INFRASTRUKTURA I EKOLOGIA TERENÓW WIEJSKICH
INFRASTRUCTURE AND ECOLOGY OF RURAL AREAS

Nr 6/2008, POLSKA AKADEMIA NAUK, Oddział w Krakowie, s. 111–130
Komisja Technicznej Infrastruktury Wsi
Commission of Technical Infrastructure of the Polish Academy of Sciences-Cracow Branch

Bernard Okoński, Antoni T. Miler, Monika Panfil

PHYSIOGRAPHIC AND METEOROLOGICAL CONDITIONS IN THE *DOPŁYW SPOD NOWEJ WSI* CATCHMENT DURING THE LAST 150 YEARS

Summary

The paper covers research on physiographic features and anthropogenic factors influence on natural pond water storage. The problem was investigated both at the level of the Dopływ spod Nowej Wsi catchment (27.53 km^2) and the smaller spatial unit Bagna Ramuckie natural pond (12.4 ha). Dynamics of physiographic features, changes of hydrographical network and anthropogenic factors including water, land and forest management practices were investigated.

The decisive factor modulating processes of water storage rebuilding for investigated spatial units seems to be dynamics and long-term directional changes of air temperature. Rebuilding of pond water storage occurred after a 40-year period of air temperature decrease and the decline of water storage after a 20-year period of air temperature increase. Precipitation had minor significance in modulating pond water storage in long-term periods, because lack of long-term precipitation trends in analysed period. Although in short-term periods precipitation have important modulating impact on a decline of pond storage. The decline occurred after the dry period from 1989 to 1995 as a result of high deficit of climatic water balance. Spectacular rebuilding of pond water storage occurred in Bagna Ramuckie after the cold and wet period from 1956 to 1965. Non-climatic physiographic features and anthropogenic factors did not influence the processes of pond water storage rebuilding and decline because both of these factors seemed to be stationary over at least eight decades of 20th century, while processes of storage rebuilding or decline lasted over the investigated spatial unit.

Key words: Warmia region, forested-agricultural catchment, natural pond storage, physiographic features impact, anthropogenic factors impact

INTRODUCTION

Climate is the main factor affecting water balance and hydrological processes over large spatial units. Nonstationarity of air temperature and precipitation of transitional climate of Poland determines the temporal variability of catchment recharge and discharge or shapes dynamics of various water storage forms. The impact of climate nonstationarity on local hydrology can be attributed to long-term changes of air temperature and precipitation or frequency of some extreme meteorological events e.g. droughts, snow cover storage.

Over less extensive spatial units non-climatic physiographic features gain apparent influence on local hydrology. Some physiographic features are relatively stable over time, e.g., geological conditions, relief, however other may change over shorter time scales, e.g., land cover form or land cover management practice, forest ecosystem state.

Current and past anthropogenic activities impact and modulate natural hydrological processes in geoecosystems. Land drainage or modification of quality and quantity of natural land cover are recognized as the most common forms of man-caused effects on natural hydrological processes in less extensive spatial units.

Problem of protection and management of more stable forms of retention such as pond or marshland retention bears important ecological and economic dimension. Recently, numerous projects and initiatives are being undertaken aiming at reversing degradation processes and restitution of natural water storage units such as ponds or marshland areas.

Decline of various forms of retention can result from a variety of factors. These factors usually interact together producing hydrological effect. The crucial importance for supporting more stable forms of water storage is related to these physiographic features which change over longer time-scales. The extent of impact inflicted by each factor may differ for various locations. Thus, the projects covering restitution and protection of pond and marshland areas require both assessment of local physiographic features impact on water storage and assessment of ability to support water storage by local hydrological units.

Assessment of particular project effectiveness and selection of technical solutions depends on results of local hydrological conditions evaluation. The example of abovementioned assessment results is presented in this paper.

MATERIALS AND METHODS

The problem of restitution possibility of pond storage was investigated both at the level of the Dopływ spod Nowej Wsi catchment (27.53 km^2) and detailed for the smaller spatial unit Bagna Ramuckie natural pond (16.40 ha). The hydrometeorological parameters of the Dopływ spod Nowej Wsi catchment were not directly controlled. The assessment of hydrological parameters dynamics was performed on the basis of air temperature and precipitation data obtained from meteorological station Tomaszkowo for the period from 1951 to 2001 and air temperature data were acquired from the IMGW Poznań-Ławica meteorological station for the period 1848-2005 [Dane z stacji IMGW Poznań-Ławica… 2005, Dane ze stacji UWM Tomaszkowo… 2007]. Meteorological station UWM Tomaszkowo is located 14 km from Bagna Ramuckie pond and 15 km from the centre of the catchment. Low spatial variability of meteorological elements (particularly temperature) for relatively close sites justifies employing the above described approach. Temperature time series from IMGW station Poznań-Ławica were employed to extend data series for meteorological station Tomaszkowo for the past (1848-1950) and the future (2001-2005) period. The distance between meteorological stations Tomaszkowo and Poznań-Ławica is ca 280 km. Nevertheless, strong linear relation between monthly and annual temperature data series for these locations (determination coefficients for annual and monthly temperatures are R^2 = 0.9755 and 0.8215) permits to employ temperature time series extension procedure for the investigated location. The procedure was not used for extension of precipitation data series because of unacceptable, although formally statistically significant at $\alpha < 0.01$ correlation, with determination coefficients 0.3182 and 0.3458 respectively. Evapotranspiration was calculated by the Ivanov method. Climatic water balance was presented for the 1971-2000 year period.

Assessment of physiographic features impact on hydrological conditions and assessment of hydrographical network changes, water management practices over past periods were performed with utilization of archival and current cartographical, land drainage, forest survey and hydrogeological documentation [Okoński 2007].

LOCATION AND PHYSIOGRAPHIC CHARACTERISTIC OF THE DOPŁYW SPOD NOWEJ WSI CATCHMENT

The Dopływ spod Nowej Wsi catchment (27.53 km^2) is located in the Warmia region in northern part of the Puszcza Napiwodzko-Ramucka forest area. The geographical coordinates of the catchment outlet are 53º37'16"N and 20º38'10"E. The outlet is located ca 15 km SE from Olsztyn. According to the classification of physiographic regions the investigated area belongs to the Mazurskie Lakeland macroregion (842.8) and Olsztyńskie Lakeland mesoregion (842.81) [Kondracki 2002]. The Bagna Ramuckie pond is located in a terrain depression in the central part of the Dopływ spod Nowej Wsi catchment.

Climate of the research area is transitional with significant influence of continental climate features with high amplitude of air temperatures (21.1ºC) and maximum monthly precipitation at the beginning of the summer season (July).

Annual air temperature is 7.2ºC. The coldest and warmest months are January (monthly temperature -3.3ºC) and July (monthly temperature 17.0ºC), respectively. Annual rainfall is 572 mm. Annual period with snow cover is 40 days and maximum thickness of snow cover usually exceeds 50 cm. Vegetation period precipitation equals 411 mm. The investigated area is characterized by high frequency of days with large cloud cover and high average relative humidity (ca 85 %). Vegetation period begins between 31st March and 15th April and ends between 31st October and 5th November. Thermic winter begins on 5th December and lasts 90 days. Thermic summer usually begins on 10 June and lasts 78 days. Annual climatic water balance is usually positive (50 mm). The period of climatic water balance deficit begins in March and ends in September.

Table 1. Selected physiographic characteristics of the Dopływ spod Nowej Wsi cachment

Physiographic characteristics	Value	
Land cover	[km^2]	[%]
Forest	16.23	59
Meadows and pastures	9.64	35
Arable, fallows included	0.83	3
Marshland and water bodies	0.55	2
Settlements	0.28	1
Soil cover		
Sand and gravel	24.50	89
Clay	1.93	7
Organic soil	1.10	4
Landform		
Morainic and sandr plateaus	20.37	74
Subglacial valleys and Morainic depressions	7.16	26
Geometric characteristics		
Total catchment area [km^2]	27.53	
Catchment length [km]	8.32	
Mean catchment width km]	3.31	
Catchment perimeter length [km]	25.62	
Catchment compactness ratio [-]	1.38	
Relief characteristics		
Minimum elevation catchment point [m] asl.	123.1	
Denivelation [m]	58.0	
Mean catchment elevation [m] asl	147.5	
Mean catchment slope [‰]	9.6	
Hydrographical characteristics		
Length of main stream [km]	6.67	
total length of hydrographical network [km]	12.89	
Mean hydrographical network density [km/km^2]	0.47	
Mean main stream slope [‰]	2.1	

According to hydrographical division of Poland, Dopływ spod Nowej Wsi is a stream of VI-th order and is a part of the hydrographical system of Dopływ z jeziora Łajskiego (V) – Kośnik/Kiermas (IV) – Wadąg (III) – Łyna (II) – Pregoła (I). The main factors shaping geological, geomorphologic and hydrographical features of the investigated area were glacial and fluvioglacial processes of Vistulian Glaciation. Sands and gravels prevail in upper soil layer. Sedimentary rocks of variable thickness reaching 20 m over the upland area are bedded by clay layers. Thickness of permeable soil layer is decreasing in lower parts of the catchment, where clay layer emerges at the terrain surface. Selected physiographic characteristics of investigated catchment are presented in Table 1.

Dominant forms of terrain relief are sander and morainic rocking uplands. Prevailing forms of land cover of the Dopływ spod Nowej Wsi catchment are forests (59%), meadows and pastures (35%). Forest stands are composed of pine (87%), oak (5%), birch (4%), spruce (3%) and alder (1%).

HYDROGRAPHIC NETWORK CHANGES AND DYNAMICS OF NONCLIMATIC PHYSIOGRAPHIC CHARACTERISTICS OF DOPŁYW SPOD NOWEJ WSI CATCHMENT

Colonization and permanent settlement of the Dopływ spod Nowej Wsi catchment area began at the turn of 18th century, nevertheless hydrographic network was not the subject of strong anthropogenic impact and sustained its natural features until 1st half of 19th century. Between existing now villages Nowa Wieś and Przykop, Lake Kalno is situated. Numerous smaller lakes, ponds and extensive marshland areas were located in other terrain depressions [Mapa komornictwa olsztyńskiego… XVII w., Mapa… 1809, Barczewski 1984, Achremczyk 1992].

According to Barczewski [1984] in the first half of the 19th century the first stage of main draining ditch construction from the direction of Łajs Lake to Nowa Wieś village was undertaken. The second stage of construction covered building the canal through local upland area close to Przykop village to Nowa Wieś. During these works Lake Kalno, neighbouring ponds and marshland area were drained. Lake Kalno was shallow (maximum depth 4 m), strongly eutrophic interior (without surface drainage) lake surrounded by peat bog area. The water surface of the lake was very unstable and strongly interacting with dynamics of meteorological conditions. According to Barczewski (1984) the Nowa Wieś village was flooded in 1855: '…*so for two years the villagers could reach their cottages only by boats and suffered immense misery at that time, although they could fish from their doorsteps. After two years the canal to Lake Łajs was completed…*'

Nowa Wieś was founded in 1820. Some new villages were also founded in the 1st half of the 19th century in the Dopływ spod Nowej Wsi catchment. The foundation of new villages resulted from the politics of German colonization of the south Warmia region inhabited exclusively by Poles. The colonization implicated deforestation and transforming land for arable use, draining marshland areas. Thus, the area of farming enclave significantly extended [Barczewski 1984].

After main sections of drainage system were constructed, detailed land drainage network was subsequently extended and local terrain depressions were drained. Main tasks were completed from 1890 to 1914 year and in the following years before WWII land drainage works were less extensive [Solarski et al. 2005]. Comparison of German archival maps (actualised in 1908, 1924 and 1938) with current cartographic documentation and drainage documentation enable to follow developing of land draining system in the Dopływ spod Nowej Wsi catchment [Mapa… 1908, Mapa… 1931, Mapa… 1942, Mapa… 1980, 1981a, 1981b, 1981c, 1982a, 1982b, Dokumentacja ewidencyjna… 2007].

Open channel ditches composed mainly pre-WWII drainage network system in the catchment, although some sections of buried pipelines are also present. Most sections of the drainage network were well managed and kept operational in the Dopływ spod Nowej Wsi catchment in the post-WWII period. No new investments in land drainage changing the layout of drainage network in the post-war period were undertaken.

The Dopływ spod Nowej Wsi catchment is an anthropogenic catchment formed on the area without natural surface draining network by building ditch and canal drainage system. Surface drainage is not a natural process in the contemporary Dopływ spod Nowej Wsi catchment and might have occurred only locally before the construction of land drainage system.

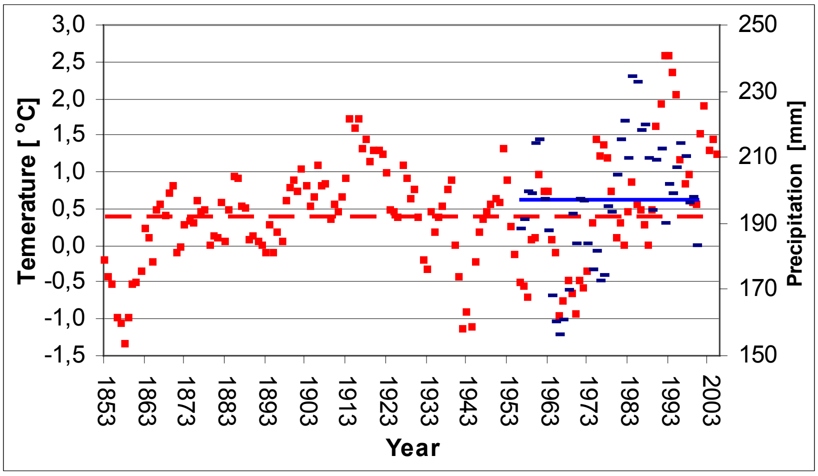
Study of cartographic material shows that proportion of forest and other forms of land cover in the Dopływ spod Nowej Wsi catchment has not changed significantly since the end of the 19th century. Increase of meadow and pasture proportion by 4% due to reduction of arable land by the end of the 20th century can only be noted [Mapa… 1899, Barczewski 1984, Mapa… 2007a, Mapa… 2007b, (Studium uwarunkowań i zagospodarowania… 1999].

Forest management practice and routines were established at the half of the 19th century. Oak and pine-oak forest stands were replaced with pine and spruce monocultures (88% of forest stand composition currently) and clear cutting harvesting routines were introduced [Mapa… 1899, Plan urządzania lasu … 2005, Mapa… 2007a, Mapa… 2007b].

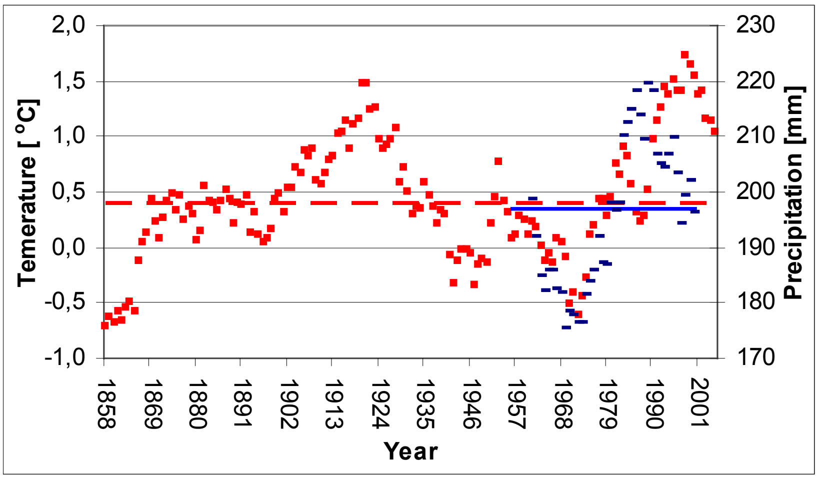
Nonclimatic physiographic conditions and anthropogenic influence determining local hydrology in Dopływ spod Nowej Wsi catchment can be recognized as stationary during at least the last eight decades period.

DYNAMICS OF METEOROLOGICAL ELEMENTS

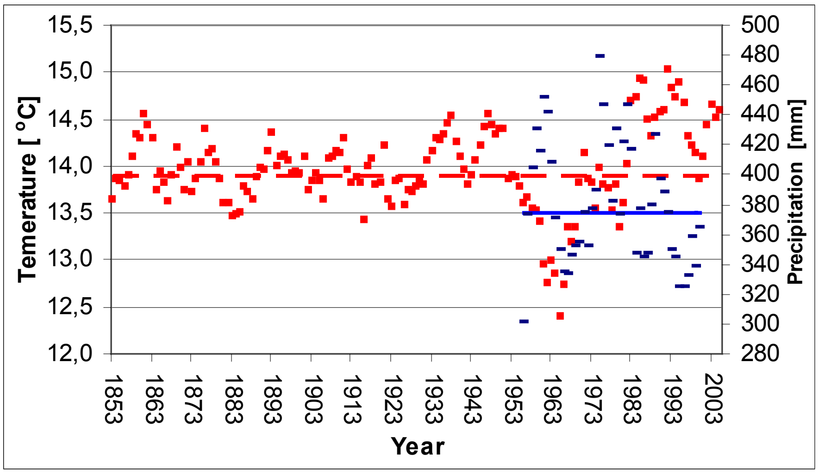
Mean multi-year air temperature increased from 1848 year until the second decade of 20th century following by air temperature decrease until the eight decade of 20th century and subsequent increase until 2005. (fig. 1). Mean annual temperatures of hydrological year increased during the period from 1848 to 1916. Increasing trend of annual temperatures for hydrological year is determined rather by changes of the winter half-year temperatures, due to similarity of the winter half-year and hydrological year directional changes of temperature.



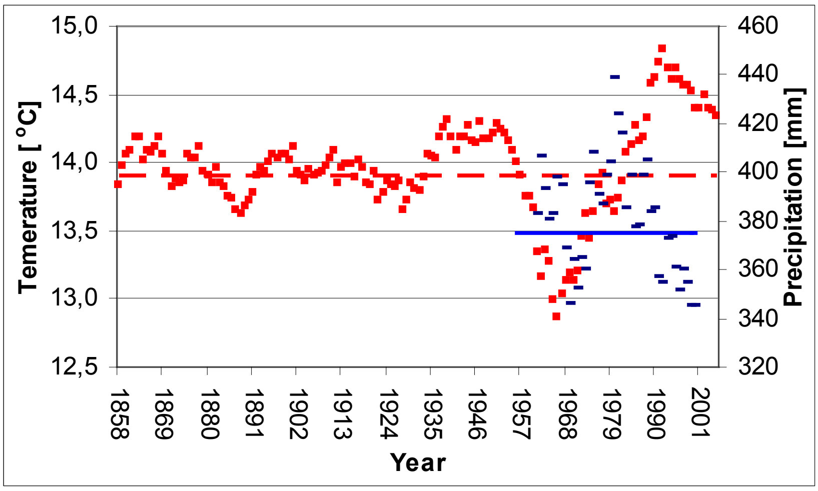
Winter half-year, 5-year moving average



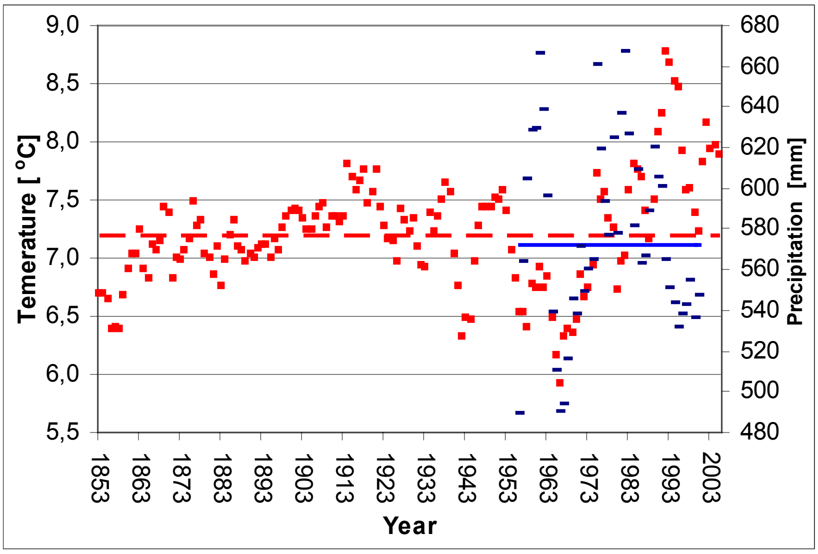
Winter half-year, 11- year moving average



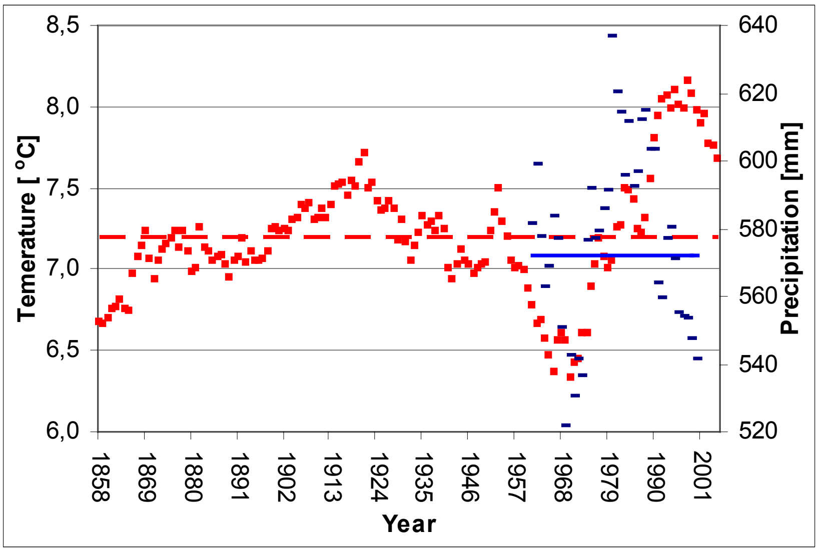
Summer half-year, 5-year moving average



Summer half-year, 11-year moving average



Hydrological year, 5-year moving average



Hydrological year, 11- year moving average

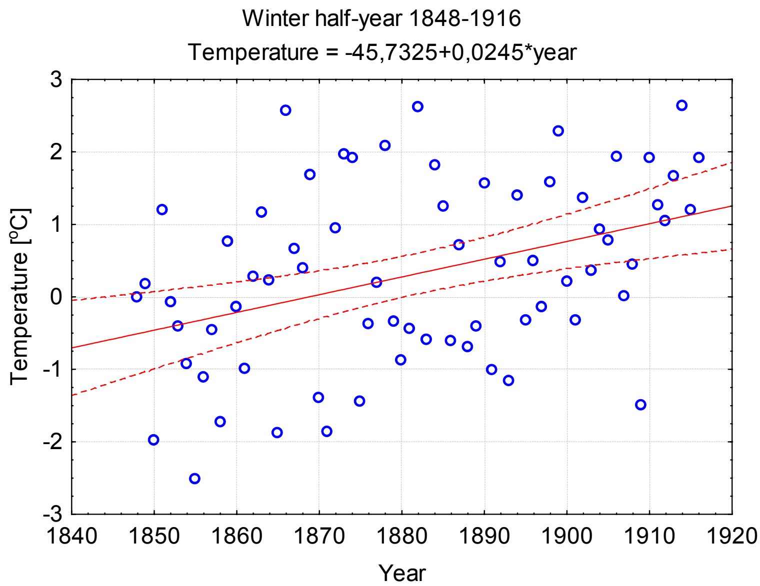
Figure 1. Dynamics of moving 5-year and 11-year average temperature and precipitation against arithmetic mean values (parallel curves) for the hydrological year, winter and summer half-year in 1848-2005 (temperature) and 1951-2000 (precipitation)

The summer half-year temperatures do not manifest directional changes for the aforementioned period (ca 0°C per 100 years). The increase of mean annual temperature for the hydrological year from 1848 to 1916 was 1.3°C per 100 years, and for the winter half-year 2.4°C per 100 years.

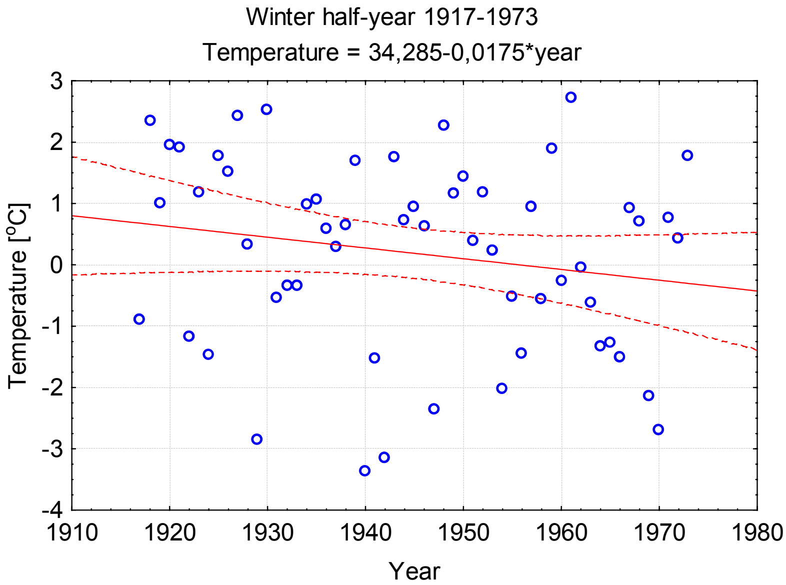
The trends of air temperature decrease occur for the subsequent period, ending in the seventh decade of 20th century. The temperatures of the hydrological year, winter and summer half-year decreased from 1917 to 1973 by 1.7, 1.3 and 1.5°C per 100 years, respectively. The trend of mean air temperature increase occurs then since the middle of seventh decade of 20th century. The temperature increased for the period of 1974-2005 by 2.1, 1.9 and 1.8°C per 100 years for the hydrological year, winter and summer half-year, respectively.

For the entire investigated period 1848-2005 the trends of air temperature increase have manifested by 0.6, 0.2, 0.4°C per 100 years for the hydrological year, winter and summer half-year periods, respectively. The hydrological year and winter half-year temperatures showed similar dynamics for entire investigated period. In addition, the dynamics of the winter half-year temperatures is more distinctive and easier to interpret than the dynamics of the summer half-year (fig. 2).

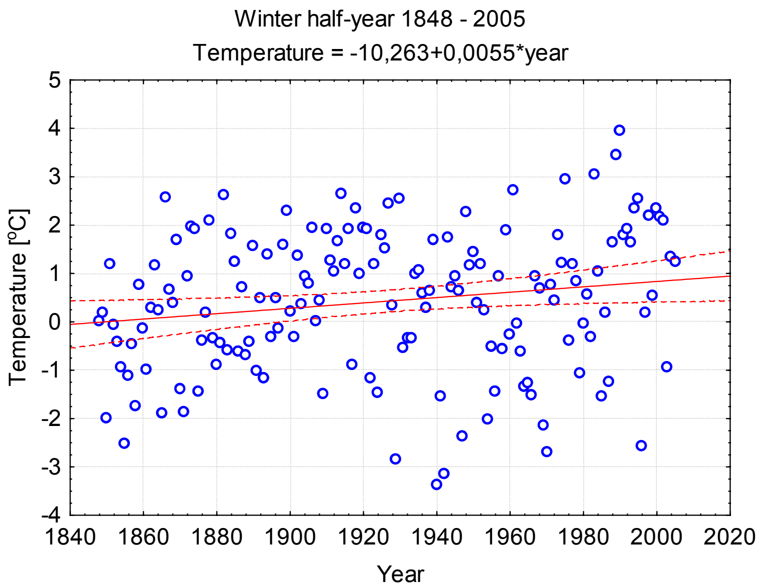
The coldest period lasted from 1951 to 1980. Thermal minimum for the entire multi-year period 1848-2005 occurred during the period from 1961 and 1965. Thermal maximum occurred during the period from 1990 and 1995 year. The warmest period lasted between 1985 and 2005 (fig. 2).



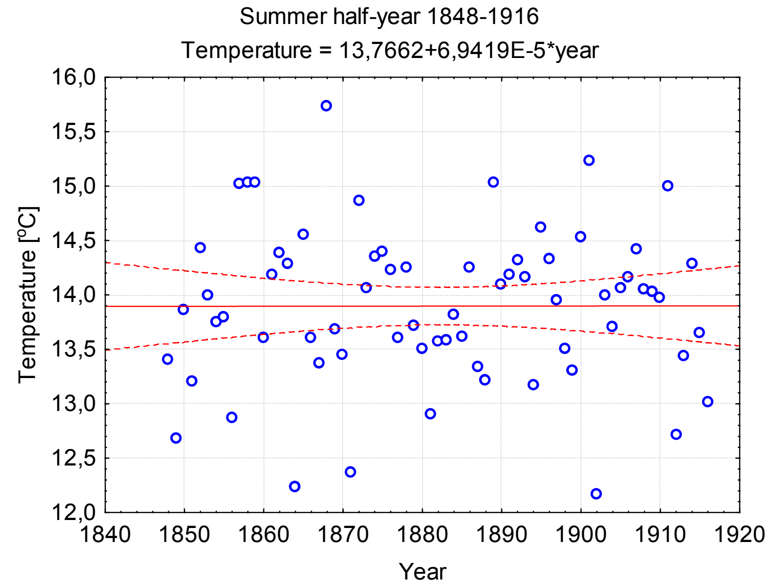
Winter half-year 1848-1916 *



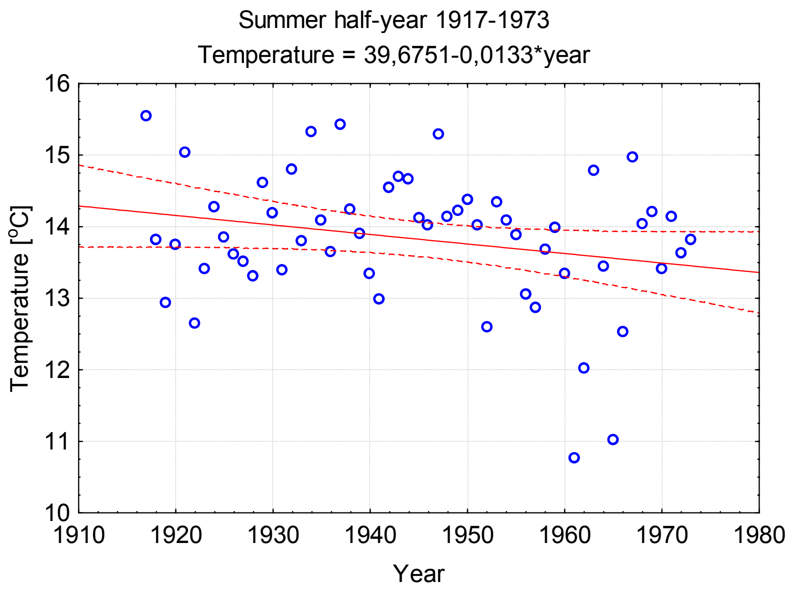
Winter half-year 1917-1973 *



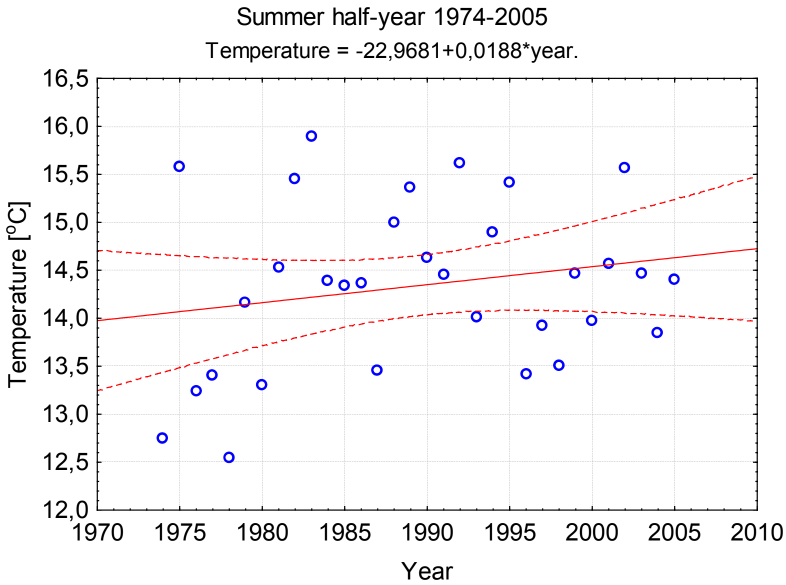
Winter half-year 1974-2005 **



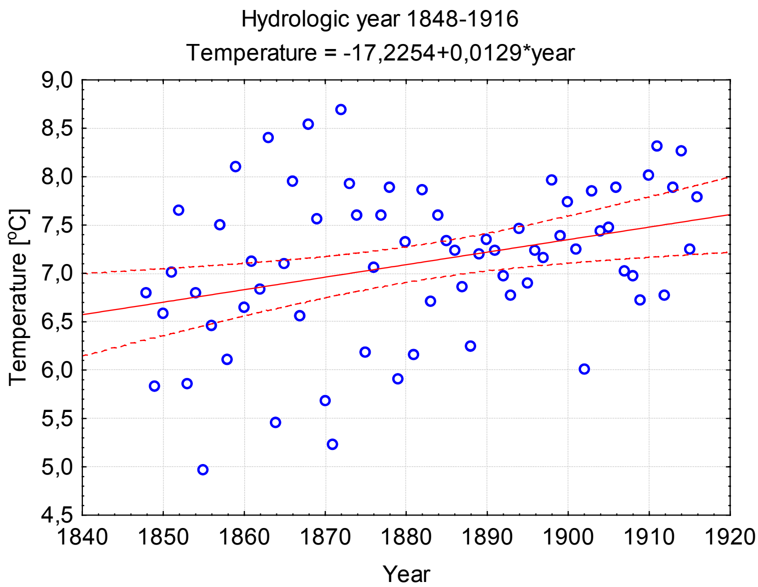
Summer half-year 1848-1916 **



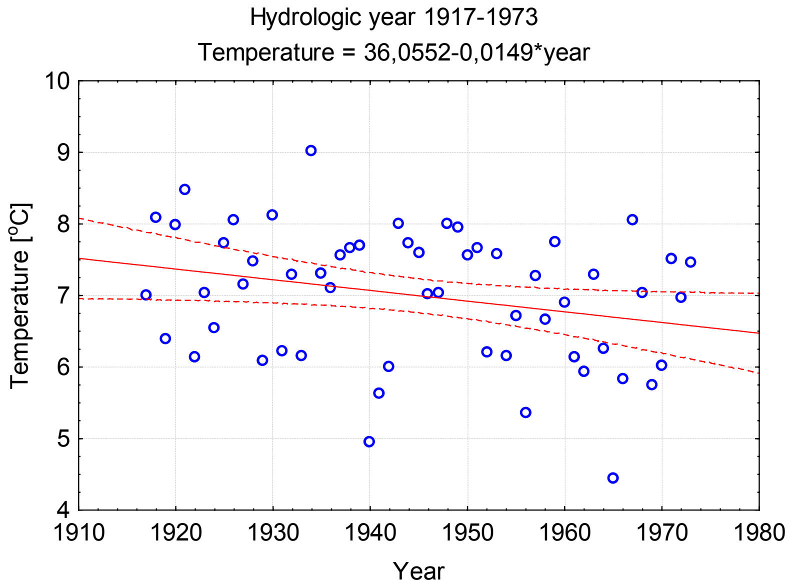
Summer half-year 1917-1973 *



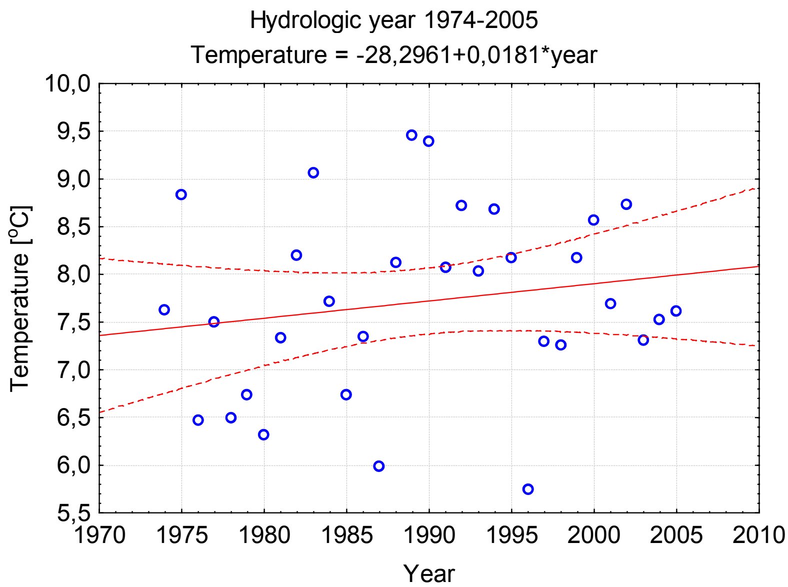
Summer half-year 1974-2005 **



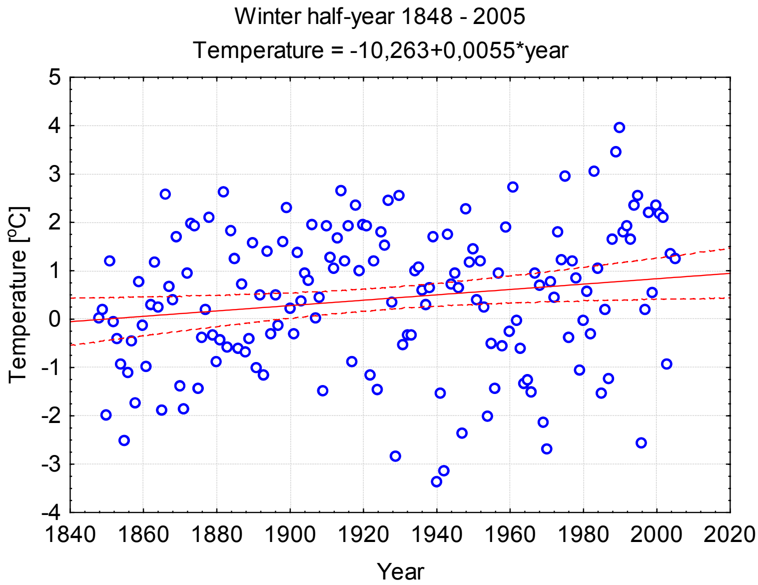
Hydrological year 1848-1916 *



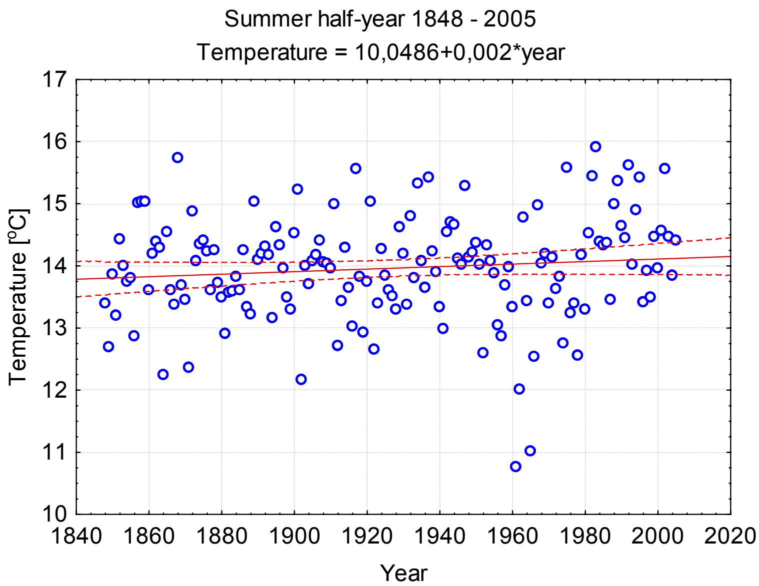
Hydrological year 1917-1973 *



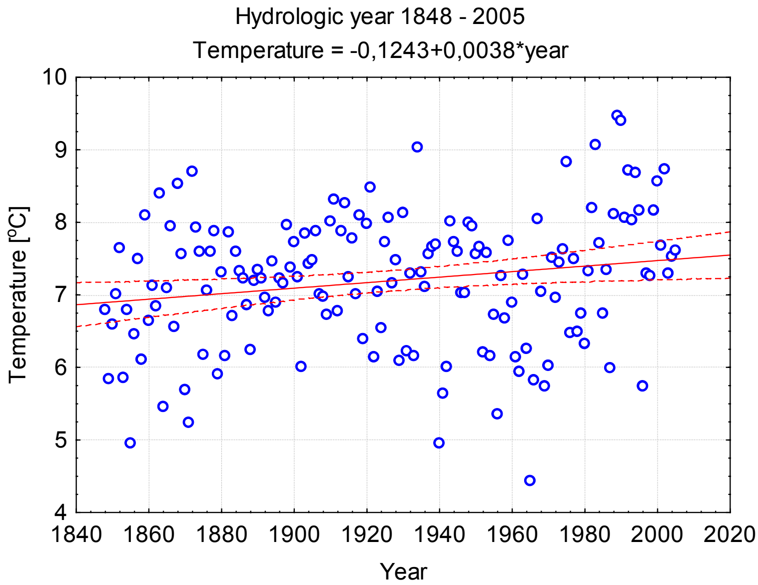
Hydrological year 1974-2005 **



Winter half-year 1848-2005 *



Summer half-year 1848-2005 **

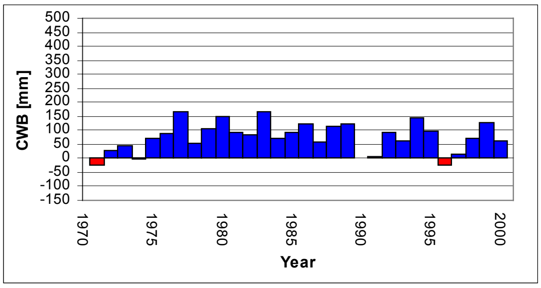


Hydrological year 1848-2005 *

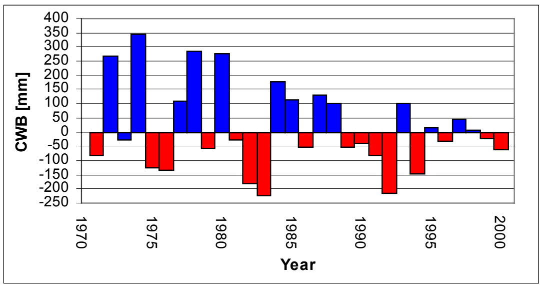
Figure 2. Trends of mean air temperatures in the Dopływ spod Nowej Wsi catchment for the hydrological year, winter and summer half-year in 1848-1916, 1917-1973, 1974-2005 and 1848-2005 (*statistically significant trends at α = 0.05, **statistically insignificant trends at α = 0.05)

Trends of precipitation were not identified for the period from 1951 to 2000. Annual precipitation range was high during the investigated period with high frequency of precipitation close to average. Dry hydrological year periods occurred from 1951 to 1955, 1960 to 1965 and 1990 to 1995, while wet ones occurred from 1955 to 1961 and 1976 to 1980. Precipitation of the winter half-year was rather more stable than summer half-year. Dry winter half-year periods occurred from 1961 to 1965, 1970 to 1975, while wet from 1981 to1985. Dry summer half-year periods occurred from 1951 to 1955, 1961 to 1965 and 1991 to 1995, while wet ones occurred from 1956 to 1960 and 1971 to 1980. The periods of air temperature increase coincided regularly with the period of precipitation increase. Precipitation was usually higher than the average during the periods of the lowest mean air temperatures. Abovementioned regularity changed in the late eighth decade of 20th century. Precipitation decreased significantly and air temperatures increased (fig. 1).

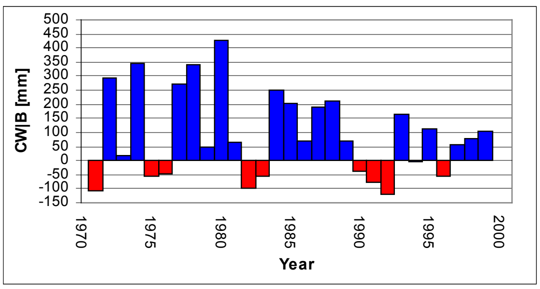
Mean climatic water balance in period from 1970 to 2000 for the hydrological year and winter half-year periods were positive and equalled 75 and 88 mm. Significant deficit of climatic water balance occurred in the period of late eighth and early ninth decade of 20th century. Climatic water balance in the period form 1989 to 1993 year was negative and equalled -60 mm. The period of the highest water balance positive values occurred in the late seventh and early eight decade of 20th century. Climatic water balance equaled 1152 mm for the period from 1977 to 1981. In general, the seventh decade of 20th century was the period of positive water balance without prolonged climatic water balance deficit (fig. 3).



Winter half-year



Summer half-year



Hydrological year

Figure 3. Climatic water balance (CWB) in the Dopływ spod Nowej Wsi catchment for the hydrological year, winter and summer half-year periods of 1971-2005

CONCLUSIONS

1. The cause of periodical occurrence of pond water storage in Dopływ spod Nowej Wsi catchment, observed as qualitative phenomenon, could be ascribed to long-term processes of meteorological conditions changes which influence local hydrological balance. Important influence factors should be sought in long-term periods shaping evapotranspiration. Two periods, for which evapotranspiration was stimulated (1848-1916 and 1974-2005) and one period, for which evapotranspiration was destimulated (1917-1973), were identified. The processes occurring in these periods influenced water alimentation and increase or decrease of water storage of the investigated spatial units (the Dopływ spod Nowej Wsi catchment and Bagna Ramuckie pond). Air temperature trends were determined by the winter half-year period temperature changes. The winter half-year is the main period catchment of recharge.
2. Dynamics of precipitation had minor significance in modulating water storage for the long-term periods. Precipitation trends were not identified for the period from 1950 to 2001. The analysis of long meteorological data series measured at least from the beginning of 19th century in other locations in Poland confirm that directional changes of precipitation does not usually occur over Poland [e.g. Miler i Miler 2000, Boryczka i Stopa-Boryczka 2004]. For the majority of shorter periods, i.e. covering a few years, high precipitation stimulated rebuilding and stabilization of water storage in the Bagna Ramuckie pond. These periods occurred in 1958-1963, 1972-1974 and 1978 -1980. Noticeable significance for producing additional hydrological effect can be also put to episodes of prolonged and high snow storage, e.g. in 1980.
3. Rebuilding of stable pond water storage in the Bagna Ramuckie pond began around middle of the sixth decade and declined in the first half of ninth decade of 20th century. The area of pond was 12.5 ha with maximum pond depth 2.1 m in 1981 year. Analysis of archive documentation confirms that pond water storage occurred also before and declined in the second half of 19th century. Stable forms of water storage occurring in the Dopływ spod Nowej Wsi catchment in forms of lakes, ponds and marshland areas were partly a result of climate cooling which lasted from the late Middle Ages until the middle of 19 century [Trepińska 2001]. Air temperature trends along with extensive drainage works caused the decline of water storage in the Bagna Ramuckie pond in the second half of 19th century. However, it is difficult to determine exact hydrological role of each factor or which of the factors prevailed. The next episode of water storage rebuilding in the Bagna Ramuckie pond occurred in sixth to ninth decade of 20th century under unchanged non-climatic physiographic conditions and stationary water management practice. Thus, climatic factor should be recognized as decisive in the pond storage rebuilding.

4. Water storage rebuilding occurred under conditions of long-term air temperature decrease. The decrease trend preceding initiation of surface water rebuilding at the Bagna Ramuckie pond lasted almost 40 years and the total decline of surface water in the pond occurred after a 20-year period of air temperature increase trend. Spectacular effect of surface water rebuilding in the pond can be attributed to frequent extreme meteorological phenomena. Absolute annual temperature minima occurred together with high precipitation in the fifth and sixth decade of 20th century. Stability of pond water storage can be explained by climatic water balance dynamics. Higher precipitation periods, unfavourable for water storage, coincided usually with higher evapotranspiration periods. However, abovementioned regularity ceased to act in the beginning of the ninth decade of 20th century, which resulted in rapid water storage decline in the Bagna Ramuckie pond.

5. Geological and geomorphologic conditions of the Dopływ spod Nowej Wsi catchments support high water storage capacity, which should explain temporal length of pond storage rebuilding process. High depth of permeable sand and gravel cover with porosity 24-35 %, low hydraulic gradients of aquifer bottom (1,3 ‰), high proportion of terrain and aquifer bed depressions, lack of valley slops convergence to mainstream determine high water storage capacity and delayed storage response of the Bagna Ramuckie pond.

REFERENCES

Achremczyk S. 1992. *Historia Warmii i Mazur: od pradziejów do 1945 roku*. Bibl. Olszt. Nr 18.Wyd. OBN im. W. Kętrzyńskiego.

Barczewski W. 1984. *Kiermasy na Warmii i inne pisma wybrane*. Wyd. Pojezierze. Olsztyn.

Boryczka J., Stopa-Boryczka M. 2004. *Cykliczne wahania temperatury i opadów w Polsce w XIX-XXIw.*, Acta Agrophysica, 3(1): 21–33.

Dane z stacji IMGW Poznań-Ławica za lata 1848-2005, 2005, IMGW, Poznań, (maszynopis).

Dane ze stacji UWM Tomaszkowo za lata 1848-2005, 2007, UWM, KMiK, Olsztyn.

Dokumentacja ewidencyjna obiektów melioracyjnych dla obrębów Butryny, Przykop, Nowa Wieś. ZSW w Olsztynie, 2007. (maszynopis).

Kondracki J. 2002. Geografia regionalna Polski, PWN.

Mapa drzewostanowa nadleśnictwa Nowe Ramuki w skali 1:20000, 2007a, Nowe Ramuki.

Mapa drzewostanowa nadleśnictwa Nowe Ramuki w skali 1:25000, 1899, Nowe Ramuki.

Mapa drzewostanowa nadleśnictwa Olsztyn w skali 1:20000, 2007b, Olsztyn.

Mapa Karte für die Manöver der 1. u. 2. Division u. des 1. Armeekorps w 1:100.000. 1908.

Mapa Karte von Ost - Preussen nebst Preussisch Lithauen und West Preussen w skali 1:150 000 , Wartemburg (s17+23). 1809. Berlin.

Mapa komornictwa olsztyńskiego. XVII w. Delineatio geographica cameratus Allensteinensis. Arch. Diec. Warm. Olsztyn.

Mapa Messtischblatt Karte 2389 Wuttrinen (Butryny) w skali 1:25000. (Akt.1938).,1942, OKH. Berlin.

Mapa Passenheim w skali 1:100000 (Akt. 1924). (1931). WIG. Warszawa.

Mapa topograficzna w skali 1:10000. Arkusz 232.222 Przykop (Akt. Top. 1980, kart. 1981)., 1981a, GEOKART. Warszawa.

Mapa topograficzna w skali 1:10000. Arkusz 232.224 Nowa Kaletka (Akt. Top. 1980, kart. 1981)., 1981b, GEKART. Warszawa.

Mapa topograficzna w skali 1:10000. Arkusz 233.111 Nowa Wieś (Akt. Top. 1980, kart. 1981)., 1981c, GEOKART. Warszawa.

Mapa topograficzne w skali 1:10000. Arkusz 222.444 Ruś (Akt. Top. 1980, kart. 1982)., 1982a, PPGK. Warszawa.

Mapa topograficzne w skali 1:10000. Arkusz 223.333 Purda (Akt. Top. 1980, kart. 1982)., 1982b, PPGK. Warszawa.

Mapa w skali 1:10000. Arkusz 233.113 Małaszewo (Akt. Top. 1976, kart. 1980)., 1980, GEOKART. Warszawa.

Miler A.T., Miler M. 2000. *Trendy i okresowości zmian temperatury oraz opadów dla Poznania w latach 1848-2000.* Zesz. Nauk. Wydz. Bud. Inż. Środ., Inż. Środ. 22, Wyd. Politech. Koszal., 945-956.

Okoński B. 2007. *Koncepcja odtworzenia leśnych obszarów mokradłowych „Bagna Ramuckie" w Nadleśnictwie Nowe Ramuki*. KIL. AR Poznań. (maszynopis).

Plan Urządzania Lasu Nadleśnictwa Nowe Ramuki na lata 2005-2014. Nadleśnictwo Nowe Ramuki. 2005. (maszynopis)

Solarski H., Błaszczyk M., Solarski K. 2005. Drenowanie gruntów ornych na obszarach morenowych pojezierza Mazurskiego. Roczniki AR Poznań. Ser Melior. Inż. Środ. CCCLXV. Poznań: 401–407.

Studium uwarunkowań i kierunków zagospodarowania przestrzennego Gminy Purda. 1999. (maszynopis).

Trepińska B. 2001. Fluktuacje termiczne w Europie od małej epoki lodowej do końca XX wieku. Postęp badań zmian klimatu i ich znaczenie dla życia i gospodarczej działalności człowieka. Wyd. WGSR UW, Warszawa.

Dr Bernard Okoński
Uniwersytet Przyrodniczy w Poznaniu
Katedra Inżynierii Leśnej
Mazowiecka 41, 60-623 Poznań
tel. 61 846 61 13, fax 61 848 73 66
okonski@up.poznan.pl

Prof. dr hab. Antoni T. Miler
Uniwersytet Przyrodniczy w Poznaniu
Katedra Inżynierii Leśnej
Mazowiecka 41, 60-623 Poznań
tel. 61 848 73 66, fax 61 848 73 66
amiler@up.poznan.pl

Dr Monika Panfil
Uniwersytet Warmińsko-Mazurski w Olsztynie
Katedra Meteorologii i Klimatologii
Pl. Łódzki 1, 10-957 Olsztyn-Kortowo
tel. 089 523 33 58, fax 61 848 73 66
monika.panfil@uwm.edu.pl

Reviewer: *Prof. Stanisław Węglarczyk, Ph. D, Dr. Sc.*