Biodiv. Res. Conserv. 9-10: 63-72, 2008

BRC
www.brc.amu.edu.pl

Vascular plants of forest dividing-lines analyzed in respect of forest complex synanthropisation

Monika Myśliwy

Department of Plant Taxonomy and Phytogeography, University of Szczecin, Wąska 13, 71-415 Szczecin, Poland, e-mail: nikabot@univ.szczecin.pl

Abstract: This multi-faceted analysis of the flora of forest dividing-lines is aimed at estimating their role in the process of synanthropisation. In contrast to typical forest roads, effects of forest dividing-lines on floristic changes within forest complexes seem to be moderate. The microhabitats connected with forest dividing-lines allow numerous non-forest species to grow and spread in forest complexes. This applies first of all to the species characteristic of meadows of the class *Molinio-Arrhenatheretea*, heatlands and clear-cut areas (*Nardo-Callunetea*, *Epilobietea*), xerothermic grasslands and fringe communities (*Festuco-Brometea*, *Trifolio-Geranietea*), sandy grasslands (*Koelerio glaucae-Corynephoretea canescentis*), and ruderal communities (*Stellarietea*, *Artemisietea*). Due to the low intensity of human pressure, only few of all the anthropophytes occurring presently in the Barlinek-Gorzów Landscape Park were noted on forest dividing-lines, and most of them do not invade forest communities. The distribution of some of them in the Park is clearly connected with this type of habitats (e.g. *Juncus tenuis*, *Oxalis fontana*). Dividing-lines as habitats have numerous features in common and show no distinct differentiation, regardless of the neighbouring forest communities. The vast majority of the species are not associated with a particular single forest type, nor are they limited to 2 related types, but appear across a range of forest types. A constancy of 50% or higher was recorded only in species with a generally low number of records.

Key words: flora, forest paths, forest complex, anthropophytes, synanthropisation, Pomerania

1. Introduction

Fragmentation of forest complexes is one of the major symptoms of human pressure on the natural environment (e.g., Reed *et al*. 1996; Turner 1996; Honnay *et al*. 2005). In commercially managed forests, many kilometres of roads, paths and timber transport routes have been constructed, and regular networks of forest dividing-lines have been added. Roads have become a prominent landscape feature (Forman & Alexander 1998). The presence of roads results in synanthropisation of forest ecosystems at many levels of plant cover organization, namely at the level of landscape, vegetation, flora, and plant populations (Faliński 1972).

Vegetation of the forest roads and their effects on the surrounding forest communities depend largely on the type of the road and the extent to which it is being used (Faliński 1961; Zielińska 2007). The present study deals exclusively with forest dividing-lines. Compared to typical forest roads, they are narrow (3-4 m) and much less intensely used. Most of them are closed to public vehicular traffic, therefore their plant cover is usually dense. They are only occasionally used by forest administration. This study involves a multi-faceted analysis of the vascular flora of forest dividing-lines and is aimed at estimating their role in the process of synanthropisation.

The main goals of the work were: (*i*) to characterize vascular flora of forest dividing-lines, (*ii*) to compare floristic composition of dividing-line cuttings through different forest types, and (*iii*) to determine the role of synanthropic plants of dividing-lines in forest complex.

2. Material and methods

2.1. Study area

Field research was conducted in the Barlinek-Gorzów Landscape Park (BGLP), which covers ca. 240 km^2 in the northern-western part of Poland (Fig. 1). According to physicogeographical regionalisation of Poland, the study area is divided between 2 mesoregions: the Myślibórz Lakeland and the Gorzów Plain. The northern part

Fig. 1. Location of the study area
Explanations: 1 – boundary of the Barlinek-Gorzów Landscape Park, 2 – main roads, 3 – towns and villages

of the Park features a set of glacial forms related to the southernmost border of the Pomeranian stage of the Vistulian glaciation. The southern part is a sandy outwash plain, incised by occasional, longitudinally oriented glacial troughs and peat-covered depressions left by the melting glacier (Kondracki 2000). The northern part of the Park covers a fragment of the River Płonia valley, whose steep slopes are incised by numerous gullies and ravines. The southern part features areas of a more gentle configuration, with abundant ribbon lakes and other postglacial lakes. The average annual precipitation in the area of the study is about 500-600 mm. The mean annual temperature is 8.1^{O}C. The growing period extends for about 200-220 days (Koźmiński *et al.* 1992).

As indicated by the chart of potential natural vegetation of Poland, the area of study features primarily the subatlantic acidophilous beech-oak forest in its Pomeranian variety. Less common are lowland forb-rich and acidophilous beech forests, as well as scattered, narrow patches of lowland alder and ash-alder forests. In addition, there are small fragments of the Central European alder fen forest, continental mesophilous oak-pine mixed forest, suboceanic Central European pine forest, and continental swamp pine forest. The Płonia valley features a subxero-thermophilous sarmatian oak and pine-oak forest (Matuszkiewicz *et al.* 1995). Due to the human pressure for many

Table 1. Groups of dividing-lines, identified on the basis of the neighboring forest type, with examples of the most frequent species

Forest type	EUNIS	No. of relevés	No. of species	Mean no. of species	Most frequent species (No. of relevés in a particular forest type)
Alnus swamp forests	G1.41	2	49	25.0	-
Robinia pseudoacacia plantations	G1.C3	2	50	25.0	-
Fagus forests aged over 60 years (FagWab)	G1.6	11	128	27.0	*Juncus tenuis* (9), *Carex ovalis* (8), *Poa annua* (8), *Achillea millefolium* (7), *Calamagrostis epigejos* (7), *Oxalis fontana* (7), *Plantago major* (7), *Stellaria media* (6), *Trifolium repens* (6)
Fagus forests aged over 30-60 years (FagWun)	G1.6	8	121	26.8	*Achillea millefolium* (6), *Hieracium pilosella* (5), *Hypericum perforatum* (5), *Trifolium repens* (5), *Agrostis capillaris* (4), *Leontodon autumnalis* (4), *Veronica chamaedrys* (4)
Acidophilous *Quercus*-dominated forests aged over 60 years (QueW)	G1.8	13	161	28.2	*Hypericum perforatum* (8), *Veronica chamaedrys* (8), *Dactylis glomerata* (7), *Plantago major* (7), *Trifolium repens* (7), *Urtica dioica* (7), *Calamagrostis epigejos* (6), *Geum urbanum* (6), *Juncus effusus* (6), *Poa annua* (6), *Ranunculus repens* (6), *Taraxacum officinale* (6)
Central European *Pinus sylvestris* forests aged over 60 years (PinWab)	G3.42	17	143	18.7	*Agrostis capillaris* (10), *Rumex acetosella* (8), *Hypericum perforatum* (7), *Poa annua* (7), *Potentilla reptans* (7), *Achillea millefolium* (6), *Carex hirta* (6), *Rubus idaeus* (6), *Veronica chamaedrys* (6)
Central European *Pinus sylvestris* forests aged over 30-60 years (PinWun)	G3.42	16	141	17.7	*Carex ovalis* (8), *Hypericum perforatum* (7), *Achillea millefolium* (6), *Calamagrostis epigejos* (6), *Campanula rotundifolia* (6), *Hieracium pilosella* (6), *Hypochoeris radicata* (6), *Plantago major* (6)
Mixed *Pinus sylvestris*-acidophilous *Quercus* woodland aged over 60 years (PQWab)	G4.7	34	183	19.7	*Hypericum perforatum* (23), *Juncus tenuis* (18), *Agrostis capillaris* (17), *Hieracium pilosella* (14), *Juncus effusus* (13), *Poa annua* (13), *Potentilla reptans* (13), *Stellaria graminea* (13), *Achillea millefolium* (12), *Calamagrostis epigejos* (12)
Mixed *Pinus sylvestris*-acidophilous *Quercus* forests aged over 30-60 years (PQWun)	G4.7	7	72	13.6	*Agrostis capillaris* (3), *Hypericum perforatum* (3), *Plantago major* (3), *Ranunculus repens* (3)
Early-stage coniferous plantations (PinPlan)	G5.74	23	177	29.0	*Agrostis capillaris* (19), *Calamagrostis epigejos* (18), *Poa annua* (17), *Hypericum perforatum* (15), *Juncus tenuis* (15), *Plantago major* (15), *Carex ovalis* (14), *Hieracium pilosella* (14), *Achillea millefolium* (13), *Potentilla reptans* (13), *Rubus idaeus* (13), *Rumex acetosella* (13), *Veronica officinalis* (13)

Explanation: EUNIS – habitat classification according to Davies *et al.* (2004)

centuries, the forest stands in that area are dominated by pine. Pine monocultures, physionomically similar to the sub-oceanic *Leucobryo-Pinetum* and representing in fact degenerative stages of pine-oak forests or acidophilous oak forests, cover a large proportion of the afforested areas. Although similar to *Querco roboris-Pinetum*, the artificial mixed pine-beech and pine-oak forests are sometimes in fact strongly transformed acidophilous oak forests. The preserved fragments of the association *Fraxino-Alnetum* are frequently deformed by the planting of alder. Anthropogenic changes in forest stands of some patches of *Galio odorati-Fagetum* led to the formation of multi-species deciduous forests of the *Stellario-Carpinetum* type. Phytosociological identification of numerous patches of forest communities subjected to long-term human use is at present very difficult.

2.2. Methods

Field surveys were carried out in 1998-2001. A total of 133 floristic relevés were taken from rectangular, possibly most homogenous plots, 2 m × 20 m in the 2-metre-wide median of the dividing-lines. The forest dividing-lines utilized as forest roads were excluded from the analysis. A database of relevés and species was set up in the Profit 2.0 package (Balcerkiewicz & Sławnikowski 1998). Floristic analyses were performed on all the relevés jointly and separately for individual groups, identified on the basis of the type of the neighbouring forest communities (Table 1). The forest types split by the dividing-lines studied were based on the EUNIS habitat classification (Davies *et al.* 2004). The analyses of species-forest type relationships were done with the CANOCO package v. 4.5 (ter Braak & Šmilauer 2002). The pattern of plant distribution was analysed by the Canonical Correspondence Analysis (CCA), because DCA results detected an unimodal distribution of data (Jongman *et al.* 1987). Very rare and rare species (frequency classes I-II, see Table 2), as well as forest types with a small number of relevés (*Alnus* swamp woods and *Robinia pseudoacacia* plantations) were excluded. Finally, 129 samples and present/absent data of 168 species related to 8 forest types were analysed by CCA.

Names of species were reported after Mirek *et al.* (2002). Raunkiaer's plant life forms were determined after Zarzycki *et al.* (2002). Syntaxonomic classification of species was adopted according to Matuszkiewicz (2002). The list of anthropophytes was based on Zając (1979), Zając *et al.* (1998), and Tokarska-Guzik (2003).

3. Results

A total of 308 vascular plant species were recorded along 133 sections of forest dividing-lines surveyed. Species composition of the flora of those habitats proved very variable. The core of the flora consists of 21 species, found in at least 25% of the relevés. Another 39 taxa were recorded in 12-25% of relevés. The most common species are: *Hypericum perforatum*, which occurred in almost 55% of the relevés (73 records), *Agrostis capillaris* (67 records), *Juncus tenuis* (62 records), *Plantago major* and *Poa annua* (each 59 records), *Achillea millefolium* (58 records), *Calamagrostis epigejos* (56 records), *Carex ovalis* (53 records), *Potentilla reptans* (51 records), and others. In the study area, some species clearly accumulate along the forest dividing-lines (e.g. *Juncus tenuis*, *Carex pallescens*) or forest dividing-lines and roads (e.g. *Oxalis fontana*, *Poa annua*, *Polygonum aviculare*). Numerous species were encountered there only sporadically. To illustrate their frequencies, the species were arranged in a series following frequency classes. Individual classes were identified from ranges of frequency of occurrence of a species relative to the total number of forest dividing-lines surveyed (Table 2).

Hemicryptophytes were found to be dominant among the life forms. In addition, therophytes were fairly abundant as well, but after analysing the number of particular species records rather than the number of species, geophytes proved second in importance (Fig. 2). Therophytes turned out to be the third most important life form due to a large proportion of species recorded only sporadically, including archaeophytes associated with arable fields.

Geographic-historical analysis of the forest dividing-lines flora showed a pronounced domination of native species (262 species; ca. 85% of flora), 2/3 of the native taxa being characterised by distinct apophytism within the BGLP. It must be stressed that apophytes

Table 2. Frequency of species found on forest dividing-lines in the Barlinek-Gorzów Landscape Park

Frequency	Frequency class	% of forest dividing-lines	No. of records	No. of species
Very rare	I	0.1-1.0	1	81
Rare	II	1.1-3.0	2-3	59
Fairly rare	III	3.1-6.0	4-7	55
Frequent	IV	6.1-12.0	8-15	53
Fairly common	V	12.1-25.0	16-32	39
Common	VI	25.1-50.0	33-66	19
Very common	VII	50.1-75.0	67-99	2
Abundant	VIII	75.1-100.0	100-133	0

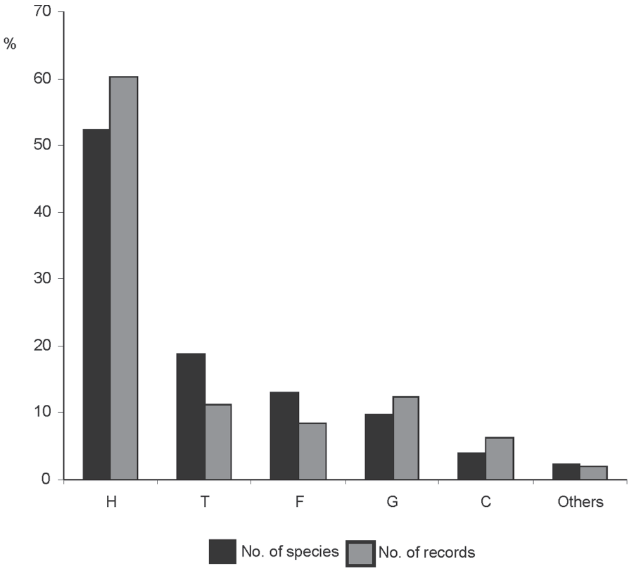

Fig. 2. Spectrum of Raunkiaer's life forms in the flora of forest dividing-lines

Explanations: C – herbaceous chamaephyte, F – phanerophyte, G – geophyte, H – hemicryptophyte, T – therophyte

are the most common species on the forest dividing-lines. The group of geographically alien species consists of 46 species, which constitute almost 30% of all anthropophytes recorded in BGLP flora (Myśliwy 2003), but the number of their records in the studied habitats is relatively low (Fig. 3A). Among anthropophytes the most common are the fallowing kenophytes: *Juncus tenuis* (62 records), *Oxalis fontana* (29 records), *Conyza canadensis* (21 records), *Picea abies* (12 records), *Impatiens parviflora* (11 records), *Epilobium ciliatum* (8 records), *Padus serotina* and *Chamomilla suaveolens* (each 6 records) and archaeophytes: *Fallopia convolvulus* (21 records), *Senecio vulgaris* (18 records), *Capsella bursa-pastoris* (15 records), *Scleranthus annuus* (8 records), *Viola arvensis* (7 records), *Spergula arvensis*, and *Matricaria maritima* subsp. *inodora* (each 5 records). Analysis of the geographic-historical classification of the flora of dividing-lines cutting through different forest types showed slight differences in the respective contributions of the species groups present (Fig. 3B).

The flora of forest dividing-lines turned out to be very diverse in respect of socioecological or syntaxonomic classification. The species recorded represented 21 phytosociological classes (Table 3). Most important in the habitats studied were the plants typical of fresh and wet meadows from the class *Molinio-Arrhenatheretea*. Important were also species representing the

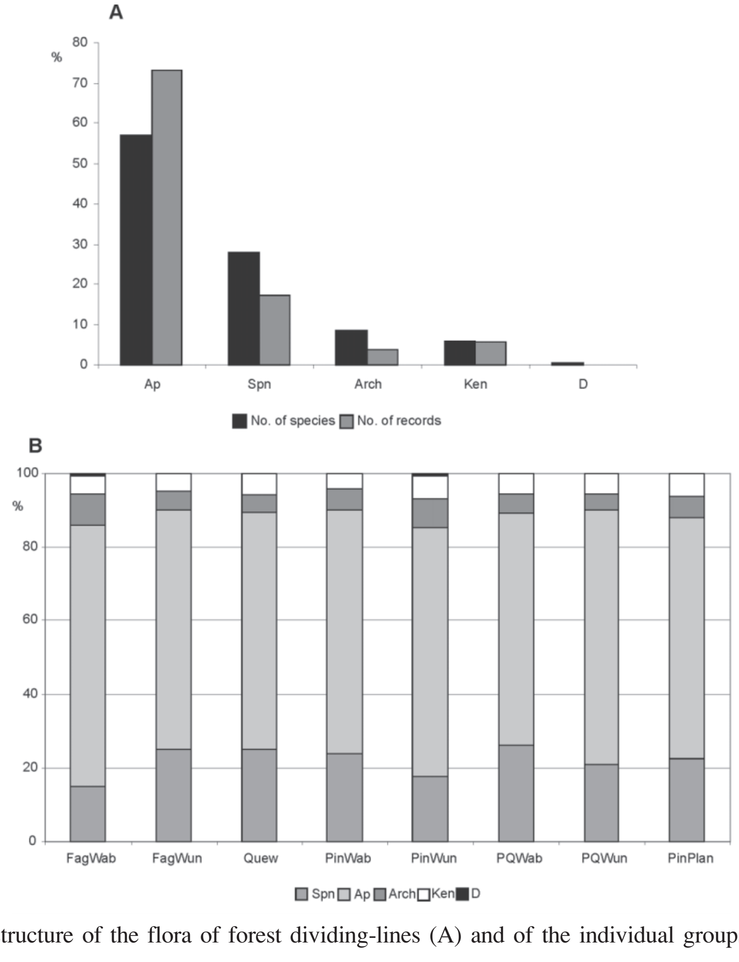

Fig. 3. Geographic-historical structure of the flora of forest dividing-lines (A) and of the individual groups identified on the basis of the neighbouring forest type (B)

Explanations: Spn – nonsynanthropic native species, Ap – apophytes, Arch – archaeophytes, Ken – kenophytes, D – diaphytes. Full names of forest types are given in Table 1.

Table 3. Syntaxonomic spectrum of the flora of forest dividing-lines

Phytosociological class	No. of species	No. of records
Querco-Fagetea (Q-F)	44	182
Rhamno-Prunetea (Rh-P)	8	32
Quercetea (Qt)	13	211
Nardo-Callunetea (N-C)	17	368
Epilobietea (Epil)	11	188
Trifolio-Geranietea (T-G)	14	69
Festuco-Brometea (F-B)	12	100
Koelerio-Corynephoretea (K-C)	21	219
Vaccinio-Piceetea (V-P)	7	99
Alnetea (Al)	4	13
Scheuchzerio-Caricetea (Sch-C)	2	2
Salicetea (Sal)	1	1
Phragmitetea (Ph)	3	3
Potametea (Pt)	1	1
Montio-Cardaminetea (M-C)	1	1
Molinio-Arrhenatheretea (M-A)	54	950
Bidentetea (Bd)	6	45
Isoeto-Nanojuncetea (I-N)	6	45
Agropyretea (Agr)	2	5
Artemisietea (Arte)	33	207
Stellarietea (Stel)	41	272
Others	7	16

classes: *Nardo-Callunetea*, *Koelerio-Corynephoretea*, *Epilobietea*, *Trifolio-Geranietea* and *Festuco-Brometea* and, unfortunately, the classes *Artemisietea* and *Stellarietea*, which include synanthropic species associated with ruderal and segetal habitats. About a quarter of all the species recorded on the dividing-lines are forest species, particularly those representing the classes *Querco-Fagetea* and *Quercetea*. They include plants that are rarely found in the Park, e.g. *Potentilla alba*, *Stellaria holostea*, and *Hypericum montanum*. Almost all the tree species appear in the dividing-lines as seedlings. Numerous forests also take advantage of these new habitats created by humans. This may be taken as a sign of most forest species being potentially apophytic. The type of the neighbouring forest community has no great significance for the syntaxonomic diversity of flora. Somewhat distinctive is a group of dividing-lines cutting through the mixed *Pinus sylvestris*-acidophilous *Quercus* woodland with trees 30-60 year old, which showed relatively low numbers of species representing the classes *Querco-Fagetea* and *Artemisietea*, while species representing the classes *Molinio-Arrhenatheretea* and *Nardo-Callunetea* were most abundant (Fig. 4A-B).

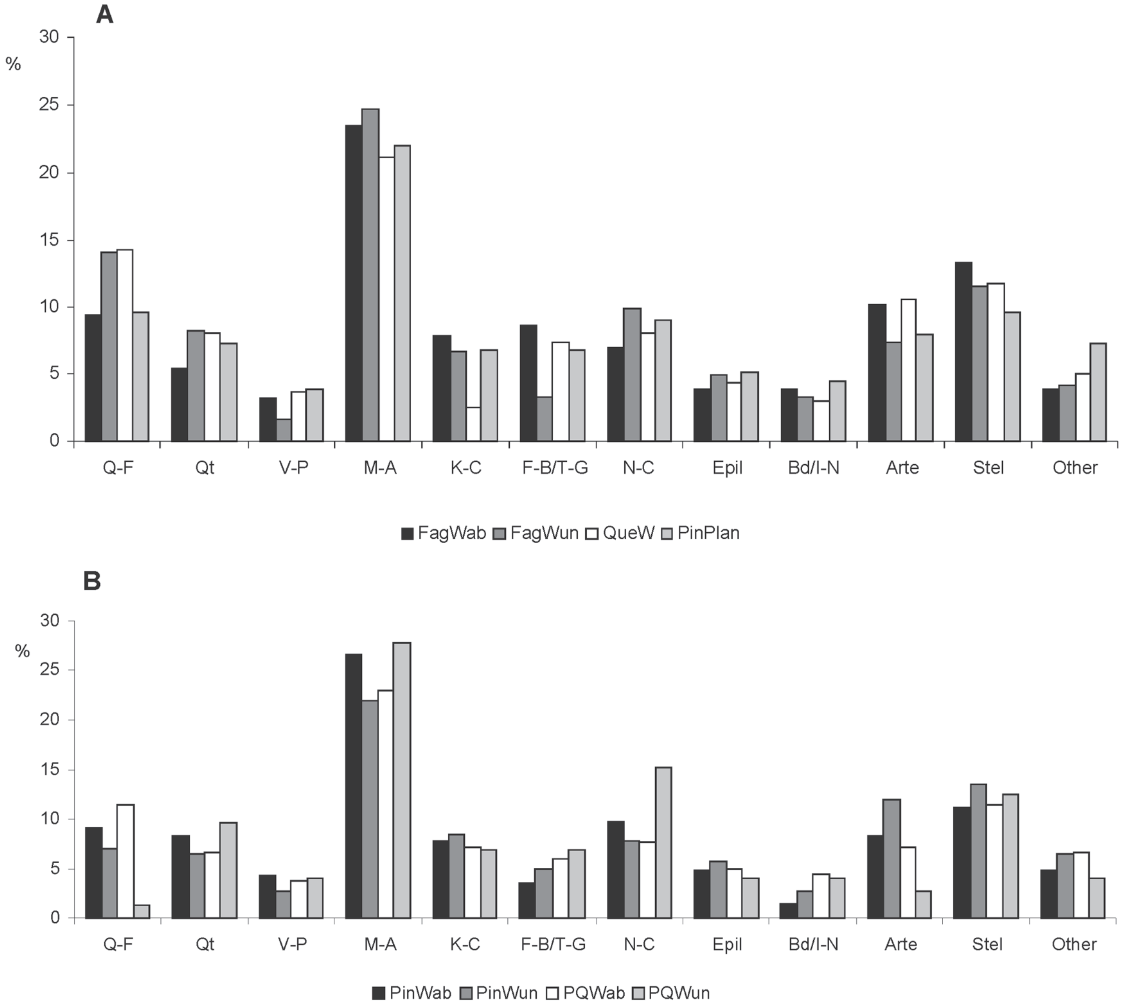

Fig. 4. Participation of the main syntaxonomic groups of species in individual groups of forest dividing-lines, identified on the basis of the neighbouring forest type

Explanations: Full names of forest types are given in Table 1. Abbreviations of syntaxonomic units are given in Table 2

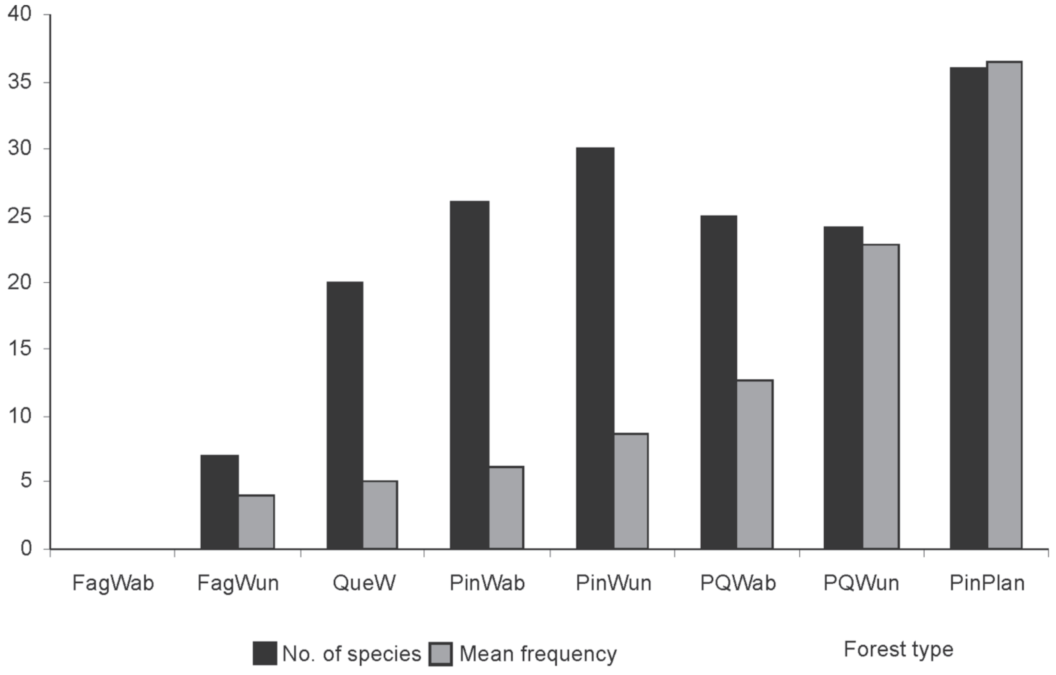

Fig. 5. Participation of species appearing in particular forest types

An analysis of constancy of species was performed in the dividing-lines cutting through different forest types. The relevés taken from the lines cutting through the *Alnus* swamp woods and *Robinia pseudoacacia* plantations as well as species from frequency classes I-II (i.e. recorded in as few as 1-3 relevés) were excluded. The results show that the vast majority of species are not associated with any particular single forest type or any 2 related types, but appear across a range of forest types (Fig. 5). The constancy of 50% and higher was revealed only in species producing a generally low number of records. For example, in the group of species recorded in 4-7 relevés (frequency class III), 75% of the *Tanacetum vulgare* records belonged to juvenile pine forests; almost 70% of the *Teesdalea nudicaulis* records were in old mixed pine-oak forests; almost 70% of the *Alliaria petiolata* records were in old beech forests; and almost 60% of the *Campanula persicifolia* records occurred in acidophilous oak forests. In some cases it may be a chance result rather than actual preferences of those plants. Constancy of the species representing higher frequency classes in the dividing-lines of individual forest types usually did not exceed 25%. Only one group of several species tended to be more frequent in two groups of dividing-lines: those cutting through old mixed forest and those leading through juvenile pine forests (e.g. *Hypericum perforatum*, *Juncus tenuis*, *Agrostis capillaris*, *Hieracium pilosella*, *Poa annua*, *Potentilla reptans*, *Plantago major*, *Carex ovalis*, and *Achillea millefolium*).

CCA ordination diagram provides information about species-forest type relationships (Fig. 6). Acidophilous *Quercus*-dominated woodland and *Fagus* woodland with trees aged over 60 years have the longest arrows, which means that they are more strongly correlated with the ordination axes than other forest types, and so they are more closely related to the pattern of species variation shown in the ordination diagram. Species close to each arrow appear more frequently in the respective forest type. The pattern of plant distribution obtained in the diagram proves that the vast majority of the species are not associated with a particular single forest type. They are placed in the centre of the ordination diagram, which indicates that they are unrelated to the ordination axes.

4. Discussion and conclusions

The plant cover of forest roads was the subject of detailed studies in the chosen forest complexes (e.g., Faliński 1961; Balcerkiewicz & Brzeg 1978; Herbich & Herbichowa 1997; Wróbel 2006). Recently researchers have paid their attention to the effects of the presence of roads on the plant cover of forest habitats (e.g., Angold 1997; Forman & Alexander 1998; Paszek & Załuski 2000; Trombulak & Frissel 2000; Godefroid & Koedam 2004; Zielińska 2007). The flora of forest dividing-lines, closed to public vehicular traffic and even rarely trodden by pedestrians, has not been studied before.

The diversity of vascular plant species is significantly greater on the roadsides in comparison with the forest interior, due to creation of new sites with different combinations of environmental conditions (Zielińska 2007).

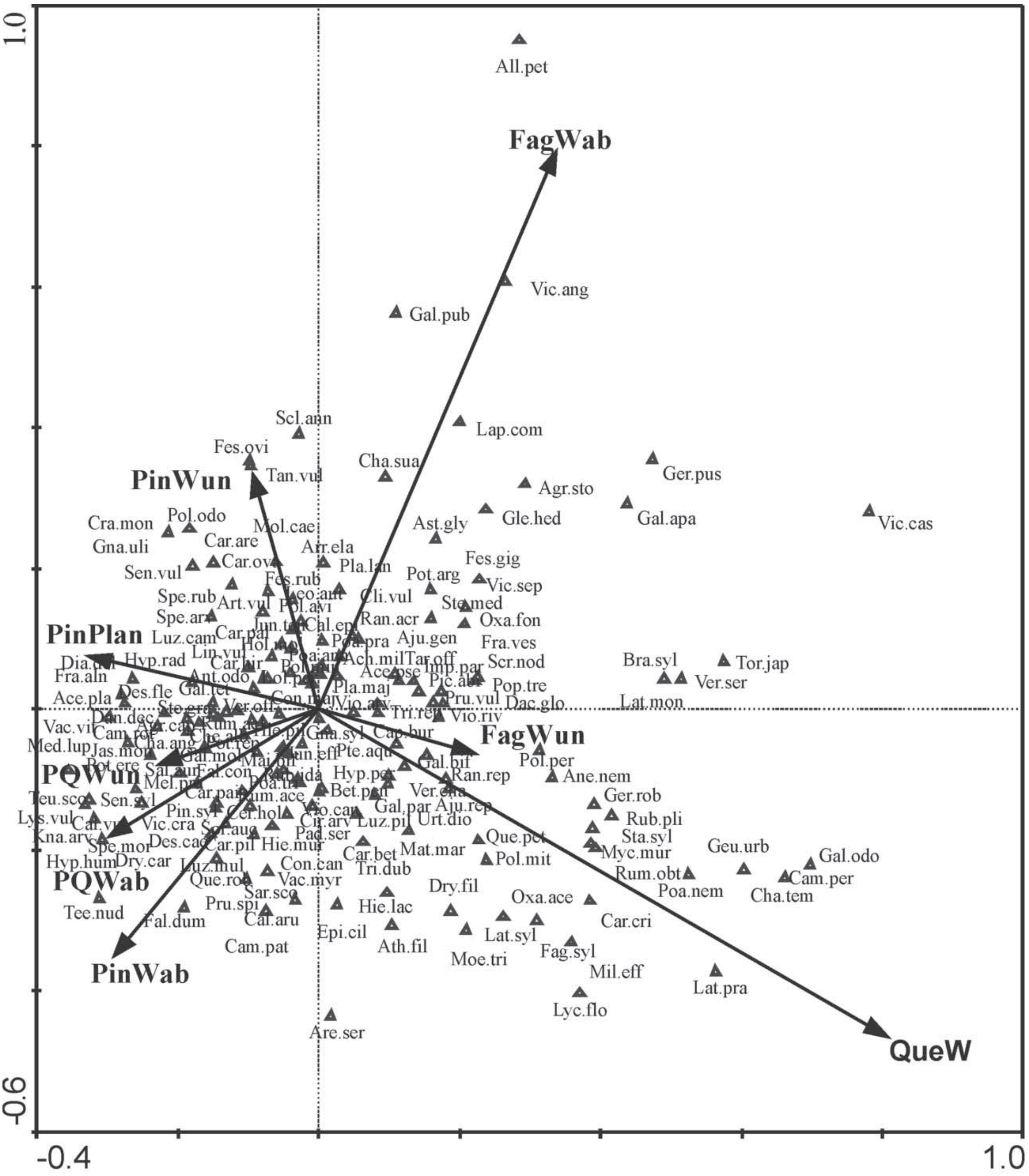

Fig. 6. CCA ordination diagram with species (triangles) and forest types (arrows)
Explanations: Full names of forest types are given in Table 1. In the diagram, the names of species are in the abbreviated form originating from the first three letters of the generic and species name, e.g. Ace.pla = *Acer platanoides*

It is known that roadsides have a lower canopy cover, allowing more light to reach understory plants, and this results in a species composition different from that of the forest interior (Paszek & Załuski 2000; Parendes & Jones 2000; Watkins *et al*. 2003; Godefroid & Koedam 2004). The present study has shown similar results: an increase in the amount of particular plant species associated with disturbance: e.g. therophytes, ruderals, and aliens. This effect may be additionally explained by the line construction phase, which destroys the plant cover. As a result of competition, higher degrees of disturbance decrease native-species richness and increase alien-species richness (McIntyre & Lavorel 1994; Paszek & Załuski 2000). Roads may be the first point of entry for alien species into a new landscape. Some aliens may then be able to move away from the roadside into adjacent patches of suitable habitat (Gucinski *et al*. 2001). According to Watkins *et al*. (2003), some anthropophytes invade the forest interior (up to 150 m), but their successful establishment and growth depend on disturbance associated with roadside. To determine the synanthropic role of forest dividing-lines, the most common anthropophytes were considered in detail, to check whether they penetrate the forest habitats in the BGLP or not. For the kenophytes the answer is 'no'. *Juncus tenuis* and *Oxalis fontana* were identified as species dynamically expanding within the Park, but closely associated with the forest dividing-lines and forest roadsides (Myśliwy 2003). Similarly, *Conyza canadensis* (= *Erigeron canadensis*) clearly accumulates along the forest dividing-lines and roadsides. This species only sporadically appears in the forest interior. *Impatiens parviflora* appears on forest dividing-lines fairly rarely (only 3.5% of all its records in the BGLP), so it spreads rather by typical roads. Species like *Picea abies* and *Padus serotina* are common in managed forests. Foresters introduced them into forest stands, where they propagate on their own and do not use dividing-lines as dispersal routes.

Among the archaeophytes that appeared on forest dividing-lines, 2 species are noteworthy: almost 15% of *Senecio vulgaris* records in the study area were in beech forests and 12% in pine forests; while *Fallopia convolvulus* appeared in beach, oak, pine, and mixed forests (11%, 6%, 6% and 15% of records, respectively). Their invasion, up till now, does not have any significant biological or ecological effects, because they do not disrupt the structure or function of an ecosystem.

Among the most common apophytes, numerous species enter the forest communities. They are mostly species typical of heathland (*Agrostis capillaris*, *Carex ovalis*), clear-cut areas (*Calamagrostis epigejos*, *Rubus idaeus*), and meadows (*Juncus effusus*, *Veronica chamaedrys*, *Dactylis glomerata*, *Stellaria graminea*, *Deschampsia caespitosa*). The role of these species clearly increases in forest patches transformed by human activity. In undisturbed forest communities they appear only in the less shaded, marginal parts of forest.

An important relationship between the degree of floristic transformations and the type of the road was proved by Zielińska (2007). As a result of the relatively low human pressure, effects of forest dividing-lines on floristic changes within the forest complexes seem to be moderate, in contrast to typical forest roads. The species that are not typical of forest phytocoenoses but thrive on forest dividing-lines, usually do not penetrate into the forest interior. At the same time, there is a large group of forest species that find good conditions in the lines and function as relicts or forest pioneers (Faliński 1961).

Dividing-lines as habitats have numerous features in common, and show no distinct differentiation, regardless of the neighbouring forest communities. Neither constancy of species on dividing-lines cutting through particular forest types, nor the pattern of species distribution shown in the CCA ordination diagram proved any significant differentiation of species composition. Instead, floristic diversity may be controlled mostly by the intensity of the line use and the microrelief, whereby species representing extremely different ecological categories, e.g., xerophytes and hygrophytes, frequently occur in close proximity to one another. The long-term forest management providing significant changes in forest communities, especially favouring the Scots pine on sites that should have been planted with broadleaves, leads to strong habitat transformation and may also influence the obtained results.

The major aspects of synanthropisation due to the presence of forest dividing-lines, are (in comparison to Paszek & Załuski 2000):

- development of a mosaic structure of forest complexes;
- increase in floristic diversity and syntaxonomic diversity of forest complexes;
- penetration of native non-forest species (especially those characteristic of meadows, dry grasslands, heathlands and clear-cut areas) into forest complexes;
- appearance of some anthropophytes (although most of them do not invade forest communities), which are the most dangerous aliens, but spread mostly along roads.

References

ANGOLD P. G. 1997. The impact of the road upon adjacent heathland vegetation: effects on plant species composition. Journal of Applied Ecology 34: 409-417.

BALCERKIEWICZ S. & BRZEG A. 1978. Vegetation on the forest roads in pine forests. In: T. WOJTERSKI (ed.). Guide to the Polish International Excurssion, pp. 115-117. Wyd. UAM, Poznań.

BALCERKIEWICZ S. & SŁAWNIKOWSKI O. 1998. Pakiet programów Profit. Instrukcja obsługi programu. Profit Spółka Cywilna, Poznań.

DAVIES C. E., MOSS D. & HILL M. O. 2004. EUNIS habitat classification revised 2004. Report to the European Topic Centre on Nature Protection and Biodiversity, European Environment Agency, October 2004.

FALIŃSKI J. B. 1961. Roślinność dróg leśnych w Białowieskim Parku Narodowym. Acta Soc. Bot. Pol. 30(1): 163-185.

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

FORMAN R. T. T. & ALEXANDER L. E. 1998. Roads and their major ecological effects. Annual Review of Ecology and Systematics 29: 207-231.

GODEFROID S. & KOEDAM N. 2004. The impact of forest paths upon adjacent vegetation: effects of the path surfacing material on the species composition and soil compaction. Biological Conservation 119: 405-419.

GUCINSKI H., FURNISS M. J., ZIEMER R. R. & BROOKES M. H. (eds.). 2001. Forest roads: a synthesis of scientific information. U.S. Department of Agriculture Forest Service, Pacific Northwest Research Station Portland, Oregon.

HERBICH J. & HERBICHOWA M. 1997. Wstępne wyniki badań nad roślinnością dróg w borach strefy przymorskiej. Zesz. Nauk. Wydz. BGiO UG, Biologia 8: 5-18.

HONNAY O., JACQUEMYN H., BOSSUYT B. & HERMY M. 2005. Forest fragmentation effects on patch occupancy and population viability of herbaceous plant species. New Phytologist 166: 723-736.

JONGMAN R. H. G., TER BRAAK C. J. F. & VAN TONGEREN D. F. R. (eds.). 1987. Data analysis in community and landscape ecology. Pudoc, Wageningen.

KONDRACKI J. 2000. Geografia regionalna Polski. 441 pp. Wyd. Nauk. PWN, Warszawa.

KOŹMIŃSKI CZ., CZARNECKA M. & GÓRKA W. 1992. Opady atmosferyczne na terenie województwa gorzowskiego. AR w Szczecinie, Urząd Woj. W Gorzowie Wlkp.,Okręg. Ośr. Rzeczozn. i Doradz. Roln. SNTLiTR w Szczecinie, Szczecin.

MATUSZKIEWICZ J. M., OLACZEK R. & WOJTERSKI T. (eds.). 1995. Potencjalna roślinność naturalna Polski. Mapa przeglądowa 1: 300000, Wojsk. Zakł. Kartogr., Warszawa.

MATUSZKIEWICZ W. 2002. Przewodnik do oznaczania zbiorowisk roślinnych Polski. In: J. B. FALIŃSKI (ed.). Vademecum Geobotanicum 3, 537 pp. Wyd. Nauk. PWN, Warszawa.

MCINTYRE S. & LAVOREL S. 1994. Predicting richness of native, rare, and exotic plants in response to habitat disturbance variables across a variegated landscape. Conservation Biology 8: 521-531.

MIREK Z., PIĘKOŚ-MIRKOWA H., ZAJĄC A. & ZAJĄC M. 2002. Flowering plants and pteridophytes of Poland. A checklist. In: Z. MIREK (ed.). Biodiversity of Poland 1, 442 pp. W. Szafer Institute of Botany, Polish Academy of Sciences, Kraków.

MYŚLIWY M. 2003. Flora roślin naczyniowych Barlinecko-Gorzowskiego Parku Krajobrazowego w warunkach antropogenicznych przemian środowiska przyrodniczego. Ph. D. Thesis. Department of Plant Taxonomy and Phytogeography, University of Szczecin, Poland.

PARENDES L. A. & JONES J. A. 2000. Role of light availability and dispersal in exotic plant invasion along roads and streams in the H. J. Andrews Experimental Forest, Oregon. Conservation Biology 14: 64-75.

PASZEK I. & ZAŁUSKI T. 2000. Forest roads in the synanthropisation process (Case study: Górzno-Lidzbark Landscape Park). In: B. JACKOWIAK & W. ŻUKOWSKI (eds.). Mechanisms of anthropogenic changes of the plant cover. Publications of the Department of Plant Taxonomy of the A. Mickiewicz University in Poznań 10: 249-257. Bogucki Wyd. Nauk., Poznań.

REED R. A., JOHNSON-BARNARD J. & BAKER W. L. 1996. Contribution of roads to forest fragmentation in the Rocky Mountains. Conservation Biology 10: 1098-1106.

TER BRAAK C. J. F. & ŠMILAUER P. 2002. CANOCO Reference Manual and User's Guide to Canoco for Windows: Software for Canonical Community Ordination (version 4.5). Microcomputer Power (Ithaca, Ny, USA).

TOKARSKA-GUZIK B. 2003. The expansion of some alien plant species (neophytes) in Poland. In: K. L. E. CHILD, J. H. BROCK, G. BRANDU, K. PRACH, P. PYŠEK, P. M. WADE & M. WILLIAMSON (eds.). Plant Invasions: Ecological Threats and Management Solutions, pp. 147-167. Backhuys Publishers, Leiden, The Netherlands.

TROMBULAK S. C. & FRISSEL C. A. 2000. Review of ecological effects of roads on terrestial and aquatic communities. Conservation Biology 14: 18-30.

TURNER I. M. 1996. Species loss in fragments of tropical rain forest: a review of the evidence. Journal of Applied Ecology 33: 200-209.

WATKINS R. Z., CHEN J., PICKENS J. & BROSOFSKE K. D. 2003. Effects of forest roads on understory plants in a managed hardwood Landscape. Conservation Biology 17(2): 411-419.

WRÓBEL M. 2006. Origin and spatial distribution of roadside vegetation within the forest and agricultural areas in Szczecin Lowland (West Poland). Pol. J. Ecol. 54(1): 137-144.

ZAJĄC A. 1979. Pochodzenie archeofitów występujących w Polsce. Rozpr. habil. UJ 29: 1-213. Druk UJ w Krakowie.

Zając A., Zając M. & Tokarska-Guzik B. 1998. Kenophytes in the flora of Poland: list, status and origin. In: J. B. Faliński, W. Adamowski & B. Jackowiak (eds.). Synantropization of plant cover in new Polish research. Phytocoenosis 10 (N.S.) Suppl. Cartogr. Geobot. 9: 107-116.

Zarzycki K., Trzcińska-Tacik H., Różański W., Szeląg Z., Wołek J. & Korzeniak U. 2002. Ecological indicator values of vascular plants of Poland. In: Z. Mirek (ed.). Biodiversity of Poland 2, 183 pp. W. Szafer Institute of Botany, Polish Academy of Sciences, Kraków.

Zielińska K. 2007. The influence of roads on the species diversity of forest vascular flora in Central Poland. Biodiv. Res. Conserv. 5-8: 71-80.