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VARIABILITY OF GROUNDWATER LEVEL DEPTH IN UNEVEN-AGED FOREST STANDS OF MARSHLAND HABITATS

Summary

The paper covers research on groundwater level depth dynamics in uneven-aged forest stands of swamp habitats as influenced by meteorological conditions (air temperature and rainfall). The research period comprised hydrological years 2002-2005 with 7 experimental plots examined. The area of investigation was located in Puszcza Zielonka ca 6 km NE of Poznań.

It has been found that the highest dynamics of groundwater level depth occurs for the experimental plots of the middle-aged stands, the lowest dynamics of groundwater depth level occurs for the older forest stands (80 to 100 years) and in lesser extent in the youngest forest stands (up to 20 years). However it should be noted that the research data were collected in a short time span, thus the conclusions concerning relations between groundwater level and forest stand age described here should only be considered as a initial thesis requiring further explanation to be proven or rejected in the course of further research.

Key words: groundwater level depth, swamp habitats, Puszcza Zielonka Forest

INTRODUCTION

Meteorological characteristics (e.g. precipitation, air temperature) are the main factors affecting hydrological conditions at the catchment level. Nevertheless, significant modulating influence should be ascribed to other non-climatic physiographical features of catchments [Dobija i Dynowska 1975]. One of these factors is forest cover (e.g. characteristics of forest habitat or forest stand age and species structure). Forest cover is considered as a local form of lowland water storage, namely landscape storage [Miler 1998]. It is commonly known that good water management practice is the precondition of sustainable biomass production and, in general, crucial to sustainable forest support. Thus, it is recommended, particularly for the areas of forest soils with unstable water conditions, that decisions over forest management operations should be preceded with thorough analysis of local hydrology [Suliński 1998].

The issue of forest stand age influence on ground water level at forest swamp sites, respectively alder swamp forest and ash-alder swam forest was considered in the course of research described in the paper. The main research question set there to answer was if, and to what extent age of forest stands modulates the ground water level.

MATERIALS AND METHODS

The research area was located in Puszcza Zielonka Forest, ca 6 km NE of Poznan, Poland. The uneven-aged forest stands placed in forest swamp habitats of alder swamp forest and ash-alder swamp forest were selected. At the experimental plots 23 wells were placed in 2001 year. The groundwater level measurements were performed on weekly basis with 1 cm accuracy. Initially, the measurements were carried out in all the wells, but since hydrological year 2003, 7 locations were selected. The measurements were performed for the selected locations on monthly cycle basis.

Total research period covered the 2002-2005 hydrological years. The verification of research thesis was to be achieved through comparison of basic statistical parameters of groundwater level dynamics calculated for measuring wells and through the analysis of groundwater dynamics charts. Groundwater measurement results were presented against the forest stand age categorized on the basis of the average values onto forest stand age classes.

Meteorological data for the research period assessment and comparison against long-term data were acquired from the Agriculture University of Poznan meteorological station located in the central area of the Puszcza Zielonka Forest. [Grodzki i Zientarski 1986-2002, Wyniki… 2000-2005].

RESULTS

General forest site and stand characteristics of the investigated experimental plots are set in Table 1. The pluvial and thermal conditions of the research period are presented against the long-term period 1987-2005 (tab. 2). The average annual temperature in the 2003 and 2005 hydrological year was lower than the long-term average temperature respectively by 9 and 2%, but for the 2002 and 2004 years the average annual temperature was higher by 10 and 2% respectively. As for the half-year periods, the relatively low average annual temperature of the 2003 year was the result of cold winter period. The average temperature of the summer half-year was significantly higher in 2003 than the long-term average. As a result the year 2003 was one of the coldest and the summer season was the most dry of the long-term period 1987-2005 (64% of average annual precipitation).

Table 1. Basic forest site and stand characteristics for the experimental plots

Characteristic \ Forest division	Zielonka		Łopuchówko				
Compartment	73g	86k	129f	86a	85f	106l	77h
Area [ha]	0.28	4.05	4.47	7.87	2.99	3.39	1.07
Forest site type	Ol[1]	OlJ[2]	Ol[1]	Ol[1]	Ol[1]	Ol[1]	OlJ[2]
Soil texture	tn/py[3]	tn/py[3]	tn/py[3]	tn/gyw[4]	tn/gyw[4]	pl/żp[5]	pl/żp[5]
Tree stand age class	IV	V	I	I	III	II	IV
Degree of crop density	0.6	1.0	1.0	0.8	0.8	0.8	0.8
Average diameter at breast high [cm]	25.5	36.5	2.5	1.5	19.0	12.0	27.5
Average height [m]	18.5	23.5	4.0	3.0	19.5	9.5	25.5
Stand volume [$m^3 \cdot ha^{-1}$]	125	330	–	–	210	–	330
Current annual increment [$m^3 \cdot ha^{-1}$]	3.0	5.5	5.7	–	5.6	6.4	5.8

[1] – Alder swamp forest,
[2] – Ash-alder swamp forest,
[3] – Peat on silt (up to 0,8m),
[4] – Peat on limy gytia (up to 0,8m),
[5] – Fine sand on sandy gravel.

Table 2. Average annual air temperature (T) and annual precipitation (P) for the period 2002-2005

Hydrological year	T [^{o}C]			P [mm]		
	Half of the year		All year (XI-X)	Half of the year		All year (XI-X)
	Winter (XI-IV)	Summer (V-X)		Winter (XI-IV)	Summer (V-X)	
2002	2.8	15.8	9.3	264	306	570
2003	0.2	15.2	7.7	161	180	341
2004	2.6	14.7	8.6	186	314	500
2005	2.3	14.2	8.3	217	353	570
Mean (1987-2005)	2.2	14.6	8.4	210	320	530
Min (1987-2005)	-1.7	13.4	5.9	104	151	341
Max (1987-2005)	4.0	15.8	9.4	319	460	655

The groundwater level measurements and the standard statistics of groundwater dynamics categorized for each experimental plot are shown in Table 3.

Table 3. Selected statistics of average groundwater level depth (h) for the experimental plots according to tree stand age classes

Hydrological year	Statistics	Tree stand age lass				
		I	II	III	IV	V
2002	$\bar{h}$ [cm]	88	98	106	112	94
	h_{min} [cm]	70	72	71	80	79
	h_{max} [cm]	105	115	160	148	109
	Δh [cm]	36	43	89	68	30
	σ [cm]	12	15	33	22	10
2003	$\bar{h}$ [cm]	88	95	115	114	93
	h_{min} [cm]	55	62	59	70	71
	h_{max} [cm]	131	126	181	160	119
	Δh [cm]	76	64	122	90	48
	σ [cm]	29	24	44	34	14
2004	$\bar{h}$ [cm]	85	95	101	108	87
	h_{min} [cm]	59	69	63	70	71
	h_{max} [cm]	113	113	153	143	99
	Δh [cm]	54	44	90	73	28
	σ [cm]	17	14	28	26	10
2005	$\bar{h}$ [cm]	98	102	117	126	91
	h_{min} [cm]	70	71	82	95	74
	h_{max} [cm]	133	134	168	160	105
	Δh [cm]	63	63	86	65	31
	σ [cm]	19	21	30	21	10
2002 - 2005	$\bar{h}$ [cm]	90	97	110	115	91
	h_{min} [cm]	55	62	59	70	71
	h_{max} [cm]	133	134	181	160	119
	Δh [cm]	78	72	122	90	48
	σ [cm]	20	19	34	26	11

σ –Standard deviation

For the 2002-2005 period the depth of ground water level for the experimental plots situated in forest swamp sites of alder swamp forest and ash-alder swamp forest categorized by stand age class ranged from 55 to 181 cm b.g.s. The highest average annual groundwater levels (107 cm b.g.s.) were observed in the 2005 hydrological year (the minimum level 70 and the maximum 168 cm b.g.s respectively). The lowest groundwater levels were observed in the 2003 hydrological year (63 cm b.g.s.). The 2003 hydrological year was likewise noteworthy, as far as the amplitude of groundwater level is considered (the highest value 80 cm compared to the lowest of the 2002 year - 53 cm).

The pattern of groundwater dynamics compared by stand age category is similar for all the experimental plots (fig. 1). Thorough analysis of results allows drawing the following conclusions and make observations:

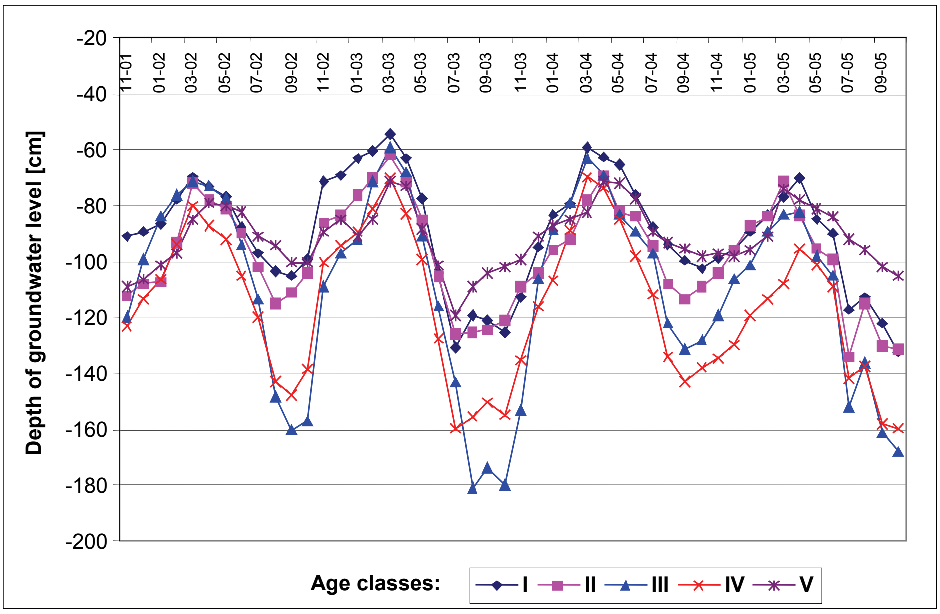

Figure 1. Dynamics of groundwater level depth for the experimental plots in the hydrological years 2002–2005 according to tree stand age classes

– The greatest changes of groundwater level occurred in vegetation period and should probably be considered as a result of plant uptake,

– Rebuilding of groundwater storage usually occurred in March, sometimes extending to April,

– During the period of three hydrological years, namely the 2002, 2003, 2004 years, the groundwater levels significantly decreased in experimental plots situated in forest stands of age classes II (stand age 20 to 40 years) and IV (stand age 60 to 80 years),

– The lowest variability and the steady pattern of groundwater level occurred for the forest stands of age class V (stand age 80 to 100 years) and to less extent in the forest stand of age class I (stand age 1 to 20 years),

– The highest dissimilarity of groundwater level dynamics patterns in vegetation period were observed for the year of the lowest precipitation (2003). The dissimilarity was noted between stand age class III (40-60 years) and the other forest stand age classes,

– The dissimilarity of groundwater dynamics pattern for stand age class V (80-100 years) and the other forest stand age classes in the vegetation period was noted for hydrologic year 2005.

DISCUSION

The pattern of groundwater level dynamics is a result of interactions between groundwater inflow, soil retention capacity and loss of water, namely due to evapotranspiration and outflow. Inflow of water is caused by precipitation, surface and subsurface flow input. Groundwater output is shaped by infiltration and percolation to groundwater soil zone and horizontal water movements [Spychalski 1998].

Variability of groundwater levels, especially at shallow water locations, tends to show cyclic regularity, modulated for particular years by irregularity of weather conditions – mainly the precipitation and temperature, but physiographical features such as soil, vegetation, drainage network, water bodies, surface relief affect water conditions significantly nevertheless as an exclusively modulating factor [Komisarek 2000, Miler i Przybyła 1997, Przybyła i Kozłowski 2003].

The results of the research prove the main effect of air temperature and precipitation on pattern of groundwater level dynamics in forest swamp habitats as a general regularity. The above mentioned conclusion supports additionally the results of recent research on climatic water balance for the area of experimental plots location [Okoński i Miler 2006].

Anyway, the question arises about no expected dissimilarity in groundwater level depth between the extreme years as far as precipitation is concerned (the years 2003, 2002 and 2005). No groundwater level dynamics decrease along with increase of groundwater level depth observed was another irregularity observed. Probably significant, modulating influence on groundwater dynamics in forest swamp sites may be ascribed to forest stand age [Grajewski 2004]. Along with maturing of forest stand, for example, changes the dynamics of stand biomass growth, which is strongly related to transpiration level and uptake of water from soil by plants. The phenomena described above may explain variability of groundwater level dynamics patterns for the experimental plots.

The results of research were affected by employing relatively short groundwater level data series and very inconsistent meteorological conditions of the research period (pluvial and thermal). Thus, the current stage of research cannot justify drawing more accurate and distinct conclusions. The thesis of forest stand age impact on groundwater level depth variability requires broader explanation and cannot be supported or rejected basing on the current research results. The project opened in 2002 year is continued to achieve assumed research objectives.

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