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EFFECT OF DRAIN-BLOCKING AND METEOROLOGICAL FACTORS ON GROUNDWATER TABLE FLUCTUATIONS IN KAMANOS MIRE

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Abstract. The study was carried out in a raised bog located in the Kamanos state reserve in northwestern Lithuania (56º16´N, 22º39´W). The area of the raised bog is 1722 ha. To assess the effect of meteorological factors and damming of drainage ditches on the water regime of the Kamanos mire, we have analysed the water table depth fluctuations over the last 22 years in the northern part of the mire, which was drained out in 1907, and the drainage ditch was dammed in 1999. The control plots were established in the central part of the raised bog without draining activities, where *Eriophorum vaginatum-Sphagnum spp.* communities prevail in the ground vegetation and small Scots pine trees may also be found.

The results showed that, in both natural and damaged-by-drainage sites of the raised bog, the air moisture deficiency and the amount of precipitation had a significant effect on the fluctuation of the water table depth during the growth period ($R^2 = 0.416 – 0.761$ $p < 0.05$). In comparison with the control plots, in 7 years after establishing dams in a 0.9–1.2 m deep ditch, the groundwater table increased by 9.8 to 12.2 cm in the area up to 980 m apart from the ditch. After damming the ditches in the extensively and intensively drained parts of the raised bog, the levelling out of the water table to a similar depth as in the control plots, occurred within 4 years and is forecasted to occur within 12 years, respectively. The water table of the drained sites of the raised bog was more sensitive to increasing annual temperatures than the water table in the undrained sites of the raised bog.

Keywords: hydrology, drainage blocking, meteorological factors, peatland, groundwater level.

1. Introduction

Presently, in most of the EU countries, including Lithuania, restoration of natural development and conservation of biodiversity in drained wetlands has become increasingly important. Furthermore, climatic change markedly affects natural development of the ecosystems in raised bogs. It is commonly recognized that global warming leads to drier eco-hydrological conditions, increased water table depth and succession of species communities (Faubert *et al.* 2004). In comparison with other wetlands, raised bogs are most isolated from the surrounding communities, therefore, raised bogs may be the most sensitive to climatic change. In raised bogs precipitation is the only source of moisture, and the water table depth is one of the most important indicators of the hydrological regime. According to Bragg (2002), the fluctuation of the water table depth reflects the overall balance of the surface water, certain components of which are difficult to assess. Furthermore, the water table depth in wetlands is directly connected with the ecology, micro-topography and vegetation of wetlands (Nungesser 2003; Tahvanainen, Tolonen 2004; Minayeva, Glushkov 2003). Therefore, it is efficient to assess the effects of human activity and climatic factors by studying long-term fluctuations in the water table depth in natural raised bogs and those affected by drainage activities (e.g. damming ditches) (Faubert *et al.* 2004).

Most of the studies on the soil hydrological regime in Lithuania (Dilys 1993; Gulbinas, Samuila 2001) were made in mineral soils, thus, such studies in raised bogs are rare (*e.g.* Эйтманавичюс 1972). To increase the understanding on possible effects of global climatic change and the damming of drainage ditches, we have studied fluctuations in the water table depth in the part of mire of the Kamanos reserve, which was partially affected by human activities. The objective of this study was to assess (a) the relationship between long-term fluctuations of the water table depth in the raised bog of Kamanos mire and climatic conditions, (b) the effect of damming the drainage ditches on the relationship between the water table depth and climatic factors.

2. Material and Methods

The study was carried out in the raised bog of the Kamanos state reserve, located in north-western Lithuania in the watershed of the basins of the Dabikinė and Vadakstis rivers (56º16‘*N*, 22º39‘*W*). Area of the raised bog is 1722 ha. The first drainage activities at the outer parts of

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the Kamanos mire were started in 1850–1860. Before the Kamanos mire was declared as a state reserve in 1979, there were no efforts taken to reset the natural water regime in the mire. In the raised bog, the first small-scale damming activities of the drainage ditches were started in 1985 and reached a large-scale level during 1999–2000, when dams were built in most of the drainage ditches in the raised bog and in several ditches in the surrounding forests. These activities were funded by the Society of Zoology of Frankfurt. In 1983, the officers of the reserve established 8 transections with the total length of more than 10 km in the Kamanos mire. Along each transection, 12 to 15 wells at each 70 to 100 m were drilled for studying the variation in the water table depth (75 mm plastic tubes with 5 mm holes were inserted 1 to 2 m into the soil). The exact position and coordinates of the water wells were marked on the map. During April to November, the water table depth in the water wells was measured at 10-day intervals.

To assess the effect of damming and climatic change on the hydrological regime of the Kamanos mire, we have analysed fluctuations in the water table depth over the past 22 years in the northern part of the mire which was drained in 1907 and dams in the ditch were established in 1999 (a 1.0 to 1.2 m deep drainage ditch connected to a 5.6 ha large lake in the mire was fully dammed with 4 dams) (Fig. 1). The drained out area of the raised bog was subdivided into two parts: intensively drained (study plot 1, located 200 m northeast from the main drainage ditch of the Kamanos lake and the bog) and extensively drained part (study plot 2, located 300–900 m towards the south of this drainage ditch) (Fig. 1). The main cause of the efficient draining in study plot 1 (located on the slope of the mire) was restriction of the through-flow of water from upslope peatland by the draining ditch. In study plot 1, natural regeneration of Scots pine after the drainage and ground vegetation with *Ledum palustre* prevail (age of Scots pine trees was 60–70, mean height – 16–17 m, density – 1600–1700 trees per ha). In study plot 2, there was no marked change in the species composition following the drainage: scarce 3,5–4,0 m high trees of Scots pine, widespread *Calluna vulgaris, Eriophorum sp., Sphagnum spp.*, *Ledum palustre* and other typical species for ground vegetation in bogs. Control plots (study plots 3 and 4) were established in the central part of the raised bog, which was not affected by the drainage activities (Fig. 1). In the control plots, ground vegetation is dominated by *Eriophorum vaginatum, Sphagnum spp.,* and dwarf trees of Scots pine may also be found. Additional assessments of the damming effect on the water table depth were made by using the method described by Chang (2004). For this purpose, the hydrologic and climatic data for the period of 15 years prior to the damming of the ditches was used in the regression analysis with the water table depth as a dependent variable. The regression functions obtained were used to predict the water table depth over the 6-year-period after the damming of the ditches (*i.e.* for 2000 to 2006). Moreover, in the assessments of the effect of the climatic data on the water table depth, the data on water table fluctuations collected from all the 98 water wells, established in the raised bog over the last two decades, were used. The climatic data for the description of the climate of the Kamanos mire were collected from three of the closest climatic stations which are located within a 10–14 km radius from the mire (Kamanos reserve,

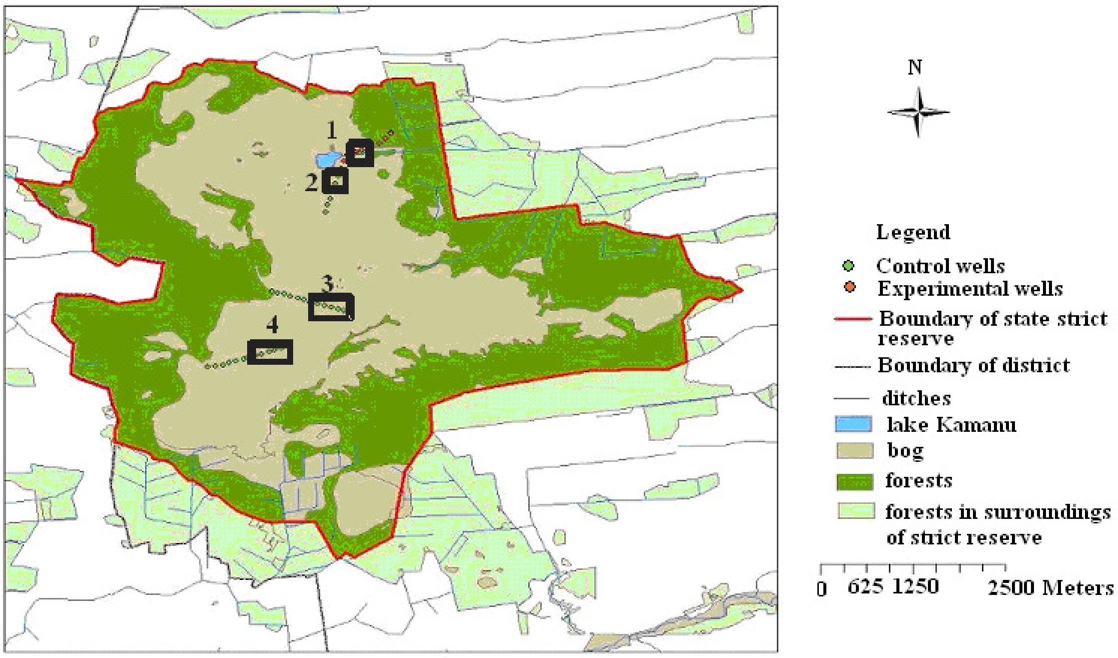

Fig. 1. Layout of the study plots in the bog of Kamanos mire. Study plot 1 is located in the part which was intensively drained in 1907 and the ditches were dammed in 1999. Study plot 2 is located in the part which was extensively drained in 1907 and the ditches were dammed in 1999. Plots 3 and 4 are locatead in undrained part and were used for control

Mažeikiai and Naujoji Akmenė climatic stations). Evaporation rate (E_0) was calculated according to Dirsė and Seniūnas (1995):

$$E_0 = 0{,}5\Sigma d + 7{,}0, \quad (1)$$

where Σd is mean air moisture deficiency sum over a ten-day period (mb).

This formula was used to calculate the coefficient k which is described in the Results and Discussion section.

Statistical analyses were carried out with MS Excel and Statistica 5.5.

3. Results and discussion

3.1. Dependence of the water table depth during the growth period on the climatic and hydrological factors in spring

In the drained (study plots 1 and 2) and undrained (study plots 3 and 4) parts of the raised bog as well as when regressing the data from all the plots pooled, the water table depth during the growth period was mainly dependent on the precipitation amount during May to October (r = –0.562 – (–0.761), p = 0.000–0.032) and moisture deficiency during May to October (r = 0.416 – 0.660, p = 0.005–0.031) (Table 1). Dependency of the water table depth on precipitation may be explained by the fact that precipitation is the only source for the maintenance of the groundwater, whereas the mineral subsoil below the peat layer does not add but drains the moisture out of the peat layer.

Air moisture deficiency indicates the evaporation intensity of the precipitation moisture (Dirse and Seniunas 1995; Ruseckas 2002), *i.e.* the more moisture evaporates from tree stems, branches and leaves, the soil surface and is absorbed by tree roots, the less moisture remains in the soil to renew the groundwater resources. According to Jablonskis (1992), Tilickis (1994), Gailiušis *et al.* (1999), in the analysis of the hydrological data, the relationships are efficiently revealed when the amount of precipitation during a certain period (P) is combined with the evaporation rate (E_0) into one index k $\left(k = \sum P / E_0\right)$. In our study, the evaporation rate (E_0) during 1984–1990 (formula by Dirse and Seniūnas 1995) and k (by the formula given above) were related with the mean water table depth in the drained (study plots 1 and 2) and undrained plots (study plots 3 and 4) during May to October (r = – 0.753–0.839, p = 0.000–0.023) (Table 1).

The mean air temperature during the vegetation period (May to September) was stronger related with the water table depth in the drained study plots (plots 1 and 2, r = 0.514–0.586, p = 0.029–0.042) than in undrained plots

Table 1. Correlation coefficients between the climatic data and water table depth ($h_{V\text{-}X}$) during the growth period (V–X), which were unadjusted ($h_{V\text{-}X}$) and adjusted by the formula $h_{(V\text{-}X)k} = h_{V\text{-}X} - 0{,}3h_{V.1}$ (where $h_{V.1}$ is the water table depth for May 1) in different parts of the raised bog in Kamanos mire

Climatic indexes	Intensively drained plots (data collected during 1984–1999, *i.e.* before damming)		Extensively drained plots (data collected during 1984–1999, *i.e.* before damming)		Undrained part of the bog (data collected during 1990–2006)		All for bog of Kamanos mire (data 1984–2006)
	$h_{V\text{-}X}$	$h_{V\text{-}X} - 0{,}3\ h_{V.1}$	$h'_{V\text{-}X}$	$h'_{V\text{-}X} - 0{,}3\ h_{V.1}$	$h''_{V\text{-}X}$	$h''_{V\text{-}X} - 0{,}3\ h_{V.1}$	$h'''_{V\text{-}X}$
Mean water table depth in April	0.578* p = 0.022	–	0.420* p = 0.047	–	0.380 p = 0.076	–	0.482* p = 0.011
Water table depth on May 1	0.571* p = 0.017	–	0.326* p = 0.041	–	0.316 p = 0.09	–	0.384* p = 0.003
Mean temperature during May to September	0.543* p = 0.029	0.586* p = 0.017	0.452 p = 0.078	0.514* p = 0.042	0.386 p = 0.096	0.412 p = 0.084	0.421* p = 0.016
Mean air moisture deficiency during May to September	0.601* p = 0.014	0.660* p = 0.005	0.553* p = 0.026	0.569* p = 0.021	0.416* p = 0.031	0.542* p = 0.001	0.621* p = 0.002
Hydrothermal coefficient during May to September, *k*	–0.753* p = 0.001	–0.797* p = 0.001	–0.841* p = 0.000	–0.873* p = 0.000	–0.776* p = 0.010	–0.811* p = 0.000	–0.839* p = 0.000
Precipitation during May to October	–0.592* p = 0.016	–0.632* p = 0.023	–0.740* p = 0.000	–0.761* p = 0.000	–0.584* p = 0.012	–0.632* p = 0.032	–0.562* p = 0.011
Precipitation during April to October	–0.601* p = 0.034	–	–0. 795* p = 0.000	–	–0.626* p = 0.012	–	–0.682* p = 0.004*
Precipitation during June to September	–0.496* p = 0.028	–0.563* p = 0.012	–0.621* p = 0.002	–0.684* p = 0.000	–0.634* p = 0.000	–0.684* p = 0.000	–0.589* p = 0.000

(plots 3 and 4, r = 0.386–0.412, p = 0.084–0.096). This indicates that the water table in the drained sites of the bogs is more sensitive to climatic change (higher mean annual and summer temperatures) than in undrained sites of the bogs.

The mean water table depth on April 1 and May 1 was stronger related with the mean water table depth during the growth period in the drained plots of the raised bog (r = 0.326–0.578, p = 0.017–0.047) than in undrained plots of the raised bog (r = 0.316–0.380, p = 0.08–0.09). This result is also supported by the fact that after subtracting the water table depths of spring ($h_{V.1}$) from the means over the growth period (H_{V-X}) (*i.e.* using the water table depth at the beginning of the growth period) and correlating these corrected water table depths with the climatic data, 5 to 10% higher correlation coefficients were obtained.

3.2. Fluctuations of the water table depth in the raised bog in 1984–1999

To determine the long-term irreversible cycles of fluctuations of the water table depth in the Kamanos raised bog, we have analysed the variation of the water table depth during the growth period (H_{V-X}) over time (Figs. 2 and 3). The results of the correlation and regression analyses showed that there was a trend in fluctuations of the water table depth starting from 1984 (start of the data collection) to 1999 (the dams were established) – R^2 = 0.39–0.40, p = 0.01. In the intensively drained part of the raised bog (study plot 1) with 50–60-year old Scots pine trees with an admixture of birch, this relationship between fluctuations in the water table depth and years was 3.3 times stronger than in the extensively drained part of the raised bog (study plot 2). During 1984–2000, the water table in intensively and extensively drained study plots 1 and 2 decreased by 27 cm and 8 cm, respectively.

During the past 16 years (1990–2006) in the undrained part of the raised bog (plots 3 and 4), the variation in the water table depth was comparably smaller and was reaching 0.68 cm per year (Fig. 2). The observations that the water table depth is increasing more rapidly in the more dry sites of the raised bogs with a tree cover than in undrained wet and open sites, was also confirmed by the Estonian scientists (Lode *et al.* 2003): the long-term climatic changes were more expressed in the more dry sites of bogs with tree cover than in wet sites with many small water pools.

According to Bragg (2002), the tree crowns in raised bogs consume a share of precipitation and in this way reduce the amount of the precipitation reaching the soil surface and ground water. The amount of precipitation is the main factor affecting the fluctuation of ground water table in certain areas of Lithuania (Gulbinas and Samuila 2001). This observation was confirmed by our study as well (Table 1). However, in our study, there were no significant trends of co-variation of precipitation with the water table depth during 1984 to 2000 (a tendency of reduction in precipitation was not observed, r^2 = 0.001, Fig. 4). The increase of the water table depth in the raised bog of Kamanos reserve during the last few decades of the 20th century, is caused by the variation in temperatures during the growth period, which continues for more than 200 years and was especially expressed during 1984–2006 (Bukantis *et al.* 2001) and by the trend of increase of the mean daily air moisture deficiency (R^2 = 0.33–0.21, p < 0.05) (Fig. 5). These factors may cause a gradual increase of the cumulative evaporation and in the same way intensify the decrease of water table in raised bogs (Ruseckas 2000). This may indicate that the water table depth in raised bogs and especially in the drained sites of the raised bogs will increase in response the warming climate. These assumptions were also confirmed by a number of studies (Bragg 2002; Faubert *et al*. 2004). At the end of the last century, the water table depth increased not only in raised bogs but also in other forested and agricultural land (Gulbinas and Samuila 2001; Pierzgalski and Tyzska 1999). The most efficient method to slow dawn the process of increasing in water table depth is damming of the drainage ditches in bogs (Kose 2003; Mieriauskas *et al.* 2005), as discussed in the next section.

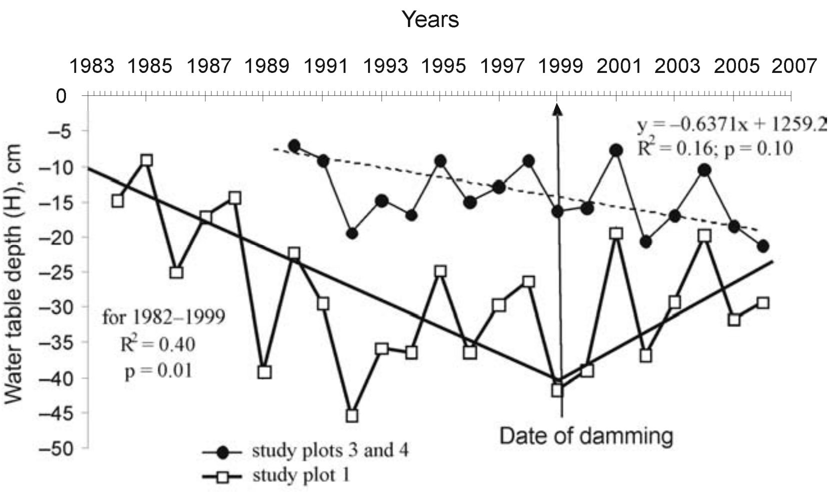

Fig. 2. Variation in water table depth during the growth period (May to October) in the intensively drained and dammed site (study plot 1, the line marked with open squares) and in the naturally developing part (control study plots 3 and 4, marked with filled cycles) during 1984–2006

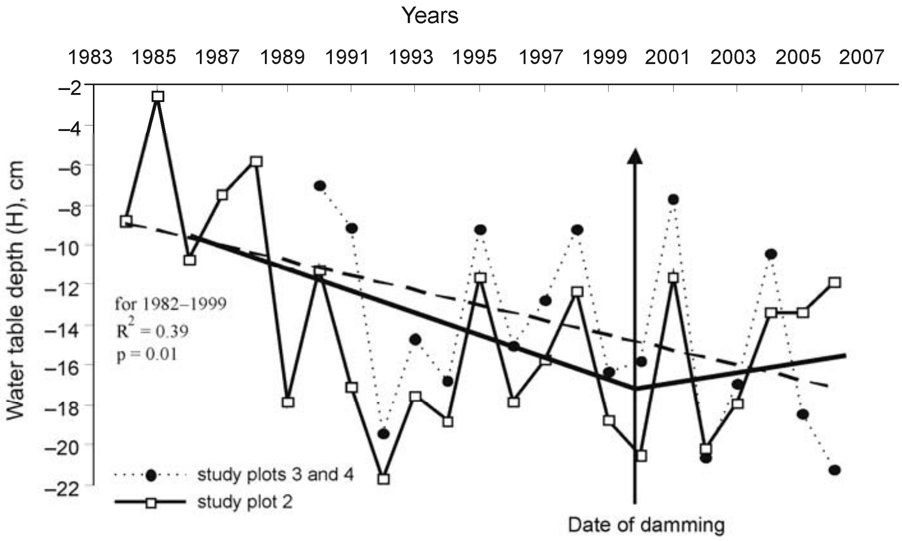

Fig. 3. Variation in water table depth during the growth period (May to October) in the extensively drained and dammed site (study plot 2, the line marked with open squares) and in the naturally developing part (control study plots 3 and 4, marked with filled cycles) during 1984–2006

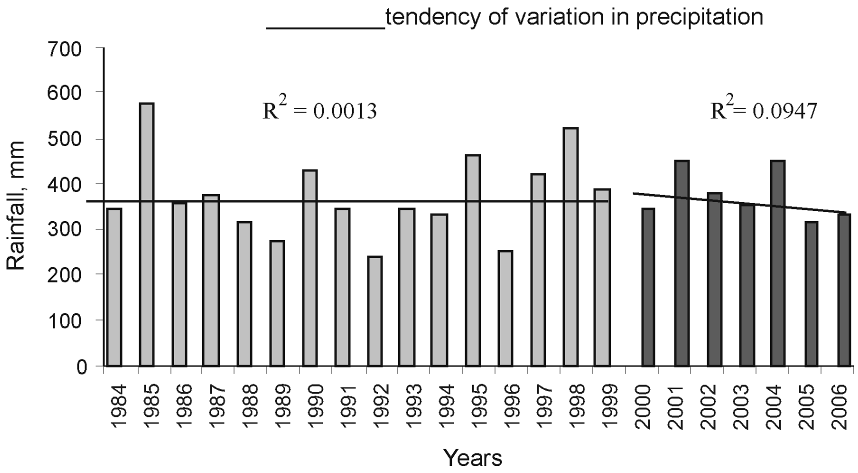

Fig. 4. Variation in the amount of precipitation during the period of active growth (May–October) during 1984–2006 (1984–1999 is the period before damming, and 2000–2006 is the period after damming)

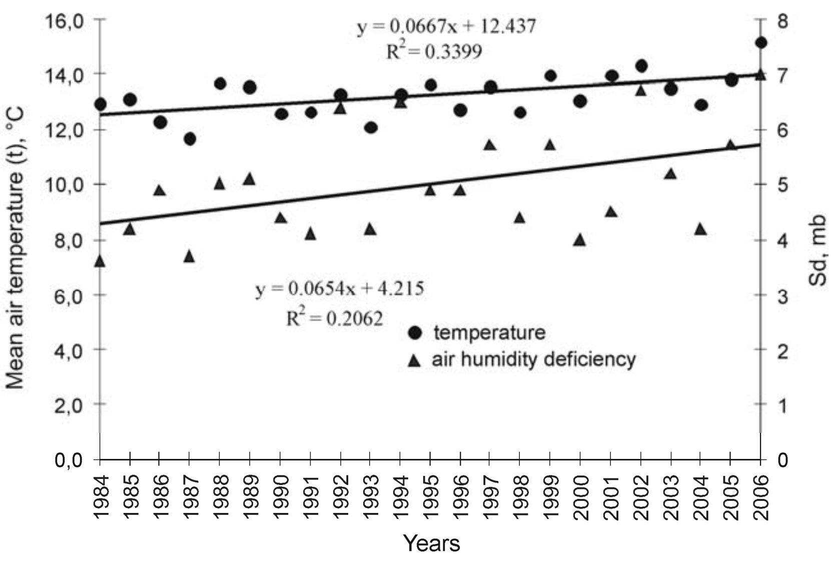

Fig. 5. Variation in mean air temperature and mean daily moisture deficiency (Sd) during the period of active growth (May to October) during 1984–2006

3.3. Fluctuations of the water table depth in Kamanos raised bog after renewal of the hydrological regime in 1999

First, let's review shortly the effect of drainage in the northern part of the Kamanos mire (study plots 1 and 2). After establishment of the 1.2–1.5 m deep drainage ditch draining water out of the Kamanos lake (the size of the lake is 5.6 ha) across the bog, the water level in this lake dropped by 1 m (Brundza *et al.* 1937), and in the 210 m-wide northern side of this ditch, the water table dropped by 15–35 cm (Ruseckas 2007). As a consequence, 70–80 years ago, natural regeneration of Scots pine occurred and presently developed into Scots pine stand of the 3rd bonitet class in this part of the bog (study plot 1). After partially draining the 4–5 m deep lake, which interacts with the adjacent groundwater pools, the water table depth in the 900 m wide belt at the fore hill increased by 7–14 cm (study plot 2). The effect of this extensive drainage on the species composition of the ground vegetation was minor, however, presently we noticed spreading of *Calluna vulgaris* and single naturally regenerating seedlings of Scots pine (Ruseckas and Grigaliūnas 2006).

After damming (Fig. 6) of the main ditch, draining the Kamanos lake and mire in 1999, the water table depth in both intensively drained study plot 1 and extensively drained study plot 2 decreased (Figs. 2 and 3), whereas the water table depth in control plots 3 and 4 increased. The mean decrease of the water table depth over the past 7 years in the intensively (plot 1) and extensively (plot 2) drained parts of the bog was 5.27 cm and 3.58 cm, respectively (Table 2). According to Zalytis (Залитис 1983), such an increase in the groundwater table may reduce the quality of forest stands by 0.5 of the bonitet class. The tendency of gradual raise of the groundwater table after damming may indicate (Table 3) that the data from the latest measurements in 2006 is a more precise indicator of absolute raise of the groundwater table (Δh) than the averaged data. According to these data from 2006, the Δh values in intensively (plot 1) and extensively (plot 2) drained plots were 12.2 cm and 9.8 cm, respectively. In 2006 (7 years after damming), the groundwater table restored its former depth in the intensively drained plot, whereas in the extensively drained plot, the water table still lays 10–12 cm below the level of the control plots (Fig. 7). The predictions based on equation given in Fig. 7, indicate that, to restore the groundwater table to the control level, 5–6 years may be needed. Note that due to the drainage the surface of the bog itself was lowered down by 30–40 cm, therefore, to restore the groundwater table to absolute levels before the drainage, one or more centuries may be needed. A separate discussion is needed on the effects of climatic factors on the water table depth during the period of the restoration of the hydrological regime in the Kamanos bog (1999–2006). During 1999–2006, the amount of precipitation during the growth period (May to October) tended to decrease in the study areas. This had intensified increase in the water table depth, which was also noticed in the central part of the bog with natural conditions (study plots 3 and 4, Fig. 2). The period of 1999 to 2006 was

Fig. 6. One of the dams in the drainage ditches in the Kamanos mire

Table 2. The water table depth during the growth period (May to October) ($h_{V\text{-}X}$, given in cm) and the difference of water table depths before and after damming of the ditches (cm) given separately for the intensively (plot 1), extensively (plot 2) drained parts and undrained parts of the raised bog (control plots 3 and 4)

Years	$H'_{V\text{-}X}$ (plot 1), *cm*	$H''_{V\text{-}X}$ (plot 2), *cm*	$H'''_{V\text{-}X}$ (plots 3, 4), *cm*	$H'_{V\text{-}X}$ (plot 1) – $H'''_{V\text{-}X}$ (plots 3, 4)	$H''_{V\text{-}X}$ (plot 2) – $H'''_{V\text{-}X}$ (plots 3, 4)	$H'_{V\text{-}X}$ (plot 1), – $H''_{V\text{-}X}$ (plot 2)
Before damming (1990–1999)						
1990	22.2	11.2	7.0	15.2	4.2	11.0
1991	29.4	17.0	9.1	20.3	7.9	12.4
1992	45.4	21.7	19.4	26.0	2.3	23.7
1993	35.8	17.5	14.7	21.1	2.8	18.3
1994	36.4	18.8	16.8	19.6	2.0	17.6
1995	19.8	11.6	9.2	10.6	2.4	8.2
1996	36.4	17.8	15.0	21.4	2.8	18.6
1997	29.6	15.7	12.8	16.8	2.9	13.9
1998	19.8	12.3	9.2	10.6	3.1	7.5
1999	41.8	18.7	16.3	25.5	2.4	23.1
Mean (I)	31.66	16.23	12.95	18.71	3.28	15.43
After damming (2000–2006)						
2000	39.0	20.5	15.8	23.2-18.71	4.7	18.5
2001	19.4	11.6	7.7	11.7	3.9	7.8
2002	36.8	20.2	20.6	16.2	–0.4	16.6
2003	29.2	17.9	16.9	12.3	1.0	11.3
2004	19.7	13.4	10.4	9.3	3.0	6.3
2005	31.7	13.4	18.4	13.3	–5.0	18.3
2006	29.32	11.9	21.2	8.1	–9.3	17.4
Mean (II)	29.30	15.57	15.86	13.44	–0.3	13.7
Mean (I)– mean (II)	2.36	0.66	–2.91	5.27	3.58	1.73

Table 3. Comparison between the observed ($H_{V\text{-}X}$) and predicted ($h_{(V\text{-}X)}$) water table depth in the restored bog of the Kamanos mire (prediction was made by functions 1 to 3)

Years	Intensively drained sites of the bog (plot 1)		Extensively drained sites of the bog (plot 2)		Undrained (natural) sites of the bog (plot 3)		$H_{V\text{-}X}$ (plot 1) – $h_{V\text{-}X}$ (plot 1)	$H_{V\text{-}X}$ (plot 2) – $h_{V\text{-}X}$ (plot 2)	$H_{V\text{-}X}$ (plot 3) – $h_{V\text{-}X}$ (plot 3)
	$H_{V\text{-}X}$ (plot 1)	$h_{V\text{-}X}$ (plot 1)	$H_{V\text{-}X}$ (plot 2)	$h_{V\text{-}X}$ (plot 2)	$H_{V\text{-}X}$ (plot 3)	$h_{V\text{-}X}$ (plot 3)			
2000	39.0	35.7	20.5	19.47	15.8	16.0	–3.3	–1.03	0.20
2001	19.4	24.6	11.6	15.12	7.7	9.73	5.2	3.52	2.03
2002	36.8	38.4	20.2	20.55	20.6	17.57	1.6	0.35	–3.03
2003	29.2	35.3	17.9	19.34	16.9	15.81	6.1	1.44	–1.09
2004	19.7	22.5	13.4	14.36	10.4	8.55	2.8	0.96	–1.85
2005	31.7	39.5	13.4	20.95	18.4	18.16	7.8	7.55	–0.24
2006	29.32	41.5	11.9	21.71	21.2	19.34	12.2	9.81	–1.86
Mean	29.30	33.93	15.56	18.79	15.86	15.02	4.63	3.23	–0.84

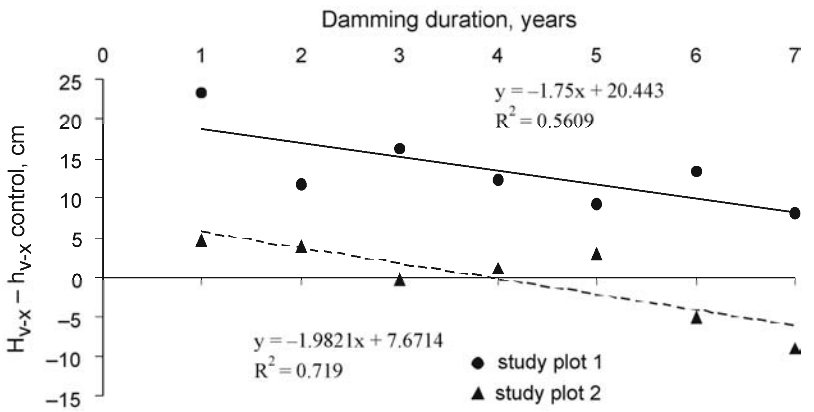

Fig. 7. Variation of difference in the water table depth between the intensively drained plots and the controls (filled cycles) and between extensively drained plot and the controls (filled triangle) (Y axis: $H_{V\text{-}X} - h_{IV\text{-}X}$ control), depending on the duration of damming

distinguishing by increasingly higher temperatures and moisture deficiency (Fig. 5). This intensified the evaporation and decrease of the groundwater table in the bog, as confirmed by the data on increase in the groundwater table depth in the control study plots 3 and 4 during 1999 to 2006 (Fig. 2). The fact, that the groundwater table would decrease during 1999–2006 in all the parts of the bog even if the ditches were not dammed, is demonstrated by the data in Table 3 and by the following functions for forecasting fluctuations in the water table depth:

$$H_{(V\text{-}X)} \text{ (study plot 1) } = 59.9119 - 34.664\ k, \quad (2)$$

$$H_{(V\text{-}X)} \text{ (study plot 2) } = 28.889 - 13.456\ k, \quad (3)$$

$$H_{(V\text{-}X)} \text{ (study plots 3,4) } = 29.730 - 19.6123\ k, \quad (4)$$

$$R^2 = 0.60\text{-}0.71,\ p < 0.05,$$

where *k* is hydrothermal coefficient; the data for the period before the ditch damming (from 1984 to 1999) were used in the regression analyses.

After comparing the forecasts of the water table depth in study plots 1 and 2 according to functions 1 to 3 given above with the real data on the water table depth (Table 3), the hydrological effect of damming was almost equal to the hydrological effect obtained by comparing the data from plots 1 and 2 with the controls. During the past 7 years in plots 1 and 2, the mean increase in the groundwater table estimated by the later method was 5.27 to 3.58 cm, respectively; whereas the estimation of the mean increase of the water table in plots 1 and 2 by using the functions with climatic factors as the dependent variable were 4.63 and 3.23 cm, respectively, (the difference was less than 12%). This indicates that both methods can be used for predicting the hydrological effects of damming.

4. Conclusions

1. At the end of the previous century, there was a reliable trend of decrease in the groundwater table during the growth period (May to October) (R^2 = 0.39–0.40 p < 0.05) in the drained part of the raised bog in the Kamanos mire, whereas in the central undrained part of the raised bog, there was only a slight tendency (R^2 = 0.16 p = 0.10) of lowering of the groundwater table during the growth period over the last 16 years.

2. In spite of the fact that the air moisture deficiency and precipitation are the main climatic factors affecting fluctuations of the water table during the growth period (GWLs) in the Kamanos mire (r = 0,416 – 0,761 p < 0,05), the mean summer temperatures (which have been increasing over the past 20 years) have a marked effect (r = 0,514 – 0,586 p < 0,05) on the GWLs only in the sites of the mire which were damaged by draining.

3. If compared with the control plots, in 7 years after the damming in the 0.9–1.2 m deep drainage ditch, the groundwater table in a 980 m wide zone along the ditch increased by 9.8 to 12.2 cm.

4. After damming of the drainage ditches, the restoration of the groundwater table to the level of the control plots occurred after 4 years in the extensively drained raised bog; whereas in the intensively drained part of the raised bog, the groundwater table is forecasted to reach the level in the control plots in approximately 12 years after damming of the ditches.

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GRIOVIŲ BLOKAVIMO BEI METEOROLOGINIŲ FAKTORIŲ ĮTAKA KAMANŲ PELKĖS GRUNTINIŲ VANDENŲ SLŪGSOJIMO LYGIO SVYRAVIMAMS

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S a n t r a u k a

Tyrimai buvo atlikti Kamanų valstybinio gamtinio rezervato aukštapelkėje (56º16´N, 22º39´W), kuri yra šiaurės vakarų Lietuvoje. Aukštapelkės plotas – 1722 ha. Tam, kad būtų įvertinta meteorologinių faktorių bei griovių tvenkimo įtaka Kamanų pelkės hidrologijai, buvo išanalizuotos gruntinių vandenų slūgsojimo lygio fluktuacijos per pastaruosius 22 metus – 1907 m. nusausintoje ir 1999 m. patvenktoje šiaurinėje pelkės dalyje. Kontroliniai plotai išskirti centrinėje nesausintoje aukštapelkės dalyje. Čia vyrauja *Eriophorum vaginatum-Sphagnum spp.* (kupstinio švylio-kiminų) bendrijos su žemaūgėmis pušelėmis.

Nustatyta, kad pagrindiniai meteorologiniai veiksniai, veikiantys vegetacijos periodo gruntinių vandenų fluktuacijas tiek natūraliuose, tiek sausinimu pažeistuose Kamanų aukštapelkės plotuose, yra oro drėgmės deficitas ir krituliai (R^2 = 0,416 – 0,761 $p < 0{,}05$). Per 7 metų periodą, praėjusį po 0,9–1,2 m gylio griovio, sausinusio aukštapelkę 92 m. blokavimo užtvaromis (1999 m.), gruntinių vandenų lygis 980 m pločio pagriovio zonoje, palyginus su kontrole, pakilo vidutiniškai 9,8–12,2 cm. Gruntinių vandenų atsistatymas iki kontrolinio lygio, blokavus griovius užtvaromis ekstensyviai nusausintose pelkės dalyse, įvyko per 4 metus, o intensyviai nusausintoje aukštapelkės dalyje, kaip rodo prognozės, įvyks apytiksliai per 12 m. Išaiškinta, kad į klimato šiltėjimą, t. y. į metinių temperatūrų didėjimą, nusausintų pelkių gruntiniai vandenys reaguoja labiau negu nenusausintų.

Reikšminiai žodžiai: gruntinio vandens lygis, griovių blokavimas užtvaromis, hidrologija, meteorologiniai veiksniai, pelkė.

ВЛИЯНИЕ ИЗМЕНЕНИЯ КЛИМАТА И УНИЧТОЖЕНИЯ КАНАВ НА ГИДРОЛОГИЧЕСКИЙ РЕЖИМ БОЛОТА КАМАНОС

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Р е з ю м е

Гидрологические исследования были проведены на верховом болоте государственного заповедника Каманос (56º16´N, 22º39´W), который находится на северо-западе Литвы. Площадь верхового болота – 1722 га. Целью работы было установить влияние метеорологических факторов и уничтожения осушительных канав на гидрологический режим верхового болота. Исходным материалом послужили данные о динамике уровня грунтовых вод за последние 22 года на в 1907 г. осушенных и в 1999 г. вновь затопленных площадях заповедника с болотными почвами. Контрольными площадями послужили нетронутые осушением участки болота, выделенные в центральной части заповедника, где преобладают сообщества пушицы и белого мха (*Eriophorum vaginatum – Sphagnum spp.*) с низкорослой сосной. Выявлено, что за 7-летний период, прошедший после уничтожения в 1999 г. осушительных канав глубиной 0,9–1,2 м, уровень грунтовых вод на приканавной полосе, равной 980 м, повысился в среднем на 9,8–12,2 см по сравнению с контрольным уровнем. Восстановление уровня грунтовых вод (до контрольного уровня) после уничтожения канав на экстенсивно осушенных площадях происходит спустя 4 года, а на интенсивно осушенных площадях – спустя 12 лет. Установлено, что на потепление климата, т. е. на повышение годовых температур, сильнее реагируют грунтовые воды осушенных болот, чем неосушенных.

Ключевые слова: уровень грунтовых вод, уничтожение канав, гидрология, метеорологические факторы, болото.

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