Appendix 3

To the application of Ewa Stefańska-Krzaczek dated 27.09.2023
re.: commencement of the procedure for the conferment
of the post-doctoral degree of doctor habilitated

Summary of Professional Accomplishments

1. **Name.**

Ewa Agata Stefańska-Krzaczek

2. **Diplomas, degrees conferred in specific areas of science or arts, including the name of the institution which conferred the degree, year of degree conferment, title of the PhD dissertation.**

2000: Bachelor's degree in biology, diploma of completion of a 3-year vocational study in biology in the field of botany; bachelor's thesis prepared at the Faculty of Natural Sciences, University of Wrocław, under the supervision of Prof. Jadwiga Anioł-Kwiatkowska, "Contribution of medicinal plants to the native dendroflora".

2002: Master's degree in biology, diploma of 2-year master's degree in botany; Master's thesis prepared at the Faculty of Natural Sciences, University of Wrocław, under the supervision of Dr Zygmunt Kącki "Structure and functioning of mid-forest clearings after abandonment of their use".

2008: PhD in biological sciences in the discipline of biology; doctoral thesis prepared at the Faculty of Biological Sciences, University of Wrocław, under the supervision of Prof. Wiesław Fałtynowicz "State and dynamic trends of the pine communities of the Bory Dolnośląskie Forest".

3. **Information on employment in research institutes or faculties/departments or school of arts.**

2007-2008: assistant in the Department of Biodiversity and Plant Cover Protection of the Institute of Environmental Biology, Faculty of Biological Sciences, University of Wrocław.

2008-2016: assistant professor in the Department of Biodiversity and Plant Cover Protection (since 2013 Department of Botany) of the Institute of Environmental Biology, Faculty of Biological Sciences, University of Wrocław.

2016-2017: assistant professor in the Department of Vegetation Ecology of the Institute of Environmental Biology, Faculty of Biological Sciences, University of Wrocław.

2017- to present: assistant professor in the Botanical Garden of the University of Wrocław, head of the Laboratory of Vegetation Ecology.

Break in scientific work:
27.04.2009-05.03.2010 – maternity and parental leave due to the birth of my son Antoni.

4. **Description of the achievements, set out in art. 219 para 1 point 2 of the Act.**

Points of the Ministry of Science and Higher Education (MNiSW) or the Ministry of Education and Science (MEiN) are given according to the POLON database. Impact Factor (IF) from the year of publication was given according to the https://www.bioxbio.com/ database, five-year Impact Factor (IF5-year) according to the Web of Science database. The number of citations is given according to Web of Science (WoS) and Google Scholar (GS).

4.1. Achievement 1

DYNAMICS AND SPECIES DIVERSITY OF MANAGED SCOTS PINE FORESTS IN CENTRAL EUROPE

4.1.1. List of publications in a cycle of scientific articles related thematically, pursuant to art. 219 para 1. point 2b of the Act.

(1A.1) Stefańska-Krzaczek E., Szymura T. 2015. Species diversity of forest floor vegetation in age gradient of managed Scots pine stands. Baltic Forestry 21(2): 233-243.
Points of $MNiSW_{2015}$=15, points of $MEiN_{2023}$=70, IF_{2015}=0.530, $IF_{5\text{-letni}}$=1, number of citations according to WoS=6, number of citations according to GS=6

My contribution to the article: independent field data collection, preparation of the database, conception of the article, posing research questions, literature search and collection, calculation of species diversity indices and performance of statistical significance tests, execution of variation partitioning analysis, writing of the text of the article, re-execution of the analyses and new analyses according to the reviewers' comments, correction of the text after the review, function of a corresponding author.

(1A.2) Stefańska-Krzaczek E., Staniaszek-Kik M., Fałtynowicz W. 2016. Positive aspects of clear-cut logging? Ground bryophyte diversity along the age gradient of managed *Pinus sylvestris* stands. Cryptogamie, Bryologie 37 (2): 181-197.
DOI: https://doi.org/10.7872/cryb/v37.iss2.2016.181
Points of $MNiSW_{2016}$=20, points of $MEiN_{2023}$=40, IF_{2016}=1.062, $IF_{5\text{-letni}}$=0.7, number of citations according to WoS=4, number of citations according to GS=5

My contribution to the article: field data collection, preparation of the database, conception of the article, posing the research questions, literature search and collection, performance of all statistical analyses, writing of the text of the article, improvement of the analyses and text after review process, function of a corresponding author.

(1A.3) Stefańska-Krzaczek E., Fałtynowicz W., Szypuła B., Kącki Z. 2018. Diversity loss of lichen pine forests in Poland. European Journal of Forest Research, 137(4), 419-431.
DOI: https://doi.org/10.1007/s10342-018-1113-4
Points of $MNiSW_{2018}$=40, points of $MEiN_{2023}$=100, IF_{2018}=2.354, $IF_{5\text{-letni}}$=2.8, number of citations according to WoS=12, number of citations according to GS=14

My contribution to the article: independent field data collection, preparation of the database, conception of the article, posing research questions, literature search and collection, cooperation in the development of a method for the identification of lichen pine forests in the Polish Vegetation Database, performance of all statistical analyses for local and regional data, writing of the text of the article, improvement of analyses and text after review process, function of a corresponding author.

(1A.4) Stefańska-Krzaczek E., Staniaszek-Kik M., Szczepańska K., Szymura T.H. 2019. Species diversity patterns in managed Scots pine stands in ancient forest sites. PLOS ONE 14(7): e0219620.
DOI: https://doi.org/10.1371/journal.pone.0219620

Points of $MNiSW_{2019}$=100, points of $MEiN_{2023}$=140, IF_{2019}=2.740, $IF_{5\text{-letni}}$=3.8, number of citations according to WoS=7, number of citations according to GS=12

My contribution to the article: field data collection, preparation of the database, conception of the article, posing the research questions, literature search and collection, performance of all statistical analyses, writing of the text of the article, improvement of the analyses and text after review process, function of a corresponding author.

(1A.5) Stefańska-Krzaczek E., Swacha G., Żarnowiec J., Raduła M. W., Kącki Z., Staniaszek-Kik, M. 2022. Central European forest floor bryophytes: Richness, species composition, coexistence and diagnostic significance across environmental gradients of forest habitats. Ecological Indicators, 139, 108954.
DOI: https://doi.org/10.1016/j.ecolind.2022.108954
Points of $MEiN_{2022}$=140, points of $MEiN_{2023}$=200, IF_{2022}=6.9, $IF_{5\text{-letni}}$=6.6, number of citations according to WoS=4, number of citations according to GS=6

My contribution to the article: conception of the article, posing the research questions, literature search and collection, calculation of bryophyte species richness and cover in forest types, determination of environmental variables for analyses, preparation of a database with bryophyte species traits, performance of ordination analyses, determination of groups of co-occurring bryophyte species and numerical analyses of these groups, preparation of maps of group distribution in Poland, writing of the text of the article, improvement of analyses and text after review, function of a corresponding author.

Total Impact Factor of the journals in the year of publication: **13.586**
Total 5-year Impact Factor of the journals: **14.9**
Total number of the points of MNiSW and MEiN for the journals in the publication year: **315**
Total number of the points of MEiN for the journals in 2023: **550**
Number of citations of all publications of the Achievement 1 according to the Web of Science database: **33**
Number of citations of all publications of the Achievement 1 according to the Google Scholar database: **43**

4.1.2. Description of the aims and results of Achievement 1 and its contribution to the development of the discipline

Introduction and research objectives

Scots pine (*Pinus sylvestris*) is one of the most important species of economic value in Europe, so its distribution covers a variety of habitats, regardless of natural factors (Mason & Alía, 2000; Houston Durrant et al., 2016). Some forests with Scots pine contribution are secondary communities for deciduous forests, requiring restoration or regenerating spontaneously (Coote et al., 2012; Czerepko, 2004; Zerbe, 2002). However, due to the fact that a larger part of Europe is within the natural range of Scots pine, pine forests are the appropriate component of the vegetation cover in habitats that are not preferred by deciduous trees (Leuschner & Ellenberg, 2017). The occurrence of Scots pine forests in Europe is favored by soil conditions determined by the course of the European sand belt (Zeeberg, 1998). The vegetation cover of Central Europe should be dominated by deciduous forests. However, most forests of fertile habitats have been cleared and converted into agricultural or grasslands.

Therefore, from the former extensive forest complexes, pine forests, forming associations classified within the *Dicrano-Pinion* alliance, are often the remaining ones (Leuschner & Ellenberg, 2017; Matuszkiewicz, 2001).

Pine forest communities, common in Poland, are intensively managed. The life cycle of a managed pine stand is relatively short, as the pine's rotation age is usually 80-120 years, depending on soil and geographic conditions. The practice of growing pine stands is very well-established (Puchniarski, 2008). The primary type of felling in fresh forest habitat is clear-cutting, followed by removal of stumps and post-felling debris and ploughing. Tending cuts are carried out throughout the growth and development cycle of the stand. Pre-commercial thinnings are carried out in stands up to 20 years of age, which involves leaving trees removed by the cuts on the forest floor to decompose. Commercial thinnings are carried out for stands older than 20 years up to the rotation age. A side effect of commercial thinning is timber harvesting, thus only branches and stumps from felled trees remain on the forest floor. Regular management practices affect the structure of the stand, regulate its composition and density, which in turn affects the species composition of the lower layers of the community (Ares et al., 2010; Augusto et al., 2003; Aussenac, 2000). Various researchers have demonstrated the significant impact of silvicultural treatments on dynamics and diversity of forests (Czerepko et al., 2021; Karazija, 2003; Moola & Vasseur, 2004; Tonteri et al., 2016; Uotila et al., 2005). However, the processes occurring in plant communities from the stand initiation stage to the mature stands in Central European Scots pine forests, especially considering vascular plants and bryophytes and lichens, are not yet well understood.

In Central Europe, deciduous forests are considered to be the primary hotspots of biodiversity (Flensted et al., 2016; Schmidt et al., 2014), as nutrient-poor habitats are preferred by a limited species pool (Cornwell & Grubb, 2003). Pine forests are considered to have relatively low species richness compared to deciduous forests (Matuszkiewicz, 2001). However, nutrient-poor habitats favor a specific flora that represents an important part of the resources of European forests. In recent years, changes in the structure of forest communities have been observed as a result of eutrophication and climate change (Diekmann et al., 2023; Keith et al., 2009; Naaf & Wulf, 2010). Particularly vulnerable to decline are the poorest forests, including Scots pine lichen forests (Reinecke et al., 2014; Zaniewski et al., 2016). Monitoring this phenomenon is crucial, as is identifying the direct causes of these changes and developing methods for their protection or even restoration of lichen pine forests (Węgrzyn et al., 2020, 2021).

Managed Scots pine forests are often treated as monocultures with little ecological significance. However, these are ecosystems built by groups of native species, whose ecological properties and mutual relationships have not been extensively analyzed. Pine forests occupying suitable habitats have a species pool that distinguishes them from secondary pine stands (Kowalska et al., 2017; Matuszkiewicz et al., 2013). At the same time, however, management activities can limit the availability of substrates and microhabitats (Paillet et al., 2010) and promote non-forest species (Marozas et al., 2005; Widenfalk & Weslien, 2009). Managed pine forests are also characterized by a specific spatial arrangement consisting of successive age classes of the stand, which differ in structure and intensity of management (Stefańska-Krzaczek, 2011; Tonteri et al., 2016). This can result in conditions not being in place for sensitive forest species to thrive, even if habitat continuity is maintained (Kolb & Diekmann, 2004; Nordén et al., 2014).

Issues related to Scots pine forests motivated me to undertake research on these communities. The aims were as follows:

1. Evaluation of changes in species diversity and species composition during growth and development of a pine stand subject to intensive management.

2. Identification of diagnostic species for the growth and development stages of pine stands.
3. Identification of directional transformations of pine forests and assessment of the possibility of preserving naturally valuable communities in the forest resources of Poland.
4. Determination of indicator species of pine forests throughout Poland and groups of co-occurring species that prefer pine forests.
5. Assessment of the characteristics of key species for shaping the structure of pine forest communities, their growth forms, life strategies and habitat requirements.

Achieving these goals first of all required taking into account spore-producing organisms, i.e., lichens and bryophytes. Even though the species pool of pine forest habitats is well documented, as is the their vegetation, my research has contributed new knowledge to the science regarding the dynamic interpretation of plant communities in intensively managed Scots pine forests.

Results of achievement and their contribution to the development of the discipline

I started my research on managed Scots pine forests with the phytosociological characteristics of pine forest communities in successive age classes. I conducted research on fresh coniferous forest habitats (Bśw) and mixed fresh coniferous forest habitats (BMśw) in the Bory Dolnośląskie Forest, in the Bolesławiec Forestry District (Stefańska-Krzaczek, 2011). Species of lichens and bryophytes, mainly mosses, proved crucial in distinguishing plant communities. I found that the identified communities differ depending on forest habitat types and tree stand development stages. Communities of different habitats were characterized by different species composition, and mainly quantitative differences were observed between the communities of forest stand developmental stages.

I subsequently focused on assessing dynamic trends in plant communities of pine stand age classes, irrespective of phytosociological classification. First, I focused on changes in species diversity along the age gradient of pine stands on oligotrophic sites in the fresh coniferous forest type (Bśw, according to the classification of forest habitats) (Stefańska-Krzaczek, 2012). My research has shown that in poor pine forest habitats, the following succession stages can be distinguished in a succession series representing 120 years of development of a forest community: 1 – Stands before crown closure (up to 10 years old), 2 – Young closed stands aged 11-40 years, and 3 – Closed stands aged over 40 years. The first stage of succession was distinguished by the highest species richness of vascular plants and lichen cover. Light-demanding species were associated with it, but forest species from the class Vaccinio-Piceetea were also regenerating. The second stage had transitional character. The compactness of the crowns favoured bryophyte cover and reduced heliophyte species. The third three was characterised by the lowest species richness and highest bryophyte cover. The last stage of succession included relatively young stands, just over 40 years old, due to the lack of differences in species composition between them and the oldest stands (81-120 years old).

Due to the low species richness in oligotrophic habitats, I also conducted analyses for coniferous forests in more fertile habitats. I conducted research on changes in species diversity on mesotrophic forest habitats of mixed fresh coniferous forest type (BMśw) (**1A.1**: Stefańska-Krzaczek & Szymura, 2015). I analyzed changes in diversity indices and species composition along the gradient of stand age and tree crown cover. Based on the results obtained, it was found that on mesotrophic habitats, crown closure and the withdrawal of heliophyte species colonizing clear-cuts occur faster than on oligotrophic habitats. The communities with the oldest tree stands were characterized by the lowest species richness, while the youngest stands (stand initiation phase) had a higher number of vascular plant and lichen species. The communities

with the oldest stands were characterized by high bryophyte cover, but lower compared to oligotrophic habitats. On the other hand, vascular plant cover was higher in mesotrophic habitats, which could be associated with better trophic conditions of mixed fresh forest habitats compared to fresh forest habitats. I expanded the research on the dynamics of communities in mesotrophic habitats by analyzing changes in the abundance of individual species. It was shown that coverage of only two species – *Pleurozium schreberi* and *Vaccinium myrtillus* – increased significantly with age. The use of ordination analyses confirmed that the species composition of communities with the youngest stands was clearly distinct from the other tree stand age classes, which was due to the presence of heliophyte species colonizing the open clear-cut areas. The study demonstrated that although the habitat of mixed fresh coniferous forest was more abundant in nutrients and better moisturized than that of fresh coniferous forest, the communities with the oldest stands (81-120 years old) were not characterized by a clear floristic difference compared to younger but already closed stands (41-80 years old). The communities with stands of closed canopies (21-120 years) were similar in terms of species composition, although they did not form as compact a group in the ordination space as the youngest stands, which was attributed to differences in tree canopy cover.

My research shows that the Scots pine forest community forms relatively quickly after the stand becomes closed, but it is formed by species that readily regenerate after clear-cutting. A characteristic feature of the communities in the oldest stands is low species richness and the absence of late-successional species, regardless of whether it is an oligotrophic or mesotrophic habitat. The communities in the oldest stands have species showing high fidelity, but they are not exclusive to the oldest age class communities of managed Scots pine stands. I have inferred that forestry operations support and accelerate the transformation of communities because they replace natural slow processes (regeneration, self-thinning, stand dieback). I found that the removal of stands during clear-cutting and the destruction of ground cover during area preparation for regeneration, as well as the relatively short life cycle of the stand, can prevent sensitive species from regenerating and persisting in managed pine forest complexes. On the other hand, the results show that clear-cutting on poor habitats does not lead to a significant expansion of non-forest species but rather favors small spore-producing species. These species usually do not occur in communities with old pine stands because they do not find favorable conditions there and are overcome by more competitive mosses and vascular plants. In view of climate change and habitat eutrophication, small oligophilous species, especially ground lichens, may at least temporarily find optimal conditions for development in stand initiation phase. The lack of specialized species associated with the oldest pine stands in mesotrophic habitats further indicates that restoration of pure pine stands or enrichment with native deciduous species is justified. Changes towards mixed coniferous forests or poor deciduous forests will not be a threat to the coniferous forest flora and may increase the mosaic vegetation of pine monocultures.

The obtained results motivated me to undertake further research on pine forests, which I conducted in the Bory Tucholskie Forest (Przymuszewo Forest District), with dominant fresh coniferous forest habitats. The preliminary studies in this area aimed to identify the plant communities of successive age classes of pine stands (Stefańska-Krzaczek & Fałtynowicz, 2014). I found significant similarity of vegetation to phytocenoses of oligotrophic habitats from the Bory Dolnośląskie Forest. Because of the role of bryophytes in the various phases of pine forest development – mainly the significant but variable abundance of mosses shaping the phytocenoses – I conducted a study of this group of organisms in the management cycle of a pine stand. The project included analyses of species diversity, species preference to forest phytocenosis, growth forms and life strategies, as well as preferences for light and soil moisture (**1A.2**: Stefańska-Krzaczek et al., 2016). I found an increase in the number of bryophyte species after stand removal and an increase in bryophyte cover in subsequent age classes, particularly

after canopy closure. I assessed that beta diversity (expressed by the Whittaker index) was lowest for mature stand communities, indicating their high homogeneity. The value of the index increased with the addition of successive age classes of forest stands, indicating that each age class contributes to an increase in species diversity in the managed forest complex. Age classes (except for stands aged 61-80 years) had their indicative species, but most distinct in terms of the moss layer were the communities of the youngest stands (the phi coefficient of fidelity was the highest). The bryophyte layer of the studied forests was composed primarily of species found equally in forests and open areas, as well as species occurring in forests but preferring open areas (Schmidt et al., 2011). In the bryoflora of all age classes, I found only two species of bryophytes described as closed forest species (true forest species), i.e., *Lophocolea heterophylla* and *Ptilium crista-castrensis*. These species favored the communities with middle-aged stands (20-40 years) rather than the oldest ones. I associated this with the significant amount of fine decaying wood, which remains after thinning and enriches the substrate and promotes more demanding bryophyte species. The results of my research also indicate that species typical of open habitats do not occur in the clear-cut areas. Heliophyte species are dominant in these areas, but only those that are components of forests according to the categories of Schmidt et al. (2011). The research also showed that the change in the species composition of the bryophyte layer was the result of appearing species according to their characteristics – growth form, life strategy or preference for light and moisture. After clear-cutting, the proportion (both in terms of numbers and coverage) of species forming turfs increased, as did the proportion of colonizers and stress-tolerant species, while the percentage of species with flat and branched wefts and perennial species decreased. After clear-cutting, species with higher light requirements and lower moisture needs appeared, and then, as the stand grew, they were replaced by bryophytes that prefer shading and higher soil moisture.

To broaden the knowledge of changes in diversity and species composition during pine stand growth, I conducted further research taking into account from the following substrates – soil, decayed wood and tree trunks. I concluded that since there are no specific ground species exclusive to the communities with the oldest stands, epiphytic or epixylic species may play this role. I selected the area of the Bory Stobrawskie Forest and the Brzeg Forest District for my research (**1A.4**: Stefańska-Krzaczek et al., 2019). The analysis of historical data showed that the selected fragment of the Bory Stobrawskie Forest lies entirely in ancient forest habitats, i.e. there has been a forest cover since the mid-18th century. Research on coniferous forests in ancient forest sites had already been conducted by other researchers, but my results obtained in the age classes of stands in ancient forest sites were new to the science. The pool of all species was relatively small (116 species), despite the collection of samples from various substrates. The number of species in the age classes was similar. The number of epiphytes increased with the age of the stand, while the number of ground lichen species decreased. Moreover, in the communities with young stands where tree canopies were already closed (20-35 years old), the highest number of species occurred on decaying wood. Therefore, the species composition changed with stand age, although the number of species remained at a similar level. Despite the inclusion of species from various substrates, the ordination analysis showed a clear distinctiveness of the communities of the youngest stands and similarity of all other age classes. In the ordination space, the oldest stands (95-110 years) did not form a separate group. In the recorded species pool, the largest proportion consisted of taxa occurring equally in forests and open areas (46%). Species of closed forests accounted for only 18% of the species pool. Their number was the lowest in the communities with the youngest tree stands, and it increased after canopy closure (20-35 years) and remained at a similar level in communities of each subsequent stage of stand growth. This was due to the colonization by closed forest species of decaying wood, which is most abundant in young closed stands because it remains after thinning operations. Species characteristic of ancient forests were sporadic and occurred randomly on

the studied plots and were not observed to co-occur with each other. The research showed that the structure of pine forests is primarily formed by species with a wide ecological range, which can inhabit two or three types of substrates and tolerate changes in microclimatic conditions. Intensive forest management, including regular clear-cutting, regeneration and thinning, may additionally decrease species richness by limiting the presence of large pieces of decaying wood and old and thick trees, as well as by disrupting the entire ecosystem by stand logging.

My studies of vegetation dynamics in the growth and development cycle of a Scots pine stand have contributed to expanding our knowledge of the processes occurring in managed forests. New contributions to this issue primarily involves understanding the specificity of these processes in fresh coniferous forests in Central Europe.

The expansion of my research on the dynamics of coniferous forests included an analysis of their directional changes observed in forest communities in recent decades. In the Bory Tucholskie Forest, significant areas were occupied by lichen pine forests (*Cladonio-Pinetum* association) in the last century – these communities are now protected as a Natura 2000 habitat (91T0 – Central European lichen pine forests). In view of the necessity to protect the lichen pine forests, I focused on assessing the conservation status of ground lichens, especially representatives of the genus *Cladonia* – taxa crucial for the identification of lichen pine forests (Stefańska-Krzaczek & Fałtynowicz, 2013). The analysis showed that only young pine stands can currently be considered refuges for *Cladonia* lichens in managed pine forests because the ground becomes dominated by more competitive bryophytes in older stands. The next step was to assess how the communities classified in the 1970s as lichen pine forests (Fałtynowicz, 1986) have changed. The research included stands that had not been cut and replanted since the 1970s of the previous century. I decided to expand the local-scale research with a regional analysis of phytosociological relevés collected in the largest vegetation database in Poland, the Polish Vegetation Database (**1A.3**: Stefańska-Krzaczek et al., 2018). In the local-scale studies (on re-examined areas of the Bory Tucholskie Forest), I confirmed that lichen cover and species richness decreased over the course of 30 years, while the abundance of herbaceous plants and bryophytes increased. The frequency of individual lichen species also declined, while the frequency of bryophyte species increased. Quantitatively, species with higher requirements for substrate trophism began to dominate. On a regional scale (across Poland), I analyzed 607 plots (phytosociological relevés) representing lichen pine forests, examined in the years 1951-1969, 1970-1989 and 1990-2011. Based on the regional data, a group of co-occurring lichen species was identified, and their presence was a crucial indicator of changes in the species composition of coniferous forests. It was determined based on statistical methods using the mutual fidelity of species expressed by the phi coefficient. The identification of this group is an important contribution to understanding the diversity of broadly defined pine forest communities on the poorest habitats, as well as their most valuable type – the *Cladonio-Pinetum* association. The designated group of lichens was found both in the plots surveyed in the earliest times and in the present day, indicating that the pool of species typical of lichen forests persists in poor forests. The disappearance of the most valuable pine forests (patches of the *Cladonio-Pinetum* association) is therefore determined by a significant reduction in lichen cover. The rapid increase in the abundance of species with higher substrate nutrient requirements allowed to identify habitat eutrophication as the main cause of changes in the structure of poor pine forests. Eutrophication, coupled with climate changes, favors development of vascular plants and bryophytes, while limiting the occurrence of less competitive lichens.

The research I conducted on directional processes in pine forests has allowed to assess that the species pool of poor coniferous forests will remain in the forests. However, phytocenoses of the *Cladonio-Pinetum* association will become increasingly rare because they are identified by a significant abundance of ground lichens, for which there are currently no favorable conditions for development. As shown in earlier studies, although clear-cutting in the

poorest habitats promotes the development of ground lichens (Stefańska-Krzaczek, 2012; Stefańska-Krzaczek & Fałtynowicz, 2013)**,** it does not lead to the regeneration of *Cladonio-Pinetum* communities.

Since bryophytes have constituted a very important group in the structure of pine forests in all my studies, I decided to pay special attention to their diversity across the entire territory of Poland. My previous research has focused on single forest complexes, thus I wanted to conduct studies that would help me understand the bryophyte resources in pine forests across the country. In order to identify the bryophyte species associated with Scots pine forests, it was necessary to analyze all the major forest types and then determine the bryophytes specific to pine forests in that context (**1A.5**: Stefańska-Krzaczek et al., 2022). From the resources of the Polish Vegetation Database, all phytosociological relevés representing forests were selected, and subsequently classified into EUNIS habitats (European Nature Information System Habitat Classification). The analyses were conducted on a dataset of 15,355 plots (phytosociological relevés) involving bryohytes. In the context of my main research topic, I particularly focused on the EUNIS T35 habitat (Temperate continental *Pinus sylvestris* forest). Based on the boosted regression tree models I found that the proportion of coniferous species in the tree stand and the low fertility of the substrate favored the cover and number of bryophyte species. Therefore, pine forests provide favorable conditions for the development of the moss layer. However, on the other hand, the number of bryophyte species and their coverage depend on soil moisture, and pine forests on dry and fresh habitats are characterized by unfavorable moisture conditions. The study also identified the most common bryophyte species of broadly defined coniferous forests (*Pleurozium schreberi, Dicranum scoparium, D. polysetum, Hylocomium splendens, Ptilidium ciliare*). I have previously recorded all of these species in pine forests during my own field research. As ordination analysis shown, for the species composition, as for the number of bryophyte species and their cover, the moisture content and trophism of the substrate were crucial. In addition, the pH of the substrate was also important, and this indicates that pine forests of dry or fresh and acidic habitats have their own bryological specificity. Bryophytes of closed forests ("true" forest bryophytes) showed a preference for deciduous stands, while bryophytes found equally in forests and open areas were associated with coniferous stands. This explained the low proportion of closed forest species in my previous studies concerning selected forest complexes. In addition, short-lived species were associated with deciduous forests, while perennial species were associated with coniferous forests. In coniferous forests, the low competition from vascular plants and the absence of growth-limiting leaf fall favor perennial species. Habitat T35, of my particular research interests, did not have a high average number of bryophyte species (4), and its diagnostic species included *Pleurozium schreberi, Dicranum polysetum, D. spurium,* and *Ptilidium ciliare* – species I have recorded in the studied forest complexes.

In my work, a new approach to the distribution of bryophytes in forests was the use of statistical methods to assess the co-occurrence of species. The phi coefficient, which measures the mutual fidelity of species, was calculated and co-occurring species were grouped together. In the forests of Poland, I found 10 groups of co-occurring bryophyte species, consisting of a total of 42 species. Three from the designated groups: *Pleurozium schreberi* species group (*Dicranum polysetum, D. scoparium, Hylocomium splendens, Pleurozium schreberi, Ptilium crista-castrensis*), *Hypnum jutlandicum* species group (*Dicranum spurium, Hypnum jutlandicum, Ptilidium ciliare*) and *Polytrichum juniperinum* species group (*Cephaloziella divaricata, Ceratodon purpureus, Polytrichum juniperinum, P. piliferum*) were associated with conifer stands and showed fidelity to habitat T35. The group of *Pleurozium schreberi* was common in all coniferous forests, and the last two groups were associated with habitats with good light conditions and low humidity, while the group *Hypnum jutlandicum* had a suboceanic character.

Thanks to my research, the resources of forest bryophytes occurring in the undergrowth of Polish forests have been assessed for the first time. I have shown the species and groups of species typical for the habitats of pine forests compared to all types of forests. The Polish Vegetation Database provided an opportunity to assess the occurrence of forest bryophytes associated only with the forest floor, since only this group is recorded in phytosociological relevés. This demonstrates how challenging it is to assess the full bryoflora, i.e., species from all the substrates and microhabitats available in the forests without a comprehensive database covering them all.

Summary, conclusions and research plans

My research demonstrates that the state of diversity in pine forest communities is associated with the specific dynamics of these forests and results from a limitation in their species pool. Good forest condition, associated with high species diversity, is linked to specific attributes such as habitat continuity, complex vertical structure, species richness, age diversity in tree and shrub layers, the presence of decaying wood and numerous microhabitats. While some attributes of valuable forests may be present in managed pine forests, such as habitat continuity, the very nature of the habitats of the studied forests – poor, acidic substrate with poor moisture content – is a limitation to diversity. This characteristic is compounded by forestry practices and the short lifespan of individual forest stands. As a result, the species composition of forest complexes including pine stands in various age primarily consists of species with a fairly broad ecological range. Nonetheless, pine forests should be regarded as reservoirs of a specific oligophilic flora/biota, which is unlikely to colonize other types of forests, especially that the diversity and species composition of communities in nutrient-poor habitat change irreversibly due to directional dynamic processes. Forest management activities can be seen as disturbances that support the occurrence of some small and competitively weak species. The complexity of the problems of pine forest diversity and dynamics indicates that monitoring these ecosystems and elucidating their diversity patterns are still needed.

My plans for further research related to the formation of pine forest diversity include both ecological studies of specific forest complexes and further analysis using materials collected in the Polish Vegetation Database. The research topic I would like to develop based on the original field data collection concerns the diversity status of isolated deciduous stands surrounded by pine monocultures. I initiated preliminary works in this area during the implementation of the Miniatura 3 project funded by the National Science Centre, titled “Importance of old oak forest stands patches for diversity of managed pine forests” (N30406431/2479). I also plan to synthesize knowledge about the species richness and phytocoenotic variability of pine forests across the entire territory of Poland based on phytosociological data available in the Polish Vegetation Database. The database contains 17,500 phytosociological relevés with varying proportions of Scots pine in the stand (coverage in the tree layer of 0.5-100%). The climate and soil data will be included in the analysis and used as explanatory variables to understand the degree of species diversity and compositional variation in Scots pine forest communities. Additionally, I plan to identify groups of species that indicate the best-preserved pine forests as well as groups of species indicating disturbances in plant communities.

4.2. Achievement 2

GROUPS OF ANCIENT FOREST SPECIES AS INDICATORS
OF HIGH SPECIES DIVERSITY

4.2.1. Scientific publication constituting Achievement 2

(2A.1) Stefańska-Krzaczek E., Kącki Z., Szypuła B. 2016. Coexistence of ancient forest species as an indicator of high species richness. Forest Ecology and Management 365: 12-21. DOI: https://doi.org/10.1016/j.foreco.2016.01.012
Points of $MNiSW_{2016}$=45, points of $MEiN_{2023}$=200, IF_{2016}=3.064, $IF_{5\text{-letni}}$=3.8, number of citations according to WoS=23, number of citations according to GS=26

My contribution to the article: development of the concept of the article, posing the research questions, preparation of the list of species necessary for the selection of the dataset from the Polish Vegetation Database, search and collection of literature, cooperation in determining the groups of co-occurring species, performance of all statistical analyses on the basis of the developed groups, writing of the text of the article, improvement of the analyses and the text after the review, function of a corresponding author.

4.2.2. Description of the aims and results of Achievement 2 and its contribution to the development of the discipline

One of the most important variables explaining forest diversity is the history of forest cover. Depending on the duration of the forest, which is determined based on available historical sources, ancient forests and recent forests can be distinguished in the landscape (Dzwonko & Loster, 2001; Orczewska, 2010). Comparing the species composition of ancient and recent forests allowed for the identification of specific species associated with forests with preserved continuity – ancient forest species (AFS) (Dzwonko & Loster, 2001; Hermy et al., 1999). However, it has also been shown that ancient forest species can appear in recent forests, especially if they are in contact with ancient forests (Dzwonko, 2001; Matuszkiewicz et al., 2013; Orczewska, 2010; Orczewska & Fernes, 2011; Schmidt et al., 2014; Wulf, 2003). However, it has been observed that in ancient forests, indicator species typically do not occur individually but in groups (Schmidt et al. 2014). Thus, I assumed that ancient forest species tend to co-occur and could play an indicator role in forests as functional groups. Therefore, the purpose of the study was to 1) demonstrate the co-occurrence of ancient forest species and develop groups of co-occurring species, 2) assess whether these groups indicate high species diversity, and 3) examine how these groups are distributed in the most important forest types in Poland.

The research was conducted using published phytosociological data collected in the Polish Vegetation Database. All forest relevés from the database in which the presence of at least one species from the list of ancient forest species was observed were selected (Dzwonko & Loster, 2001; Hermy et al., 1999). Subsequently, the forest types were identified using phytosociological classification. The final dataset amounted to 2,611 phytosociological relevés. The next step was to examine the co-occurrence of species in the analyzed dataset. Statistical methods based on the mutual fidelity of species expressed by the phi coefficient were applied. Species with the highest fidelity to each other were grouped together. While the approach to identifying valuable forests on the basis of groups of species rather than individual taxa has also been described in other publications, the statistical methods used in this study to determine indicator groups have not been previously applied in the context of ancient forest species.

The achievement of this study is demonstrating the tendency of ancient forest species to co-occur, and showing a positive relationship between the presence of groups and species richness. Eleven groups of co-occurring species were found in Polish forests, which included 51 ancient forest species (54% of the species on the list). In the surveyed dataset, 67% of the areas had at least one co-occurring species group, and a maximum of 7 groups could occur in a single plot. In forests where co-occurring groups were present, the average number of

herbaceous species, tree and shrub species, ancient forest species, and closed forest species was significantly higher compared to forests lacking these groups. In addition, a positive correlation was found between these variables and the number of groups. Therefore, my achievement shows that the proportion of ancient forest species that occur in non-coincidental groups is an indicator of the good conservation status of forest phytocenoses. This is because the groups are accompanied by other forest species, resulting in high species richness.

Moreover, the achievement has contributed to the systematization of knowledge about the species composition of forests. Groups occurred in forests with varying frequency, and in some types of forest phytocenoses (alliances V*accinio uliginosi-Pinion, Piceion abietis, Dicrano-Pinion, Alnion glutinosae* and *Salicion albae*) plots without groups were dominant. This highlighted the specificity of these forest communities, in which key structural elements include specific species such as spore-bearing, mountain, meadow or wetland species. The results of the study also confirmed that the biodiversity hotspots are deciduous forests, mainly oak-hornbeam communities.

My achievement expands on the concept of the indicator role of ancient forest species. It provides an opportunity to use species composition to assess the continuity of forest habitats when historical materials are unavailable. On the other hand, the absence of identified groups in habitats with documented continuity provides a basis for exploring other reasons for the poor state of the forest community.

4.3. Bibliography

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5. Presentation of significant scientific or artistic activity carried out at more than one university, scientific or cultural institution, especially at foreign institutions.

In this section I cite scientific papers with my contribution, a full list of which can be found in Appendix 4: List of scientific achievements.

Throughout my career, I have been scientifically active, which has resulted in achievements comprising a series of publications 1A.1-5 and 2A.1 and other articles related to ecological and botanical issues that interest me. I engaged in scientific collaborations with researchers from my alma mater, as well as scientists from other institutions. This has enabled me to achieve my goals and broaden the scope of my scientific research and interests.

The beginning of my scientific activity was involved research concerning the vegetation of mid-forest clearings conducted as part of my master's thesis (2001-2002), prepared under the supervision of Dr. Zygmunt Kącki. I carried out my first independent field research and gained knowledge of basic statistical analyses used in plant ecology. When starting my doctoral studies, I had experience in identifying vascular plant species and recognizing basic vegetation types. Studying pine forest communities was a significant challenge, as it required identifying spore-forming organisms. Therefore, I had to start my scientific work by establishing collaborations with experts in lichenology and bryology. I identified part of the lichenological materials under the supervision of my supervisor, Prof. Wiesław Fałtynowicz, but I also collaborated on a regular basis with Dr. Katarzyna Szczepańska from the Wrocław University of Environmental and Life Sciences. I received assistance in bryophyte identification from Dr. Monika Staniaszek-Kik from the University of Łódź. For my scientific development, participation in the specimen identification process was important, as well as independent identification of part of the materials based on model samples. I continued my collaboration with the aforementioned experts in my further research on pine forests, and I maintain it to this day. It has resulted in co-authored scientific publications (e.g. 1A.2: Stefańska-Krzaczek et al., 2016; 1A.4:Stefańska-Krzaczek et al., 2019), as well as the development of the Polish Vegetation Database (PVD), as Dr. M. Staniaszek-Kik verified the nomenclature of bryophytes and synonyms used in the PVD. Furthermore, I became involved in her research on the species diversity of the uprooted trees mountain areas. As part of the research, the occurrence of organisms within the microhabitats of the uprooted trees was analyzed, taking into account the influence of the surrounding plant community. This context of the results was of particular interest to me due to my own research on bryophyte distribution in forest types (1A.5: Stefańska-Krzaczek et al., 2022), especially since the plant community was a key factor determining the species composition of root plates, mounds, and pits. My role in these studies involved performing some of the statistical analyses and preparing conceptual elements of the work and discussion of the results. Through my collaboration in the studies on the uprooted trees, I also established contact with Prof. Jan Żarnowiec (University of Bielsko-Biała). Professor played a very important role in the work on forest floor bryophytes in Central Europe (1A.5: Stefańska-Krzaczek et al., 2022). His expert knowledge of bryoflora of the whole Poland and sharing his own data allowed to eliminate errors in the analyses and publish a high quality study.

Engaging in activities related to developing skills in statistical analysis of vegetation data is also important in my scientific work. The first step in acquiring these skills was a scientific course on "Application of numerical methods in ecology", which I completed at the Nicolaus Copernicus University in Toruń (2006). Thanks to the methods I learned during that time, I conducted analyses for my doctoral thesis and published a scientific monograph on plant communities in pine stands in the Lower Silesian Forest (Stefańska-Krzaczek, 2011). As part of my own studies, I also developed data analysis methods in Canoco and Juice software. The development of data analysis methods, primarily in the R programming environment, prompted me to further develop this aspect of my scientific activity. In 2021, I began independent efforts to familiarize myself with the specifics of the R program and RStudio software. In 2022, I completed a 10-hour online course on the UDEMY platform. During my research on the distribution of ground bryophytes in Central European forest types, I also established collaboration with Dr. Małgorzata Raduła (Wrocław University of Environmental and Life

Sciences) to expand data analysis using the boosted regression tree (BRT) method. In order to familiarize myself with advanced analytical methods in 2023, I completed a one-month internship (under an internship agreement) at the Academy of Technology and Humanities in Bielsko-Biała (currently the University of Bielsko-Biała), under the supervision of UBB Prof. Damian Chmura. During the internship, I became acquainted with the methods for conducting basic and more advanced analyses of vegetation data with R packages. In the Department of Environmental Protection and Engineering at the University of Bielsko-Biala, I presented a lecture showcasing my research results. Additionally, along with researchers from the Ecology and Nature Conservation Group (Prof. Jan Żarnowiec, UBB Prof. Damian Chmura), and Dr. M. Staniaszek-Kik, we prepared a manuscript on the species diversity of the uprooted trees, which was published in July 2023 (Staniaszek-Kik et al., 2023). I am currently continuing my collaboration with Prof. Damian Chmura, as part of the work on my own research material.

My scientific activity at various stages of work also included collaboration with specialists in cartography and GIS systems. I started this collaboration during my doctoral studies (2004). At that time, I completed a two-week practical internship at the the Bureau of Forest Management and Geodesy (BULiGL) in Brzeg (documented by an entry in the doctoral Transcript of Records). This is not a scientific institution, but it is a leading company in the field of cartography and technological solutions used in fieldwork related to forestry and habitat studies. During the internship, vector data essential for my doctoral thesis were prepared using the ArcGIS software. The internship also resulted in subsequent collaborations. For my scientific achievement, the most significant aspect of this collaboration was the opportunity to conduct queries and plot distribution maps in BULiGL for field research in the Miniatura 3 project funded by the National Science Centre (Narodowe Centrum Nauki). In the field of spatial analysis, I also collaborated with UWr Prof. Tomasz Szymura (University of Wrocław), and Dr. Bartłomiej Szypuła from the University of Silesia in Katowice. Thanks to these collaborations, I have published articles on succession in pine forests in mesotrophic habitats (1A.1:Stefańska-Krzaczek & Szymura, 2015; 1A.4:Stefańska-Krzaczek et al., 2019), as well as an article on changes in the structure of lichen forests and a study on co-occurring species in ancient forests (A1.3: Stefańska-Krzaczek et al., 2018; 2A.1:Stefańska-Krzaczek et al., 2016).

I was also involved in other research topics. With my colleagues from the Department of Botany in University of Wrocław I participated in the preparation of a monograph titled "Endangered archaeophytes of Lower Silesia" and co-authored three articles as part of it (Stefańska-Krzaczek & Anioł-Kwiatkowska; 2011a,b,c). In 2016, together with a team from the Botanical Garden, under the direction of UWr Prof. Zygmunt Kącki, we prepared a monographic study of the characteristics of Natura 2000 forest habitats as part of a project funded by the WFOŚ in Wrocław and Opole, and in cooperation with the Bureau of Forest Management and Geodesy. This work was innovative because the descriptions of habitats were based on an original analysis of phytosociological relevés collected in the Polish Vegetation Database (PVD). First, formal definitions of Natura 2000 habitats were prepared based on indicator species groups, and then phytosociological relevés were classified into specific habitats. Lists of diagnostic, constant, and dominant species were developed. Our work has resulted in a practical guide to Natura 2000 forest habitats in the form of a monograph (Kącki et al. 2016) as well as an internet platform: http://www.e-silva.uni.wroc.pl/. Involvement in this project was a key element of my activities related to implementation and scientific work on Natura 2000 habitats (Kącki & Stefańska-Krzaczek, 2009; Stefańska-Krzaczek & Kącki 2009; Krzaczek & Stefańska-Krzaczek, 2022). It was also an introduction to my own research on large datasets, which I conducted in collaboration with researchers from my team (UWr Prof. Zygmunt Kącki, Dr. Grzegorz Swacha) due to their experience in classification and handling large databases (1A.2: Stefańska-Krzaczek et al., 2016; 1A.5: Stefańska-Krzaczek et al., 2022).

In 2017-2018, I collaborated with Prof. Beata Woziwoda (University of Łódź). I was involved in research on the red oak, which enriched me with new experiences. I participated in analytical part of the study for a project on the role of red oak in shaping bryophyte diversity (Woziwoda et al., 2017). As part of further collaboration, I also conducted preliminary analyses on data documenting the spread of red oak in pine forests (Woziwoda et al., 2018).

My scientific interests also focused on vegetation in urban forests of Wrocław (Stefańska-Krzaczek, 2013ab; Stefańska-Krzaczek & Podgrudna, 2015). During these studies, I established cooperation with Uwr Prof. Dorota Kiewraf from the Department of Microbial Ecology and Acaroentomology. In the context of my results regarding vegetation, we analyzed data on the distribution of all developmental stages of *Ixodes ricinus* ticks in a small forest complex. Our joint study showed that the distribution of this species was highly variable, both in terms of location and number of ticks, and therefore it was not possible to precisely delimit tick risk areas (Kiewra et al., 2017).

In 2021, I was employed in an international project: "Grassland biomass as a renewable energy source – Biodiversity – Biomass – Biogas", which was carried out at the Botanical Garden from 2018 to 2021. I participated in the preparation of the preliminary publication summarizing the project (Pavlů et al., 2021).

In March 2023, I applied to participate in the project "Genomic evidence for deciduous forest refugia in the Alps, Carpathians and northern Apennines" (led by Pau Carnicero Campmany, University of Innsbruck). The project is based on vegetation data from across Europe collected in the European Vegetation Archive, of which the Polish Vegetation Database is a part. From the PVD, 4,804 phytosociological relevés have been made available to the project. As a result, collaboration within this project is planned, and I have expressed my interest in participating as a co-author.

Most of my research has been funded by my own institution; however, I also made attempts to obtain external funding. During my doctoral studies, I received a supervisor's grant for the project "Natural and anthropogenic transformations of pine forest communities in the Bory Dolnośląskie forest" (N30406431/2479), which I carried out as a researcher under the supervision of my advisor. After obtaining my doctoral degree, I applied twice for grants from the State Committee for Scientific Research (Komitet Badań Naukowych) to study pine forests in the Bory Tucholskie Forest, but I did not receive funding (2008, 2010).

In 2019, I began research on patches of old oak forest stands dispersed in pine monocultures. For the preliminary research, I received funding from the National Science Center (Narodowe Centrum Nauki) as a result of the competition Miniatura 3 for the project "Importance of old oak forest stands patches for diversity of managed pine forests" (2019/03/X/NZ8/00586). In 2020, I applied for funding under the Sonata Bis competition for a broader project titled "How important are old-growth stands for the diversity of managed forests?" but did not secure funding. I am currently conducting research on old-growth forests in collaboration with Ms. Natalia Mazurek, MSc, a doctoral student, as an associate supervisor for her doctoral thesis titled "The significance of old-growth forests for preserving species diversity in managed forests".

The results of my own or co-authored research have been presented at 19 scientific conferences/seminars. In addition, I have reviewed 17 scientific articles for national and international journals.

My scientific activity has also had an organizational aspect. I actively participated in the organization of two major scientific conferences: "National Scientific Conference: Synanthropization in the era of biodiversity change" (2011) and the international congress "27th Congress of the European Vegetation Survey. Vegetation survey 90 years after the publication of Braun-Blanquet's textbook – new challenges and concepts" (2018). I was a member of the organizing committees of these conferences and served as conference secretary. I was

responsible for correspondence with participants and also participated in the preparation and editing of conference materials and post-conference articles.

The position of assistant editor and editorial secretary of the national journal Acta Botanica Silesiaca (including the Monographiae series) from 2011 to 2016 also played an important role in my scientific development. My work in the editorial office included tasks such as selecting reviewers, correspondence with authors, preparing editorial comments, collecting author corrections, preparing manuscripts for printing, and delivering materials to the publishing house.

I was involved in organizing scientific activities in a project conducted by the company Data Techno Park, "Regional information platform for residents and local governments of Lower Silesia e-DolnySlask". In this project, I was the discipline co-editor in the field of botany, as well as co-author of articles describing natural and landscape complexes in Lower Silesia.

In summary, my scientific activity includes independent research work, development of analytical research methods, collaboration with scientists from other research centres, presentations of results, scientific internships, peer reviews of articles for scientific journals, funding applications, conference organization and editorial work in the journal Acta Botanica Silesiaca. Scientific topics I have been involved in include: diversity and dynamics of pine forests, species diversity of uprooted trees in mountain forests, vegetation status of urban forests in Wrocław, occurrence and dynamics of ticks in an urban forest complex, threats to archeophytes of Lower Silesia, role of red oak for the diversity of bryophytes, spread of red oak in pine forests, role of grasslands in biogas production, and the distribution and structure of Natura 2000 forest habitats.

6. Presentation of teaching and organizational achievements as well as achievements in popularization of science or art.

Teaching as part of employment

At the University of Wrocław, Faculty of Biological Sciences, I taught the following courses in ecology and biodiversity (for students of biology, environmental protection, environmental management, microbiology, genetics and experimental biology):

Biocenoses – Field Workshop
Biocenoses of Plants
Biology of Plants and Fungi
Biology of Seed Plants
Botany and Applied mycology
Systematic Botany
Environmental Botany – Field Workshop
Field Exercises in Karpacz
Ecology of Plant Communities
Flora of Poland
Fungi and Spore-bearing Plants
Spore-bearing Organisms and Seed Plants
Fungi and Spore-forming Organisms
Spore-forming Organisms and Seed Plants
Basic Systematics of Eucaryota
Basic Taxonomy of Plants and Fungi
Problems of Protection of Forest Vegetation (author's item)
Medicinal Plants (author's item)

Seed Plants
Seed Plants – Field Workshop
Systematics and Classification of Eucaryota

In 2021, I have set up an e-learning course in Biology of Seed Plants. This is an innovative course based on my own materials (videos, interactive worksheets, presentations) and a wide range of student activities.

Currently, I am the associate supervisor of the PhD thesis "The significance of old-growth forests for preserving species diversity in managed forests" carried out at the Botanical Garden of the University of Wrocław.

I have been the supervisor of six bachelor theses and eleven master theses.
Bachelor theses:
Beech forests and their role in nature conservation in Poland (2018)
Diversity of mesic pine forests and their role in biodiversity conservation in Poland (2018)
Threats to forest communities in urban areas (2020)
Diversity of plant communities with the oak tree stand (2022)
Formation of forest communities under the impact of different harvesting systems (2023)
Forest vegetation of the Las Strachociński forest in Wrocław (2023)
Master theses:
Vegetation of young and mature pine forests in relation to forest site classifications in Turawa Forest District (2012)
Structure of the forest community in an urban environment on the example of the Las Osobowicki forest (2012)
The condition of riparian plant communities of the Las Pilczycki forest in Wroclaw (2013)
Forest vegetation of the Las Strachociński forest in Wrocław (2015)
The condition of the vegetation of forest islands on the example of the selected urban forests in Wroclaw (2015)
Disturbance of forest vegetation in the Odra valley on the example of the Rędziński Forest in Wrocław (2019)
Species diversity of oak stands in the forest complex predominated by Scots pine monocultures (2020)
The state of the plant communities in old oak tree stands of the Namysłów Plain (2021)
Condition of forest vegetation of a part of the Widawa valley in the northern part of Wrocław (2023)
Phytosociological characteristics of forest communities in the middle part of the Las Rędziński forest (2022)
Transformation of forest vegetation in the eastern part of the Rudawy Landscape Park (2022)

For the postgraduate studies Natural Environment Management EKOEXPERT, I conducted a lecture and exercises for the topic "Natura 2000 natural habitats and vegetation of Poland – forests" (2019, 2020, 2021). I was the supervisor of the diploma thesis "Distribution, state of preservation and possibilities of protection of lichen pine forests in Chocianów Forest District" prepared within the framework of these studies (2010).

Development of teaching and substantive competences

I have expanded my teaching and learning competences through courses, workshops and webinars:

Scientific course: Application of numerical methods in ecology. Course conducted at the Nicolaus Copernicus University in Toruń (6-10.09.2006).

Scientific course: Data Science. R language for beginners. A 10-hour online course on the UDEMY platform (06.2022).

Teaching course: Didactics and methodology of e-learning. Training organised by the Centre for Distance Learning (26.02.-09.04.2021).

Training: Innovative educational technologies. Training as part of the project "GOOD STAFF – increasing the competences of the teaching staff of the University of Wrocław to strengthen the quality of education at the university" (17.12.2018).

Training: Teaching work using the WebQuest method. Training as part of the project "GOOD STAFF - increasing the competences of the teaching staff of the University of Wrocław for strengthening the quality of education at the university" (19.02.2019).

Workshop: Forestry for non-foresters. Field station of the Club of Naturalists, Owczary (2005).

Workshops organised by the Centre for Distance Learning at the University of Wroclaw:
- Classroom management and team collaboration in Teams (2021).
- Teamwork in the cloud – managing access rights in Office 365 applications (2021).
- Multimedia in teaching – basics of PowerPoint and Sway (2021).
- Operating the E-EDU platform – intermediate level (2021).
- PowerPoint for advanced (2021, 2022).
- E-EDU platform for advanced (2022).
- Building motivation and engagement in remote classes (2023).

Webinars organised by the Centre for Distance Learning (2021-2023):
- Syllabus – an indispensable tool.
- Active student in remote classes.
- Verification of learning outcomes and the effectiveness of remote classes.
- Offline remote learning – how to plan classes to make them not limited to sitting in the front of a computer.
- Supporting the development of social skills and competences in remote classes.
- Team Base Learning.
- E-EDU – extra-credit - activities for the willing.
- E-EDU – Test /Quiz module.
- E-EDU – Assignment and Gradebook module.
- E-EDU – Forum module.
- E-EDU – Wiki module.
- E-EDU – Lesson module.

<u>Organisational functions</u>

At the Faculty of Biological Sciences, University of Wrocław, I am a member of two teams:
- the team for the evaluation of the quality of education, in which I additionally act as secretary,

the team for lifelong learning, as part of which I coordinated the educational event Świdnica Night with Biology.

I am also the head of the Laboratory of Vegetation Ecology belonging to the Botanical Garden, University of Wrocław.

Popularization of science

I have actively participated in numerous science popularisation events. My achievements in this field are:

Scientific consultant function in the 5th School Astronomy Workshop on the topic "What is life", Świeradów, 2010.

Classes in the Botanical Garden for pre-school children as part of the project "May Meadow" carried out by educators of Kindergarten No. 91 "Nasz Domek" in Wrocław, 2012.

Lecture "What are the trees rustling about?", Fascination of Plants Day, Wrocław, 2013.

Workshop for high school students "Mosses, or what hides the green background" as part of the Science Festival at the Paczków High School, 2015.

Workshop for children "Is fruit always tasty", Fascination of Plants Day, 2015.

Coordination of the educational action "Świdnica Night with Biology" organised by Faculty of Biological Sciences in Świdnica II High School (5 editions of the event), Świdnica, 2015-2019.

Workshop "Medicinal plants", the 2nd Świdnica Night with Biology, Świdnica II High School, Świdnica, 2016.

Workshop "Biology of pollination", the 4th Świdnica Night with Biology, Świdnica II High School, Świdnica, 2018.

Workshop "Alternative treatments using plants", the 5th Świdnica Night with Biology, Świdnica II High School, Świdnica, 2019.

Series of lectures on herbal medicine for listeners of the University of the Third Age: "Basics of herbal medicine", "Herbs in common ailments", "Unconventional therapies using plants", University of Wrocław, 2019.

Four editions of the class "The world of plants in health care" in the educational project "Biology for practitioners". Programme for the development of interests and stimulation of educational and cultural activities for listeners of universities of the third age. POWR.03.01.00-00-T068/18, University of Wrocław, 2019, 2021.

Four editions of the class "Basics of seed plant morphology" in the educational project "Scientific cognition of the world". Programme for the development of competences

necessary for the job market for secondary school students. Powr.03.01.00-00-t067/18, University of Wrocław, 2021, 2022.

Lecture "Healing power of woody plants" for listeners of the University of the Third Age, University of Wrocław, 2023.

Workshop "Biodiversity-Biomass-Biogas – knowledge important for everyone. Knowing, identifying plants, practicing!", European Funds Open Days, Wojsławice Arboretum, Niemcza, 13.05.2023 (together with Dr. Mateusz Meserszmit).

Workshop "Succulents on a microscale", the succulent exhibition taking place 8-11 June 2023 at the Botanical Garden, Wrocław, 2023 (together with Dr Mateusz Meserszmit and Natalia Mazurek, MA).

7. Other career-related information.

During my doctoral studies, I received an honourable mention in the second edition of the Forum Akademickie competition for a popular science article entitled "Complicated and Simple. Young scientists about their research" for the text entitled. "In the forest, but not on the tree". (Forum Akademickie 1/2007, p: 39; Przegląd Uniwersytecki 1(130)/2007, p: 4).

I am also the author of several works (columns, interview), which appeared in the journal Uniwersytet Wrocławski in 2004:

The most important thing is optimism. University of Wroclaw 4, 2002, p: 28;
Between animals and angels – reflections on the photo album. University of Wrocław 3, 2003, pp: 22-23;
Looking into different drawers. University of Wrocław 1, 2004, pp: 24-25;
Miniatures of happiness. University of Wroclaw 2, 2004, pp: 22;
The most important thing is to be able to laugh – a conversation with honorary doctor Prof. Mark Seaward. University of Wrocław 2, 2004, pp: 16-17 (co-authored with Katarzyna Szczepańska).

In 2016 and 2018 I received the Rector's Award for teaching, in 2019 the Rector's Award for scientific and organisational achievements, and in 2020 the Rector's Award for teaching and organisational achievements.

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(Applicant’s signature)