



“PUSZCZA SŁUPECKA” NATURE RESERVE NEAR WARSAW AS AN EXAMPLE OF A YOUNG FOREST ABUNDANT IN ANCIENT-FOREST SPECIES

IWONA DEMBICZ, PIOTR ZANIEWSKI, ŁUKASZ KOZUB

I. Dembicz, Department of Plant Ecology and Environmental Conservation, University of Warsaw, Al. Ujazdowskie 4, 00-478 Warszawa, Poland, e-mail: i.dembicz@biol.uw.edu.pl

P. Zaniewski, Department of Molecular Plant Physiology, University of Warsaw, ul. Miecznikowa 1, 02-096 Warszawa, Poland, e-mail: piotrzaniewski@biol.uw.edu.pl

Ł. Kozub, Department of Plant Ecology and Environmental Conservation, University of Warsaw, Al. Ujazdowskie 4, 00-478 Warszawa, Poland, e-mail: lukasz.kozub@biol.uw.edu.pl

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ABSTRACT. According to the “old forest indicator species” concept, the presence of many old forest indicator species suggests long ecological continuity of a patch of the forest. During the survey of the vascular flora of the “Puszcza Słupecka” Nature Reserve (Kotlina Warszawska Mesoregion, central Poland) 304 vascular plant species were recorded, including 58 species, which are indicators of ancient woodlands. Despite the fact that the area of the current “Puszcza Słupecka” Nature Reserve 70 years ago was covered by grasslands and ponds, the number of these species nowadays are similar to the number encountered in forests of a comparable size with preserved forest continuity. A few hypotheses may explain this phenomenon. Firstly, the reserve area could have had mid-field groups of trees, which had been refuges for undergrowth plants and which have become centers of expansion of these species in recent decades. Secondly, an important role could have been played by well-preserved oak-hornbeam and riparian forests in the neighbourhood and presence of a watercourse in the reserve.

KEY WORDS: vascular plants, forest flora, Puszcza Słupecka, indicators of ancient woodlands, old forest indicator species, forest continuity, nature reserve

INTRODUCTION

Due to the severe deforestation and introduction of modern forestry European broad-leaved forest became a rare habitat, which needs protection (SCHMIDER 1990, COUNCIL DIRECTIVE... 1992, ZERBE 2002). There is an urgent need to protect the best preserved forest communities, however some difficulties in the correct identification of considered patches appeared. In order to facilitate the assessment of the conservation status of particular forest patches, the “old forest indicator species concept” was introduced. The evaluation of quality of forest patches using vascular plants was presented by PETERKEN (1974) and developed as a list of 132 indicator species by HERMY *et al.* (1999). In Poland, the list of 155 species was published by DZWONKO and LOSTER (2001). According to the mentioned authors, the species meeting the criteria for “old forest indicator” must be strongly associated with the forest environment, exhibit low dispersal properties and weak ability to reproduce generatively. Such species tend to survive only in well preserved forest patches with a long ecological continuity. **It is still not clear** to what extent “old forest indicator species” really indicate long forest continuity (ROLSTAD *et al.* 2002).

The aim of the presented paper is to discuss, on a basis of the floristic inventory of a nature reserve, whether a forest without long forest continuity can host many of the “old forest indicator species”.

OBJECT OF RESEARCH

“Puszcza Słupecka” Nature Reserve was established by the decree of Minister of Environmental Protection, Natural Resources and Forestry on 31 December, 1993 (MP, 1994, No. 5, pos. 41) in order to protect forest communities. It occupies an area of 160.56 ha. It is located in the Kotlina Warszawska mesoregion (KONDRACKI 2002) in a relatively small forest complex of approximately 25 km² situated in the northwest of the Marki town in the Nieporęt municipality, Legionowo county. It is located within the ED07 square of the ATPOL cartogram (ZAJĄC 1978).

From the northwest the reserve borders with partly managed and partly abandoned, overgrowing wet meadows (Fig. 1 A). From the southeast it borders with wastelands of the Czarna Struga village, from the south with allotments, while in other places its boundaries are in contact with the forests of Drewnica Division

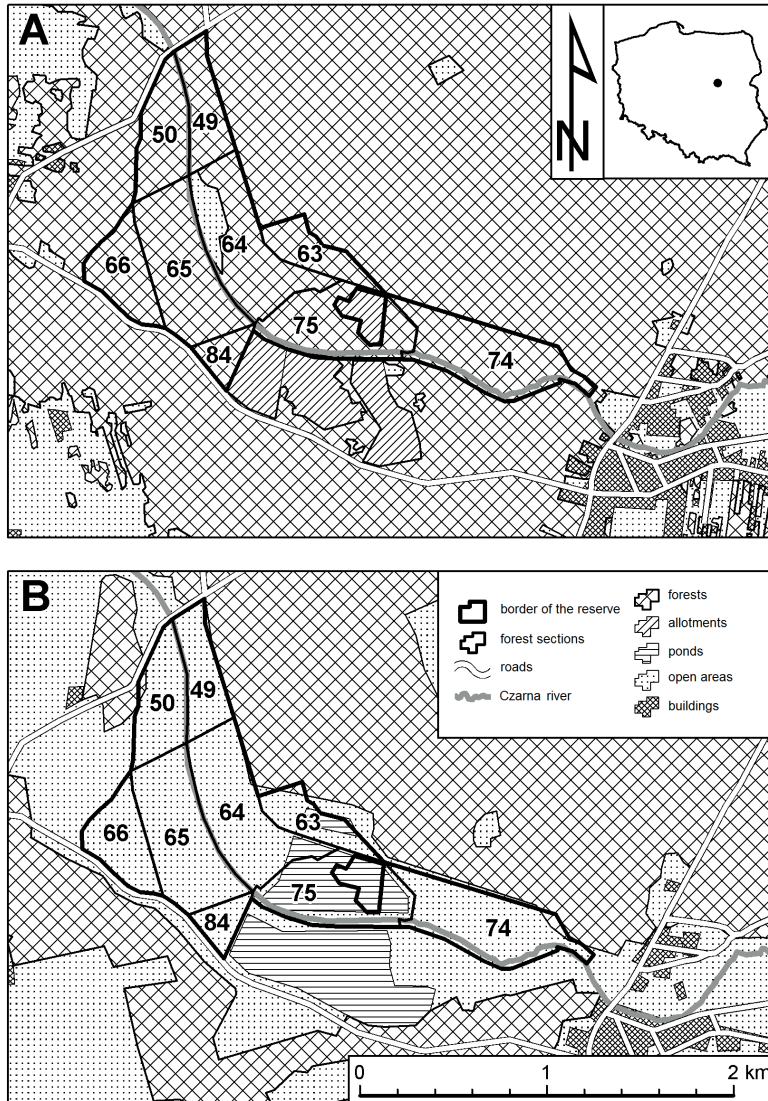


FIG. 1. Land use of the reserve and its nearest vicinity: A – present state, B – approx. 70 years ago

of the State Forests. A large part of the reserve edge is marked with the voivodeship road No. 632. An area of 4.8 ha of young planted forest present within the reserve is excluded from protection. At northern edge of the reserve runs on the embankment of a pre-war narrow gauge railway which was used to transport peat excavated in the past about 1 km north of the reserve. In the vicinity of the reserve, the “Łęgi Czarnej Strugi” nature reserve, established in 1980 to protect oak-hornbeam and elm-ash carr forests, is situated. One of its corners is located about 30 m from the south corner of the “Puszcza Słupecka” reserve.

The reserve area consists of the Czarna river valley and the dunes adjacent to the valley from the south-east. The elevation difference between the bottom of the valley and the tops of the dunes is about 5.5 m. A large part of the reserve is located within the Czarna river floodplain. This watercourse was straightened many years ago (MAPA TAKTYCZNA... 1933) but its riverbed is embankment exclusively outside the reserve. Within the reserve water can easily flood the area up to the edge of the dunes. For example in the summer of 2011

a large area of the valley (about 30 ha) was flooded up to a depth of about 0.5-1.0 m. The water outflow from the reserve is furthermore impeded by the embankment of the road Słupno-Stanisławów.

The past of the reserve has been very important for the development of its flora. Before World War II the area was almost entirely accounted for wet meadows and fish ponds (Fig. 1 B). At that time within the area of today's reserve only solitary trees occurred or in small groups. The only piece of the forest (of about 2 ha) was present on the northwest edge of the modern reserve area. Uniform forest areas began in a short distance to the east and south from the modern borders of the “Puszcza Słupecka” reserve (MAPA TAKTYCZNA... 1933).

Nowadays the vegetation of the reserve is dominated by forest communities. A significant area of the valley of the Czarna river is occupied by *Tilio-Carpinetum*, *Fraxino-Alnetum* and *Ribeso nigri-Alnetum*. There are also patches of vegetation that can be associated with the regenerating *Ficario-Ulmetum*. The dunes are mainly covered with coniferous forest communities such as *Quercu-Pinetum* and *Peucedano-Pinetum* but there are

also patches of *Tilio-Carpinetum*. Tree stands of the reserve originate partly from natural succession and partly from planting (pine, oak and additionally geographically alien spruce). Signs of coppicing are visible on some of the alders growing in wetlands. Fallen trees, some cut by beavers, and dead wood are abundant in the reserve. Near the riverbed still single specimens of the willow *Salix fragilis* are still present, which probably originated from the times when the reserve was occupied mainly by meadows. The small area of a meadow of about 4.8 ha is still present within the reserve. It is dominated by *Deschampsia caespitosa* and sedges (mainly *Carex acuta* and *C. acutiformis*). The meadow is also heavily penetrated by the wild boar and roe deer. During the survey moose has also been observed there.

The flora of the “Puszcza Słupecka” nature reserve has not been the topic of a separate publication yet, and the degree of knowledge about it was insufficient. Some data on the natural values of the reserve can be found on the Internet (e.g. PRZEWODNIK PO PUSZCZY SŁUPECKIEJ).

MATERIALS AND METHODS

Survey on the flora of vascular plants was carried out during the spring and summer of 2010 and spring of 2011. The study was conducted with topographic method (FALIŃSKI 1990). It included the entire area of the reserve evenly and all habitat types occurring within it. Data on the occurrence of the species were collected from floristic inventories. The names of vascular plant species and their status as anthropophytes follow MIREK et AL. (2002).

RESULTS

The flora of the vascular plants of the reserve consists of 304 species, including 237 dicotyledons, 57 monocotyledons, three gymnosperms and seven pteridophytes. There are 12 protected species, five of which are strictly protected and seven are under partial protection (ROZPORZĄDZENIE... 2004). One species is listed on the Polish “red list” of vascular plants (ZARZYCKI and SZELĄG 2006). Within the reserve borders 21 species alien to the Polish flora were found (ZAJĄC et AL. 1998, RUTKOWSKI 2006). 58 of the recorded species are considered as indicators of old forests (DZWONKO and LOSTER 2001)

List of species

Species are listed in alphabetical order within the classes. Following additional information is provided in the parentheses:

- the category from “red list”: V – an endangered species in isolated localities, outside the main area of distribution (ZARZYCKI and SZELĄG 2006);
- protection of species: S – strictly protected species, P – partially protected species (ROZPORZĄDZENIE... 2004);
- old forests indicator species: OF (DZWONKO and LOSTER 2001);
- species alien to the Polish flora: A (ZAJĄC et AL. 1998, RUTKOWSKI 2006);

- species recorded only outside the forest, in the meadow within the reserve: M;
- species recorded only on the forest edges, roadsides or borders of the reserve: E.

Equisetopsida

Equisetum pratense, *E. sylvaticum* (OF).

Polypodiopsida

Athyrium filix-femina (OF), *Dryopteris carthusiana* (OF), *D. filix-mas* (OF), *Polypodium vulgare* (S), *Pteridium aquilinum* (OF).

Pinopsida

Picea abies, *Pinus sylvestris*, *Taxus baccata* (S).

Magnoliopsida

Acer negundo (A), *A. platanoides*, *A. pseudoplatanus*, *Achillea millefolium*, *A. salicifolia* (M), *Acinos arvensis* (E), *Adoxa moschatellina* (OF), *Aegopodium podagraria* (OF), *Agrimonia eupatoria* (E), *Ajuga reptans* (OF), *Alliaria petiolata*, *Alnus glutinosa*, *Anemone nemorosa* (OF), *A. ranunculoides* (OF), *Angelica sylvestris*, *Anthriscus sylvestris*, *Arctium lappa* (E), *Artemisia absinthium* (E), *A. campestris* (E), *A. vulgaris* (E), *Asarum europaeum* (P, OF), *Berteroa incana* (E), *Betula pendula*, *B. pubescens*, *Bidens frondosa* (A), *Calluna vulgaris*, *Caltha palustris*, *Calystegia sepium*, *Campanula rotundifolia*, *Capsella bursa-pastoris* (E), *Cardamine amara*, *C. pratensis* (M), *Cardaminopsis arenosa* (E), *Carpinus betulus*, *Cerastium holosteoides*, *Chaerophyllum aromaticum*, *Chamaecytisus ratisbonensis*, *Chamomilla suaveolens* (A, E), *Chelidonium majus*, *Chenopodium album* (E), *Ch. polyspermum* (E), *Chrysosplenium alternifolium* (OF), *Circaea intermedia* (OF), *Cirsium arvense* (M), *Convolvulus arvensis* (E), *Conyza canadensis* (A, E), *Corydalis solida* (OF), *Corylus avellana*, *Crataegus rhytidophylla*, *Cuscuta europaea* (E), *Cytisus nigricans*, *Daphne mezereum* (S, OF), *Dianthus deltooides* (M), *Echinocystis lobata* (A), *Epilobium adenocaulon* (A, M), *E. montanum* (OF), *E. palustre* (M), *Erigeron annuus* (A, E), *Erophila verna* (E), *Erysimum cheiranthoides* (E), *Euonymus europaea*, *E. verrucosa*, *Eupatorium cannabinum*, *Euphorbia esula* (E), *Fallopia convolvulus* (E), *Ficaria verna* (OF), *Filipendula ulmaria*, *Fragaria vesca*, *Frangula alnus* (P), *Fraxinus excelsior*, *Galeobdolon luteum* (OF), *Galeopsis bifida*, *G. speciosa*, *G. tetrahit*, *Galinsoga ciliata* (A, E), *G. parviflora* (A, E), *Galium aparine*, *G. boreale*, *G. mollugo*, *G. schultesii* (OF), *G. uliginosum*, *Genista tinctoria*, *Geranium robertianum*, *Geum rivale*, *G. urbanum* (OF), *Glechoma hederacea*, *Gnaphalium sylvaticum* (E), *Hedera helix* (P, OF), *Helichrysum arenarium* (P, E), *Heracleum sphondylium*, *Herniaria glabra* (E), *Hieracium lachenalii* (E), *H. murorum* (OF), *H. pilosella*, *H. umbellatum*, *Hottonia palustris*, *Humulus lupulus*, *Hypericum perforatum*, *Hypochoeris radicata*, *Impatiens noli-tangere* (OF), *I. parviflora* (A), *Inula britannica* (M), *Isopyrum thalictroides* (OF), *Jasione montana* (E), *Lamium maculatum* (E), *L. purpureum* (A, E), *Lapsana communis* (E), *Lathraea squamaria* (OF), *Lathyrus pratensis* (M), *L. vernus* (OF), *Leontodon autumnalis* (M, E), *Linaria vulgaris* (E), *Lotus uliginosus* (M), *Lychnis flos-cuculi*, *Lycopus europaeus*, *Lysimachia nummularia*, *L. vulgaris*, *Lythrum salicaria*, *Malus domestica*, *M. sylvestris*, *Medicago falcata* (E), *M. sativa* (A, E), *Melampyrum nemorosum* (OF, E), *M. pratense* (OF), *Melandrium album*, *Mentha aquatica*, *M. arvensis* (M), *Mercurialis*

perennis (OF), *Moehringia trinervia* (OF), *Mycelis muralis* (OF), *Myosotis palustris*, *Myosoton aquaticum*, *Oenothera biennis* (E), *Oxalis acetosella* (OF), *Padus avium*, *P. serotina* (A), *Paris quadrifolia* (OF), *Parthenocissus inserta* (A, E), *Peucedanum oreoselinum*, *P. palustre*, *Pimpinella saxifraga*, *Plantago lanceolata*, *P. major*, *Polygonum aviculare*, *P. hydropiper*, *P. persicaria*, *Populus nigra*, *P. tremula*, *P. × canescens*, *Potentilla anserina*, *P. argentea* (E), *P. erecta* (M), *P. reptans* (M), *Prunella vulgaris*, *Prunus cerasifera* (A), *Pyrus communis* (A), *P. pyraster*, *Quercus petraea*, *Q. robur*, *Q. rubra* (A), *Ranunculus acris*, *R. auricomus* (OF), *R. flammula*, *R. repens*, *Raphanus raphanistrum* (E), *Rhamnus cathartica*, *Ribes nigrum* (P, OF), *R. spicatum* (OF), *Rorippa amphibia*, *Rosa* sp., *Rubus saxatilis*, *R. idaeus*, *R. plicatus*, *Rumex acetosa*, *R. acetosella*, *R. crispus*, *R. obtusifolius*, *R. thyrsoifolius*, *Salix caprea*, *S. cinerea*, *S. fragilis*, *Sambucus nigra*, *Saponaria officinalis* (E), *Scorzonera humilis*, *Scrophularia nodosa* (OF), *Scutellaria galericulata*, *Sedum acre* (E), *S. sexangulare* (E), *Selinum carvifolia*, *Senecio jacobea* (E), *S. vernalis* (E), *Silene nutans*, *S. vulgaris* (E), *Sisymbrium officinale* (A), *Sium latifolium*, *Solidago canadensis* (A), *S. gigantea* (A), *S. virgaurea* (OF), *Sorbus aucuparia*, *Spergula morisonii* (E), *Stachys palustris*, *S. sylvatica* (OF), *Stellaria graminea*, *S. holostea* (OF), *S. media*, *S. nemorum* (OF), *S. palustris*, *Succisella inflexa* (V, S, M), *Symphytum officinale*, *Tanacetum vulgare* (E), *Taraxacum officinale*, *Thalictrum flavum* (M), *Th. lucidum* (M), *Tilia cordata*, *Torilis japonica*, *Tragopogon pratensis* (E), *Trientalis europaea* (OF), *Trifolium arvense* (E), *T. campestre* (E), *T. pratense* (M), *T. repens* (E), *Ulmus laevis*, *Urtica dioica*, *Vaccinium myrtillus* (OF), *V. vitis-idaea* (OF), *Verbascum nigrum*, *Veronica chamaedrys*, *V. dillenii* (E), *V. longifolia* (M), *V. officinalis*, *Viburnum opulus* (P), *Vicia angustifolia* (E), *V. arvensis* (E), *V. cracca* (E), *V. reichenbachiana* (OF), *V. riviniana* (OF), *Viscum album*.

Liliopsida

Agrostis capillaris, *A. stolonifera*, *Alopecurus pratensis* (M, E), *Anthoxanthum odoratum*, *Bromus hordeaceus* (E), *Calamagrostis arundinacea*, *C. epigejos*, *Carex acuta*, *C. acutiformis*, *C. digitata* (OF), *C. ericetorum*, *C. hirta* (E), *C. nigra*, *C. ovalis* (E), *C. praecox* (E), *C. riparia*, *C. vesicaria*, *C. vulpina*, *Convallaria majalis* (OF, P), *Corynephorus canescens* (E), *Dactylis glomerata*, *Danthonia decumbens*, *Deschampsia caespitosa*, *Elymus repens*, *Epipactis helleborine* (OF), *Festuca gigantea* (OF), *F. ovina*, *F. rubra*, *Gagea lutea* (OF), *Glyceria fluitans* (E), *G. maxima*, *Holcus mollis*, *Iris pseudacorus*, *Juncus effusus*, *J. tenuis* (E, A), *Lemna minor*, *Lilium martagon* (OF, S), *Lolium perenne* (E), *Luzula campestris*, *L. multiflora*, *L. pilosa* (OF), *Maianthemum bifolium* (OF), *Melica nutans* (OF), *Millium effusum* (OF), *Molinia caerulea* (M), *Phalaris arundinacea*, *Phleum pratense*, *Poa compressa*, *P. nemoralis* (OF), *P. pratensis*, *Polygonatum multiflorum* (OF), *P. odoratum* (OF), *Sagittaria sagittifolia*, *Scirpus sylvaticus*.

Remarks on distribution and abundance of selected plant species

Daphne mezereum – strictly protected, a few specimens in the oak-hornbeam forest, division 65.

Epipactis helleborine – strictly protected, single individuals at roadsides and within oak-hornbeam forest communities, divisions 49 and 74.

Hedera helix – partially protected, distributed over the whole reserve area, a few generative specimens on the trunks of *Betula pendula* and *Ulmus laevis*, divisions 50 and 65.

Lathraea squamaria – species hardly reported from the middle Mazovia (MIREK et AL. 2003), within oak-hornbeam forest a few populations consisting of a few dozen flowering shoots, divisions 65 and 66.

Lilium martagon – strictly protected, several shoots at the foot of the sand dunes in oak-hornbeam forest, division 50.

Polypodium vulgare – strictly protected, many in the forest mixed in old trenches, one by one in a clump in alder carr, divisions 50 and 65.

Succisella inflexa – category V on the Polish “red list” (ZARZYCKI and SZELĄG 2006), a population of several dozen individuals on a meadow, division 64.

Taxus baccata – strictly protected, probably outside of the species natural range, it is possible that the seeds were brought by birds from the nearby allotments, single seedlings were found in a mixed forest in the southwestern part of the reserve and in an oak-hornbeam forest in its southern part, divisions 50 and 84.

DISCUSSION

Flora of the reserve “Puszcza Słupecka” can be regarded as a relatively rich and comparable to species lists from similar objects in central Poland such as “Mokry Jegiel” reserve (263 species – WIERZBA et AL. 2008), “Las Bielański” reserve (416 species – SUDNIK-WÓJCIKOWSKA 1982, 2010, SOLIŃSKA-GÓRNICKA et AL. 1997, PAWLIKOWSKI 2004). The relative plant species richness of the reserve may result from the diversity of habitats within its borders. It includes oak-hornbeam forests, riparian forests, coniferous forests as well as alder carr and the meadow area. In addition, proximity to metropolitan area of Warsaw and man-altered habitats result in a presence of a group of kenophytes, which also increases the number of species in the reserve.

Alien species represent more than 5% of the flora of the reserve “Puszcza Słupecka”. Most of the recorded kenophytes are species permanently and for long time established in Polish flora (ZAJĄC et AL. 1998, RUTKOWSKI 2006). Most of them grow at the edges of the reserve near the roads. Only *Impatiens parviflora* and *Solidago gigantea* are common in the forests of the reserve, while *Echinocystis lobata* abundantly overgrows an edge of the meadow. In comparison with reserves located far from urban areas the ratio of kenophytes in the reserve flora is relatively high (WIERZBA et AL. 2008), but in flora of a reserve, situated among the build-up areas as “Las Bielański” that ratio is even higher (SUDNIK-WÓJCIKOWSKA 1982, 2010, SOLIŃSKA-GÓRNICKA et AL. 1997, PAWLIKOWSKI 2004).

Within the “Puszcza Słupecka” reserve borders, 58 species considered as indicators of old forests (DZWONKO and LOSTER 2001) were found. This number falls within the range of old forest indicator species numbers in complexes of deciduous forests with well-documented continuity of the forest and similar area. For example, the numbers of old forest indicator species

in the reserves surveyed so far were as follows: "Las Bielański" – 50 species (SUDNIK-WÓJCIKOWSKA 1982, 2010, SOLIŃSKA-GÓRNICKA et AL. 1997, PAWLIKOWSKI 2004); "Puszcza Mariańska" – 69 species (JAKUBOWSKA-GABARA and ŁUCZAK 2002), "Kozi Rynek" – 64 species (PAWLIKOWSKI et AL. 2011). However, "Puszcza Słupecka" reserve was not yet covered by forest 70 years ago (MAPA TAKTYCZNA... 1933). According to DZWONKO and LOSTER (2001) the presence of a relatively large number of old-forest indicator species should be the evidence of ecological continuity of the forest ecosystem at a given location. Indicator species of old forests tend to have weak dispersal ability at large distances. They often reproduce vegetatively, and their seeds do not have adaptations to the long-distance dispersal as dominant ways of diaspora propagation is myrmekochory or autochory (DZWONKO and LOSTER 1992, MATLACK 1994, GORB and GORB 2003).

The relative abundance of old-forest indicator species within the reserve borders may be associated with the presence of the Czarna river watercourse, and its extensive flooding. Diaspores of old-forest species could be transported by water from upstream areas of the catchment. The role of flooding in dispersal of forest plant species was highlighted by JOHANSSON et AL. (1996). Another hypothesis involves the possibility of presence in the past small forest enclaves were not presented in the maps. Those wooded patches could have been constant environmental islands enabling the survival of old-forest species (see JAMONEAU et AL. 2011). The proximity of the "Łęgi Czarnej Strugi" reserve that conserves patches of well-preserved oak-hornbeam and riparian forests rich in species regarded as old-forest indicators, may be also important. In that reserve *Aegopodium podagraria*, *Anemone nemorosa*, *A. ranunculoides*, *Asarum europaeum*, *Chrysosplenium alternifolium*, *Corydalis solida*, *Galeobdolon luteum*, *Hepatica nobilis*, *Isophyrum thalictroides*, *Lathraea squamaria*, *Mercurialis perennis*, *Millium effusum*, *Oxalis acetosella*, *Ranunculus lanuginosus*, *Stellaria holostea* oraz *S. nemorum* were recorded (NAMURA-OCHALSKA unpublished, CHOJNACKI personal communication). The "Łęgi Czarnej Strugi" reserve is separated from the "Puszcza Słupecka" by an paved road, which was already visible on the WIG maps in 1933 (MAPA TAKTYCZNA... 1933). Although this road is a barrier for species with no adaptations for long-distance diaspora transfer, it can be assumed that the animals crossing the road may become a vector for many of them (see JAROSZEWICZ et AL. 2008).

It is not clear whether the biodiversity or the continuity of ecological processes should be considered as more important from the conservational point of view (NORDEN and APPELQVIST 2001). We believe, that the presence of many old-forest indicator species in the reserve is a sign of a quick regeneration of the forest patches and this processes are worth to be protected.

CONCLUSIONS

"Puszcza Słupecka" reserve is an interesting forest, which despite the lack of continuity, is inhabited by a large number of vascular plant species indicative for

old deciduous forests. The number of those species is comparable with other forests in central and north-eastern Poland, which have documented forest continuity. This evokes a discussion on the use of species considered as indicative of old-growth forests to determine the ecological continuity of a forest site. The example of the "Puszcza Słupecka" reserve proves that this type of assessment should be supported by other criteria, if they are available.

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