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An assessment of the impact of environmental changes on two riverine bird species

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Abstract. River channels undergo dynamic and frequent changes of environments due to both natural flow regimes and anthropogenic transformations. Riverine habitats are major hotspots of biodiversity, especially in industrialized countries. Despite the protection of high nature value sites, rivers and riverine species are threatened. Therefore, quality of riverine habitats and biodiversity need to be monitored e.g. by use of selected umbrella species. Here, two bird species characteristic for river channels: Common Kingfisher and Common Sandpiper, were examined in respect to their utility as umbrella species for riverine habitats. Data were collected in 2007, 2011 and 2012 in submontane river channels of Western Carpathians (SE Poland). Both species found to be depended on high share of natural habitats in river channels (alluvia, scarps) and less on hydromorphology and anthropopressure. Presence of Kingfishers and Sandpipers was highly correlated with high diversity of riverine birds. Moreover, both birds increased in number after channel renaturalization by the severe flood and decreased after intensive hydrotechnical alterations. These results suggest that due to Kingfisher's and Sandpiper's relations with naturalness and biodiversity of river ecosystems and because of relatively easy detection and counting, these birds could be used as umbrella species for riverine habitats and assemblages. Monitoring of Kingfisher and Sandpiper populations may be a good tool for tracking changes in quickly and severely transformed river valleys.

Key words: *Alcedo atthis*, *Actitis hypoleucos*, Common Kingfisher, Common Sandpiper, indicators, umbrella species, nature conservation, rivers, Western Carpathians.

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I. INTRODUCTION

River channels are the most dynamic environments on the Earth due to natural flow regimes with frequent inundations and irregular floods (SPARKS 1995). These ecological corridors are also severely influenced by anthropogenic transformations like hydrotechnical alterations (channel regulation and damming), excavation of materials from the river bed

(e.g. gravel, sand, woody debris) and direct use of water (for transport, agriculture and industry, as drinking supplies) (e.g. NILSSON & DYNESIUS 1994; NILSSON & BERGGREN 2000; KORPAK 2007). Simultaneously, rivers are hot spots of biodiversity and major migration routes, especially important in industrialized areas like in Europe (TOMIAŁOJĆ & DYRCZ 1993; WARD et al. 1999). These man-made alterations cause e.g. habitat fragmentation and loss (SAUNDERS et al. 1991; HINSLEY et al. 2006). Despite this degradation, river valleys of high nature value are still present (ALLAN & FLECKER 1993), mainly due to spontaneous renaturalisation processes (REEVES et al. 1996). Some of them are conserved under various protection forms (BENNET 1994; JONGMAN 1995), including the European network of Natura 2000 and nature reserves. Monitoring of changes in river valleys environment quality is challenging due to the high complexity of habitats (riparian forests, marshes, oxbow lakes, river channels etc.) and the numerous species which live there, including rare and threatened taxa. This could be solved by monitoring selected species. The species should be relatively easy to find and count, should have specific habitat requirements and their occurrence should be correlated with general biodiversity and habitat quality (LAMBECK 1997; HILTY & MERENLENDER 2000). Such species are considered as good indicators of the environment quality or/and can serve as umbrella species for specific habitats and their characteristic faunal assemblages (CARO & O'DOHERTY 1999). Many bird species comply with these requirements and were used for monitoring and protection of specific habitats (ROBERGE & ANGELSTAM 2004), including rivers (VAUGHAN et al. 2007). In Central Europe the following bird species were evaluated as umbrella species for riparian forests: Middle-spotted Woodpecker *Dendrocopos medius*, White-backed Woodpecker *D. leucotos,* Collared Flycatcher *Ficedula albicollis*, Pied Flycatcher *F. parva*, Hazel Grouse *Bonasa bonasia* and Common Kingfisher *Alcedo atthis* (MACHAR 2008; KAJTOCH et al. 2015). On the other hand, similar studies for riverine habitats (within channels) are scarce, with the exception of study on Goosanders *Mergus merganser* (KAJTOCH et al. 2014), which utilize both riparian forests and river channels, and White-throated Dipper *Cinclus cinclus* and Grey Wagtail *Motacilla cinerea* (SORACE et al. 2002; DOBRZAŃSKA & STRUŻYŃSKI 2009), but these birds are associated only with mountainous waters. Moreover, several waterbird species, including Common Kingfisher, Common Sandpiper *Actitis hypoleucos*, White-throated Dipper and Grey Wagtail were evaluated as indicators of the direct water quality (MEADOWS 1972; VICKERY 1991).

The aim of the study is to fill the knowledge gap related to the selection of Common Kingfishers and Common Sandpipers as umbrella species in order to perform assessment of environment quality in river channels. First, basic habitat requirements of selected species were evaluated. Next, the responses of these birds on changes in the riverine environment caused by both natural flow regimes and anthropogenic alterations were examined.

II. MATERIALS AND METHODS

Study area and data collection

The study was performed in submontane river valleys localized in the Western Carpathians (south-eastern Poland, south to the city of Kraków, approx. center 49.899°E, 20.203°N, Fig. 1). Collection of data was performed in two steps. First, in 2007 year birds

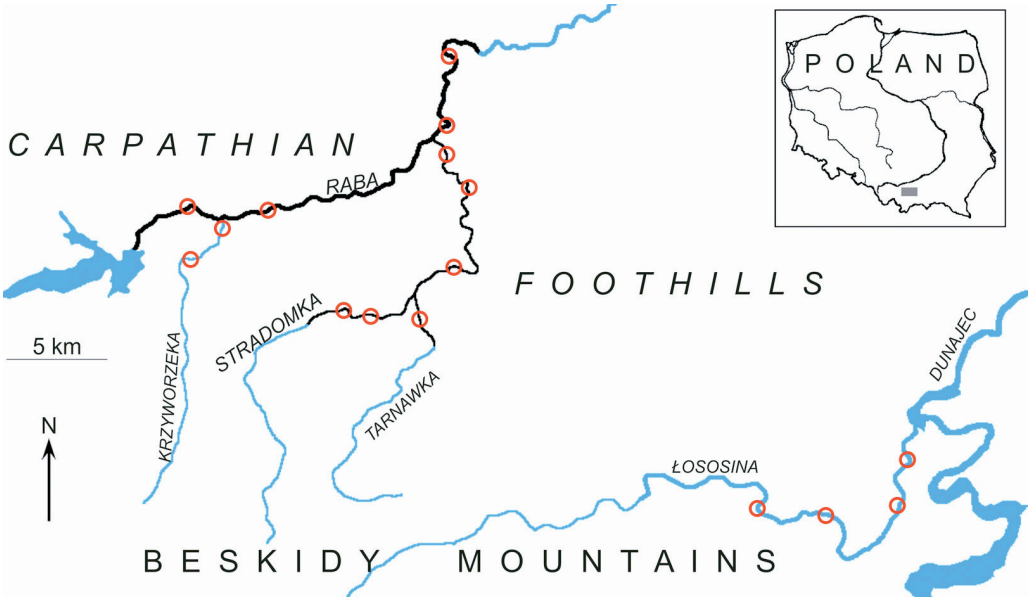


Fig. 1. Map of river systems with localization of sections along which bird inventory was executed: i) for first part of the research in 2007 year (in black) and ii) for second part of the research in 2007, 2011 and 2012 years (circles).

were counted along 52 sections, each of 1 km length, in river channels of middle part of the Raba tributary. Details about study area and bird census methods (according to BIBBY et al. 2000) are described in KAJTOCH et al. (2014). Second, in the years 2007, 2011 and 2012 birds were counted along 16 sections, each of 1 km length, in river channels of middle part of the Raba tributary and adjacent Łososina river valley. These sections were selected in relation to their status in 2007 (before flood) and covered in equal proportions natural and regulated river banks (KAJTOCH & FIGARSKI 2013). Counts in 2011 were done one year after the severe flood which happened in 2010, whereas counts in 2012 were executed just after intensive hydrotechnical works and removal of gravel and woody debris, which took place at the turn of 2011 and 2012. Details about localization of studied sections and bird inventory techniques are the same like in KAJTOCH & FIGARSKI (2013) and FIGARSKI & KAJTOCH (2015).

Target species

In the submontane river channels of the Western Carpathians 17 bird species were found to breed (KAJTOCH & PIESTRZYŃSKA-KAJTOCH 2008; KAJTOCH 2012; WILK & MAZGAJ 2016): Little Ringed Plover *Charadrius dubius*, Ringed Plover *Ch. hiaticula*, Northern Lapwing *Vanellus vanellus*, Common Sandpiper, Common Tern *Sterna hirundo*, Little Tern *Sternula albifrons*, Black-headed Gull *Chroicocephalus ridibundus*, Common

Gull *Larus canus*, Caspian Gull *L. cachinnans*, White Wagtail *Motacilla alba*, Yellow Wagtail *M. flava*, Grey Wagtail, White-throated Dipper, Goosander, Common Kingfisher, Sand Martin *Riparia riparia* and European Bee-eater *Merops apiaster*. Among them, Common Kingfisher (hereafter Kingfisher) and Common Sandpiper (hereafter Sandpiper) were selected due to: i) their known association with riverine habitats (most of other species breed also in replacement environments like gravel pits or ponds) – the first is breeding in river banks (scarps) and the second in gravel or stony alluvia, ii) relatively easy detection in the field, due to behavior – characteristic loud vocalization while disturbed e.g. by observers, iii) known substantial number of breeding pairs in examined river systems, iv) territoriality and solitary breeding.

Environmental and biodiversity data

The following data were taken into account (described in three groups): i) hydromorphological: river breadth (hereafter BREADTH [m]), river depth (DEPTH [m]), water fall (FALL [m/km]); a group of naturalness characteristics: share of alluvia (ALLUVIA [% of riverbank length]) and scarps (SCARPS [% length]) within channels, share of forests on river banks (FORESTS [% length]); and iii) anthropogenic factors: the level of regulation (REGULATION [% length]), the distance to the nearest roads (ROADS [m]) and the distance to the nearest buildings (BUILDINGS [m]). Environmental variables were either calculated in the field or measured using digital maps and GIS software (http://maps.geoportal.gov.pl). Moreover, in all river sections inventoried in 2007, presence-absence data on birds breeding along the channels (listed above) were investigated.

Statistics

Due to the small sample size and/or non-normal data distribution, nonparametric statistics were used. Sections with presence or absence of examined species (either Kingfisher or Sandpiper) were compared in respect to all environmental variables and biodiversity of riverine birds with use of Mann-Whithey U-test (MANN & WHITNEY 1947). Next, Spearman rank correlation (SPEARMAN 1904) was adopted to verify which of environmental variables could be correlated. Consequently, due to high correlations (Rho>0.7), three groups of environmental variables were assigned with use of Principal Component Analysis (according to KING & JACKSON 1999): HYDROMORPHOLOGY component (BREADTH + DEPTH + FALL [Principal Component 1; PC1=71.4%]); NATURALNESS component (ALLUVIA + SCARPS + FORESTS + REGULATION [PC1=82.2%]) and ANTHOPOPRESSURE component (ROADS + BUILDINGS [PC1=82.1%]) (Fig. 2). These three components were next used for building of set of Generalized Linear Models (GLM) (NELDER & WEDDERBURN 1972) and the performance of these models in explanation of selected birds presence was evaluated with use of Akaike Information Criterion (AIC) (AKAIKE 1974; BURNHAM & ANDERSON 2004). Moreover, relations of the Kingfisher to share of the scarps and Sandpipers to share of the alluvia were visualized with use of regression curves. Finally, numbers of breeding pairs of Kingfishers and Sandpipers in three periods: pre-flood, post-flood and post-alterations, were compared with use of Friedman repeated measures analysis of variance by ranks (FRIEDMAN 1937). A probability value of less than 0.05 was considered to be statistically significant. All statistical analyses were executed in Statistica 11 (STATSOFT, POLAND).

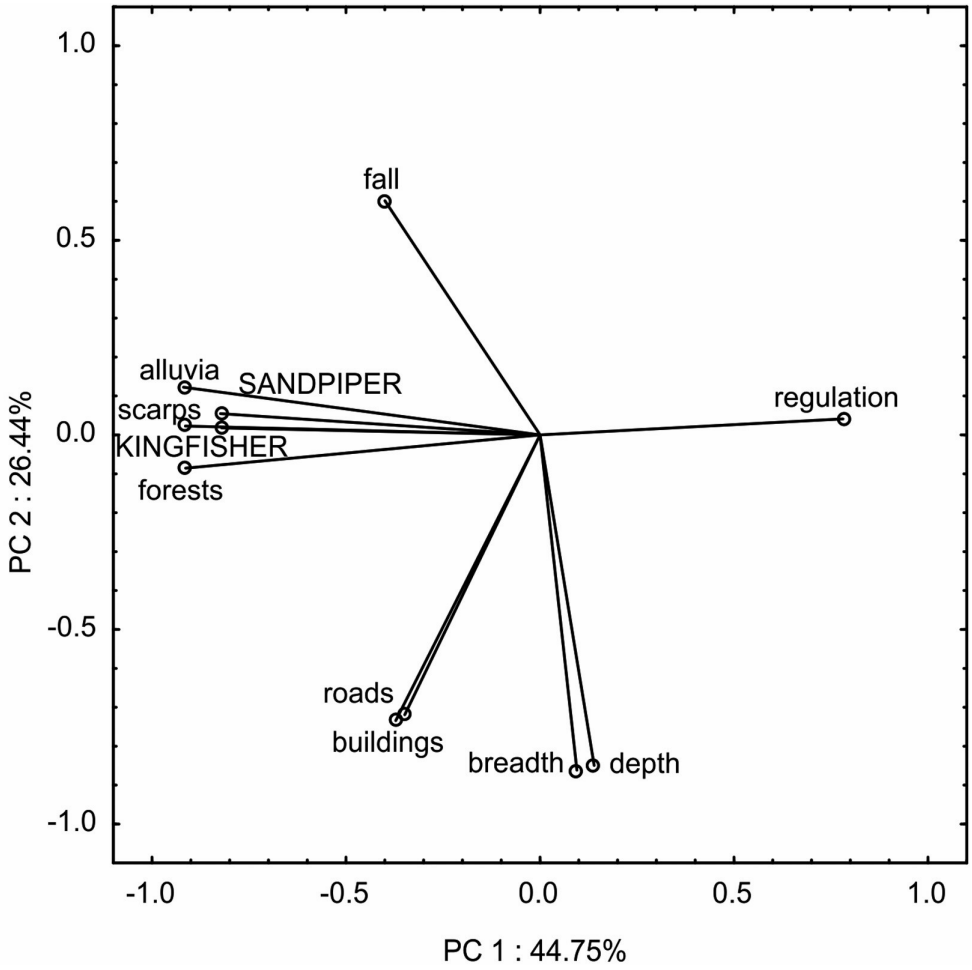


Fig. 2. Principal Component Analysis presenting relations among selected environmental variables and occurrence of examined bird species breeding in river channels.

III. RESULTS

During inventory in 2007, Kingfishers were found in 23 out of 52 1 km river sections, whereas Sandipers were present in 25 out of 52 sections, and both species co-occured in 20 sections.

Four estimated environmental variables (ALLUVIA, SCARPS, FORESTS, REGULATION) significantly differentiated in sections occupied and not occupied by both: Kingfishers and Sandpipers (highlighted in Table 1). These four variables (considered together as principal component NATURALNESS) explained the presence of bird species the best (alone this component had 51% AIC weight for Kingfisher and 41% AIC weight for Sandpiper, Table 2,

Table 1

Basic statistics showing differences in selected environmental variables in respect to presence or absence of Common Kingfishers and Common Sandpipers breeding in river channels. SD – standard deviation, Z – Mann-Whitney test statistics, p – probability value (differences statistically significant in bold)

Factor	Bird	Mean	Min	Max	SD	Z	p	Mean	Min	Max	SD	Z	p
		Kingfisher						Sandpiper					
BREADTH	present	23	10	35	8.2	0.62	0.537	23	10	35	8.0	0.74	0.458
	absent	21	10	35	9.1			21	10	35	9.2		
DEPTH	present	1	1	3	0.6	0.76	0.445	1	1	3	0.6	1.44	0.151
	absent	1	0	3	0.6			1	0	3	0.6		
FALL	present	2	1	3	0.8	-1.03	0.302	2	1	3	0.7	-1.52	0.128
	absent	2	1	5	1.3			2	1	5	1.3		
ALLUVIA	**present**	**10**	**0**	**20**	**6.8**	**-5.21**	**0.000**	**11**	**0**	**35**	**8.2**	**-4.81**	**0.000**
	absent	**29**	**10**	**50**	**11.3**			**27**	**10**	**50**	**11.6**		
SCARPS	**present**	**6**	**0**	**20**	**6.1**	**-5.04**	**0.000**	**6**	**0**	**20**	**6.1**	**-5.07**	**0.000**
	absent	**20**	**10**	**35**	**8.1**			**19**	**10**	**35**	**8.1**		
REGULATION	**present**	**52**	**0**	**100**	**34.8**	**3.82**	**0.000**	**53**	**0**	**100**	**34.8**	**3.86**	**0.000**
	absent	**14**	**0**	**70**	**17.8**			**15**	**0**	**70**	**19.2**		
FORESTS	**present**	**10**	**0**	**40**	**10.5**	**-5.09**	**0.000**	**9**	**0**	**35**	**9.4**	**-5.49**	**0.000**
	absent	**34**	**10**	**70**	**15.1**			**34**	**15**	**70**	**14.4**		
ROADS	present	241	50	660	175.6	-1.44	0.151	240	50	660	180.8	-1.47	0.143
	absent	337	50	1000	249.3			330	50	1000	240.9		
BUILDINGS	present	182	50	500	140.1	-1.69	0.092	175	50	500	130.5	-1.74	0.082
	absent	250	50	720	166.4			252	50	720	170.6		

Fig. 3). However, although other components found to be also important according to the GLM, Kingfishers were apparently more vulnerable to factors related with anthropopressure, whereas Sandpipers were more prone to hydromorphological factors (Table 2). Both species showed similar sudden increase of occurrence probability with increasing share of natural elements in river channels (Fig. 3) – probability of Kingfisher occurrence reached 50% when share of scarps was at least 15% and probability of Sandpiper occurrence reached 50% when share of alluvia was more than 20%.

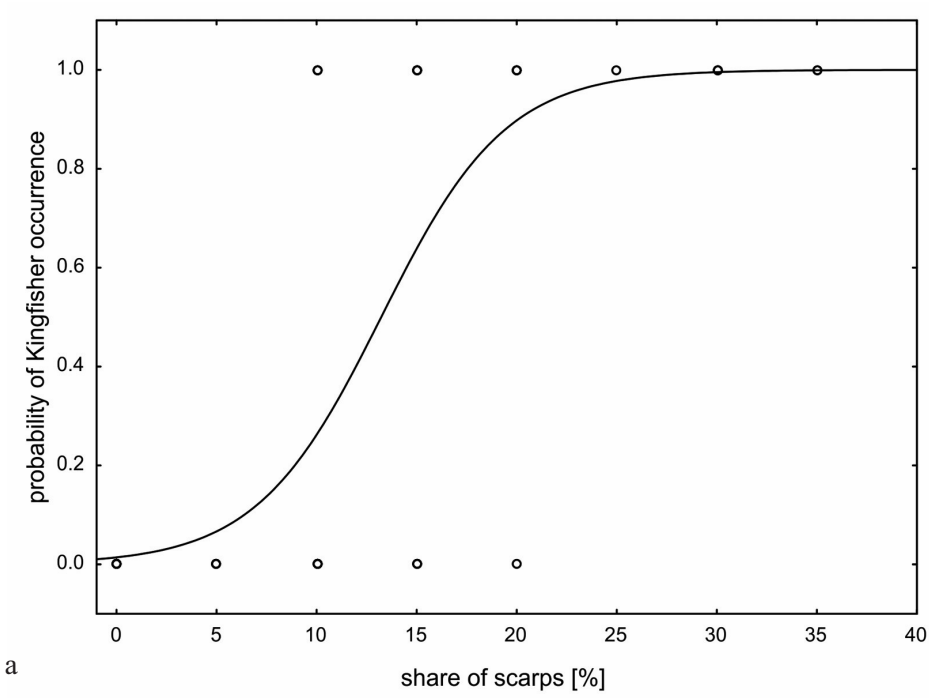
Table 2

Series of Generalized Linear Models showing evaluation of three components of environmental variables in respect to occurrence of examined bird species breeding in river channels. AIC – Akaike Information Criterion, Δ – delta, *w* – AIC weight

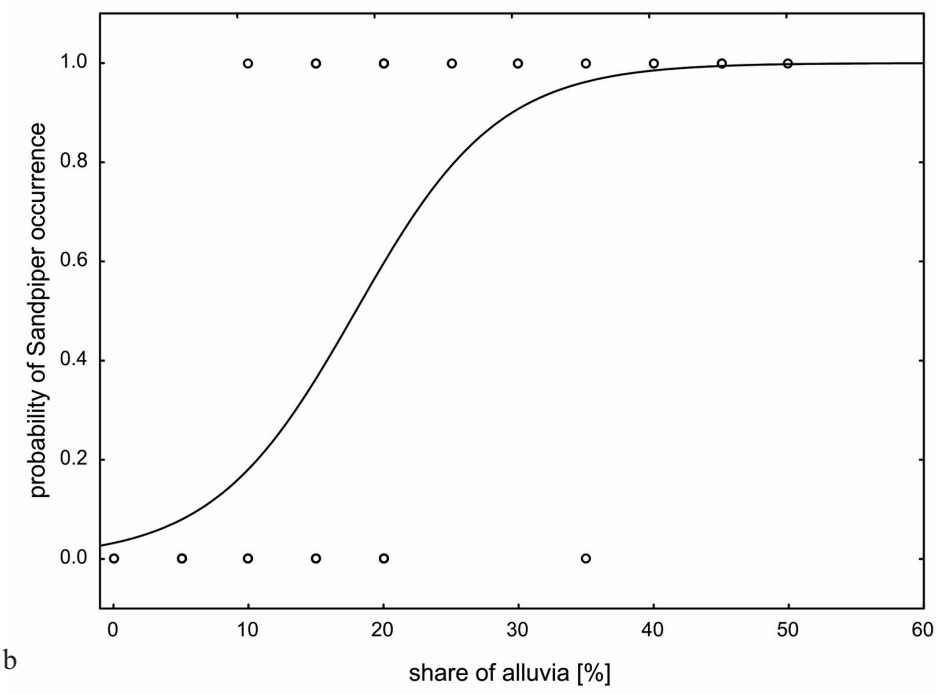
No.	Model	AIC	Δ	*w*
Kingfisher				
	intercept	73.4	37.8	0.00
1	NATURALNESS	35.6	0.0	0.51
2	NATURALNESS+ANTHROPOPRESSURE	37.3	1.7	0.22
3	HYDROMORPHOLOGY+NATURALNESS	37.6	2.0	0.19
4	HYDROMORPHOLOGY+NATURALNESS+ANTHROPOPRESSURE	39.3	3.7	0.08
5	HYDROMORPHOLOGY+ANTHROPOPRESSURE	67.9	32.3	0.00
6	ANTHROPOPRESSURE	72.2	36.6	0.00
7	HYDROMORPHOLOGY	74.0	38.4	0.00
				Σ=1.00
Sandpiper				
	intercept	74.0	0.0	36.1
1	NATURALNESS	37.9	0.0	0.41
2	HYDROMORPHOLOGY+NATURALNESS	38.5	0.5	0.31
3	NATURALNESS+ANTHROPOPRESSURE	39.9	2.0	0.15
4	HYDROMORPHOLOGY+NATURALNESS+ANTHROPOPRESSURE	40.4	2.5	0.12
5	HYDROMORPHOLOGY+ANTHROPOPRESSURE	64.6	26.7	0.00
6	ANTHROPOPRESSURE	72.5	34.6	0.00
7	HYDROMORPHOLOGY	73.4	35.5	0.00
				Σ=1.00

In sections where either Kingfishers or Sandpipers were present, the diversity of riverine birds was 3-4-fold higher than in sections without these species ($Z=-5.16$, $p<0.001$, $Z=-4.67$, $p<0.001$; respectively, Fig. 4).

Finally, comparison of Kingfishers and Sandpipers breeding pairs in three periods: pre-flood (2007), post-flood (2011) and post-alterations (2012), showed that both species react strongly to changes in the riverine environment ($N= 16$; $\chi^2(2) = 18.82$, $p<0.001$; $\chi^2(2) = 18.53$, $p<0.001$, respectively, Fig. 5).



a



b

Fig. 3. Logistic regression curves showing relationship between occurrence of (a) Kingfishers with share of scarps along river channels and (b) Sandpipers with share of alluvia along river channels.
Regression coefficient: y=exp(-4.24+(0.32)*x)/(1+exp(-4.24+(0.32)*x)) for Kingfishers
y=exp(-3.41+(0.19)*x)/(1+exp(-3.41+(0.19)*x)) for Sandpipers.

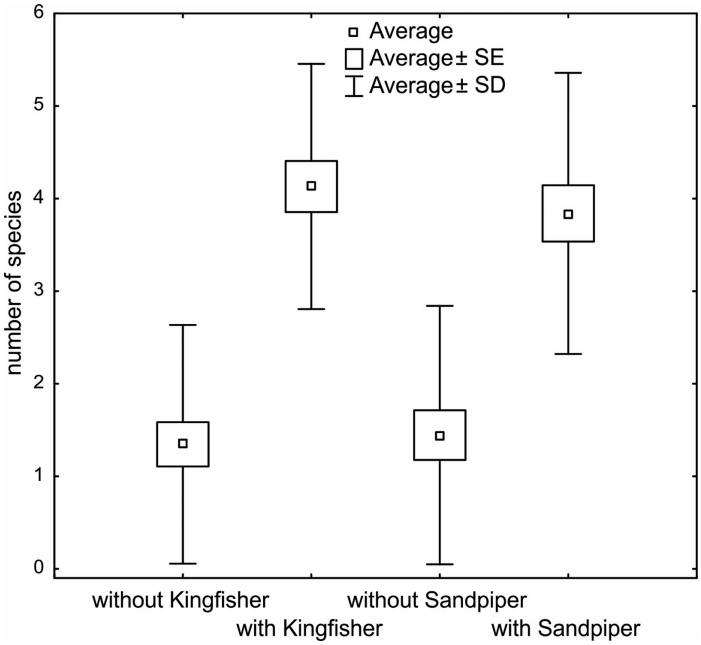


Fig. 4. Differences in number of birds breeding in river channels with and without Kingfishers and Sandpipers.

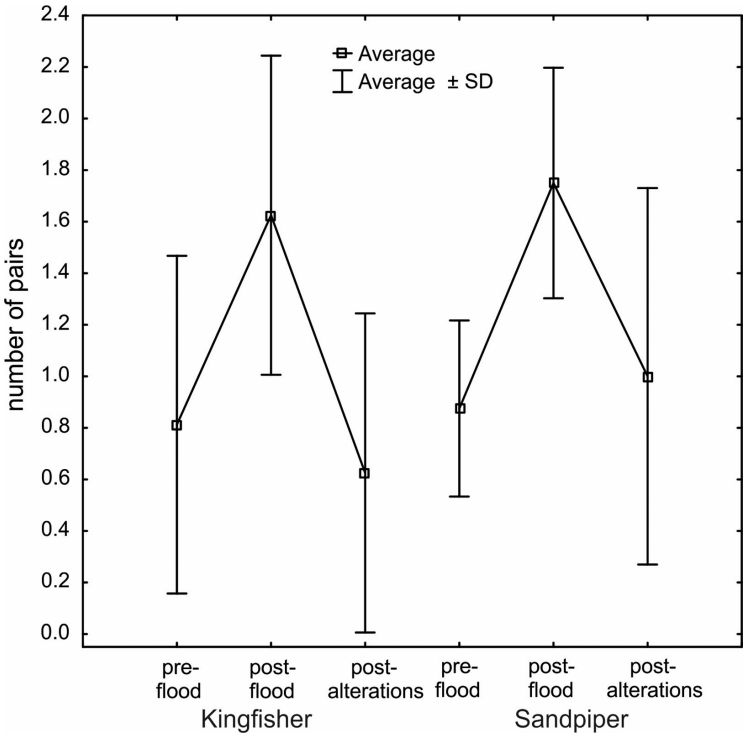


Fig. 5. Changes in number of breeding pairs of Kingfishers and Sandpipers in three periods of study differing by environmental factors: natural flood and man-made alterations of river channels.

IV. DISCUSSION

Kingfishers and Sandpipers are characteristic birds for river valleys across most of Europe (CRAMP 1985; HAGEMEIJER & BLAIR 1997). The knowledge about habitat requirements of both selected bird species is not equal and restricted only to some populations. There are several papers about habitat preferences of Kingfishers, but they are restricted to Iberia (PERIS & RODRIGUEZ 1996; 1997; CAMPOS et al. 2000; VILCHES et al. 2012), whereas almost all similar data for Sandpiper are from Britain (YALDEN 1986a,b; 1992; DOUGALL et al. 2010). In this respect, Kingfisher was examined in Central Europe, but in very narrow scale (KUCHARSKI 2001). The only study which verifies the utility of Kingfisher as umbrella species was executed in Czechia (MACHAR 2008; POPRACH & MACHAR 2015), but for riparian forests, not river channel habitats. Among species breeding on gravel or stony alluvia in Central Europe, only White-throated Dipper and Grey Wagtail were examined in respect to their umbrella role in nature conservation, and only the former species found to be appropriate for such purposes (SORACE et al. 2002; DOBRZAŃSKA & STRUŻYŃSKI 2009). Sandpiper, which often occupies similar habitats like abovementioned birds, was never examined in this respect.

This study clearly shows that both Kingfisher and Sandpiper are depended on similar environmental factors, among which most important are these related with river habitats quality. Kingfisher, due to its breeding in scarps on river banks and foraging in water on small fishes (PERIS & RODRIGUEZ 1996; CAMPOS et al. 2000; KUCHARSKI 2001; VILCHES et al. 2012), is highly vulnerable to alterations in river habitats, particularly to i) scarps leveling, usually during river channel regulation, ii) changes in fish composition and availability, which are prone to damming of river channels, and iii) deforestation, which often follows river channel alterations or preceded development of gravel or sandy pits. Similarly, Sandpipers, which breed and forage on gravel or stony alluvia along riverbanks or on islands (YALDEN 1986a,b; DOUGALL et al. 2010), are exposed to loss of natural habitats and decrease in the number of riverine invertebrates.

Interestingly, presence of both species, despite breeding and foraging in different ways and on different food, is found to be highly correlated with high diversity of birds breeding within river channels (terns, gulls, plovers, martins, wagtails, dippers and others). This association was already noticed in a previous study on Goosanders (KAJTOCH et al. 2014), which also found to be correlated with high number of species in river channels and floodplains.

An important finding of this study is that Kingfishers and Sandpipers quickly and intensively respond to the changes in the environment. The year after the severe flood both species increased approximately two-fold in number of breeding pairs. Obviously the flood, which happened in the middle of breeding period, must have caused loss of all their broods, with only some birds probably able to repeat their broods in replacement habitats like gravel pits (JANKOWIAK & ŁAWICKI 2014), but such habitats are often ecological traps due to continued gravel excavation (KAJTOCH 2007). Apparently both species are evolutionary and ecologically adapted to such disturbances and in following breeding period they increased in number. This was the most probably caused by inflow of birds from other areas, which seized the opportunity of unoccupied habitats and food availability in channels renaturalized by the flood (KAJTOCH & FIGARSKI 2013). Conversely, intensive

hydrotechnical works and removal of gravel and woody debris reversed the effect of the flood and reduced number of both species to the level lower than prior to the flood (FIGARSKI & KAJTOCH 2015).

V. CONCLUSIONS

Both examined species occupy different niches in river channels – Kingfishers breed in scarps on river banks overgrown by trees and forage on fish (PERIS & RODRIGUEZ 1996; CAMPOS et al. 2000; KUCHARSKI 2001; VILCHES et al. 2012), whereas Sandpipers breed in gravel or stony alluvia and forage on invertebrates (YALDEN 1986a,b; DOUGALL et al. 2010). Despite these differences, this study proves that both birds react in similar way to changes in riverine environment and that their occurrence substantially correlates with diversity of breeding birds in river channels. As both birds are still relatively abundant and easy to observe and count, this pair of species should be considered as valuable indicators of river channels naturalness and biodiversity. Recurrent counts of both these species could be effective tool in river ecosystems monitoring. Monitoring of either Kingfishers or Sandpipers should also be sufficient (e.g. the first on rivers with more lowland character and the latter on rivers in highlands and mountains). Current monitoring program of birds in Poland (http://monitoringptakow.gios.gov.pl/) includes e.g. marshland and marine waterbirds, but not riverine birds with exception of some gulls and terns monitored as flagship birds only in some sites. Consequently, this ecological group of birds is relatively poorly studied and monitored. On the other hand monitoring of riverine bird communities (the best jointly with riparian communities represented by candidate indicators like Goosanders and Middle-spotted Woodpeckers; MIKUSIŃSKI et al. 2001, KAJTOCH et al. 2014, 2015, STACHURA-SKIERCZYŃSKA & KOSIŃSKI 2016), could be excellent tool for tracking of changes in quickly and severely transformed river valleys.

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REFERENCES

AKAIKE H. 1974. A new look at the statistical model identification. *IEEE Transactions on Automatic Control*, **19**: 716-723.

ALLAN J.D., FLECKER A.S. 1993. Biodiversity conservation in running waters. *BioScience*, **43**: 32-43.

BENNET G. 1994. Conserving Europe's natural heritage. Towards to European Ecological Network. London, Dordrecht, Boston. 334 pp.

BIBBY C.J., BURGESS N.D., HILL D.A., MUSTOE S.H. 2000. Bird Census Techniques, 2nd ed. Academic Press, London. 302 pp.

BURNHAM K.P., ANDERSON D.R. 2004. Multimodel Inference. Understanding AIC and BIC in Model Selection. *Sociological Methods & Research,* **33**: 261-304.

CAMPOS F., FERNÁNDEZ A., GUTIÉRREZ-CORCHERO F., MARTIN-SANTOS F., SANTOS P. 2000. Diet of the Eurasian kingfisher (*Alcedo atthis*) in northern Spain. *Folia Zoologica*, **49**: 115-121

CARO T.M., O'DOHERTY G. 1999. On the use of surrogate species in conservation biology. *Conservation Biology*, **13**: 805-814.

CRAMP S. 1985. Handbook of the Birds of Europe, the Middle East and North Africa, Vol. 4, Oxford University Press, Oxford, UK. 960 pp.

DOBRZAŃSKA J., STRUŻYSKI W. 2009. Indirect species conservation on the example of the co-occurrence of Dipper (*Cinclus cinclus*), Brown Trout (*Salmo trutta* m. Fario), Noble Crayfish (*Astacus astacus*) and Caddies Flies (Trichoptera). *Teka Komisji Ochrony i Kształtowania Środowiska Przyrodniczego – OL PAN,* **6**: 58-63. (In Polish).

DOUGALL T.W., HOLLAND P.K., YALDEN D.W. 2010. The population biology of common sandpipers in Britain. *British Birds,* **103**: 100-114.

FIGARSKI T., KAJTOCH Ł. 2015. Alterations of riverine ecosystems adversely affect bird assemblages. *Hydrobiologia*, **744**: 287-296.

FRIEDMAN M. 1937. The use of ranks to avoid the assumption of normality implicit in the analysis of variance. *Journal of the American Statistical Association*, **32**: 675-701.

HAGEMEIJER W. J. M., BLAIR M. J. (eds.). 1997. The EBCC Atlas of European Breeding Birds. Their Distribution and Abundance. T & A.D. Poyser, London.

HILTY J., MERENLENDER A. 2000. Faunal indicator taxa selection for monitoring ecosystem health. *Biological Conservation,* **92**: 185-197.

HINSLEY S.A., DOHERTY P.F.Jr., BELLAMY P.E., GRUBB T.C. Jr. 2006. Consequences of habitat fragmentation on birds: comparison between Europe and North America. *Acta Zoologica Sinica*, **52**: 187-190.

JANKOWIAK Ł., ŁAWICKI Ł. 2014. Marginal habitats as important refugia for riparian birds during flood years. *Bird Study,* **61**: 125-129.

JONGMAN R.H.G. 1995. Nature conservation planning in Europe: developing ecological networks. *Landscape and Urban Planning*, **32**: 169-183.

KAJTOCH Ł. 2007. Wpływ przekształceń podgórskich dolin rzecznych na ptaki i ich ochronę. [The impact of submontane river channels regulation on birds and their protection] [In:] GRZEGORCZYK M. (ed.) Integralna Ochrona Przyrody. Instytut Ochrony Przyrody PAN. Kraków; 117-123. (In Polish).

KAJTOCH Ł. 2012. Znaczenie karpackich dolin rzecznych dla lęgowych ptaków: przykład dorzeczy Stradomki i Łososiny. [Importance of Carpathian river valleys for breeding birds: example of Stradomka and Łososina river's basins] *Chrońmy Przyrodę Ojczystą,* **68**: 3-12.

KAJTOCH Ł., FIGARSKI T. 2013. Short-term revival of riverine bird assemblages after severe flood. *Bird Study,* **60**: 327-334.

KAJTOCH Ł., PIESTRZYŃSKA-KAJTOCH A. 2008. Zmiany, zagrożenia i propozycje ochrony awifauny doliny środkowej Raby. [Changes, threats and proposition of protection of bird communities in the middle part of the Raba River valley (SE Poland)] *Chrońmy Przyrodę Ojczystą,* **64**: 28-45. (In Polish with English summary).

KAJTOCH Ł., WILK T., BOBREK R., MATYSEK M. 2015. The importance of forests along submontane stream valleys for bird conservation: The Carpathian example. *Bird Conservation International,* **26**: 350-365.

KAJTOCH Ł.. ŻMIHORSKI M., PIESTRZYŃSKA-KAJTOCH A. 2014. The Goosander as potential indicator of naturalness and biodiversity in submontane river valleys of northern Carpathians. *Ecological Indicators,* **45**: 83-92.

KING J.R., JACKSON D.A. 1999. Variable selection in large environmental data sets using principal components analysis. *Environmetrics*, **10**: 67-77.

KORPAK J. 2007. The influence of river training on mountain channel changes (Polish Carpathian Mountains). *Geomorphology,* **92**: 166-181.

KUCHARSKI R. 2001. Wybiórczość siedliskowa i ekologia rozrodu zimorodka *Alcedo atthis* w Borach Tucholskich w latach 1992-1998 [Habitat preferences and breeding ecology of Common Kingfisher *Alcedo atthis* in Bory Tucholskie Forest in 1992-1998 years]. *Notatki Ornitologiczne*, **42**: 1-14. (In Polish with English summary).

LAMBECK R.J. 1997. Focal species: a multi-species umbrella for nature conservation. *Conservation Biology*, **11**: 849-856.

MACHAR I. 2008. A proposed target state for a floodplain forest ecosystem within an ecological network, with reference to the ecological requirements of an umbrella bird species: the common kingfisher. *Journal of Landscape Ecology*, **2**: 80-98.

MANN H. B., WHITNEY D. R. 1947. On a test of whether one of two random variables is stochastically larger than the other. *Annals of Mathematical Statistics*, **18**: 50-60.

MEADOWS B.S. 1972. Kingfisher numbers and stream pollution. *Ibis,* **114**: 443-451.

MIKUSIŃSKI G., GROMADZKI M., CHYLARECKI P. 2001. Woodpeckers as indicators of forest bird diversity. *Conservation Biology*, **15**: 208-217.

NELDER J., WEDDERBURN R. 1972. Generalized Linear Models. *Journal of the Royal Statistical Society. Series A (General).* **135**: 370-384.

NILSSON C., BERGGREN K. 2000. Alterations of riparian ecosystems caused by river regulation. *BioScience,* **50**: 783-792.

NILSSON C., DYNESIUS M. 1994. Ecological effects of river regulation on mammals and birds: a review. *Regulated Rivers*, **9**: 45-53.

PERIS S.J., RODRÍGUEZ R. 1996. Some factors related to distribution by breeding Kingfisher (*Alcedo atthis* L.). *Ekologia Polska,* **44**: 31-38.

PERIS S.J., RODRIGUEZ R. 1997. A survey of the Eurasian kingfisher (*Alcedo atthis*) and its relationship with watercourses quality. *Folia Zoologica*, **46**: 33-42.

POPRACH K., MACHAR I. 2015. Distribution of the Common Kingfisher (*Alcedo atthis*) in the Ramena řeky Moravy National Nature Reserve (Czech Republic) in relation to the coppice-with-standards. *Acta Universitatis Agriculturae et Silviculturae Mendelianae Brunensis*, **63**: 447-455.

REEVES G.H., BENDA L.E., BURNETT K.M., BISSON P.A., SEDELL J.R. 1996. A disturbance-based ecosystem approach to maintaining and restoring freshwater habitats of evolutionarily significant units of anadromous salmonids in the Pacific Northwest. *American Fisheries Society Symposium,* **17**: 334-349.

ROBERGE J.M., ANGELSTAM P. 2004. Usefulness of the umbrella species concept as a conservation tool. *Conservation Biology*, **18**: 76-85.

SAUNDERS D.A., HOBBS R.J., MARGULES C.R. 1991. Biological consequences of ecosystem fragmentation: a review. *Conservation Biology*, **5**: 18-32.

SORACE A., FORMICHETTI P., BOANO A., ANDREANI P., GRAMEGNA C., MANCINI L. 2002. The presence of a river bird, the dipper, in relation to water quality and biotic indices in central Italy. *Environmental Pollution,* **118**: 89-96

SPARKS R.E. 1995. Need for ecosystem management of large rivers and floodplains. *BioScience*, **45**: 168-182.

SPEARMAN C. 1904. The proof and measurement of association between two things. *Americal Journal of Psychology*, **15**: 72-101.

STACHURA-SKIERCZYŃSKA K., KOSIŃSKI Z. 2016. Do factors describing forest naturalness predict the occurrence and abundance of middle spotted woodpecker in different forest landscapes? *Ecological Indicators*, **60**: 832-844.

TOMIAŁOJĆ L., DYRCZ A. 1993. Przyrodnicza wartość dużych rzek i ich dolin w Polsce w świetle badań ornitologicznych [Natural value of large rivers and their valleys in Poland in the light of ornithological studies]. In: TOMIAŁOJĆ L. (ed.). Ochrona przyrody i środowiska w dolinach nizinnych rzek Polski. IOP PAN, Kraków: 11-36. (In Polish).

VAUGHAN I.P., NOBLE D.G., ORMEROD S.J. 2007. Combining surveys of river habitats and river birds to appraise riverine hydromorphology. *Freshwater Biology*, **52**: 2270-2284.

VICKERY J. 1991. Breeding density of dippers *Cinclus cinclus*, Grey Wagtails *Motacilla cinerea* and Common Sandpipers *Actitis hypoleucos* in relation to the acidity of streams in south-west Scotland. *Ibis,* **133**: 178-185.

VILCHES A., MIRANDA R., ARIZAGA J., GALICIA D. 2012. Habitat selection by breeding Common Kingfishers (*Alcedo atthis* L.) in rivers from Northern Iberia. *Annales de Limnologie International Journal of Limnology*, **48**: 289-294.

WARD J.V., TOCKNER K., SCHIEMER F. 1999. Biodiversity of floodplain ecosystems: Ecotones and connectivity. *Regulated Rivers*, **15**: 125-139.

WILK T., MAZGAJ S. 2016. Gniazdowanie rybitwy białoczelnej *Sternula albifrons* w dolinie dolnego Dunajca [Breeding of Little Tern *Sternula albifrons* in Dunajec river valley]. *Ornis Polonica*, **57**: 71-76. (In Polish with English summary).

YALDEN D. W. 1986a. Diet, food availability and habitat selection of breeding Common Sandpipers, *Actitis hypoleucos*. *Ibis,* **128**: 23-36.

YALDEN D. W. 1986b. The habitat and activity of Common Sandpipers *Actitis hypoleucos* breeding by upland rivers. *Bird Study,* **33**: 214-222.

YALDEN D.W. 1992. The influence of recreational disturbance on common sandpipers *Actitis hypoleucos* breeding by an upland reservoir, in England. *Biological Conservation*, **61**: 41-49.