





THE VASCULAR FLORA ECOLOGICAL DIVERSITY IN THE MID-FIELD WOODLOTS SITUATED ON THE AGRICULTURAL OUTSKIRTS OF WROCLAW

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ABSTRACT. The paper presents an analysis of the ecological requirements and sociological-ecological relations of 403 species of vascular plants recorded in 82 mid-field woodlots located among crop fields in the agricultural outskirts of Wrocław. The aim of the research and analyses was to determine what is the species composition of these woodlots and whether they are ecologically more similar to those situated in environment of farmlands or urban wastelands. The authors assumed the latter. It was found that the mid-field woodlots occupied less than 1% of arable land and were located exclusively in close proximity to the city's administrative borders, and more than half of them were related to the hydrographic network of the area. Their flora, in general assessment, shows a great variety in terms of water requirements and has the features of woodlots described from typically agricultural areas. This applies to the dominance of forest, shrub and meadow species with a constant, usually not exceeding 20%, share of ruderal plants and a small number of weeds in crops. Thus, the assumption that the flora of the studied woodlots will show signs of ruderalization to a large extent has not been confirmed. 72% of species occurred in no more than 10 objects, which shows that the described ecological diversity of the flora studied is based on single or few locations. The most frequent species were nitrophilic and in over 50% they represented a group of shrub communities. The list of the species recorded with estimation of their frequency is provided.

KEY WORDS: marginal habitats, forest islands, bryophytes in agriculture landscape, invasive plant species, ancient woodlands indicator plant species, flora of Lower Silesia

INTRODUCTION

At present there is no doubt that in rural landscapes mid-field woodlots (irrespective of their form, linear or patches) perform important protective functions, both for the abiotic environment and biodiversity, what was documented by many studies carried out in the last decades (i.a. BANASZAK & CIERZNIK 2000, LE COEUR et al. 2002, MARSHALL & MOONEN 2002, SCHMUCKI et al. 2002, GAMRAT 2012, FUDALI et al. 2015, KOSZELNIK-LESZEK et al. 2015, TOMASZEWSKA et al. 2016). Most of these studies were carried out in traditionally rural regions. Agricultural lands

situated within the administrative borders of cities have usually been overlooked in such research and the structure and biodiversity of their landscape is poorly known. Studies in Warsaw showed that cities develop in many directions at the same time, which means that typical urban structures are pushed deep into the zone of typically agricultural areas (ZIMNY 2005). Taking into account the overall impact of the city development on vegetation (SOLIŃSKA-GÓRNICKA & SYMONIDES 1990, SUDNIK-WÓJCIKOWSKA 1991, 1998, ELMQVIST et al. 2016) it can be expected that the process of the agricultural lands' urbanization transform both landscape and flora.

During the last two decades almost 40% of the agricultural areas in the outskirts of Wrocław has been built or is prepared for investors. The rest area is still used as crop fields (mostly maize and cereals). As they were not floristically studied so far, research on the mid-field woodlots were undertaken in 2019 to find what is species composition of their flora and whether it is ecologically more similar to that found in agricultural lands or in urban wastelands? In this way, we wanted to answer the question, whether the fragments of agricultural landscape preserved in the city's outskirts retain their attributes in the context of multi-functionality of agricultural areas (WILKIN 2008) or whether they are losing them as a result of urbanization pressure? We assumed the latter.

The paper presents ecological analysis of the flora found in the mid-field woodlots situated within crop fields in suburbs of Wrocław in relation to the species requirements to the moist condition in the habitats, their trophy and sociological-ecological relations.

MATERIALS AND METHODS

STUDY AREA CHARACTERISATION

Wrocław is one of the biggest towns in Poland which area amounts to 293 km² and is inhabited by about 640,000 people. The city is situated in the south-western part of the country, in a flat area formed by the Odra River and its five tributaries, whose waters occupy about 3% of the city area (LEWICKI, ed. 2014). The climate is transitional, between oceanic and continental. Winters are short (65 days) and mild. The average annual precipitation in the 20th century was 583 mm. The average annual temperature is 9°C, and the annual temperature amplitude is 19.2°C. The most frequent winds are from a westerly direction (27.6% of days a year; the highest speed of 4.4 m/s during winter and 3.4 m/s in summer) and from the south (23.1%).

The area of Wrocław, like in most old and big cities, is spatially diversified in terms of land use and almost 25% of the city area is currently occupied with the crop fields (ZAKRZEWSKA-PÓŁTORAK 2017). But still in the first decade of the 21st century, agricultural lands made up 47% of the city's area (LEWICKI, ed. 2014). In recent decades they have been partly fallowed and, more recently, systematically built-up with residential and housing estates. The resources of non-build soils that are constantly used for agriculture are unevenly distributed in the area of Wrocław. Only narrow peripheral strips occur in the southern part of the city (the best black lands) and in the eastern (quite fertile, but waterlogged river muds and glial soils). Much larger areas are occupied by agricultural land in the western (fertile and moist river marshes) and north-western sectors of Wrocław

(acidic light soils, weak in terms of agriculture) (KABALA & CHODAK 2002). The forests, located mainly in the north-west, cover 7.5% of the city area.

WOODLOTS STUDIED

The studies included all the mid-field woodlots occurring in a crop field landscape, outside built-up areas (villages or new house-settlements) and public roads covered with asphalt. Altogether, 82 mid-field woodlots were identified. They were located peripherally in parts W, N and E of the city, close to the city's administrative borders. Any such object was found in the agricultural areas situated deeper towards the center.

In the field nine various forms of woodlots were recognised: 1) row of trees and shrubs along the roadside ditch – 6 objects; 2) row of trees and shrubs along field road without ditch – 1; 3) row of trees and shrubs along the border of the fields (without roads and ditches) – 3; 4) single or double-rows of trees along the watercourses and ditches in the field – 22; 5) 5–7 m wide strips with trees and shrubs along the watercourse or ditch – 16; 6) forest cultivation among fields – 4; 7) trees and shrubs on the ruderal habitat – 3; 8) afforested patches with a water reservoir or a preserved fragment of the watercourse – 6 and 9) afforested patches among crop fields – 21, quite often in a small depression of the land. For the further analysis, they have been reduced to three basic types: (P) surface clusters of trees characterised by a compact shape – 34 objects, (LP) strip plantings 5–7 m wide, in the vicinity of a watercourse or ditch – 16 and (L) single-row, rarely double-row, tree plantings distinguished by a strongly elongated shape, not exceeding 2–3 m wide – 32; these were consistent with the classifications of other authors (GAMRAT & BURCZYK 2007). The size (length and area) of the woodlots studied was very differentiated: in the P-type objects an area amounted from 0.001 to 8.47 ha, on average – 0.98 ha, in the LP-type woodlots it ranged from 0.004 to 1.2 ha, on average – 0.48 ha. The length of L-type objects was from 67 to 1025 m, on average 233 m.

FIELD STUDIES AND THE DATA DESCRIPTION

The research objects (mid-field woodlots) were initially selected on the basis of satellite photos (www.1) and then verified in the field. The verification was aimed at determining whether the object is a tree stand among crop fields. Floristic research was carried out in the growing season of 2019 using the route method by recording all observed species separately in each of the layers of vegetation (trees, shrubs, herbaceous plants, bryophytes). The area within the range of tree crowns (vertical projection) was assumed as the area of a given object. Most of the plant species were identified in the field. Doubtful or

unknown species were collected and then species recognised via use of the microscope in the laboratory.

The classes of relative frequency were determined according to the own scale: very frequent – the species was present in at least 75% of the sites, frequent – 50–74.9%, rare – 25–49.9%, very rare – in less than 25% of the sites but in more than one site, sporadic species – recorded only in one site.

The ecological requirements of the plant species in relation to water regime and trophy of habitats were defined using the ecological indicator values by ELLENBERG et al. (2001) and the sociological-ecological affiliation of species was determined according to conception by MAAREL (1971) using the available phytosociological literature (OBERDORFER 2001, MATUSZKIEWICZ 2008). The ancient woodlands plant indicators were recognized according to DZWONKO & LOSTER (2001). Nomenclature of the vascular plant species follows MIREK et al. (2002). Invasive alien plant species were recognised according to TOKARSKA-GUZYK et al. (2012).

RESULTS

GENERAL COMMENTS ON THE FLORA AND THE RELATIVE ABUNDANCE OF SPECIES

In total, 423 species of plants were recorded (Appendix – Table 1). In terms of taxonomy at the division-level, flora showed little diversity: apart from the dominant angiosperms, there were found: one representative of gymnosperms, three – ferns, three – horsetails, two – liverworts and 18 – mosses. The share of bryophytes was negligible, both in terms of the size of the occupied area and the number of objects in which their presence was recorded – 21, therefore this group was omitted in further analysis. The following bryophyte species were identified: liverworts – *Lophocolea bidentata* (L.) Dumort. (1 object) and *Marchantia polymorpha* L. (2), mosses – *Amblystegium serpens* (Hedw.) Schimp. (1), *Atrichum undulatum* Web. et Mohr. (6), *Brachytheciastrum velutinum* (Hedw.) Ignatov et Huttunen (7), *Brachythecium albicans* (Hedw.) Schimp. (2), *Brachythecium rutabulum* (Hedw.) Schimp. (13), *Brachythecium salebrosum* (Hoffm. ex F. Weber et D. Mohr) Schimp. (2), *Ceratodon purpureus* (Hedw.) Brid. (1), *Cirriphyllum piliferum* (Hedw.) Grout. (2), *Eurhynchium hians* (Hedw.) Sande Lac. (3), *Eurhynchium striatum* (Hedw.) Schimp. (2), *Kindbergia praelonga* (Hedw.) Ochyra (1), *Plagiomnium affine* (Blandow ex Funck) T. Kop. (3), *Plagiomnium undulatum* (Hedw.) T. Kop. (6), *Plagiothecium nemorale* (Mitt.) A. Jaeger (2), *Pleurozium schreberi* (Willd. ex Brid.) Mitt. (2), *Pseudoscleropodium purum* (Limpr) M. Fleisch. ex Broth. (2), *Pohlia nutans* (Hedw.) Lindb. (1) and *Polytrichastrum formosum* (Hedw.) G.L. Sm. (1).

Considering the plant morphology, herbaceous species dominated (83% of flora). Among plants

with woody shoots, 40 species of trees and 42 bushes were recorded, and 15 of them were alien (e.g. *Aesculus hippocastanum*, *Fraxinus latifolia*, *Quercus palustris*, *Q. rubra*, *Padus serotina*, *Robinia pseudoacacia*, *Cydonia oblonga*, *Sorbaria sorbifolia*, *Rosa rugosa*, *Rhus typhina*). With regard to the length of the life cycle, perennial plants had the largest percentage incidence (78%), including 48 species of geophytes.

The number of species found in individual woodlots varied considerably, ranging from 17 to 122; on average – 50. Such large differences in the species richness of individual sites were reflected in the analysis of the relative frequency of species. No species occurred in all the sites and only 18 in at least half of the studied objects (including *Crataegus monogyna*, *Sambucus nigra*, *Urtica dioica*, *Solidago gigantea* and *Quercus robur* in more than 75% of the sites). Thus, very rare species had a dominant incidence. Quite numerous was also the group of species recorded only in one site (class of sporadic species), constituting 23% of the identified vascular flora (Fig. 1).

ECOLOGICAL AND SOCIOLOGICAL-ECOLOGICAL SPECTRUM OF FLORA

The analysis of ecological requirements in relation to the habitat's humidity showed that the core of the flora are mesophilic plants (species of moderately humid habitats), although the presence of plant species preferring habitats with extreme humidity conditions and plants neutral to water regime was also noted (Fig. 2, Table 1).

All xerophytes represented the classes of very rare and sporadic species (Fig. 2, Table 1). Similarly, the group of aquatic plants consisted almost entirely of very rare and sporadic species. The exception was *Phragmites australis* with a slightly higher frequency (22 objects – class of rare species). Greater differentiation as to the relative frequency of occurrence

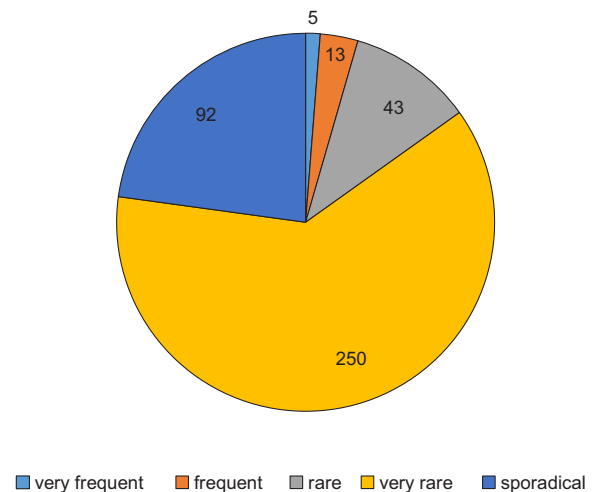


Fig. 1. Incidence of species in the distinguished relative frequency classes

was found in the groups of higrophytes and species neutral in relation to the humidity of the habitat, although very rare species also dominated in them (Fig. 2). The most common higrophytes were, among others, trees: *Padus avium* (39 objects), *Salix fragilis* (36) and *Alnus glutinosa* (33), and among herbaceous plants: *Humulus lupulus* (46), *Phalaris arundinacea* (27), *Poa trivialis* (26), *Symphytum officinale* (25) and *Lysimachia vulgaris* (24).

Regarding the trophic conditions of the habitats, species with moderate requirements and neutral were also predominant, but nearly one third of plants showed a preference for habitats that are rich and very rich in nitrogen compounds (Fig. 3). Nitrophilic plants showed differentiated relative frequency, but

it should be noted that in the classes of very frequent and frequent species they had about 60% share, and in the remaining ones no more than 30%.

The presented differentiation of the requirements for humidity and trophy of the habitat is reflected in the sociological-ecological diversity of the flora. Representatives of 10 sociological-ecological groups were found (Fig. 4).

In each of the woodlots, the presence of forest and forest-scrub species was recorded (Fig. 5), and in almost all (80) there were meadow and ruderal plants. In a large number of sites, the presence of species from the groups of segetal plants (63 objects) as well as utility and ornamental plants (60) was also recorded, and in more than half of the

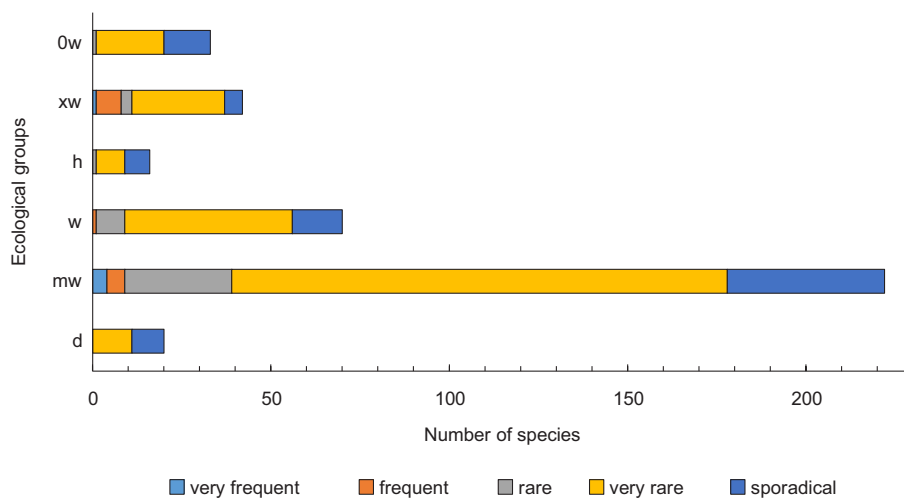


Fig. 2. The number of plant species in ecological groups of different requirements in relation to the humidity of the habitat, with information of their relative frequency

Explanations: d – plants in dry habitats (Ellenberg's index value 1–3), mw – plants in moderately humid habitats (4–6), w – plants in humid and wet habitats (7–9), h – aquatic plants (10–12), xw – plants neutral in relation to changes in humidity, 0w – no data on moisture requirements.

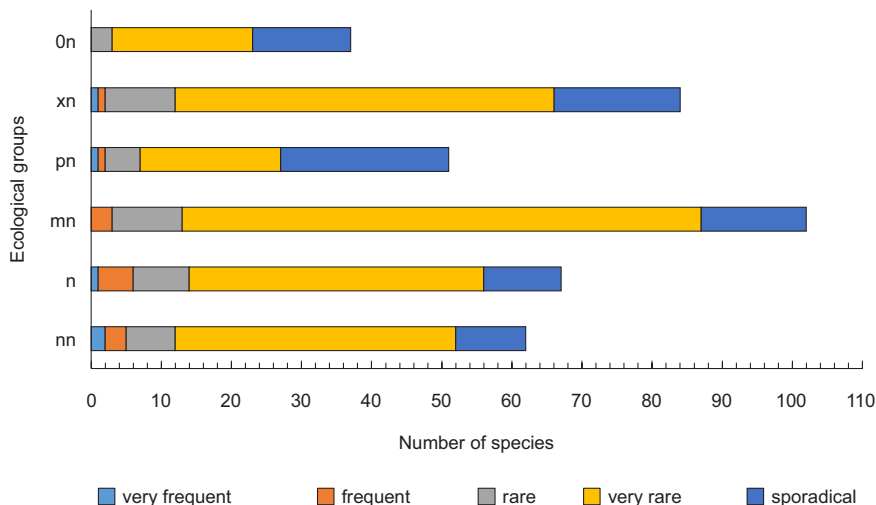


Fig. 3. The number of plant species in ecological groups of different requirements in relation to the fertility of the habitat, with information of their relative frequency

Explanations: nn – plants of very rich habitats (Ellenberg's index value 8–9), n – plants of rich habitats (7), mn – plants of moderately rich habitats (4–6), pn – plants of poor habitats (1–3), xn – plants neutral in relation to the fertility of the habitat, 0n – no data on trophic requirements.

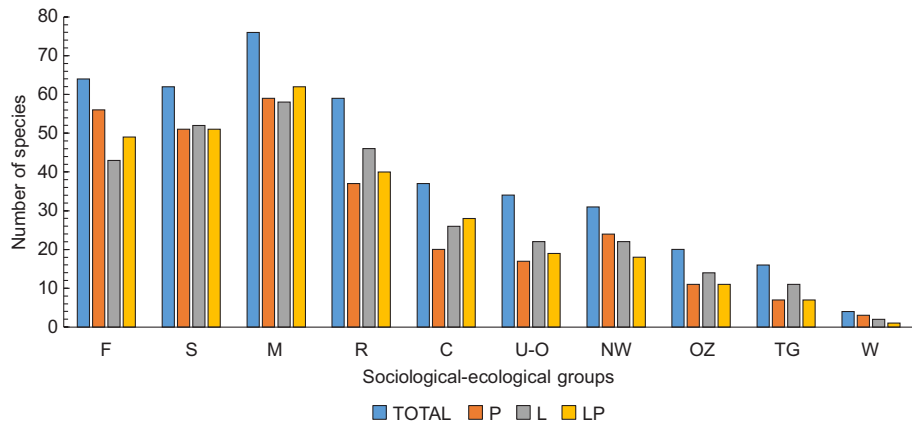


Fig. 4. The number of species representing the distinguished sociological-ecological groups in the flora studied, in total and in relation to individual types of mid-field woodlots
 Explanations: sociological-ecological groups: C – plants of segetal communities, F – plants of forest communities, M – meadow plants, TG – plants of termophilic grassland communities, NW – plants of communities developing near water, OZ – communities of the forests’ herbal fringes, R – plants of ruderal communities, S – plants of scrub communities, U-O – utility and ornamental plants, W – aquatic communities; object types: P – surface, L – row, LP – strip.

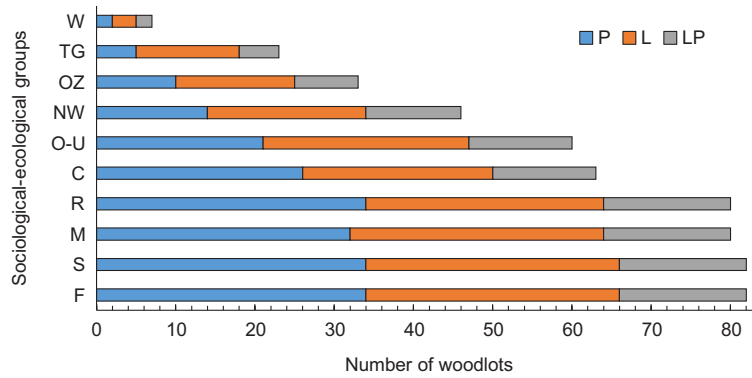


Fig. 5. Number of woodlots in which species representing individual sociological-ecological groups occurred, with the indication of the woodlot’s type
 Explanations: symbols as in Figure 4.

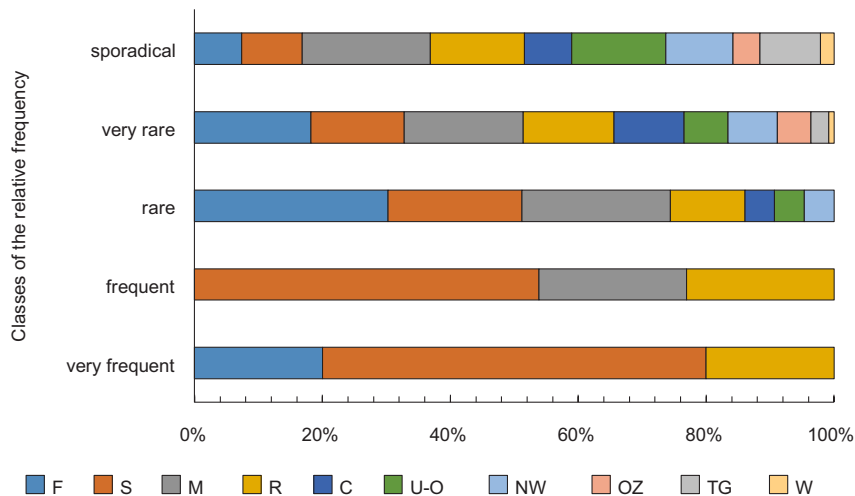


Fig. 6. Percentage incidence of species representing sociological-ecological groups in the relative frequency classes
 Explanations: symbols as in Figure 4.

woodlots – plants associated with aquatic communities (46). The occurrence of species representing other sociological-ecological groups was limited to a much smaller number of objects (Fig. 5).

The largest group (76 species) were meadow plants (Fig. 4). Their percentage incidence in the flora of individual woodlots ranged from 2 to 40%, most often in the range 11–20%. The total number of plants associated with forest communities was slightly lower (64) and their share in the flora of individual sites was within a wide range of 6–54%, with almost a half of them exceeding 20%. It is worth adding that 30 species from the forest group were plants showed as indicators of ancient woodlands, with among others: *Brachypodium sylvaticum*, *Convallaria majalis*, *Elymus caninus*, *Equisetum sylvaticum*, *Majanthemum bifolium*, *Pulmonaria obscura*, *Solidago virgaurea* (Table 1). The number of plants in scrub communities was similar to the number of forest species (62). Their percentage incidence in the flora of individual objects was always higher than 10% and reached 46%, and most often ranged between 21–40%. The group of ruderal plants was less numerous (59); their percentage share in the flora of individual objects ranged

from 3 to 40%, and most often was between 11 and 20%. Representatives of three sociological-ecological groups: segetal (37), ornamental and usable plants (34) and those associated with communities developing near water (31) were recorded in over half of the sites, but their percentage incidence in the flora of individual woodlots usually did not exceed 10%. Like species representing other groups.

More than half of the plants belonging to the classes of very frequent and frequent species were associated with shrub communities (Fig. 6), the rest of the very frequent class represented the groups of ruderal and forest plants, and of the frequent class – groups of meadow and ruderal plants. Representatives of these four groups also made up most of the rare species class. The greatest sociological-ecological diversity was shown by plants of the classes of very rare and sporadic species.

COMPARISON OF FLORA FOUND IN INDIVIDUAL TYPES OF WOODLOTS

The number of species found in each type of woodlots was almost the same in types LP and P, respectively:

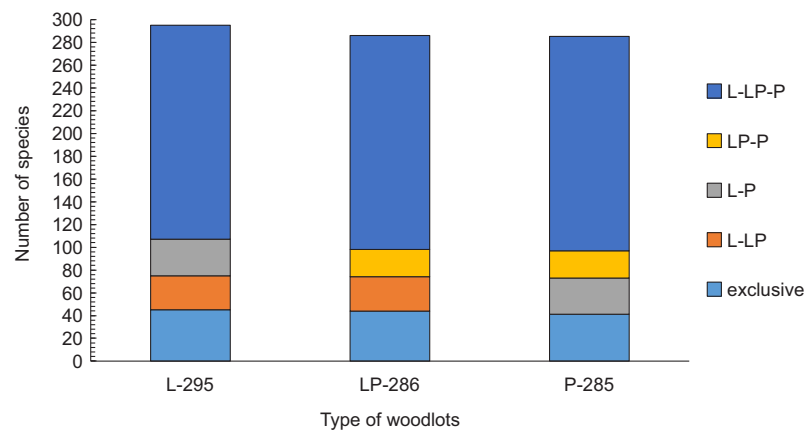


Fig. 7. The incidence of species that occurred exclusively in one of the given type of woodlots, in two types and in each. Explanations: symbols as in Figure 4.

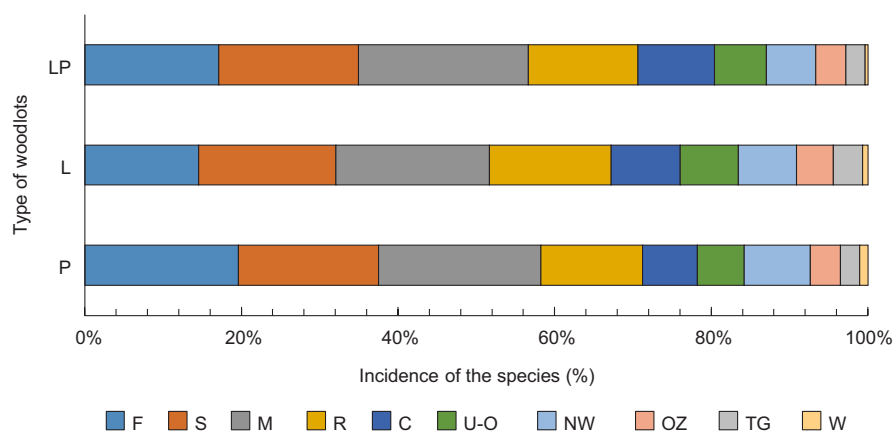


Fig. 8. Percentage incidence in the flora of individual type of woodlots of the species representing distinguished sociological-ecological groups. Explanations: symbols as in Figure 4.

286 and 285, while in type L there were more of them – 295. In all three types, individual objects differed greatly in terms of the number of species: in P-type, the minimum number was 18 and the maximum – 89, with an average of 42 species; in L-type: min. 17, max. 122, on average 50; in the LP-type: min. 29, max. 107, on average 58.

The comparison of the lists of species compiled for each of the woodlots type showed that nearly half of the flora (188 species) occurred in each type. This number included all plants classified as very frequent, frequent and rare, and 51% of very rare. Only in one type of the woodlots occurred, respectively: L – 45 species (including 30 sporadic ones), LP – 44 (44), P – 41 (28). The P-type had more species in common with the L-type than LP-type (Fig. 7).

The numbers of species representing individual sociological-ecological groups (Fig. 4) and their percentage incidence in the flora of each of the three types of woodlots (Fig. 8) differed, although to a small extent. These differences were most clearly marked in the group of forest species, which had a much higher share in the P-type than in the others (Fig. 8). This type was also distinguished by the largest number of species associated with water-related communities (although only 6 objects were situated close to water reservoir) and the smallest number of segetal, ruderal, ornamental and usable species. Compared to the other types, there is also a noticeable greater number and share of segetal species in the woodlots of LP-type and the ruderal and those occurring in termophilic grassland communities in the L-type.

DISCUSSION AND CONCLUSIONS

Research has shown that in the agricultural outskirts of Wrocław, mid-field woodlots occur almost exclusively near the city administrative borders, and their total area does not exceed 1% of the agricultural area (SZYMANOWSKI 2020, unpublished). Despite the relatively small acreage and quite close proximity to intensively emerging housing estates, the woodlots studied have features of marginal habitats occurring in a typical agricultural landscape, which include, among others, significant species richness of plants with diverse ecology, most of which are permanent (perennial) species (LOSTER 1991, MARSHALL & MOONEN 2002, GAMRAT 2012). As in southern Norway (EDVARSDEN et al. 2010), the studied flora consisted of both common species in the country as well as endangered and rare species in the Lower Silesia region (FUDALI et al. 2020). The similarity to the woodlots located in agricultural areas was clearly visible with regard to the sociological-ecological diversity of flora. This applies to the dominance of forest, scrub and meadow elements with a constant, usually not exceeding 20%, share of ruderal plants and a small

number of weeds in crops (WÓJCIK & WASIŁOWSKA 1994, MARSHALL & MOONEN 2002, EDVARSDEN et al. 2010, KOSZELNIK-LESZEK et al. 2015). Thus, our assumption that the flora of the studied woodlots will show signs of ruderalisation in large extent has not been confirmed neither in the general assessment nor in relation to the individual types of woodlots. The distinguishing feature was the nearly 10% share of ornamental and usable species, probably resulted from abandonment of biological waste from gardens and crops in these objects, and from intentional plantings.

In addition to the relatively high species richness and ecological diversity, the studied flora is characterised by a significant incidence of species with a low relative frequency – 72% of species were recorded in no more than 10 objects. Among them were representatives of all sociological-ecological groups, including all species associated with aquatic communities and almost all occurring in: termophilic grassland communities, segetal communities, communities of the forests' herbal fringes, communities developing near water as well as utility and ornamental plants. Thus, the described sociological-ecological and ecological diversity of the flora of the studied woodlots is based on single or few locations, what at the same time indicates a high degree of its threat.

Noteworthy is the occurrence of species considered as plant indicators of ancient woodlands. This role is assigned to nearly half (48%) of the forest plants found (DZWONKO & LOSTER 2001). Twenty one of them showed a clear preference for occurrence in P-type and LP-type, which seems obvious (ORCZEWSKA 2009, FUDALI et al. 2015). But L-type woodlots were also habitats for many of the ancient woodlands indicator plants, e.g. *Ajuga reptans*, *Brachypodium sylvaticum*, *Dactylis polygama*, *Galeobdolon luteum*, *Melampyrum nemorosum*, *Polygonatum multiflorum*, *Scrophularia nodosa*, *Stellaria nemorum*. The relative frequency of most species in this group was very low, they occurred in no more than 10 sites.

Distribution of the studied woodlots was strongly related to the hydrographic network – more than half of the objects (50) were located in the vicinity of natural watercourses or ditches. This resulted in a nearly 20% share of higrrophytes and hydrophytes in the studied flora, including three species, *Carex buekii*, *Oenanthe fistulosa* and *Salvinia natans*, with a high threat status in Lower Silesia (FUDALI et al. 2020). Unfortunately, many of them (28%) were recorded in only one locality. The importance of in-field ditches, watercourses and water bodies for the preservation of rare species not found in other farmland habitats was pointed out by many researchers (e.g. GAMRAT et al. 2007, HERZON & HELENIUS 2008, KRYSZAK et al. 2011, ARCZYŃSKA-CHUDY 2012, TOMASZEWSKA et al. 2016). Our studies has shown that even with far-reaching landscape fragmentation, these habitats can support

specific flora. In the agricultural areas adjacent to Wrocław, the share of woodlots along the ditches was different. They appeared in a similar number as the surface woodlots and those associated with communication routes (ORŁOWSKI & NOWAK 2005).

The location of the studied objects among fertilized cultivated fields is the most likely cause of the presence of a large group of nitrophilic plants (LE COEUR et al. 2002). They formed the majority of the frequent and very frequent species classes, but the core of the group of nitrophytes consists of plants classified as very rare and sporadic. These plants retain nitrogen compounds flowing or blown away from the fields by building them into their tissues. In this way, they also protect surface waters against eutrophication (ARCZYŃSKA-CHUDY 2012). An additional source of nitrogen compounds for the flora of the objects studied can be biological and municipal waste, unfortunately often abandoned there. Certainly, the treatment of mid-field woodlots as landfills for various types of waste cause to the destruction of flora and habitats (GAMRAT 2012), and thus may be a factor in the sporadic occurrence of many species.

Protecting of the agro-ecosystems environment is an important function expected to mid-field woodlots. Many studies indicate their importance in protecting soils against erosion, water retention, modifying the microclimate of fields or maintaining populations of insects and birds beneficial for crops (BANASZAK & CIERZNIAK 2000, LE COEUR et al. 2002, MARSHALL & MOONEN 2002, SCHMUCKI et al. 2002, SYMONIDES 2010, CHAPPELL & LAVALLE 2011, LINDBORG et al. 2014 – and literature cited therein). A rich and ecologically diverse flora is indispensable for this. The presented research has shown that in the agricultural outskirts of Wrocław, there are still preserved floristically and ecologically diverse mid-field woodlots, the presence of which enables them to perform the above-mentioned functions, although their percentage incidence in the crop field acreage is very small (0.87%). At least some of them deserve conservation due to the presence of protected species (*Centaurea erythraea*, *Epipactis helleborine*, *Salvinia natans*), endangered species (*Bromus arvensis*, *B. ramosus*, *Lathyrus latifolius*, *Oenanthe fistulosa*) and rare species in the Lower Silesia region (*Carex buekii*, *Euphorbia lucida*, *Silaum silaus*) (FUDALI et al. 2020). However, it should be added here that these woodlots are also places of migration for many species of invasive alien plants, such as e.g. *Solidago canadensis*, *S. gigantea*, *Padus serotina*, *Robinia pseudoacacia*, *Impatiens parviflora*, *Rosa rugosa*, *Bidens frondosa*, *Reynoutria japonica*, *R. × bohemica* and *Acer negundo* (TOKARSKA-GUZIŁ et al. 2012).

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APPENDIX

Table 1. List of the species found arranged according to their requirements in relation to the humidity of the habitat, together with data on their frequency (number of woodlots in which the species was recorded), trophic requirements and assignation to sociological-ecological group

Symbols: trophic requirements: nn – plants of very rich habitats (Ellenberg index value 8–9), n – plants of rich habitats (7), mn – plants of moderately rich habitats (4–6), pn – plants of poor habitats (1–3), xn – plants neutral in relation to the fertility of the habitat, ln – no data on trophic requirements; sociological-ecological groups: C – plants of segetal communities, F – plants of forest communities, M – meadow plants, TG – plants of warm grassland communities, NW – plants of communities developing near water, OZ – communities of the forests' herbal fringes, R – plants of ruderal communities, S – plants of scrub communities, U-O – utility and ornamental plants, W – aquatic communities; ff – ancient woodlands indicator; * – alien plants (kenophytes).

HYDROPHYTES $\Sigma = 16$

Alisma plantago-aquatica L. [1, nn, NW]; *Eleocharis palustris* (L.) Roem. & Schult. [1, ln, NW]; *Glyceria maxima* (Hartm.) Holmb. [8, nn, NW]; *Glyceria notata* Chevall. [1, nn, NW]; *Hottonia palustris* L. [4, mn, W]; *Lemna minor* L. [3, mn, W]; *Lemna trisulca* L. [1, mn, W]; *Oenanthe aquatica* (L.) Poir. [5, mn, NW]; *Oenanthe fistulosa* L. [1, n, NW]; *Phragmites australis* (Cav.) Trin. ex Steud [22, n, NW]; *Rorippa amphibia* (L.) Besser [2, nn, NW]; *Rumex hydrolapathum* Huds. [5, n, NW]; *Salvinia natans* (L.) Allioni [1, n, W]; *Schoenoplexus lacustris* (L.) Palla [1, mn, NW]; *Sparganium erectum* L. em. Rchb. [3, n, NW]; *Typha latifolia* L. [3, nn, NW].

HIGROPHYTES $\Sigma = 71$

Agrostis canina L. [1, pn, M]; *Agrostis gigantea* Roth [12, mn, M]; *Agrostis stolonifera* L. [4, mn, M]; *Alnus glutinosa* (L.) Gaertn. [33, xn, F]; *Alopecurus aequalis* Sobol. [1, nn, NW]; *Alopecurus geniculatus* L. [1, n, M]; *Angelica sylvestris* L. [6, mn, M]; *Athyrium filix-femina* (L.) Roth [3, mn, ff]; **Bidens frondosa* L. [6, nn, NW]; *Carex acutiformis* L. [16, mn, NW]; *Carex buekii* Wimm. [3, mn, NW]; *Carex gracilis* Curt. [10, mn, NW]; *Carex nigra* Reichard [1, pn, NW]; *Chenopodium chenopodioides* (L.) Aellen [1, nn, R]; *Circaea intermedia* Ehrh. [2, mn, F]; *Cucubalus baccifer* L. [15, n, S]; *Cuscuta europaea* L. [3, n, S]; *Deschampsia caespitosa* (L.) P.B. [13, pn, M]; *Epilobium hirsutum* L. [4, nn, S]; *Epilobium palustre* L. [1, pn, NW]; *Epilobium parvifolium* Schreb. [2, mn, S]; *Equisetum sylvaticum* L. [1, mn, ff]; *Eupatorium cannabinum* L. [2, nn, S]; *Euphorbia lucida* Waldst. et Kit. [3, mn, M]; *Festuca gigantea* (L.) Vill. [2, mn, ff]; *Filipendula ulmaria* (L.) Maxim. [16, mn, M]; *Frangula alnus* Mill. [21, xn, F]; *Galium palustre* L. [2, mn, NW]; *Galium uliginosum* L. [2, pn, M]; *Glyceria fluitans* (L.) R. Br. [9, n, NW]; *Humulus lupulus* L. [46, nn, S]; *Iris pseudoacorus* L. [17, n, NW]; *Juncus conglomeratus* L. [2, pn, M]; *Juncus effusus* L. [16, mn, M]; *Lychnis flos-cuculi* L. [1, xn, M]; *Lycopus europaeus* L. [6, n, NW]; *Lysimachia vulgaris* L. [24, xn, M]; *Lythrum salicaria* L. [15, xn, M]; *Molinia caerulea* (L.) Moench [1, pn, M]; *Myosotis palustris* Hill. [3, mn, M]; *Myosoton aquaticum* (L.) Moench [6, nn, S]; *Padus avium* Mill. [39, mn, F]; *Phalaris arundinacea* L. [27, n, NW]; *Poa trivialis* L. [26, n, M]; *Polygonum hydroper L.* [4, nn, NW]; *Polygonum lapathifolium* L. subsp. *lapathifolium* [2, nn, NW]; *Populus nigra* L. [7, mn, F]; *Ranunculus flammula* L. [1, pn, M]; *Ranunculus repens* L. [8, n, M]; **Reynoutria japonica* Houtt. [4, n, R]; *Ribes spicatum* Robson [5, mn, ff]; *Rumex crispus* L. [14, mn, M]; *Rumex maritimus* L. [1, nn, NW]; *Salix alba* L. [6, mn, F]; *Salix cinerea* L. [11, mn, F]; *Salix fragilis* L. [36, mn, F]; *Salix rosmarinifolia* L. [1, pn, S]; *Salix triandra* L. [1, mn, S]; *Salix viminalis* L. [2, xn, S]; *Scirpus silvaticus* L. [8, mn, M]; *Scutellaria galericulata* L. [5, mn, NW]; *Selinum carvifolia* L. [5, pn, M]; *Solanum dulcamara* L. [6, nn, NW]; *Stachys palustris* L. [8, mn, M]; *Stachys sylvatica* L. [4, n, ff]; *Stellaria nemorum* L. [2, n, ff]; *Symphytum officinale* L. [25, nn, M]; *Ulmus laevis* Pall. [17, mn, F]; *Valeriana officinalis* L. [3, mn, M]; *Veronica anagalis-aquatica* L. [1, mn, NW]; *Veronica longifolia* L. [1, mn, M].

XEROPHYTES $\Sigma = 20$

Anthyllis vulneraria L. [1, pn, M]; *Artemisia campestris* L. [1, pn, TG]; *Asparagus officinalis* L. [2, mn, TG]; *Berteroa incana* (L.) DC. [3, mn, R]; *Bromus tectorum* L. [1, mn, R]; *Dianthus carthusianorum* L. [1, pn, TG]; *Dianthus deltooides* L. [1, pn, TG]; *Euphorbia cyparissias* L. [15, pn, TG]; *Hieracium umbellatum* L. [6, pn, OZ]; *Medicago falcata* L. [2, pn, OZ]; *Melilotus officinalis* (L.) Pall. [1, pn, R]; *Peucedanum oreoselinum* (L.) Moench [1, pn, OZ]; *Pimpinella saxifraga* L. [6, pn, M]; *Potentilla argentea* L. [6, pn, TG]; *Potentilla collina* Wibel [2, pn, TG]; **Cerasus mahaleb* (L.) Mill. [1, pn, S]; *Rosa agrestis* Savi [15, pn, S]; *Sedum maximum* L. [7, pn, OZ]; *Trifolium arvense* L. [3, pn, TG]; *Vincetoxicum hirundinaria* Medik. [1, pn, OZ].

NEUTRAL IN RELATION TO CHANGE OF HUMIDITY IN HABITAT $\Sigma = 41$

Acer platanoides L. [17, xn, F]; *Agrostis capillaris* L. [15, mn, OZ]; *Antoxanthum odoratum* L. [1, xn, TG]; *Arrhenaterum elatius* (L.) P. Beauv. ex J. & C. Presl [50, n, M]; *Atriplex nitens* Schkuhr. [2, n, R]; *Betonica officinalis* L. [2, pn, M]; *Betula pendula* Roth [28, xn, F]; *Bromus hordeaceus* L. [2, pn, M]; *Calamagrostis epigejos* (L.) Roth [46, mn, S]; *Carpinus betulus* L. [12, xn, F]; *Centaurea jacea* L. [7, xn, M]; *Cirsium arvense* (L.) Scop. [42, n, R]; *Corylus avellana* L. [6, mn, F]; *Deschampsia flexuosa* L. [1, pn, F]; *Dryopteris carthusiana* (Vill.) H.P. Fuchs [3, pn, ff]; *Elymus repens* (L.) Gould [46, n, R]; *Equisetum arvense* L. [30, pn, R]; *Festuca ovina* L. [2, pn, TG]; *Fraxinus excelsior* L. [39, n, F]; *Galium aparine* L. [44, nn, S]; *Geranium robertianum* L. [6, n, S]; *Matricaria maritima* L. subsp. *inodora* [6, mn, C]; *Pinus sylvestris* L. [4, xn, F]; *Plantago lanceolata* L. [6, xn, M]; *Polygonum amphibium* L. fo. *terrestris* [8, mn, NW]; *Prunus spinosa* L. [52, xn, S]; *Quercus robur* L. [63, xn, F]; *Ranunculus acris* L. [1, xn, M]; *Ribes uva-crispa* L. [1, mn, S]; *Rubus caesius* L. [59, n, S]; *Rubus idaeus* L. [5, mn, S]; *Rumex acetosa* L. [9, mn, M]; *Salix purpurea* L. [3, xn, S]; *Silaum silaus* (L.) Schinz & Thell. [5, pn, M]; *Sorbus aucuparia* L. [8, xn, F]; *Ulmus minor* Mill. [17, xn, F]; **Solidago canadensis* L. [7, mn, S]; *Stellaria media* (L.) Vill. [15, nn, C]; *Viburnum opulus* L. [12, mn, F]; *Vicia angustifolia* L. [2, xn, C]; *Viola arvensis* Murr. [1, xn, C].

MESOPHYTES $\Sigma = 223$

Acer campestre L. [25, mn, F]; *Achillea millefolium* L. [21, mn, M]; **Acer negundo* L. [5, n, S]; *Acer pseudoplatanus* L. [8, n, F]; *Aegopodium podagraria* L. [14, nn, ff]; *Aethusa cynapium* L. [1, mn, C]; *Agrimonia eupatoria* L. [15, mn, OZ]; *Ajuga reptans* L. [6, mn, ff]; *Alliaria petiolata* (M. Bieb.) Cavara et Grande [39, nn, S]; *Allium vineale* L. [9, n, S]; *Alopecurus pratensis* L. [21, n, M]; **Amaranthus retroflexus* L. [2, n, R]; **Amelanchier* \times *lamarckii* F.G. Schroed. [1, pn, U-O]; *Anchusa arvensis* L. [1, mn, C]; *Anthriscus sylvestris* L. [9, nn, S]; *Apera spica-venti* L. [5, xn, C]; *Arctium lappa* L. [9, nn, R]; *Arctium minus* (Hill) Bernh. [16, nn, R]; *Arctium tomentosum* Mill. [3, nn, R]; *Arenaria serpyllifolia* L. [1, xn, TG]; *Armoracia rusticana* G. Gaertn. et al. [3, nn, R]; *Artemisia vulgaris* L. [44, nn, R]; *Astragalus glycyphyllos* L. [6, pn, OZ]; *Atriplex patula* L. [5, n, C]; *Avena fatua* L. [4, xn, C]; *Ballota nigra* L. [30, nn, R]; *Bellis perennis* L. [1, mn, M]; *Brachypodium sylvaticum* (Huds.) P. Beauv. [15, mn, ff]; *Bromus arvensis* L. [2, mn, C]; *Bromus inermis* Leys. [14, mn, R]; *Bromus ramosus* Huds. [1, mn, S]; *Bromus sterilis* L. [36, mn, R]; **Bryonia alba* L. [1, n, R]; **Bryonia dioica* Jacq. [2, n, R]; *Calamagrostis arundinacea* L. Roth. [8, mn, F]; *Calystegia sepium* (L.) R.Br. [21, nn, S]; *Campanula glomerata* L. [1, pn, TG]; *Campanula trachelium* L. [2, nn, ff]; *Capsella bursa-pastoris* (L.) Medik [2, mn, C]; *Carduus acanthoides* L. [1, n, R]; *Carduus crispus* L. [2, nn, R]; *Carex hirta* L. [25, mn, M]; *Carex pairae* F.W. Schultz [16, mn, S]; *Carex palleseus* L. [2, pn, S]; *Carex sylvatica* Huds. [2, mn, ff]; *Carlina vulgaris* L. [1, pn, TG]; *Centaurium erythraea* Rafn [2, mn, S]; *Cerastium holosteoides* Fr. em. Hyl. [1, mn, M]; *Chaerophyllum temulum* L. [33, nn, S]; *Chamaenerion angustifolium* (L.) Schur [1, nn, S]; *Chamomilla recutita* (L.) Rauschert [1, mn, C]; *Chelidonium majus* L. [21, nn, S]; *Chenopodium album* L. [20, n, C]; *Chenopodium hybridum* L. [1, nn, R]; *Chenopodium polyspermum* L. [5, nn, C]; **Chenopodium strictum* Roth. [2, mn, C]; *Cichorium intybus* L. [16, mn, R]; *Cirsium vulgare* (Savi.) Ten. [17, nn, R]; *Clinopodium vulgare* L. [4, pn, OZ]; *Conium maculatum* L. [14, nn, R]; *Consolida regalis* Gray [2, mn, C]; *Convallaria majalis* L. [5, mn, ff]; *Convolvulus arvensis* L. [18, xn, R]; **Coryza canadensis* (L.) Cronquist [10, mn, R]; *Cornus sanguinea* L. [21, xn, S]; *Crataegus laevigata* (Poir.) DC. [3, mn, S]; *Crataegus* \times *macrocarpa* Hegetschw. [2, ln, S]; *Crataegus monogyna* Jacq. [75, pn, S]; *Crepis biennis* L. [1, mn, M]; *Crepis capillaris* (L.) Wallr. [2, mn, M]; **Cruciata glabra* (L.) Ehrend. [1, mn, S]; **Cydonia oblonga* Mill. [1, mn, U-O]; *Dactylis glomerata* L. [51, mn, M]; *Dactylis polygama* Horv. [30, mn, ff]; *Daucus carota* L. [24, mn, M]; *Descurainia sophia* (L.) Webb ex Prantl [1, mn, R]; *Digitaria sanguinalis* (L.) Scop. [1, mn, C]; *Dryopteris filix-mas* (L.) Schott [4, mn, ff]; *Echinochloa crus-galli* (L.) P. Beauv. [6, nn, C]; *Echium vulgare* L. [2, mn, R]; *Elymus caninus* (L.) L. [10, nn, ff]; **Epilobium ciliatum* Raf. [2, nn, R]; *Epipactis helleborine* (L.) Crantz [1, mn, F]; *Equisetum pratense* Ehrh. [9, pn, M]; **Erigeron annuus* (L.) Pers [16, nn, R]; *Erodium cicutarium* (L.) L'Her. [3, xn, M]; *Erysimum cheiranthoides* L. [6, n, R]; *Euonymus europaea* L. [32, mn, ff]; *Euphorbia esula* L. [4, xn, OZ]; *Euphorbia helioscopia* L. [3, n, C]; *Euphorbia peplus* L. [2, n, C]; *Fagus sylvatica* L. [1, xn, F]; *Fallopia convolvulus* (L.) Á. Löve [38, mn, C]; *Festuca pratensis* Huds. [1, mn, M]; *Festuca rubra* L. [11, xn, M]; *Fragaria vesca* L. [8, mn, S]; *Galeobdolon luteum* Huds. [2, mn, ff]; *Galeopsis bifida* Boenn. [1, nn, S]; *Galeopsis pubescens* Willd. [10, mn, R]; *Galeopsis speciosa* Mill. [4, nn, C]; *Galeopsis tetrahit* L. [18, n, S]; **Galinsoga parviflora* Cav. [3, nn, C]; *Galium boreale* L. [2, pn, M]; *Galium mollugo* L. [23, ln, M]; *Galium verum* L. [9, pn, OZ]; *Geranium pusillum* L. [3, n, C]; *Geranium sylvaticum* L. [2, n, S]; *Geum urbanum* L. [59, n, S]; *Glechoma hederacea* L. [21, n, S]; *Hedera helix* L. [4, xn, ff]; **Helianthus tuberosus* L. [2, nn, R]; *Heraclium sphondylium* L. [12, nn, M]; *Holcus lanatus* L. [17, mn, M]; *Holcus mollis* L. [2, pn, F]; *Hordeum murinum* L. [3, mn, R]; *Hypericum perforatum* L. [44, mn, M]; *Hypochoeris radicata* L. [1, pn, TG]; **Impatiens parviflora* DC. [46, mn, S]; **Juglans regia* L. [10, n, U-O]; *Lactuca serriola* L. [26, mn, R]; *Lamium maculatum* L. [2, nn, S]; *Lamium purpureum* L. [1, n, C]; *Lapsana communis* L. [13, n, S]; *Lathyrus latifolius* L. [2, pn, OZ]; *Lathyrus pratensis* L. [7, mn, M]; *Lathyrus tuberosus* L. [3, mn, R]; *Leontodon autumnalis* L. [1, mn, M]; *Leonurus cardiaca* L. [8, nn, R]; *Leucanthemum vulgare* Lam. [1, pn, M]; *Ligustrum vulgare* L. [9, pn, S]; *Linaria vulgaris* L. [10, mn, R]; **Lolium multiflorum* Lam. [4, nn, U-O]; *Lolium perenne* L. [10, n, M]; *Lonicera xylosteum* L. [2, mn, F]; *Lotus corniculatus* L. [3, pn, M]; *Luzula campestris* (L.) DC. [1, pn, OZ]; *Lysimachia nummularia* L. [15, xn, M]; *Maianthemum bifolium* (L.) DC. [1, pn, ff]; *Malva sylvestris* L. [2, nn, R]; *Malus sylvestris* (L.) Mill. [14, mn, F]; *Medicago lupulina* L. [5, xn, TG]; **Medicago sativa* L. [2, xn, R]; *Melampyrum nemorosum* L. [10, mn, fOZ]; *Melandrium album* (Mill.) Garcke [11, n, R]; *Melica nutans* L. [2, pn, ff]; *Milium effusum* L. [9, mn, ff]; *Moehringia trinervia* (L.) Clairv. [13, n, ff]; *Myosotis arvensis* (L.) Hill [2, mn, C]; **Oenothera biennis* L. [3, mn, R]; *Oxalis acetosella* L. [1, mn, ff]; **Oxalis fontana* Bunge [5, n, C]; **Padus serotina* Ehrh. [40, ln, F]; *Papaver dubium* L. [1, mn, R]; *Papaver rhoeas* L. [2, mn, C]; *Pastinaca sativa* L. [4, mn, M]; *Phleum pratense* L. [16, n, M]; *Picris hieracioides* L. [5, mn, R]; *Pimpinella major* L. Huds [1, mn, M]; *Plantago major* L. [7, mn, R]; *Poa annua* L. [1, nn, M]; *Poa nemoralis* L. [30, mn, ff]; *Poa pratensis* L. [17, mn, M]; *Polygonatum multiflorum* (L.) All. [4, mn, ff]; *Polygonum aviculare* L. [13, mn, C]; *Polygonum persicaria* L. [3, n, C]; *Populus alba* L. [10, mn, F]; *Populus tremula* L. [26, xn, S]; **Portulaca oleracea* L. [1, n, R]; *Potentilla anserina* L. [6, n, M]; *Potentilla reptans* L. [21, mn, M]; *Prunella vulgaris* L. [1, xn, M]; *Prunus avium* L. [36, mn, F]; *Pulmonaria obscura* Dumort. [2, n, ff]; **Pyrus communis* L. [28, xn, U-O]; *Pyrus pyraeaster* (L.) Burgsd. [2, ln, S]; *Ranunculus polyanthemos* L. [1, pn, F]; *Reseda lutea* L. [1, mn, R]; *Rhamnus catharticus* L. [12, mn, S]; **Robinia pseudo-acacia* L. [19, nn, F]; *Rosa arvensis* Huds. [4, mn, S]; *Rosa canina* L. [13, xn, S]; *Rubus fruticosus* L. [32, pn, S]; *Rumex obtusifolius* L. [2, nn, R]; *Salix caprea* L. [9, n, S]; *Sambucus nigra* L. [69, nn, S]; *Sambucus racemosa* L. [2, nn, S]; *Sanguisorba officinalis* L. [7, mn, M]; *Saponaria officinalis* L. [5, mn, R]; *Scrophularia nodosa* L. [22, n, ff]; *Senecio jacobaea* L. [6, mn, R]; *Setaria glauca* (L.) Beauv. [3, mn, C]; **Sisymbrium loeselii* L. [15, mn, R]; *Sisymbrium officinale* (L.) Scop. [1, n, R]; *Solanum nigrum* L. [1, nn, R]; **Solidago gigantea* Aiton [67, n, R]; *Solidago virgaurea* L. [2, mn, ff]; *Sonchus asper* (L.) Hill. [1, n, C]; *Sonchus oleraceus* L. [4, nn, C]; *Stellaria graminea* L. [4, pn, M]; *Tanacetum vulgare* L. [34, mn, R]; *Taraxacum officinale* F.H. Wigg. [11, nn, M]; *Thlaspi arvense* L. [3, mn, C]; *Tilia cordata* Mill. [19, mn, F]; *Tilia platyphyllos* Scop. [5, n, F]; *Torilis japonica* D.C. [31, nn, S]; *Tragopogon pratensis* L. [1, mn, M]; *Trifolium campestre* Schreb. [1, pn, TG]; *Trifolium medium* L. [4, pn, OZ]; *Trifolium pratense* L. [4, xn, M]; *Trifolium repens* L. [4, mn, M]; *Tussilago farfara* L. [3, xn, R]; *Urtica dioica* L. [68, nn, R]; *Verbascum densiflorum* Bertol. [1, mn, R]; *Verbascum thapsus* L. [1, n, R]; *Verbena officinalis* L. [2, n, R]; *Veronica chamaedrys* L. [10, mn, M]; *Vicia cracca* L. [26, xn, M]; *Vicia hirsuta* (L.) Gray [7, mn, C]; *Vicia sepium* L. [1, mn, OZ]; *Vicia tetrasperma* (L.) Schreb. [1, mn, C]; *Vicia villosa* Roth. [6, mn, C]; *Viola odorata* L. [2, nn, S]; *Viola reichenbachiana* Jordan ex Bor. [12, mn, ff].

SPECIES OF NOT DEFINED BY ELLENBERG et al. (2001) REQUIREMENTS TO HUMIDITY $\Sigma = 32$

**Aesculus hippocastanum* L. [7, ln, U-O]; **Aronia melanocarpa* (Michx.) Elliott [1, ln, U-O]; *Avena sativa* L. [1, ln, U-O]; **Cerasus vulgaris* Mill. [2, ln, U-O]; **Fraxinus latifolia* Benth. [3, ln, U-O]; **Ipomoea purpurea* (L.) Roth [1, ln, U-O]; *Iris germanica* L. [2, ln, U-O]; *Linum usitatissimum* L. [1, ln, U-O]; **Lycopersicon esculentum* (L.) Karst. ex Farw. [1, ln, U-O]; **Malus domestica* Borkh. [14, ln, U-O]; **Miscanthus sacchariflorus* (Maxim.) Hack. [1, ln, U-O]; **Morus alba* L. [2, ln, U-O]; **Parthenocissus inserta* (A. Kern.) Fritsch [9, ln, U-O]; **Populus* \times *canadensis* Moench [2, ln, U-O]; **Prunus cerasifera* Ehrh. [20, ln, U-O]; **Prunus domestica* L. [7, ln, U-O]; *Prunus domestica* L. subsp. *syriaca* (Borkh.) Janch [9, ln, U-O]; **Quercus palustris* Münchh. [1, ln, U-O]; **Quercus rubra* L. [5, ln, F]; **Reynoutria* \times *bohemica* Chrtk & Chrtkova. [2, ln, R]; **Rhus typhina* L. [1, ln, U-O]; **Rosa multiflora* Thunb. [4, ln, U-O]; **Rosa rugosa* Thunb. [1, ln, U-O]; *Salix* \times *fruticosa* Döll. [1, ln, U-O]; *Salix* \times *multinervis* Döll. [8, ln, S]; *Salix* \times *reichardtii* A.Kern. [2, ln, S]; *Secale cereale* L. [1, ln, U-O]; **Sida hermaphrodita* (L.) Rusby [1, ln, U-O]; **Silybum marianum* (L.) Gaertner [1, ln, U-O]; **Sorbaria sorbifolia* (L.) A. Br [2, ln, U-O]; **Symphoricarpos albus* Duhamel [4, ln, U-O]; *Triticum aestivum* L. [2, ln, U-O].