

THE IMPACT OF WATERMILLS ON CHANGES IN THE HYDROGRAPHIC NETWORK IN THE CARPATHIAN FOOTHILLS IN POLAND

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Abstract: The impact of watermills on transformations in the hydrographic network in the highlands has not yet been examined. However, these issues were discussed in depth in regard to lowland areas where milling constituted an important part of the economy. Our studies prove that it was watermills that significantly affected the transformation of the hydrographic network in the Carpathian Foothills. The aim of our studies was to determine the impact of the structure, functioning, and closing of watermills on the hydrographic network in Wadowice and the surrounding area (west Carpathian Foothills, Lesser Poland Province, Poland). The studies were conducted based on archived topographic maps and historical sources. The development of milling in Wadowice that started in the 15th century had led to the increased density and transformation of the river network due to about 6.8 kilometres of mill race. Despite nearly all the mill races being closed down in the 20th century, they left a lasting mark in the altered river network. At present, fragments of former man-made beds constitute part of a drainage network, whereas the course of two tributaries of the Skawa does not correspond to this day to the morphology of the bottom of the Skawa valley. Despite not having any significant role in the economy throughout history, water milling in the Carpathian Foothills has left a lasting mark in the river network.

Keywords: watermill, mill race, mill pond, hydrographic network, valley density, anthropopression

1. INTRODUCTION

Man affects water relations in various ways, e.g. by transforming a river network. Human activities should be carried out with respect for natural resources, diversity, and for future generations (Ianos et al., 2009). The scale of human impact on the environment depended on historical conditions. This is especially evident in post-socialist countries (Ianos et al., 2012). Natural resource management should be implemented with the involvement of all stakeholders while minimizing conflicts, (Hersperger et al., 2015; Hossu et al., 2018). The difference in perception of the environment by society and authority is visible in the extremely different understanding of flooding (Ceobanu & Grozavu, 2009). Nowadays, all investments affecting the natural environment are analysed in order to limit their negative impact. The negative impact of river regulation (Klimek, 1987)

and construction of water reservoirs is underlined (Brandt, 2000). In the past, until the second half of the twentieth century, when planning investment, the most important factor was the economic factor, as evidenced by waterways projects (Janac, 2012). One of the economic activities that has been using employing surface waters for centuries is milling (Jankowski, 1998; Podgórski, 2004a). As claimed by Podgórski (2004b), water milling is understood as an umbrella term comprising all manufacturing facilities powered by water, i.e. grain mills, sawmills, fulling mills, etc. The first constructors of watermills were ancient peoples of the Eastern Mediterranean, and, later Greek and Romans (Curwen, 1944). According to Moog (1994), water milling could have been known already in Ancient Egypt. The vertical waterwheel had not been widely used in Europe until the Middle Ages (Bloch, 1935). In the 12th century, there were about 20 thousand water facilities in France, while in the 15th century

the number rose to 70 thousand (Braudel, 1990). According to Kreiner (1996), the construction of mills in Western Europe peaked in the 13th century. By 1300, as many as 22 mills were erected within the Erft river basin (the Rhineland in Germany), covering an area of about 1800 square kilometres.

The first watermill in Poland was built in Zgorzelec in 1071 (Demińska & Wojtowska, 1973). The development in the area of milling in Poland progressed from west to east, as in other parts of Europe (Brykała & Podgórski, 2008). In the 13th century, there were about 500 watermills operating in Silesia, Greater Poland, Lesser Poland and Pomerania (Gładkowski, 2008). The great prime of water milling in Poland was in the 16th century (Kaniecki & Brychcy, 2010). In Poland, milling developed primarily in the northern and central parts of the country, in lowlands and lake districts. This was due to topography and dense river networks (Brykała & Podgórski, 2008; Kaniecki & Brychcy, 2010). Natural terrain was used, e.g. tunnel valleys, river terraces (Podgórski, 2009). Most mills were situated upon natural watercourses. Occasionally, short mill races and mill ponds were constructed (Podgórski, 2004b). The fundamental factor of mill construction was the demand for a raw material – the economic factor. Oftentimes, structures were built in unfavourable environmental conditions (Brykała, 2001). Watermills were an element of anthropogenic impact, alternating the flow and material transport (Florek et al., 2015; Rutkiewicz & Gawior, 2016).

Southern Poland, the Carpathians and the Carpathian Foothills offered less favourable conditions for the development of milling. The construction of facilities directly on mountain watercourses characterised by intense flow involved a risk of a mill being destroyed due to swelling (Jost, 1976). Hindered development of grain milling did not pose any problems, as local economy was based on potato production (Wyźga et al., 2013). Despite unfavourable environmental conditions, water milling continued to develop further. In the 1850s, as many as 1246 water devices were operating in the Polish Carpathians (Franczak et al., 2017). Both in the mountains and in the lowlands, the impact of mills on the hydrographic network is visible. The development of milling required adjusting the natural channels for production, including edge protection. The terrain conditions often required the construction of channel and mill ponds, which affected changes in water relations.

To date, water milling in highlands has been examined mainly by historians. The studies covered, among others, mills of the Cistercians or milling in Podhale (Baran, 2014; Jost, 1969, 1976). In the

literature, there are few instances of research on the impact of watermills on the natural environment in highlands, with the exception of studies on mill races and mill ponds in England (Downward & Skinner, 2005); rocky beds of watercourses in Scotland formerly employed for milling purposes (Bishop & Jansen, 2005; Bishop & Muñoz-Salinas, 2013), the ecology of unused mill ponds and mill races (Raeymaekers et al., 2009; Wood & Barker, 2000).

The primary aim of our studies was to determine the impact of the structure, functioning and closing of watermills on the hydrographic network in the Carpathian Foothills. We chose the surroundings of the town of Wadowice (Poland, Lesser Poland Province) as the research area.

1.1. Methods

The historical 18th-century river network of Wadowice was reconstructed based on an Austrian map of Josephinische Landesaufnahme (1763-1787) – First Military Survey. The following maps were analysed for the subsequent periods:

- Administrativ Karte von der Konigreichen Galizien und Lodomerien (1855) – Kammersberg Map (scale 1:115 000),
- Franziszeische Landesaufnahme (1806-1869 - on area of research 1861-1864) – Second Military Survey (scale 1:28 800),
- Franzisco-Josephinische Landesaufnahme (1869-1887 – Third Military Survey (scale 1:25 000),
- Spezialkarte der osterreichisch-ungarischen Monarchie (1909, scale 1:75 000),
- Tactical Map of Poland issued by the Polish Military Geographical Institute (1934, scale 1:100 000),
- Wadowice city map (1938, scale 1:5 000),
- A detailed map of Poland issued by Oberkommando des Heeres / Generalstab (1943, scale 1:25 000).
- A detailed map of Poland (1995, scale 1:10 000).

The above maps were analysed regarding the course of watercourses and locations of watermills. Counted water mills were marked on the map with the signature described in the legend. As a result, a map depicting changes in the river network and situation of milling areas from the 18th century to the 20th century was developed. In order to analyse the river network density geo-referenced maps for the years 1909, 1934 and 1943. Received residuals 9,6 m (1943), 14,4 (1934), 23,5 (1909). A relatively large residual is not a problem because information about the length of watercourses was obtained, not their exact location. The modern-day traces of

historical structures were verified using a digital elevation model, whereas spatial and temporal changes were verified using a revision of sources and literature. These historical materials were discussed by Witkowski & Witkowski (2017).

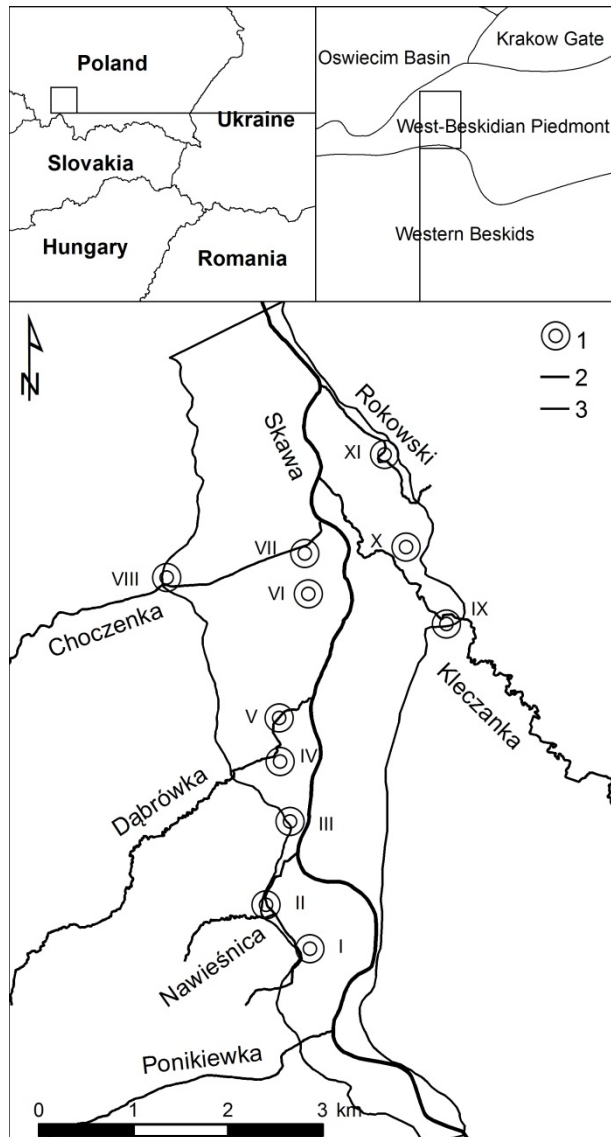


Figure 1. Area of research

1. locations of watermill, 2. rivers, 3. area of research.

1.2. Area of research

The area of research constitutes a fragment of the basin of the Skawa valley, with the river itself flowing from the Żywiec Beskids in the Outer Western Carpathians, at the Spytkowice Pass (701 m a.s.l.). In the upper catchment area, among others, the massif of Mount Babia (1725 m a.s.l.) is located. The Skawa watershed partially overlaps with the main European Watershed (the Vistula and the Danube watershed). In the upstream area, the Skawa River drains the waters of the Żywiec Beskids, the

Island Beskids, the Maków Beskids, and the Little Beskids. The Upper Skawa River is closed off by a dam in Świnna Poręba, which holds as many as 160 million m³ of water in a reservoir. The dam is located 26.6 km down river. In the downstream area, the Skawa runs along the border between the Silesian Foothills and the Wieliczka Foothills. At the ninth kilometre, it enters the Vistula valley area where it joins the Vistula. The total length of the Skawa is 96.4 km, whereas the catchment area is 1160 km² large.

Wadowice is located in the foothills of the Little Beskids, on the border of the Silesian Foothills and the Wieliczka Foothills. The town is partially located in the bottom of the lower Skawa, which is up to 2.6 km wide at this point. The elongated slope of the river bed in the entire downstream area is 1.9‰. The Skawa and its tributaries have gravel beds. In the downstream area the bedrock is exposed only in the last mountain gorge.

The area of research covers a 13.9 square-kilometre fragment of the bottom of the Skawa valley below the water dam in Świnna Poręba (Fig. 1.). The section subjected to the study begins with the last mountain gorge of the river. Below in the area of Wadowice, the Skawa runs in a wide valley bottom formed on tectonic faults between the Foothills and the Little Beskids. The widening of the valley was significantly affected by Choczenka, a tributary of the Skawa. The section subjected to the research is closed by a road bridge in Tomice, near which the valley becomes significantly narrower, forming a gorge section in the Foothills area. Here, 11 locations of former watermills were identified, dating from the 18th to the 20th century.

Table 1. Continuity in the functioning of watermills in specific locations.

	1763	1787	1855	1863	1869	1887	1909	1934	1938
I									
II									
III									
IV***									
V									
VI**									
VII									
VIII									
IX**									
X									
XI									

In locations marked with ** two watermills were operating in some years, while in those marked with *** three watermills were functioning.

1.3. The history of milling in Wadowice

The first watermills and sawmills in the area of Wadowice were built in Cistercian villages (Baran, 2014). The proliferation of milling was related to ducal and royal privileges, the first of which were granted in the 15th century. Over the following centuries, mills were erected by townsmen and local nobles, while from the second half of the 19th century also by Jews. In the second half of the 19th century, milling experienced a retrograde step. Watermills, though modernised, failed to compete with modern steam devices. There were 77 mills still operating in the entire Wadowice County in 1885, 3 of which were located in Wadowice (Meus, 2013) and 8 in the area of research. The last watermill in the area of research was still functional in 1938 (Table 1.)

2. TRANSFORMATION OF THE HYDROGRAPHIC NETWORK IN WADOWICE

By the mid-15th century, i.e. before the beginning of milling in Wadowice, human interference in the river network was limited solely to maintaining a narrow bed of the watercourse that fed fish ponds in the northern part of Wadowice. At that time, the Skawa River along with its main tributaries Choczenka, Kleczanka and Dąbrówka served as the axis of the river network. The said watercourses were fed by a number of short tributaries which drained inter alia wetlands that are non-existent today.

Due to the topography of the bottom of the Skawa valley, particularly an insignificant drop, natural courses could not be employed as a power source for watermills. The only exception was the estuaries of Choczenka and Kleczanka, where mills were located. The bed of the Skawa River could not be used for powering such devices, since until the end of the 19th century it was characterised by a multi-channel system in the Wadowice section (Witkowski, 2017).

After the privilege of building mills and damming up the waters of the Skawa was granted, a golden age in the history of Wadowice water milling began. The growth of the milling industry was reflected in the dense river network. A weir was built at the time in Świnna Poręba, which then fed a 6-kilometre-long mill race that joined several streams. The building of this mill race had the most profound effect on the river network in Zaskawie in Jaroszowice (part of the village on the left, i.e. west, bank of the Skawa), where Zbywaczowski and

Nawieśnica streams flowed to a man-made ditch running parallel with the bed of the Skawa River, and then joined the mill race. Formerly, these two natural watercourses that drain Iłowiec had flowed directly to the Skawa River. Despite the mill race being closed down in the 20th century, the said streams did not regain their original course. This was due to high-density housing in the area of the former beds. A mill race was also built in the 18th century on the right bank of the Skawa in Rokow, about 0.8 of a kilometre long, joining two natural beds.

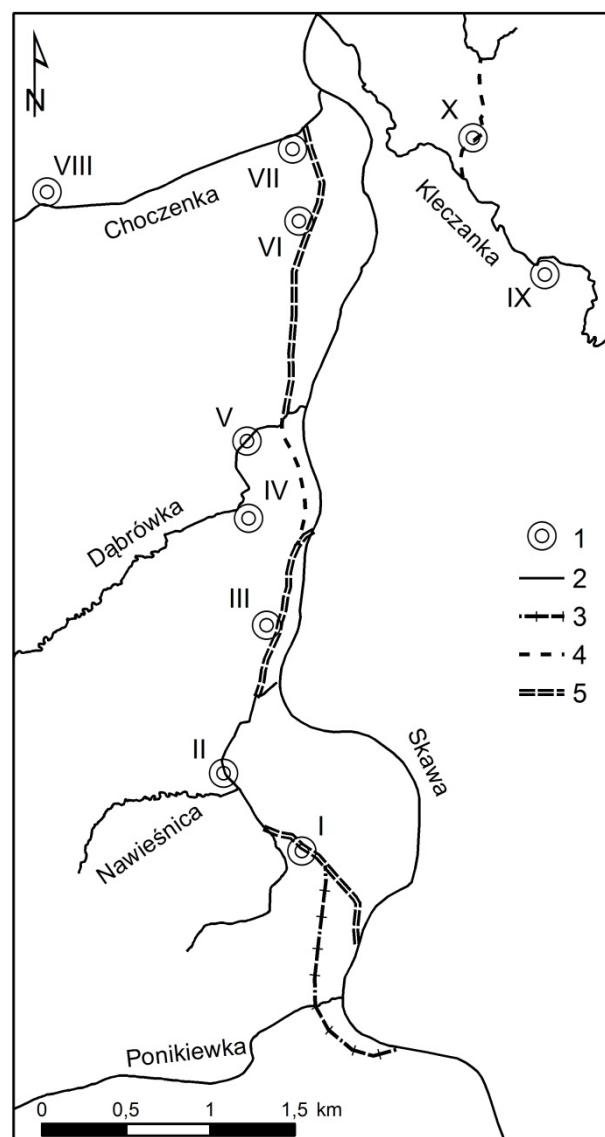


Figure 2. Mill race liquidated in the 20th century.

1. locations of watermill, 2. rivers, 3. mill race liquidated in the 1920s., 4. mill races liquidated in 1930s., 5. mill races liquidated in 1950s.

The building of two man-made beds has led to the increased density of the river network in the area of research, which was a clear indication of the impact of water mills on changes in the hydrographic network. The river network density

was estimated at 2.55. The location of natural river mouths was changed and in extreme cases they were filled up in order to force all the waters into mill races. A thus modernised river network was functioning until the 1920s, when part of the mill race on the left bank of the Skawa River was filled up, and the weir that used to feed it was relocated down the river (Fig. 2). At the time, the course of the said mill race was reduced by about 1.5 kilometre, while the river network density fell to 2.44, consequently. In the 1930s, the mill race on the right bank of the Skawa was filled up. The mill race on the left bank was divided in two. As a result of these transformations, the total length of mill races was reduced to 3.8 kilometres. The last fragments of mill races were filled up at the turn of the 1950s, while the remaining sections were included in a drainage network. When the sewage system within the boundaries of Wadowice was completed by the 1960s, the river network density became stable at 2.05 (Table 2.).

Table 2. Parameters of the river network at the time of issuance of the selected maps.

	1909	1934	1943	1995
channel length [km]	35,38	33,92	32,34	28,51
mill race length [km]	6,87	5,41	3,83	0
valley density	2,55	2,44	2,33	2,05

3. DISCUSSION

In the Carpathian Foothills, where conditions were anything but favourable for agriculture, milling developed to satisfy the needs of the local people, similarly as in Podhale (Jost, 1976). Milling in the Carpathians was dependent on privileges granted by landowners, i.e. the king or an order (Baran, 2014; Jost, 1969). In the Polish lowlands, where conditions were more favourable for milling, the rapid increase in the number of mills at the turn of the 15th century was determined by a recovery in trade between Lithuania, Russia and Germany (Kaniecki & Brychcy, 2010).

The geographic conditions of Wadowice Land forced millers to create mill races, since natural watercourses could be used for powering mills only sporadically. In northern Poland, the building of mills on rivers and streams, as well as the creation of mill ponds was a common practice (Kaniecki & Brychcy, 2010). The diversity in the development of medieval milling determined by environmental conditions was observed also in the British Isles. Owing to the greater drop of rivers and streams in Scotland, mill ponds created there could be of a

smaller size than those in England, which were situated in areas of less significant height differences (Bishop & Muñoz-Salinas, 2013).

However, the basic condition determining the building of mills in the Carpathian Foothills was economy and not environmental conditions, which is similar for the Skrwa catchment area in northern Poland (Brykała, 2001). Owing to the mill race being fed by a mountain river, the Skawa, it was possible to maintain good conditions for mill operation throughout the year. As in the case of England (Bishop & Jansen, 2005; Bishop & Muñoz-Salinas, 2013), water retention in man-made structures for periods of low river flow was necessary in the Polish Lowlands (Brykała, 2001; Brykała & Podgórski, 2008; Podgórski, 2004a). Mills on the Skawa River were situated on meadows and breeding areas away from households. Owing to the different environmental conditions, mills in northern Poland were located nearby human settlements or even in villages or towns themselves using tunnel valleys, among others (Brykała, 2001; Podgórski, 2009).

The building of mills by damming up pond water contributed to increased ground water levels (Kaniecki & Brychcy, 2010). A similar effect could have been created by a high-density river network in the Carpathian Foothills owing to the construction of mill races, although they were not equipped with ponds. Water mills in the studied area caused changes in the hydrographic network through the construction of new channels and backfilling of natural beds.

4. CONCLUSION

The changes in the density of the river network in Wadowice that had taken place by the mid-20th century resulted from either the construction or the closing down of mill races or watercourses that used to feed mill ponds. The construction of a combined sewage system and storm sewer system that followed served as an impulse for covering a part of surface watercourses and further changes in the hydrographic network. The development of water milling in Wadowice and the surrounding area has led to a higher density of the river network in the Skawa valley.

With the decline of water milling in the 20th century, mill races ceased to be of any use. Over time, unkempt watercourses started posing a flood risk and were also an obstacle for spatial development of the town. Subsequent parts of mill races were gradually closed down, leaving only sections overlapping with natural watercourses. This

process has led to an emergence of a network of semi-natural streams whose course in the Skawa valley does not correspond to the local morphology and constitutes a clear confirmation that the watercourses used to be employed for economic purposes. Both construction and liquidation of water mills affected changes in the hydrographic network.

The Carpathian Foothills hold numerous relics of the former hydrographic network. The example of Wadowice and the surrounding area shows that water milling has exerted a great impact on hydrographic conditions. Therefore, water milling should always be given due weight account in research on changes in the hydrographic network in the Carpathians. Particularly, the impact of milling should be noted in studies on changes in the removal of slope material (e.g. Kijowska-Strugała & Demczuk, 2015).

REFERENCES

- Baran, A.**, 2014. *Młyny w dobrach wiejskich opactwa cystersów w Mogile (XVI-XVIII w.)*. Studia Historyczne, 225, 1, 5–20.
- Bishop, P. & Jansen, J. D.**, 2005. *The geomorphological setting of some of Scotland's east coast freshwater mills: A comment on Downward and Skinner (2005) „Working rivers: The geomorphological legacy...”*. Area, 37, 4, 443–445.
- Bishop, P. & Muñoz-Salinas, E.**, 2013. *Tectonics, geomorphology and water mill location in Scotland, and the potential impacts of mill dam failure*. Applied Geography, 42, 195–205.
- Bloch, M.**, 1935. *Avènement et conquêtes du moulin a eau*. Annales d'histoire économique et sociale, 7, 36, 538–563.
- Brandt, S. A.**, 2000. *Classification of geomorphological effects downstream of dams*. Catena, 40, 4, 375–401.
- Braudel, F.**, 1990. *Frankreich, Band 3: Die Dinge und die Menschen*. Stuttgart: Klett-Cotta.
- Brykała, D.**, 2001. *Uwarunkowania przyrodnicze lokalizacji młynów wodnych w zlewni Skrwy*. Problemy Ekologii Krajobrazu, 10, 164–171.
- Brykała, D. & Podgórski, Z.**, 2008. *800 years of watermills' existance on Polish rivers and their role in hydrographical systems' modification*. International Conference in the UNESCO Year of Planet Earth Studying, Modeling and Sense Making of Planet Earth.
- Ceobanu, C. & Grozavu, A.**, 2009. *Psychosocial effects of the floods. Perception an attitudes*. Carpathian Journal of Earth and Environmental Sciences, 4, 2, 25–38.
- Curwen, E. C.**, 1944. *The Problem of Early Water-mills*. Antiquity, 18, 71, 130–146.
- Dembińska, M. & Wojtowska, R.**, 1973. *Przetwórstwo zbożowe w Polsce Średniowiecznej (X-XIV wiek)*. Wrocław: Instytut Historii Kultury Materialnej PAN, Ossolineum.
- Downward, S. & Skinner, K.**, 2005. *Working rivers: The geomorphological legacy of English freshwater mills*. Area, 37, 2, 138–147.
- Florek, W., Jonczak, J., Niska, M. & Pasamonik, I.**, 2015. *Environmental changes in the catchment of the Jaroslavianka Stream recorded in mill pond deposits*. Limnological Review, 15, 2, 71–76.
- Franczak, P., Ostafin, K., Kaim, D. & Szwagrzyk, M.**, 2017. *Młyny i tartaki o napędzie wodnym w krajobrazie Polskich Karpat od połowy XIX w. do lat 70-80. XX w.* Interdyscyplinarne Seminarium Naukowe „Młyny wodne w dorzeczu dolnej Wisły od początku XVIII do początku XXI wieku”. Toruń.
- Gładkowski, A.**, 2008. *Historia techniki młynarstwa polskiego*. [in:] Z. Mrugalski (red.), Inżynierowie Polscy w XIX i XX wieku. Polskie Towarzystwo Historii Techniki, Warszawa, 13-100.
- Hersperger, A. M., Ioja, C., Steiner, F. & Tudor, C. A.**, 2015. *Comprehensive consideration of conflicts in the land-use planning process: a conceptual contribution*. Carpathian Journal of Earth and Environmental Sciences, 10, 4, 5–13.
- Hossu, C. A., Ioja, C., Susskind, L., Badiu, D. & Hersperger, A. M.**, 2018. *Factors driving collaboration in natural resource conflict management: Evidence from Romania*. Ambio, 1, 1–15.
- Ianos, I., Peptenatu, D. & Zamfir, D.**, 2009. *Respect for environment and sustainable development*. Carpathian Journal of Earth and Environmental Sciences, 4, 1, 81–93.
- Ianos, I., Sirodoev, I. & Pascariu, G.**, 2012. *Land-use conflicts and environmental policies in two post-socialist urban agglomerations: Bucharest and Chisinau*. Carpathian Journal of Earth and Environmental Sciences, 7, 4, 125–136.
- Janac, J.**, 2012. *European Coasts of Bohemia. Negotiating the Danube-Oder-Elbe Canal in a Troubled Twentieth Century*. Amsterdam University Press, Amsterdam.
- Jankowski, G.**, 1998. *Economical activities of cistercian monastery and its influence on landscape of Rudy Wielkie vicinity*. [in:] J. Szabo & J. Wach (red.), Anthropogenic aspects of geographical environment transformations. Lajos Kossuth University, University of Silesia, Debrecen – Sosnowiec, 95–101.
- Jost, H.**, 1969. *Watermills in Podhale in Southern Poland*. Transactions of the Second International Symposium on Molinology, TIMS, Danmark, 411–419.
- Jost, H.**, 1976. *Młyny zbożowe podhalańskie dawniej i obecnie*. Kwartalnik Historii Nauki i Techniki, 21, 4, 687–708.
- Kaniecki, A. & Brychcy, D.**, 2010. *Średniowieczne młyny wodne i ich wpływ na przemiany stosunków wodnych na przykładzie zlewni Obry*

- Skwierzyńskiej*. *Badania Fizjograficzne Seria A - Geografia Fizyczna*, 61, 1, 145–156.
- Kijowska-Strugała, M. & Demczuk, P.**, 2015. *Impact of land use changes on soil erosion and deposition in a small Polish Carpathians catchment in last 40 years*. *Carpathian Journal of Earth and Environmental Sciences*, 10, 2, 261–270.
- Klimek, K.**, 1987. *Man's Impact on Fluvial Processes in the Polish Western Carpathians*. *Geografiska Annaler. Series A, Physical Geography*, 69, 1, 221–226.
- Kreiner, R.**, 1996. *Städte und Mühlen im Rheinland. Das Erftgebiet zwischen Müstereifel und Neuss vom 9. bis ins 18. Jahrhundert*. Alano Herodot Verlag, Aachen.
- Meus, K.**, 2013. *Wadowice 1772 - 1914. Studium przypadku miasta galicyjskiego*. Kraków.
- Moog, B.**, 1994. *The horizontal watermill: History and technique of the first prime mover (Bibliotheca molinologica)*. International Molinological Society.
- Podgórski, Z.**, 2004a. *Functional changes of the mill reservoirs in the Chełmińskie Lakeland*. *Limnological Review*, 4, 215–222.
- Podgórski, Z.**, 2004b. *Wpływ budowy i funkcjonowania młynów wodnych na rzeźbę terenu i wody powierzchniowe Pojezierza Chełmińskiego i przyległych części dolin Wisły i Drwęcy*. Uniwersytet Mikołaja Kopernika, Toruń.
- Podgórski, Z.**, 2009. *Młyny wodne w krajobrazie Pojezierza Chełmińskiego*. *Prace i Studia Geograficzne*, 41, 151–161.
- Raeymaekers, J., Raeymaekers, D., Koizumi, I., Geldof, S. & Volckaert, F.**, 2009. *Guidelines for restoring connectivity around water mills: a population genetic approach to the management of riverine fis*. *Journal of Applied Ecology*, 46, 562–571.
- Rutkiewicz, P. & Gawior, D.**, 2016. *Natural and anthropogenic indicators of fluvial system changes, the Bobrza Valley (Holy Cross Mts) as an example*. *Contemporary Trends in Geoscience*, 5, 1, 46–60.
- Witkowski, K.**, 2017. *Transformacja układu korytowego dolnej Skawy*. *Prace Geograficzne*, 150, 41–59.
- Witkowski, K. & Witkowski, M.**, 2017. *Wpływ młynów wodnych na przekształcenia sieci hydrograficznej Wadowic (Pogórze Karpackie)*. *Interdyscyplinarne Seminarium Naukowe „Młyny wodne w dorzeczu dolnej Wisły od początku XVIII do początku XXI wieku”*. Toruń.
- Wood, P. J. & Barker, S.**, 2000. *Old industrial mill ponds: A neglected ecological resource*. *Applied Geography*, 20, 1, 65–81.
- Wyźga, B., Zawiejska, J. & Hajdukiewicz, H.**, 2013. *Uwarunkowania występowania i przyczyny zaniku wielonurtowej morfologii rzek polskich Karpat*. [in:] B. Wyźga (red.), *Stan środowiska Południowej Polski i możliwości jego poprawy - wybrane aspekty*, Instytut Ochrony Przyrody PAN, Kraków, 7-32.

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