IOŚ-PIB OCHRONA ŚRODOWISKA I ZASOBÓW NATURALNYCH
ENVIRONMENTAL PROTECTION AND NATURAL RESOURCES 2017
DE GRUYTER OPEN
VOL. 28 NO 4(74): 37-42
DOI 10.1515 /OSZN-2017-0029

Katarzyna Szyszko-Podgórska*, Leszek Stankiewicz

Organic coal reserves in field and forest systems vs. Avifauna biodiversity

Węgiel organiczny w systemach polno - leśnych, a bioróżnorodność awifauny

*Dr inż. Katarzyna Szyszko-Podgórska - Institute of Environmental Protection-National Research Institute, Krucza 5/11d St., 00-548 Warsaw

Keywords: avifauna, biodiversity, organic coal, human economic activity
Słowa kluczowe: awifauna, bioróżnorodność, węgiel organiczny, działalność gospodarcza człowieka

Abstract
The objective of this work was to determine the occurrence of birds depending on the use of the area and the content of organic coal in field-and-forest systems. The research demonstrated a great diversity of bird species and great differences in the content of organic coal in individual areas. According to the conducted analyses, human economic activity can influence the content of organic coal and, therefore, it also influences the occurrence of specific bird species. In connection with the fact that the entire area covered with the research has been modelled by humans, the content of organic coal, the composition of bird species and their functioning in spatial systems are derivatives of such an activity.

Streszczenie
Celem pracy było określenie występowania ptaków w zależności od użytkowania terenu i zawartości węgla organicznego w systemach polno-leśnych. Badania wykazały dużą różnorodność gatunkową ptaków jak i duże różnice w zawartości węgla organicznego na poszczególnych powierzchniach. Z przeprowadzonych analiz wynika, że działalnością gospodarczej człowieka możemy wpływać na zawartość węgla organicznego, a tym samym na występowanie określonych gatunków ptaków. W związku z tym, że cały teren objęty badaniami jest ukształtowany ręką człowieka, zarówno zawartość węgla organicznego, skład gatunkowy ptaków jak i funkcjonowanie w układach przestrzennych są pochodnymi jego działalności.

1. INTRODUCTION

Coal accumulation is closely related to stages of succession. With time, each natural system is subjected to succession processes, i.e. enriched with organic substances as measured by organic coal [Szyszko 2010]. Each natural system in a specific phase of the succession has specific species and a specific content of the organic substances. Obviously, these processes occur with varied intensity, varying with time. The natural system becomes enriched with the progress of succession and creates conditions promoting the occurrence of different species. A stage of succession is closely correlated with the economic activity. Humans stimulate the development of succession processes through their use of natural resources. The occurrence of birds also changes with the change of succession processes.

2. OBJECTIVE AND SCOPE

The objective of this work was to determine the occurrence of birds depending on the use of the area and the content of organic coal in field-and-forest systems as well as to indicate whether the biodiversity of species changes with the change of coal content in natural systems. The above-mentioned issue was analysed from the holistic perspective. The analysis, among other things, involved the evaluation of the natural environment using a single indicator selected to ascertain the condition of the ecosystem and its changes, i.e. organic coal in this case. From the determinist perspective, analysis of bird species occurring in an area, also including indicators and parameters characterizing these species, was done [Dymitryszyn et al. 2011].

3. MATERIALS AND RESEARCH METHODS

The research area covered the “Martew” forest areas belonging to the Tuczno Forest District located in the Zachodniopomorskie voivodship and the “Krzywda” field-and-forest area of the D&B research studio in Tuczno. Observation areas represented a specific type of the environment or a mosaic of habitats. The observations involved the comparison of a few areas both as regards changes in the content of organic coal and the content of avifauna species. The “Krzywda” research area was established in early 1990s. Observations were carried out in over 172 ha of the fallow land, pastures, wasteland and marshes. These areas formed as a result of the cessation of agricultural production 25 years ago. Observations in the forest took place in three types of habitats: in a 94-year-old beech forest stand formed from the underbrushes after the removal of a 130-year-old pine stand planted in the place of a natural stand; in a 110-year-old pine stand with a beech underbrush planted 47 years ago and in a young pine stand with an addition of birch.

Table 1. Description of research areas.

Forest habitat type	The study plot	Compartment	Plant community	Rodzaj użytkowania (land use)	Forest stands	Parent rock	Texture class PTG 2009	Organic horizon	Classification of forest soils in Poland [2000]	Polish Soil Classification [2011]	WRB – World Reference Base for Soil Resources [2009]
FMBF	94 yo beech stand	321	*Luzulo pilosae-Fagetum*	forest	Bk, age Bk 95	Qfgp	sand	moder-mull fresh	Gleba rdzawa właściwa (RDw)	Gleba rdzawa typowa (RWt)	Brunic Arenosol
FMCF	110 yo pine stand	339g	*Leucobryo-Pinetum*	forest	8So age So108	Qfpg	sand	moder-mor fresh	Gleba rdzawa bielicowa (RDb) porolna	Gleba rdzawa z cechami bielicowania (RWbi)	Albic Brunic Arenosol
FCF	Young pine stand with birch	328a	*Leucobryo-Pinetum*	forest	8So, age So68	Qfpg	sand	moder-mor fresh	Gleba rdzawa bielicowa (RDb) porolna	Gleba rdzawa z cechami bielicowania (RWbi)	Albic Brunic Arenosol
-	Krzywda marshes	211	-	ecotone wetland/ fallow	8So, age So40	Qfpg	sand	-	Czarna ziemia właściwa (CZw)	Czarna ziemia typowa (Czt)	Gleyic Chernozem
-	Krzywda fallow land	182	-	fallow	7So, age So90	Qfpg	sand	-	Gleba rdzawa właściwa (RDw)	Gleba rdzawa typowa (RWt)	Brunic Arenosol

FMBF –fresh mixed broadleaved forest , FMCF – fresh mixed coniferous forest, FCF – fresh coniferous forest, Qfpg fluvio-glacial sands

Bird species found in the studied area were determined on the basis of observations and listening. Site trips were undertaken early in the mornings and in the evenings (morning aspect and evening aspect). The area was combed thoroughly and all the specimens observed were recorded. Particular attention was given to tree canopies, unformed hedges, groups of trees and bushes. Specialist optic equipment was used to locate specimens (binoculars and spotting scopes).

In six stations representing the forest habitat characteristic for the complex, soil profiles were made, morphological description was prepared and the systematic position of soils was determined according to Klasyfikacja gleb leśnych Polski [Biały et al. 2000], Systematyka gleb Polski [2011] and WRB [Bednarek et al. 2009]. The habitat type of the forest and the plant association were determined. Samples were collected from genetic levels in soil profiles to determine the content of organic coal using the Tiurin method [Ostrowska et al. 1991; Bednarek et al. 2004]; bulk density of dry soil (D) for mineral levels was determined by gravimetric method using cylinders having a capacity of 100 cm^3; density for organic levels was calculated following Borek [1983], Janowska and Czępińska-Kamińska [1983] and Karczewska [2007]. For granulometric content, Bouyoucose aerometric method modified by Cassagrande and Prószyński was used while granulometric groups were determined according to PTG [2009] Organic coal reserve was calculated using the following formula: Z_p [kg m^2] = [(*h D* mo)/10] · (1 – θ%) where *h* is the thickness of levels (cm); *D* is the bulk density (g cm^{-3}); mo is the percentage of organic coal in a level; 10 is the conversion factor of weight and surface units to obtain the result in kg m^2; θ is the percentage of skeletal parts (> 2mm). Data from the Communication No. 431 of the Independent Studio for the Valuation and Estimation of Environmental Resources and the Association for Sustained Development of Poland were used in order to determine the organic coal reserve.

4. RESULTS AND DISCUSSION

Sixty-nine bird species from 25 families were observed in total (Tab.2). Forty-seven species are regularly nesting species, 16 species nest occasionally and six species use the environment as the feeding ground only. A great variety of the spatial arrangement and a number of individual species were observed. Birds occur in different niches of the environment. Some of the observed species are confined to a specific habitat while others penetrate a few environments.

The analysis of the obtained data with regard to the content of organic coal demonstrated that the organic coal content in

Table 2. List of bird species inventoried in the research objects in Tuczno.

No.	Gatunek/stanowisko Species/station	94 yo beech stand	110 yo pine stand	Young pine stand with birch	Krzywda marshes	Krzywda fallow land
1	*Acrocephalus palustris*	-	-	-	d/n/g/ż	-
2	*Acrocephalus arundinaceus*	-	-	-	d/n/g/ż	-
3	*Acrocephalus scirpaceus*	-	-	-	d/n/g/ż	-
4	*Acrocephalus schoenobaenus*	-	-	-	d/n/g/ż	-
5	*Alauda arvensis*	-	-	-	-	d/n/g/ż
6	*Anas platyrhynchos*	-	-	-	d/n/g/ż	-
7	*Anser anser*	-	-	-	d/n/g/ż	-
8	*Anthus trivialis*	-	n/d/g/ż	-	-	-
9	*Apus apus* -	-	-	-	d/n/ż	d/ż
10	*Ardea cinerea*	-	-	-	d/n/ż	-
11	*Bucephala clangula gągo*	d/g	-	-	d/n/ż	-
12	*Butaurus stellaris*	-	-	-	d/n/g/ż	-
13	*Buteo buteo m*	-	d/n/g	-	d/ż	d/n/ż
14	*Carduelis carduelis*	d/n/g/ż	-	-	-	d/n/ż
15	*Carduelis chloris*	d/n/g/ż	-	-	-	d/ż
16	*Ciconia ciconia*	-	-	-	d/ż	d/ż
17	*Cionia nigra*	-	-	-	d/ż	-
18	*Circus aeruginosus*	-	-	-	d/n/g/ż	d/n/ż
19	*Coccothraustes coccothraustes*	d/n/g/ż	-	-	-	-
20	*Columba oenas*	d/n/g/ż	-	-	-	-
21	*Columba palumbus*	d/n/g/ż	d/n/g/ż	-	-	d/n/ż
22	*Corvus corax*	-	d/n/g/ż	-	-	d/ż
23	*Cuculus canorus*	-	d/n/g/ż	-	d/n/g/ż	-
24	*Cygnus olor*	-	-	-	d/n/g/ż	-
25	*Dentrocopos major*	d/n/g/ż	d/n/g/ż	-	-	-
26	*Dryocopus martius*	d/n/g/ż	d/n/g/ż	-	-	-
27	*Delichon urbica*	-	-	-	d/n/ż	d/n/ż
28	*Emberiza calandra*	-	-	-	d/n/g/ż	d/n/g/ż
29	*Emberiza citrinella*	d/n/g/ż	d/n/g/ż	-	d/n/g/ż	d/ż
30	*Emberiza schoeniclus*	-	-	-	d/n/g/ż	-
31	*Erithacus rubecula*	d/n/g/ż	d/n/g/ż	d/n/g/ż	-	-
32	*Ficedula parva*	d/n/g/ż	-	-	-	-
33	*Fringilla coelebs*	d/n/g/ż	d/n/g/ż	d/n/g/ż	-	d/ż
34	*Fulica atra*	-	-	-	d/n/g/ż	-
35	*Garrulus glandarius*	d/ż	d/n/g/ż	d/n/g/ż	d/g/ż	d/ż
36	*Grus grus*	-	-	-	d/n/g/ż	d/ż
37	*Hippolais icterina*	-	-	-	d/n/g	d/n/ż
38	*Hirundo rustica*	-	-	-	d/n/ż	d/n/ż
39	*Lanius collurio*	-	-	-	d/n/g/ż	d/ż
40	*Lanius excubitor*	-	d/n/g/ż	-	d/n/ż	d/ż
41	*Locustella luscinioides*	-	-	-	d/n/g/ż	-
42	*Lullula arborea*	-	-	-	-	d/n/g/ż
43	*Motacilla alba*	-	-	-	d/n/g/ż	d/n/ż
44	*Motacilla flava*	-	-	-	-	d/n/g/ż

Continued Table 2. List of bird species inventoried in the research objects in Tuczno.

No.	Gatunek/stanowisko Species/station	94 yo beech stand	110 yo pine stand	Young pine stand with birch	Krzywda marshes	Krzywda fallow land
45	*Oriolus oriolus*	d/n/g/ż	d/n/g/ż	-	-	-
46	*Parus caeruleus*	d/n/g/ż	d/n/g/ż	d/n/ż	d/n/ż	-
47	*Parus cristatus*	-	d/n/g/ż	d/n/g/ż	-	-
48	*Parus major*	d/n/g/ż	d/n/g/ż	d/n/ż	d/n/ż	-
49	*Passer montanus*	-	-	-	-	d/ż
50	*Poecile palustris*	-	d/n/g/ż	-	-	-
51	*Phalacrocorax carbo*	-	-	-	d/ż	-
52	*Phylloscopus collybita*	d/n/g/ż	d/n/g/ż	d/n/ż	-	-
53	*Phylloscopus sibilatrix*	d/n/g/ż	d/n/g/ż	d/n/ż	d/ż	-
54	*Phylloscopus trochilus*	-	-	d/n/g/ż	-	-
55	*Pica pica*	-	-	d/n/g/ż	d/n/g/ż	d/n/ż
56	*Picus viridis*	d/n/g/ż	d/n/g/ż	-	-	-
57	*Pyrrhula pyrhula*	d/n/g/ż	-	-	-	-
58	*Regulus ignicapilla*	d/n/g/ż	-	-	-	-
59	*Saxicola rubicola*	-	-	-	d/n/g/ż	d/n/g/ż
60	*Saxicola torguata*	-	-	-	d/n/g/ż	-
61	*Sylvia curruca*	-	d/n/g/ż	-	-	-
62	*Sturnus vulgaris*	d/n/g/ż	d/n/g/ż	-	-	d/n//ż
63	*Sylvia atricapilla*	d/n/g/ż	d/n/g/ż	d/n/g/ż	-	-
64	*Sylvia communis*	-	-	-	d/n/g/ż	-
65	*Troglodytes troglodytes*	d/n/g/ż	d/n/g/ż	-	-	-
66	*Turdus merula*	d/n/g/ż	d/n/g/ż	d/n/g/ż	-	d/n//ż
67	*Turdus philomelos*	d/n/g/ż	d/n/g/ż	d/n/g/ż	-	d/n//ż
	Liczba gatunków Number of species	23	27	18	38	24

d - morning aspect, n - evening aspect, g - nesting, ż - feeding, - not observed

individual areas is different in the litter, forest stand and mineral soil (Figures 1 to 4). Soils are the basic link in the biotransformation of organic coal. The total content of organic coal bound in soils is three times as large as the content in surface parts [Czępińska – Kamińska 2013]. It varies with the form and history of use, age of the stand and its species content (Figure 1): the content of coal in the 94-year-old beech stand is estimated at about 158 t/ha in the entire system, in the 110-year-old pine stand, it is approximately 124 t/ha, in a young pine stand with an addition of birch, it is 24.4 t/ha and about 20 t/ha + a reserve in the peat in the marshy area and in the fallow land.

Individual types of habitats such as fields, urbanized areas, forests or meadows have characteristic compositions of bird groups. It was observed that individual bird species preferred areas with a specific content of organic coal. Bird species characteristic for beech stands were *Fringilla coelebs, Columba oenas, Dryocopus martius, Ficedula parva* and *Coccothraustes coccothraustes.* Species such as *Ficedula parva, Columba oenas* and *Dryocopus martius* are area characteristic for the oldest stages of succession where the coal reserve in the litter amounted to 53.3 ton/ ha and are worthy of attention. In a more than 100-year-old pine stand, species characteristic for the system consisted of *Fringilla coelebs, Parus major, Emberiza citrinella* and *Dendrocopos major*. This forest stand has the coal reserve amounting to 48.8 t/ha in the litter and to 124 t/ha in the soil profile. In turn *Turdus philomelos, Turdus merula* and *Philloscopus trochilus* occurred in a young stand where the coal content amounted to ca. 20 t/ha. Forty-nine bird species were observed in the Krzywda area. The following species occur in open areas where the coal reserve amounts to about 20 tons/ha: *Alauda arvensis, Saxicola rubicola* and *Emberiza calandra*. Species occurring in reed fields and marshes where the coal reserve is estimated at a few hundred tons/ha: *Acrocephalus scirpaceus, Acrocephalus arundinaceus, Botaurus stellaris* and *Circus aeruginosus.* It is worth mentioning that six bird species recorded do not nest in the above-mentioned area and only use the habitat as the feeding ground. They are as follows: *Apus apus, Delichon urbica, Cicconia cicconia, Cicconia nigra, Hirundo rustica* and *Passer montanus.* There are also species that need various habitats with varied contents of organic coal to live. Such species include *Ciconia nigra, Ciconia ciconia,*

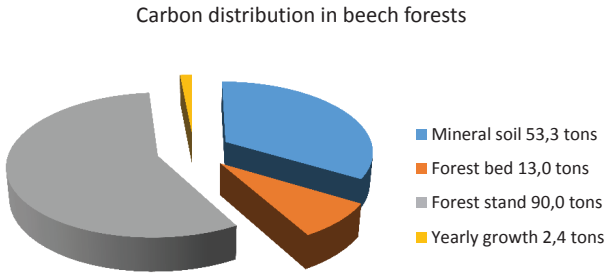

Figure 1. Organic coal reserve in beech stands.
[based on Szyszko 2007, 2013]

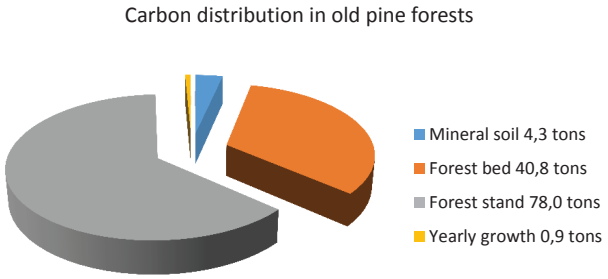

Figure 2. Organic coal reserve in old pine stands.
(based on Szyszko 2007, 2013)

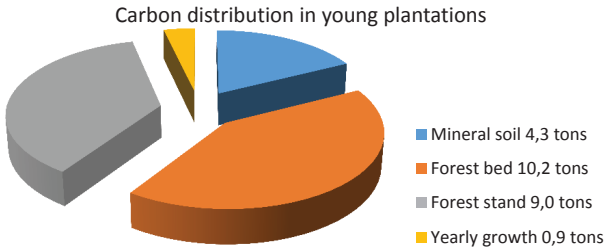

Figure 3. Reserve of organic coal in young stands.
(based on Szyszko 2007, 2013)

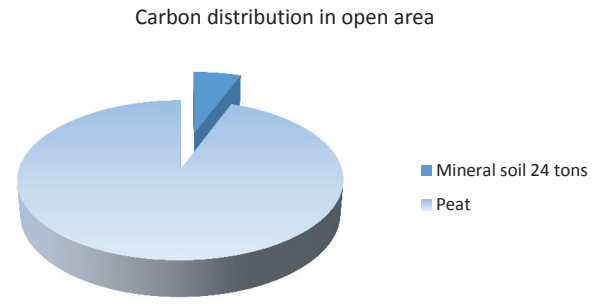

Figure 4. Content of organic coal in open areas.
(based on Szyszko 2007, 2013, changed)

Grus grus and *Bucephala clangula* recorded in the area. These species use certain habitats as the feeding grounds while using other habitats for nesting and still other ones in order to rest. The observations showed that *Buteo buteo* and *Columba palumbus* use both open areas with a low reserve of organic coal, i.e. ca. 20 t/ha, and old pine stands or natural stands where the coal content varies from 124 to 158t/ha. They move to the former ones to find food while they nest and raise young ones in the latter. *Corvus corax*, the species that builds nests in forest systems with the coal content amounting to at least 124 t/ha, searches for food migrating between fields and fallows where the coal content is ca. 20 t/ha. The content of organic coal is closely correlated to the economic activity of humans. Where the succession is inhibited due to mowing, cutting and removal of biomass, the content of organic coal amounts to about 20 t/ha. Thanks to forest management, the content of organic coal increases as a result of an increase in the cutting age or as a result of the introduction of deciduous underbrushes, e.g. beeches where, depending on the history of use, the content of coal in the litter varies from 13.0 to 40.80 t/ha. In richer habitats, penetration areas are smaller and a greater number of pairs of specific species in an area are found, which is due to a less intense competition within the species and between species. As we can see, species change their life strategies with a change of environmental conditions. Birds use space within the limits of a habitat and their numbers and density depend on the fertility of the habitat and its structure. According to several findings, each stage of the succession has its characteristic species and content or organic coal. The occurrence of birds depending on the use of the area and the content of organic coal in field-and-forest systems as well as the indication whether the biodiversity of species changes with the change of coal content in natural systems is directly related to the aspect of soils. When modelling an area, we shape the living environment of animal species occurring there. Our activity does not need to have a negative impact on the occurrence of species; on the opposite, we can stimulate and positively influence the avifauna with the use of various activities to increase its biodiversity as well as model the environment where the species live in individual stages of the succession.

5. SUMMARY AND CONCLUSIONS

- Various environments have varied content of organic coal, which influences the occurrence of specific bird species.
- The research area was modelled with the human economic activity, which influences the content of organic coal and, therefore, it also influences the occurrence of specific bird species.
- The content of organic coal, the composition of bird species and their functioning in spatial systems derivate from the human economic activity.
- Research results are indicative of the possibility to shape habitats and landscapes with the use of the environmental engineering to model biodiversity.
- With the human economic activity, we can create conditions promoting the occurrence of a full range of domestic species of wild fowl, accumulate coal and protect biodiversity.

REFERENCES

BEDNAREK R., CHARZYŃSKI P., KABAŁA C. (translation and ed.), 2009. Klasyfikacja Zasobów Glebowych Świata 2006. Wyd. UMK w Toruniu: 145 ss.

BIAŁY K., BROŻEK S., CHOJNICKI J., CZĘPIŃSKA-KAMIŃSKA D., JANUSZEK K., KOWALSKOWSKI A., KRZYŻANOWSKI A., OKOŁOWICZ M., SIENKIEWICZ A., SKIBA S., WÓJCIK J., ZIELONY R., 2000. Klasyfikacja gleb leśnych Polski. Centrum Informacyjne Lasów Państwowych, Warszawa: 127 ss.

BOREK S., 1983. Niektóre właściwości fizyczne gleb Rezerwatu Granica w Kampinoskim Parku Narodowym. Wpływ działalności człowieka na środowisko glebowe w Kampinoskim Parku Narodowym. Wyd. SGGW-AR, Warszawa:73-80.

DEGÓRSKI M. 2005: Wpływ sposobu użytkowania lasu na zapasy węgla organicznego w glebie W: Monitoring Środowiska Przyrodniczego nr 6, Kielce. Wyd. Kieleckie Towarzystwo Naukowe, p. 75-83

DYMITRSZYN 2011: Przykłady kompensacji przyrodniczej dla Natury 2000 elementem edukacji dla Lasów Państwowych. Studia i Materiały CEPL w Rogowie R. 13. Zeszyt 2 (27) / 2011

CZĘPIŃSKA – KAMIŃSKA D. 2013: Rozpoznawanie i ocena wartości gleb. W: Ocena i wycena zasobów przyrodniczych. Warszawa, Wyd. SGGW p.114-125

KARCZEWSKA A., SZOPKA K., BOGACZ., KABAŁA C., DSZYŃSKA D., 2007. Rozważania nad metodyką monitoringu gleb strefy leśnej Karkonoskiego Parku Narodowego (KPN) – w świetle zróżnicowania właściwości tych gleb. – In: Štursa J. & Knapik R. (eds), Geoekologické problémy Krkonoš. Sborn. Mez. Věd. Konf., říjen 2006, *Svobodan. Úpou. Opera Corcontica*, 44, 1: 95–105

KELLER M. 2013: Ptaki. W: Ocena i wycena zasobów przyrodniczych. Warszawa, Wyd. SGGW p.188-194

Komunikat nr 431 Samodzielnej Pracowni Oceny i Wyceny Zasobów Przyrodniczych i Stowarzyszenia na Rzecz Zrównoważonego Rozwoju Polski

KRUSZEWICZ A. 2006: Ptaki Polski Tom 1. Warszawa, Multico Oficyna Wydawnicza

KRUSZEWICZ A. 2006: Ptaki Polski Tom 2. Warszawa, Multico Oficyna Wydawnicza

KONDRAS M. et al.2010: Zapas węgla organicznego oraz właściwości fizykochemiczne gleb w kompleksie leśnym „Dąbrowy Krotoszyńskie. W: Roczniki glebowe TOME LXI No. 4, Warszawa, Wyd. SGGW p.113-122

OSTROWSKA A, GAWLIŃSKI S, SZCZUBIAŁKA Z.,1991. Metody analizy i oceny właściwości gleb i roślin. Warszawa, Instytut Ochrony Środowiska, 334 ss.

SZYSZKO K et al. 2002: Operating model of field and forest landcape „Krzywda. In: Landscape architekturę as the basic element in the protection of native species p.60-67

SZYSZKO J.,2007: Combating climate change: Land use and biodiversity – Poland's point of view. In R. Gani (ed.):International seminar on nuclear war and planetary emergencies 38th Sessions: Erice:5-12

SZYSZKO J., TOBOLSKI K. (red.) 2010. Podstawy kompensacji przyrodniczej. Wydawnictwo WSKSiM, Toruń

SZYSZKO J. 2013: Stadia sukcesyjne i ocena wartości przyrodniczych krajobrazu na podstawie taksonów. W: Ocena i wycena zasobów przyrodniczych. Warszawa, Wyd. SGGW p.195-202

SCHWERK A. i inni. 2009: Roczny raport retrospektywno-prognostyczny z obserwacji dokonanych na powierzchniach prognostycznych w nadleśnictwach znajdujących się w zasięgu Regionalnej Dyrekcji Lasów Państwowych w Pile (typescript). Samodzielna Pracownia Oceny i Wyceny Zasobów Przyrodniczych SGGW, Warszawa

SVENSSON L. i inni. 2016: Ptaki Europy i obszaru śródziemnomorskiego .wydanie II zaktualizowane. Warszawa, Multico Oficyna Wydawnicza.

Systematyka Gleb Polski, 2011. Wyd. 5, *Rocz. Glebozn*. 62, 3, 193.