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The impact of beaver ponds on tree stand in a river valley

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Abstract: The number of beavers in Poland rapidly increases which may result in conflicts between man and beavers. Despite the fact that beaver ponds play important role in increasing of biodiversity, water retention and soil moisture, they may also cause the die out of tree stands in river valleys and lead consequently to disappearance of typical riparian forest communities. Field studies demonstrated that long term flooding inhibited tree growth. Many trees died after 2 years of flooding. Long flooding caused the death of 80% of trees.

Key words: *beaver dam, beaver ponds, Białowieża forest, Castor fiber, forest stand*

INTRODUCTION

Many technical works affecting water regime are now being made in forest areas to achieve several goals like e.g.: wetland protection or restoration, recovery of ecological functions in formerly drained areas, protection and enhancement of biodiversity biologicznej (DROBIEWSKA, 2008; FRYDEL, 2008; KOWALSKI, 2008; MIODUSZEWSKI, 2008; PRZYBYŁEK and GOŹDZIK, 2008; RYŚ, 2008; SCHWARTZ, 2008; ZABROCKA-KOSTRUBIEC, 2008). These works consist in building water reservoirs (through-flow or stagnant) and dams on streams and reclamation ditches or even by filling the latter. Parallel to such human activities the expansion of the European beaver is observed all over the country. Beavers' activity is thought by many people as positive and sufficient to achieve the goals mentioned above (CZECH, 1999; KOSSAK, 2001; ZDZIENICKI, 2002; CYWICKA and BRZUSKI, 2008; DERWICH and MRÓZ, 2008).

STUDY AIM AND RANGE

This work was undertaken to demonstrate changes in tree stand growing in a river valley under the effect of beaver dams. The study was carried out in waters running through the area of the Forest District Browsk in Białowieża Forest. Measurements of water table in study objects were initiated there several years ago. Study plots are under the direct effect of artificial and beaver-made dams. The effect of beaver ponds on tree stand was estimated by performing:
– tree inventory with special attention paid to their health,
– analysis of annual tree increments.

METHODS

Studies were carried out in northern part of Białowieża Forest on sampling plots (Fig. 1) with various analyses made on each:

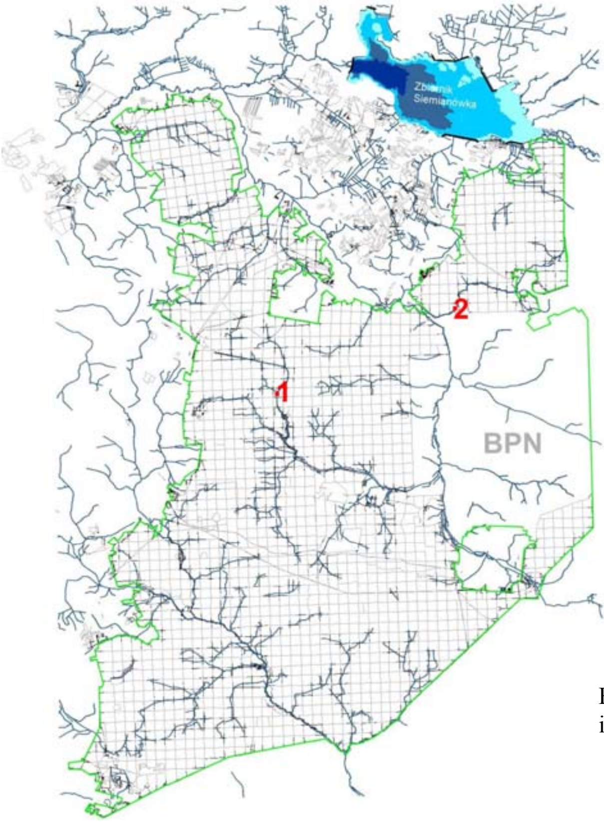

Fig. 1. Location of the sampling plots in Białowieża Forest

- plot 1 – measurements of water level in a stream up- and downstream the dam, measurements of ground water table within the range of reservoir's impact, measurements of tree diameter at breast height (DBH) in the stream valley and estimation of tree health status, measurements of tree growth increments in the last years;
- plot 2 – measurements of water level in a stream up- and downstream the dam, measurements of ground water table within the range of reservoir's impact, measurements of water flow in a stream, measurement of tree growth increments in the last years.

Water levels were measured automatically every 6 hours with electronic limnigraphs DATAFLOW SYSTEMS PTY LTD. Tree growth increments were assessed from tree cores drilled with the Pressler gimlet and analysed with PRZYROST ver. 2.02 Biotronic software. The cores were taken from the black alder trees: two dead, two weakened and two live trees in areas not affected by floods in plot 1 and from two weakened and two live trees in plot 2. The analysis was performed on the last 20 growth increments i.e. for the period 1989–2008. 60 years old trees were measured.

DESCRIPTION OF STUDY PLOTS

Plot 1 is situated in subdivision 182C in the area of the Forest District Browsk near its border with the Forest District Hajnówka. The subdivision is cut by a narrow valley of the Łutownia stream (Fig. 2) where the Northpodlasian Society for Bird Protection (PTOP) built a dam in 2001 to create favourable conditions for forest birds (particularly for the water rail), to increase water retention and biodiversity and to protect valuable communities of forest vegetation. In 2005 beavers

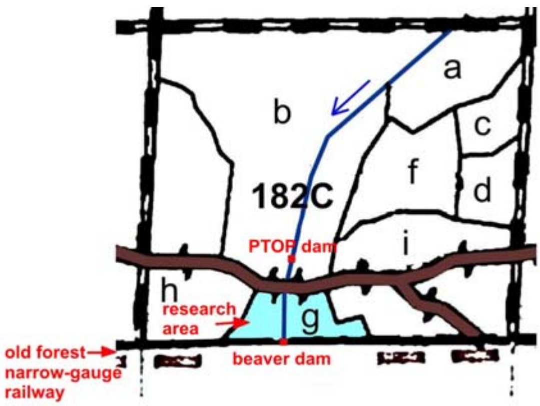

Fig. 2. Location of studied dams in the Łutownia stream in subdivision 182C

built a dam in this stream using the already existing culvert under the railway embankment. Beaver dam flooded the area between the railway embankment and road embankment. Ash-alder swamp dominates there.

Plot 2 is situated in subdivision 82C and covers part of the Braszcza stream valley north of the asphalt road that cuts the subdivision from west to east (Fig. 3).

Fig. 3. Location of studied dams in the Braszcza stream in subdivision 82C

Before dam construction the tree stand was composed of the black alder in the stream valley and of pine, spruce and oak in more elevated areas. Initially the dam in this object was constructed by PTOP 5 m from the road bridge in 2001. In autumn 2006 the dam was markedly raised by beavers.

RESULTS

WATER LEVELS IN STREAMS AND GROUND WATER TABLE DEPTH

In plot 1 localised in division 182 of the Forest District Browsk water levels were measured in wells situated in stream and at a distance of 15 m from it from 1st February till 30th September of the years 2005 and 2008. The first period corresponds to the situation when beavers appeared on the reaserach area, second is when beavers left their place of living.

The lowest stream water table in 2005 (159.57 m a.s.l.) was noted on 2nd March and the highest – on 18th August (160.36 m a.s.l.) (Fig. 4a). Ordinate of the measurement well was 159.23 m a.s.l. so the water depth increased from 34 cm in March to 113 cm in August. Beavers that appeared in spring near the plot were the reason of such remarkable water raising. Water table raised also in a well 15 m from the stream. The lowest water table was recorded there on 11th February (159.83 m a.s.l.) and the highest – as in the stream – on 18th August (160.21 m

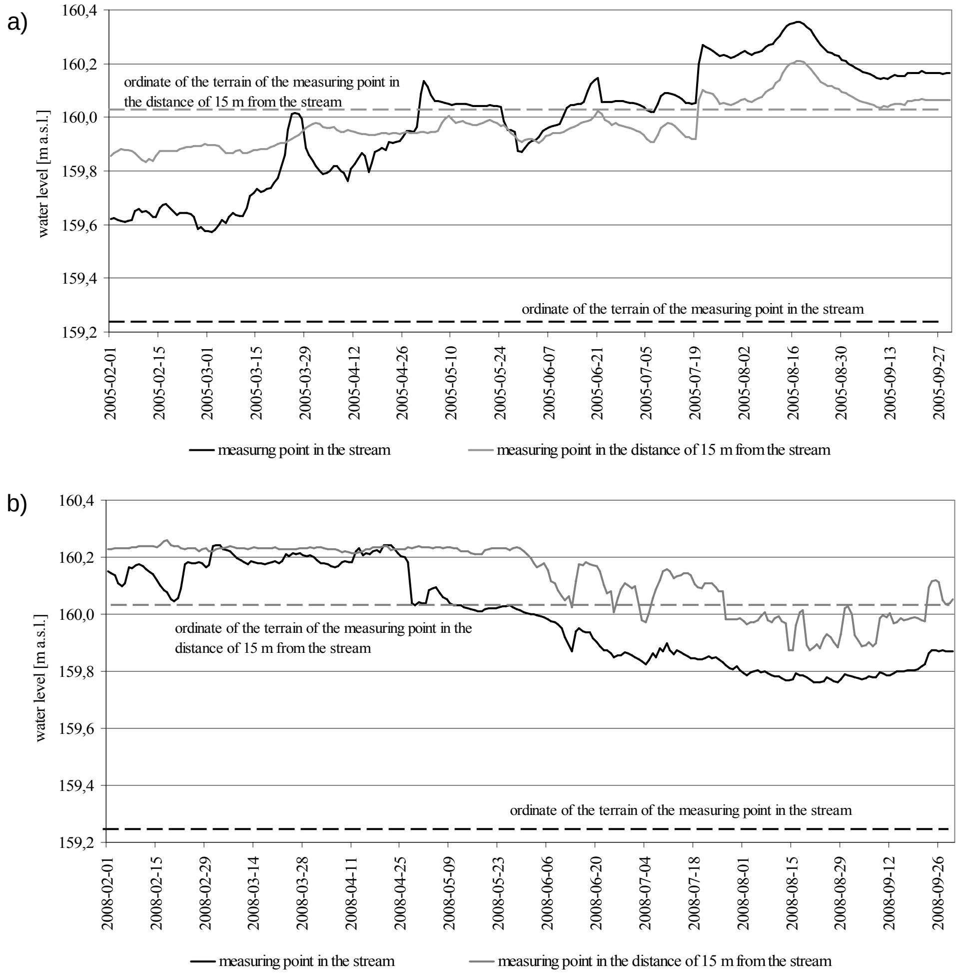

Fig. 4. Changes in the water table level in study plot 1 in the year 2005 (a) and in 2008 (b)

a.s.l.). Maximum difference of water tables was 79 cm in the stream and 38 cm in sampling point 15 m from the stream. Mean water levels were 159.99 m a.s.l. and 159.98 m a.s.l. in the stream and 15 m onshore, respectively.

The effect of beaver dam became visible in the second study period (1st Fabruary – 30th September 2009). Water table levels were higher than those in 2005 (fig. 4b). Maximum height of water table in the stream was noted on 4th March (160.23 m a.s.l.) and minimum – on 28th August (159.76 m a.s.l.) Maximum difference in stream water depth was 47 cm being smaller than the difference in the year 2005 by 22 cm. Extreme levels of water table 15 m from the stream were found on 18th February (maximum – 160.26 m a.s.l.) and on 20th August (minimum – 159.87 m a.s.l.). Mean levels of water table for that period were 159.99 m a.s.l. in the stream and 160.13 m a.s.l. at a distance of 15 m from it.

Comparison of water table levels between the years 2005 and 2008 shows the effect of beaver dam. This is particularly true for minimum levels of water table in the stream which was higher by 19 cm in 2008.

The second studied plot was localised in division 82 of the Forest District Browsk. Data for the comparison of water table changes were from the whole years 2005 and 2007. In the end of summer 2006 an increased beaver's activity was observed. The animals started to build their dam. Water table levels without the effect of beaver dam (2005 – Fig. 5a) and with this effect (2007 – Fig. 5b) were compared.

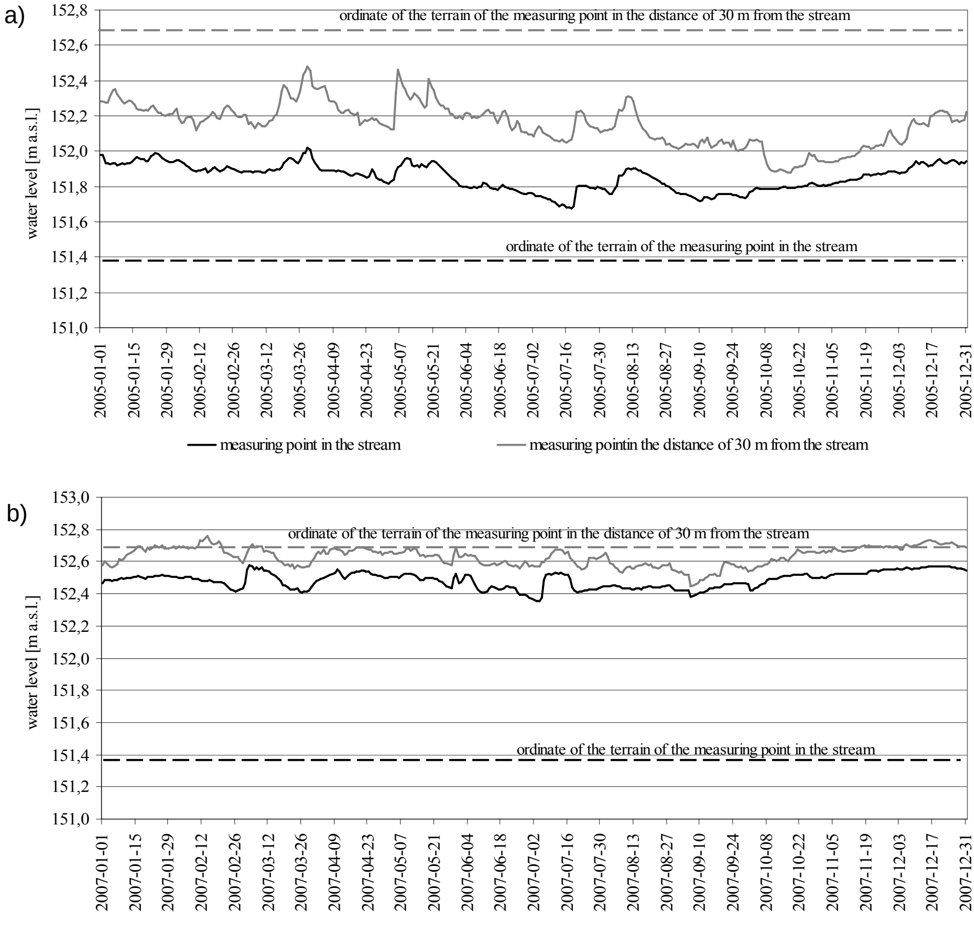

Fig. 5. Changes in the water table level in study plot 2 in the year 2005 (a) and in 2007 (b)

Annual mean of the stream water table level in 2005 was 151.85 m a.s.l. Minimum water table was noted on 19th July (151.69 m a.s.l.) and maximum – on 30th March (152 m a.s.l.). The second measurement well was 30 apart from the stream. In 2005 water table in this well was beneath the ground surface all year round. Minimum water table level was noted on 18th October (151.88 m a.s.l.). Maximum level appeared on the same day as that in the stream i.e. on 30th March (152.46 m a.s.l.). Mean ground water table depth for the whole study period was 152.15 m a.s.l. Comparison of the water tables show that amplitudes were smaller in the stream than in the well 30 m apart.

Remarkable impact of beaver dam on water table levels could be seen in the year 2007. Water raising resulted in periodical appearance of water on ground surface 30 m from the stream. At the same time minimum and maximum levels of water table increased. Maximum elevation of water table (152.74 m a.s.l.) was noted on 15th February. Minimum value of 152.45 m a.s.l. was found on 7th October. As could be seen, beaver dam limited the amplitude of changes of water tables. In the year 2005 the difference between maximum and minimum elevation of water table 30 apart from the stream was 57.9 cm and in 2007 – 29 cm. Mean level of water table in 2007 was 152.63 m a.s.l.

Water table in the stream was also largely elevated. Minimum water table was at 152.36 m a.s. l. (4th July) being more that 60 cm higher than before beaver dam construction. Maximum level was noted on 5th March (152.57 m a.s.l.). Mean stream water table level in this period was 152.49 m a.s.l. and was higher by 63 cm than that in 2005.

TREE GROWTH INCREMENTS IN FLOODED AREAS

Tree growth increments were measured in plot 1 and 2. Annual rings were analysed in 10 trees. In plot 1 alder trees 5 and 6 were live, 7 and 8 – dead and 9, 10 were the trees very weakened. In plot 2 alder trees 1 and 2 were dead and 3 and 4 – live trees. Annual increments of analysed trees were set up in Table 1.

Plot 1

Live trees dealt with as the reference achieved annual growth increments (the width of annual ring) from 0.85 to 3.64 mm in tree no. 5 and from 0.62 to 2.62 mm in tree no. 6. Mean increment was 1.83 mm (tree no. 5) and 1.71 mm (tree no. 6). After appearance of beaver ponds these alder trees achieved large increments whose maximum in tree no. 6 was found just in this period. On average the trees increased their diameter by 2.34 mm (tree no. 5) and by 2.41 mm (tree no. 6) during the last 3 years.

Dead trees preserved annual rings till their death in 2007. Before flooding tree no. 7 achieved annual increments between 0.55 mm and 3.64 mm with the mean of

Table 1. The width of annual rings in alder trees growing on study plots 1 and 2

Year	Plot 1						Plot 2			
	live		dead		weakened		dead		live	
	5	6	7	8	9	10	1	2	3	4
2008	2.01	2.20			1.36	0.41	0.38	1.19	2.54	2.61
2007	2.29	2.41	0.55	0.59	1.58	0.91	0.48	1.26	4.06	3.96
2006	2.71	2.62	0.62	0.68	0.99	0.71	0.34	1.05	3.05	3.17
2005	1.35	2.13	2.26	1.52	0.99	0.71	0.48	1.46	2.34	2.37
2004	2.12	2.06	1.56	1.44	1.19	1.52	0.34	3.56	2.58	1.41
2003	2.03	1.79	1.87	1.02	0.99	1.12	0.48	3.01	2.24	1.35
2002	1.27	1.72	1.25	0.93	1.09	1.02	0.55	1.23	1.32	1.27
2001	1.52	1.31	3.04	1.95	1.68	1.22	0.62	3.01	3.66	1.31
2000	2.88	2.06	0.86	2.12	2.67	1.32	1.31	2.60	3.96	1.39
1999	2.03	2.06	0.55	1.55	2.17	2.24	1.51	3.29	4.27	1.74
1998	1.78	1.86	0.62	1.78	1.28	1.73	1.10	1.03	2.54	1.35
1997	1.10	1.03	0.78	1.35	1.28	1.42	1.72	3.01	6.5	2.29
1996	1.69	1.17	2.65	1.86	1.28	1.22	0.96	2.05	5.99	2.85
1995	3.64	1.10	2.57	1.44	0.69	0.51	0.69	2.12	2.24	3.01
1994	1.02	0.62	2.88	1.35	1.09	1.02	0.89	1.99	1.93	1.58
1993	1.10	1.17	2.57	1.27	0.59	0.71	1.45	4.31	3.25	2.37
1992	0.85	1.86	1.56	1.52	0.69	1.22	0.48	5.61	6.30	2.53
1991	1.69	2.13	1.56	1.02	1.38	0.41	0.62	3.70	6.10	1.9
1990	1.52	1.10	1.95	1.35	2.57	1.02	1.31	4.38	7.31	3.88
1989	2.03	1.86	2.03	1.69	2.97	1.32	1.17	3.22	4.83	3.88

1.80 mm. Tree no. 8 increased its diameter annually by 0.59 to 2.12 mm before flooding (mean 1.47 mm). After flooding the trees rapidly decreased their growth increments which in the year 2006 equalled 0.62 mm (tree no. 7) and 0.68 mm (tree no. 8) and 0.55 mm and 0.59 mm, respectively in the year 2007.

Annual rings in tree no. 7 showed smaller increments corresponding to the years 1997 – 2000. Increments in those years were similar to those from the last years of the tree growth. The tree survived, however, the former period of unfavourable growth condition and later rings were much larger. The lack of respective growth inhibition in tree no. 8 might be explained by the place of growth of both trees. Tree no. 7 grew closer to the stream than tree no. 8 and, therefore, was more affected by the variability of water table in the stream.

Weakened alder trees in the period before damming had the annual rings from 0.59 to 2.97 mm wide (tree no. 9) and from 0.41 to 2.24 mm wide (tree no. 10). Mean width of annual ring was 1.48 and 1.18 in trees no. 9 and 10, respectively. Mean increment after the construction of beaver dam was 1.31 mm in tree no. 9 and 0.68 mm in tree no. 10 (Fig. 6).

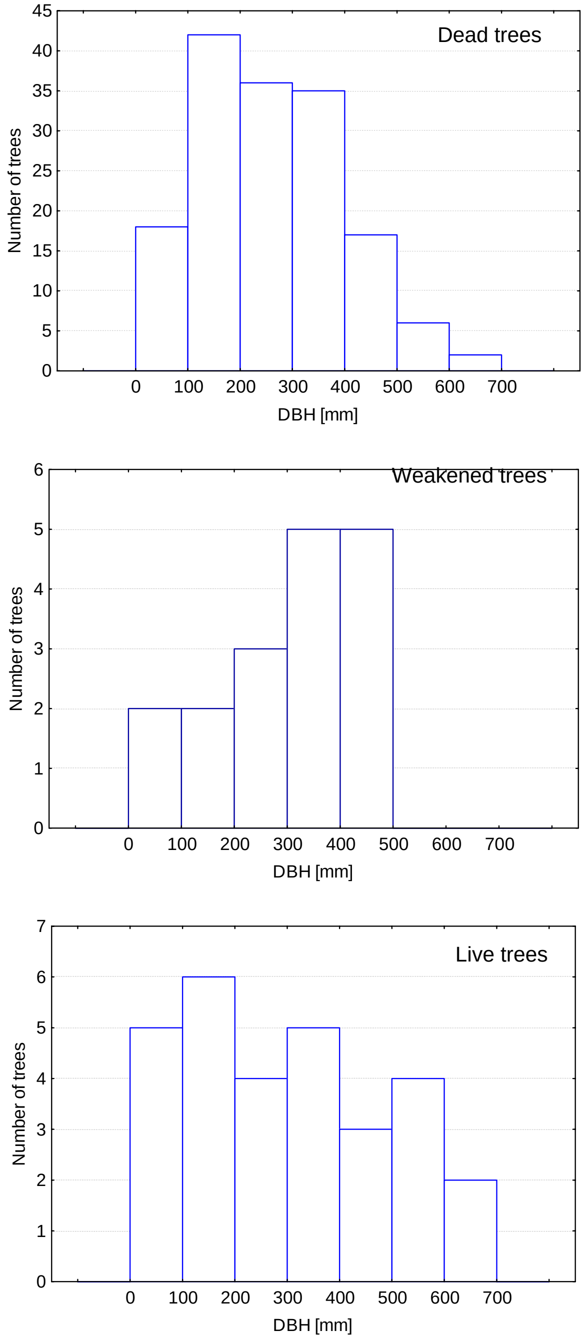

Fig. 6. The number of trees in size classes divided into dead, weakened and healthy trees

The trees were also subject to unfavourable growth conditions in the years 1991–1995 which resulted in the annual increments similar to those from the last period. Recently, however, tree no. 10 has achieved smaller increments than tree no. 9 which might evidence its poorer condition. In the prolonged period of unfavourable growth conditions caused by flooding this tree should have died earlier than tree no. 9. The difference resulted probably from the fact that tree no. 10 grew closer to the stream channel and was thus affected by changes in water table levels.

Plot 2

Cores from live and weakened trees were collected in plot 2. Mean annual increment in weakened trees was 0.84 mm in tree no. 1 and 2.65 mm in tree no. 2. So high differences were caused by the fact that the former tree grew near the stream channel and its growth was affected by dam constructed by PTOP while the latter tree grew farther from the stream and had more favourable growth conditions (air-water relations in soil) for its all lifetime. Marked growth inhibition was caused only when beavers raised water level. Tree no. 1 started to "feel" the effect of flooding already in 2001. Earlier, the width of annual ring ranged from 0.48 to 1.72 mm and the mean width was 1.10 mm. After PTOP constructed their dam annual tree ring varied between 0.34 and 0.62 mm with the mean of 0.46 mm. It seems probable that poorer growth conditions encountered by this tree for its whole lifetime made it more resistant to long-term floods. Despite reduced annual increments the tree managed to survive 8 years after water table raising. Rapid and long lasting growth inhibition was observed in tree no. 2 only after development of PTOP dam by beavers. Mean annual increment in this tree between 2005 and 2008 was 1.24 mm ranging from 1.05 mm to 1,46 mm. Earlier, before the flood enlargement, mean annual increment was 3.01 mm and ranged from 1.03 mm to 5.61 mm.

One of the live alder trees alse grew in better conditions and hence achieved larger increments. Annual increments in tree no. 3 varied between 1.32 mm and 7.31 mm with the mean width of annual ring equal to 3.85 mm. Annual rings of tree no. 4 had a width varying from 1.27 mm to 3.96 mm and mean width was 2.31 mm. Large increments have been observed in both trees recently. Mean increase of tree diameter in the last 4 years was 3 mm in both trees. In the last years both trees increased their diameter by almost the same values. It is possible that growing outside the direct range of surface waters the trees were affected by elevated ground water table which was stable and provided better and comparable growth conditions for both.

HEALTH STATUS OF TREES IN FLOODED AREAS

Due to long flooding of plots 1 and 2 all trees practically died. Detailed measurements were made in plot 1 where beaver pond appeared between culverts under the road and railway embankments. All standing trees, stumps and fallen trees were measured.

Only trees with diameter at breath height were measured. Only stumps and fallen trees devoid of the symptoms of decay were considered assuming they originate from the last period – after flooding. In total 202 tree trunks, 6 stumps and 9 fallen trees were measured.

Only spruce stumps were found in the area which indicated that trees were removed by man. All stumps were of a large size; diameter of the largest exceeded 700 mm so, only old spruce trees were removed. Spruce trees of such dimensions were not found among standing trees. According to the information obtained from foresters dead spruces which were attacked by the spruce bark beetle were cut down.

Fallen trees were represented by two species – the black alder and the European hornbeam. In total 7 fallen alder trees and 2 hornbeams were found. Alder trees had diameters ranging from 151 mm to 630 mm, hornbeam fallen trees were of small sizes – their diameter was 85 mm and 147 mm as measured 1.3 m from the root cervix.

Standing trees were dominated by a group of 156 died trees. Dead standing trees were represented by 5 species: the black alder – 135 trees, the Norway spruce – 7 trees, the European hornbeam – 11 trees, the European ash – 1 tree, the white birch – 1 tree, and the Norway maple – 1 tree. There were 17 weakened trees: 13 alder trees, 3 hornbeams and 1 ash tree. Twenty nine live trees were found – 19 alder trees, one spruce tree, five hornbeams, two ash trees and two maple trees. The European hornbeam and maple trees grew at the border of the stream valley but the effect of flooding reached there so, that part of trees of these species died.

Trees from the plot had the diameter up to 700 mm. The largest were the black alder trees. The thickest alder tree among dead trees had DBH of 626 mm, among weakened trees – the alder tree of DBH equal to 481 mm and in the group of live trees – the alder tree of DBH of 616 mm. The smallest DBHs noted in particular groups were: 75 mm of alder tree among dead trees, 74 mm of alder tree among weakened trees and 16 mm of spruce tree among live trees.

Most numerous was the size class 101–200 mm which included 50 alder trees. At the same time it was the most numerous class among dead trees represented by 42 trees and among live trees represented by 6 trees. Most weakened trees were found in the classes 310–400 mm and 401–500 mm – 5 trees in each. In total, trees from size classes from 101 mm to 400 mm constituted 67% of all trees in the plot. Such size distribution was determined by dead trees which constituted 72% of all trees in these three classes. The least numerous was the largest size class 601–700 mm. It contained only two live and two dead trees (Fig. 6).

DISCUSSION

The European beaver is a natural component of biocoenoses in Poland. Traces of this species are being found in archaeological studies. For centuries beaver was a game species valuable for its fur and meat. Strong human pressure on this species brought about already in the 10th century the first restrictions in hunting for beavers which became a privilege of noble men. In the 13th century a post of beaver administrator was founded at prince's or royal courts to manage the beaver populations. Restrictions in hunting were abolished in the 14th century (APOSTOŁOWICZ, 2005).

The occurrence of beavers in the 12th century may be considered the natural range of the European beaver. In those day beaver was present in the whole continent except for Italy, Greece, Ireland and Denmark. In the next centuries the range shrunk rapidly: in the 13th century the species was exterminated in England and Wales, in the 14th century – in Belgium and north-western France and in 17th century – in the rest of France and in Iberian Peninsula. Till the end of the 19th century beaver was extinct in Moldova, Yugoslavia, Austro-Hungarian Empire, Sweden, Holland, Finland, and Switzerland (MISZCZUK and OGLĘCKI, 2004). Main reasons of the extinction of this species were mass tree felling and impoverishment of the food base, wetland drainage and regulation of streams, degradation of beavers' habitats by intensive farming, fishery and poaching (JANISZEWSKI *et al*., 2007).

Free hunting, high fur value and mass poaching led to the extinction of beaver from Polish territory. Only in the Prypeć River drainage basin in north-eastern part of the country several hundred individuals remained until the II World War. In the rest of the country last beavers were noted in 1830 in the Nogat River near Elbląg (APOSTOŁOWICZ, 2005) and in the Narew River valley (GIZAK, 2001). Attempts of reintroduction of the European beaver were undertaken in the Experimental Station of the Polish Academy of Sciences in Popielno since the year 1959. In 1974 professor Wirgiliusz Żurowski initiated there the Programme of Protection of the European Beaver in Poland. Success of this enterprise was an effect of many factors:

– good status of natural environment in the country,
– many areas of topographic and water conditions favourable for this species,
– longevity of the species – beavers live up to 25 years,
– relatively large progeny (up to 5 young in the litter) and parental care,
– a lack of natural enemies – only wolf and lynx may efficiently prey on beavers.

These circumstances led to the expansion of beavers all over the country. Main Statistical Office (Ochrona…, 2007) reported that the country population of beavers increased as follows: 1980 – 1500 individuals, 1985 – 3 200, 1990 – 5 000, 1995 – 12 740, 2000 – 24 464, 2005 – 43 499, 2006 – 49 040. One may notice that the population practically doubles every five years. If the rate of expansion remains at the same level than we will have 300 000 beavers in Poland in the year 2020. Distribution of beavers in Poland is not uniform. They are most numerous in Podlaskie Province and least numerous in Śląskie and Opolskie Provinces. The numbers of the European beaver in particular provinces in 2006 were as follows (Ochrona…, 2007): Dolnośląskie – 800, Kujawsko-Pomorskie – 2 050, Lubelskie – 2 650, Lubuskie – 3 800, Łódzkie – 450, Małopolskie – 1 000, Mazowieckie – 3 800, Opolskie – 110, Podkarpackie – 4 100, Podlaskie – 14 000, Pomorskie – 1 200, Śląskie – 110, Świętokrzyskie – 4 200, Warmińsko-Mazurskie – 5 000, Wielkopolskie – 3 900, Zachodniopomorskie – 1 870.

The presence of beavers and their activity largely transform the habitat they live in. Beavers' activity has its pros and contras. Positive aspects of beavers' activity include: increase of water retention, soil irrigation, decrease of the water flow in a stream, initiation of the swamping processes, increase of water aeration, purification of water – beaver pond is a settling reservoir where bacteria decrease the concentration of pollutants and increase biodiversity (GIZAK, 2001; MISZCZUK and OGLĘCKI, 2004; MISIUKIEWICZ, 2006). Negative effects of beavers' activity include: grazing on and destruction of trees, dying of flooded trees, flooding of croplands, digging burrows and tunnels in flood embankments and dikes around fishponds, digging and eroding road and railway embankments (GIZAK, 2001; ŚWIĘCICKI, 2002; WARCHOLAK, 2007).

In the next years one may expect intensification of conflicts between man and beaver due to increasing population density of the latter. Now, problems with forest flooding and dying of tree stands are solved by abandoning the economic tasks in particular forest divisions. Such area is termed non-forested ground and is intended for legal protection due to legal species protection of beavers. Moreover, in agreement with the Order 67 of the General Director of State Forests such area may be intended for natural succession.

There is an interesting situation now in Białowieża Forest where such actions were undertaken by both man (PTOP) and beavers. Presented examples demonstrate that beavers are able under favourable conditions to develop man-made dams to obtain larger and deeper ponds. This, however, leads to uncontrolled die-off of a tree stand. Initially small beaver population in Białowieża Forest made little harm to tree stands and engineering works were necessary to retain water in streams. Now, beaver density is so high that man-made dams in most stream stretches are not necessary since beavers sooner or later will make their own dams. But large areas of Białowieża Forest are inaccessible to beavers. That's because many forest streams are in long parts periodical water courses. The amount of water carried by such streams strictly depends on precipitation and spring snow melting. At early snow melting (which was often the case in recent years – BOCZOŃ, 2006) and small spring precipitation the length of forest streams may be reduced even by half. In areas with water deficit beavers will not build their dams. This, however, often involves naturally valuable spring areas. Just such areas should focus special attention and human activities should aim at providing enough water to protect their unique character and biodiversity. A plan considering water demands of Białowieża Forest, inventory of spring areas and the periodicity of particular streams should be worked out to undertake such actions and supplement works made by beavers.

CONCLUSIONS

Field and literature studies allowed drawing some conclusions.

1. Tree growth rapidly declines in flooded areas and many trees die after 2 years of flooding.

2. Nearly 80% of trees died in long flooded areas. Surviving trees grew at the border of flooding range which is not affected by flood during long rainless periods.

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STRESZCZENIE

Wpływ stawów bobrowych na drzewostan w dolinie rzecznej

Słowa kluczowe: *bóbr europejski, drzewostan, Puszcza Białowieska, stawy bobrowe, tamy bobrowe, zalew*

W artykule podjęto problem wpływu budowli piętrzących wznoszonych na ciekach przez bobry na otaczający drzewostan. Przedstawiono wyniki pomiarów przyrostów rocznych drzew rosnących w zasięgu zalewu, a także oszacowano stan zdrowotny drzewostanu, będącego pod wpływem podniesienia poziomu wody. Badania przeprowadzono na ciekach płynących przez Nadleśnictwo Browsk, położone w północnej części Puszczy Białowieskiej.

Liczebność bobrów w Polsce gwałtownie wzrasta, co może w najbliższych latach skutkować nasileniem występowania sytuacji konfliktowych między człowiekiem a bobrami. Pomimo, że stawy bobrowe pełnią ważną rolę w zwiększaniu różnorodności biologicznej, w zwiększaniu retencji wodnej, zwiększaniu uwilgotnienia gleby, to jednak na terenach leśnych doprowadzają do zamierania drzewostanów w dolinie rzecznej, w wyniku czego dochodzi do powstawania wylesionych dolin i zanikania typowych leśnych zbiorowisk przyrzecznych. Przeprowadzone prace terenowe wykazały, że na terenach zalewu gwałtownie obniża się przyrost drzew, wiele z drzew już po 2 latach zalewania zamiera. Długotrwałe zalewanie doprowadziło do zamarcia blisko 80% drzew.

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