Project **LIFE12NAT/LT/000965**
LIFEAUKSTUMALA Restoration of Aukstumala Raised Bog in Nemunas Delta Regional Park

Action D2:

HYDROLOGICAL MONITORING AT THE TARGETED SITES

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Executive summary

Hydrological and vegetation dynamics is one of the key factors indicating the success of implemented nature management actions in restored raised bogs. To assess the efficiency of project action, data from 123 water level measurement wells (located in six different sites) was obtained and changes in vegetation cover from 40 study plots was estimated.

Previous studies in Aukštumala raised bog indicates that aiming to restore hydrological regime favourable to natural raised bog plant communities, average water table depth during vegetation season should be upheld above at leats-30 cm.

Hydrological monitoring performed during the project period 2014–2017 shows positive impact of implemented nature management actions, as in majority of treated sites water level increased significantly. In the southern part of the bog, where dam building and tree cutting actions were performed, average water level increased by 20–35 cm. In the northern part of the bog, where clearing of birch offshoots and damming actions were implemented, average water level increased by 5–20 cm. Almost in all treated sites water level did not fall lower than 30 cm beneath the peat surface, which is considered to be minimal limit for the maintenance of typical raised bog habitats. Whereas in the drained sites, where project actions were not implemented, recorded average water level is 50 cm beneath peat surface and reaches 1 m during the driest seasons. Moreover, the effect of the nature management actions was also noticeable on the amplitude of seasonal water level fluctuation, which did not exceed 30 cm and was significantly lower compared to the period before treatment.

Hydrological data obtained in the central part of the bog serves as the control site representing the pristine hydrological conditions. Further investigations and comparison of hydrological data will allow to get a more precise view on the efficiency of implemented actions.

The decrease of vital *Calluna vulgaris* individuals coverage indicates the efficiency of applied restoration measures in all three monitoring transects. Moreover, the appearance of sphagnum mosses and typical raised bog vegetation (*Drosera sp. Rhynchosphora alba, Eriophorum vaginatum, Polytrichum strictum, etc*.) in majority of study plot, shows clear shifts from degraded to active raised bog habitats. However, too short period has passed since the implementation of project actions, therefore changes in vegetation cover will be more evident during upcoming years.

HYDROLOGICAL MONITORING

Material and methods

To assess the drainage effect and the efficiency of project action on the hydrology of the Reserve, a hydrological monitoring system consisting of 123 water level measurement well was installed (twelve transects with 6–10 water level measurement wells in each). The water level measurements were carried out with monthly interval during vegetation season in May–October, 2014–2017. All hydrological monitoring profiles were grouped into 5 sites depending on hydrological conditions and the foreseen actions (*Fig. 1*).

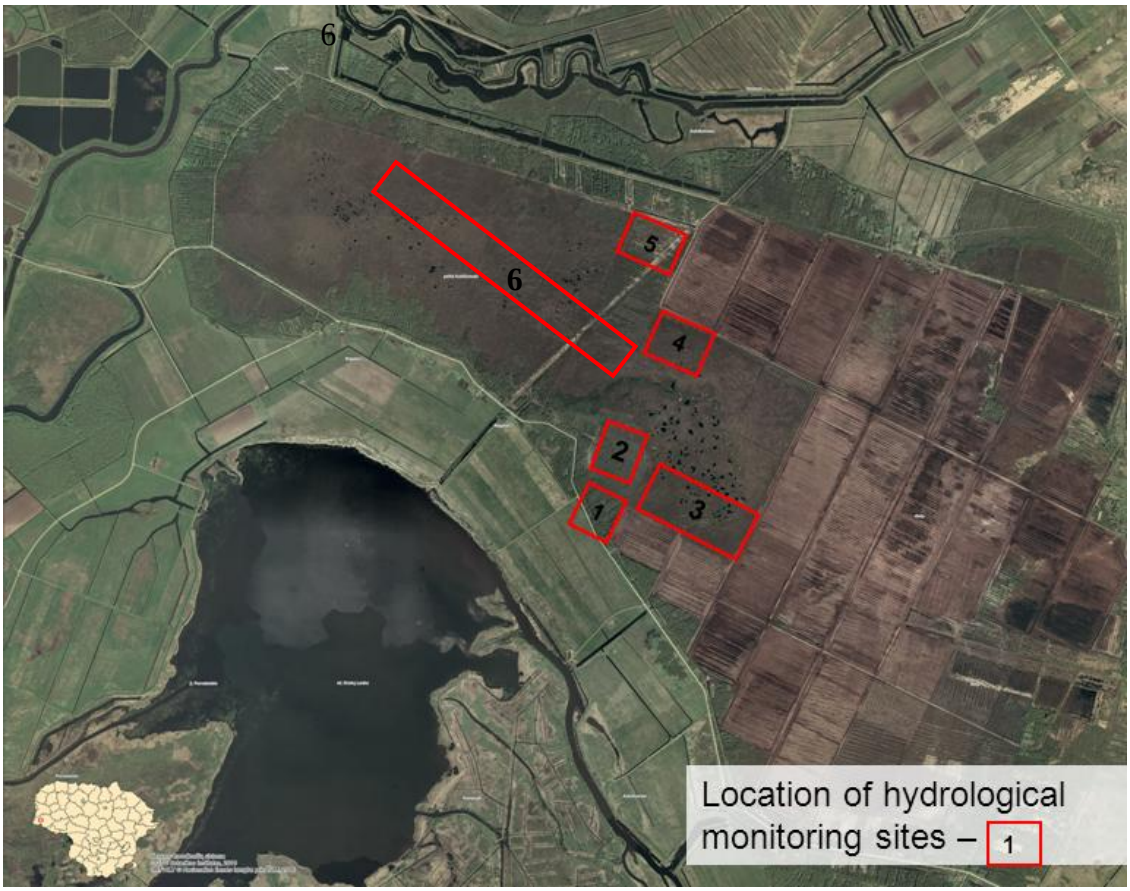

Fig. 1. Location of hydrological monitoring sites in Aukštumala Telmological Reserve

Hydrological monitoring transects:

- **Site 1.** Two transects (110 m length) with 6 water level measurement tubes in each. Due to the old drainage system this site is characterised as degraded raised bog with intensive tree cover. Only one big dam on the collective ditch was installed in the southern edge of the site in 2016.
- **Site 2.** One transect (360 m length) with 10 water level measurement tubes. The site is also qualified as degraded raised bog. Tree cuttings and damming activities were performed in 2016 to improve hydrological conditions.
- **Site 3.** Six transects (170 m length) with 9 water level measurement tubes in each. Profiles are located in the contact zone of the Reserve and peat harvesting fields (southern, south-eastern part of the reserve). Few plastic pile sheet dams were installed in the site in 2015. Water level measurement are being performed not only to investigate the success of the project actions but to monitor overall hydrological conditions of the bog and to check the efficiency of water retaining polyethylene membrane installed in 2007.

- **Site 4.** Two transects (170 m length) with 9 water level measurement tubes in each. The site is located in the northern part of the reserve, which in 2011 was damaged by fire. The northern edge of the site is also drained by 5–6 deep ditches. To improve hydrological conditions drainage ditches were blocked blocked (using peat and plastic dams).
- **Site 5.** One transect (190 m length) with 10 water level measurement tubes. The site is located in the northern part of the reserve, which was damaged by fire in 2011. This hydrological monitoring transect was installed in April, 2016 as an additional measure to follow the success of project actions (offshoot clearing and ditch blocking). The area is also characterized by the dense network (every 20 m) of drainage ditches. Instalment of peat dams started in November 2015, birch offshoot clearing was repeatedly performed since November 2015.
- **Site 6. Nine Separate water level measurement wells in the central part of the bog** represent the control hydrological data of pristine active raised bog habitats.

Results

According to previous hydrological studies and the data gained from the central part of the bog water level in typical open raised bog communities during the vegetation season does not decrease less than 25–30 cm below the peat surface. Researches indicate that cover of *Sphagnum* spp. exceeded 50% of the investigation plot area when WTD values did not exceed -30 cm, whereas the cover of *Calluna vulgaris* increased significantly when WTD values reached -30 cm and more (*Fig*. 2). Therefore in order to recreate favourable conditions for peat accumulation and natural functioning of the bog ecosystem, the water level should be raised at least up to -30 cm.

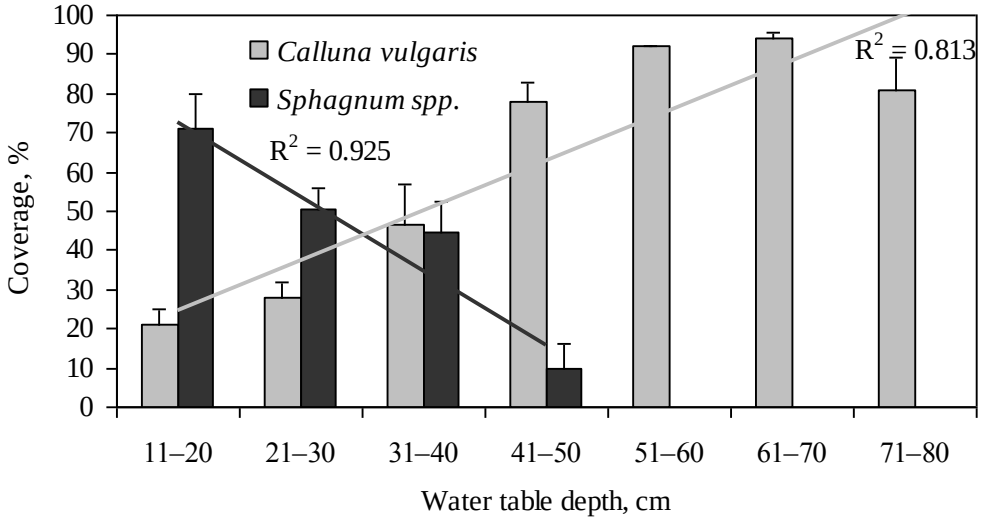

Fig. 2 Correlation between water table depth and coverage of *Calluna vulgaris* and *Sphagnum* spp. in the Aukštumala Telmological Reserve

Site 1

The site is located near the southern edge of the Reserve, which is extensively drained by shallow ditches. Mean water level was low in whole investigation period (2014–2017) and almost in all cases did not exceeded -30 cm (*Fig.* 3.). Although water level was higher in the 2016-2017 period, the hydrological conditions in the site are still not favourable for active

peat accumulation and formation of typical raised bog habitats. The site is also negatively influenced by the peat harvesting fields in the neighbourhood area. Therefore water level during the dry season decreases to 148 cm below the peat surface in the edge of the Reserve. According to hydrological monitoring data, mean water level in both profiles ranged between -18 to -117 cm in 2014–2017 (*Fig.* 3.).

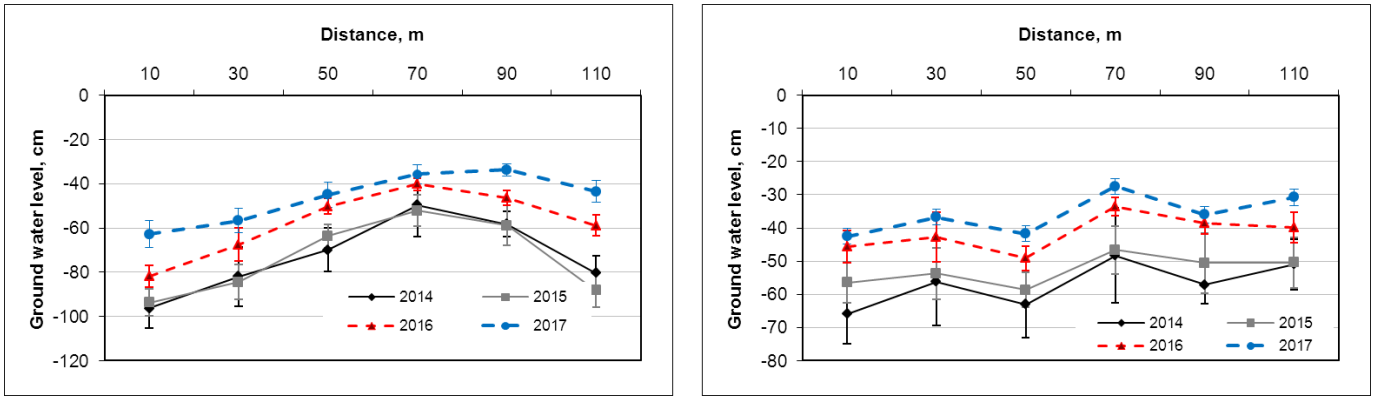

Fig.3. Average ground water level in hydrological monitoring transects located in **Site 1** during 2014 –2017 vegetation seasons. Dotted curves indicate the period after nature management implementation.

Site 2

Nature management activities (dam building and tree cutting) in this site were performed in the end of 2016. Before treatment (2014–2016) this site was represented by degraded raised bog habitats, low water table and relatively high water level fluctuations, which were determined by the system of deep drainage ditches. After the implementation of nature management actions average water level increased by -20 – 35 cm and in all measurement wells did not fell below – 20 cm (*Aiming to restore hydrological regime favourable to natural raised bog plant communities, mean water table depth during vegetation season should be upheld above -30 cm*) (*Fig.* 4). Whereas, before the treatment (2014–2016), mean water level in the site ranged from -23 to -58 cm and decreased to -90 cm during the driest seasons.

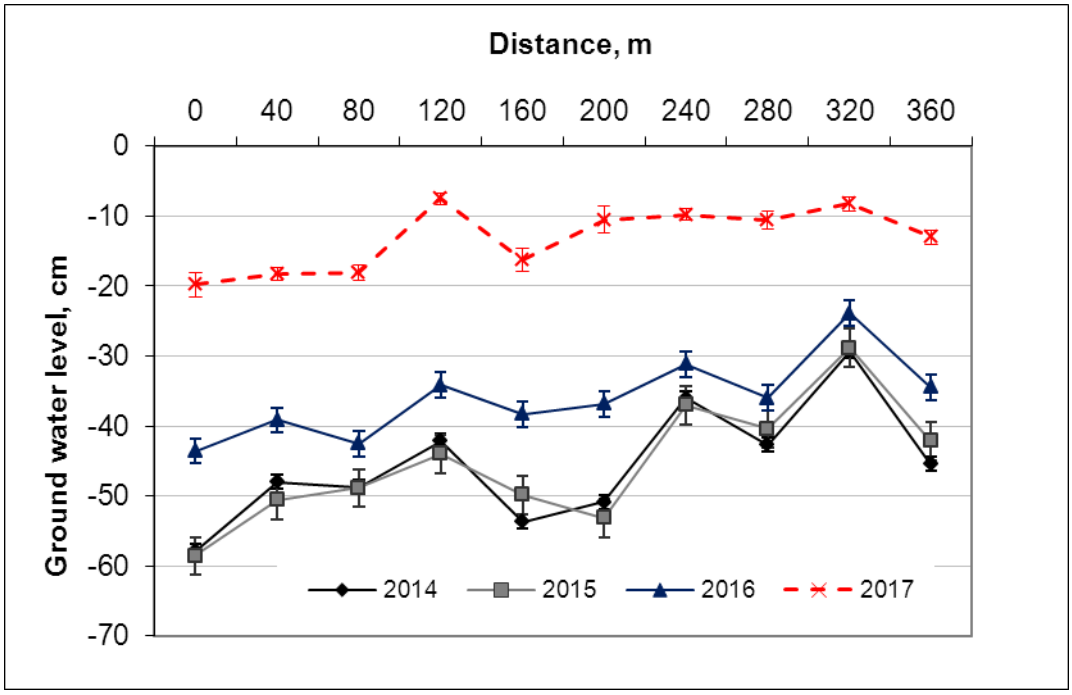

Fig. 4. Average ground water level in hydrological monitoring transect located in **Site 2** during 2014 – 2017 vegetation seasons. Dotted curve indicate the period after nature management implementation.

Site 3

The site is represented by relatively good hydrological conditions and open raised bog communities. However, the edge of the reserve is under the impact of peat harvesting fields in the neighbourhood area. As a result water level in the wells which are located in the contact zone (approx. 50 wide) is low and unfavourable for typical open raised bog habitats. In order to reduce negative impact posed by peat harvesting fields, experimental polyethylene membrane (1 km length) in 2007 was installed. To assess the efficiency of polyethylene membrane water level was measured in 3 profiles where this measure was installed and in 3 control profiles. Curves in Figure 5 illustrates mean water level in both treated and untreated sites in 2007–20117 period. Polyethylene membrane turned out to be an efficient measure to retain water in the bog and mitigate negative hydrological impact of peat harvesting from adjacent fields. Moreover, in further distant wells (70–170 m) water level remained relatively high and favourable for peat accumulation process in both (control and treated) profiles. Significant differences in water level before and after plastic sheets installation (in 2015) were not noticed. This is partly determined by the fact, that drainage ditches in the site are not deep and already overgrown by typical bog vegetation. However, implemented actions will definitely improve hydrological conditions in the site, further investigations needed. Figure 5 represents general hydrological condition of Aukštumala raised bog in 2007–2017 vegetation seasons.

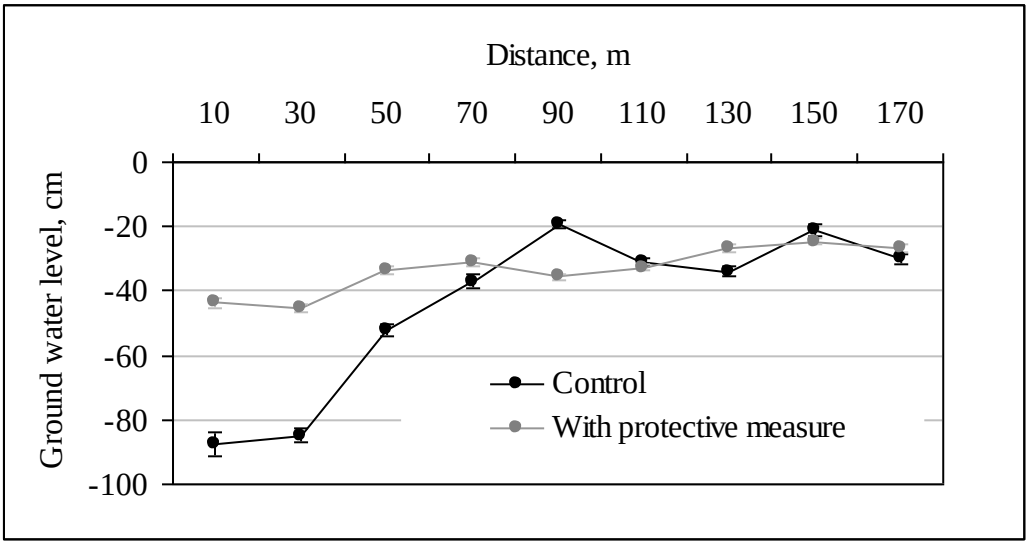

Fig. 5 Average ground water level in **Site 3** during 2007–2017 vegetation seasons.

Site 4.

Although northern edge of this site is drained by deep ditches, water level is not so drastically low in both installed profiles. Relatively good hydrological situation of the site is caused by two reasons:

1. Fire in 2011 has killed off all trees and resulted reduce in evapotranspiration;
2. Experimental dams were constructed in 2011, 2013.

The results of hydrological monitoring obtained in 2014–2017 in site 4 shows, that after implementation of project actions in 2015 (ditch blocking using several types of dams/ offshoot clearing), the average water level had increased from 5 to 20 cm. in 2016 – 2017 vegetation period. Almost in all treated sites average water level did not fall lower than 30 cm beneath peat surface, which is considerate to be minimal limit for the formation of raised bog habitats (*Fig.* 6, 7). These changes are illustrated by Figures 6, 7, where both average and monthly water level values are being presented.

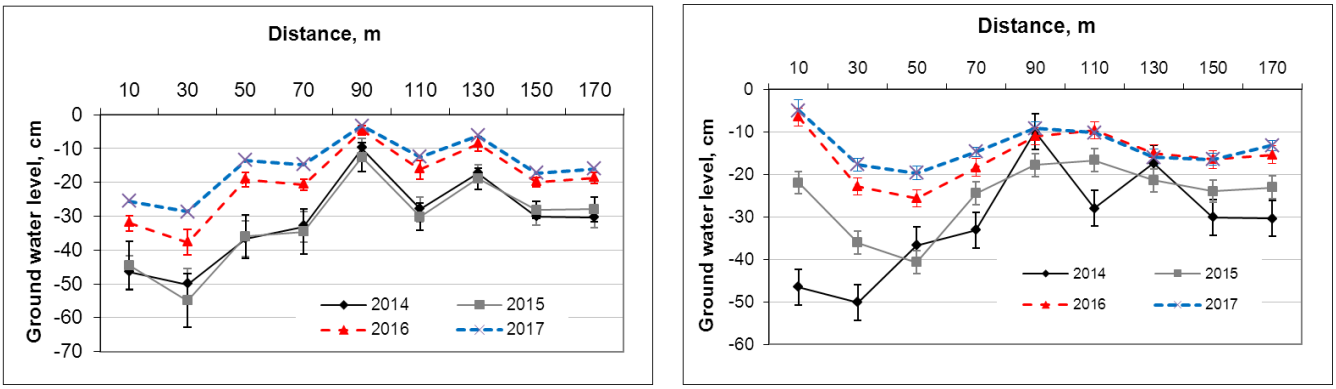

Fig. 6. Average ground water level in hydrological monitoring transects located in **Site 1** during 2014 –2017 vegetation seasons. Dotted curves indicate the period after nature management implementation.

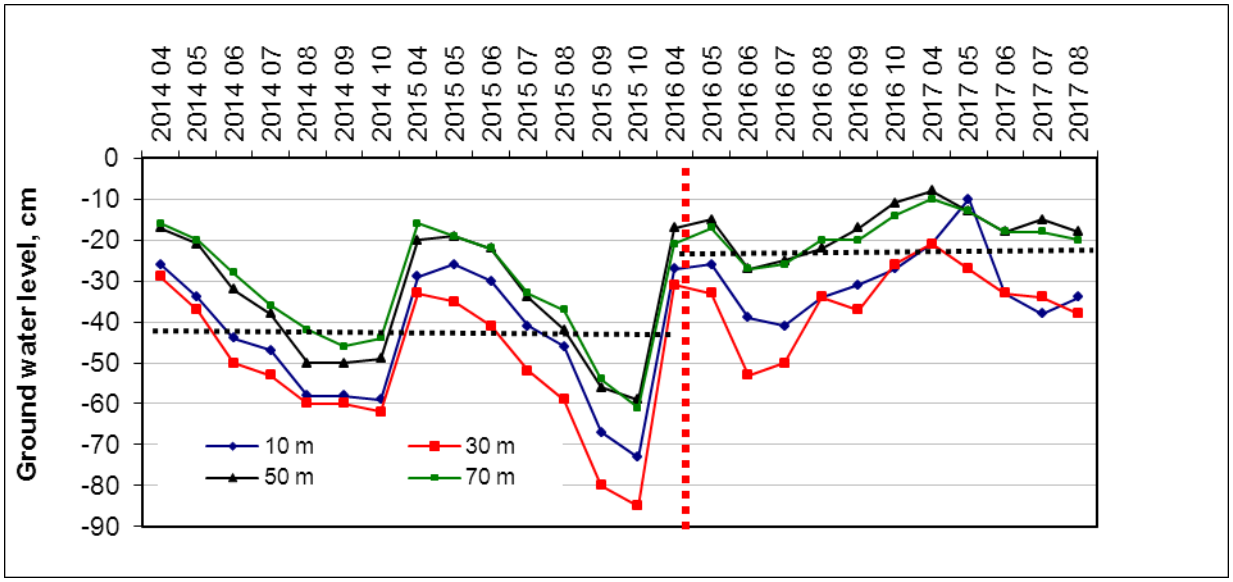

Fig 7. Monthly water level fluctuations in site 4 (10-70m from the edge of Reserve). Dotted red vertical line indicates the nature management implementation time. Dotted black horizontal line indicates the average ground water level before and after the damming.

To have a closer look to the gradual changes in hydrological conditions of **Site 4**, the graph indicating water level dynamics of one water level measurement well (located 20 m from the peat mining fields) is given. Figure 8 indicates 3 separate stages of hydrological changes in the site:

- 2011 04–2013 08. 1st stage of experimental dam instalment
- 2013 08–2015 10. 2nd stage of experimental dam instalment
- 2015 10 till now. Nature management actions implemented by LIFE project

As a result of gradual hydrological restoration activities, the average water level was raised by 25 cm.

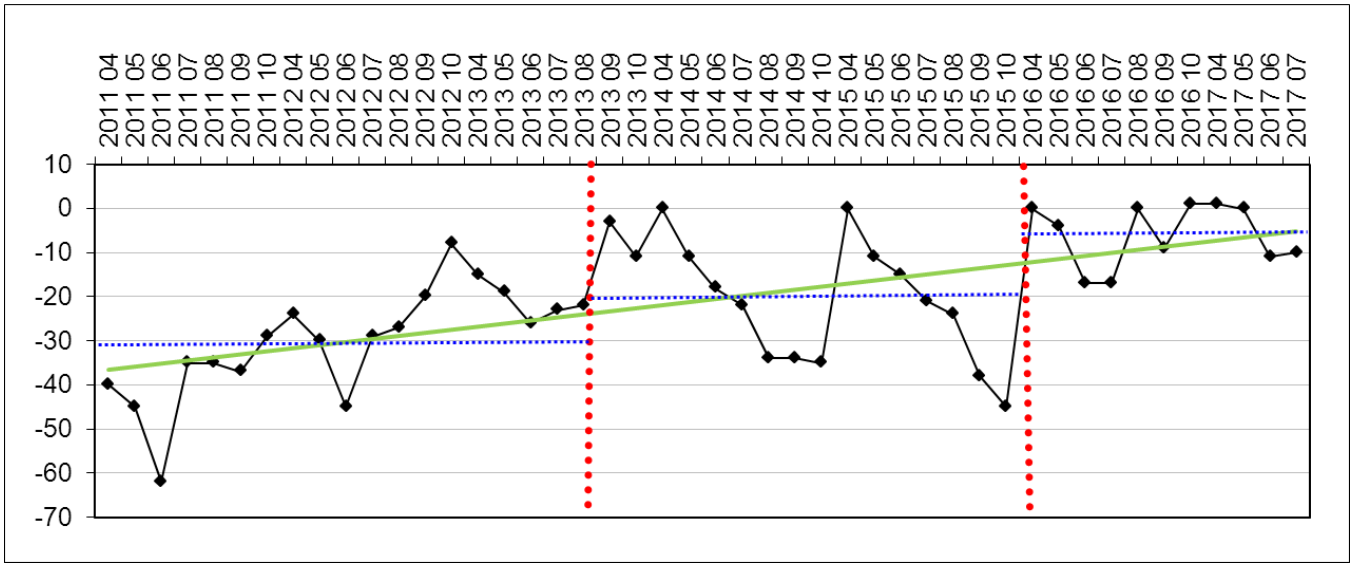

Fig 8. Monthly water level fluctuations in monitoring point located 20 m from the peat mining fields in **Site 4.** Dotted red vertical line indicates the nature management implementation time. Dotted blue horizontal line indicates the average ground water level before and after the damming

Site 5

Transect was equipped in 2016, right after the implementation of nature management actions. Therefore the data before damming is missing. However, comparison of the same year hydrological data shows that water level in **Site 5** is significantly higher compared to the **Site 1** (without restoration activities). Hydrological monitoring data obtained in 2016–2017 indicates, that average water level was too low in some of the monitoring points in year 2016, however during the next year hydrological conditions has stabilized and water level did not fell below -30 cm almost throughout the whole transect. Moreover nature management actions had a positive impact on water level fluctuations as well (*Fig*. 9).

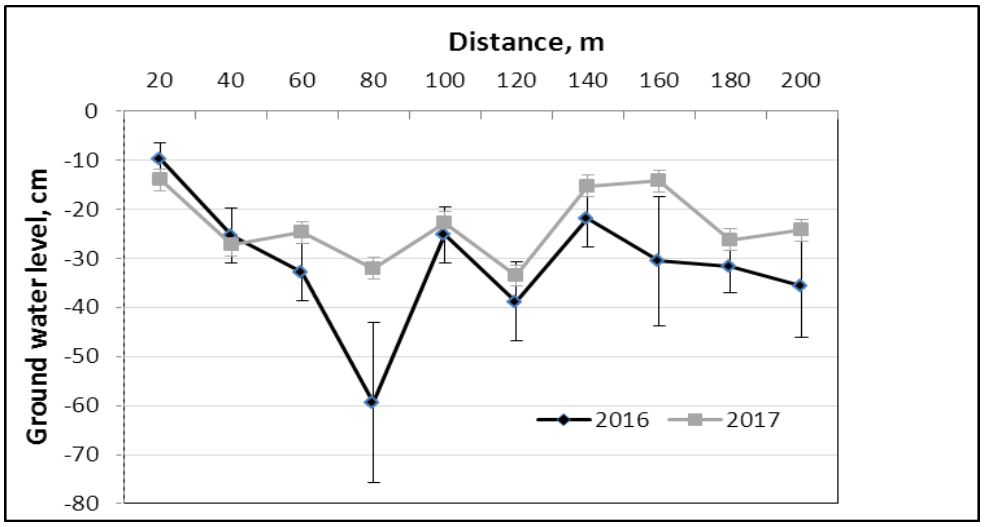

Fig. 9 Average ground water level in hydrological monitoring transects located in **Site 5** during 2014 –2017 vegetation seasons

Site 6. Water level measurement in the central (control) part of the bog

These measurements indicate the hydrological conditions of pristine raised bog habitats. According to hydrological data obtained in the central part of the bog, average water level ranged from -1 to - 17 cm during the project period. Since the area is rather remote from the negative drainage influence, none of the significant water level differences were noticed before and after the implementation of nature management actions. Further investigations and comparison of hydrological data would allow to get a more precise view on the efficiency of implemented actions.

VEGETATION COVER MONITORING

Material and methods

To estimate vegetation changes in the project site three liner transects (A, B, C) were established. In each transect vegetation monitoring was performed in 10-20 study plots (1.0×1.0 m), where percentage cover of vascular plants and mosses was inventoried. For the current study only the data of vital *Calluna vulgaris* coverage was presented, as the changes of this species vitality dynamics represent the habitat shifts from degraded to active raised

bog habitats. In addition some data about the appearance of sphagnum mosses in some study plots was given.

- **Transect A**: 380 m length transect was established in degraded raised bog area with dense net of drainage ditches and low water level. The site is characterised by dominant tree cover (*Betula pendula*, *B. pubescens*, *Pinus sylvestris*). 20 study plots, (*Fig*. 10.) were distributed every 20 m.

- **Transect B**: 180 m length transect was established in fire damaged area with dense net of drainage ditches and low water level. Before the fire (2011) the site was characterised by dominant tree cover (*Betula pendula*, *B. pubescens*, *Pinus sylvestris*), *Sphagnum* cover was absent. Currently dwarf-shrubs *Calluna vulgaris* dominate in the vegetation cover. 10 study plots were distributed every 20 m.

- **Transect C**: 180 m length transect was established in damaged by fire area, perpendicularly to the contact line of the Reserve and peat harvesting fields. The northern edge of the transect is drained by ditches (degraded raised bog), whereas southern is characterised by open raised bog communities. 10 study plots were distributed every 20 m.

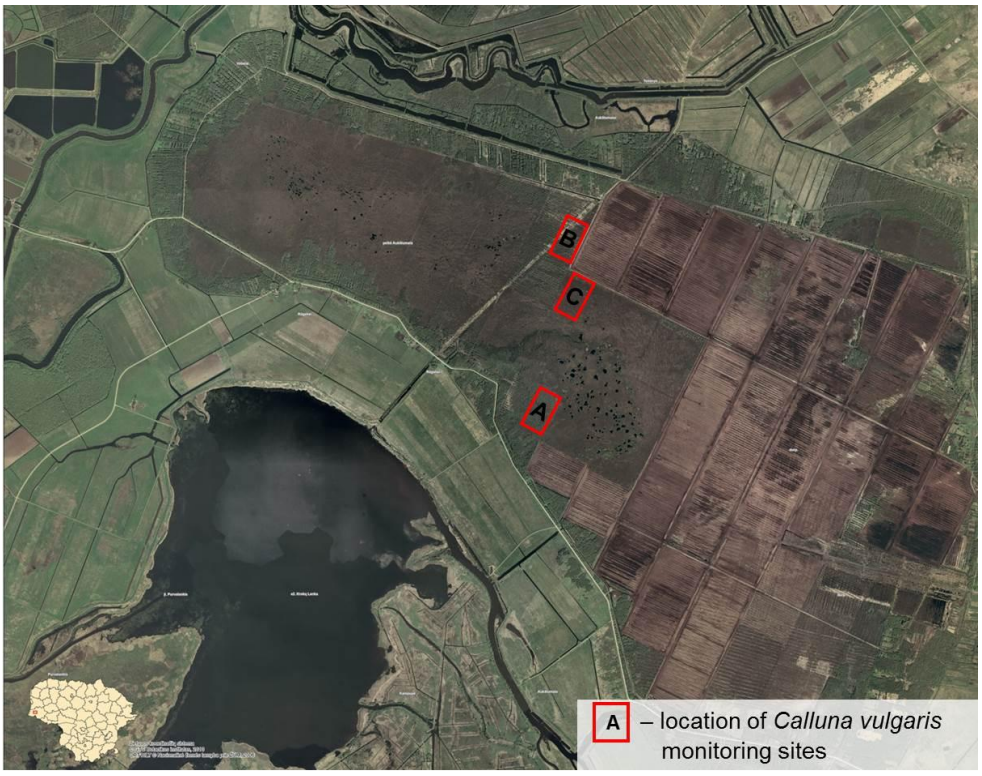

Fig.10. Location of vegetation monitoring sites in Aukštumala Telmological Reserve

Results

Transect A

Nature management activities (dam building and tree cutting) in this site were performed in the end of 2016. Before treatment (2014–2016) this site was represented by degraded raised bog habitats and low water table. According to vegetation monitoring data the coverage of vital *Calluna vulgaris* individuals has decreased by 16 % during the last project years (2017) (*Fig. 11).* Only one year have passed since the restoration actions, therefore the fragments of sphagnum are still absent in the transect.

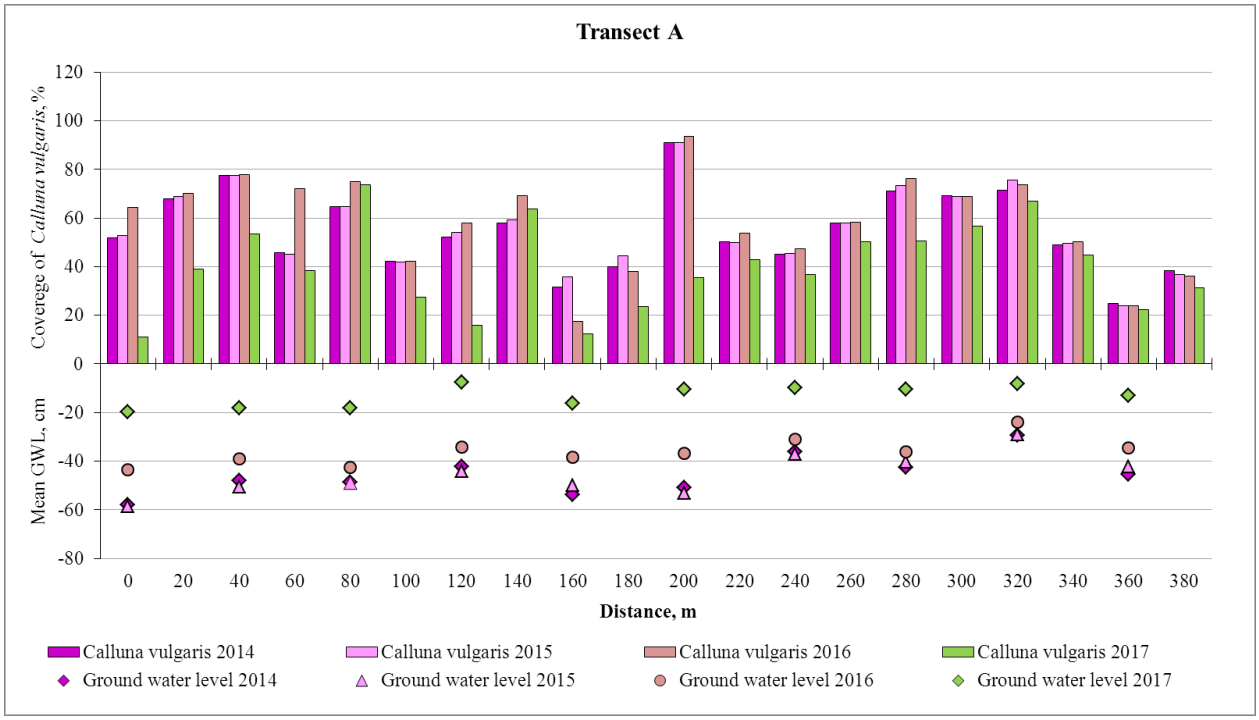

Fig 11. Heath (*Calluna vulgaris*) coverage dynamics in transect A (2014–2017)

Transect B

Successful implementation of dam installation and offshoot clearing actions in 2015, resulted that average coverage of vital *Calluna vulgaris* individuals decreased by 20 % during the last project years (2017) (*Fig.* 12). Moreover sphagnum moss fragments were inventoried is some of the study plots (0,3–1,5%)

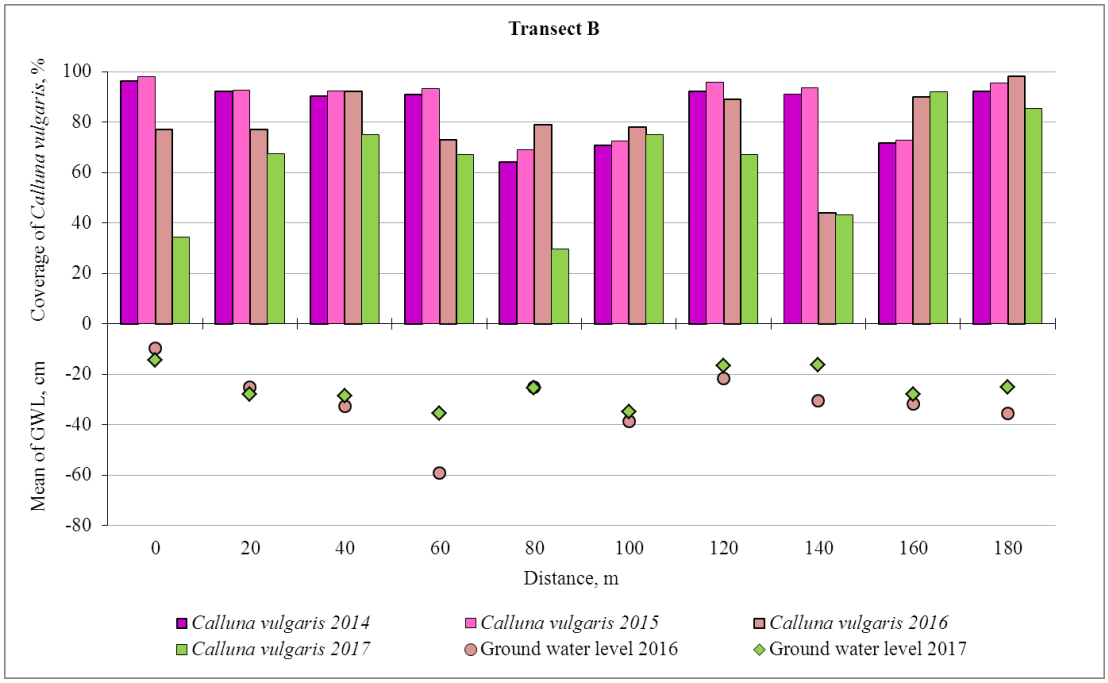

Fig 12. Heath (*Calluna vulgaris*) coverage dynamics in transect B (2014–2017)

Transect C

The first efforts to restore hydrological regime in the site were started in 2011, therefore first fragments of sphagnum moss appeared before the project action implementation. However, vegetation monitoring data obtained in 2014–2017 indicates clear shifts towards the typical raised bog habitats as the average coverage of vital *Calluna vulgaris* individuals decreased by 25% in 2017 (*Fig.* 13) and the increase of other typical raised bog species (*Drosera sp. Rhynchosphora alba*, *Eriophorum vaginatum*, *Polytrichum strictum*, etc.) was observed.

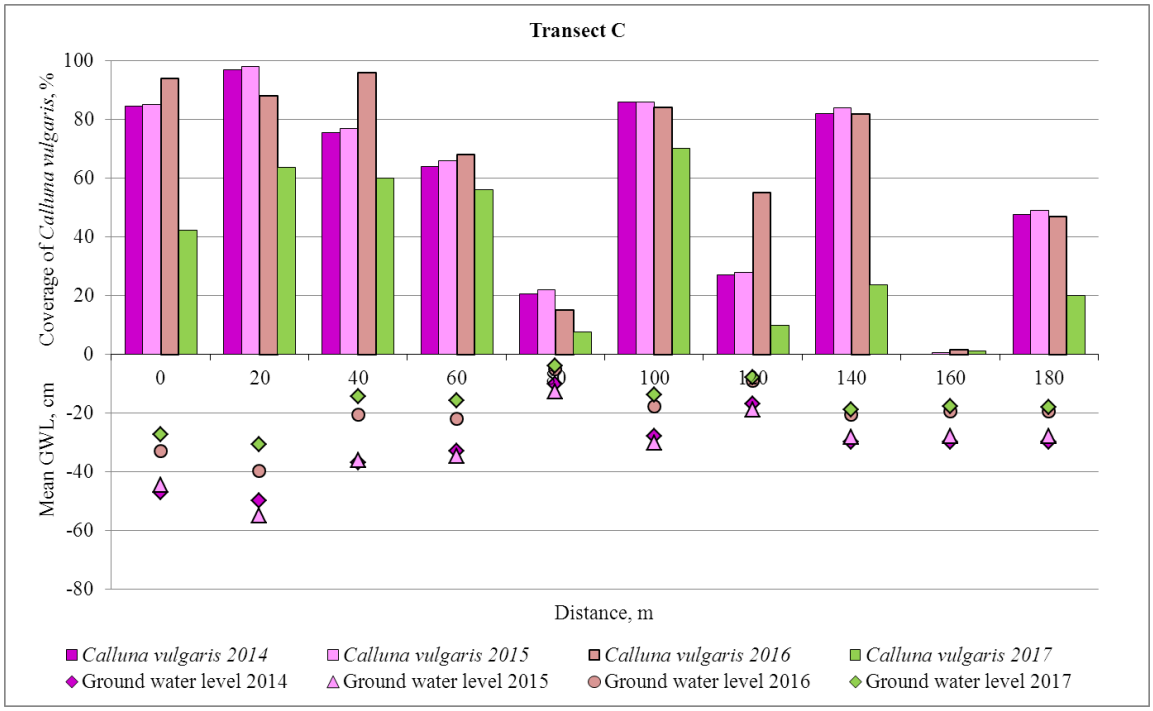

Fig 13. Changes in heath (*Calluna vulgaris*) cover in transect C (2014–2017) depending on distance

The decrease of vital *Calluna vulgaris* individuals coverage indicates the efficiency of applied restoration measures in all three monitoring transects. Moreover, the appearance of sphagnum mosses and typical raised bog vegetation (*Drosera sp. Rhynchosphora alba, Eriophorum vaginatum, Polytrichum strictum, etc*.) in majority of study plot, shows clear shifts from degraded to active raised bog habitats. However, too short period has passed since the implementation of project actions, therefore changes in vegetation cover will be more evident during upcoming years.

Transects B and C were equipped in the fire damaged (2011) site. This has drastically changed the top soil mineralization and thus created favorable conditions for not typical raised bog species, such as heath (*Calluna vulgaris*) during the first year period.