OECESIS OF WHITE WILLOW COMMUNITIES IN THE NATURE RESERVE VĚSTONICKÁ NÁDRŽ RESERVOIR

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Abstract

Maděra P., Svobodová I., Packová P.: Oecesis of white willow communities in the Nature Reserve Věstonická nádrž reservoir. Ekológia (Bratislava), Vol. 28, No. 1, p. 7–21, 2009.

The construction of Nové Mlýny water reservoir has caused the break of floodplain corridors connectivity between alluviums of Dyje, Svratka and Morava rivers. The Czech Ministry of Environment adopted the ecologisation policy of Nové Mlýny middle water reservoir after 1989. Within this policy the water level was lowered by 85 cm in July of the 1996 (to the spot height 169.5 m a. s.l.). Two artificial islands were built up to perform as a part of regional biological corridor running through middle water reservoir. After the lowering of water surface level in the reservoir 80 ha of banks arised and in the Jihlava and Svratka rivers confluence in process of intensive sedimentation formed a new island. The viable seeds of anemochorous willow and poplar trees could not show up in the air in July, at the time of water surface level lowering, because a rain of seeds is present only in May and June. Nevertheless in September the depositions without vegetation were covered by the white willow and black poplar seedlings. The population density reached as many as 45 specimens per square meter. The paper describes the way of white willow communities oecesis in nature reserve Věstonická nádrž reservoir. The phenology of *Salix alba*, seeds rain and seeds germination in dry environment and in water were observed. The seeds of *Salix alba* had the germinative activity in dry environment most 17 days (2,5% of seeds). In water seeds germinated promptly and seedlings lived on more than 40 days. The oecesis was made thanks to „a seedlings waterbank". The seedlings were washed up on the uncovered depositions and lakesides. The white willow behaves in juvenile phase in water as a natant or submerged hygrophyte species and prolongs its ability to occupy a new territory.

Key words: *Salix alba*, germination, oecesis, phenology, seeds rain, NR Věstonická nádrž reservoir

Introduction

The hydroengineering structure of Nové Mlýny was built in 1975–1989 within the framework of complex hydrotechnical regulations in South Moravia (Jakubec, 1981). It consists of three lakes of which the middle one was decreed as the Nature Reserve of Věstonická nádrž (Věstonice Water Reservoir) due to the occurrence and nesting of abundant waterfowl species. Seen from the viewpoint of landscape ecology, however, the hydraulic structure on the confluence of Dyje, Jihlava and Svratka rivers disrupted the connectivity (Forman, Godron, 1986) of floodplain biotopes between the Dyje-Svratka and the Dyje-Morava rivers alluvial plains (Buček et al., 1992). Rare biotopes of floodplain forests, alluvial meadows, bog wetlands, riverine lakes, meandering water courses and xerotherm communities of sand dunes ceased to exist under the reservoir's water surface (Buček, Pelikán, 1985).

After 1989, the Ministry of Environment of the Czech Republic adopted a policy for the ecologization of the Nové Mlýny middle reservoir within the framework of which the water level was lowered in July 1996 by 85 cm to a spot height of 169.50 m a.s.l. and a construction of two artificial islands was launched that would serve as a part of the regional biocorridor (Forman, 1983; Buček, Lacina, 1996) running through the floodplain. The islands are meant to abridge the distance over the reservoir's water surface which is for many organisms too large to pass.

The water level lowering caused denudation of sediment loads in the Jihlava and Svratka rivers mouth tracks, enlargement of the existing holms area in the reservoir and denudation of border dam bases – all this on an area of several tens of hectares. Flamiková (1996) mentions approximately 70 ha of newly denudated surfaces. These newly denudated surfaces provided optimal conditions for the oecesis of soft floodplain communities. At the time of water surface lowering in July 1996, seeds of soft floodplain tree species could not have been any longer present in the air, especially those of anemochoric willows. Nevertheless, seedlings of white willow, black poplar and interspersed seedlings of other willow species emerged on the sediment loads in high population densities of up to 45 individuals per a square meter (Konůpek, 1998; Kovářová, 2003).

The paper aims at a description of the oecesis, i.e. establishment of white willow communities on the denudated sediment loads as the experience may be utilized in similar revitalization measures in alluvial plains.

Vitality of white willow seeds is described as very short in literature. If the seeds fail in finding a suitable place for germination, they would lose their germinative capacity within a few days (Chmelař, Meusel, 1986). This indicates that the above-mentioned advance growths could not have emerged from a seed bank. In the first step it was necessary to confirm by phenological observations the assumption that there was not any seed rain occurring in the surveyed area at the time of water level lowering in the reservoir.

A working hypothesis was that seeds fallen into water at the time of seed rain would keep a longer germinative capacity than seeds fluttering in the air and fallen on the ground. Hence, that an analogy exists to the soil bank of seeds also in water – as a water seed bank composed of hydrochoric plant species, whose function -apart from the displacement of diaspores- consists also in the extension of seed vitality and thus in an enhanced chance for the plant establishment.

Material and methods

The middle water reservoir of the Nové Mlýny hydroengineering structure is situated some 40 km south of Brno on the former confluence of the rivers Svratka, Jihlava and Dyje. The water level lowering to the spot height of 169.50 m a.s.l. was made on 6 July 1996. Denudated sediment loads, particularly those in the mouth tracks of Svratka and Jihlava rivers were of clay character with a negligible superelevation. Konůpek (1998) mentions 15 cm on a 40 m long transect perpendicular to river bank line, Kovářová (2001) measured only 8 cm on a 30 m long transect perpendicular to river bank line. Denudated dam bases feature a significant admixture of gravel and represent a somewhat different ecotope.

Phenological observations in the area under study included the monitoring of fruits ripening phenophase in white willow, i.e. the beginning of the first opening of capsules and the end of the occurrence of last seeds in the capsule. The beginning of the phenological phase of fruits ripening was compared with the weather course in the respective year, and the sums of effective temperatures were calculated as a total of mean daily temperatures higher than 5 °C (Havlíček et al., 1986). The information about the mean daily temperatures in the studied period of time was provided by the Czech Hydrometeorological Institute (ČHMÚ) and its gauging station in Brod nad Dyjí (175 m a.s.l.).

To corroborate the hypothesis comparative field trials were established to test the germinative capacity of white willow seeds stored in different ways. Some seeds were stored in uncovered containers placed in the open environment and protected from rainfall, some seeds were stored in water taken from the Svratka river in containers 40 cm deep, at all times in two variants – extracted seeds with the fluff removed and non-extracted seeds with the fluff. A sample of 50 seeds was to be taken each day from each storage variant for the test of germinative capacity.

Seed collection in the locality of Nové Mlýny took place on 23 May 2003 and 7 June 2004. Mature seeds of white willow were extracted from capsules on sieves with holes sized 1.5x1.5 mm. The seeds got gradually separated from the white clumps of fluff by means of wheeling and fell through the holes onto the underlying paper. A part of the seeds were left with the fluff.

From the first day, two control samples were established, each of fifty seeds stored dry. In the first week, the trials were established by days, then by two days until the time when the seeds stopped germinating at all. Germinative capacity was recorded in the individual germination trials each day. With regard to the fact that the seeds stored in water all germinated within two days, the trial design was modified to study the survival time of seedlings in water.

The seed rain was monitored only for orientation in an interval of one hour on 12 June 2004, i.e. at the time of the greatest occurrence of seeds in the air when white willow seeds fallen on an outspread white canvas sized 2 m were counted. For a better information about the seed source a survey followed of sex representation in between the trees growing around the reservoir on two transects long 150 and 300 m. Moreover, a tree model was created with respect to seed production. The inflorescence of white willow generates in the spring from the last year's annual shoots. The terminal bud gives rise to a sterile, just foliaged shoot and the lateral buds give rise to shorter shoots with catkins. Based on the destructive analyses of 18 trees of different sizes (with girths ranging from 7.5 to 180 cm) that were carried out to establish the primary production of early succession stages of white willow communities (Buček et al., 2004) a relation could be constructed between the tree girth at breast height and the number or length of annual shoots. Their distribution at different crown depths was known, too. In order to estimate seed production in a tree of the given girth the number of catkins on annual shoots was determined at different crown depths together with the number of capsules in catkins and the number of seeds in capsules. These input data were collected from the trees of various sizes in the given area in 2004–2006, always at several repetitions in order to calculate the arithmetic mean.

The site fitted for the oecesis in the Věstonická nádrž reservoir locality was retroactively modelled in the GIS TOPOL environment because the water level in the reservoir was raised again in 2001 to a spot height of 170.00 m a.s.l. A groundwork document was the map of floor depths produced in 2003 by Povodí Moravy State Enterprise, the level lines of which were digitalized. The area and distribution of denudated surfaces were determined by the intersection of the layer with the level line at 170.35 m a.s.l. (situation before the water level lowering) and the layer with the level line at 169.50 m a.s.l. (situation after the water level lowering in 1996).

Results

Phenology of white willow in the Nature Reserve Věstonická nádrž reservoir

White willow (*Salix alba*) flowers in the area of the NR Věstonická nádrž reservoir as early as in the second half of April, which means that fruits start ripening in the second half of May. In 2003, the capsule bursting and the flutter of fluffed seeds was first observed on 23 May. To the date, the sum of effective temperatures was 461.20 °C. The emptying of capsules took approximately 14 days. In the time period from 23 May to 7 June, the seeds of willow were occurring in the air thus being dispersed anemochorically. The seed rain was most profound at the turn of May and June. After the cold spring of 2004, the ripening of capsules was observed as late as from 5 June. To the date, the sum of effective temperatures was 531.20 °C, which resulted in seed dispersal until 20 June. The ripening of capsules required a higher sum of effective temperatures in 2004 due to a considerably colder weather course in May (Table 1), the month that is rather decisive for the ripening of capsules after the end of blossoming.

The ripening of capsules for the year 1996 can be therefore retrospectively established to have occurred roughly between 1 June (sum of effective temperatures 464.70 °C) and 5 June (sum of effective temperatures 525.20 °C). Taking into account the May temperatures higher than in 2004, we may rather incline to an earlier onset of this phenological stage. It can be assumed that the seeds of willows occurred in the air till 14–20 June with the highest intensity of occurrence in the period from 7–13 June. It is therefore evident that the abundant natural regeneration after the reservoir water level lowering in July could not have likely originated from the seed rain.

T a b l e 1. Average monthly temperatures from January to June in 1996, 2003 and 2004, the station in Brod nad Dyjí (175 m a.s.l.).

Year	January	February	March	April	May	June	I-VI
1996	-3.76	-4.67	0.84	9.52	15.31	18.24	6.02
2003	-1.75	-2.55	4.78	9.18	17.29	21.41	8.12
2004	-2.99	1.53	3.74	10.88	13.36	17.39	7.31

Seed rain

Tree model with respect to seed production

One capsule contains on average 9 seeds, one catkin infructescence contains on average 65 capsules. The number of catkins on annual shoots is variable within the annual shoot's position within the crown. Annual shoots occurring at the crown base with a lower light treat are shorter and the number of infructescences on them is lower. The higher the position of the annual shoot within the crown, the greater its length and the higher number of infructescences occurring on it (Table 2). An average occurrence rate is 1 catkin per 2.26 cm of the shoot.

Dependence between the total number of annual shoots in the tree (y) and the girth at breast height (x), valid in an interval from 7.5–180 cm (Fig. 1) can be expressed by the following equation:

T a b l e 2. Average number of catkin infructescences on annual shoots sampled from different crown sections in trees from the enclosed canopy and in solitary standing trees.

Part of crown	Enclosed canopy	Soliter
crown base	3.43	10.87
crown middle	9.86	
crown top	13.18	16.70

$$y = 0.4955x^{2.307} \; (R^2 = 0.8977).$$

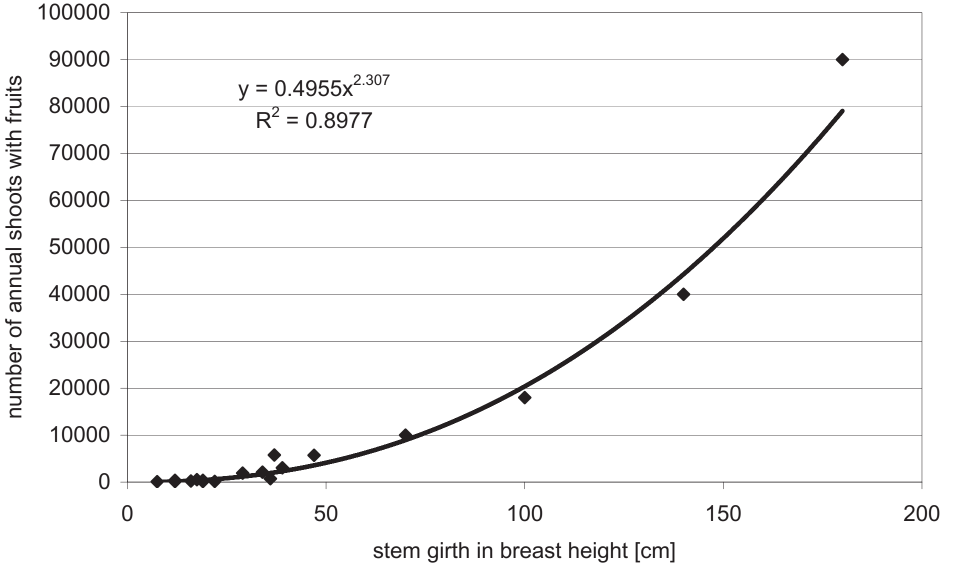

Fig. 1. The correlation between girth at breast height and number of annual shoots.

Dependence between the total length of annual shoots in the tree (y) and the girth at breast height (x), valid in an interval from 7.5–47 cm was expressed in a similar way (Fig. 2):

$$y = 695.97e^{0.1063x} \; (R^2 = 0.8705).$$

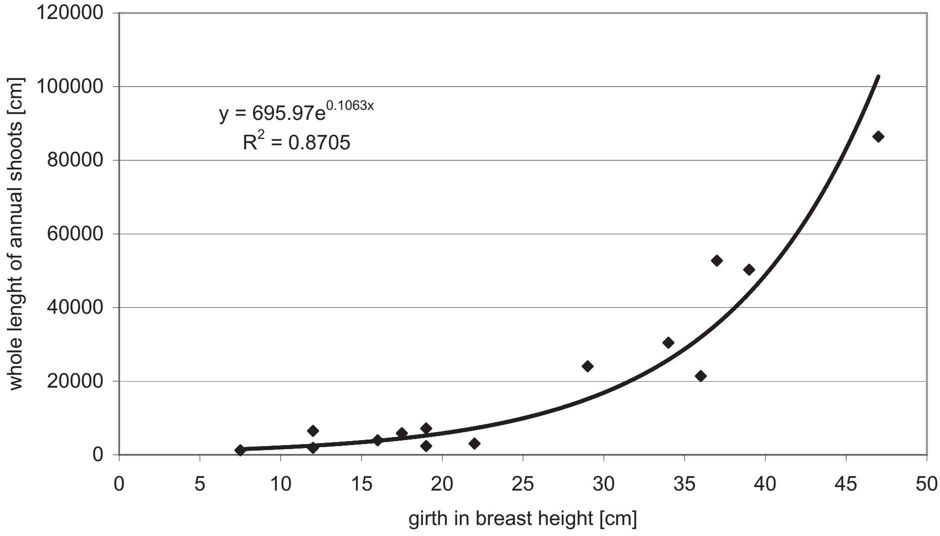

Fig. 2. The correlation between girth at breast height and total length of annual shoots.

T a b l e 3. The relative representation (%) of annual shoots within the crowns of white willow sample trees.

Part of crown	Number of annual shoots	Total length of annual shoots %
crown base	12.89	6.73
crown middle	39.99	27.31
crown top	47.12	65.96
lower half of the crown	27.18	15.78
upper half of the crown	72.82	84.22

A calculation that followed was that of the distribution of annual shoots within the crown (Table 3). The total number of annual shoots gradually increases from the crown base up to the tree top with merely 12.89% of them being found at the crown base. As to a total length of annual shoots, the crown base even contains only 6.73% of annual shoots length, which is a characteristic feature of the profoundly light-demanding tree species such as white willow.

Based on all above mentioned input data an estimate could be made of seed numbers in the trees of diverse girths both according to the number of annual shoots (Fig. 3) and according to their length (Fig. 4). The model seed numbers calculated according to the length of annual shoots were on average by 30% lower than those calculated according to

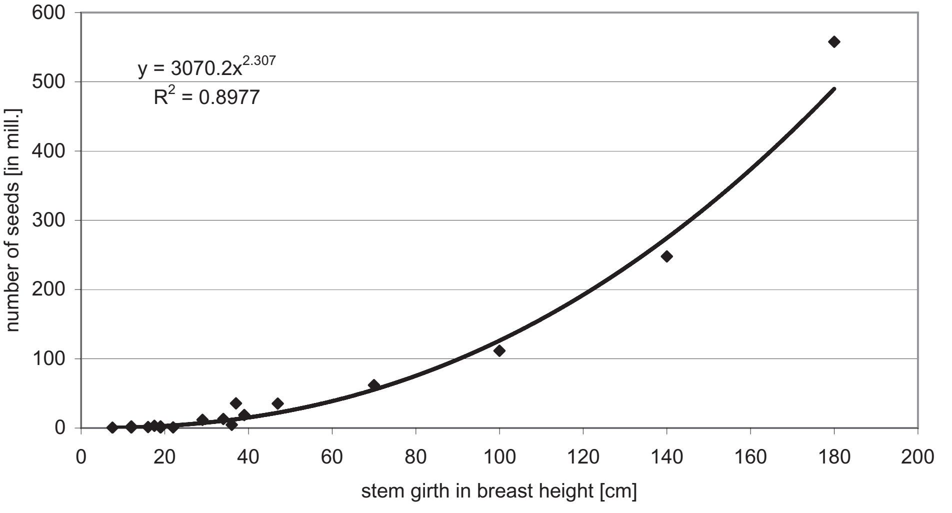

Fig. 3. Correlation between the girth at breast height and the number of seeds in the tree, calculated according to the number of annual shoots serving for the estimation of seed source size.

Fig. 4. Correlation between the girth at breast height and the number of seeds in the tree, calculated according to the length of annual shoots serving for the estimation of seed source size.

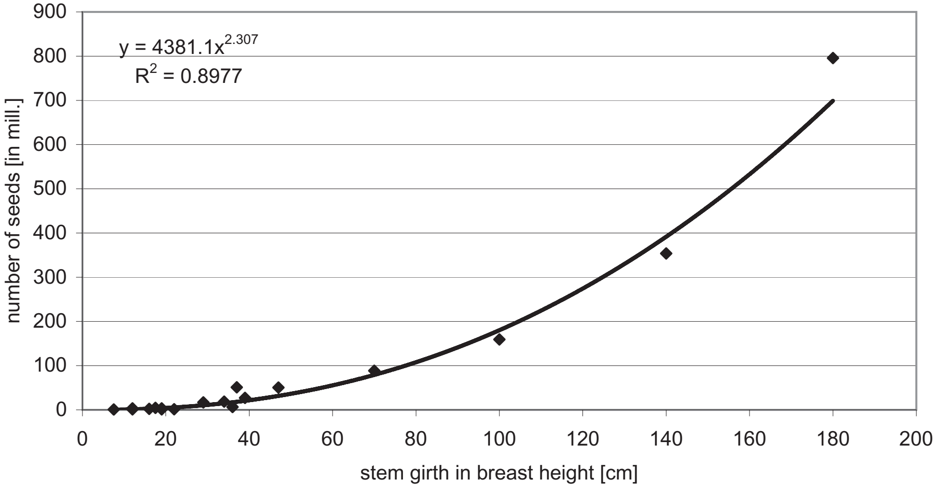

Fig. 5. Correlation between the girth at breast height and the number of seeds in solitary tree calculated according to the number of annual shoots serving for the estimation of seed source size.

the number of annual shoots. Another estimate was made for the number of seeds in solitary growing trees (Fig. 5), which is certainly different than in trees growing in the enclosed canopy. Annual shoots from the solitary trees did not show such a gradient in the decreasing number of capsules with the crown depth as shown in the enclosed canopy trees (Table 2). Soliters had a better insolated crown and the annual shoots occurring even at greater crown depths are longer and bear more inflorescences. The model calculation showed that solitary trees have by about 30% of seeds more than trees in the enclosed canopy.

Correlation between the girth at breast height (x) and the number of seeds in the tree (y) calculated according to the number of annual shoots with respect to their distribution within the crown (Table 3) valid for a girth interval from 7.5–180 cm was expressed by the following correlation equation:

$$y = 3070.2^{*}x^{2.307} \quad (R^2 = 0.8977).$$

Correlation between the girth at breast height (x) and the number of seeds in the tree (y) calculated according to the length of annual shoots valid for a girth interval from 7.5–47 cm was expressed by the following correlation equation:

$$Y = 180151^{*}e^{0.1063^{*}x} \ (R^2 = 0.8705).$$

Correlation between the girth at breast height (x) and the number of seeds in solitary tree (y) calculated according to the number of annual shoots with respect to their distribution within the crown (Table 3), valid for a girth interval from 7.5–180 cm was expressed by the following correlation equation:

$$y = 4381.1^{*}x^{2.307} \quad (R^2 = 0.8977).$$

White willow is a dioecious tree species and with respect to seed production it is therefore necessary to know the representation of pistillate specimens. The proportion of staminate and pistillate specimens in the studied area located on the transects was slightly in favour of the female trees (51.85%).

The above models justify a statement that the number of seeds on trees with girth over 40 cm may be estimated to range from tens to hundreds of millions. Hence it follows that the seed source for seed rain is huge, which is very important for a tree species with the R population strategy (Grimme, 1979).

The seed rain observation revealed on average 30 seeds fallen on a m^2/h at the time of the highest intensity of the emptying of capsules on 12 June 2004. The measurements were made at mild wind. The facts suggest that there may be hundreds to thousands of seeds falling on 1 m^2 of ground surface during the seed rain.

Germination of seeds stored dry

The entire experiment was planned to approximate to natural conditions as much as possible. The seeds were stored in open containers at outdoor conditions being only protected

T a b l e 4. Germinative capacity and germination rate of white willow seeds in dependence on the length of dry storage.

Extracted seeds without fluff			Non-extracted seeds with fluff		
storage time [days]	germinating capacity [%]	germination rate [days]	storage time [days]	germinating capacity [%]	germination rate [days]
1	100	1	1	100	1
2	100	1	2	100	1
3	99	1	3	98	1
4	85	2	4	86	2
5	75	2	5	77	2
6	62	3	6	63	3
7	48	4	7	49	4
9	30	5	9	31	5
11	23	5	11	20	5
13	18	6	13	15	6
15	14	6	15	12	6
17	3	6	17	2	6
19	0	0	19	0	0

from rain. Each day, 50 seeds were taken for a germination trial. Results of the trial are presented in Table 4.

Germinative capacity in the first two days was 100% and on Day 3 it was on av. 98.5%; in these three days the seeds germinated within 24 hours. On Day 4 and Day 5 there were 85.5% and 76% of seeds, respectively, germinated within two days. Germination on Day 6 was 62.5% of seeds germinated within three days and on Day 7 it was 48.5% of seeds germinated within four days. Then the germinative capacity rapidly dropped below 30% and the germination rate drew out to 5–6 days. The last viable seeds (2.5%) were found after 17 days of storage.

Germination of seeds stored in water

Establishing the experiment we assumed that the seeds stored in water would keep the germinative capacity longer than those stored dry. However, already on the first day the seeds stored in water were found to have germinated at nearly 100% – both extracted and fluffed, floating or submerged seeds.

This circumstance made us to operatively embark on studying the survival of seedlings in the water medium. To our great surprise we found out that the seedlings of white willow have a high capacity to survive in water – both floating and submerged (Table 5). The seedlings survived without any loss for 35 days. The mortality of seedlings observed on Day 36, Day 40, Day 43, Day 46 and Day 47 was 10%, 35%, 50%, 95% and 100%, respectively.

T a b l e 5. Survival of white willow seedlings in the water medium in experiments carried out in 2003 and 2004.

Date	Mortality (%)	Date	Mortality (%)
24.5.2003	0	8.6.2004	0
27.6.2003	10	14.7.2004	11
1.7.2003	35	19.7.2004	33
4.7.2003	50	23.7.2004	45
7.7.2003	95	26.7.2004	95
8.7.2003	100	27.7.2004	100

Biotopes fitted for soft floodplain oecesis in the Nature Reserve Věstonická nádrž reservoir

The lowering of water level in the reservoir by 85 cm from the spot height of 170.35 m a. s.l. to the spot height of 169.50 m a.s.l. in 1996 resulted in the denudation of embankments of the holms, sediment loads in the mouth tracks of Jihlava and Svratka rivers and bases of border dams. Furthermore, the water level lowering in the reservoir gave rise to two new islands.

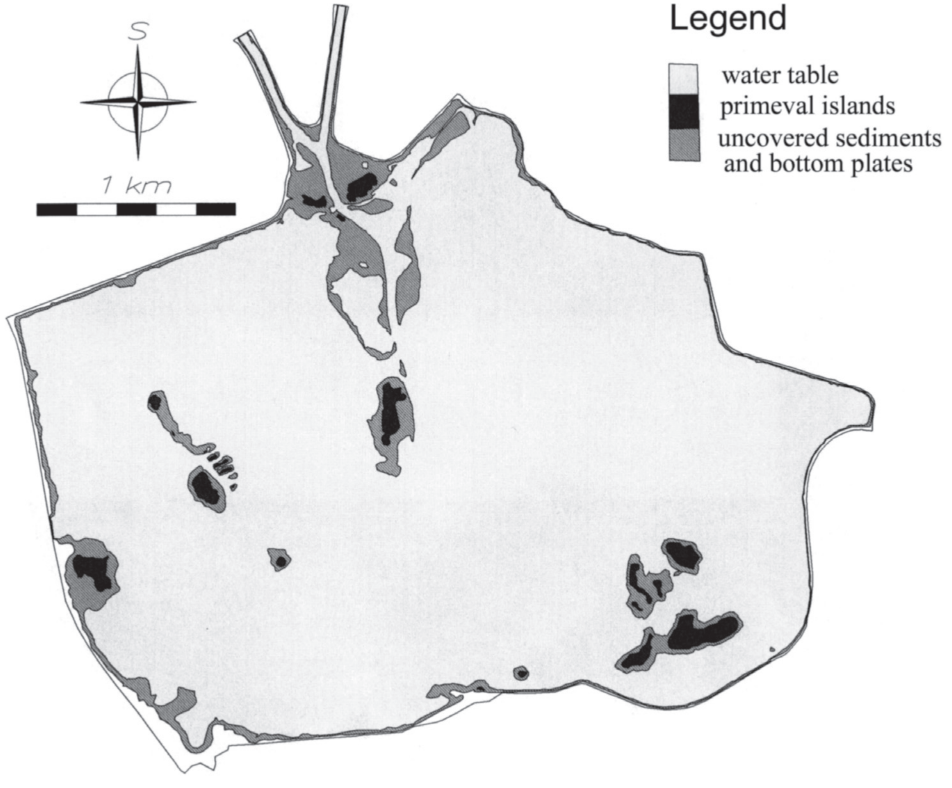

Fig. 6. The map of denudated plots in the NR Věstonická nádrž Reservoir after the water level lowering to a spot height of 169.50 m a.s.l.

The spatial distribution of denudated plots is illustrated in the map (Fig. 6). According to the model, a total denudated floor area of the reservoir was 80.86 ha of which an absolute majority is formed by ecotopes answering with their character to the *Alni glutinosae-saliceta* or *Ulmi-fraxineta populi* group of geobiocoene types (Buček, Lacina, 1999).

Discussion and conclusion

Proper establishment of white willow communities on denudated sediment loads dwells on the correct timing of the reservoir water level lowering with the phenological exhibitions of white willow (*Salix alba*) in the reservoir's surroundings. It is necessary that the water level is lowered at the time of fruits ripening when the anemochoric willow seeds flutter in the air at abundant numbers. Their viability is very short and as mentioned by Chmelař, Meusel (1986), if they cannot find a place favourable for germination, their germinative capacity is lost within just a couple of days. White willow is ranked in the group of species with an orthodoxically short viability of seeds also by Maroder et al. (2003). Our experiments show that the seeds can keep a nearly 100% germinative capacity for 3 days that are followed by a rapid decrease, though. The last seeds germinated after 17 days of dry storage. Very similar conclusions were arrived at by Maroder et al. (2000) who found that the storage of seeds at 25 °C resulted in a total loss of their vitality in two weeks. In their opinion the germinative capacity can be extended by storage in liquid nitrogen up to 5 months at 9% humidity and -20 °C. Arya et al. (1988) tested the storage of white willow seeds in sealed bottles extending in this way their viability to 10 weeks.

Boedeltje et al. (2004) observed that hydrochoric species spreading in the spring have usually seeds without dormancy with a shorter period of release and dispersal. This group of species includes also white willow whose generative cycle is well adapted to spring floods which as a rule leave behind denudated alluvia as a biotope favourable for the establishment and germination of seeds (Hughes et al., 2001). In 2003, the fruits of white willow in the area of the middle reservoir started to ripen on 23 May while in 2004 the capsules ripened after a very cold month of May as late as from 5 June. The seed rain duration was two weeks in the both years. It was retrospectively documented that the rain of seeds lasted until max. 20 June also in 1996, and that the oecesis of seeds was not likely to have had occurred by means of the seed rain. Guilloy-Froget et al. (2002) observed that the period of black poplar (*Populus nigra*) seed dispersal along the Garonne river lasted 12 weeks. A considerable length of the period is explained by the high individual variability of individual trees in the shedding of seeds. Similar conclusions were published by Farmer (1966) in the population of 60 trees of *Populus deltoides* at the Mississippi river. While the seed dispersal occurred for a period of two months, individual trees had a relatively short period of seed production (as short as 2 weeks). Any similar variability was however not recorded in the white willow trees growing in the locality under study.

The water level lowering occurred in the middle reservoir as late as on 6 July and in spite of the fact the seedlings of willows and poplars emerged instantly at considerable densities (Konůpek, 1998). It was originally assumed that seeds blown by wind onto the water surface would have a longer viability in water than ashore. But the explanation was slightly different because the collected seeds of white willow stored in water that were in this way prepared for the test of germinative capacity after having had stayed in water for various lengths of time began to germinate very intensively already the second day. Thus, it was seedlings rather than seeds that were surviving in the water environment – both floating on the water surface and immersed. The seedlings in water remained completely vital for 4 weeks with their mortality being 30% at the end of the fifth week and 100% as late as on Day 47 of the experiment. This shows that willow at a juvenile stage of its life cycle exhibits amphibious capabilities being able to survive as natant or submersion hydrophyte, thus creating a water bank of seedlings, which extends the species's capacity of dispersal.

Hosner (1957) published similar observations in *Populus deltoides* and *Salix nigra*. The both species can even germinate under water without any damage to the seedling.

This is how it happened that there were seedlings remaining on the denudated sediment loads and embankments during the gradual lowering of the water level in July 1996, or deposited there by means of surge, which would also explain the attendance of white willow communities in a more or less broad strip (up to 60 m) along the banks. Grassland and herbaceous communities were developing at a greater distance from the banks. A similar distribution of tree species seedlings in linear parallel strips along the Waal river in the Netherlands was observed by Van Splunder et al. (1995). Along the Waal r. the seed dispersal occurred in the spring in a following sequence: *S. viminalis*, *S. triandra*, *S. alba* and *Populus nigra*. The seeds germinated in narrow belts parallel to the river; the seedlings of *Salix viminalis* were found at a higher altitude than those of *S. alba*. The altitude of seedlings occurring on the river bank was related to the water level during the period of dispersal of *Salix* spp. but not of *Populus nigra*. *P. nigra* showed a significantly longer seed viability than the *Salix* species and germinated at a lower soil moisture content.

The seedlings of white willow and black poplar exhibited a further successful development on the denudated sediment loads in 1996 although they might have been exposed to very extreme conditions such as drying out of the boggy substrate. This is in a good agreement with results presented by Van Splunder et al. (1996) who detected a high drought resistance in the seedlings of white willow and black poplar, which is enabled by lower transpiration than for example in almond-leaved willow and osier willow in which a considerable drought-induced mortality was observed. On the other hand, Guilloy et al. (2002) claim that the flooding of black poplar seedlings impairs their capacity of survival, which was fully corroborated in the studied area during the July flood in 1997 when black poplar disappeared from most research plots (Konůpek, 1998; Kovářová, 2003; Buček et al., 2004). Barsoum (2002) recorded a 83% mortality in one-year old seedlings of black poplar after a summer flood, while the mortality of white willow seedlings was only 52%.

Taking into account the model of trees with respect to seed production it is possible to claim that in 1996 there was a sufficient number of fruiting female trees in the close vicinity of the reservoir that could have been able to provide for the production of a seed amount required for the oecesis of white willow communities on approximately 80 ha of denudated plots. With an average density of seedlings at 30 pcs per 1 m^2 observed in the research plots in 1996, i.e. in the first year of the evolution of the communities (Konůpek, 1998), it was a total of 24 million seedlings, which is according to the above described model the produce of one middle-sized tree. Our model results are in a good agreement with observations made by Braatne et al. (1996) (In: Karrenberg et al., 2002) who report a production of 25 million seeds in *Populus deltoides*. The seed rain at the time of its highest intensity reached up to 30 seeds per m /h in the studied locality in 2004. This was however at the time when there were already thousands of 8-year-old trees fruiting in the area under study. Barsoum (2002) published his research results for black poplar in floodplain forests along the Drome river in France. Seeds caught in traps sized 24*37 cm amounted to a minimum of 74 in the period from May to June in 1995 and 1996, i.e. 833 seeds per 1m^2 for the entire period of seed rain.

The ascertained results may be useful for revitalization measures in alluvial plains. If the creation of soft floodplain ecotope occurs at the time of seed rain and the seed source is within the reach, the oecesis of communities will doubtlessly take place instantly. In the case that the period of seed rain is missed, the time for the establishment of communities can be extended by about a month. Then it is however necessary to flood the plots planned for the soft floodplain at the time of seed rain and to subsequently provide for a gradual lowering of the water level.

Translated by M. Svobodová

Acknowledgements

The research was funded from the Research Project of the Faculty of Forestry and Wood Technology, Mendel University of Agriculture and Forestry in Brno – Partial task "Characteristic of the condition and development of floodplain geobiocoenoses in Moravian alluvial plains" (Reg. no. MSM: 6215648902).

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