ECOSYSTEM SERVICES PROVIDED BY WHITE STORK *Ciconia ciconia*
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CHAPTER 1
HABITAT SERVICES

The abundance and presence of bird species can have great ecological significance and determine the quality of habitat. The diversity of birds is an important measure of the ecosystem condition. The white stork is a icon of nature protection and easiest birds to monitor. Selectivity high value of habitats for reproduction by white stork can be an important and valuable indicator of the value of a habitat and other animal groups. Therefore, the white stork can be a good indicator of the abundance and species diversity of birds in the agricultural landscape. This research where tested followed question:

Does the presence of nesting storks positively affect the number and number of bird species in the agricultural landscape?

Does the presence of nesting storks positively affect the diversity of bird species in the agricultural image?

Are there significant differences between occupied, unoccupied nest and random points in abundance and diversity of birds?

Does the composition of bird species differ in between occupied, unoccupied nest and random points?

Materials and Methods

The 39 occupied white stork nest, 31, unoccupied white stork nest and 34 random points were selected. The birds count was contacted up to 100 meter buffer on each type in two times (early spring and spring – summer period). Birds were counted at three random points in a buffer 100 m from the white stork nest, unoccupied white stork nest and random points. Birds on each point were counted for 5 minutes to 4.5 hours from sunrise. The CORINE Land Cover (European Commission 1993) spatial database was used, which provides a pan European inventory of biophysical land-cover classes. The processing plug-in for QGIS to analyse the share of 20 land-cover classes was used in the 500- m-radius buffers created around each nest type and random point. the following classes were used: continuous urban fabric (> 80% of the land surface is covered by impermeable features like buildings, roads, and artificially surfaced areas); discontinuous urban fabric (impermeable features range from 30 to 80% land coverage); industrial or commercial units; mineral extraction sites; construction sites;

green urban areas; sport and leisure facilities; non-irrigated arable land; fruit trees and berry plantations; pastures; complex cultivation patterns; land principally occupied by agriculture, with significant areas of natural vegetation; broad-leaved forest; coniferous forest; mixed forest; transitional woodland-shrub; sparsely vegetated areas; inland marshes; water courses; water bodies. Then these classes was assembled into seven groups appropriate for studied species to make data easier to analyse and present: areas greatly altered by humans (including continuous urban fabric, discontinuous urban fabric, industrial or commercial units, mineral extraction sites, construction sites, green urban areas, and sport and leisure facilities); non-irrigated arable land; other agricultural land (fruit trees and berry plantations; complex cultivation patterns; land principally occupied by agriculture, with significant areas of natural vegetation); pastures and meadows; forests (broad-leaved forest, coniferous forest, mixed forest, transitional woodland-shrub); inland marshes; inland waters (water courses, water bodies).

Statistic analyses

The generalized linear mixed models were used to examine differences between non-occupied white stork nests, occupied white stork nests and random points on abundance, species richness, diversity (Simpson diversity index, Shannon-Wiener diversity index) and species evenness of birds (Pielou's evenness and Hill's evenness) up to 100 meter buffer on each types, separately for two periods (early spring census and summer census). To verify goodness of final models explanation were used two types of covariates. First type include environmental variables (share of built up, non irrigated agricultures, grassland and pasture, other agriculture and marshland areas) as the covariates in each models. In the second type include reduction of environmental variables using the Principal Component Analyses (PCA) as the covariates in each models. The first principal component (PCA 1) was associated with a gradient from built up areas to forest land. The second principal component (PCA 2) was associated with a gradient from grassland and pastures to non-irrigated agriculture land. Associations between the two extracted components and original explanatory continuous variables are given in Table 1. The abundance of birds were tested using Poisson error structure with log link function. The number of bird species and birds diversity (measured by Shannon Wiener Index) were tested using Gaussian error structure with identity link function. In all models the ID bird count points were used as a random factor.

To verify habitat quality (share of each environmental variables) between non-occupied white stork nests, occupied white stork nests and random points was used the non parametric test Kruskal–Wallis H test.

The generalized linear models were used to verify each environmental variables influence on abundance, species richness, diversity (Simpson diversity index, Shannon-Wiener diversity index) and species evenness of birds (Pielou's evenness and Hill's evenness) in up to 100 meter buffer around occupied white stork nests. Thus, the Principal component analysis were used to reduction of environmental variables into three components. In all models the ID bird count points were used as a random factor.
Bird species composition and abundance between non-occupied white stork nests, occupied white stork nests and random points were compared by using non-metric multidimensional scaling (NMDS) with the 999 permutations test separately for two periods (early spring census and summer census). The permutation multivariate analysis of variance PERMANOVA was used to check differences between centroids and dispersion of groups representing non-occupied white stork nests, occupied white stork nests and random points.

Tab. 1 Principal Component Analyses. Total explain 54.7 % of variance.

Variables	PCA 1 30.16%	PCA 2 24.55%
Share of built up are	0.328	*0.602*
Share of non-irrigated agriculture	*0.719*	*0.403*
Share of grassland and pasture	*-0.981*	0.082
Share of other agriculture	0.156	*-0.679*
Share of forest	*0.432*	*-0.628*
Shate of marshland	-0.102	0.295

Results

In total were recorded 2868 individuals of 111 bird species on each count points. In early spring period were detected of 65 birds species (mean±SE 12.65±0.75) up to 100 meter buffer in non-occupied white stork nest, 82 (17.23±1.09) in occupied white stork nest and 64 (12.06±0.84) in random points. In spring and summer period were detected 72 of birds species (10.61±0.64) up to 100 meter buffer in non-occupied white stork nest, 83 (18.41±1.07) in occupied white stork nest and 63 (11.24±0.63) in random points. Descriptive analysis for dependent variables used in the analyses include mean, standard error, minimum, maximum and 95% confidential intervals for non-occupied white stork nests, occupied white stork nests and random points were present in Tab. 2 for early spring period and Tab. 3 spring-summer period.

Tab. 2 Descriptive analysis for dependent variables used in the analyses include mean, standard error, minimum, maximum and 95% confidential intervals for each types for early–spring period.

Dependent variable	Non-occupied nest			Occupied nest			Random point		
	Mean (SE)	Min-Max	95%CI	Mean (SE)	Min-Max	95%CI	Mean (SE)	Min-Max	95%CI
Abundance	25.84(3.38)	9-95	18.94-32.74	53.41(7.18)	6-227	38.87-67.95	22.15(3.20)	5-95	15.63-28.67
Species richness	12.65(0.75)	5-24	11.10-14.19	17.23(1.09)	4-30	15.02-19.45	12.06(0.84)	4-27	10.35-13.76
Shannon-Wiener index	2.17(0.07)	1.26-2.85	2.02-2.32	2.03(0.08)	1.04-2.84	1.87-.2.18	2.03(0.08)	0.91-2.63	1.86-2.19
Simpson index	0.82(0.02)	0.52-0.93	0.78-0.85	0.76(0.02)	0.41-0.93	0.72-0.81	0.79(0.02)	0.43-0.91	0.74-0.84
Pielou's evenness	0.32(0.01)	0.23-0.41	0.31-0.33	0.29(0.01)	0.14-0.42	0.26-0.30	0.33(0.01)	019-0.52	0.31-0.35
Hill's evenness	0.18(0.01)	0.11-0.32	0.16-0.19	0.15(0.01)	0.07-0.32	0.13-0.17	0.21(0.01)	0.11-0.54	0.17-0.23

Tab. 3 Descriptive analysis for dependent variables used in the analyses include mean, standard error, minimum, maximum and 95% confidential intervals for each types for spring-summer period.

Dependent variable	Non-occupied nest			Occupied nest			Random point		
	Mean(SE)	Min-Max	95%CI	Mean (SE)	Min-Max	95%CI	Mean (SE)	Min-Max	95%CI
Abundance	18.77(1.30)	8-42	16.12-21.43	48.46(5.05)	8-139	38.23-58.70	17.76(1.01)	7-32	15.70-19.82
Species richness	10.61(0.63)	5-20	9.31-11.91	18.41(1.07)	5-43	16.24-20.58	11.24(0.63)	5-18	9.96-12.52
Shannon-Wiener index	1.93(0.08)	0.72-2.68	1.76-2.11	2.06(0.08)	0.95-2.75	1.90-2.23	2.01(0.06)	1.31-2.83	1.88-2.13
Simpson index	0.79(0.02)	0.39-0.91	0.73-0.83	0.76(0.02)	0.34-0.94	0.71-0.81	0.81(0.01)	0.57-0.93	0.78-0.84
Pielou's evenness	0.35(0.01)	0.17-0.44	0.33-0.36	0.28(0.01)	0.11-0.36	0.26-0.29	0.34(0.01)	0.25-0.40	0.33-0.35
Hill's evenness	0.24(0.01)	0.13-0.50	0.21-0.27	0.14(0.01)	0.07-0.28	0.12-0.16	0.22(0.01)	0.12-0.33	0.20-0.23

Early spring bird counts

The generalized linear models showed significant differences on birds abundance between non-occupied white stork nests, occupied white stork nests and random points (Wald chi-square = 7.92, $p=0.019$, Tab 3, Fig. 1). The post hoc test showed significant differences between non-occupied nest and occupied nest ($p<0.05$), and between occupied and random points ($p<0.01$). Moreover share of built up area ($\beta= 2.73\pm0.76$, $p<0.001$), grasslands ($\beta=1.05\pm0.36$, $p=0.004$), arable field ($\beta=2.97\pm0.79$) and quadratic term of arable field ($\beta=-2.10\pm0.95$, $p=0.027$) had a significant effect on birds abundance. The species richness were significant different between three types of count plots ($F=3.59$, $p=0.031$, Tab. 4, Fig. 2). The post hoc test showed significant differences between non-occupied nest and occupied nest ($p<0.05$), and between occupied and random points ($p<0.01$). Additionally the share of urban ($\beta=14.06\pm6.74$, $p=0.039$) and quadratic term of arable land ($\beta=22.27\pm9.39$, $p=0.019$) had a significant effect on bird species richness.

There were no significant differences between three types of count plots and effect of environmental variable on bird diversity (measure by Shannon-Wiener and Simpson index, Tab. 5, 6). The species evenness (measure by Pielou's evenness and Hill’s evenness) were significant different between three types of count plots ($F=4.26$, $p=0.016$, $F=8.02$, $p<0.001$; respectively for Pielou's evenness and Hill’s evenness (Tab. 7, 8, Fig. 3). The post hoc test showed significant differences on Pielou's evenness between occupied nest and random points ($p<0.05$). The post hoc test showed significant differences on Hill’s evenness between occupied nest and random points ($p<0.001$). Additionally in two models showed that share of arable ($\beta= -0.07\pm0.02$, $p=0.0053$, $\beta=-0.08\pm0.03$,$p=0.012$; respectively for Pielou's evenness and Hill’s evenness) and grassland ($\beta=-0.06\pm0.02$, $p=0.004$, $\beta=-0.09\pm0.08$, $p=0.002$; respectively for Pielou's evenness and Hill’s evenness) had significant effect on species evenness.

The models include reduction of environmental variables into PCA ordinations showed significant difference on abundance and species richness between non-occupied white stork nests, occupied white stork nests and random points (Tab. 9, 10). The PCA 1 and PCA 2 had significant effects on bird abundance, in addition PCA 2 had significant effect on species richness (Tab. 10). There were no significant dependent variables effects on bird diversity measure by Shannon-Wiener and Simpson index (Tab. 11, 12). In the both models for species evenness showed significant differences between non-occupied white stork nests, occupied white stork nests and random points (Tab. 13, 14). Additionally the PCA 2 and interaction between type and PCA 2 had significant effect on species evenness.

Tab. 3 Results of the generalized linear mixed models with Poisson distribution describing the relationship of the abundance of bird species with localization and environmental factor. Abbreviations: Type, type of localizations (occupied white stork nest, non-occupied white stork nest, random points); Urban, share of built up land; Arable, share of non-irrigated arable land; Grassland, share of grasslands and pastures land; Agri_land, share of other agriculture land; Marshland, share of marshland land. The R^2 was 32.62%.

Variables	Wald Chi2	df	p
Type	7.92	2	0.019
Urban	12.88	1	0.003
Arable	14.09	1	<0.001
Arable2	4.83	1	0.028
Grassland	8.42	1	0.003
Agri_land	1.07	1	0.301
Marshland	1.90	1	0.168

Tab. 4 Results of the generalized linear mixed models with Gaussian distribution describing the relationship of the number of bird species with localization and environmental factor. Abbreviations: Type, type of localizations (occupied white stork nest, non-occupied white stork nest, random points); Urban, share of built up land; Arable, share of non-irrigated arable land; Grassland, share of grasslands and pastures land; Agri_land, share of other agriculture land; Marshland, share of marshland land. he R^2 was 17.05%.

Variables	F	df	p
Type	3.59	2	0.031
Urban	4.35	1	0.039
Arable	0.40	1	0.527
Arable2	5.62	1	0.020
Grassland	1.92	1	0.168
Agri_land	0.01	1	0.893
Marshland	1.01	1	0.317

Tab. 5 Results of the generalized linear mixed models with Gaussian distribution describing the relationship of the Shannon diversity of birds (log+1 transformed) with localization and environmental factor. Abbreviations: Type, type of localizations (occupied white stork nest, non-occupied white stork nest, random points); Urban, share of built up land; Arable, share of non-irrigated arable land; Grassland, share of grasslands and pastures land; Agri_land, share of other agriculture land; Marshland, share of marshland land. The R^2 was 3.74%.

Variables	F	df	p
Type	1.13	2, 96	0.326
Urban	0.12	1, 96	0.729
Arable	0.06	1, 96	0.803
Grassland	0.16	1, 96	0.690
Agri_land	0.002	1, 96	0.959
Marshland	0.61	1, 96	0.437

Tab. 6 Results of the generalized linear mixed models with Gaussian distribution describing the relationship of the Simpson diversity of birds (log+1 transformed) with localization and environmental factor. Abbreviations: Type, type of localizations (occupied white stork nest, non-occupied white stork nest, random points); Urban, share of built up land; Arable, share of non-irrigated arable land; Grassland, share of grasslands and pastures land; Agri_land, share of other agriculture land; Marshland, share of marshland land. The R^2 was 4.18%.

Variables	F	df	p
Type	0.93	2, 96	0.396
Urban	0.39	1, 96	0.531
Arable	1.02	1, 96	0.313
Grassland	0.19	1, 96	0.663
Agri_land	0.02	1, 96	0.885
Marshland	0.37	1, 96	0.543

Tab. 7 Results of the generalized linear mixed models with Gaussian distribution describing the relationship of the Pielou's evenness (log+1 transformed) with localization and environmental factor. Abbreviations: Type, type of localizations (occupied white stork nest, non-occupied white stork nest, random points); Urban, share of built up land; Arable, share of non-irrigated arable land; Grassland, share of grasslands and pastures land; Agri_land, share of other agriculture land; Marshland, share of marshland land. The R^2 was 15.66%.

Variables	F	df	p
Type	4.27	2, 96	0.016
Urban	3.82	1, 96	0.053
Arable	8.15	1, 96	0.005
Grassland	8.64	1, 96	0.004
Agri_land	0.22	1, 96	0.639
Marshland	0.15	1, 96	0.690

Tab. 8 Results of the generalized linear mixed models with Gaussian distribution describing the relationship of the Hill's evenness (log+1 transformed) with localization and environmental factor. Abbreviations: Type, type of localizations (occupied white stork nest, non-occupied white stork nest, random points); Urban, share of built up land; Arable, share of non-irrigated arable land; Grassland, share of grasslands and pastures land; Agri_land, share of other agriculture land; Marshland, share of marshland land. The R^2 was 18.13%.

Variables	F	df	p
Type	5.89	2, 96	0.003
Urban	3.14	1, 96	0.079
Arable	6.53	1, 96	0.012
Grassland	10.41	1, 96	0.002
Agri_land	0.18	1, 96	0.670
Marshland	1.19	1, 96	0.277

Tab. 9 Results of the generalized linear mixed models with Poisson distribution describing the relationship of the abundance of bird species with localization and environmental factor and their interactions. The R^2 was 24.62%.

Variables	Wald Chi2	df	p
Type	22.26	2	<0.001
PCA1	4.66	1	0.031
PCA2	13.05	1	<0.001
Type x PCA 1	0.66	2	0.717
Type x PCA 2	4.80	2	0.091

Tab. 10 Results of the generalized linear mixed models with Gaussian distribution describing the relationship of the number of bird species with localization and environmental factor, and their interactions. The R^2 was 10.83%.

Variables	F	df1,df2	p
Type	7.14	2,95	0.001
PCA1	1.08	1,95	0.300
PCA2	4.39	1,95	0.039
Type x PCA 1	0.18	2,95	0.836
Type x PCA 2	1.42	2,95	0.245

Tab. 11 Results of the generalized linear mixed models with Gaussian distribution describing the relationship of the Shannon diversity of birds (log+1 transformed) with localization and environmental factor and their interactions. The R^2 was 18.13%.

Variables	F	df	p
Type	1.17	2, 95	0.311
PCA1	1.15	1, 95	0.284
PCA2	0.001	1, 95	0.974
Type x PCA 1	0.25	2, 95	0.778
Type x PCA 2	0.15	2, 95	0.854

Tab. 12 Results of the generalized linear mixed models with Gaussian distribution describing the relationship of the Simpson diversity of birds (log+1 transformed) with localization and environmental factor and their interactions. The R^2 was 5.88%.

Variables	F	df	p
Type	1.11	2, 95	0.332
PCA1	1.18	1, 95	0.281
PCA2	1.11	1, 95	0.293
Type x PCA 1	0.89	2, 95	0.413
Type x PCA 2	0.06	2, 95	0.938

Tab. 13 Results of the generalized linear mixed models with Gaussian distribution describing the relationship of the Pielou's evenness (log+1 transformed) with localization and environmental factor and their interactions. The R^2 was 25.03%.

Variables	F	df	p
Type	8.02	2, 95	<0.001
PCA1	1.02	1, 95	0.315
PCA2	13.18	1, 95	<0.001
Type x PCA 1	2.95	2, 95	0.057
Type x PCA 2	3.97	2, 95	0.022

Tab. 14 Results of the generalized linear mixed models with Gaussian distribution describing the relationship of the Hill's evenness (log+1 transformed) with localization and environmental factor and their interactions. The R^2 was 28.93%.

Variables	F	df	p
Type	11.91	2, 95	<0.001
PCA1	0.21	1, 95	0.650
PCA2	13.47	1, 95	<0.001
Type x PCA 1	2.87	2, 95	0.062
Type x PCA 2	5.69	2, 95	0.005

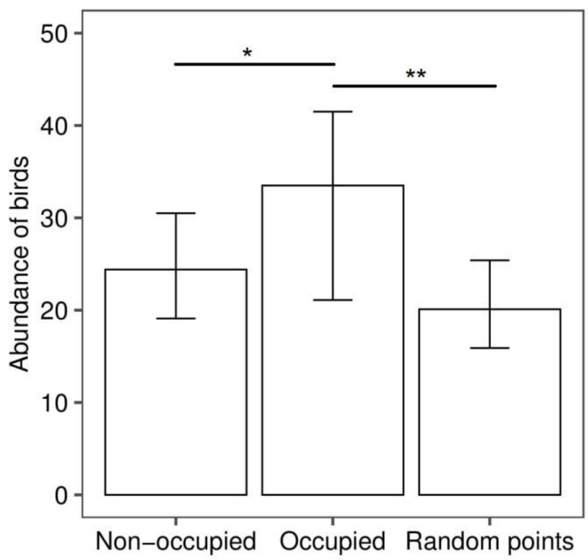


Fig. 1 The mean and 95% CI of abundance of birds. Asterisks indicate significant differences (* p<0.05, ** p<0.01).

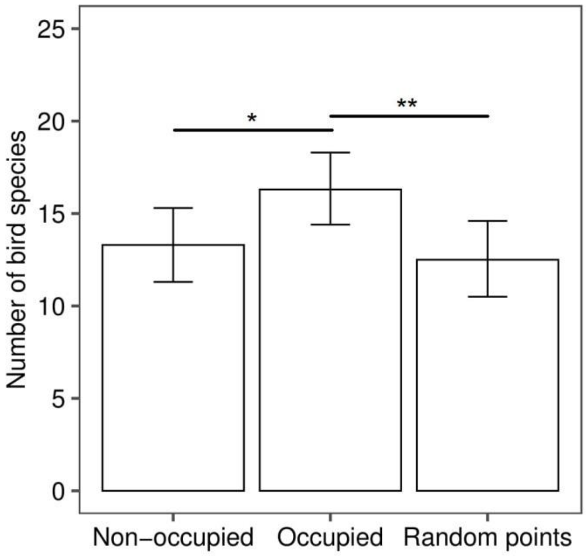


Fig. 2 The mean and 95% CI of number of bird species. Asterisks indicate significant differences (* p<0.05, ** p<0.01).

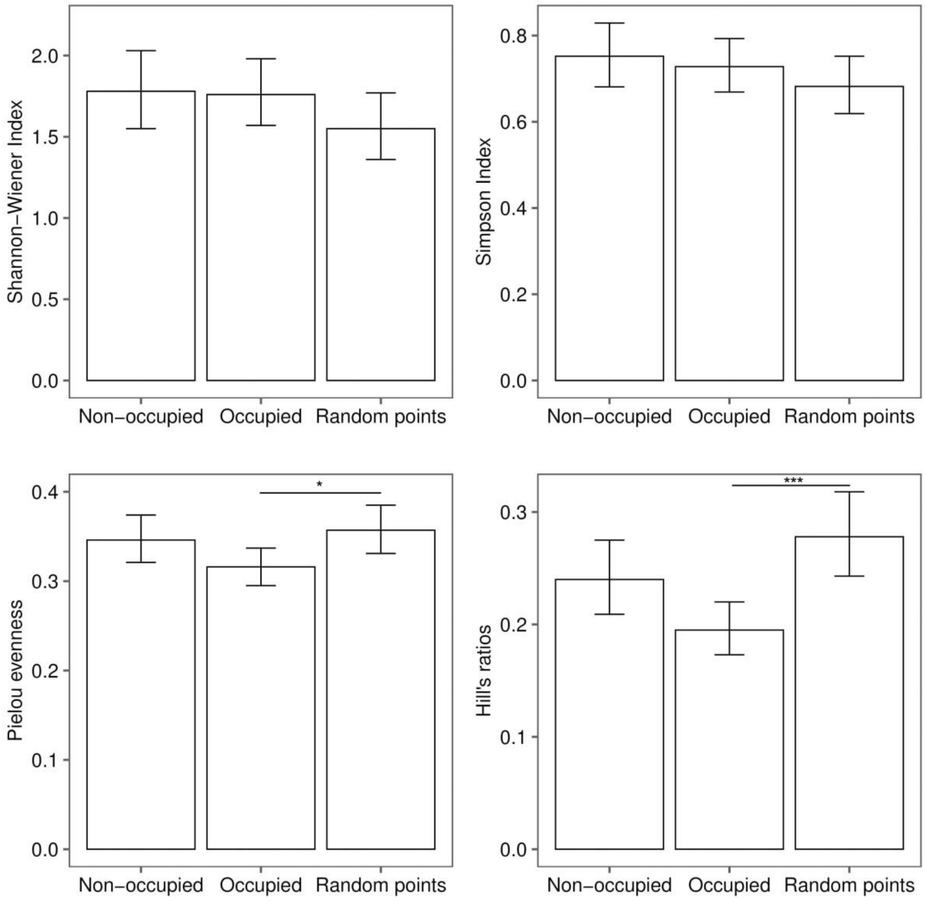


Fig. 3 The mean and 95% CI of diversity and evenness of birds. Asterisks indicate significant differences (* p<0.05, *** p<0.001).

Spring and Summer bird counts

The generalized linear mixed models showed that only the type of bird count plots were different on abundance (Wald chi-square = 44.31, df=2, p<0.001, Tab. 15, Fig. 4) and species richness (F=15.04, p<0.001, Tab. 16, Fig. 5). The post hoc test for both models showed significant differences between non-occupied nest and occupied nest (p<0.01), and between occupied and random points (p<0.01). In case models for diversity indexes none of the explanatory variables were significant (Tab. 17, 18). The species evenness (measure by Pielou's evenness and Hill's evenness) were significant different between three types of count plots (F=14.76, p<0.001, F=17.17, p<0.001 respectively for Pielou's evenness and Hill's evenness, Tab. 18, 19, Fig. 6). The share of marshland had significant effect on Pielou's evenness (β=-0.14±0.06, p=0.021). The share of urban (β =-0.04±0.03,p=0.024) and share of marshland (β=-0.19±0.07, p=0.024) had a significant effect on Hill's species evenness. The models include reduction of environmental variables into PCA ordinations showed only significant difference on abundance (Wald chi square=74.13, p<0.001, Tab. 20) and species richness (F=15.87, p<0.001, Tab. 21) between non-occupied white stork nests, occupied white stork nests and random points. There were no significant dependent variables effects on bird diversity measure by Shannon-Wiener and Simpson index (Tab. 22, 23). In the both models for species evenness showed only significant differences between non-occupied white stork nests, occupied white stork nests and random points (F=20.08, p<0.001, F=32.71, p<0.001; respectively for Pielou's evenness and Hill's evenness, Tab. 24, 25). The post hoc test showed significant differences on Pielou's evenness between non-occupied nest and occupied nest (p<0.001), and between occupied nest and random points (p<0.001). The post hoc test showed significant differences on Hill's evenness between non-occupied nest and occupied nest (p<0.001), and between occupied nest and random points (p<0.001).

Tab. 15 Results of the generalized linear mixed models with Poisson distribution describing the relationship of the abundance of bird species with localization and environmental factor. Abbreviations: Type, type of localizations (occupied white stork nest, non-occupied white stork nest, random points); Urban, share of built up land; Arable, share of non-irrigated arable land; Grassland, share of grasslands and pastures land; Agri_land, share of other agriculture land; Marshland, share of marshland land.
The R^2 was 19.96%.

Variables	Wald Chi2	df	p
Type	44.32	2	<0.001
Urban	2.28	1	0.131
Arable	0.19	1	0.658
$Arable^2$	1.16	1	0.279
Grassland	0.05	1	0.815
Agri_land	2.43	1	0.118
Marshland	0.44	1	0.506

Tab. 16 Results of the generalized linear mixed models with Gaussian distribution describing the relationship of the number of bird species with localization and environmental factor. Abbreviations: Type, type of localizations (occupied white stork nest, non-occupied white stork nest, random points); Urban, share of built up land; Arable, share of non-irrigated arable land; Grassland, share of grasslands and pastures land; Agri_land, share of other agriculture land; Marshland, share of marshland land. The R^2 was 20.02%.

Variables	F	df	p
Type	15.04	2, 95	<0.001
Urban	3.75	1, 95	0.055
Arable	0.14	1, 95	0.703
$Arable^2$	0.41	1, 95	0.520
Grassland	2.52	1, 95	0.114
Agri_land	2.53	1, 95	0.115
Marshland	2.51	1, 95	0.116

Tab. 17 Results of the generalized linear mixed models with Gaussian distribution describing the relationship of the Shannon diversity of birds (log+1 transformed) with localization and environmental factor. Abbreviations: Type, type of localizations (occupied white stork nest, non-occupied white stork nest, random points); Urban, share of built up land; Arable, share of non-irrigated arable land; Grassland, share of grasslands and pastures land; Agri_land, share of other agriculture land; Marshland, share of marshland land. The R^2 was 3.74%.

Variables	F	df	p
Type	2.27	2, 95	0.135
Urban	0.33	1, 95	0.566
Arable	0.14	1, 95	0.711
Grassland	0.12	1, 95	0.730
Agri_land	0.01	1, 95	0.937
Marshland	0.57	1, 95	0.453

Tab. 18 Results of the generalized linear mixed models with Gaussian distribution describing the relationship of the Simpson diversity of birds (log+1 transformed) with localization and environmental factor. Abbreviations: Type, type of localizations (occupied white stork nest, non-occupied white stork nest, random points); Urban, share of built up land; Arable, share of non-irrigated arable land; Grassland, share of grasslands and pastures land; Agri_land, share of other agriculture land; Marshland, share of marshland land. The R^2 was 1.82%.

Variables	F	df	p
Type	0.80	2, 95	0.449
Urban	0.24	1, 95	0.620
Arable	0.16	1, 95	0.690
Grassland	0.36	1, 95	0.547
Agri_land	0.25	1, 95	0.616
Marshland	0.25	1, 95	0.613

Tab. 19 Results of the generalized linear mixed models with Gaussian distribution describing the relationship of the Pielou's evenness (log+1 transformed) with localization and environmental factor. Abbreviations: Type, type of localizations (occupied white stork nest, non-occupied white stork nest, random points); Urban, share of built up land; Arable, share of non-irrigated arable land; Grassland, share of grasslands and pastures land; Agri_land, share of other agriculture land; Marshland, share of marshland land. The R^2 was 17.58%.

Variables	F	df	p
Type	14.76	2, 95	<0.001
Urban	2.03	1, 95	0.156
Arable	0.91	1, 95	0.341
Grassland	0.62	1, 95	0.431
Agri_land	1.55	1, 95	0.215
Marshland	5.49	1, 95	0.021

Tab. 20 Results of the generalized linear mixed models with Gaussian distribution describing the relationship of the Hill's evenness (log+1 transformed) with localization and environmental factor. Abbreviations: Type, type of localizations (occupied white stork nest, non-occupied white stork nest, random points); Urban, share of built up land; Arable, share of non-irrigated arable land; Grassland, share of grasslands and pastures land; Agri_land, share of other agriculture land; Marshland, share of marshland land. The R^2 was 28.23%.

Variables	F	df	p
Type	17.17	2, 95	<0.001
Urban	5.20	1, 95	0.024
Arable	2.33	1, 95	0.130
Grassland	2.39	1, 95	0.125
Agri_land	3.91	1, 95	0.051
Marshland	5.89	1, 95	0.017

Tab. 21 Results of the generalized linear mixed models with Poisson distribution describing the relationship of the abundance of bird species with localization and environmental factors and their interactions. The R^2 was 6.58%.

Variables	Wald Chi2	df	p
Type	74.13	2	<0.001
PCA1	0.01	1	0.921
PCA2	1.18	1	0.275
Type x PCA 1	5.37	2	0.067
Type x PCA 2	5.02	2	0.081

Tab. 22 Results of the generalized linear mixed models with Gaussian distribution describing the relationship of the number of bird species with localization and environmental factor and their interactions. The R^2 was 3.14%.

Variables	F	df1,df2	p
Type	26.27	2,95	<0.001
PCA1	1.09	1,95	0.297
PCA2	0.31	1,95	0.577
Type x PCA 1	0.19	2,95	0.819
Type x PCA 2	0.16	2,95	0.848

Tab. 23 Results of the generalized linear mixed models with Gaussian distribution describing the relationship of the Shannon diversity of birds (log+1 transformed) with localization and environmental factor and their interactions. The R^2 was 4.48%.

Variables	F	df	p
Type	0.41	2, 95	0.668
PCA1	0.02	1, 95	0.880
PCA2	0.50	1, 95	0.481
Type x PCA 1	0.19	2, 95	0.812
Type x PCA 2	0.22	2, 95	0.806

Tab. 24 Results of the generalized linear mixed models with Gaussian distribution describing the relationship of the Simpson diversity of birds (log+1 transformed) with localization and environmental factor and their interactions. The R^2 was 3.66%.

Variables	F	df	p
Type	1.18		0.310
PCA1	0.01		0.942
PCA2	0.26		0.613
Type x PCA 1	0.211		0.809
Type x PCA 2	0.51		0.602

Tab. 25 Results of the generalized linear mixed models with Gaussian distribution describing the relationship of the Pielou's evenness (log+1 transformed) with localization and environmental factor and their interactions. The R^2 was 31.43%.

Variables	F	df	p
Type	20.09		<0.001
PCA1	0.06		0.811
PCA2	0.04		0.842
Type x PCA 1	0.06		0.940
Type x PCA 2	1.82		0.166

Tab. 26 Results of the generalized linear mixed models with Gaussian distribution describing the relationship of the Hill's evenness (log+1 transformed) with localization and environmental factor and their interactions. The R^2 was 42.81%.

Variables	F	df	p
Type	32.71		<0.001
PCA1	0.03		0.857
PCA2	0.25		0.617
Type x PCA 1	0.12		0.887
Type x PCA 2	1.25		0.291

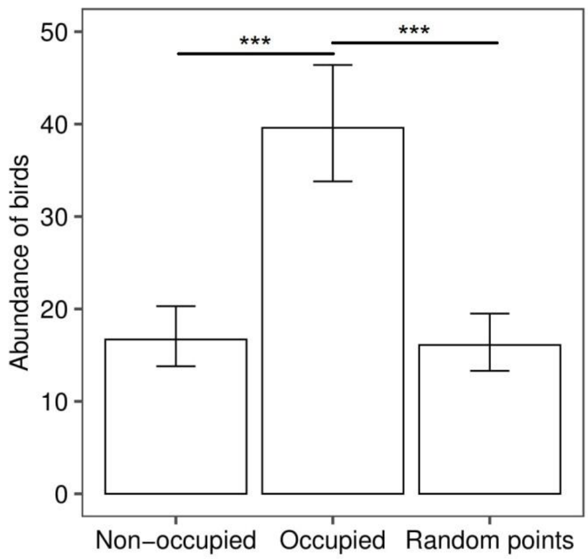


Fig. 4 The mean and 95% CI of abundance of birds. Asterisks indicate significant differences (* p<0.05, ** p<0.01).

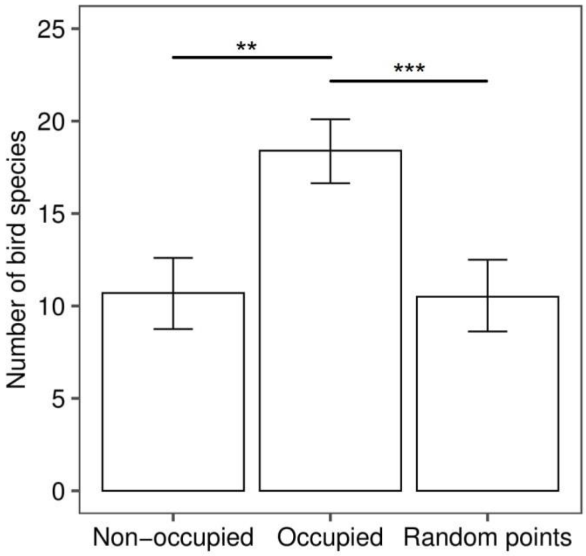


Fig. 5 The mean and 95% CI of abundance of birds. Asterisks indicate significant differences (* p<0.05, ** p<0.01).

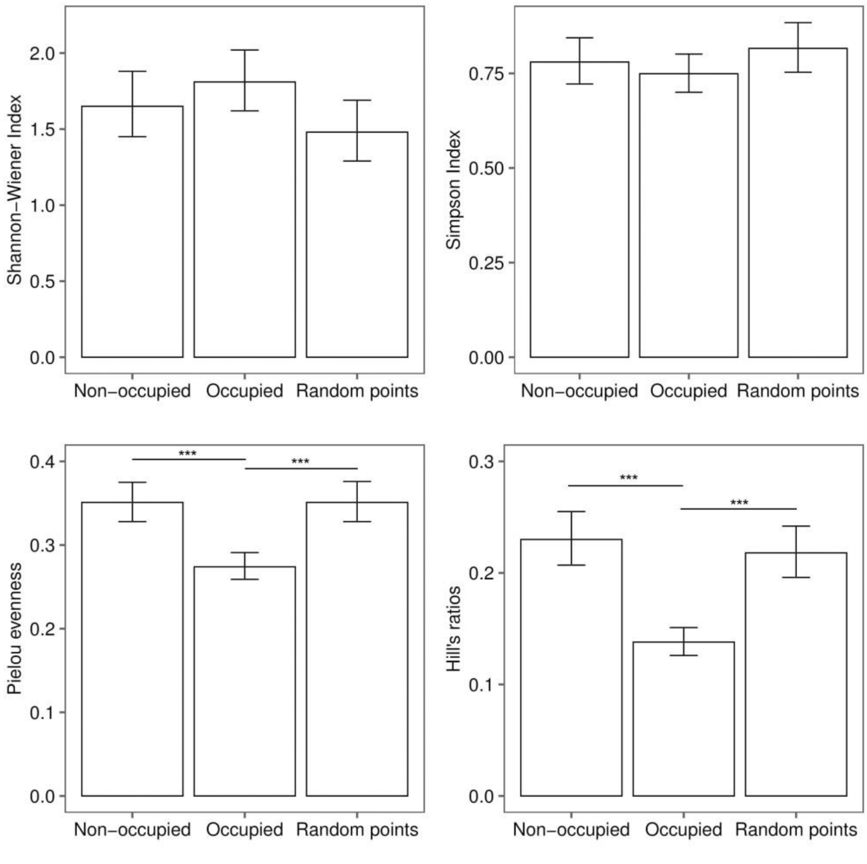


Fig. 6 The mean and 95% CI of diversity and evenness of birds. Asterisks indicate significant differences (*** p<0.001).

Habitat quality

The Kruskal Wallis test showed that share of built up area ($p<0.001$), grassland land ($p<0.001$) and other agricultural land ($p=0.017$) significantly differ between non-occupied white stork nests, occupied white stork nests and random points (Tab. 27). In case share built up area post hoc test showed significant differences between occupied white stork nest and random points ($p<0.001$), and between non-occupied nest and occupied nest ($p=0.038$). In case share of grassland lands post hoc test showed significant differences between non-occupied white stork nests and random points ($p=0.002$), and between occupied nest and random points ($p=0.001$). In case irrigate arable land post hoc test showed significant differences between occupied white stork nest and random points ($p=0.037$), and between non-occupied nest and random point ($p=0.041$).

Tab. 27 The result of the Kurskal Wallis test.

Environmental variable	Kruskal Wallis H	df	p	Mean rang		
				Non-occupied nest	Occupied nest	Random points
Share of built up are	17.99	2	<0.001	50.27	63.64	41.75
Share of non-irrigated agriculture	5.26	2	0.072	49.98	60.82	45.25
Share of grassland and pasture	15.72	2	<0.001	44.15	44.47	69.32
Share of other agriculture	8.19	2	0.017	57.61	57.00	42.68
Share of forest	4.96	2	0.084	60.61	45.28	53.38
Shate of marshland	2.71	2	0.258	50.53	56.22	50.03

Bird species composition

The PERMANOVA indicated statistical differences on bird species composition between non-occupied white stork nests, occupied white stork nests and random points in early spring period ($F=3.52$, $df=2$, $p=0.001$, Fig. 7,8) and spring – summer period ($F=4.35$, $df=2$, $p=0.001$, Fig. 9, 10). However the R^2 in both case were low ($R^2=0.06$ for early spring period and $R^2=0.08$ for summer period). The graphical visualization showed weakly separated points of occupied nest compare with the non-occupied nest and random points. In case non-occupied nest and random points the centroids were closer together. However, there was no clear separation of species composition of birds between types.

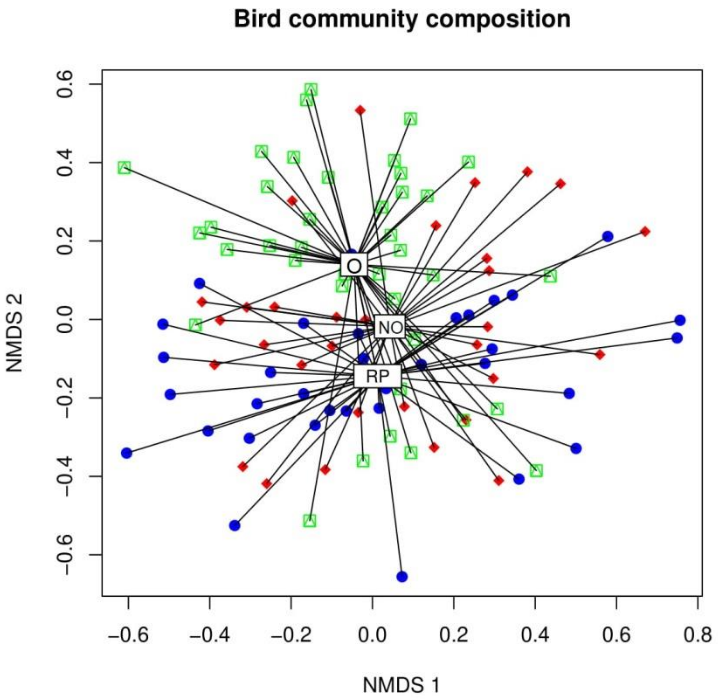


Fig. 7 Dissimilarities between bird communities in non-occupied white stork nests, occupied white stork nests and random points for early spring period.

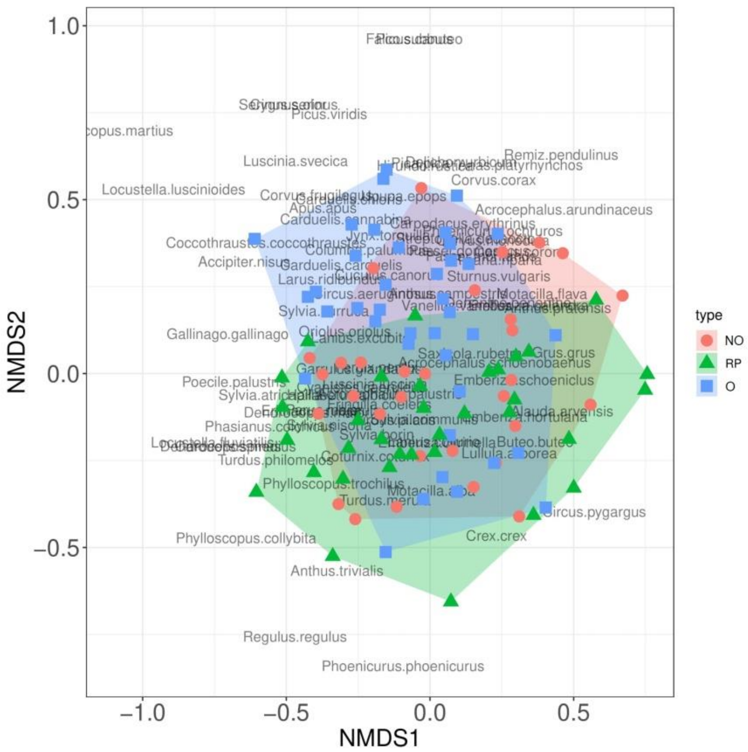


Fig. 8 Dissimilarities between bird communities in non-occupied white stork nests, occupied white stork nests and random points for early spring period.

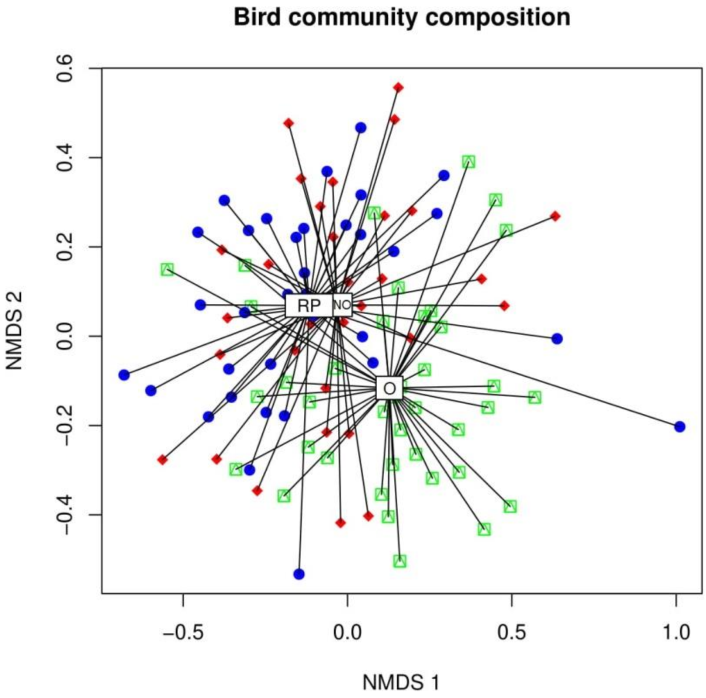


Fig. 9 Dissimilarities between bird communities in non-occupied white stork nests, occupied white stork nests and random points for spring-summer period.

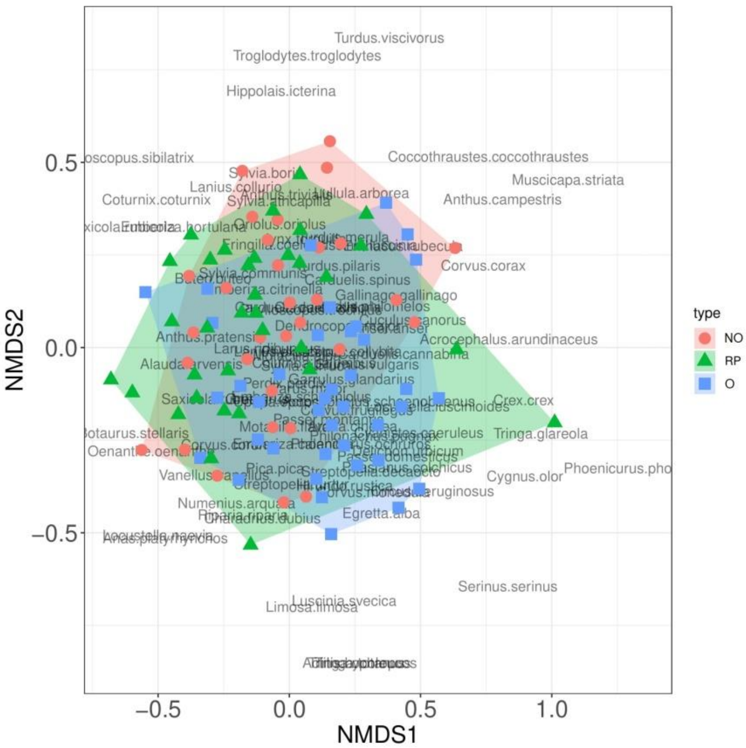


Fig. 10 Dissimilarities between bird communities in non-occupied white stork nests, occupied white stork nests and random points for spring-summer period.

Environmental factors affected on birds in occupied white stork nest buffer

The PCA analyses reduced environmental variables into three PCA ordinations. Associations between the three extracted components and original explanatory continuous variables are given in Table 28.

Tab. 28 Principal Component Analyses. Total explain 75.05 % of variance.

Variables	PCA 1 34.5%	PCA 2 22.26%	PCA 3 18.24%
Share of built up are	0.205	*0.845*	*0.047*
Share of non-irrigated agriculture	*0.896*	0.074	-0.351
Share of grassland and pasture	*-0.897*	-0.203	-0.319
Share of other agriculture	-0.098	*-0.740*	0.196
Share of forest	0.034	-0.192	*0.781*
Shate of marshland	-0.127	*0.530*	*0.568*

Early spring

The generalized mixed model showed that abundance of birds was positively correlated with PCA 2 (and thus negatively correlated with share of built up area and marshland, and positively correlated with the other agriculture land, Tab 29). The species richness was positively correlated with PCA 2 (and thus and thus negatively correlated with share of built up area and marshland, and positively correlated with the other agriculture land Tab. 29). The Hill's evenness was negatively correlated with PCA 2 (and thus positively correlated with share of built up area and marshland, and negatively correlated with the other agriculture land, Tab 29). Not one environmental variable was associated with the Shannon-Wiener diversity index, Simpson diversity index and Pielou's species evenness (Tab. 29).

Tab. 29 The result of the generalized linear mixed models.

	Intercept		PCA1		PCA2		PCA3		
Model for	Estimate(SE)	p	Statistic test	p	Statistic test	p	Statistic test	p	R^2
Abundance	3.675(0.11)	<0.001	0.43(↑)	0.509	*11.46(↑)*	*<0.001*	2.55(↓)	0.109	0.28
Species richness	2.755(0.06)	<0.001	0.01(↑)	0.922	*5.49(↑)*	*0.025*	2.67(↓)	0.159	0.16
Shannon-Wiener index	2.032(0.08)	<0.001	0.46(↓)	0.500	0.09(↓)	0.762	0.01(↓)	0.943	0.01
Simpson index	-0.286(0.02)	<0.001	0.06(↓)	0.799	0.24(↓)	0.626	0.25(↑)	0.621	0.01
Pielou's evenness	0.285(0.01)	<0.001	0.62(↑)	0.435	3.28(↓)	0.079	1.84(↑)	0.183	0.13
Hill's evenness	0.152(0.01)	<0.001	1.99(↑)	0.167	*4.20(↓)*	*0.048*	1.79(↑)	0.190	0.17

Spring – Summer period

Not one environmental variable was associated with the abundance, species richness, Shannon-Wiener diversity index, Simpson diversity index and Pielou's species evenness (Tab. 30).

Tab. 30 The result of the generalized linear mixed models.

Model for	Intercept Estimate(SE)	p	PCA1 Statistic test	p	PCA2 Statistic test	p	PCA3 Statistic test	p	R2
Abundance	3.677(0.11)	<0.001	0.58(↑)	0.446	0.23(↑)	0.630	0.07(↑)	0.787	0.02
Species richness	2.842(0.07)	<0.001	0.36(↓)	0.552	1.63(↑)	0.210	0.04(↓)	0.853	0.05
Shannon-Wiener index	2.032(0.08)	<0.001	0.46(↓)	0.500	0.09(↓)	0.762	0.01(↓)	0.943	0.01
Simpson index	0.768(0.02)	<0.001	0.02(↓)	0.894	0.78(↓)	0.380	0.41(↓)	0.536	0.03
Pielou's evenness	0.279(0.01)	<0.001	0.00(↓)	0.949	2.50(↓)	0.122	0.56(↓)	0.460	0.07
Hill's evenness	0.142(0.01)	<0.001	0.02(↑)	0.886	2.86(↓)	0.099	0.19(↓)	0.666	0.07

Conclusion

The white stork are a good indicator to farmland bird abundance and species richness. Our results showed that abundance and species richness of farmland bird species significant difference between types (occupied, unoccupied nest and random points). The amount of bids and amount of number of bird species were higher in territory occupied by white stork than other types. The weakly dissimilarity of bird composition between types was observed.

CHAPTER 2
CULTURAL SERVICES

Awareness of the society of perception of nature and its value is an important aspect in taking actions of active local nature protection. The public's attitude towards conservation practices aimed at protecting a given species or habitats is crucial and may facilitate given action. These studies are aimed at assessing public awareness of nature conservation in a region where the white stork population is high. The presence of a white stork iconic species for society can affect a positive feeling about nature conservation and a greater awareness of local conservation practices. The second part of the research aims to see how the very presence of a white stork can change the perception of society in assessing the intensity of agriculture.

Materials and Methods

The survey was carried out on a random sample of people of different ages from 18 to 82. The number of respondents was 262. The respondents were divided into two groups: living near the white stork nest and people living away from the nest. The respondents answered a number of questions contained in Appendix 1. The answers contained in the survey received points.

Attributed ranks for answers:

1 – Definitely no

2 – No

3 – Indifferentl

4 – Yes

5 – Definitely yes

The second part of the research involved people's perception of different landscapes from intense (four photographs) to extensive (four photographs) include in Appendix 2, 3. For this purpose, two types of boards with photos were prepared, each board prepared in 8 versions with photos arranged in different order so as to ensure the independence of assessing the attractiveness of the presented landscapes. The first board will include photos of the agricultural landscape itself to varying degrees of intensity (8 photos). The second board will contain the same photos as on the first board, graphically processed, where some of the photos will include white storks (1 placed in the extensive landscape and 3 - placed in the intensive landscape. Respondents are to assign according to an 8-degree scale which landscape they are more attractive, where 1 is the best and 8 is the worst. We show the interviewee only one of the two boards (trying to change the sets for each of the boards). We change the board at the next person interviewed. A third board will be prepared, on which photos from the first and second boards will be in the correct order of importance for the protection of local nature. The third board will be useful when entering data into the database.

Statistical analysis

Questionnaire

Prior to analyses the answers for each questions included in the questionnaire were standardization. Because the questions were positively answer arranged (from 1 to 5, were 5 was the high score of the pro conservation initiative), were used scale from -2 to +2. Then, each answer for one person has been added up for each questions. People with a high score were characterized by pro-nature conservation thinking. This score was used to the analysis.

First the linear mixed model with person ID as a random factors was used to verify effect on presents white stork (coded 1=Yes, 0=No), sex (F=female, M=male), people age, and interaction between presents white stork and sex , and presents white stork and people age. Second was used the redundancy analysis (RDA) to check composition of the question answer depended on sex (F=female, M=male), presence of the white stork (coded 1=Yes, 0=No) and people age. This analyses showed effect on explanatory variable affected on each question answers separately. Third was used U Mann-Whitney test to check differences between white stork presence in the farm or not for each question answers separately.

Boards with photos

Prior to analyses the score for each photos (growth with the intensification of agricultural landscape) were transform from 0 to 1. Scores have been changed as follows (1 – 0; 2 – 0.25; 3 – 0.375; 4 – 0.5; 5 – 0.625; 6 – 0.75; 7 – 0.875; 8 – 1). The photos 1, 2, 3 and 4 were categorized as extensive farmland landscape the photos 5, 6, 7 and 8 were categorized as intensive farmland landscape. Three separate analyzes were carried out. First, the effect on presents the white storks to change of the human perception to classification the farmland intensity (were used boards with presents white stork on four photos and without white stork) were checked. Second, the effect on presents of white storks to change of perception but only for photos 4, 5, 6 and 7 (with white stork and without white stork) were checked. Third analyses the human perception farmland classification (from extensive to intensive) on photos without white stork were checked. The generalized linear mixed models with beta distribution were used. The person ID was used as a random factor. On each models the effect on type boards (with and without white stork), photo category (E – extensive farmland; I – intensive farmland), presence the white stork in farm (coded 1=Yes, 0=No), sex (F=female, M=male) and age were used as a explanatory variables. Additionally, the farmland intensification index between categorical variables were compared by using non-metric multidimensional scaling (NMDS) with the 999 permutations test. The permutation multivariate analysis of variance PERMANOVA was used to check differences between centroids and dispersion of groups representing each categorical variables on farmland intensification index classification. The significant results were only present.

Results

Questionnaire

The linear mixed model showed significant differences between male and female on question answer scale ($F=7.04$, $p=0.008$). The rest explanatory variables were no significant (Tab. 1). The models showed that female (mean±SE 13.23±0.54) had a higher scale index that male (11.02±0.70). The RDA analysis showed significant differences on composition question answer (pseudo-$F=2.03$, $p=00.2$). The graphical visualization presents that Question Q10, Q11, Q18 were positive correlated with the presence white stork in farm. The question answers (Q1, Q4, Q19) were negative correlated with the people who does not have white storm nest in farm (Fig. 2, 3). Moreover graphical visualization showed that many question were positive answer correlated with female. The question answer composition was significant difference between male and female; and between presence white stork nest and lack white stork nest (Fig. 2, 3). The age of respondents had correlated with positive question answer for some questions (Fig. 2, 3). The U Mann Whiney test for the single question tested showed significant differences between people who had white stork nest in farm and people with lack white stork nest on Q10 ($Z=3.38$, $p<0.001$), Q11 ($Z=2.05$, $p=0.040$), Q18 ($Z=1.96$, $p=0.050$), where the mean rang for these question were higher for people with the white stork nest in farm.

Tab. 1 The result of the linear mixed model.

Variables	F	df	p
Presence white stork (PWS)	0.48	1, 250	0.488
Age (A)	1.21	1, 250	0.272
Sex (S)	7.04	1, 250	0.008
PWS × A	2.45	2, 250	0.118
PWS × S	2.51	2, 250	0.113

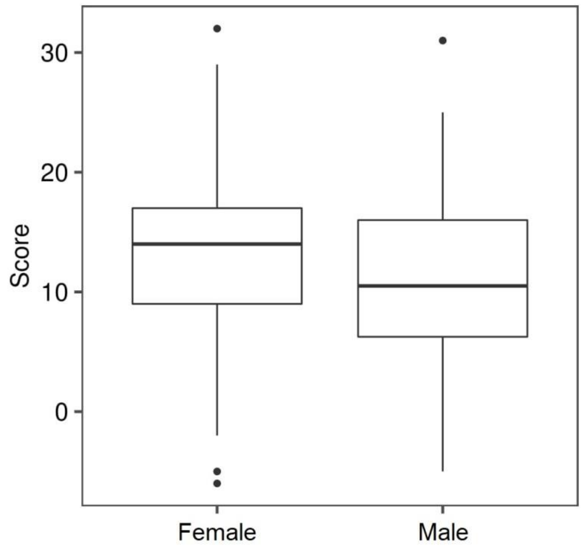


Fig. 1 The box plot showed differences between female and male on question answer score. The higher score mean pro-nature conservation thinking.

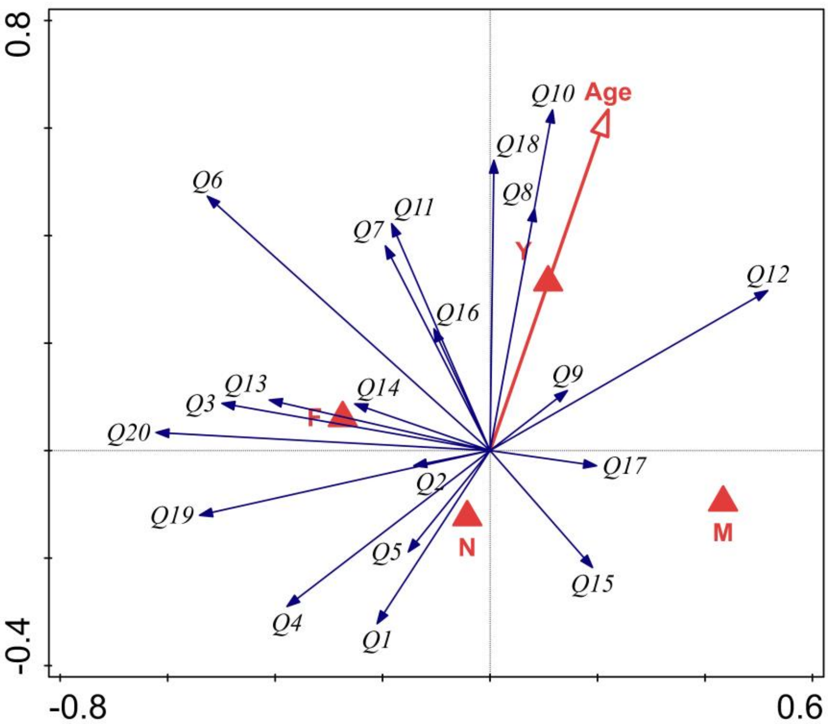


Fig. 2 The result of the RDA including all explanatory variables.

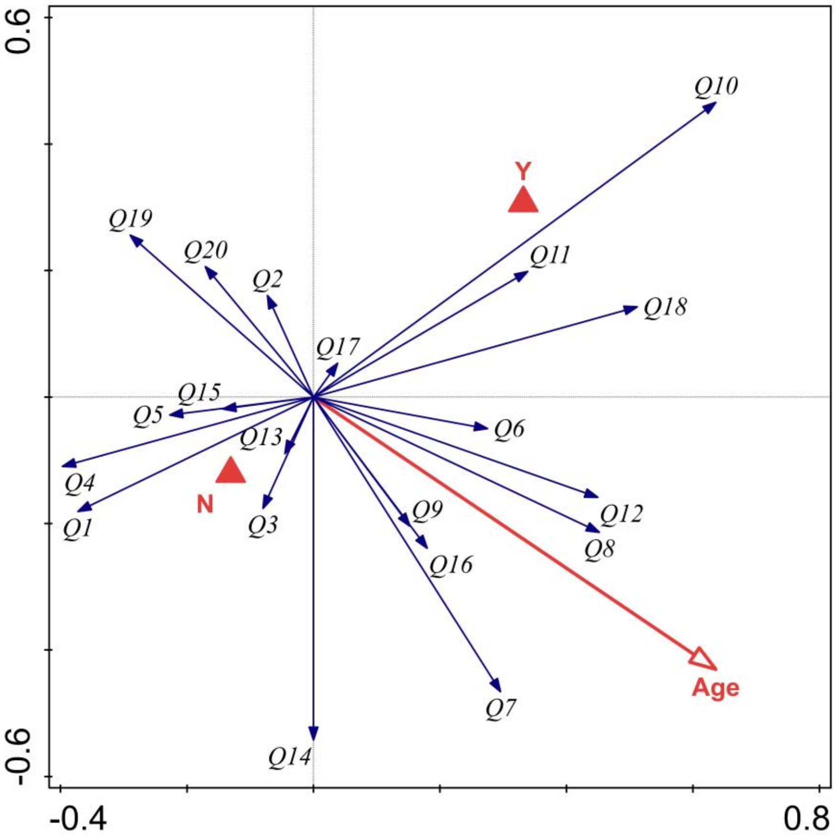


Fig. 3 The result of the RDA with selected explanatory variables.

Boards with photos

The generalized linear mixed models showed significant difference farmland category (Chi-square 8.91, p=0.003, Tab. 2) and interaction between type boards (with and without white stork) and farmland category (Chi-square = 27.07, p<0.001, Tab. 2) on farmland intensification index. The presence of the white stork on the board change the perception of habitat classification. The photos from intensive farmland with white stork on the boards had a lower farmland intensification index than photos without white stork on the boards (Fig. 4). The same results were found for photography including white stork and without (Chi-square = 40.24, p<0.001, Tab. 3, Fig. 5). The generalized linear mixed models showed significant differences between extensive farmland photographs and intensive farmland photographs on farmland intensification index (Tab. 4, Fig. 6). The intensive farmland photographs had a higher index level than extensive farmland photographs. The NMDS analyses showed significant differences between composition of photographs farmland intensification index between board with white stork and without white stork (F=19.07, p<0.001, Fig. 7).

Tab. 2 The result of the generalized linear mixed model with beta distribution.

Variables	Chi-square	df	p
Type of board	0.0003	1	0.986
Presence white stork	0.0007	1	0.979
Farmland type	8.91	1	0.003
Sex	0.0024	1	0.961
Age	0.0046	1	0.945
Type of board × Farmland type	27.07	1	<0.001

Tab. 3 The result of the generalized linear mixed model with beta distribution.

Variables	Chi-square	df	p
Type of photo	40.24	1	<0.001
Presence white stork	0.41	1	0.519
Sex	0.23	1	0.634
Age	0.11	1	0.743

Tab. 4 The result of the generalized linear mixed model with beta distribution.

Variables	Chi-square	df	p
Farmland type	33.93	1	<0.001
Presence white stork	0.0002	1	0.988
Sex	0.0015	1	0.969
Age	0.0006	1	0.980

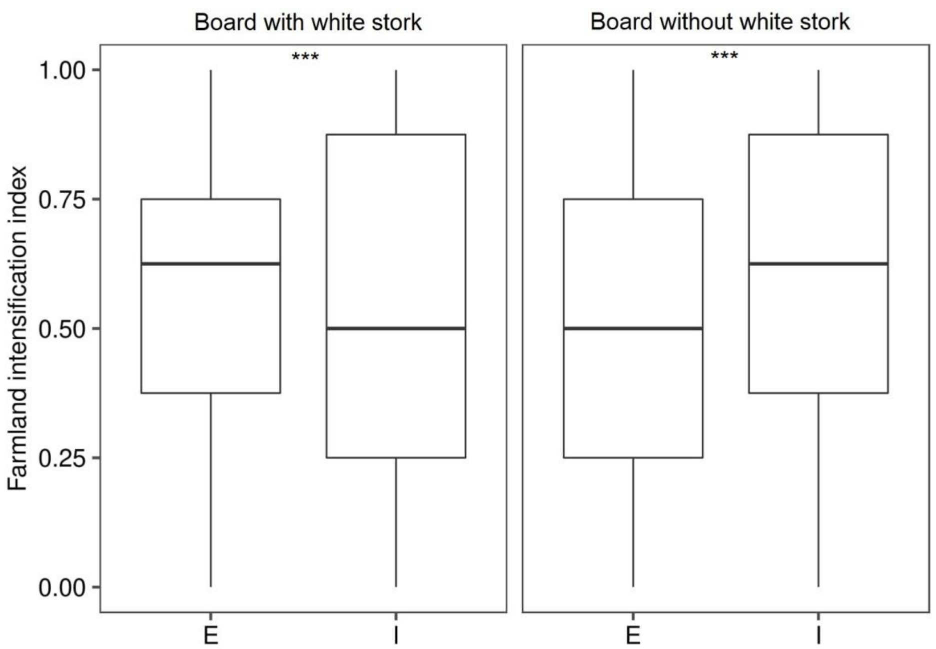


Fig. 4 The result of the interaction between farmland type (E=extensive, I=intensive) and board type (with and without white stork). Asterisks indicate significant differences (*** $p<0.001$).

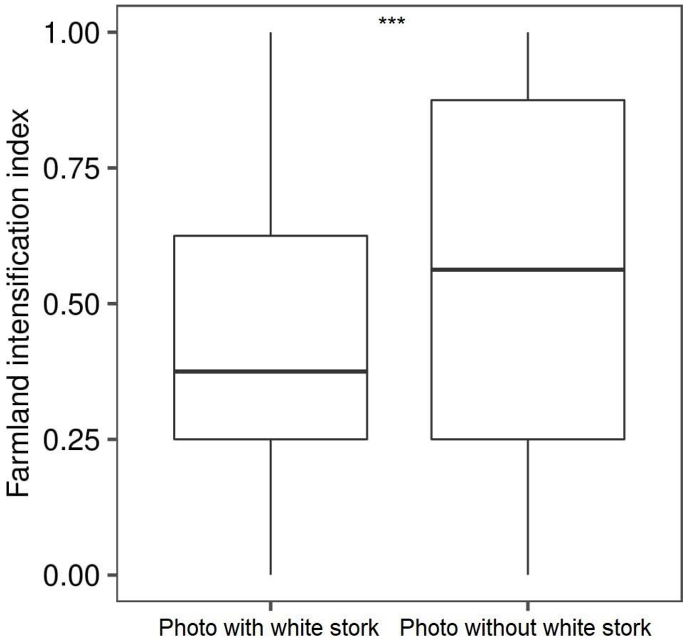


Fig. 5 The box plot showed difference between type of photos (with and without white stork) on farmland intensification index. Asterisks indicate significant differences (*** p<0.001).

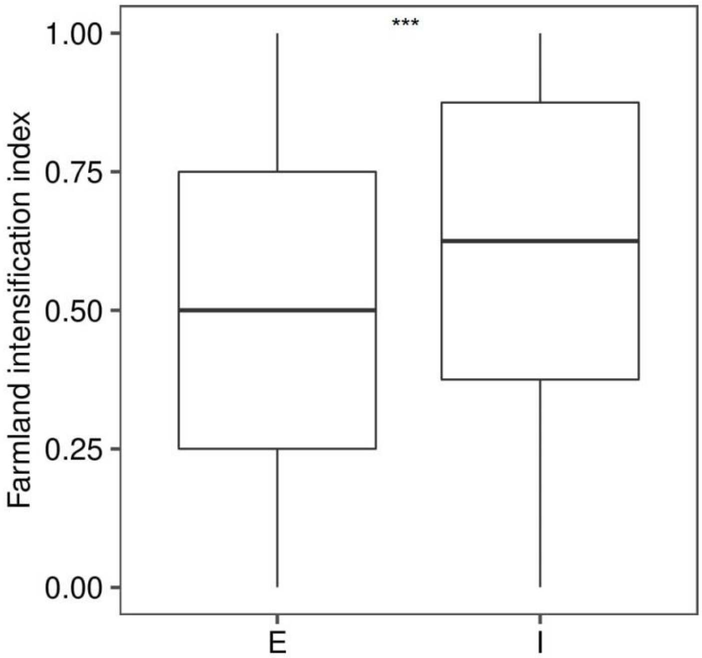


Fig. 6 The box plot showed difference between farmland type (E=extensive, I=intensive) on farmland intensification index. Asterisks indicate significant differences (*** p<0.001).

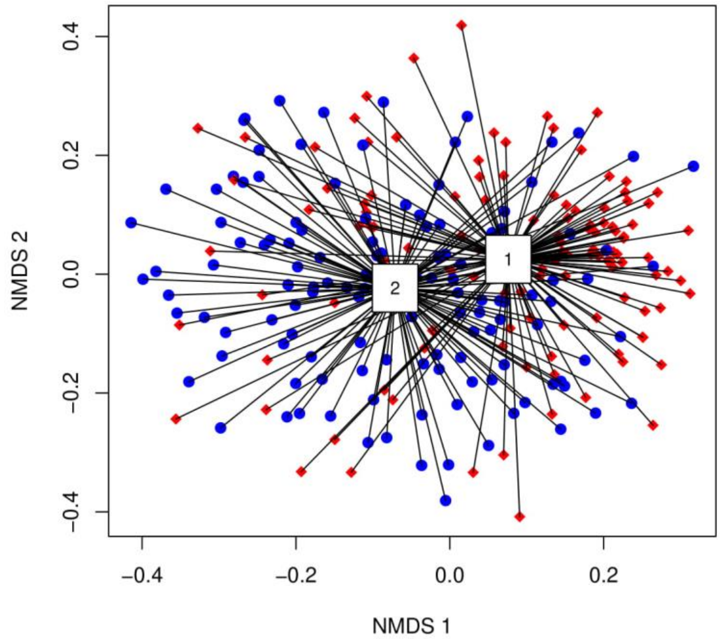


Fig. 7 Dissimilarities between photographs composition (with gradient on farmland intensification index) in board with white stork (1) and without (2).

Conclusion

Research has shown a high public awareness of nature protection and conservation practices. However, survey results show significant differences between men and women. The results also showed that the presence of a white stork had a significant effect on the responses. In the case of landscape assessment, people attributed high values of farmland landscape intensity for photos taken in an intense agricultural landscape. This result indicates that the awareness of the society where activities aimed at species and habitat protection are carried out is high. However, the presence of a white stork in the pictures changed the assessment of the assigned categories of landscape. Pictures taken in the intense landscape in which the white stork was inserted received a low landscape intensity indicator compared to pictures without the white stork.

CHAPTER 3
ANTI–SERVICES

A serious problem resulting from the size of the stork nest and its reuse in subsequent breeding seasons is its mass. The weight of nests resulting from accumulated nesting material can contribute to hazardous situations, often resulting in high losses. A good practice that is used in this species is to reduce the nest by mechanically breaking down the nest material from time to time. However, the procedure for releasing the nest material or removing the entire nest is done by the eye method when significant overload caused by the nest is visible. The development of a method that allows you to easily assess the weight of the nest would be a helpful tool in protecting nature and maintaining adequate security.

Materials and Methods

For 117 randomly selected typical nests of white storks, standard measurements of nest height and diameter were carried out. Then, the mass of each random nest was measured.

Statistical analysis

The generalized linear models with the Gaussian distribution were performed. The models included following explanatory variables: nest height, nest diameter and compaction nest index. The quadratic term of nest height and nest diameter were included. The employed the information-theoretic approach (Burnham and Anderson, 2002) were performed to identify the most parsimonious models explaining variation in all dependent variables. Based on the full model, in each analysis was constructed a set of candidate models that included different combinations of the predictors. For model selection, the Akaike Information Criterion, adjusted for small sample sizes (AICc) was used. The best model from 334 models with the lowest AICc and high R^2 was choose to estimate the nest mass based on the three variables. The predicted-observed visualization were performed to check the goodness of the chosen model.

Results

The nest height is characterized by high variability than nest diameter (Fig. 1). The mean value of the nest height was mean±SD 57.7±28.1, the coefficient of variation was 0.49 (Fig. 2). The mean value of the nest diameter was 141.2±24.2, the coefficient of variation was 0.17 (Fig. 3). The final equation for calculation of white stork nest mass have 91% of predictive effectiveness. The equation include 16 beta parameters (Tab. 2); D – nest diameter, H – nest height, ubicie - compaction nest index.

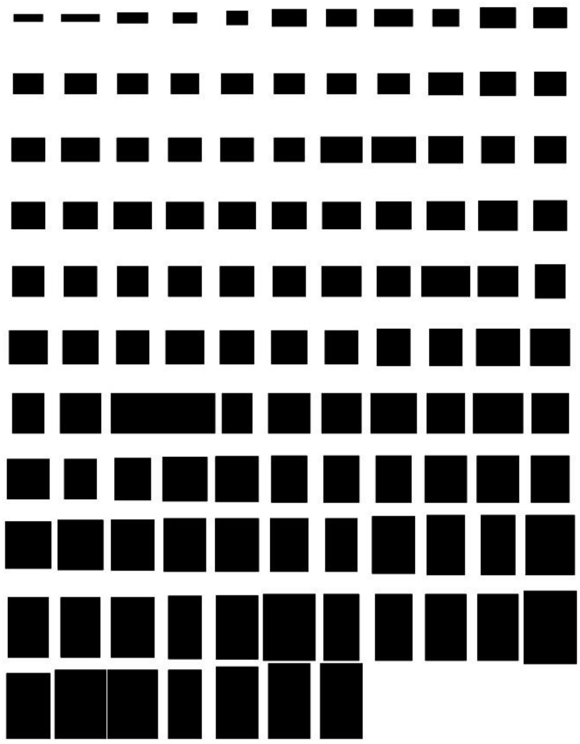


Fig. 1 The simple visualization of the white stork nest shape variation.

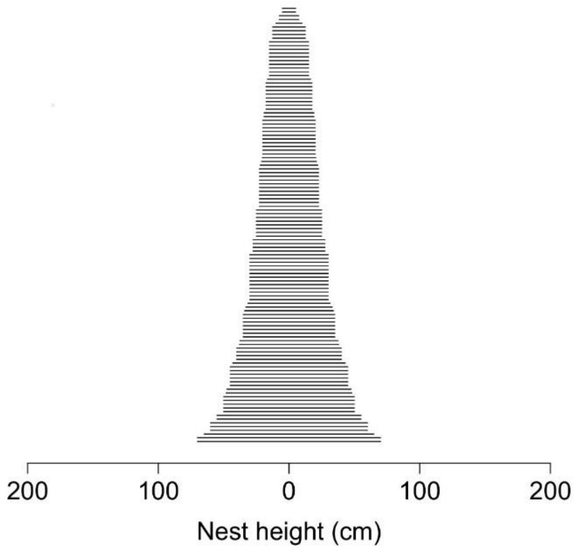


Fig. 2 The variation of the nest height (n=117).

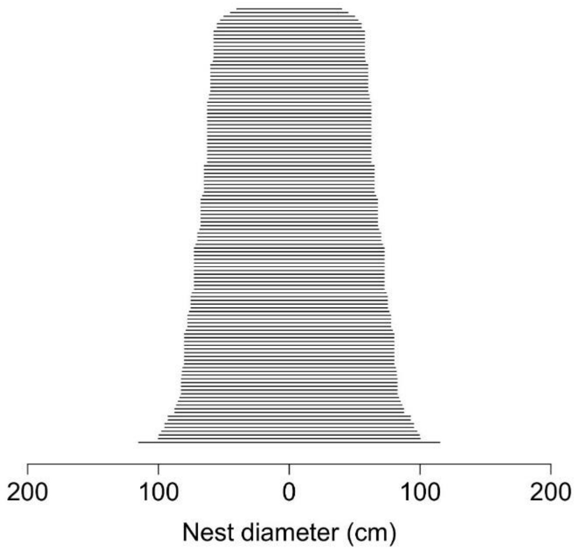


Fig. 3 The variation of the nest diameter (n=117).

Tab. 1 The fragment of the model selection procedure. Abbreviation: h – nest height, d – nest diameter, c – compaction nest index; R^2 – coefficient of determination, AIC - Akaike information criterion, CI 99% – confidence interval.

Model	R^2	AIC	Predictive effectiveness		
			CI 99%	**±100 kg**	**±50 kg**
~ h	0.68	1509.8	**29%**	**60%**	**30%**
~ d	0.51	1559.7	**27%**	**44%**	**25%**
~ h + d	0.77	1473.4	**34%**	**62%**	**39%**
~ h * d	0.79	1467.6	**42%**	**69%**	**39%**
~ h * d + d^2	0.82	1445.9	**39%**	**69%**	**37%**
~ h * d * d^2	0.83	1440.8	**47%**	**73%**	**44%**
(334 models)	…	…	…	…	…
~ h * d * h^2 * d^2 + c	**0.91**	**1386.5**	64%	86%	56%

Final model:

$$masa = \alpha + (\beta_1 \times D) + (\beta_2 \times H) + (\beta_3 \times D^2) + (\beta_4 \times H^2) + (\beta_5 \times ubicie) + (\beta_6 \times D \times H) + (\beta_7 \times D \times D^2) + (\beta_8 \times H \times D^2) + (\beta_9 \times D \times H^2) + (\beta_{10} \times H \times H^2) + (\beta_{11} \times D^2 \times H^2) + (\beta_{12} \times D \times D^2 \times H) + (\beta_{13} \times D \times H \times H^2) + (\beta_{14} \times D \times D^2 \times H^2) + (\beta_{15} \times H \times D^2 \times H^2) + (\beta_{16} \times D \times H \times D^2 \times H^2)$$

Tab. 2 The alpha and betas parameters values.

Parametr	Value
α	36758.327
β_1	-808.950
β_2	-2882.783
β_3	5.870

β_4	62.044
β_5	-0.995
β_6	62.203
β_7	-0.014
β_8	-0.442
β_9	-1.308
β_{10}	-0.397
β_{11}	0.009
β_{12}	0.001
β_{13}	0.008
β_{14}	-0.0000208
β_{15}	-0.0000558
β_{16}	0.000000125

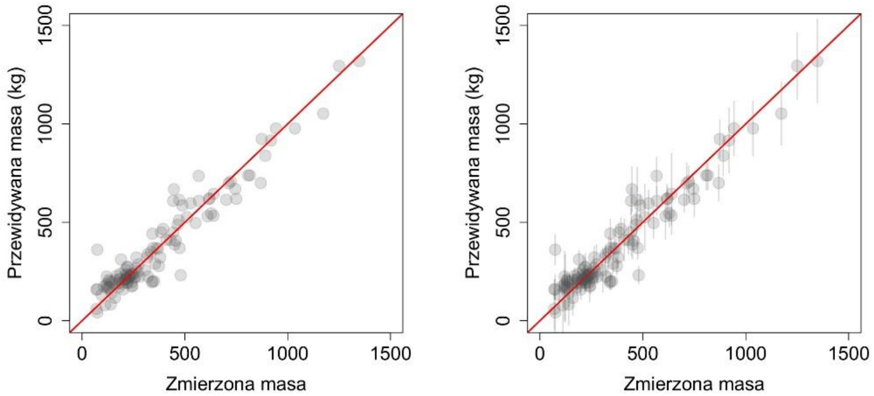


Fig. 4 The graphs present the predicted and observed nest stork mass based on the final model.

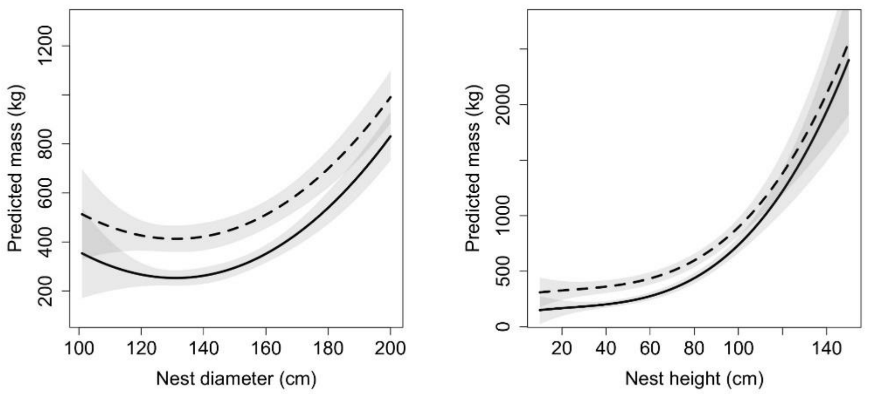


Fig. 5 The graphs present the relationship between (left) nest diameter and (right) nest height on predicted mass.

The R code for automatic calculation nest masses based on 117 random nests measurement (Appendix 4):

```
install.package(emmeans)
library(emmeans)
model=glm(m ~ d * h * d2 * h2 + c , data = data) # prepare model
parameter=list(d=__, h=__, d2=__, h2=__, c=__) #put following nest parameters
emmeans(m,~ d * h * h2 * d2 + c , at = parameter) # output the predictive nest mass
```

Conclusion

The resulting model will allow estimating the mass of the white stork's nest based on three measurements (height, width and compaction). Using the simple R code with our data, we can simple calculation of the nest masses based only on three measurements. The obtained model can be used by energy services to quickly estimate mass and potential danger resulting from its excessive weight and pressure on energy elements. Thanks to the quick tool to determine the weight of the socket, the costs associated with the potential damage to high voltage lines as well as other structures such as chimneys and roofs can be significantly reduced. In addition, due to the known mass, quick steps can be taken to remove some of the nesting material without exposing you to danger.

CHAPTER 4
REGULATION SERVICES

Based on standard population and productivity monitoring, the energy consumption of white stork pairs will be estimated in the area under study. The energy demand of a pair of storks producing 1-2 young is 1.141 kg per day, and steam producing 3-6 feeders - 1.317 kg per day. Assuming that the couple spends about 150 days on the breeding ground, the total biomass of food collected from the environment can be calculated. On the other hand, on average, 34.3 kg from hatching to the first outlet and about 5.5 kg of food are needed for one chick. On this basis, by multiplying by the number of chicks that have fallen out of the nest, the total mass of food consumed by a specific family can be calculated. Having information about the productivity of the entire studied population, we can calculate the biomass collected by storks in a given area.

However, each population has a slightly different diet composition due to local habitat conditions. Undigested food remains were collected for 30 randomly selected nests, which are deposited on and under the nests in the form of pellets. On their basis, the percentage composition of the diet was estimated, which will allow a more accurate estimation of the biomass of food intake. The rashes were collected for two periods (to capture the entire variety of diet): 1 - the period of small chicks May 15 - May 31, 2 - the period of medium chicks June 1 - June 15. Each collected pellet was placed in a paper envelope described with the following information: date of sample collection, nest ID (unique name or number), number of puffs from a given nest collected on a given day.

Statistical analysis

The simple Chi-square test was used to compare number of animal group in pellet between localization. The ANOVA was used to compare mean number of individuals of animals in pellet between localizations.

Results

In total the 7585 individuals from 130 animal groups was found in the white stork pellet (Tab 1). The most frequent animals were *Chorthippus* sp. (51.91%), *Metrioptera* sp. (11.05%) and *Phyllopertha horticula* (10.04%). Animals group found in pellets for each localization was include in Appendix X. The number of animal group in pellets were different between localization (Chi-square = 33.28, df = 16, p = 0.007, Tab.

2). The mean vale of individuals of each animal group in pellet were no significant different between localizations (F=0.91, p=0.564).

Tab. 1 The list of animal group found in the white stork pellets.

Animals group (include order, family, genus, species)	Amount	Percentage
Chorthippus sp.	3751	51.91
Metrioptera sp.	799	11.06
Phyllopertha horticula	726	10.05
Silpha sp.	319	4.41
Tettigonia sp.	175	2.42
Carabus cancellatus	117	1.62
Gryllotalpa gryllotalpa	116	1.61
Pterostichus sp.	112	1.55
Melolontha melolontha	66	0.91
Myrmica sp.	63	0.87
Amphimallon solsitialis	60	0.83
Poecilus sp.	55	0.76
Amara sp.	42	0.58
Lepidoptera larvae	41	0.57
Coleoptera inne	40	0.55
Ophonus sp.	38	0.53
Agriotes sp.	36	0.50
Coreus marginatus	36	0.50
Philonthus sp.	34	0.47
Lasius sp.	30	0.42
Dytiscidae larvae	22	0.30
Orthoptera inne	22	0.30
Hydrochara caraboides	21	0.29
Hydrochara caraboides larvae	21	0.29
Pentatomidae	20	0.28
Ichneumonidae	18	0.25
Forficula auricularia	17	0.24
Calathus sp.	16	0.22
Lasius niger	16	0.22
Forficula sp.	15	0.21
Anomala sp.	14	0.19
Corymbites tesselatus	14	0.19
Formicidae	14	0.19
Tettigonidae sp.	14	0.19
Staphylinus caesareus	13	0.18
Otiorrhynchus sp.	12	0.17
Thanatophilus sinuatus	12	0.17
Dytiscus marginatus	11	0.15
Carabus hortensis	10	0.14
Chrysomelidae	10	0.14
Selatosomus sp.	10	0.14

Acridiidae	9	0.12
Bembidion sp.	9	0.12
Dorcus parallelipipodus	9	0.12
Geotrupes sp.	9	0.12
Microtus sp	9	0.12
Ceutorrhynchus sp.	8	0.11
Dolycoris baccarum	8	0.11
Odonata	8	0.11
Rhantus sp.	8	0.11
Cetonia sp.	7	0.10
Dytiscus marginalis	6	0.08
Hydrobius fuscipes	6	0.08
Oulema melanopus	6	0.08
Colymbetes sp.	5	0.07
Curculionidae	5	0.07
Mollusca	5	0.07
Nicrophorus sp.	5	0.07
Selatosomus coeruleus	5	0.07
Carabidae inne	4	0.06
Colymbetes striatus	4	0.06
Gryllus camprestris	4	0.06
Hister sp.	4	0.06
Hydraticus sp.	4	0.06
Coleoptera larvae	3	0.04
Cryptophagidae	3	0.04
Curculionidae inne	3	0.04
Eurygaster maura	3	0.04
Metrioptera	3	0.04
Poecilus	3	0.04
Acilius sulcatus	2	0.03
Aelia acuminata	2	0.03
Agabus sp.	2	0.03
Aphodius sp.	2	0.03
Apodemus sp.	2	0.03
Araneae	2	0.03
Carabidae	2	0.03
Carabus clatratus	2	0.03
Cercyon sp.	2	0.03
Corymbites sp.	2	0.03
Dytiscus sp.	2	0.03
Dytiscus sp. larvae	2	0.03
Elateridae	2	0.03
Formica rufa	2	0.03
Formica sp.	2	0.03
Hydrophilus piceus	2	0.03
Micraspis sedecimpunctata	2	0.03
Nabis sp.	2	0.03
Orconectes limosus	2	0.03
Pentatoma sp.	2	0.03

Phyllobius sp.	2	0.03
Prionus coriarius	2	0.03
Staphylinidae	2	0.03
Acilius sp.	1	0.01
Amphibia	1	0.01
Apidae	1	0.01
Aromia moschata	1	0.01
Aves	1	0.01
Balaninus sp.	1	0.01
Carabus granulatus	1	0.01
Carabus sp.	1	0.01
Carabus violaceus	1	0.01
Cetonia aurata	1	0.01
Cicindella sp.	1	0.01
Coccinella sp.	1	0.01
Coelambus sp.	1	0.01
Coreus sp.	1	0.01
Corymbites coeruleus	1	0.01
Cryptocephalus sp.	1	0.01
Dolycoris sp.	1	0.01
Heteroptera	1	0.01
Histeridae	1	0.01
Hydaticus sp.	1	0.01
Hymenoptera	1	0.01
Lacerta sp.	1	0.01
Leptinotarsa decemlineata	1	0.01
Liparus sp.	1	0.01
Malachius sp.	1	0.01
Micraspis sp.	1	0.01
Noterus clavicornis	1	0.01
Notoxus sp.	1	0.01
Pentatomidae inne	1	0.01
Propylaea sp.	1	0.01
Scarabaeidae	1	0.01
Selatosomus aeneus	1	0.01
Spondylis buprestoides	1	0.01
Staphylinus sp.	1	0.01
Talpa europea	1	0.01
Tenthredinidae	1	0.01
Viviparus viviparus	1	0.01

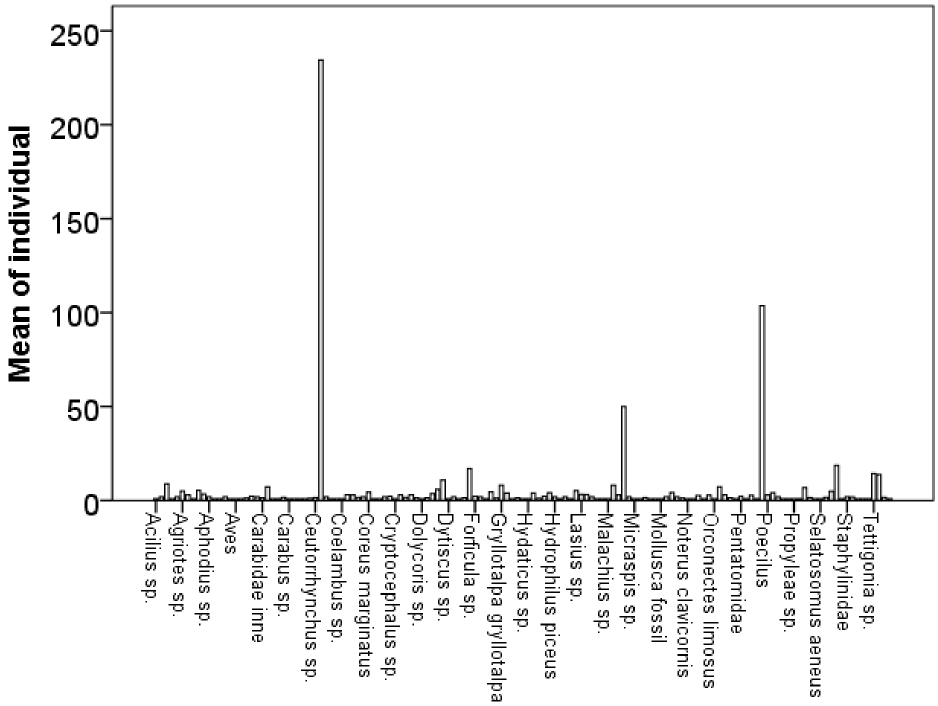


Fig. 1 The mean value for the most representative animal groups in pellet.

Tab. 2 The number of animal groups and individuals for each localization.

Localization	Groups	Individuals
Białogrądy	29	323
Brychy	22	65
Brzostowo 1	37	79
Brzostowo 2	20	344
Chyliny	27	79
Czachy	27	108
Góra Strękowa 1	42	563
Góra Strękowa 2	39	291
Izbiszcze	32	822
Izbiszcze Kolonia 1	46	393
Izbiszcze Kolonia 2	38	522
Kapice 1	35	414
Kapice 2	28	398
Kapice 3	25	594
Kapice Kolonia 1	38	631
Kapice Kolonia 2	23	199
Kapice Kolonia 3	18	524
Karpowicze	24	1236

Conclusion

Analysis of randomly selected pellets from 18 locations showed a high diversity of animal groups, mainly insects included in the diet of the white stork. The diversity of groups varied significantly between locations. There were no significant differences in the number of animal groups eaten between locations. The high frequency of two Orthoptera species and the *Phyllopertha horticula* beetle indicates the important role of the white stork in regulating these species in the environment. Research also indicates the important role of the stork in regulating crop pests and fruit trees and shrubs. The analysis of pellets showed a minor role in the regulation of rodents in the environment. The low number of rodents in the diet may be due to the age of the chicks. The hatching collection was made for small and medium chicks. Analysis of white stork pellets can be an important tool for determining the species diversity of animals in the environment.

Appendix 1 Questionnaire (in polish).

ANKIETA DOTYCZĄCA LOKALNEJ OCHRONY PRZYRODY

Proszę o wypełnienie poniższych pól

☐Mężczyzna

☐Kobieta

Wiek: ☐

Czy u Pana/Pani na posesji znajduje się gniazdo bociana białego ? ☐ TAK ☐ NIE

Jeśli nie, jaka jest odległość od Pana/Pani miejsca zamieszkania do najbliższego gniazda bociana białego ?

☐ poniżej 100 metrów ☐ 100 metrów ☐ 200 metrów ☐ 500 metrów ☐ powyżej 500 metrów

Proszę o zaznaczenie jednej odpowiedzi przy każdym pytaniu.

1. Czy ochrona przyrody (ochrona gatunków zwierząt i roślin/ochrona dzikich terenów/ochrona lasów, jezior, gór) jest dla Pani/Pana ważna?

☐ Zdecydowanie nie ☐ Nie ☐ Obojętnie ☐ Tak ☐ Zdecydowanie tak

2. Czy ochrona bociana białego jest konieczna?

☐ Zdecydowanie nie ☐ Nie ☐ Obojętnie ☐ Tak ☐ Zdecydowanie tak

3. Czy zgodził/ła by się Pan/Pani przeznaczyć środki finansowe na budowę gniazda bociana?

☐ Zdecydowanie nie ☐ Nie ☐ Obojętnie ☐ Tak ☐ Zdecydowanie tak

4. Czy zgodził/ła by się Pan/Pani przeznaczyć środki finansowe na ochronę lokalnej przyrody?

☐ Zdecydowanie nie ☐ Nie ☐ Obojętnie ☐ Tak ☐ Zdecydowanie tak

5. Czy warto chronić lokalną przyrodę?

☐ Zdecydowanie nie ☐ Nie ☐ Obojętnie ☐ Tak ☐ Zdecydowanie tak

6. Czy intensywne zabiegi agrotechniczne przyczyniają się do zanikania lokalnej przyrody?

☐ Zdecydowanie nie ☐ Nie ☐ Obojętnie ☐ Tak ☐ Zdecydowanie tak

7. Czy przeznaczył/ła by Pan/Pani kawałek swojego ogródka jako nieużytek?

☐ Zdecydowanie nie ☐ Nie ☐ Obojętnie ☐ Tak ☐ Zdecydowanie tak

8. Czy bocian biały jest szkodnikiem?

☐ Zdecydowanie nie ☐ Nie ☐ Obojętnie ☐ Tak ☐ Zdecydowanie tak

9. Czy wymagana jest regulacja/odstrzał bociana białego w Polsce?

☐ Zdecydowanie nie ☐ Nie ☐ Obojętnie ☐ Tak ☐ Zdecydowanie tak

10. Czy pozwolił/ła by Pan/Pani na założenie pierwszego/kolejnego gniazda bociana na swojej posesji?

☐ Zdecydowanie nie ☐ Nie ☐ Obojętnie ☐ Tak ☐ Zdecydowanie tak

11. Czy należałoby zwiększyć liczbę obszarów objętych prawną ochroną w Polsce?

☐ Zdecydowanie nie ☐ Nie ☐ Obojętnie ☐ Tak ☐ Zdecydowanie tak

12. Czy na terenie miasta/wsi ilość terenów zielonych (parki, kwietniki, zieleńce) jest wystarczająca?

☐ Zdecydowanie nie ☐ Nie ☐ Obojętnie ☐ Tak ☐ Zdecydowanie tak

13. Czy tworzenie obszarów Natura 2000 w Polsce jest wg Pana/Pani potrzebne?

☐ Zdecydowanie nie ☐ Nie ☐ Obojętnie ☐ Tak ☐ Zdecydowanie tak

14. Czy wg Pana/Pani nieużytkowane grunty zwiększają liczebność ptaków i owadów zapylających ?

☐ Zdecydowanie nie ☐ Nie ☐ Obojętnie ☐ Tak ☐ Zdecydowanie tak

15. Czy wprowadzanie obcych gatunków roślin i zwierząt wpływa negatywnie na lokalną przyrodę?

☐ Zdecydowanie nie ☐ Nie ☐ Obojętnie ☐ Tak ☐ Zdecydowanie tak

16. Czy wg Pani/Pana zmniejsza się liczba gatunków ptaków w krajobrazie rolniczym?

☐ Zdecydowanie nie ☐ Nie ☐ Obojętnie ☐ Tak ☐ Zdecydowanie tak

17. Czy lubi Pani/Pana spędzać wolny czas na łonie przyrody?

☐ Zdecydowanie nie ☐ Nie ☐ Obojętnie ☐ Tak ☐ Zdecydowanie tak

18. Czy okolica Pani/Pana wsi jest atrakcyjnym przyrodniczo miejscem?

☐ Zdecydowanie nie ☐ Nie ☐ Obojętnie ☐ Tak ☐ Zdecydowanie tak

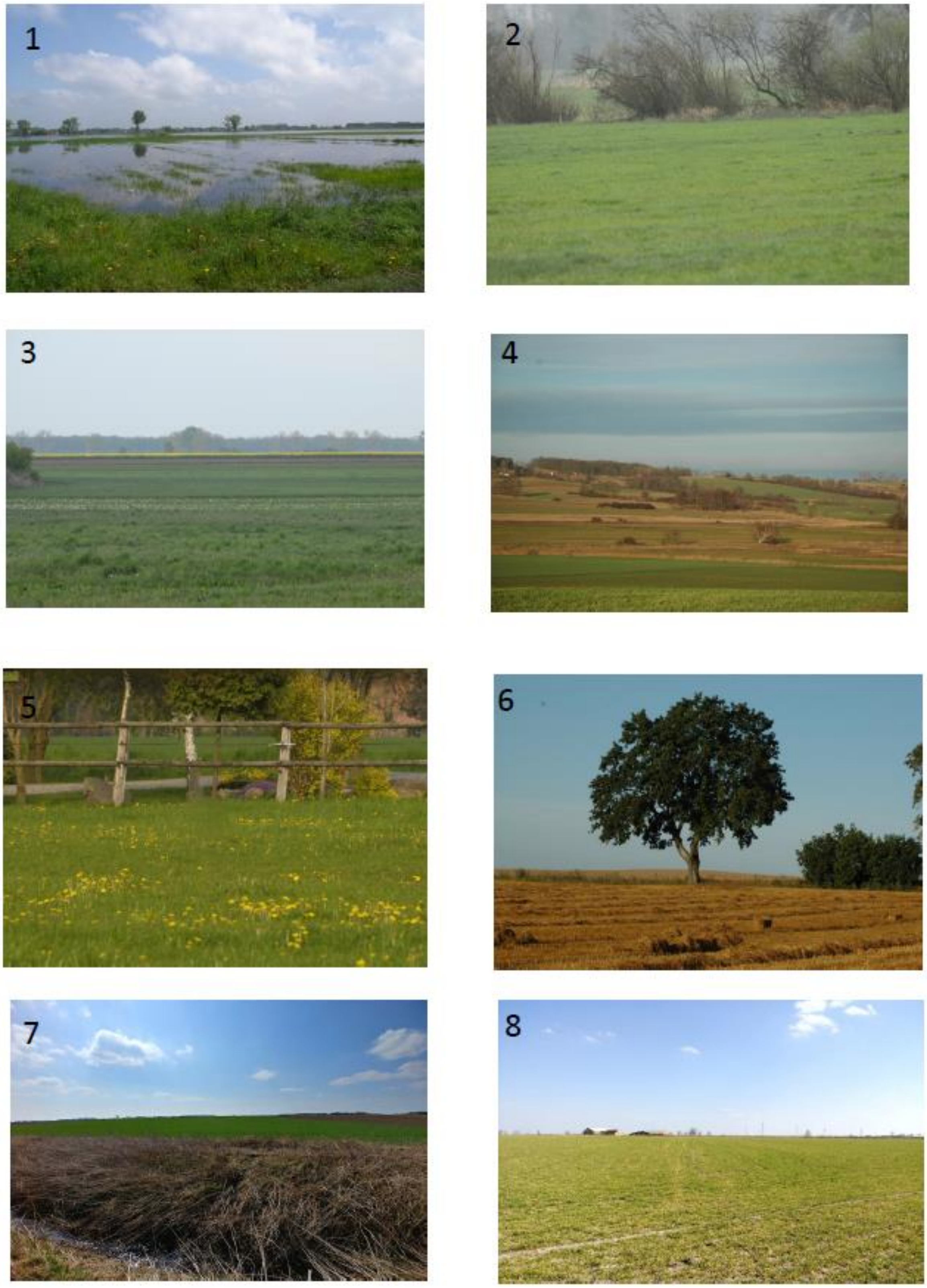
19. Czy wg Pani/Pana działalność człowieka ma negatywny wpływ na przyrodę?

☐ Zdecydowanie nie ☐ Nie ☐ Obojętnie ☐ Tak ☐ Zdecydowanie tak

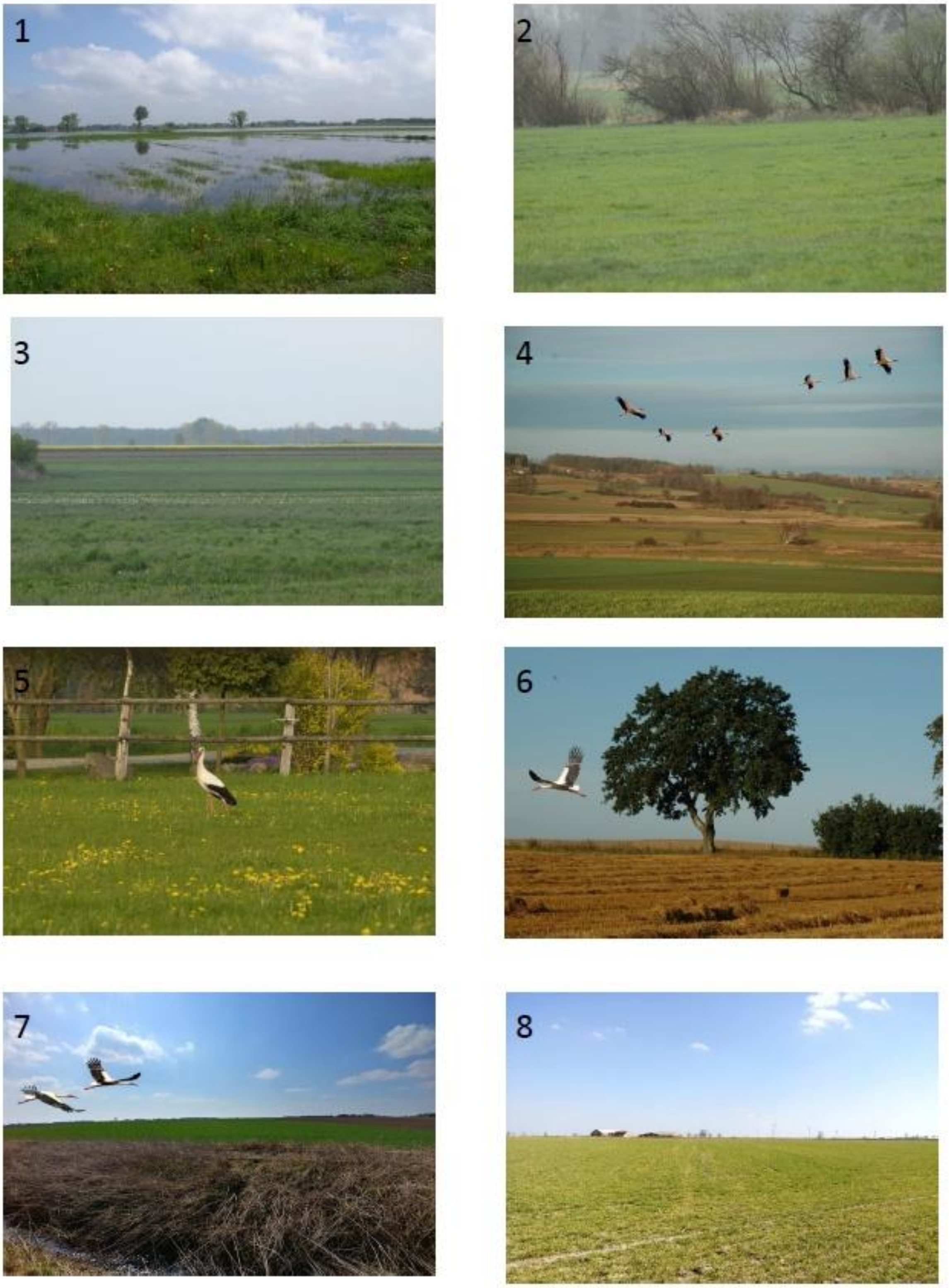
20. Czy wg Pani/Pana należy ograniczyć działalność ludzką na niektórych chronionych terenach?

☐ Zdecydowanie nie ☐ Nie ☐ Obojętnie ☐ Tak ☐ Zdecydowanie tak

Appendix 2 The board with photos arranged according to an farmland intensification gradient.



Appendix 3 The board with photos arranged according to an farmland intensification gradient including white storks.



Appendix 4 The measurements of the 117 random white stork nests use for the model estimation.

d	h	m	h2	d2	c
145	40	74	1600	21025	133,9881
140	40	134	1600	19600	114,986
150	60	190	3600	22500	112,2113
130	25	132	625	16900	99,51754
115	30	70	900	13225	99,1705
165	90	443	8100	27225	87,55838
115	30	74	900	13225	87,40236
135	70	264	4900	18225	80,01744
145	35	195	1225	21025	72,98511
140	100	567	10000	19600	72,76093
160	96	745	9216	25600	72,36
120	60	220	3600	14400	72,25781
115	50	210	2500	13225	70,80569
160	70	384	4900	25600	69,39688
145	90	528	8100	21025	68,27404
125	45	120	2025	15625	66,52065
115	60	275	3600	13225	64,11647
135	50	169	2500	18225	63,4846
163,5	86	488	7396	26732,25	62,78016
190	60	447	3600	36100	61,52844
140	60	221	3600	19600	56,97509
145	50	214	2500	21025	48,5805
115	35	120	1225	13225	48,25882
115	25	95	625	13225	47,89035
125	120	640	14400	15625	47,86345
130	50	230	2500	16900	42,48068
185	90	610	8100	34225	40,5252
150	45	232	2025	22500	39,84096
130	40	130	1600	16900	39,72175
135	70	317	4900	18225	39,68346
125	50	240	2500	15625	38,95149
145	25	242	625	21025	38,26286
125	50	186	2500	15625	38,00604
135	30	162	900	18225	34,46742
165	110	713	12100	27225	34,24672
185	45	510	2025	34225	33,18721
125	55	270	3025	15625	31,67428
162,5	76	471	5776	26406,25	29,77541
120	35	180	1225	14400	28,04268
165	60	456	3600	27225	26,26668
125	40	210	1600	15625	24,5463

125	95	410	9025	15625	23,52707
135	35	220	1225	18225	23,48058
135	70	380	4900	18225	20,90238
120	30	131	900	14400	20,87972
160	130	874	16900	25600	20,50374
120	40	185	1600	14400	19,65313
145	80	394	6400	21025	19,38926
120	30	180	900	14400	17,56923
160	140	943	19600	25600	14,01703
125	40	215	1600	15625	13,4507
115	15	140	225	13225	13,43216
130	40	225	1600	16900	12,39042
130	45	215	2025	16900	11,19443
80	20	74	400	6400	10,9226
190	120	919	14400	36100	10,72912
110	10	112	100	12100	10,24211
199	100	473	10000	39601	9,850646
155	90	620	8100	24025	9,179375
145	42	179	1764	21025	9,139134
170	66	465	4356	28900	7,815061
145	70	370	4900	21025	7,242633
145	50	245	2500	21025	5,858914
132,5	41	159	1681	17556,25	5,377124
122,5	60	261	3600	15006,25	2,641874
130	40	208	1600	16900	0,215939
122	30	107	900	14884	0,124192
195	120	1250	14400	38025	-2,18395
90	15	120	225	8100	-6,79075
116,5	45	250	2025	13572,25	-8,12468
160	140	1035	19600	25600	-8,94226
125	35	144	1225	15625	-9,55664
230	60	1348	3600	52900	-9,88547
125	45	230	2025	15625	-10,1005
160	60	362	3600	25600	-10,5077
100	25	70	625	10000	-11,1028
155	60	319	3600	24025	-12,3501
120	35	220	1225	14400	-12,588
167,5	38	306	1444	28056,25	-13,711
200	110	1173	12100	40000	-15,641
160	60	346	3600	25600	-18,694
125	35	240	1225	15625	-26,4933
145	10	123	100	21025	-26,4982
110	30	143	900	12100	-31,8051
157,5	38	217	1444	24806,25	-33,7523
155	100	808	10000	24025	-39,2875

155	100	816	10000	24025	-44,8577
145	60	355	3600	21025	-55,9302
172,5	75	628	5625	29756,25	-57,4841
125	45	280	2025	15625	-59,4805
125	45	260	2025	15625	-60,081
148,5	44	254	1936	22052,25	-61,5359
145	40	342	1600	21025	-64,0379
152,5	45	220	2025	23256,25	-64,1001
165	55	475	3025	27225	-65,1908
125	45	320	2025	15625	-73,7752
105	30	160	900	11025	-75,1306
125	30	245	900	15625	-75,2574
175	60	552	3600	30625	-80,9178
150	90	701	8100	22500	-85,0382
136,5	63	342	3969	18632,25	-86,1957
150	55	374	3025	22500	-87,3596
142,5	40	350	1600	20306,25	-99,7477
160	80	639	6400	25600	-106,384
115	30	199	900	13225	-111,965
125	35	340	1225	15625	-121,377
120	80	444	6400	14400	-158,184
135	50	450	2500	18225	-160,118
165	80	723	6400	27225	-174,043
125	55	430	3025	15625	-174,462
164	68	617	4624	26896	-178,066
130	90	750	8100	16900	-186,947
130	33	335	1089	16900	-187,589
135	100	891	10000	18225	-204,386
120	45	480	2025	14400	-223,94
175	70	869	4900	30625	-293,723

Appendix 5 The list of animal groups from 18 localizations.

Group of animal	Pellet 1	Pellet 2	Sum
Brychy			
Aelia acuminata		1	1
Amara sp.	1		1
Amphimallon solsitialis	2	8	10
Carabus cancellatus	1	1	2
Carabus clatratus		1	1
Carabus hortensis	1		1
Cetonia sp.		1	1
Coleoptera inne	1		1
Dorcus parallelipipodus		2	2
Elateridae		1	1
Forficula sp.	1		1
Gryllotalpa gryllotalpa	1		1
Lasius sp.	1		1
Lepidoptera larvaea	1	1	2
Melolontha melolontha		1	1
Metrioptera sp.	4	5	9
Myrmica sp.	1	2	3
Philonthus sp.	1		1
Poecilus sp.		2	2
Pterostichus sp.	2	1	3
Silpha sp.	9	10	19
Thanatophilus sinuatus	1		1
Brzostowo 1			
Acilius sp.	1		1
Amara sp.		1	1
Amphimallon solsitialis	1		1
Carabidae inne		1	1
Carabus cancellatus	1	1	2
Cetonia sp.	1		1
Chorthippus sp.	5	4	9
Chrysomelidae		2	2
Coelambus sp.		1	1
Colymbetes striatus		1	1
Corymbites sp.	2		2
Dorcus parallelipipodus		1	1
Dytiscidae larvae		1	1
Dytiscus sp.		1	1
Elateridae		1	1
Hydraticus sp.		4	4
Hydrobius fuscipes		1	1
Hydrochara caraboides	2	1	3
Hydrochara caraboides larvae	1		1
Hydrophilus piceus	1	1	2

Lepidoptera larvae	1		1
Melolontha melolontha		1	1
Metrioptera	3		3
Microtus sp	1		1
Mollusca (fossil)	1		1
Myrmica sp	2		2
Noterus clavicornis		1	1
Ophonus sp.	4	2	6
Orconectes limosus	1		1
Pentatomidae	1	1	2
Poecilus sp.	2	1	3
Pterostichus sp.	4	1	5
Rhantus sp.		2	2
Silpha sp.	8	1	9
Staphylinus sp.		1	1
Tenthredinidae		1	1
Thanatophilus sinuatus	1	1	2
Białogrądy			
Agabus sp.	2		2
Amphimallon solsitialis	1	2	3
Anomala sp.	1		1
Aromia moschata		1	1
Carabus cancellatus	1	1	2
Carabus clatratus		1	1
Carabus violaceus	1		1
Chorthippus sp.	15	8	23
Colymbetes sp.	1	1	2
Curculionidae	1	1	2
Dytiscidae larvae		6	6
Dytiscus marginalis	6		6
Dytiscus marginatus		11	11
Geotrupes sp.		1	1
Gryllotalpa gryllotalpa	2	4	6
Hydrochara caraboides	1	4	5
Hydrochara caraboides larvae	2	6	8
Hymenoptera		1	1
Lasius sp.	1		1
Lepidoptera larvae	1	1	2
Metrioptera sp.	138	53	191
Microtus sp.	1	1	2
Myrmica sp.	1		1
Odonata	1		1
Ophonus sp.	4	1	5
Pentatomidae		1	1
Poecilus sp.	2		2
Silpha sp.	17	9	26
Tettigonia sp.	3	6	9

Chyliny			
Amara sp.		1	1
Carabidae	2		2
Carabus cancellatus	5	1	6
Carabus hortensis	1	1	2
Chorthippus sp.	11		11
Chrysomelidae	1		1
Coleoptera inne	3		3
Corymbites tesselatus		5	5
Hister sp.		1	1
Ichneumonidae	1	1	2
Melolontha melolontha	1	10	11
Metrioptera sp.	4	1	5
Microtus sp.		1	1
Mollusca		1	1
Nicrophorus sp.	1		1
Odonata		1	1
Ophonus sp.	3		3
Pentatomidae	2		2
Philonthus sp.	2		2
Poecilus sp.		1	1
Pterostichus sp.	1		1
Pterostichus sp.		3	3
Silpha sp.	3	2	5
Staphylinidae		2	2
Staphylinus caesareus	1		1
Tettigonia sp.	3		3
Thanatophilus sinuatus	1	1	2
Czachy			
Amara sp.	1		1
Anomala sp.	3		3
Calathus sp.		4	4
Carabus cancellatus	3	6	9
Carabus hortensis		3	3
Chorthippus sp.	1		1
Coelambus sp.	1		1
Coreus sp.	1		1
Dorcus parallelipipodus	1	1	2
Dytiscus sp. larvae		2	2
Gryllotalpa gryllotalpa	1		1
Heteroptera		1	1
Hydrobius fuscipes	1	1	2
Hydrochara caraboides	1		1
Lepidoptera larvae	2	2	4
Melolontha melolontha	21	17	38
Metrioptera sp.	1		1
Mollusca (fossil)	1		1

Ophonus sp.		1	1
Oulema melanopus		1	1
Philonthus sp.	1		1
Pterostichus sp,		1	1
Rhantus sp.		1	1
Selatosomus aeneus	1		1
Silpha sp.	6	16	22
Tettigonia sp.		1	1
Thanatophilus sinuatus	2	1	3
Góra Strękowa 1			
Agriotes sp.		1	1
Amara sp.	2		2
Amphibia		1	1
Bembidion sp.		1	1
Cercyon sp.		1	1
Cetonia aurata	1		1
Ceutorrhynchus sp.	1		1
Chorthippus sp.	276	8	284
Coleoptera inne	1		1
Coleoptera larvae		3	3
Colymbetes sp.	2		2
Coreus marginatus	2	1	3
Corymbites coeruleus		1	1
Corymbites tesselatus		1	1
Dolycoris baccarum		1	1
Dorcus parallelipipodus	1		1
Dytiscidae larvae		4	4
Forficula sp.	1	1	2
Gryllotalpa gryllotalpa		5	5
Hydrochara caraboides	2		2
Hydrochara caraboides larvae		1	1
Ichneumonidae	1		1
Lasius niger		13	13
Lasius sp.	1		1
Malachius sp.	1		1
Melolontha melolontha	1	5	6
Metrioptera sp.	39	2	41
Myrmica sp.		1	1
Nicrophorus sp.	2		2
Odonata	4	2	6
Ophonus sp.		1	1
Orthoptera inne	16	2	18
Otiorrhynchus sp.	6		6
Pentatoma sp.	1		1
Philonthus sp.	3		3
Phyllobius sp.		1	1
Phyllopertha horticula		67	67

Poecilus sp.	3	4	7
Pterostichus sp.	3		3
Scarabaeidae		1	1
Silpha sp.	8	7	15
Tettigonia sp.	47	2	49
Góra Strękowa 2			
Acilius sulcatus		2	2
Agriotes sp.	1		1
Amara sp.		1	1
Amphimallon solsitialis		1	1
Araneae		2	2
Bembidion sp.	1		1
Carabus cancellatus	1		1
Carabus hortensis	1		1
Ceutorrhynchus sp.		1	1
Chorthippus sp.	75	31	106
Cicindella sp.	1		1
Coleoptera inne	2	2	4
Colymbetes striatus	1	2	3
Coreus marginatus		1	1
Dytiscidae larvae	4		4
Gryllotalpa gryllotalpa	3	1	4
Hister sp.	1		1
Histeridae	1		1
Hydaticus sp.	1		1
Hydrobius fuscipes		1	1
Hydrochara caraboides	1	1	2
Hydrochara caraboides larvae	1	8	9
Lepidoptera larvae	2		2
Melolontha melolontha	1		1
Metrioptera sp.	62	32	94
Myrmica sp.	1	2	3
Ophonus sp.	4		4
Ophonus sp.		4	4
Orthoptera inne		2	2
Philonthus sp.	2	4	6
Phyllopertha horticula	5		5
Poecilus sp.	2		2
Pterostichus sp.	2		2
Rhantus sp.	2		2
Silpha sp.	4	4	8
Spondylis buprestoides		1	1
Staphylinus caesareus	3		3
Thanatophilus sinuatus	1	1	2
Viviparus viviparus		1	1
Izbiszcze			
Agriotes sp.		3	3

Amara sp.	1	1	2
Amphimallon solsitialis	28	3	31
Anomala sp.	6		6
Apodemus sp.		1	1
Bembidion sp.	1		1
Calathus sp.	4		4
Carabus cancellatus	1		1
Ceutorrhynchus sp.	1		1
Chorthippus sp.	102	134	236
Coleoptera inne		2	2
Coreus marginatus	6	19	25
Corymbites tesselatus	1	3	4
Cryptocephalus sp.		1	1
Curculionidae		2	2
Dolycoris baccarum	2		2
Geotrupes sp.		1	1
Gryllotalpa gryllotalpa	5	1	6
Ichneumonidae		1	1
Lasius sp.	4	2	6
Metrioptera sp.	31	89	120
Micraspis sp.		1	1
Myrmica sp.	2	1	3
Ophonus sp.		2	2
Pentatomidae	4	1	5
Phyllopertha horticula	288	18	306
Poecilus sp.	4	4	8
Pterostichus sp.	10	1	11
Selatosomus coeruleus	1	1	2
Silpha sp.	10	4	14
Tettigonia sp.	9	4	13
Thanatophilus sinuatus		1	1
Izbiszcze Kolonia 1			
Aelia acuminata	1		1
Agriotes sp.	7	9	16
Amara sp.	7	6	13
Amphimallon solsitialis		1	1
Anomala sp.	2	2	4
Aves	1		1
Calathus sp.	2		2
Carabus cancellatus	9	2	11
Cetonia sp.	1		1
Ceutorrhynchus sp.	3		3
Chorthippus sp.	41	9	50
Chrysomelidae	3	1	4
Coccinella sp.		1	1
Coleoptera inne	4	4	8
Coreus marginatus	1		1

Corymbites tesselatus	1	1	2
Cryptophagidae	3		3
Curculionidae		1	1
Dolycoris baccarum	2		2
Dorcus parallelipipodus	1	1	2
Dytiscidae larvae	1	1	2
Eurygaster maura	1	1	2
Geotrupes sp.	1	1	2
Gryllotalpa gryllotalpa	3	1	4
Gryllus camprestris	1	3	4
Hister sp.	2		2
Hydrochara caraboides		1	1
Hydrochara caraboides larvae	1	1	2
Ichneumonidae	4		4
Lasius niger	2		2
Lepidoptera larvae	4		4
Metrioptera sp.	81	48	129
Micraspis sedecimpunctata		2	2
Myrmica sp.	5	7	12
Nicrophorus sp.	1		1
Ophonus sp.	2	2	4
Otiorrhynchus sp.	1		1
Oulema melanopus	1		1
Philonthus sp.	4		4
Phyllopertha horticula	8		8
Poecilus sp.	5	4	9
Propylea sp.	1		1
Pterostichus sp.	6	15	21
Selatosomus coeruleus		1	1
Silpha sp.	8	4	12
Tettigonia sp.	22	9	31
Izbiszcze Kolonia 2			
Agriotes sp.	5	5	10
Amara sp.	6	3	9
Amphimallon solsitialis		2	2
Aphodius sp.	1	1	2
Carabus cancellatus	4	1	5
Chorthippus sp.		9	9
Coleoptera inne	3	6	9
Colymbetes sp.	1		1
Coreus marginatus	3		3
Dolycoris baccarum	1		1
Dytiscus sp.	1		1
Forficula sp.	1		1
Formica rufa	2		2
Geotrupes sp.		1	1
Gryllotalpa gryllotalpa		1	1

Hydrochara caraboides	1		1
Ichneumonidae	2	1	3
Lasius sp.	9		9
Lepidoptera larvae	1		1
Metrioptera sp.	6	27	33
Microtus sp.		2	2
Mollusca fossil		1	1
Myrmica sp.	10		10
Notoxus sp.		1	1
Orthoptera inne	2		2
Oulema melanopus	1	2	3
Pentatomidae		1	1
Pentatomidae inne	1		1
Philonthus sp.	9	2	11
Phyllopertha horticula	328	8	336
Poecilus sp.	5	5	10
Propyleae sp.		1	1
Pterostichus sp.	2	2	4
Selatosomus coeruleus	1	1	2
Selatosomus sp.	5		5
Silpha sp.	4	7	11
Staphylinus caesareus	1	2	3
Tettigonidae sp.		14	14
Kapice 1			
Agriotes sp.		2	2
Amara sp.		5	5
Amphimallon solsitialis	1	3	4
Carabidae inne	2		2
Carabus cancellatus	3	4	7
Cetonia sp.		1	1
Chorthippus sp.	159	123	282
Coleoptera inne	3		3
Curculionidae inne		3	3
Eurygaster maura	1		1
Formicidae		10	10
Geotrupes sp.	1		1
Gryllotalpa gryllotalpa	3	4	7
Hydrobius fuscipes		1	1
Ichneumonidae	1	1	2
Lacerta sp.		1	1
Lasius sp.	2		2
Lepidoptera larvae	3	2	5
Metrioptera sp.	9	9	18
Mollusca	1		1
Myrmica sp.	3	3	6
Odonata Zygoptera		1	1
Ophonus sp.		1	1

Otiorrhynchus sp.	3		3
Oulema melanopus		1	1
Pentatomidae	3	1	4
Philonthus sp.	2		2
Phyllopertha horticula	2	1	3
Poecilus		3	3
Propylaea sp.		1	1
Pterostichus sp.	3	1	4
Silpha sp.	7	3	10
Staphylinus caesareus	1	1	2
Talpa europea	1		1
Tettigonia sp.	3	11	14
Kapice 2			
Amara sp.	1		1
Amphimallon solsitialis		3	3
Bembidion sp.		1	1
Calathus sp.	1		1
Carabus cancellatus	1	4	5
Chorthippus sp.	150	154	304
Chrysomelidae	2		2
Coleoptera inne	2		2
Dolycoris baccarum	1		1
Forficula sp.	4	1	5
Formica sp.		1	1
Formicidae	3		3
Gryllotalpa gryllotalpa	2	1	3
Hydrobius fuscipes	1		1
Ichneumonidae	2		2
Lasius sp.		2	2
Lepidoptera larvae	1	3	4
Leptinotarsa decemlineata	1		1
Metrioptera sp.	1	12	13
Myrmica sp.	1		1
Ophonus sp.	1		1
Philonthus sp.	1		1
Poecilus sp.	3		3
Pterostichus sp.	5	2	7
Selatosomus sp.	3	2	5
Silpha sp.	5	11	16
Staphylinus caesareus		1	1
Tettigonia sp.	3	5	8
Kapice 3			
Amara sp.	1		1
Bembidion sp.		1	1
Calathus sp.		3	3
Carabus cancellatus	1	3	4
Ceutorrhynchus sp.		2	2

Chorthippus sp.	153	290	443
Coreus marginatus		1	1
Dolycoris baccarum	1		1
Forficula sp.		3	3
Formicidae		1	1
Gryllotalpa gryllotalpa	7	8	15
Ichneumonidae	1		1
Lasius sp.	3		3
Lepidoptera larvae		1	1
Metrioptera sp.	7	21	28
Myrmica sp.	1		1
Pentatoma sp.	1		1
Pentatomidae		1	1
Philonthus sp.		1	1
Poecilus sp.	1	2	3
Pterostichus sp.	3	7	10
Silpha sp.	13	46	59
Staphylinus caesareus	1	1	2
Kapice Kolonia 1			
Agriotes sp.	1	2	3
Amara sp.	1	2	3
Amphimallon solsitialis	1	2	3
Balaninus sp.		1	1
Bembidion sp.	2		2
Calathus sp.		1	1
Carabus cancellatus	18	24	42
Carabus hortensis		2	2
Cercyon sp.		1	1
Cetonia sp.	1		1
Chorthippus sp.	363	3	366
Coleoptera inne		1	1
Coreus marginatus		1	1
Corymbites tesselatus		1	1
Dytiscidae larvae		5	5
Formica sp.	1		1
Geotrupes sp.	1	1	2
Gryllotalpa gryllotalpa	14	19	33
Hydrochara caraboides		5	5
Ichneumonidae	1	1	2
Lasius niger		1	1
Lepidoptera larvae	4	1	5
Liparus sp.		1	1
Metrioptera sp.	44	3	47
Microtus sp.	1	1	2
Myrmica sp.	2	5	7
Nabis sp.		2	2
Otiorrhynchus sp.	2		2

Pentatomidae	2		2
Philonthus sp.		1	1
Phyllobius sp.		1	1
Poecilus sp.		2	2
Prionus coriarius		2	2
Pterostichus sp.	14	5	19
Rhantus sp.		2	2
Silpha sp.	15	28	43
Staphylinus caesareus	1		1
Tettigonia sp.	15		15
Kapice Kolonia 2			
Carabus cancellatus	1	1	2
Carabus hortensis		1	1
Chorthippus sp.	135	12	147
Coleoptera inne	2	1	3
Corymbites tesselatus		1	1
Dorcus parallelipipodus		1	1
Forficula sp.	1	1	2
Gryllotalpa gryllotalpa		1	1
Hydrochara caraboides		1	1
Lepidoptera larvae	1		1
Melolontha melolontha		6	6
Metrioptera sp.	2	2	4
Myrmica sp.		2	2
Ophonus sp.	2	1	3
Orconectes limosus		1	1
Pentatomidae	1	1	2
Phyllopertha horticula		1	1
Poecilus sp.	2	1	3
Pterostichus sp.	2	2	4
Rhantus sp.		1	1
Silpha sp.	3	2	5
Tettigonia sp.	5	1	6
Thanatophilus sinuatus		1	1
Kapice Kolonia 3			
Amara sp.	1		1
Amphimallon solsitialis	1		1
Apodemus sp.		1	1
Bembidion sp.	1	1	2
Calathus sp.	1		1
Carabus cancellatus	4	8	12
Carabus granulatus	1		1
Chorthippus sp.	172	175	347
Coleoptera inne	2		2
Gryllotalpa gryllotalpa	26	3	29
Lepidoptera larvae	5	2	7
Melolontha melolontha		2	2

Metrioptera sp.	22	34	56
Microtus sp.	1		1
Myrmica sp.	1		1
Pterostichus sp.	4	2	6
Silpha sp.	13	18	31
Tettigonia sp.	4	19	23
Karpowicze			
Acridiidae		9	9
Apidae	1		1
Carabidae inne	1		1
Carabus cancellatus	3	3	6
Carabus sp.		1	1
Cetonia sp.	1	1	2
Chorthippus sp.	867	266	1133
Chrysomelidae		1	1
Coleoptera inne	1		1
Coreus marginatus	1		1
Dolycoris sp.	1		1
Forficula auricularia	13	4	17
Forficula sp.	1		1
Geotrupes sp.	1		1
Lasius sp.	5		5
Lepidoptera larvae	4		4
Metrioptera sp.	7	3	10
Myrmica sp.	8	2	10
Nicrophorus sp.	1		1
Ophonus sp.		3	3
Philonthus sp.	1		1
Pterostichus sp.	3	6	9
Silpha sp.	7	7	14
Tettigonia sp.	2	1	3