

IMPACT OF WOODLAND ISLANDS ON SPECIES RICHNESS
IN JAWORZNO TOWN AND PROBLEM OF THEIR CONSERVATION

DAMIAN CHMURA

Instytut Ochrony Przyrody Polskiej Akademii Nauk, al. Adama Mickiewicza 33, 31-120 Kraków

Keywords: forest islands, biodiversity, nature conservation, Jaworzno.

WPLYW REMIZ LEŚNYCH NA BOGACTWO FLORY W JAWORZNIE
I PROBLEM ICH OCHRONY

Artykuł przedstawia wyniki badań przeprowadzonych w latach 1995–2002 w 10 wybranych wyspach leśnych położonych w strefie podmiejskiej Jaworzna. Badane obiekty to między innymi: pozostałości lasów gądownych lub nasadzenia sosny i modrzewia na siedlisku murawy kserotermicznej. W porównaniu z florą całego miasta udział gatunków niesynantropijnych i grup synekologicznych związanych z naturalnymi siedliskami jest znacznie wyższy. Pomimo wielkiego zróżnicowania są one cennymi ostojami wielu gatunków zarówno leśnych, murawowych i łąkowych występujących w ich obrębie i otoczeniu.

Summary

The paper presents the results of field studies carried out in 10 chosen forest islands in a suburban area of the town of Jaworzno in the years 1995–2002. Different objects have been studied, among others: natural remnants of oak-hornbeam forest and planted pine-larch woodlots cultivated on the habitat of xerothermic grasslands. In comparison with the total flora of the town, the participation of non-synantropic species and synecological groups associated with natural habitats is much bigger. There are 24 protected species to be found, 40% of protected flora of the town. Despite their diversity, they are precious refuges of many woodland and grassland as well as meadow species occurring within the areas and in their vicinity.

INTRODUCTION

The role of forest islands and mid-field woodlots in proper functioning of nature as well as advantages for man, have been mentioned in literature many times [1, 12]. Therefore remnants of ancient woods or secondary woodlots caused by spontaneous succession or planting should be protected. The purpose of this work is to show the significance of forest islands as refuges of many rare and endangered species, to introduce actual state and diversity of flora of these objects against the background of the whole town, to qualify the role and the need for preservation of forest islands in urban landscape exemplified by Jaworzno.

MATERIAL AND METHODS

Study area

Jaworzno is a medium-size town (area 152.2 km², population near 100,000) situated in the Silesian Upland. The geomorphological structure of this area is complex. The town lies within the lower subunit – Jaworzno Hills (Pagóry Jaworznickie), which are typified by many heights and wide depressions. The northern and western borders of the town are marked by rivers: the Biała Przemsza and the Przemsza. The elements of geological structure are mainly Carboniferous (conglomerates, sandstones, coal shales) and Triassic formations (clays, sandstones, limestones and dolomites). Since the beginning of mineral extraction (zinc, silver and lead ores) in the 13th century processes of environmental transformation had started and later became more intense as a result of development of urbanization and industrialization.

Nowadays, the town structure is a “city-skeleton” – the centre of the town with districts around it. The suburban zone resembles even an agricultural landscape. Apart from buildings, settlements, arable fields and wastelands there is no lack of forest islands, mid-field woodlots – natural and anthropogenic in nature [17].

Origin of forest islands

Ten objects differing in an area, shape and size were chosen for the investigation (Fig. 1, Tab. 1):

- Objects (1–5) – a complex of 5 planted pine-larch or birch naturally established woodland islands, close to quarry in the vicinity of “Góra Sodowa” (Fig. 1B), on habitat of fresh pine wood and mixed forest.
- Object no. 6 – woodland island “Bucze” – a remnant of hornbeam forest on dolomite slope;
- Object no. 7 – “Pod Leszczyną” European hazel-hornbeam woodland island with an admixture of planted larch;
- Object no. 8 – “Góra Przygoń” – pine woodland on habitat of oak-hornbeam forest on the highest hill within the town;
- Object no. 9 – “Góra Grodzisko” – a mixed forest about 350 m a.s.l. It is surrounded by arable fields, meadows, situated in Jaworzno-Bory;
- Object no. 10 – “Wzgórze Korzeniec” – anthropogenic beech wood on habitat of oak-hornbeam forest in Cezarówka Dolna.

Data collection

The studies were conducted during the period between 1995–2002 [3–5]. The data were completed from literature [16–18]. In the years 1995–1997 and 2002 a geobotanical survey of chosen objects was carried out. The field investigations comprised: collection of herbal material, mapping of flora and phytosociological relevés according to Braun-Blanquet method. The distinguished objects and their neighbourhood with the width of 30 meters from the forest edge were examined. In the vicinity, fragments of xerothermic grasslands, meadows, fallows and ruderal sites were found. Based on division of species into sociological-ecological groups after Jackowiak flora of woodland islands was analyzed [9]. Participation of species into geographical-historical groups was given after Jackowiak and Kornaś [9, 10].

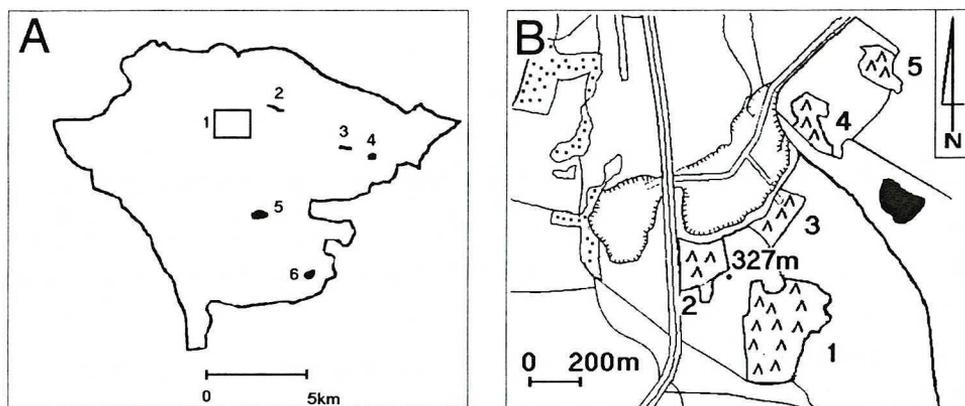


Fig. 1A. Localisation of the studied forest islands on the territory of Jaworzno. 1 – complex of forest islands in the neighbourhood of Góra Sodowa, 2 – Bucze, 3 – Pod Leszczyną, 4 – Góra Przygoń, 5 – Góra Grodzisko, 6 – Wzgórze Korzeniec. 1B. Numeration of forest islands in neighbourhood of Góra Sodowa

Table 1. Parameters of forest islands

Object	Area (ha)	Species number A+B	Species number A	Species number B	Species number C	Species number I	Vicinity
1	10	144	42	102	40	17	m, g, q, a
2	3,4	103	41	62	39	17	m,g, q, a, r
3	2,3	87	21	66	18	8	g, q, a
4	2,4	107	35	66	12	8	g, q, a
5	2	83	25	58	22	9	g, a
6	4,5	152	77	75	28	30	g, w, a, q, r
7	4,8	110	48	62	28	22	g, r, a, m
8	5,5	105	35	70	23	14	g, r, m
9	12,7	123	65	58	70	18	g, m
10	12,5	104	52	52	25	15	a, r, m, g

Explanations: Comparison of forest islands floras. Species number: A – species recorded only within objects, B – species recorded within objects and in surroundings, C – species in vicinity non-penetrating forest islands; I – ancient woodland plant species indicators; Vicinity: g – grasslands, m – meadows, q – quarry, w – wastelands, a – arable fields, r – ruderal habitats (dumping site)

In chosen woodlands the mapping of sites of protected and rare species was made. Next, their resources on the basis of scale of number of specimens proposed by Bernacki were estimated [2]. Classes of number of specimens were given according to the following scale: I – 1–3 specimens, 2 – 4–10; III – 11–30; IV – 31–100; V – 101–300; VI – 301–1000; and so on. If the number of shoots (specimens) did not exceed 100 they were precisely calculated, otherwise resources were valued. The species list was given in an alphabetical order in three groups: (1) strictly protected species, (2) partially protected species, [15] (3) rare species [13, 20]. For each species the number of particular woodland island and appropriate class of number of specimens were given. For some species a date of last record was given. The rest without a date reflects contemporary state.

RESULTS

Analysis of life forms and geographical-historical groups

In the examined woodland islands and in their adjacent areas 395 vascular plants species of 976 of total town flora were confirmed [17]. The spectrum of Raunkiaer's life forms of the flora of the chosen objects indicates the prevalence of hemicryptophytes over remaining groups of species (Fig. 2A). Successively, therophytes, geophytes, phanerophytes as well as chamaephytes were noted. This situation does not differ too much from the participation of these groups in native flora in our climatic zone [8]. The indigenous flora of woodland islands includes: 228 spontaneophytes (57.8%) and 100 apophytes (25.4%). Among antropophytes, 37 species are archaeophytes (9.4%), kenophytes (neophytes) – 23 species (5.8%) and diaphytes (not established species) only 6 species (1.5%). In comparison with the total flora of the town, native non-synanthropic species preponderate, distinctly there are fewer native synanthropic species – apophytes. However, contribution of alien species (anthropophytes): archaeophytes, kenophytes, and diaphytes, is similar (Fig. 2B).

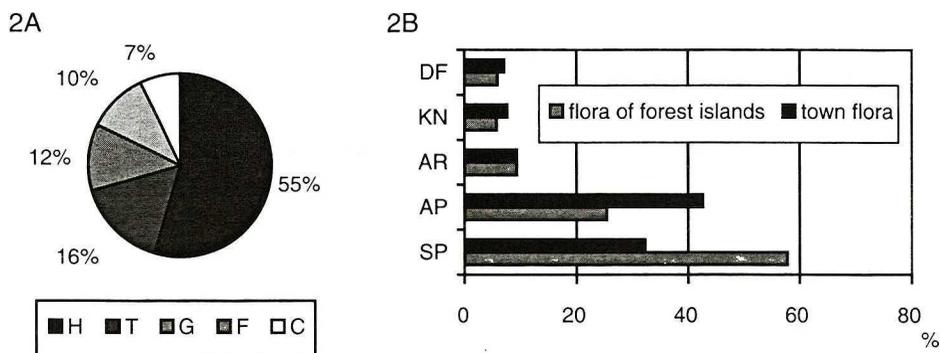


Fig. 2A. Participation of Raunkiaer's life forms in flora of examined forest islands. 2B. Comparison of participation of geographical-historical groups in flora of chosen objects and the town. Explanations: H – hemicryptophytes, T – therophytes, G – geophytes, F – phanerophytes, C – chamaephytes, DF – diaphytes, AR – archaeophytes, KN – kenophytes (neophytes), AP – apophytes, SP – spontaneophytes.

Floristic comparison of the examined objects was made in relation to the total number of species recorded within them, the vicinity and species occurring both inside the objects and in the vicinity (Tab. 1). The average number of species in particular woodland islands amounts 111. The biggest number was confirmed in object no. 6 (“Bucze”) – 152. Also the biggest number of species confirmed only within woodland island was recorded there – 77. The smallest number of species was noted in objects 3 and 5 in the vicinity of “Góra Sodo-wa” i.e. 87 and 83 as well as fewest species occurring only inside the woodlands: 21 and 25. Most species from the vicinity, penetrating the woodland too, was recorded in object no. 1 – 102. This species number is larger than the number of species occurring only inside this woodland – 42. However, in object no. 9 (“Góra Grodzisko”) the biggest number of species in the vicinity not penetrating woodland was observed – 70.

Presence of ancient woodland plant species indicators

In the studied woodland islands the total number of ancient woodland plant species indicators 148 was confirmed [7]. Their biggest contribution is found in object no. 6 – 30 species. Other woodland islands abundant in these species are: woodland no. 7 (22 species), woodland no. 9 (18 species), and woodlands 1 and 2 (17 species). The fewest species were noted in forest islands no. 3, 4 and 5 (Tab. 1). The average numbers 14 and 15 were observed in objects 8 and 9.

Participation of sociological-ecological groups

In the examined woodland fragments most woodland species were confirmed. Among them species of deciduous and shrub communities make the biggest contribution (“Pod Leszczyną”, “Bucze” and woodland island no. 2 close to “Góra Sodowa”).

The phytosociological survey revealed the presence of patches from alliance *Carpinion-Betuli* resembling plant association *Tilio-Carpinetum* in woodland islands (no. 6 and 7) (Fig. 3). In the complex of woodlands on “Góra Sodowa” objects: 1, 3, 4, 5 have most species from the *Festuco-Brometea* and *Trifolitea-Geranietea* class (Fig. 3). The mentioned woodland islands are situated on the border of quarry and in their vicinity there are xerothermic grasslands.

The xerothermic grasslands communities occur also on clearings. Species of fresh and moist meadows (*Molinio-Arrhenatheretea*), found in the vicinity, make a large contribution, too. As to “Góra Grodzisko” (object 9) deciduous and shrub communities species are also numerous, species of pine and mixed forest as well as species of communities replacing them, clear-cut areas, grassland (*Quercion, Epilobion, Nardetalia*) make a huge contribution too. It is due to the fact, that the tree stand of the object is composed mainly of pine trees with admixture of deciduous species (Fig. 3).

In “Wzgórze Korzeniec” (object 10) the most numerous species are from group 4 (*Festuco-Brometea, Trifolio-Geranietea*), despite the fact that it is an anthropogenic beech wood on oak-hornbeam forest. Well developed patches of forest edge communities from alliance *Geranion sanguinei* were observed there. Similar communities plentiful in species richness were noted in objects: 6, 7, 8 and 9. In remaining woodland islands in the surrounding of “Góra Sodowa” – 1, 2, 3, 4, 5 dominated species from alliance *Trifolion medii*. Of synanthropic communities species from thermophilous, long-lived ruderal communities as well as root crop weed communities (*Polygono-Chenopodietea*) were recorded. Their presence is determined by the vicinity – in some arable fields root plants are cultivated and some are fallows (Fig. 3).

Analysis of resources of protected and rare plants

In total woodland islands covering about 54.6 ha 24 protected species which is 40% (59 species) of total protected flora of the town. Five species have only one locality within the town, in examined woodlands. They are: *Cephalanthera damasonium*, *Pulsatilla patens*, *Digitalis grandiflora*, *Ornithogalum umbellatum*, *Melitis melisophyllum* (Tab. 2). Altogether the data of 117 local populations were gathered, but against a background of a grid of ATPOL with division into basic fields: squares with a side of 1 kilometre [22]

there are 108 localities in 7 squares. This is above 20% of total localities of protected species within the town. However, on the territory of the town there are 658 localities of protected plant species in 131 squares [16–18]. Comparing mean numbers of protected species in 1 square, there are: 15.4 species per 1 km² in examined objects and 4.9 species per 1 km² – in all basic fields of the town where protected species were confirmed.

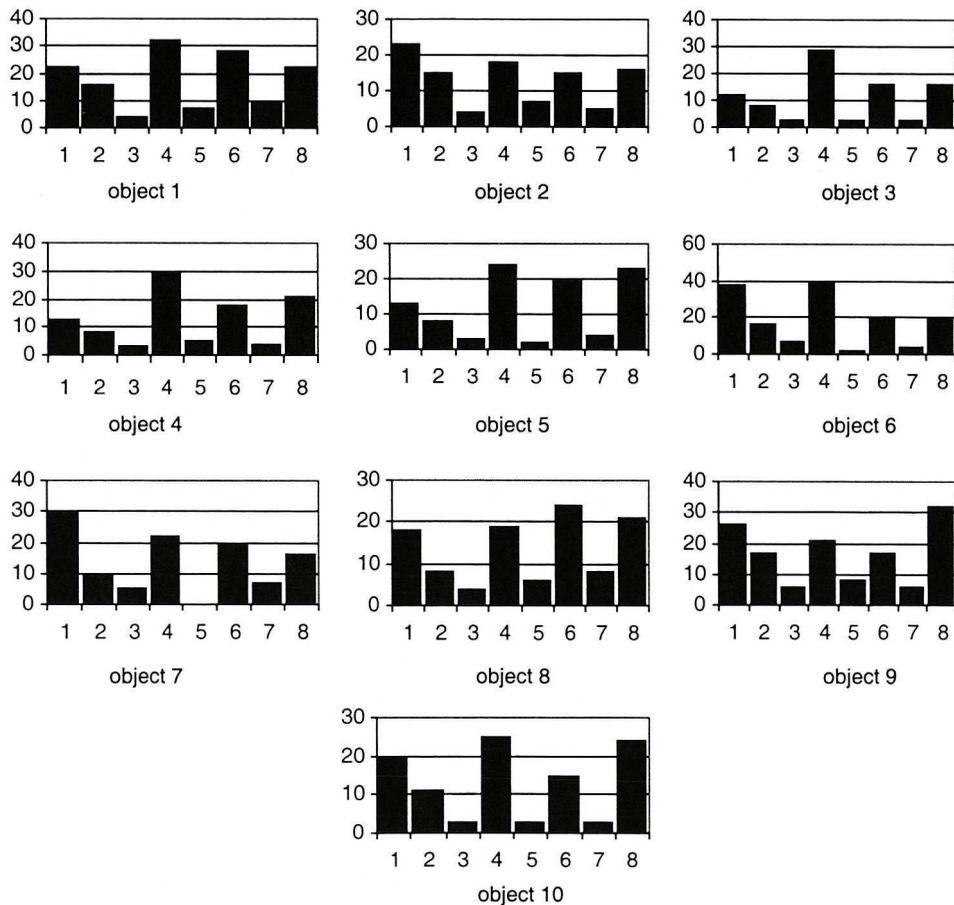


Fig. 3. Participation of species of sociological-ecological groups in forest islands

Explanations: 1 – eutrophic deciduous forests and scrub communities species, 2 – acid oak and mixed coniferous forests, 3 – nitrophilous brushwood and edge communities, 4 – thermophilous communities, edge of forest and xerothermic grassland communities, 5 – wet meadows, brushwood and forests of wetlands, rush and water communities, 6 – fresh and moist meadows, 7 – nitrophilous grasslands and tramled communities, 8 – rest of species

Of woodland islands the most strictly protected plants species – 6 were recorded in object no. 6, successively in woodlands no. 1 and 7 – respectively 5 and 4 species. However, in the remaining objects this number does not exceed 3 (Fig. 4). Objects 1 and 6 are also rich in partially protected species – 5 species. Only in woodland no. 9 there is more – 6. In the case of rare species, woodland island no. 6 has most of them. Another abundant in rare species is object no. 1. Taking all species into consideration, it is the woodland

“Bucze” which is the most affluent in protected and rare species. Next is the biggest woodland fragment of “Góra Sodowa” – object 1. The object no. 5 also of the surroundings in “Góra Sodowa” has the fewest species.

Table 2. A list of protected species and their resources

Species	No. of object									
	1	2	3	4	5	6	7	8	9	10
Strictly protected species										
<i>Aquilegia vulgaris</i> L.								I		
<i>Carlina acaulis</i> L.	III		II	III	III	IV	III			
<i>Cephalanthera damasonium</i> MILL. (DRUCE)						II				
<i>Dactylorhiza majalis</i> (RCHB.) P. F. HUNT & SUMMERH.									III	
<i>Daphne mezereum</i> L.										I
<i>Digitalis grandiflora</i> MILL.		II								
<i>Epipactis atrorubens</i> (HOFFM.) BESSER	III	II				III				
<i>Epipactis helleborine</i> (L.) CRANTZ	III					IV		III	III	III
<i>Gentianella germanica</i> (WILD.) BÖRNER			III	IV						
<i>Hedera helix</i> L.						VI	VI			
<i>Lilium martagon</i> L.						III	III	III		
<i>Pulsatilla patens</i> (L.) MILL. (1998)	IV									
<i>Tofieldia calyculata</i> (L.) WAHLENB.							II			
Partially protected species										
<i>Asarum europaeum</i> L.						III	III			
<i>Centarium erythraea</i> RAFN								III		II
<i>Convallaria maialis</i> L.	IV	IV				IV	IV	IV	IV	
<i>Dianthus carthusianorum</i> L.	II		III	III				II	IV	
<i>Dianthus deltoidem</i> L.				II				I	III	
<i>Frangula alnus</i> MILL.	III									I
<i>Hepatica nobilis</i> SCHREB	III	IV	II	III	III	V	VI	V	V	VII
<i>Melitis melisophyllum</i> L. (1997)						I				
<i>Ononis spinowa</i> L.	I	II				III				
<i>Primula veris</i> L.	IV	III	IV							
<i>Viburnum opulus</i> L.							I			
Rare species in Upper Silesia										
<i>Anthericum ramosum</i> L.	IV		VI	VI	VI	III		V		
<i>Carex pilulifera</i> L.	VI	VI				V				
<i>Crepis praemorsa</i> (L.) TAUSCH						III				
<i>Laserpitium latifolium</i> L.	II					II				
<i>Prunella grandiflora</i> (L.) SCHOLLER	IV	IV	V	V	VI	IV	IV	IV	V	IV

Explanations: I-VII – see: material and methods

Participation of montane species

Eight species treated as mountain species were observed in the studied woodlands [23]. They are: *Cardaminopsis halleri* – woodland no. 1, *Chamaenerion palustre* – woodland no. 2, *Gentianella germanica* – woodlands: no 3 and 4, *Petasites albus* – woodland no.

9, *Polygala amara* subsp. *brachyptera* – woodlands no: 1, 3, 4, 5, *Sambucus racemosa* – woodland no. 9, *Senecio fuchsii* – woodland no. 9, *Valeriana sambucifolia* – woodland no. 10. Six mentioned species occur frequently in lowlands, among others: *Cardaminopsis palustre* growing on dumping sites and quarries as well as waste-heaps. *Valeriana sambucifolia* appears in moist places, however, *Sambucus racemosa* and *Senecio fuchsii* are forest and shrub species. The remaining taxa are rare: *Gentianella germanica* is a strictly protected plant, *Polygala amara* is a species associated with limestone.

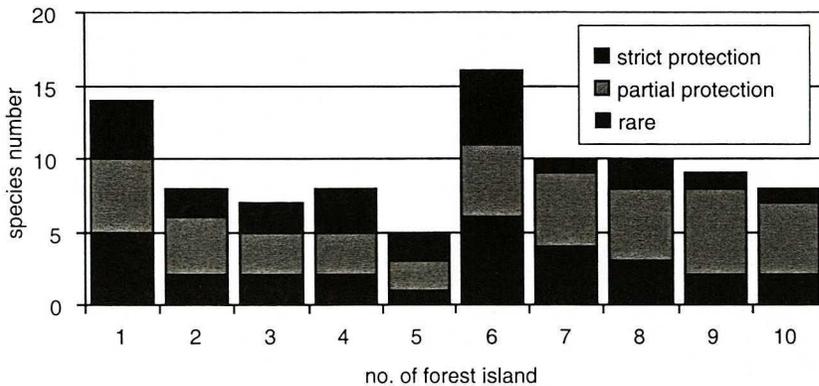


Fig. 4. Comparison of the number of protected and rare species in examined forest islands

Significance for nature conservation

Some described objects are proposed to be under protection as ecological use areas: a woodland island “Bucze” [3, 4, 19], the hornbeam-European hazel woodland island “Pod Leszczyną” and “Góra Przygoń” [19]. In the area of the largest woodland on “Góra Sodowa” there is a nature monument founded for the protection of the stand of eastern pasque flower *Pulsatilla patens* [5]. This complex of woodlands is proposed as special area of conservation according to Habitats Directive, as well as the species which are listed in this document [11].

DISCUSSION

The results of studies confirmed the literature data about the significance of the origin of forest islands for biodiversity [6], in this case for the flora. The majority of woodland species, amongst geophytes, were recorded in object no. 6 or remnant of oak-hornbeam forest. There most of species occurring within woodland, not found in the vicinity, were observed. This woodland island with regard to habitat and localisation (dolomite hill) has not been exploited in agricultural way. Thus, it maintained its natural character. It has been proved, among others, by huge participation of woodland species especially ancient woodland species indicators. Similar relations are to be found in woodlands 7 and 8 as well as in 9 and 10 but not to such high extent. In remaining objects many grassland, meadow and synanthropic species were encountered. The contribution

of grassland and meadow species in woodlands, which are birch loose woodlots, was the greatest. The comparison of floristic composition of the vicinity and ecotone as well as inside woodlands shows the large contribution of species of vicinity in the flora of these objects. These woodland islands are featured by (though irregular) increase of number of species together with the increase of area. The results obtained are similar to those in the studies conducted in Mazury [21].

In nature conservation, the goal is usually to maximize the number of species per area, especially, protected species [14]. Woodland islands, principally those of natural origin comply with these requirements. In agricultural or suburban landscape they are sometimes the only fragments of ecosystems, ecological corridors, refuges of fauna and flora. Their ecotones also play a major role – they enrich biodiversity. The examined objects occur on limestone soils which are favourable to development of mid-field woodlots *Rhamno-Prunetea* or patches of communities from class *Trifolio-Geranietea* in the ecotone of analyzed woodland islands. For instance, such rare species like *Crepis praemorsa*, *Laserpitium latifolium* were confirmed in object no. 6.

CONCLUSIONS

1. Woodland islands situated in suburban landscape might be sometimes the only refuges of natural vegetation. Contribution of non-synanthropic species is smaller here and the spectrum of life forms is similar to a natural one. The character of suburban woodland islands in relation to their state and vicinity do not differ too much from those described in agricultural landscape.
2. Within woodland islands and in their neighbourhood there are many species, among others protected and rare, susceptible to anthropogenic pressure.
3. Forest fragmentation may lead to the formation of complex systems, mixtures of different types of habitats and plant communities which influence the enrichment of vegetation cover.
4. Spatial planning should include woodland islands occurring in suburban zone in order to maintain local biodiversity.

REFERENCES

- [1] Banaszak J.: *Ekologia wysp leśnych*, Wyd. WSP, Bydgoszcz 1998.
- [2] Bernacki L.: *Materiały do atlasu rozmieszczenia oraz stanu zasobów roślin chronionych i zagrożonych rejonu górnośląskiego – PRES Część 3. Dactylorhiza majalis (RCHB.) P. F. HUNT et SUMMERH. (Orchidaceae)*, Acta Biol. Sil., Katowice, **52**, 95–112 (1998).
- [3] Chmura D.: *Flora naczyniowa remiz leśnych i zarośli śródpolnych w strefie podmiejskiej miasta Jaworzna*, Praca magisterska Wydział Biologii i Ochrony Środowiska, Uniwersytet Śląski, Katowice 1997.
- [4] Chmura D.: *Projekt użytku ekologicznego „Bucze” w Jaworznie – Szczakowa*. Kształtowanie środowiska geograficznego i ochrona przyrody na obszarach uprzemysłowionych i zurbanizowanych”, UŚ WBIOS WNoZ Katowice - Sosnowiec, **27**, 30–34 (1999).
- [5] Chmura D.: *Zagrożenia lokalnych populacji sasanki otwartej Pulsatilla patens L. (MILL) na przykładzie stanowiska na Górze Sodowej*, Chron. Przyr. Ojczystą, **59**(5), 14–27 (2003)
- [6] Dzwonko Z., S. Loster: Species richness of small woodlands on the western Carpatian foothills, Vegetatio, **76**, 15–27 (1988).
- [7] Dzwonko Z., S. Loster: Wskaźnikowe gatunki roślin starych lasów i ich znaczenie dla ochrony przyrody i kartografii roślinności, Typologia zbiorowisk i kartografia roślinności w Polsce, Prace Geograficzne, **178**, 119–132 (2001).

- [8] Falińska K.: Ekologia roślin, PWN, Warszawa 1997.
- [9] Jackowiak B.: Antropogeniczne przemiany flory roślin naczyniowych Poznania, Uniw. im. A. Mickiewicza w Poznaniu, Poznań 1990.
- [10] Kornaś J.: Oddziaływanie człowieka na florę: mechanizmy i konsekwencje, *Wiad. Bot.* 25, 165–182 (1981).
- [11] Makomaska-Juchiewicz M., J. Perzanowska, K. Zając: Dyrektywa Siedliskowa – występujące w Polsce gatunki ważne dla Wspólnoty Europejskiej, *Chroń. Przyr. Ojczystą*, 57(2), 5–60 (2001).
- [12] Oleszkiewicz D.: Zadrzewienia śródpolne, Green Park (Europejski Rok Ochrony Przyrody na zlec. MOŚZNIL), Warszawa 1994.
- [13] Parusel J., S. Wika, R. Buła (red.). Czerwona lista roślin naczyniowych Górnego Śląska, Raporty i Opinie, 1, 8–42 (1996).
- [14] Pyšek P., V. Jarošík, T. Kučera: Patterns of invasion in temperate nature reserve, *Biol. Conserv.*, 104, 13–24 (2002).
- [15] Rozporządzenie Ministra Środowiska z dnia 11.09.2001. w sprawie określenia listy gatunków roślin rodzimych dziko występujących objętych ochroną ścisłą i częściową oraz zakazów właściwych dla tych gatunków i odstępstw od tych zakazów, Dz. U. nr 106, poz. 1167, Warszawa 2001.
- [16] Tokarska-Guzik B.: Rozmieszczenie i zasoby roślin chronionych na terenie miasta Jaworzno, *Acta Biol. Siles.*, 47, 106–124 (1997).
- [17] Tokarska-Guzik B.: Atlas rozmieszczenia roślin naczyniowych w Jaworznie (Wyżyna Śląska), *Prace Botaniczne* 34, Instytut Botaniki UJ, Kraków 1999.
- [18] Tokarska-Guzik B.: Spatial differentiation in the flora of Jaworzno town (Silesia Upland), [w:] B. Jackowiak, W. Żukowski (red.): Mechanisms of anthropogenic changes of the plant cover, University of Adam Mickiewicz, Poznań 2000, 281–289.
- [19] Tokarska-Guzik B., A. Rostański, A. Herczek, J. Gorczyca, R. Dulias: Waloryzacja przyrodnicza miasta Jaworzna. Obszary o szczególnych wartościach przyrodniczych, Zakład Badawczo-Usługowy „Ekos” 1996.
- [20] Wika S.: Ochrona gatunkowa roślin w Polsce i w województwie katowickim w świetle nowej ustawy o ochronie przyrody, *Kształtowanie Środowiska Geograficznego. i Ochrona Przyrody na Obszarach Przemysłowych i Zurbanizowanych*, *WBIOS WNoZ UŚ*, Katowice - Sosnowiec 4, 26–31 (1992).
- [21] Wójcik Z., A. Wasiłowska: The vegetation of transition zones between forest islands and cultivated fields, [w:] E. Dąbrowska-Prot (red.): Forest islands in the landscape of Masurian Lakeland; Ecotones between forest and crop fields, *Ekol. Pol.*, 43, 7–50 (1994).
- [22] Zając A.: Założenia metodyczne „Atlasu rozmieszczenia roślin naczyniowych w Polsce”, *Wiad. Bot.*, 22(3), 145–155 (1978).
- [23] Zając M.: Mountain vascular plants in the Polish Lowlands, *Polish Botanical Studies*, 11, 1–92 (1996).

Received: April 7, 2003, accepted: January 7, 2004.