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# The role of ponds in modification of water relations in forest microcatchments in the Siemianice Forest Experimental Station

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**Abstract:** The study presents results of investigations conducted in catchments of three forest ponds in the hydrological year 2003/2004. Results showed a significant role of ponds in water relations of their microcatchments. Water retained in ponds nos. 1 and 6 in the periods of precipitation deficiency supplied ground waters of adjacent forest sites. In turn, pond no. 5 retained water flowing in from adjacent sites throughout the hydrological year, contributing to optimal moisture levels of these sites. Calculations concerning dependencies of changes in water retention in the analyzed ponds with changes in moisture contents in the 0 - 100cm layer of adjacent sites showed the relationships were strong. The correlation coefficient for the dependence calculated fro the entire hydrological year 2003/2004 was 0.71, the relationship being significant at $\alpha = 0.05$.

**Key words:** water relations, forest catchment, typological soil map, forest pond, retention changes, headstream waters

## Introduction

Ponds, being elements of the so-called small retention, play a significant role in water relations of forest areas. According to (Drwal and Lange 1985), most frequently these ponds are numerous dead ice depressions, permanently or periodically filled with water, serving the function of natural regulators of water circulation in their catchments. As it was reported by (Kucharski 1996), a typical phenomenon observed in interior depressions is the considerable fluctuation in levels of surface water, which in dry years may disappear entirely. In contrast, in periods of heavy rains the water rise may be so big that it exceeds retention capacity of reservoirs and then water floods the nearest areas. According to (Major 2003), geomorphologists have focused on interior forms as elements of surface features for a long time; however, to date there have been few studies concerning the functioning of interior depressions in the contemporary landscape of the last glaciation zone. Reliable knowledge on the effect of forest ponds on adjacent sites justifies the necessity to protect the ponds themselves as well as increase water resources in their catchments (Szafrański and Korytowski 2004).

When analyzing the role of forest ponds in water relations of their microcatchments it is essential to determine the fluctuations in water levels in these ponds in view of the changes in basic weather conditions, which to a considerable degree may contribute to the assessment of the degree, in which they affect water relations in adjacent sites.

The aim of the study was to determine the role of forest ponds as modifying water relations in their microcatchments and especially to assess the effect of these reservoirs on the supply of ground waters in adjacent forest sites.

## Methods

The study presents results of investigations conducted in the hydrological year 2003/2004 in catchments of three forest ponds located in the Siemianice Forest Experimental Station in the Wielisławice Forest District (pond no. 1) and in the Laski Forest District in case of ponds nos. 5 and 6 (Fig. 1).

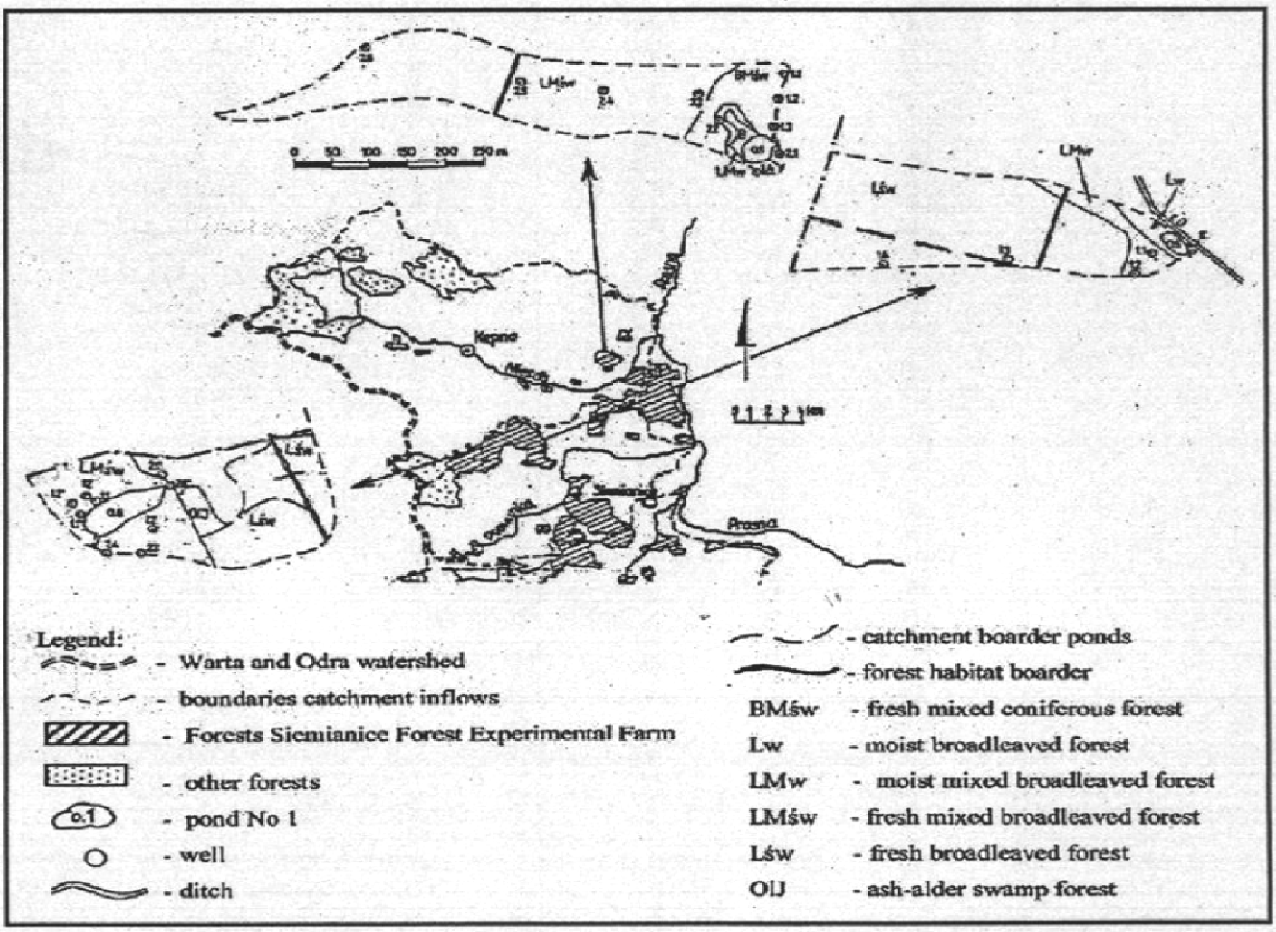


Fig. 1. Location of catchments of forest ponds nos. 1, 5 and 6 in the Siemianice Forest Experimental Station

Forests in these forest districts are located within the Southern Wielkopolska Lowland in the Wieruszów Plateau, a denuded moraine plain cut across by the upper course of the Prosna River (Kondracki 1978). Catchments of the analyzed forest ponds are located in the basins of the Niesób and Pomianka Rivers, being left-bank tributaries of the Prosna.

Analyzed forest ponds nos. 1 and 6 are interior ponds. They are 0.13 and 0.35 ha in area, respectively, at the mean depth of 1 m. Ponds nos. 1 and 6 are thawed-out ponds located within the Würm glaciation zone (Kosturkiewicz et al. 2002). In turn, the runoff pond no. 5 is of anthropogenic origin. This reservoir is intensively supplied with headstream waters from adjacent areas. It is characterized by slight variation in water levels as the amount of water flowing out of this pond is balanced by the headstream inflow.

The predominant forest site type in the catchments of analyzed ponds is fresh mixed broadleaved forest, which covers approx. 95% area, while the dominant species in the stand is pine aged 90 years. The soil cover in analyzed catchments varies considerably. Lessive brown soils predominate in the catchment of pond no. 6, covering approx. 60% catchment area, while in the catchment of pond no. 1 it is podzolic brown soils covering 90% area. In turn, in the catchment of runoff pond no. 5 most of the area (60%) is covered by proper acid brown soils. The most common soil textural group in analyzed catchments is slightly loamy sand.

Water levels in the ponds were measured using staff gauges installed there. In turn, ground water levels were measured in wells drilled in sections penetrating representative sites. Wells located nearest investigated forest ponds were selected for analysis (Fig. 1).

Water levels in ponds and ground water levels in selected wells were measured once a week. Weather conditions in hydrological year 2003/2004 are described on the basis of results recorded at the rain gauging station and observations at the weather station of the Siemianice Forest Experimental Station. Changes in water retention in analyzed forest ponds were determined on the basis of changes in water lev-

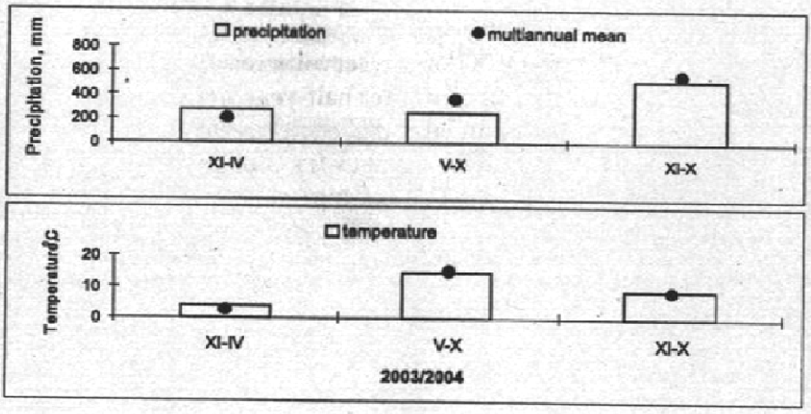


Fig. 2. Half-year and annual precipitation totals and mean air temperatures in hydrological year of 2003/2004 in view of multiannual means for the period 1974/75 - 2000/2001 at the weather station of the Siemianice Forest Experimental Station.

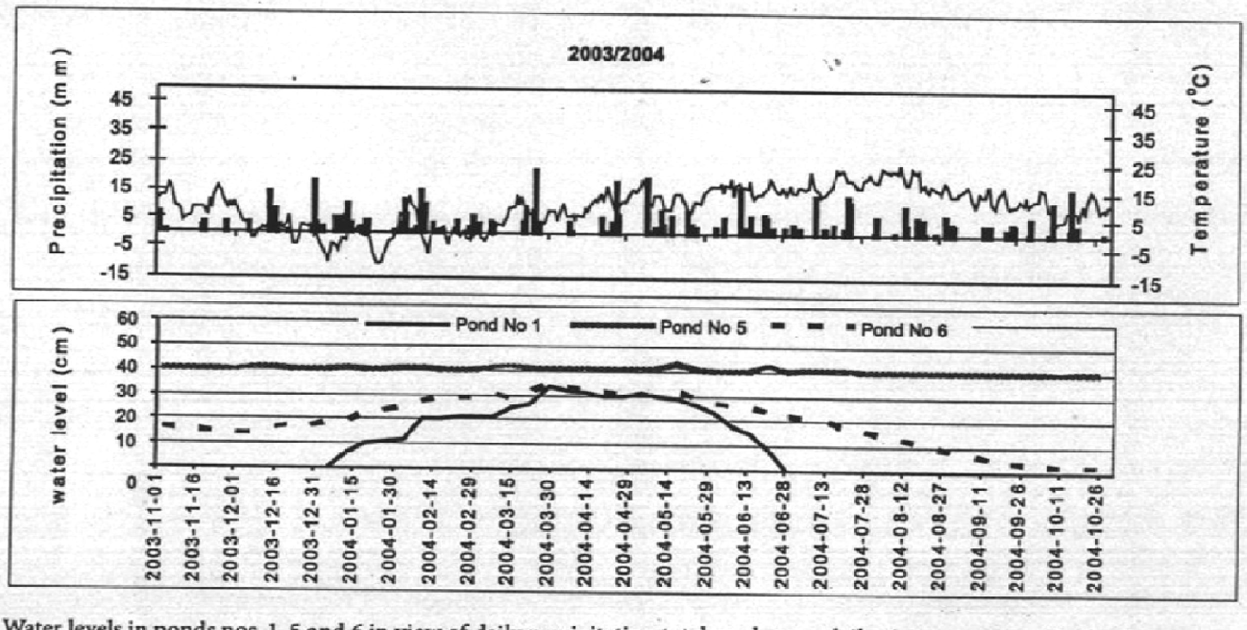


Fig. 3. Water levels in ponds nos. 1, 5 and 6 in view of daily precipitation totals and mean daily air temperatures in the Siemianice Forest Experimental Station in hydrological year 2003/2004

els in those reservoirs. In turn, changes in soil moisture levels in forest sites adjacent to those ponds in a 0 – 100 cm layer were determined based on recorded moisture levels in the analog microcatchment located in the Siemianice Forest Experimental Station. This microcatchment is similar in terms of soil and site conditions to catchments of analyzed ponds. Moisture levels were determined using the drying gravimetric method at the beginning and end of each hydrological half-year. Ranges of forest site types in catchments of investigated ponds were assumed following the typological soil map (Operat…1999).

## Results and Discussion

The analyzed hydrological year (XI-X) of 2003/2004 was an average year, in which precipitation total was 538 mm, being by 34 mm lower than the multiannual average (Fig. 2).

In turn, mean temperature was 9.5°C and it was similar to the multiannual average. That year the winter half-year (XI-IV) was very humid, with precipitation total of 278 mm, being higher than the multiannual average by 71 mm. Probability of such a precipitation total or higher is 14%, i.e. one in approx.

seven years. Mean air temperature in that half-year was 3.9°C. In contrast, the summer half-year (V-X) of 2004 was very dry, as precipitation total was 260 mm and it was by 105 mm lower than the multiannual mean at the mean air temperature of 15°C. Probability of such a precipitation total or lower is 81%, i.e. one in approx. five years.

At the beginning of the winter hydrological half-year of 2003/2004 in pond no. 1 water table was not found (Fig. 3). In the two other analyzed ponds nos. 5 and 6 the water table was observed starting from the beginning of that half-year and water levels were on average 40 cm and 15 cm, respectively. Precipitation total of 52 mm, i.e. such as that recorded in the second and third decade of December, resulted in the appearance of water table in pond no. 1. Starting from the third decade of December to the end of March water levels in ponds nos. 1 and 6 were rising. On 29 March in those reservoirs maximum water levels of the analyzed winter half-year were recorded, amounting to 34 cm and 35 cm, respectively. In turn, in pond no. 5 water levels did not vary considerably and in that period remained at an average of 41 cm. Starting from the beginning of April to the end of the winter half-year water levels in ponds nos. 1 and 6 were dropping.

It was caused by the weather conditions in the first two decades of April, when at the mean air temperature for that period of 8.4 C, precipitation total was only 10 mm. At the end of the winter half-year water levels in ponds nos. 1 and 6 were 30 cm. In contrast, in pond no. 5, in which fluctuations of water levels were seriously affected by it being supplied by the headstream water, the water level did not change and amounted to 41 cm.

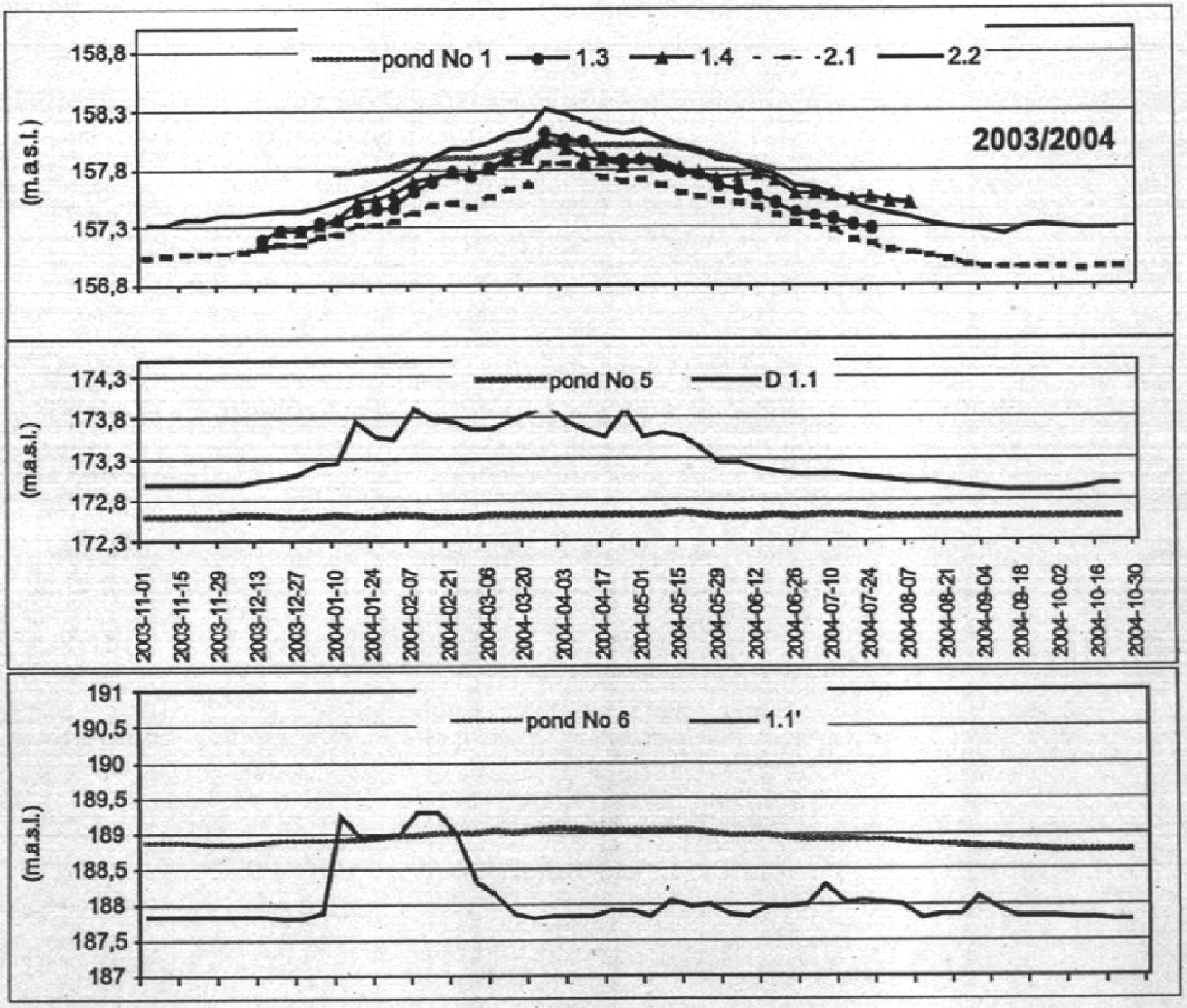


Fig. 4. Altitudes of water levels in ponds nos. 1, 5 and 6 and ground water levels in catchments of ponds, in wells located closest to ponds, in hydrological year 2003/2004.

Table 1. Number of days when ground waters in adjacent forest sites were supplied by waters of ponds nos. 1, 5 and 6 and pond waters were supplied by ground waters from adjacent sites in hydrological year 2003/2004

| Pond No. | Well | Number of days | |
|---|---|---|---|
| | | Ground waters in adjacent sites by pond waters | Pond waters by ground waters in adjacent site |
| 1 | 2.1 | 160 | - |
| | 1.4 | 160 | - |
| | 1.3 | 139 | 21 |
| | 2.2 | 68 | 92 |
| 4 | 4.1 | - | 92 |
| 5 | 1.1 | - | 365 |
| 6 | 1.1' | 323 | 42 |

Total precipitation of 21 mm, observed at the beginning of the summer half-year between 7 and 16 May, resulted in the maximum water levels of that half-year being recorded in analyzed ponds. In ponds nos. 1 and 6 maximum water levels were 30 and 31 cm, respectively (Fig. 3). In contrast, in pond no. 5 maximum water level was 43 cm and at the same time it was the maximum for that pond for the entire analyzed hydrological year. From the last decade of May, at mean air temperature for the summer half-year of 15°C and intensive evaporation from the surface of the ponds, water levels in reservoirs nos. 1 and 6 started to subside. On 28 June water table disappeared in pond no. 1. Water table did not appear in that pond until the end of the summer half-year. In turn, in pond no. 6, in which water level was also dropping, at the end of the half-year it was only 2 cm and was by 29 cm lower than that found in that pond at the beginning of the summer half-year. In pond no. 5, characterized by the lowest variation in water levels, at the end of the summer half-year it was 40 cm.

When analyzing the effect of investigated ponds on water relations in adjacent areas it may be stated that they play a crucial role. Results recorded in the hydrological year of 2003/3004 showed that water retained in ponds nos. 1 and 6 supplied adjacent forest sites. Forest pond no. 1 supplied adjacent areas located in the direction of wells nos. 2.1 and 1.4 throughout the period when the water table was found in the pond. Altitudes of the water table in that pond were recorded to be below altitudes of ground water in analyzed wells for 160 days, i.e. from 10 January to 26 June (Fig. 4, Tab. 1). In turn, the period in which adjacent areas were supplied by waters of the pond from the direction of wells nos. 1.3 and 2.2 was shorter and lasted for 139 and 68 days, respectively. In the period from 16 February to 17 May altitudes of the ground water table from the direction of well no. 2.2 remained above altitudes of water table in the pond and for 92 days ground waters from the direction of that well supplied waters of the pond. To a limited degree, i.e. only for 21 days, the analyzed pond was also supplied by ground waters from the direction of well no. 1.3. The longest lasting supply of water in pond no. 1 with ground waters from the adjacent site from the direction of well no. 2.2 resulted from its location in the land channel, to which ground waters from higher areas of the catchment flow in.

In case of pond no. 6 adjacent forest sites were also found to be supplied by pond waters. Adjacent areas were supplied by pond waters for 323 days (Fig. 4, Tab. 1). In turn, ground waters of adjacent sites supplied waters of the analyzed pond to a limited degree from the direction of well no. 1.1'. Altitude of ground water table in that well remained above the altitude of water table in the pond for 42 days, from 12 January to 23 February. The primary factor supplying this pond was precipitation falling directly onto its surface.

In the analyzed hydrological year of 2003/2004 man-made pond no. 5 did not supply adjacent forest sites with its waters. Ground waters of adjacent sites throughout the period of the study supplied this pond, as altitude of ground water table from the direction of well no. 1.1 remained at a level above the altitude of water table in the pond throughout the entire hydrological year and those waters supplied pond water for 365 days (Fig. 4, Tab. 1).

Figure 5 presents changes in retention in the analyzed forest ponds and in the 0 -100 cm layer of

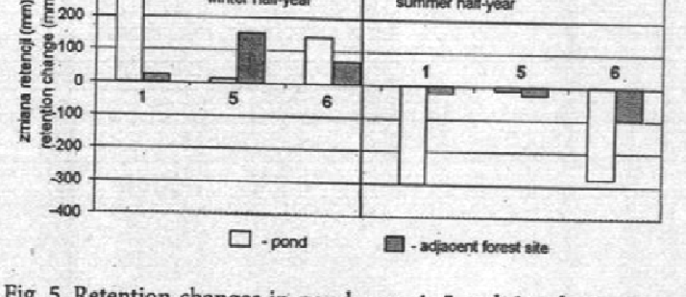


Fig. 5. Retention changes in ponds nos. 1, 5 and 6 and retention changes in adjacent sites in winter and summer hydrological half-years 2003/2004.

adjacent forest sites in the analyzed hydrological year 2003/2004. Both in the winter and summer half-years of that year changes in water retention in those ponds were bigger than changes in retention in soils of sites adjacent to those ponds. In the winter hydrological half-year in ponds nos. 1 and 6 retention increments were 300 and 140 mm, respectively, and exceeded retention increments in the adjacent area by 278 and 71 mm. In turn, the smallest retention increment was recorded in pond no. 5, where it was only 10 mm. In the very dry summer half-year of the analyzed hydrological year retention decrements were recorded in all analyzed ponds and in the adjacent forest sites. In ponds nos. 1 and 6 retention decrements were 300 and 280 mm, respectively. They exceeded retention decrements in adjacent sites by 280 and 185 mm. It needs to be stressed that retention decrement found in that half-year in pond no. 1 caused the disappearance of the water table in that pond. In turn, in pond no. 5 the decrement in the summer half-year of 2003/2004 was smallest, amounting to 11 mm.

Analysis of changes in retention in analyzed ponds and those in adjacent sites showed that forest ponds have a significant effect on moisture levels of those sites. This is also confirmed by calculated relationships of water retention changes in analyzed ponds with changes in water retention within the 0 – 100 cm layer of adjacent sites. The correlation coefficient for the dependence calculated for the analyzed hydrological year of 2003/2004 was 0.71 (Fig. 6) and it was significant at $\alpha$=0.05.

## Conclusions

1. Investigations showed that forest ponds discussed in this study are of various origin. Ponds nos. 1 and 6 are thawed-out and interior ponds. In turn, forest pond no. 5 is a runoff pond, intensively supplied by headstream waters from adjacent areas. It was created as a result of human activity, as it is shown by its regular shape.
2. Analyses confirmed that investigated ponds nos. 1 and 6 react more intensively to climatic factors than soils in forest sites adjacent to those ponds. Both in case of retention increments in the winter half-year, which were primarily caused by a higher precipitation total as well as decrements in the summer half-year resulting from high evaporation, those values in ponds are always higher than in the adjacent sites.
3. Investigations showed that water retained in ponds nos. 1 and 6 supplied ground water in adjacent forest sites. The period of this supply ranged from 68 to 323 days. In turn, the period when ponds were supplied by adjacent areas was shorter, lasting from 42 to 92 days.
4. Another course of retention changes was found in pond no. 5, which was intensively supplied by headstream waters from adjacent areas throughout the year. That pond was characterized by slight variation in water levels. Thus, changes in retention in that pond were slight and smaller than those recorded in the moist mixed broadleaved forest site adjacent to the pond.
5. Retention changes in ponds analyzed in this study are closely related to changes in retention in adjacent forest sites. The correlation coefficient for the relationship of retention changes in ponds with retention changes in the 0 – 100 cm layer in adjacent sites in the hydrological year of 2003/2004 was 0.71 and it was significant at $\alpha$=0.05.

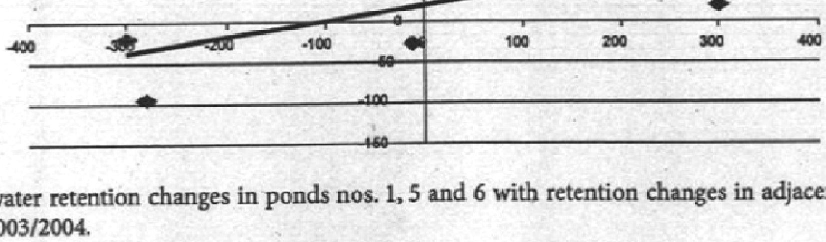


Fig. 6. The relationship of water retention changes in ponds nos. 1, 5 and 6 with retention changes in adjacent sites in the 0 – 100 cm layer in hydrological year 2003/2004.

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