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THE VASCULAR PLANTS IN THE "PUSZCZA NOTECKA" FOREST ROADSIDE

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Abstract

This paper presents the edge effect of a very low-volume road on the belt of roadside vegetation in the "Puszcza Notecka", Poland – one of the largest compact forest complexes in Europe. The observations were carried out in the vicinity of pine stands in the fresh coniferous forest and fresh mixed coniferous forest sites. Twelve rectangular experimental sites 30 and 50 meters wide at a distance of 0 to 10 meters from the edge surfaces were established. 75 species characteristic for the 13 phytosociological classes and 20 species associated devoided of the diagnostic value were recognized in the roadside area. Native species dominated, where the most numerous species belonged to meadow communities (Molinio-Arrhenatheretea) and ruderal (Artemisietea vulgaris). Despite the significant participation of synanthropic plants, there was no invasion of alien species.

Key words: forest roads, road edge effect, Scots pine, pine forests, vegetation cover

INTRODUCTION

The contemporary civilisation cannot function without the transportation routes. Not without the reason, the density of the road network is considered to be an indicator of the economic development of countries. However, road transport is also one of the causes of the degradation of the natural environment especially in countries with highly developed economies. The character of damages depends on the size of the forest complex. Large forest complexes are at the greatest risk. Small forests are typically homogeneous with rather common species where the construction of roads will cause only quantitative losses not connected with the extinction of the rare representatives of fauna and flora. Whereas, the interference into a large and compact forest complex featuring a mosaic of forest sites and the richness of species will first result in qualitative changes, i.e. the loss of the most valuable and the rarest elements of the environment (Sheate and Taylor 1990).

The impact of transportation routes on the environment is a very broad problem and it is frequently investigated by experts from various fields of biological, technical and economic sciences nowadays (eg., Kopecký 1978, Forman and Alexander 1998, Olander et al. 1998, Kuitunen et al. 2003, Jakubowska-Gabara and Zielińska 2005, Koivula and Vermeulen 2005, Bignal et al. 2007, Czerniak et al. 2007, Eigenbrod et al. 2008, Garcia-Gonzaleza et al. 2012, Valentukevičienė 2016). The obtained results indicate an existence in the vicinity of a road lane an ecotone zone at the edge of stands, of an approximate width of 30 – 100 (200) meters (Marcantonio et al. 2013). However, the most characteristic physiognomic changes occur in the first 10-15 (20) m wide belt adjacent to the stand wall. The results come from the changes in lighting conditions, humidity, wind strength, soil fertility as well as air and soil pollution (frequently including salinity), noise and vibrations, etc. (Bernhardt et al. 2004, Corney et al. 2006, Hawbaker et al. 2006, Delgado et al. 2007, Suárez-Esteban et al. 2013).

According to Faliński (1961), the vegetation of forest roads exhibits many characteristics of the synanthropic vegetation in particular ruderal. Synanthropisation processes become particularly visible on the border of forest complexes (Balcerkiewicz and Kasprowicz 1989) and at the edges of transportation routes. There are clear analogies between these two situations, i.e. the belt-like arrangement of components, the concentration of many plant communities over a small area and an exceptional floristic abundance (Paszek and Załuski 2000). These transition zones are frequently referred to as ecological corridors or margins (Ratyńska and Szwed 1996, Szwed et al. 1999, Koivula and Vermeulen 2005, Szwed and Perkiewicz 2010).

Based on the studies conducted in the Białowieża Forest, Faliński (1961) inclines to the proposal put forth by Tüxen and classifies all ruderal communities overgrowing the roadway sections of forest roads to the Plantaginetea majoris class, regardless of the type of the adjacent forest. In turn, species characteristic of forest phytocenoses overgrow road slopes. However here, the type of a forest site has no effect also on the vegetation variation, but specific soil and water conditions resulting from the diverse microrelief of the roadway. The vegetation of forest roads in the Białowieża National Park in terms of geo-historical groups is composed of forest apophytes at 72.0%, non-forest apophytes at 27.2% and anthropophytes – only 0.8% (Faliński 1961).

Roads constitute passage routes for plants and they facilitate penetration into the forest for alien geographically and ecologically species (Szwed et al. 1999, Andres 2005, Hansen and Clevenger 2005, Szwed and Perkiewicz 2010). A greater number of plant species is encountered along roads rather than inside the forest. However, the proportion between forest and non-forest species is disturbed to the advantage of the latter (forest edge, grassland, clearance, meadow, segetal and ruderal, less frequently swamp). The forest boundary zone is characterised by an increased share of annual plants, anthropophytes and heliophilous species, occasionally halophytes and the simultaneous reduction of importance of sciophilous and forest plants (Balcerkiewicz and Kasprowicz 1989). Changes in the vertical structure of the forest community are also observed. The species and structural changes result from the modification in the light conditions (increased access to the lateral lighting) and moisture conditions, specific microrelief, disturbance of the soil cover and the use of the foreign substrate for road construction (Czępińska-Kamińska et al. 1997, Szwed et al. 1999, Andres 2005, Szwed and Perkiewicz 2010). Ziarnek (2000), based on the example of the Bukowa Forest, calculated that from the reported there 423 plant species, 16% are never found next to roads, 47% taxa grow both near roads and in the middle of forests, while 37% are found only in the vicinity of roads. Similar values were obtained by Paszek and Załuski (1998) from the Górznieńsko-Lidzbarski Landscape Park. Microhabitats (grasslands, gravel heaps, puddles) formed with the rise of the road and paths networks constitute in managed even-aged stands substitutes for rarely found there small water reservoirs, watercourses, gaps and thinings which are typical of uneven-aged and terminal forest phases. Forest roads contribute to the increased incidence not only of alien non-forest species, but also forest species even those endangered (Ziarnek 2000). Moreover, at the boundaries of sub-Atlantic forest complexes, thermophilic species may gather of the subcontinental range (Balcerkiewicz and Kasprowicz 1989, Balcerkiewicz and Brzeg 1993). Roads are thus a factor enhancing biodiversity (Paszek and Załuski 1998, 2000, Szwed et al. 1999, Szwed and Perkiewicz 2010).

Roadside vegetation is partly formed spontaneously and partly by human activity. In the strongly transformed areas, roadside sections of transportation routes are refuges for seminatural communities (meadows, grasslands). They promote an increased biodiversity of the region and constitute ecological corridors. Floristic diversity of roadsides in the Wielkopolska region was inventoried by Szwed and Perkiewicz (2010). They recorded 358 vascular plant species from 225 genera and 65 families including 59 typical forest species and 9 species protected by law in Poland. The families Asteraceae and Poaceae were represented by the greatest numbers of species. Among phytosociological classes, the greatest number of plant species characteristic for the meadow communities Molinio-Arrhenatheretea and field communities Stellarietea mediae. The representatives of native flora accounted for 72%, while the alien species accounted for 28%. The dominant life forms were hemicryptophytes and therophytes.

At the population level, synanthropisation processes in the vegetation cover can be manifested e.g. in the development of dwarf forms. Vitality of plants growing on forest roads depends on the frequency of their use. Andres (2005) associates the resistance of the individual plant species to treading with their Raunkiaer plant life-form. The rate of regeneration of vegetation destroyed as a result of transport operations (e.g. wood extraction) depends directly proportionally to the fertility of a given forest site (Gibert 1996).

The aim of the study was a floristic characteristics of a roadside belt of a very extensively exploited provincial road no. 150 (comparable to the main forest road) under the conditions of coniferous forest sites in the “Puszcza Notecka” Forest in Poland.

METHODS

The results presented in this paper were obtained from the conducted extensive research on the impact of the provincial road no. 150 (DW 150) to the neighbouring stands, the results of which are gradually being prepared for publication.

Field observations on the designated 12 rectangular experimental sites were conducted in July-August 2010 in roadside belt and in the area of roadside pine stands of older age classes neighbouring with the provincial road, i.e. from km 21+220 to km 26+696 of that road (Figure 1). The experimental sites of a 30 or 50 meters width were set at a distance of 0-10 meters from the edge of the road surface and were the elements of belt transects which location, the way of setting and characteristics were described in detail by Mizera and Grajewski (2016).

Vascular flora analysis was conducted on each experimental areas with the use of “floristic survey” method, which is more adequate method for such inventories prepared in this study (Szwed and Perkiewicz 2010). The condition to use a phytosociological photo is the homogeneity of its area, and a single photo cannot cover the transition zones between phytocenoses (Fukarek 1967; Wysocki and Sikorski 2009). However, the area of research plots comprises of almost an entire ectone zone, characterised by the presence of a huge richness of elements within a very limited space most frequently distributed in the belt pattern. Thus, the condition of homogeneity of a phytosociological photo would not be met and the attempt to isolate the basic syntaxonomic units i.e. plant associations would not be possible. For this purpose, it would be necessary to exclude from the analysis unpaved elements of the roadway or make this inventory more detailed by including the microrelief criterion in it. There are no obstacles to indicate species characteristic of phytosociological classes and to verify which of them were represented in the greatest numbers. This procedure provides a certain general picture of richness of vegetation in the studied roadside zones.

The nomenclature of plants families and species was adopted after Rutkowski (2011), while that of phytosociological classes after Matuszkiewicz (2012). The subject of the analyses were the origin (the geographic-historic group) and life forms according to Raunkiaer. Moreover, the forest species (Matuszkiewicz 2012), the indicator species of old forests (Dzwonko 2007) and the species protected by law were also indicated (Rozporządzenie… 2014).

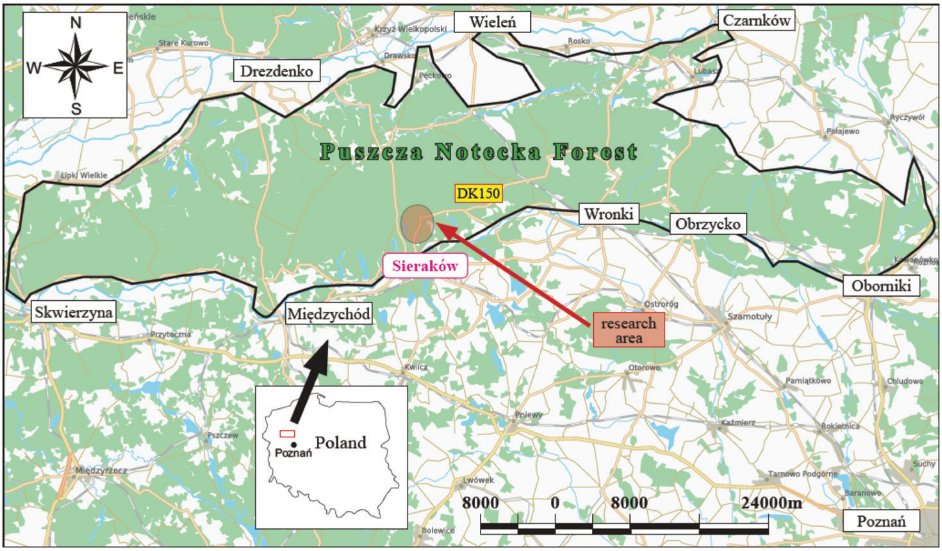

Figure 1. The location of the "Puszcza Notecka" Forest in relation to the national borders of Poland

RESULTS

A total of 95 taxa from 78 genera and 40 families were identified in the vicinity of road DW 150. The greatest numbers of taxa were recorded for the families Rosaceae (12), Asteraceae (11) and Poaceae (9). As many as 25 families were represented by only one taxon (Table 1). A total of 75 species characteristic of 13 phytosociological classes and 20 companion species of no diagnostic value were recorded in the roadsides. The species of meadow communities from the class Molinio-Arrhenatheretea (19) and species of ruderal communities from the class Artemisietea vulgaris (11) were the most numerous. The other eleven classes were represented by fewer than 10 species (Figure 2).

Native species were dominant. They accounted for 86% of all species of which non-synanthropic spontaneophytes comprised 14%, while apophytes constituted 72%. Alien species amounted to 14% with archeophytes at 3% and kenophytes at 11%. Life forms comprised mainly of hemicryptophytes (41%), therophytes (18%) and megaphanerophytes (15%). Chamaephytes were the least numerous constituting only 9%.

Table 1. The list of inventoried taxa in terms of families indicating phytosociological classes, origin of species, life forms according to Raunkiaer, forest species and indicator species of old forests as well as protected species

Family	Species	GHG	PC	F	OFG	L.F.	PP
Aceraceae	*Acer negundo* L.	Kn	-	-	-	M	-
Aceraceae	*Acer platanoides* L.	Ap	Q-F	+	-	M	-
Aceraceae	*Acer pseudoplatanus* L.	Ap	Q-F	+	-	M	-
Apiaceae	*Chaerophyllum temulentum* L.	Ap	Q-F	+	-	T	-
Apiaceae	*Daucus carota* L.	Ap	M-A	-	-	H	-
Apiaceae	*Heracleum sphondylium* L.	Ap	M-A	-	-	H	-
Aspidiaceae	*Dryopteris carthusiana* (Vill.) H.P. Fuchs	Ap	-	-	-	H	-
Aspidiaceae	*Dryopteris filix-mas* (L.) Schott.	Ap	Q-F	+	-	H	-
Asteraceae	*Achillea millefolium* L.	Ap	M-A	-	-	H	-
Asteraceae	*Artemisia vulgaris* L.	Ap	A	-	-	Ch	-
Asteraceae	*Centaurea stoebe* L.	Ap	F-B	-	-	H	-
Asteraceae	*Cirsium arvense* (L.) Scop.	Ap	A	-	-	G	-
Asteraceae	*Conyza canadensis* (L.) Cronq.	Kn	Sm	-	-	T	-
Asteraceae	*Erigeron acer* L.	Ap	-	-	-	T	-
Asteraceae	*Helichrysum arenarium* (L.) Moench	Ap	K-C	-	-	H	TT
Asteraceae	*Hieracium pilosella* L.	Ap	N-C	-	-	H	-
Asteraceae	*Leontodon hispidus* L.	Ap	Tr	-	-	H	-
Asteraceae	*Mycelis muralis* (L.) Dum.	Sp	-	-	+	H	-
Asteraceae	*Teraxacum officinale* Weber	Ap	M-A	-	-	H	-
Balsaminaceae	*Impatiens parviflora* DC.	Kn	A	-	-	T	-
Betulaceae	*Betula pendula* Roth	Ap	-	-	-	M	-
Brassicaceae	*Alliaria petiolata* (Bieb.) Cav. et Grande	Ap	A	-	-	H	-
Campanulaceae	*Jasione montana* L.	Ap	K-C	-	-	H	-
Caprifoliaceae	*Sambucus racemosa* L.	Kn	Ea	-	-	N	-
Caryophyllaceae	*Silene latifolia* Poiret	Ap	A	-	-	T	-
Caryophyllaceae	*Stellaria media* (L.) Vill.	Ap	Sm	-	-	T	-

Family	Species	GHG	PC	F	OFG	L.F.	PP
Chenopodiaceae	*Chenopodium album* L.	Ap	Sm	-	-	T	-
Convolvulaceae	*Convolvulus arvensis* L.	Ar	A i-r	-	-	G	-
Crassulaceae	*Sedum acre* L.	Ap	K-C	-	-	C	-
Cupressaceae	*Juniperus communis* L.	Sp	-	-	-	N	-
Cyperaceae	*Carex hirta* L.	Ap	M-A	-	-	G	-
Dipsacaceae	*Knautia arvensis* (L.) Coult.	Ap	M-A	-	-	H	-
Equisetaceae	*Equisetum arvense* L.	Ap	A i-r	-	-	G	-
Ericaceae	*Calluna vulgaris* (L.) Hull	Sp	N-C	-	-	Ch	-
Ericaceae	*Vaccinium myrtillus* L.	Sp	V-P	+	+	Ch	-
Ericaceae	*Vaccinium vitis-idaea* L.	Sp	V-P	+	+	Ch	-
Euphorbiaceae	*Euphorbia cyparissias* L.	Ap	F-B	-	-	H	-
Fabaceae	*Caragana arborescens* Lam.	Kn	-	-	-	N	-
Fabaceae	*Lotus corniculatus* L.	Ap	M-A	-	-	H	-
Fabaceae	*Medicago lupulina* L.	Ap	-	-	-	T	-
Fabaceae	*Robinia pseudoacacia* L.	Kn	-	-	-	M	-
Fabaceae	*Trifolium arvense* L.	Ap	K-C	-	-	T	-
Fabaceae	*Trifolium pratense* L.	Ap	M-A	-	-	H	-
Fabaceae	*Trifolium repens* L.	Ap	M-A	-	-	C	-
Fagaceae	*Fagus sylvatica* L.	Kn	Q-F	+	-	M	-
Fagaceae	*Quercus robur* L.	Ap	-	-	-	M	-
Fagaceae	*Quercus rubra* L.	Kn	-	-	-	M	-
Geraniaceae	*Geranium robertianum* L.	Ap	A	-	-	T	-
Hypericaceae	*Hypericum perforatum* L.	Ap	-	-	-	H	-
Lamiaceae	*Ajuga reptans* L.	Sp	-	-	+	H	-
Lamiaceae	*Galeopsis tetrahit* L.	Ap	Sm	-	-	T	-
Lamiaceae	*Glechoma hederacea* L.	Ap	A	-	-	G	-
Lamiaceae	*Thymus serpyllum* L.	Ap	K-C	-	-	C	-
Liliaceae	*Polygonatum multiflorum* (L.) All.	Sp	Q-F	+	+	G	-
Malvaceae	*Malva neglecta* Wallr.	Ar	Sm	-	-	H	-
Papaveraceae	*Chelidonium majus* L.	Ap	A	-	-	H	-
Pinaceae	*Pinus sylvestris* L.	Sp	V-P	+	-	M	-
Plantaginaceae	*Plantago lanceolata* L.	Ap	M-A	-	-	H	-
Plantaginaceae	*Plantago major* L.	Ap	M-A	-	-	H	-
Plumbaginaceae	*Armeria maritima* (Mill.) Willd.	Ap	K-C	-	-	H	-
Poaceae	*Agrostis capillaris* L.	Ap	N-C	-	-	H	-

Family	Species	GHG	PC	F	OFG	L.F.	PP
Poaceae	*Anthoxanthum odoratum* (L.) P.B.	Kn	-	-	-	T	-
Poaceae	*Bromus sterilis* L.	Ar	Sm	-	-	T	-
Poaceae	*Calamagrostis epigejos* (L.) Roth	Ap	Ea	-	-	G	-
Poaceae	*Corynephorus canescens* (L.) P.B.	Ap	K-C	-	-	T	-
Poaceae	*Dactylis glomerata* L.	Ap	M-A	-	-	H	-
Poaceae	*Deschampsia caespitosa* (L.) P.B.	Ap	M-A	-	-	H	-
Poaceae	*Deschampsia flexuosa* (L.) Trin.	Sp	-	-	-	H	-
Poaceae	*Festuca rubra* L.	Ap	M-A	-	-	H	-
Polygonaceae	*Polygonum arviculare* L.	Ap	Sm	-	-	T	-
Polygonaceae	*Rumex acetosa* L.	Ap	M-A	-	-	H	-
Polygonaceae	*Rumex acetosella* L.	Ap	K-C	-	-	G	-
Polygonaceae	*Rumex crispus* L.	Ap	M-A	-	-	H	-
Pyrolaceae	*Orthilia secunda* (L.) House	Sp	V-P	+	+	Ch	-
Ranunculaceae	*Ranunculus acris* L.	Ap	M-A	-	-	H	-
Rhamnaceae	*Frangula alnus* Mill.	Sp	-	-	-	N	-
Rosaaceae	*Potentilla arenaria* Borkh.	Ap	F-B	-	-	H	-
Rosaceae	*Fragaria vesca* L.	Ap	Ea	-	-	H	-
Rosaceae	*Geum urbanum* L.	Ap	A	-	+	H	-
Rosaceae	*Malus domestica* Borkh.	Kn	-	-	-	M	-
Rosaceae	*Potentilla reptans* L.	Ap	M-A	-	-	H	-
Rosaceae	*Prunus padus* L.	Sp	Q-F	+	-	M	-
Rosaceae	*Prunus serotina* Ehrh.	Kn	-	-	-	M	-
Rosaceae	*Prunus spinosa* L.	Ap	R-P	+	-	N	-
Rosaceae	*Pyrus communis* L. em. Gaertner	Ap	-	-	-	M	-
Rosaceae	*Rosa canina* L.	Ap	R-P	+	-	N	-
Rosaceae	*Rubus idaeus* L.	Ap	Ea	-	-	N	-
Rosaceae	*Rubus sp.div.* L.	Ap	R-P	+	-	N	-
Rubiaceae	*Galium aparine* L.	Ap	A	-	-	T	-
Rubiaceae	*Galium mollugo* L.	Ap	M-A	-	-	H	-
Rubiaceae	*Galium verum* L.	Ap	T-G	-	-	H	-
Scrophulariaceae	*Melampyrum pratense* L.	Sp	V-P	+	+	T	-
Scrophulariaceae	*Veronica chamaedrys* L.	Ap	-	-	-	C	-
Ulmaceae	*Ulmus laevis* Pall.	Ap	Q-F	+	-	M	-
Urticaceae	*Urtica dioica* L.	Ap	A	-	-	H	-

Legend:
GHG – geographical-historical group (Ap – apophytes, Sp – non-synanthropic spontaneophytes, Kn – kenophytes, Ar – archeophytes)
PC – phytosociological classes (M-A – *Molinio-Arrhenatheretea*, Sm – *Stellarietea mediae*, A – *Artemisietea vulgaris*, Q-F – *Querco-Fagetea*, K-C – *Koelerio glaucae-Corynephoretea canescentis*, Ea – *Epilobietea angustifolii*, R-P – R*hamno-Prunetea*, F-B – *Festuco-Brometea*, A i-r – *Agropyretea intermedio-repentis*, T-G – *Trifolio-Geranietea sanguinei*, V-P – *Vaccinio-Piceetea*, N-C – *Nardo-Callunetea*, Tr – *Thforest-pietea rotundifolii)*
F – forest species according to Matuszkiewicz (2012)
OFG – old forest species according to Dzwonko (2007)
RG – Raunkiaer's group (H – hemicryptophytes, T – therophytes, M – megaphanerophytes, G – geophytes, N – nanophanerophytes, Ch – herbaceous chamaephytes, C – woody chamaephytes)
PSP – protected species in Poland (TT – partial protection)

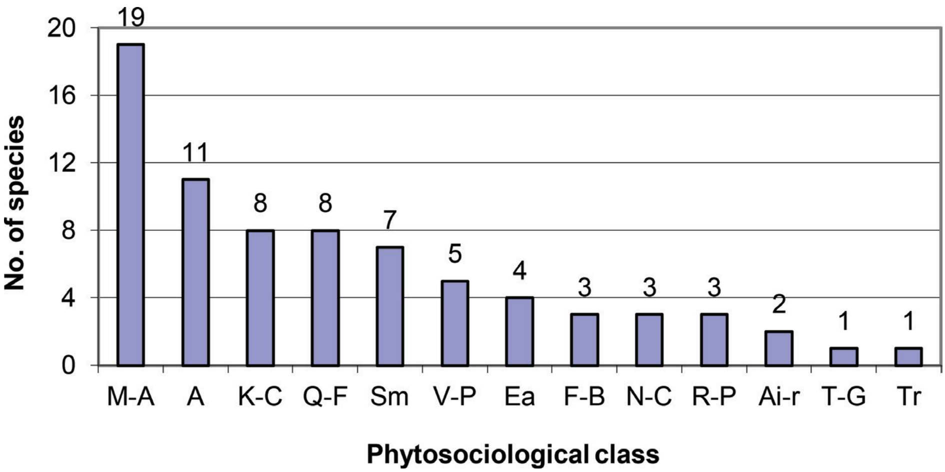

Figure 2. Characteristic species of individual phytosociological classes (legend to abbreviations as in Table 1)

Forest taxa, i.e. characteristic of classes Rhamno-Prunetea, Vaccinio-Piceetea and Querco-Fagetea (Matuszkiewicz 2012) represented by 16 taxa accounted for 17% of flora in the roadsides. Eight species were considered to be the indicator species of the old deciduous forests (Dzwonko 2007), while one species – Helichrysum arenarium – was identified as covered in Poland by partial protection.

DISCUSSION

The obtained results are almost completely consistent with the results of an inventory conducted in the Wielkopolska region by Szwed and Perkiewicz (2010) with the dominance of species from the families of Asteraceae, Poaceae and Rosaceae. Alongside road DW 150 a lower share was recorded for species characteristic of field communities from Stellarietea mediae class, in “the rank” they were after the forest species from Querco-Fagetea class. This fact is not surprising in view of the vicinity of the road. We also need to stress the presence of psammophilic grassland species from Koelerio glaucae-Corynephoretea canescentis class with the dominant grey hair-grass. Sandy grassland together with heaths from Nardo-Callunetea class constitute substitute communities for the sub-Atlantic fresh coniferous forest within the so-called dynamic series of Leucobryo-Pinetum communities (Wojterska 2003). The predominance of local elements confirms further the thesis proposed by Balcerkiewicz and Brzeg (1978) on the susceptibility of communities to neophyte invasion depending on their trophic levels, while the frequency of life forms is consistent with the observations by Andres (2005) concerning resistance of flora to anthropopressure.

In this study, there was no expansion of Impatiens parviflora along the routes described by many authors. This species occurred only in two research areas. It is also worth mentioning that the occurrence of I. parviflora in coniferous forest sites constitutes a novelty. Most authors attribute the occurrence of small balsam to fertile and moist deciduous forests. In the Bialowieza Forest, it was found solely in oak-hornbeam forests (Kujawa-Pawlaczyk 1991). This may indicate an extension of the range of ecological expansion of this species in Poland. The presence of I. parviflora may also result from the stands growing on the former farmland where this species occured. Not a single specimen of small balsam was found in the other experimental sites established in the fresh coniferous forest which confirms a thesis by Balcerkiewicz and Brzeg (1978) that mesotrophic, rather than oligotrophic, forest sites are at a greater risk of colonisation by neophytic species.

Literature sources mention several factors influencing diversification of the vegetation cover in the vicinity of transportation routes (eg., Bernhardt et al. 2004, Corney et al. 2006, Hawbaker et al. 2006, Delgado et al. 2007, Suárez-Esteban et al. 2013). At the investigated road DW 150, a decisive role could have been played by light conditions and it may have also been accompanied by the diverse microrelief in the immediate vicinity.

SUMMARY

The obtained results are consistent with the literature data and confirm the formation of a characteristic boundary zone, ecotone, along the research road at the edges of pine stands. This zone is characterized by an extraordinary richness.

Despite the high proportion of plant species characteristic of synanthropic communities, no invasion of alien species (neophytes) was observed and the native species were dominant.

The boundary zone needs to be managed in an adequate and conscious manner, since it constitutes a buffer zone shielding stands located farther providing protective, biological, social and aesthetic functions. If possible, new road investment sites should be located at the edges of forest complexes using the existing ecotone zones.

Stands neighboring transportation routes require special attention from the forest administrators constituting fascinating experimental sites for ecological studies.

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