia borów. Zgromadzone dane wskazują na bardzo silne ich „przywiązanie" do kompleksów leśnych, a w wypadku wysp – częstsze występowanie w większych obiektach (kategoria wielkościowa III i IV).

Wierzbowo-topolowe zbiorowiska lasów i zarośli łęgowych – klasa *Salicetea purpureae*

Wartości współczynników wykorzystujących podział gatunków na eufity i allofity obliczone dla poszczególnych zespołów, a zwłaszcza nadrzecznego łęgu wierzbowego *Salicetum albo-fragilis* i wiklin *Salicetum triandro-viminalis*, wykazują dość zbliżoną wielkość. Zespół łęgu topolowego *Populetum albae* cechuje nieco wyższa średnia wartość współczynnika E/A pokrycie i E/A liczba. Średnie wartości liczby i pokrycia antropofitów dla badanych zbiorowisk z klasy *Salicetea purpureae* osiągają odpowiednio: 1,94–2,65 gatunku oraz 12,7–20,7% pokrycia w zdjęciu (Tables 15–17, Figs. 10 i 11). Wartości te zawyżają wprawdzie pojedyncze, silnie opanowane przez antropofity płaty, jednak nie zaprzecza to znacznemu negatywnemu wpływowi tej grupy gatunków na stan nadrzecznych zbiorowisk (tak znaczny udział antropofitów, przy pominięciu zbiorowisk tworzonych przez antropofity, odnotowano jedynie w zespole *Fraxino-Alnetum*).

Zbiorowiska olsowe i łozowiska – klasa *Alnetea glutinosae*

Analiza wartości poszczególnych wskaźników wykazała wyższą średnią wartość E/A liczba oraz E/A pokrycie w łozowisku *Salicetum pentandro-cinereae* w porównaniu z olsem porzeczkowym *Ribeso nigri-Alnetum.* Na podkreślenie zasługuje niski udział antropofitów w badanych płatach. Średnia liczba gatunków z tej grupy w zdjęciu fitosocjologicznym wynosi 0,7–1,0, a średnie pokrycie – ok. 5% w zbiorowisku leśnym i ok. 2% w zaroślowym (Tables 18 i 19). Olsy w Dolinie Górnej Wisły zlokalizowane są w kompleksach leśnych oraz w największych wyspach leśnych (głównie IV klasa wielkości).

Udział antropofitów w poszczególnych zespołach i odmiennych kategoriach krajobrazowych badanej roślinności

Porównanie zaobserwowanych zbiorowisk pod kątem obecności w ich płatach antropofitów (z uwzględnieniem liczby odnotowanych gatunków, ich grupowego pokrycia oraz wartości systematycznej grupy), wykazało najniższe wartości wymienionych parametrów w zbiorowiskach: *Tilio-Carpinetum corydaletosum* (grądy niskie), *Vaccinio uliginosi-Pinetum*, *Molinio-Pinetum, Pinus sylvestris-Carex brizoides* oraz *Calamagrostio villosae-Pinetum* (Tab. 20, Figs. 12 i 13). Najwyższe wartości odnotowano w zbiorowiskach, w których strukturze dominuje gatunek kenofita: rdestowiec ostrokończysty w zbiorowisku *Reynoutria japonica* oraz robinia akacjowa w zespole *Chelidonio-Robinietum.* Poza wymienionymi jednostkami znaczna rola antropofitów uwidacznia się głównie w zbiorowiskach łęgowych: *Salicetum albo-fragilis, Populetum albae, Salicetum triandro-viminalis* oraz *Fraxino-Alnetum*. Wpływają na to w decydującej mierze następujące czynniki: znaczne nasilenie antropopresji oddziałującej na zbiorowiska nadrzeczne, fragmentaryczny stopień zachowania omawianych fitocenoz, zaburzająca rola zalewów, ułatwiająca wniknięcie antropofitów do płatów roślinnych czy wreszcie korytarzowa funkcja dolin rzecznych, wspomagająca rozprzestrzenianie się gatunków obcych.

Ocena naturalności, a jednocześnie podatności na przekształcenia wydzielonych typów krajobrazowych roślinności (kompleksy leśne, wyspy leśne oraz zakrzewienia), bez uwzględniania różnorodności syntaksonomicznej tworzących ją zbiorowisk, przeprowadzona na podstawie liczby gatunków oraz łącznego pokrycia antropofitów, wykazała najmniejszy ich udział w kompleksach leśnych, a największych w zbiorowiskach zaroślowych (Tab. 21, Fig. 14 i 15). Takie wyniki są jednak uwarunkowane znaczącym wpływem, ujętych w kategorii zakrzewień, dwóch zbiorowisk budowanych w dominującej mierze przez antropofity: zb. *Reynoutria japonica* i *Che-*

lidonio-Robinietum. W wypadku ich wyłączenia z analiz najwyższa wartość pokrycia antropofitów przestaje być związana z zaroślami, a dotyczy wysp leśnych, zaś najmniej zsynantropizowaną kategorią pozostają kompleksy leśne.

Wyniki uzyskane dla czterech podgrup wydzielonych w obrębie wysp leśnych wykazały najniższe wartości średniej liczby gatunków antropofitów i ich średniego pokrycia dla wysp o największej powierzchni (Tab. 22). Statystycznie istotna różnica (dla liczby i pokrycia antropofitów) potwierdzona została dla pary pierwsza–ostatnia podgrupa (najmniejsze–największe wyspy). Dowodzi to silniejszej synantropizacji płatów cechujących się niewielką powierzchnią w stosunku do wysp leśnych o największej powierzchni. Te ostatnie nawiązują poniekąd poprzez omawiane parametry znacznie bardziej do kompleksów leśnych niż wysp, do których zostały zaklasyfikowane.

Udział gatunków starych lasów liściastych w poszczególnych kategoriach krajobrazowych badanej roślinności

W celu potwierdzenia hipotezy wieloletniego trwania na swych historycznych stanowiskach lasów występujących w Dolinie Górnej Wisły porównano łączne pokrycie oraz liczbę gatunków reprezentujących grupę roślin starych lasów liściastych występujących w zdjęciach fitosocjologicznych podzielonych na wskazane wcześniej krajobrazowe kategorie roślinności. Przeprowadzona analiza nie wykazała istotnych statystycznie różnic pomiędzy poszczególnymi grupami ze względu na liczbę gatunków starych lasów – średnia wynosi 7,0–8,25 (Fig. 16). Wartość tę należy uznać za całkiem wysoką, co świadczy o trwałości przebadanych płatów leśnych na analizowanym obszarze i uprawnia do zaliczenia ich do grupy starych lasów. Ocena istniejących wysp leśnych przy użyciu opisanej metody w wielu wypadkach nie mogła niestety zostać zastosowana. Liczne obiekty nie zawierały bowiem leśnych zbiorowisk liściastych lub nie można było dokonać ich jednoznacznej klasyfikacji.

Podsumowanie wyników i wnioski

1. W wyniku badań fitosocjologicznych w Dolinie Górnej Wisły stwierdzono występowanie 12 zespołów i 4 zbiorowisk leśnych oraz 5 zespołów i 1 zbiorowiska zaroślowego. Reprezentują one łącznie 8 klas, 9 rzędów i 10 związków. W wypadku 3 zbiorowisk leśnych niemożliwe było ustalenie ich przynależności syntaksonomicznej.
2. Roślinność rzeczywista terenu badań znacznie odbiega od jego potencjalnej roślinności naturalnej. Większa różnorodność stwierdzona w obrębie fitocenoz leśnych, w tym obecność zbiorowisk o trudnej do ustalenia przynależności syntaksonomicznej oraz zbiorowisk tworzonych przez antropofity, jest przejawem antropogenicznego przekształcenia roślinności.
3. W wypadku znacznej części stwierdzonych jednostek analiza składu florystycznego zbiorowisk wykazała ich zubożenie w stosunku do bogactwa gatunkowego podawanego dla analogicznych syntaksonów z terenu Polski. Zjawisko to objawia się przede wszystkim brakiem gatunków charakterystycznych dla zespołów i wyższych jednostek fitosocjologicznych.
4. W obrębie zbiorowisk leśnych odnotowano występowanie wszystkich wyróżnionych przez Olaczka (1972, 1974a) form degeneracji, spośród których najczęściej występującymi aktualnie w Dolinie Górnej Wisły są cespityzacja i fruticetyzacja. Gatunkiem, którego ekspansja najczęściej przyczynia się do cespityzacji płatów jest turzyca drżączkowata *Carex brizoides*. Powszechne i łanowe występowanie tego gatunku jest powodem tak znacznych przekształceń fitocenoz, że niemożliwa jest ich klasyfikacja syntaksonomiczna (zb. *Pinus sylvestris*-*Carex brizoides*, zb. *Quercus robur*-*Carex brizoides*, częściowo zb. *Alnus glutinosa*).
5. W trakcie analizy danych dostrzeżono istotne problemy metodologiczne związane z wykorzystaniem zaproponowanego przez Olaczka (1972, 1974a) systemu faz degeneracji. System ten został zmodyfikowany, a uzyskane w ten sposób wyniki posłużyły określeniu stanu zachowania płatów w obrębie poszczególnych zbiorowisk i grup zbiorowisk o podobnym charakterze.

6. Ocena udziału antropofitów wykazała największą ich rolę w zbiorowiskach ksenospontanicznych. Spośród fitocenoz naturalnych największe znaczenie gatunki obce posiadają w grupie zbiorowisk łęgowych: *Salicetum albo-fragilis*, *Populetum albae*, *Salicetum triandro-viminalis* i *Fraxino-Alnetum*. Wynika to z ich znacznej fragmentacji, wpływu nasilonej antropopresji i zaburzeń naturalnych ułatwiających wnikanie antropofitów.
7. Uwzględniając krajobrazowe zróżnicowanie roślinności na kompleksy leśne, wyspy leśne i zakrzewienia, wykazano najmniejszy udział antropofitów w płatach wchodzących w skład kompleksów. Wyniki uzyskane dla różnych kategorii wielkościowych wysp leśnych dowiodły silniejszego podobieństwa enklaw o największej powierzchni (50,5–150,0 ha) do kompleksów niż do pozostałych wysp leśnych.
8. Analiza udziału gatunków starych lasów liściastych w zbiorowiskach z klasy *Querco-Fagetea* wykazała brak istotnych różnic pomiędzy fitocenozami kompleksów oraz wysp leśnych reprezentujących różne kategorie wielkości. Średnia liczba gatunków tej grupy w badanych płatach wynosi w przybliżeniu 8, co wraz z wnioskami wynikającymi z analiz kartograficznych wskazuje na trwałe występowanie przebadanych lasów na zajmowanych powierzchniach, upoważniające do określenia ich mianem starych lasów.
9. Gospodarcze użytkowanie lasów oraz zabiegi powodujące zmianę stosunków wodnych (związane bądź to z gospodarką leśną, bądź też gospodarką wodną) są głównymi czynnikami powodującymi przekształcanie roślinności leśnej i zaroślowej Doliny Górnej Wisły.
10. Leśne wyspy środowiskowe o zróżnicowanej wielkości pełnią w krajobrazie silnie przekształconym przez człowieka bardzo ważną rolę. Na terenie Doliny Górnej Wisły niektóre zbiorowiska pierwotnie powszechnie występujące, zajmujące najżyźniejsze siedliska, obecnie ograniczone zostały w znacznej mierze do powierzchni wysp leśnych (np. grąd subkontynentalny *Tilio-Carpinetum*) lub bardzo wąskich, pasowych układów (np. nadrzeczne łęgi wierzbowe i topolowe *Salicetum albo-fragilis* i *Populetum albae*). Ochrona wciąż istniejących enklaw leśnych z udziałem tych zbiorowisk jest więc zagadnieniem szczególnie istotnym.
11. Istniejące formy ochrony przyrody wobec stopnia synantropizacji roślinności mezoregionu w niewystarczającym stopniu zabezpieczają przed potencjalną utratą wartości zachowane do dnia dzisiejszego naturalne układy leśne. Wskazane jest powołanie nowych obszarów chronionych, na których prowadzony będzie monitoring przyrodniczy mający na celu rozpoznanie aktualnych zagrożeń, poprawę stanu środowiska przyrodniczego oraz zapobieganie dalszej synantropizacji szaty roślinnej.

Photo-documentation

Photo 1. The Vistula River in Strumień

Photo 2. The Goczałkowice Reservoir

Photo 3. The Skawa River in Zator

Photo 4. The landscape of the western part of the Upper Vistula River

Photo 5. Czechowice-Dziedzice – an example of urbanisation in the Upper Vistula Valley

Photo 6. The Silesia mine in Czechowice-Dziedzice

Photo 7. A typical patch of an oak-hornbeam forest in the "Żaki" Nature Reserve

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Photo 9. A well-preserved patch of *Tilio-Carpinetum* in the “Przeciszów” Nature Reserve

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Photo 11. A middle-European alder fen forest in Brzeszcze – proposed nature and landscape complex

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Photo 15. A patch of the *Salicetum albo-fragilis* in the Soła River that is dominated by *Rudbeckia laciniata*

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Photo 17. A patch of *Salicetum albo-fragilis* with *Robinia pseudoacacia* in the Soła River Valley

Photo 18. *Impatiens glandulifera* and *Echinocystis lobata* in the *Salicetum triandro-viminalis* patch in the Soła River Valley

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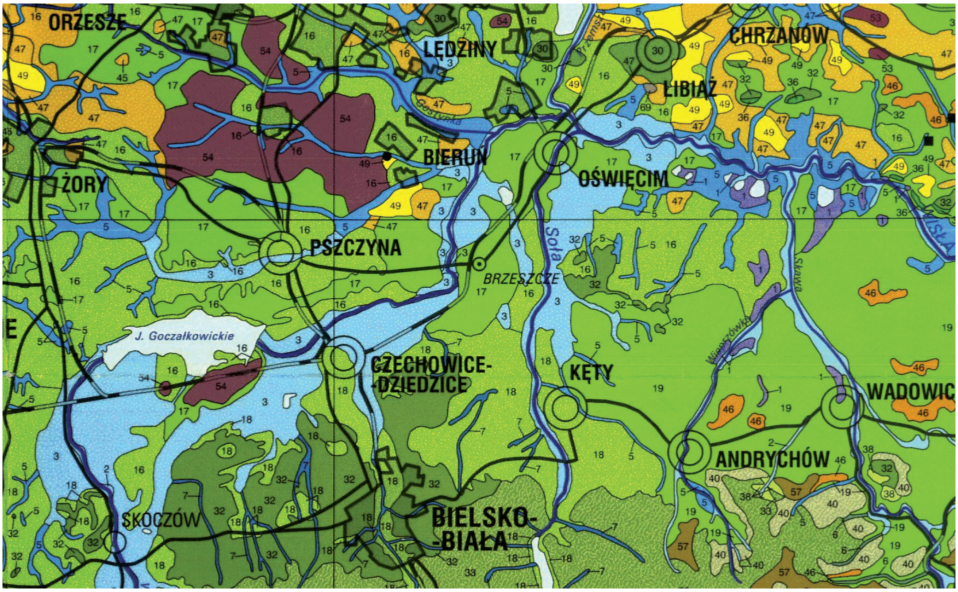

Fig. 6. A map of the potential natural vegetation of the Upper Vistula Valley

Source: Matuszkiewicz W., Faliński J. B., Kostrowicki A., Matuszkiewicz J., Olaczek R., Wojterski T. 1995. Potencjalna roślinność naturalna Polski. Mapa przeglądowa 1:300 000, Arkusz 11. Wyżyna Śląska, Beskidy Zachodnie i Tatry. PAN IGiPZ, Warszawa.

Explanations: **1**. Middle-European alder fen forest (*Ribeso nigri-Alnetum* and *Sphagno squarrosi-Alnetum*) – Ols środkowoeuropejski; **2**. Lowland willow-poplar floodplain forest; regularly flooded – (dynamic complex of *Salici-Populetum*, *Salicetum triandro-viminalis* etc.) – Niżowe nadrzeczne łęgi wierzbowo-topolowe w strefie zalewów periodycznych (kompleks dynamiczny *Salici-Populetum, Salicetum triandro-viminalis*); **3**. Lowland ash-elm floodplain forest; occasionally flooded (*Ficario-Ulmetum typicum*) – Niżowe nadrzeczne łęgi jesionowo-wiązowe w strefie zalewów epizodycznych; **5**. Lowland alder and ash-alder forest on periodically swamped ground-water soils (*Fraxino-Alnetum*) – Niżowe łęgi olszowe i jesionowo-olszowe siedlisk wodogruntowych, okresowo lekko zabagnionych; **16–18**. Subcontinental submontane lime-oak-hornbeam forest (*Tilio-Carpinetum*); Lesser-Poland-vicariant with beech, fir and spruce – Grądy subkontynentalne lipowo-dębowo-grabowe, odmiana małopolska z bukiem i jodłą; **30**. Submontane forb-rich sudetian beech forest (*Dentario enneaphylli-Fagetum*) – Żyzna buczyna sudecka; **32**. Submontane forb-rich carpathian fir-beech forest (*Dentario glandulosae-Fagetum*) – Żyzna buczyna karpacka; **36**. Calciphilous and subthermophilous beech forests with many orchid species in the undergrowth (*Cephalantero-Fagenion*) – Wapieniolubne buczyny storczykowe; **45**. Middle-European lowland acidophilus oak forest (*Calamagrostio-Quercetum petraeae*) – Niżowa dąbrowa acydofilna typu środkowoeuropejskiego; **46**. Submontane Middle-European acidophilus oak forests (*Luzulo-Quercetum petraeae*) – Podgórska dąbrowa acydofilna typu środkowoeuropejskiego.; **47**. Continental mesotrophic oak-pine mixed forest (*Querco roboris-Pinetum* and *Serratulo-Pinetum*) – Kontynentalne bory mieszane; **49**. Suboceanic Middle-European pine forest in a complex of fresh (*Leucobryo-Pinetum*), dry (*Cladonio-Pinetum*), wet (*Molinio-Pinetum*) – Suboceaniczne śródlądowe bory sosnowe w kompleksie boru świeżego, suchego i wilgotnego; **53**. Continental bog pine forest (*Vaccinio uliginosi-Pinetum*) – Kontynentalny bór bagienny; **54**. Submontane moist spruce pine forest (*Calamagrostio villosae-Pinetum*) – Podgórski wilgotny bór trzcinnikowy; **69**. Devastated environment vegetation, succesion unknown and areas without vegetation – Roślinność środowisk zdewastowanych o nieznanej tendencji sukcesyjnej, obszary pozbawione roślinności.

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