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ORIGINAL PAPER

Distribution of Natura 2000 forest habitats in managed oak forest stands of south-western Poland

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ABSTRACT

Pedunculate oak and sessile oak *Quercus robur* and *Q. petraea* are of significant economic importance in Central Europe, but they are also species with an important ecological function. Therefore, forest management in oak forests should consider both timber production and environmental goals. The aim of the present study was to assess the occurrence of valuable Natura 2000 forest habitats in managed oak forest stands, the distribution and connectivity of their patches, and also the age of the oak stands. The analyses included forest stands with a dominance of native oak species located in SW Poland. Spatial analysis was performed with ArcGIS 10.7 software, and the age of trees was analysed with Statistica 12.

In total, 66% of the area of managed oak stands was occupied by Natura 2000 habitats. The largest area was recorded for oak-hornbeam forests (9170), and the smallest for oak steppic woods (91I0). The area of Natura 2000 habitats was similar within and outside Special Areas of Conservation (SACs). The oak stands that did not represent Natura 2000 forest habitats had a larger area outside the SACs. Moreover, oak stands representing Natura 2000 forest habitats formed a greater number of forests larger than 5 ha. Oak stands not representing Natura 2000 forest habitats were more fragmented and dispersed. The mean age of trees in oak stands was significantly higher for Natura 2000 habitats. Forest stands of most oak-hornbeam forests (9170), acidophilous oak forests (9190) and oak steppic woods (91I0) were older than 80 years. Riparian mixed forests (91F0) were more frequently represented by younger forest stands.

The study revealed that the old-age oak stands which formed larger and more compact forests, mainly within SACs, were the most valuable within managed oak stands. These forest stands mostly represented Natura 2000 habitats. However, the coherence of the Natura 2000 network was also improved by the Natura 2000 habitats located outside SACs. As a result of forest stand logging and regeneration, patches of Natura 2000 habitats are expected to lose their specific structure and functions. Therefore, it is important to preserve at least fragments of old forest stands to facilitate the regeneration of the forest community. The ranges of Natura 2000 habitats should be designated based on the presence of model habitat patches and the surrounding vegetation representing dynamic phases of plant communities.

KEY WORDS

forest fragmentation, native oak species, natural habitats, old forest stands, Special Areas of Conservation

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Introduction

Pedunculate oak and sessile oak *Quercus robur* L. and *Q. petraea* (Matt.) Liebl. are long-lived deciduous trees, widely distributed in Europe (Eaton *et al.*, 2016; EUFORGEN, 2022). They co-occur at many sites and tolerate a wide range of habitat conditions. However, pedunculate oak may grow on moist and fertile soils in more continental climate, whereas sessile oak is drought tolerant and prefers well-drained soils and oceanic climate (Bugała, 2006; Eaton *et al.*, 2016). They are the most economically and ecologically important deciduous forest tree species in Europe (Spiecker, 2021). The wood of both species is very hard and durable, and is widely used in the furniture and construction industries, as well as in other sectors of the economy (Bugała, 2006; EUFORGEN, 2022). Additionally, oak species play an important role in the structure of forest communities which sustain biodiversity (Eaton *et al.*, 2016; Mölder *et al.*, 2019; Bölöni *et al.*, 2021). In Central Europe both pedunculate oak and sessile oak are key components of acidophilous oak forests (class *Quercetea robori-petraeae*), termophilous oak forests (class *Quercetea pubescentis*), and mixed deciduous forests (class *Carpino-Fagetea*): oak-hornbeam forests and riparian mixed forests (Kącki *et al.*, 2013, 2016). In Poland, as dominant species, oaks cover about 7% of the total forest area (Zielony and Kliczkowska, 2012). This is a quite low percentage value in comparison with other countries of Europe (Spiecker, 2021). However, in Poland oaks are the most abundant deciduous species, followed by birch, beech and alder species (Milewski, 2018). All natural forest communities with a significant proportion of pedunculate and sessile oak in their tree layer represent Natura 2000 forest habitats, and they host native flora specific for temperate forests (Herbich, 2004; Mróz, 2010, 2012; Matuszkiewicz *et al.*, 2013b; Kącki *et al.*, 2016).

As oak stands are important for the economy and natural environment, their management should both maintain their productive function and preserve their biodiversity and differentiation of communities (Löf *et al.*, 2016; Mölder *et al.*, 2019). The concept of multifunctional forests assumes that it is possible to achieve conflicting goals of timber production and biodiversity conservation by using sustainable forest management (Gustafsson *et al.*, 2012). This management strategy is the main concept for nature conservation in the Natura 2000 network (Rutkowski, 2009; Trochet and Schmeller, 2013; Winter *et al.*, 2014; Winkel *et al.*, 2015). This is the most important biodiversity conservation effort being implemented in European Union Member States. Conservation measures are focused on certain species and natural habitats, and the Natura 2000 network is made up of two types of area: Special Protection Areas (SPAs) for the protection of birds and Special Areas of Conservation (SACs) for the protection of natural habitats (Council Directive, 1979, 1992; Directive, 2009). The great advantage of this system is that valuable and threatened species and habitats may also be designated and protected outside the network of areas (Kącki *et al.*, 2016). The specificity of the Natura 2000 system is the protection of habitats and species without the elimination of human activity; in this policy the protection of habitats and species is of key importance, but not by stopping the use of protected sites (European Commission, 2022). However, in the case of forest communities, this approach lead to the presence of different growth phases of forest stands, which results directly from management activities (Kovač *et al.*, 2018).

The aim of the present study was to assess the occurrence of Natura 2000 forest habitats in managed oak forest stands, the distribution and connectivity of their patches, and also the age of the oak stands. To achieve the primary objective, the following detailed questions were put forward: 1) What percentage of the area occupied by managed forest stands with a dominance of native oaks are Natura 2000 forest habitats? 2) What is the area of these habitats within and outside Special Areas of Conservation (SACs)? 3) Do oak stands representing Natura 2000 forest habitats form larger forests than oak stands that do not represent Natura 2000 habitats? 4) What is the age of oak stands representing and not representing Natura 2000 forest habitats?

We intended to show the role of managed forest stands in maintaining valuable vegetation and provide guidelines for planning future conservation in oak forests.

Materials and Methods

Dataset. In our study we used data available in the Forest Data Bank (2022). We used the data covering all forest districts in southwestern Poland (18,845.86 km^2), under the administration of the Regional Directorate of State Forests in Wrocław (RDLP Wrocław). We selected forest stands with the share of oaks ≥60% (combined pedunculate oak *Quercus robur* and sessile oak *Q. petraea*). As a single forest stand we assumed a patch of the forest uniform with structure and forest management and meeting the above-mentioned criterion of the percentage proportion of oaks. Selected oak stands were used to create a feature class in ArcGIS 10.7 software (ESRI, 1999-2018). This feature class was defined as Db60 (12,399 oak stands). Then, another feature class was created covering selected Natura 2000 habitats, i.e. only these habitats which could be dominated by *Quercus robur* or *Q. petraea* (cover of a tree layer higher than 60%) (Kącki *et al.*, 2016): 9170 *Galio-Carpinetum* oak-hornbeam forests, 9190 old acidophilous oak woods with *Q. robur* on sandy plains, 91F0 riparian mixed forests of *Q. robur*, *Ulmus laevis* Pall. and *U. minor* Mill., *Fraxinus excelsior* L. or *F. angustifolia* Vahl, along the great rivers *Ulmenion minoris*, and 91I0* Euro-Siberian steppic woods with *Quercus* spp (names of Natura 2000 habitats are in accordance with the Interpretation Manual of European Union Habitats 2013). This feature class was defined as N2000. Data needed for the N2000 were derived from resources gathered at the Bureau for Forest Management and Geodesy in Brzeg (BULiGL Brzeg). Data were acquired from forest management plans, forest inventories, and phytosociological research conducted by the BULiGL Brzeg. We selected only those forest stands where Natura 2000 habitats covered at least 50% of a forest stand area. Next, two additional feature classes were created based on Db60 and N2000: 1) oak stands representing Natura 2000 forest habitats (Db60N2000), and 2) oak stands not representing Natura 2000 forest habitats (Db60nN). In the obtained GIS project with the Db60N2000 and Db60nN feature classes we also included a feature class with the boundaries of Special Areas of Conservation (SACs) acquired from the Central Register of Nature Conservation Forms (2022).

Data analysis. First, we calculated the area of Db60 and its percentage in the area of all forest stands in the studied region. We also calculated the total area occupied by the selected Natura 2000 habitats (together 9170, 9190, 91F0 and 91I0) in the studied region. Next, we calculated the area of Db60N2000 stands and separately the areas of 9170, 9190, 91F0 and 91I0 within Db60N2000, and the area of Db60nN stands. Moreover, we calculated the area of Db60N2000 and Db60nN in SACs and outside them.

We also analysed stands of Db60N2000 and Db60nN in terms of their connectivity and fragmentation. For this purpose, we grouped into larger forests those oak stands that were at a distance of ≤30m from each other. After that we calculated the number of forests of the following ranges of area (in hectares): <0.50, 0.51-1.00, 1.01-5.00, 5.01-10.00, 10.01-20.00, 20.01-50.00, 50.01-100.00, >100.00. At first Db60N2000 and Db60nN were considered separately. Then, this procedure was also repeated for all analysed Db60 stands (together Db60N2000 and Db60nN) to check whether oak stands that do not represent Natura 2000 forest habitats are in close contact with

Natura 2000 forest habitats and could increase their area. Spatial analyses were conducted in ArcGIS 10.7 software.

To analyse the age of the oak stands, we prepared figures illustrating the number of oak stands of Db60N2000 and Db60nN in subsequent age classes. Then, we calculated the mean age for Db60N2000 and Db60nN stands. The significance of differences between the means was verified using the non-parametric Mann-Whitney test at the significance level p=0.05. Figures presenting the age distribution for oak stands of Db60N2000 were also prepared separately for each forest habitat (9170, 9190, 91F0 and 91I0), and the mean age of oak stands for each habitat was calculated. We analysed only oak stands where one habitat was identified. The significance of differences between the means was verified with the Kruskal-Wallis test. Statistical tests were carried out using Statistica 12 software (Tibco, 2020).

Results

Oak stands of Db60 occupied a total area of 36,651.95 ha which accounted for 7% of all forest stands in the studied region (RDLP Wrocław). Natura 2000 forest habitats of Db60N2000 accounted for 66% of the area of Db60 (Table 1). Habitat 9170 occupied the largest area of the Db60 and Db60N2000 stands (31% and 47%, respectively), and habitat 91I0 the smallest area (2% and 3%, respectively). Db60N2000 stands occupied the largest area in the total area of 9190 and 91I0 habitats (Table 1).

The area of Db60N2000 stands was similar within Special Areas of Conservation (SACs) and outside them, while the area of Db60nN stands outside SACs was almost two-fold higher than that within SACs (Table 2, Fig. 1).

Db60N2000 stands more frequently formed large forests, while Db60nN stands were more fragmented (Fig. 1, 2). There were more forests of Db60N2000 stands with an area greater than 5 ha, while for Db60nN stands the number of forests with an area lower than 1 ha was higher. When we combined stands representing and not representing Natura 2000 habitats and analysed all Db60 stands the number of forests with an area of 5 ha or more increased (Fig. 2).

The mean age of Db60N2000 stands was significantly higher than the mean age of Db60nN stands (100 and 68 years, respectively). In most of the stands of Db60N2000 the age of trees was 80-140 years, while the number of younger forest stands, up to 40 years, was small (Fig. 3). The distribution in age classes for Db60nN stands was relatively even for stands aged 40-120

Table 1.
Area of managed oak stands in the Regional Directorate of State Forests in Wrocław (SW Poland)

Oak stands	Area [ha]	%Db60	% Db60N2000	% total area of Natura 2000 habitat
Db60	36,651.95	–	–	–
Db60N2000	24,225.01	66	–	–
Db60N2000: 9170	11,461.00	31	47	45
Db60N2000: 9190	7,435.50	20	31	71
Db60N2000: 91F0	4,580.66	13	19	47
Db60N2000: 91I0	747.84	2	3	88
Db60nN	12,426.94	34	–	–

Explanations: Db60 – oak stands with the proportion of oak species ≥60%, Db60N2000 – oak stands with the proportion of oak species ≥60% which represent Natura 2000 forest habitats, 9170 – *Galio-Carpinetum* oak-hornbeam forests, 9190 – old acidophilous oak woods with *Quercus robur* on sandy plains, 91F0 – riparian mixed forests of *Quercus robur, Ulmus laevis* and *Ulmus minor, Fraxinus excelsior* or *Fraxinus angustifolia*, along the great rivers *Ulmenion minoris*, 91I0 – Euro-Siberian steppic woods with *Quercus* spp, Db60nN – oak stands with the proportion of oak species ≥60% which do not represent Natura 2000 forest habitats. Names of Natura 2000 habitats are in accordance with the Interpretation Manual of European Union Habitats (2013)

Table 2.
Area of managed oak stands within and outside of Special Areas of Conservation (SACs)

Oak tree stands	Within SACs [ha]	Within SACs % of Db60	Outside of SACs [ha]	Outside of SACs % of Db60
Db60N2000	12,645.08	34	11,579.93	32
Db60N2000: 9170	5,856.51	16	5,604.49	15
Db60N2000: 9190	2,329.79	6	5,105.71	14
Db60N2000: 91F0	3,911.97	11	668.69	2
Db60N2000: 91I0	546.81	1	201.03	1
Db60nN	4,362.89	12	8,064.05	22

Explanations: Db60, Db60nN, Db60N2000, 9170, 9190, 91F0, 91I0 – see Table 1.

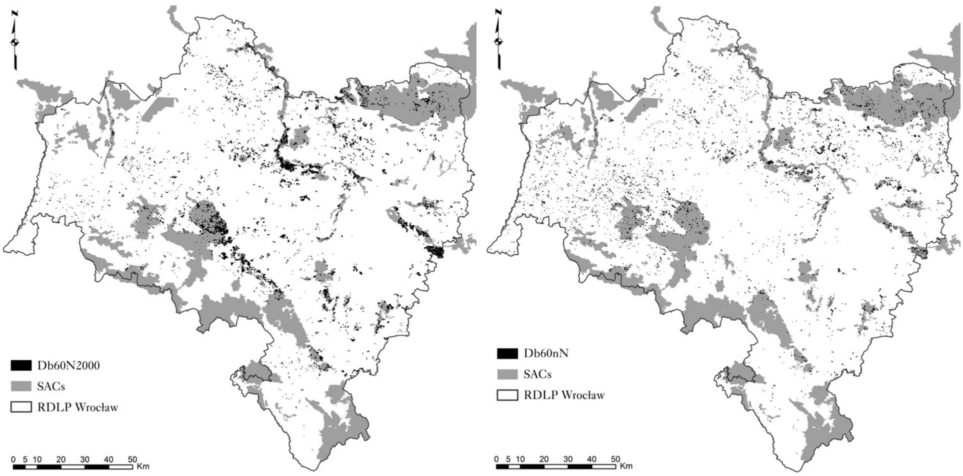

Fig. 1.
Distribution of managed oak forest stands which represent (Db60N2000) and do not represent (Db60nN) Natura 2000 forest habitats on the background of Special Areas of Conservation (SACs).
Explanations: RDLP Wrocław – the Regional Directorate of State Forests in Wrocław, the region of the study.

years. However, there was also a considerable number of the youngest forest stands, up to 20 years (Fig. 3).

The age of forest stands of habitat 9170 was highest in comparison to the forest stands of other Natura 2000 habitats (Table 3). Most of the Db60N2000 stands classified as 9170 and 9190 and 91I0 were older than 80 years (Fig. 4). For habitat 91F0 the number of old stands was high, but this habitat was also represented by younger forest stands (Fig. 4).

Discussion

Findings from our study indicated that most of the areas occupied by managed oak stands (66%) were valuable communities representing Natura 2000 habitats. This is a confirmation of previous observations which revealed that some patches in managed forests only slightly differ from those unmanaged (Baran *et al.*, 2018, Burrascano *et al.*, 2018). Because of their important role for industry, oaks are promoted in habitats suitable for their proper growth even if other deciduous species also correspond to the particular habitat conditions. In oak-hornbeam forests and riparian forests this might lead to a specific form of degeneration, *i.e.*, simplification of the tree layer composition (Olaczek, 1972; Ciurzycki and Marciszewska, 2018). However, despite the simpli-

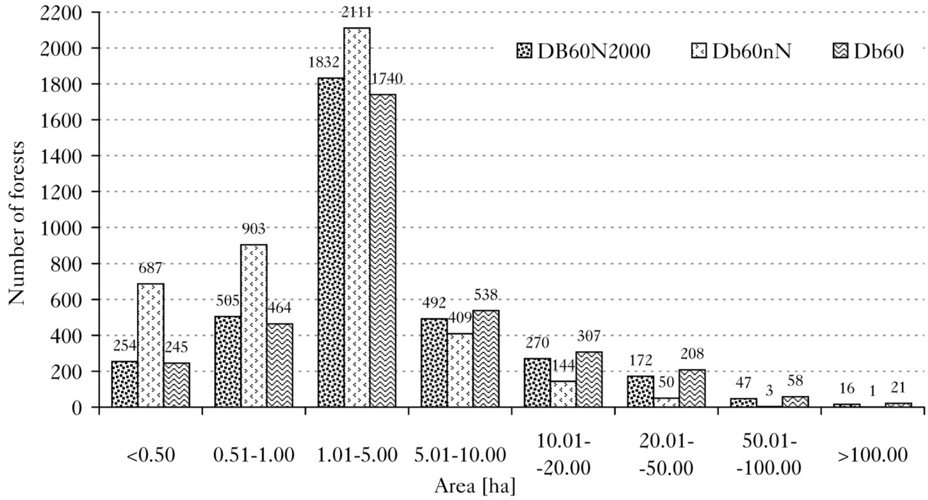

Fig. 2.

Number of forests obtained by grouping of all managed oak stands (Db60) and oak stands which represent (Db60N2000) and do not represent (Db60nN) Natura 2000 forest habitats.

Explanations: grouping was conducted for oak stands that were at a distance of ≤30m.

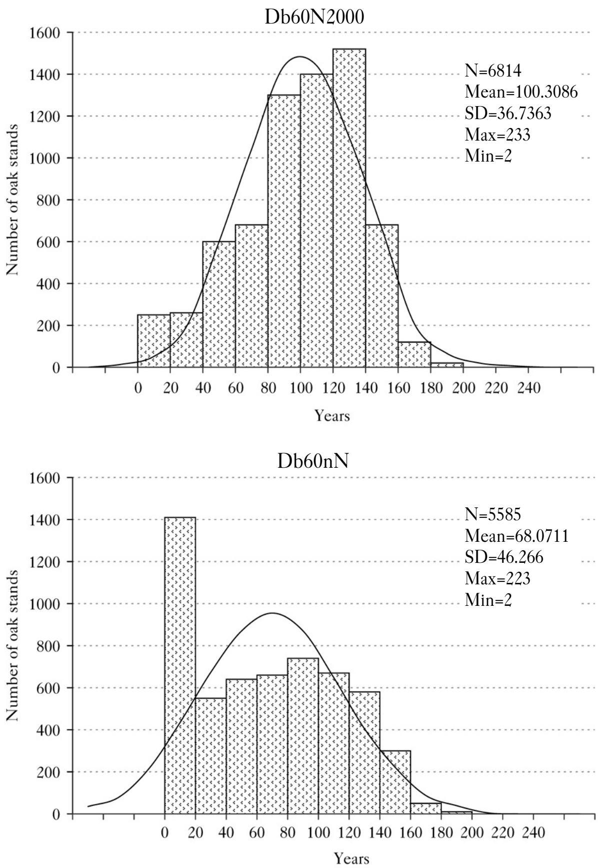

Fig. 3.

Number of managed oak stands which represent (Db60N2000) and do not represent (Db60nN) Natura 2000 forest habitats in subsequent age classes.

Explanations: Differences between means are statistically significant according to the Mann--Whitney test with p=0.05.

Table 3.
Statistics for age of managed oak stands which represent Natura 2000 forest habitats

Habitat code	N	Mean age	Minimum	Maximum	SD
9170	3086	103.61	2.00	222.00	37.097
9190	2206	96.94a	3.00	192.00	32.156
91F0	1213	97.76b	3.00	233.00	44.858
91I0	87	97.24ab	17.00	144.00	19.919

Explanations: 9170, 9190, 91F0, 91I0 – see Table 1, Kruskal-Wallis test: H (3, N=6592) =72.30064 p=0.0000, mean values of age followed by the same letter are not statistically significant

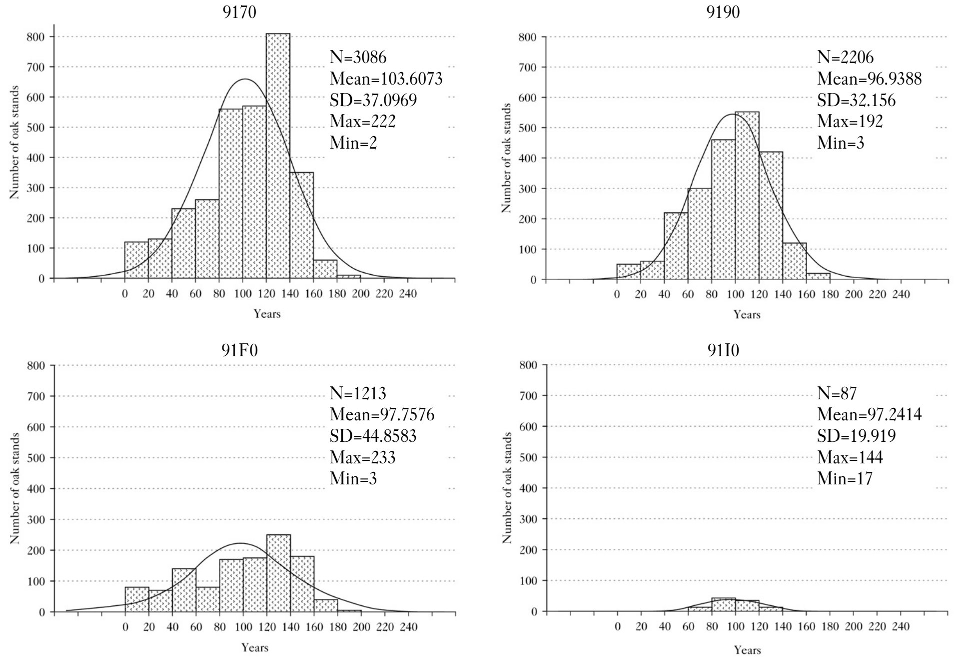

Fig. 4.
Number of managed oak stands which represent individual Natura 2000 forest habitats in subsequent stand age classes. Explanations: 9170, 9190, 91F0, 91I0 – see Table 1.

fication of the stand structure, the undergrowth may still meet the criteria of natural forests because of the presence of specific forest plant species.

The Natura 2000 habitats are distinguished by geographic, abiotic, and biotic features and their conservation status and biodiversity may differ (Kovač *et al.* 2016, 2020). However, the combination of plant species and specific vegetation characteristics are still necessary criteria for the identification of habitat types (Herbich, 2004; Mróz, 2010, 2012; Kącki *et al.*, 2016; Alberdi *et al.*, 2019; Mandžukovski *et al.*, 2021). Most of the European forests are exposed to different types of anthropogenic pressures which result in the formation of various secondary forest communities (Spiecker, 2003; Zerbe, 2003). Forest communities at various dynamic phases of forest stands may significantly differ from the typical structure of a habitat (Łaska, 2006; Stefańska-Krzaczek and Kącki, 2009; Kovač *et al.*, 2018). Also, afforested areas are covered with plant communities with a species composition different from natural forest communities (Flinn and Vellend, 2005; Matuszkiewicz *et al.*, 2013a). In these cases the absence of habitat indicator species and the disturbed species combination prevented oak stands from being included in the Natura 2000 habitats.

Oak-hornbeam forests (9170) occupied the largest area of the studied managed oak forests. This is in line with the general distribution of forest types in Central Europe, where oak-hornbeam forests are the most widespread communities with oaks in this region (Novák *et al.*, 2020). In south-western Poland, the second largest area was that occupied by old acidophilous oak woods (9190). These are also zonal communities which prefer a mild sub-Atlantic climate, and therefore they cover a significant area in the western region of Poland (Kasprowicz, 2010; Pawlaczyk, 2012a; Reczyńska, 2015; Kącki *et al.*, 2016). However, the area of old acidophilous oak woods in the study area may be slightly underestimated in relation to their potential range, because some of the poor and acidic soils that could be occupied by oaks are covered with pine forests or mixed forests with a dominance of pine (Kasprowicz, 2010). Moreover, old acidophilous oak woods and also steppic woods of the analysed Db60N2000 stands occupied a larger area in the total area of 9190 and 91I0 habitats in south-western Poland than other habitats. This is due to the fact that definitions of these two habitats assume a slight variation in the species composition of the tree layer, so other species rarely dominate or co-dominate in the patch, which is the case for oak-hornbeam forests and riparian forests (Pawlaczyk, 2012a, b; Perzanowska *et al.*, 2015, Kącki *et al.*, 2016). Forests representing 9170 and 91F0 habitats may also be co-dominated by other species, *i.e.*, *Tilia cordata* Mill. and *Carpinus betulus* L. (9170), *Fraxinus excelsior*, *Ulmus minor* and *U. laevis* (91F0) (Kącki *et al.*, 2016; Novak *et al.*, 2020; Mandžukovski *et al.*, 2021). Therefore, the studied oak stands Db60N2000 are only part of the total area of habitats 9170 and 91F0.

The area of the analysed habitats was similar within the Special Areas of Conservation in the Natura 2000 network and outside them, while the stands that did not represent Natura 2000 habitats covered a larger area outside the Natura 2000 network. This finding confirms the role of SACs in the conservation of biodiversity, and may also indicate that these areas function in connection with vegetation outside them (Kącki *et al.*, 2016; Niculae *et al.*, 2017). This spatial relation may reduce the isolation of valuable ecosystems as the connectivity of the patches and the flow of diaspores help maintain biodiversity (Richling and Solon, 1994; Vandekerkhove *et al.*, 2013; de la Fuente *et al.*, 2018). In addition, the significant number of even small isolated patches of habitat has a positive effect on local biodiversity (Zacharias and Brandes, 1990; Fahrig, 2013; Fahrig *et al.*, 2019). Oak stands that represent Natura 2000 forest habitats form large forests than stands that do not represent Natura 2000 habitats. This confirms that the preservation of indicator species, particularly forest specialists, is promoted by the close connectivity between forest patches (Honnay *et al.*, 2002, 2005; Takahashi and Kamitani, 2004). Our analysis also revealed that the number of large forests increased when we analysed Natura 2000 forest habitats together with stands that do not represent Natura 2000 habitats. This might suggest that the stands attached to large forests are also Natura 2000 habitats which did not have relevant indicators at the time of the inventory, probably due to the dynamic phase of the stand development. It also shows that in order to designate the total range of a Natura 2000 forest habitat which is under continuous management, the criterion of the structure and function of a forest community is insufficient (Łukaszewicz and Paluch, 2009). This criterion should be met in model fragments of the forest habitat. All directly adjacent forest stands should be added to this model fragment of vegetation, even if temporarily they do not have their own indicators, but still represent dynamic phases of the model vegetation. It emphasizes the role of potential vegetation in the inventories of Natura 2000 habitats (Alberdi *et al.*, 2019).

Most of the analysed Natura 2000 habitats are characterized by an old forest stand. The age of the stand is not crucial to identify a Natura 2000 habitat, but younger stands are usually lacking a species composition diagnostic for the habitat (Kącki and Stefańska-Krzaczek, 2009). Probably for this reason, most of the young stands were not included in the Natura 2000 forest habitats, although, as mentioned before, in many cases it might be only a temporary dynamic phase of the habitat. Model Natura 2000 habitat patches occur primarily in old stands, as they provide conditions promoting the growth and survival of specialist forest species (Spies and Franklin, 1996; Nordén *et al.*, 2014). However, old stands in the analysed habitats will be gradually logged and regenerated in accordance with the forest management plans, which may result in the loss of the structure and function of forest patches (Pawlaczyk, 2012c). Felling methods used for the regeneration of deciduous stands are complex, but the regeneration process is long and complicated. Cutting methods, harvesting areas, cutting interval, and regeneration periods are different depending on the type of felling (ZHL, 2012; Mödler *et al.*, 2019). The old stands might therefore be temporally replaced with degenerated phases of the previous ecosystem or a mosaic of various secondary plant communities (Łaska, 2006). Regeneration of the undergrowth can be more effective and faster if the disturbed patches remain in contact with well-preserved habitats (Czerepko *et al.*, 2021; Fornal-Pieniak *et al.*, 2021). For this reason it is vital to maintain unmanaged fragments of old forest stands as model (reference) patches of Natura 2000 habitats. The age structure of habitats should achieve a balance over time, as the old forest stands will be logged, giving way to younger stands. However, the maintenance of the patches of well-structured oak forests may be complicated because of the problem of oak decline in recent years (Bernadzki and Grynkiewicz, 2006; Oszako, 2007).

Managed forests dominate in the total forest area in Europe (Sabatini *et al.*, 2017), and despite the significant human impact on biodiversity, they should be regarded as sources of native and specialist plant species (Hansen *et al.*, 1991; Horák *et al.*, 2019). In the face of global changes, especially climate change, it is necessary to aim at the preservation of vegetation that hosts native forest flora (Ammer *et al.*, 2018).

Conclusions

- Most of the managed oak stands are valuable forest communities and represent Natura 2000 forest habitats.
- Special Areas of Conservation (SACs) play an important role in the protection of Natura 2000 forest habitats as they cover large forests, and this contributes to the preservation of biodiversity.
- The sustainability of the Natura 2000 network is enhanced by connections with patches of habitats outside the network, and therefore the monitoring and maintenance of these patches is just as important as the maintenance of habitats within SACs.
- The forest stands of Natura 2000 forest habitats are mainly formed by old-growth trees which are gradually regenerated in line with the principles of silviculture. In order to maintain the species diversity in Natura 2000 forest habitats, it is important to leave at least fragments of old forest stands to enable the regeneration of plant community structure and functions.
- The ranges of Natura 2000 habitats should not be established solely based on the identification of habitat indicators in each patch, because the management of habitats disturbs their structure and function, sometimes for a long time. The range of a habitat should be established based on the area of a model habitat patch extended by dynamic phases of vegetation in the surroundings. Such an approach would allow for the detailed monitoring of dynamic changes induced by management in natural habitats at various phases of their development.

Authors' contributions

R.K. – conceptualization, methodology, resources, data curation, formal analysis, visualization, writing original draft, writing review and editing; E.S-K. – conceptualization, formal analysis, methodology, writing original draft, writing review and editing.

Conflicts of interest

The authors declare no conflicts of interest.

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STRESZCZENIE

Rozmieszczenie leśnych siedlisk przyrodniczych Natura 2000 w gospodarczych drzewostanach dębowych południowo-zachodniej Polski

Dąb szypułkowy i bezszypułkowy są najważniejszymi lasotwórczymi gatunkami liściastymi w Polsce. Drewno obu gatunków jest bardzo wytrzymałe i trwałe, więc znajduje szerokie zastosowanie w różnych gałęziach gospodarki. Drzewostany dębowe pełnią także istotne funkcje przyrodnicze. Wszystkie naturalne zbiorowiska leśne ze znaczącym udziałem dębu szypułkowego i bezszypułkowego reprezentują siedliska Natura 2000 i są siedliskami rodzimej flory specyficznej dla lasów strefy umiarkowanej. Gospodarka leśna w drzewostanach dębowych powinna zatem uwzględniać cele produkcyjne i przyrodnicze. Celem pracy była ocena występowania cennych siedlisk leśnych Natura 2000 w gospodarczych drzewostanach dębowych, ich powiązań przestrzennych oraz wieku drzewostanów. Badania miały pokazać rolę drzewostanów gospodarczych w utrzymywaniu cennych zasobów przyrodniczych oraz dostarczyć wskazówek do planowania przyszłych działań ochronnych.

W analizach uwzględniono tylko drzewostany (wydzielenia leśne) z dominacją rodzimych dębów (udział w wydzieleniach leśnych minimum 60%) występujące w granicach RDLP we Wrocławiu. Dane pozyskano z Banku Danych o Lasach. Do oceny występowania siedlisk przyrodniczych Natura 2000 w wybranych drzewostanach wykorzystano dane zgromadzone w Biurze Urządzania Lasu i Geodezji Leśnej Odział w Brzegu. Do analiz wybrano te siedliska przyrodnicze

Natura 2000, w których drzewostan może być zdominowany przez dęby *Quercus robur* i *Q. petraea*: 9170 grąd środkowoeuropejski i subkontynentalny, 9190 kwaśne dąbrowy, 91F0 łęgowe lasy dębowo-wiązowo-jesionowe oraz 91I0* ciepłolubne dąbrowy. Granice specjalnych obszarów ochrony siedlisk (SOO; ang. Special Areas of Conservation, SACs) pozyskano z Centralnego Rejestru Form Ochrony Przyrody. Analizy występowania drzewostanów dębowych wykonano w programie ArcGIS 10.7, a analizy wieku drzewostanów w programie Statistica 12.

Siedliska przyrodnicze Natura 2000 stanowiły 66% powierzchni zajmowanej przez gospodarcze drzewostany z przewagą rodzimych gatunków dębów (tab. 1). Największy udział miały grądy 9170, a najmniejszy ciepłolubne dąbrowy 91I0. Powierzchnia siedlisk przyrodniczych Natura 2000 była podobna w specjalnych obszarach ochrony siedlisk (SOO) i poza nimi (tab. 2; ryc. 1). Drzewostany dębowe niereprezentujące siedlisk przyrodniczych Natura 2000 miały większą powierzchnię poza SOO. Ponadto drzewostany reprezentujące siedliska przyrodnicze Natura 2000 tworzyły więcej kompleksów leśnych o powierzchni większej niż 5 ha (ryc. 1, 2). Drzewostany niebędące siedliskami przyrodniczymi Natura 2000 były bardziej pofragmentowane i rozproszone. Połączenie w kompleksy wydzieleń leśnych z siedliskami Natura 2000 oraz wydzieleń z drzewostanami dębowymi niereprezentującymi tych siedlisk zwiększało liczbę dużych kompleksów leśnych. Średnia wieku drzewostanów siedlisk przyrodniczych Natura 2000 była istotnie wyższa od średniej wieku dla drzewostanów niereprezentujących siedlisk przyrodniczych (ryc. 3). Najstarsze były drzewostany grądów 9170 (tab. 3). Drzewostany grądów 9170, kwaśnych dąbrów 9190 oraz ciepłolubnych dąbrów 91I0 były przeważnie w wieku powyżej 80 lat (ryc. 4). W przypadku łęgów 91F0 siedlisko reprezentowało więcej drzewostanów młodszych.

Wyniki pracy pokazują, że najcenniejsze układy przyrodnicze (reprezentujące chronione siedliska przyrodnicze Natura 2000) to stare drzewostany dębowe tworzące większe i bardziej zwarte kompleksy leśne, przede wszystkim w specjalnych obszarach ochrony (SOO). Spójność systemu poprawiają jednak powierzchnie siedlisk także poza tymi obszarami. Ponadto siedliska Natura 2000 oraz drzewostany dębowe niereprezentujące tych siedlisk są powiązane przestrzennie. Niektóre drzewostany mogły nie zostać włączone do siedlisk przyrodniczych ze względu na tymczasowy brak gatunków wskaźnikowych. Kolejne inwentaryzacje siedlisk mogłyby przyczynić się do poszerzenia zasięgów siedlisk Natura 2000. W wyniku odnowienia drzewostanów płaty siedlisk Natura 2000 będą tracić swoistą strukturę i funkcje, dlatego tak ważne jest zachowywanie przynajmniej fragmentów starodrzewów dla ułatwienia procesu odnowy zbiorowiska. Możliwość użytkowania siedlisk powoduje, że w ich granicach powinny znajdować się różne fazy rozwojowe drzewostanów, choć część drzewostanów może być pozbawiona wskaźników siedliska Natura 2000.