Marginal Wetland Planting for Oligotrophic Swimming Ponds

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Introduction

Not only in Austria and Germany, swimming ponds are becoming increasingly popular as a natural alternative to pools that are treated with chemicals. To produce clear water, nutrients are minimised by artificially circulating the water through natural filtration systems (FLL 2006). The water filtration and purification is guaranteed primarily by substrates rather than by plants. For the most part, helophytes from eutrophic sites are used in current facilities, which show nutrient-deficiency-symptoms as a result of strong filtration. There are relatively few swamp-plants from oligotrophic natural sites growing submerse or in shallow water, and these species are often difficult to cultivate. Research projects should determine if marginal vegetation with emerged plants from acid bogs, transition bogs and lime-fens poor in nutrients are suitable for emersed marginal planting zones of intensively filtered swimming ponds. Plant mixtures, which produce suitable design concepts, follow the combination principles recommended in Riedel et al. (2007).

Methods of the research

74 native and exotic species from oligo- to moderately mesotrophic bog and fen communities where chosen based on Ellenberg et al. (1991) and recommendations from diverse botanical gardens and specialized nurseries (see also Kircher, 2004, p. 230-231). Many interesting species have not yet been cultivated propagation material was provided by the Institute "Landschaftsökologie 2" of the Technical University of Munich, as well as several botanical gardens and nurseries.

The species were researched on six test sites. All sites are located in the Central German Drought Area with an average annual precipitation of only 460 to 480 mm.

Site 1: private swimming pond in Staßfurt; constructed in 1998 – see figure 1. 100 m² total area is divided into 60 m² regeneration and 40 m² swimming area. Approx. 20 m² of marginal zone are planted with species from oligotrophic poor fens as well as with bog plants in individual areas. The filtering technique is classified in "Type 2" following the systematic of FLL (2006). Water is pumped from the swimming zone to the stream in the south and then it runs back through a narrow regeneration area. The permanently running water supports plants with a greater demand for nutrients (zones R1, R2 & R3). In the standing water of the swimming zone, the marginal planting beds were expected to be less infiltrated with nutrients from the waterbody. Along the northern and eastern shore perennials from lime fens and transition bogs were established (zones Z1 and Z4). A southern marginal area was covered with *Sphagnum* and species from bogs and poor acid mires (zone H).

Site 2: private swimming pond in Aschersleben; constructed in 2001. Approx. 25 m² total area which is planted with species from oligotrophic fens or bogs or rather with plants from mires moderately rich in nutrients; each habitat is established in specific areas;

Site 3: ornamental pond with stream in Staßfurt with 6 m² of marginal pond-zone and stream planted with poor lime-fen species; constructed in 1998 – see figure 2. The stream is sealed

with water proof concrete. It runs along the edge of a rock garden and ends in a cascade which falls down about 1m into a round shaped pond. A separate swamp bed beside the stream (K2) has no connection with the circulated water and contains lime fen vegetation.

Site 4: 10 m² swamp-bed with bog-vegetation in Staßfurt; constructed in 2001
Site 5: 12 m² swamp-bed with lime-fen plants in Bernburg; constructed in 1999
Site 6: 12 m² swamp-bed with bog-vegetation in Bernburg; constructed in 1999

The substrate layers were 30 to 40 cm deep. In areas planted with bog species, the substrate layers were constructed of sand (0-2mm) and were covered with 5-10 cm acid peat with about 30 % bark compost mixed in. In areas with fen and transition-bog plants, the substrate was enriched with 20 to 30% limestone chips (2-8 mm). All species relevant for this investigation are planted 5 to 20 cm above water level.

Plants were arranged in mixed compositions. The proportion of plants in the mixture should reflect naturalistic patterns according to the design categories of Borchardt (1996; see table 1): “Dominant plants” should show the tallest layer being placed as specimen plantings at adequate distances. „Companion plants“ form small groups and low growing “ground cover plants” connect the whole composition with a shallow carpet. Plants from these categories were used in amounts of 12 to 20 plants per m², in bog plantings with a layer of *Sphagnum* moss only 6 to 10, because no extra ground cover plants were necessary. “Scattered plants” are species with no relevant demand for space. These can be Geophytes with short-term visual effect, like *Dactylorhiza* and *Gladiolus*, or species with very slim shoots, like *Gentiana pneumonanthe*. In addition, several short lived hemi parasites were sown between the planted perennials in order to determine if they improve the visual display of the planting without significantly reducing the vitality of the grasses or other hosts (Hodgson 1993).

The following explanations focus on the Staßfurt sites number 1 and 3, which were monitored most intensively. For further descriptions of these sites see Kircher (2005).

Results

The chemical analysis (table 2) shows very low nitrate, ammonium and phosphate amounts. Compared with the classification of Schwarzer (2007) the expectation of having oligotrophic conditions was fulfilled. Only in April 2006 was there a very high level in Phosphate, especially on site 3. However, by July it had been broken down or rather deposited and was not present any more.

The vegetation formed a dense cover of over 90% within three vegetation periods. The north shore of the swimming zone of site 1 displays the character of a natural fen. The southern bed still carries the bog species from acidic natural sites. Though both planting types were fed by the same water body, their respective fundamental character is still evident, although after four years, *Drosera rotundifolia* and *Sphagnum palustre* as bog plants from zone H appeared in zone Z1, whilst some fen species positioned themselves in the “bog-zone” H.

Table 2 lists all the species with a rating of the vitality value of at least “5” in average over all relevant facilities (see legend in table 2).

.Not listed are *Potentilla palustris, Carex nigra, Anthoxanthum odoratum, Carex appropinquata, Molinia caerulea* and *Succisa pratensis* because their rampantly growing rhizomes are too invasive with respect to seeds. On the other hand, *Caltha palustris, Chrysosplenium oppositifolium, Gentiana sino-ornata, Fritillaria meleagris, Myosotis rehsteineri, Iris setosa* subsp. *canadensis, Primula rosea* and *Trollius pumilus* showed very poor vitality.

The sown hemiparasites, *Pedicularis sceptrum-carolinum*, the American *Castilleja miniata* and the annual *Rhinanthus serotinus* brought exciting effects during the first 4 years and then their vitality declined. *Castilleja* disappeared completely and new seedlings from *Rhinanthus* and

Pedicularis could only develop in zones R1 and R2 of site 1 and in some open spots of site 2. A significant effect on host plants was not observable.

Table 1: Chemical analysis site 1 (swimming pond) and 3 (ornamental pond) in Staßfurt

Date of Extraktion	25.10.2001		21.11.2001		13.12.2001		22.05.2002		12.01.2004		18.04.2006		11.07.2006	
Site	1	3	1	3	1	3	1	3	1	3	1	3	1	3
pH	7,11	6,95	8,03	8,04	no analysis		7,9	7,7	7,5	7,66	7,94	7,51	no analysis	
Conductivity µS/cm	441	294	439	293	no analysis		no analysis		no analysis		305	321	no analysis	
Hardiness °dH	9,5	7,7	9,6	7,6	no analysis		8,4	5,3	>10	>10	7,6	5,2	no analysis	
NO_3^- mg/l	0,08	n.p.	0,07	n.p.	0,07	n.p.	0,10	0,10	0,17	0,20	0,47	1,57	0,04	0,14
Phosphate mg/l	n.p.	n.p.	n.p.	n.p.	n.p.	n.p.	n.p.	n.p.	n.p.	n.p.	1,8	12,1	n.p.	n.p.
NH_4^+ mg/l	n.n	n.n	n.n	n.n	n.n	n.n	0,5	0,4	no analysis		0,6	1,9	no analysis	
K^+ mg/l	7,2	5,0	8,5	4,4	8,1	5,9	8,4	5,2	no analysis		3,5	4,7	no analysis	

n.p. = not provable

Weeding and mowing in early spring or late autumn were the only forms of maintenance. Significant differences in the plant development were recognized only with *Schoenus nigricans*, because its shoots appear very early. Their terminal inflorescences were damaged by spring mowing. Weeding was only time-intensive on site 2 with a demand of more than 10 man-minutes / m² per year. Site 1 and 3 only required 1 to 3 man-minutes / m² per year, not including the extraction of seedlings from the too invasive planted species mentioned above.

Discussion

Some species from Table 1 showed a relatively weak growth with vitality valuation ratings of 5 or 6, for example *Gentiana pneumonanthe* or *Helonias bullata*. On one hand, they appear to be important for this planting style. But further trials should be run to find ways to support their vitality, for example by a increasing the penetration of the substrate with water. On the other hand, a weaker growth of normally vigorous or invasive perennials like *Lythrum* 'Robert' or *Cardamine pratensis* can be considered beneficial. To promote a continuously flowering effect, more species with attractive blooming effects should be found for March-April, mid July to mid August and October. American species like *Liatris spicata* or *Spiranthes cernua* have already proven to be effectual fillers for the summer respectively autumn bloom-gaps. To guarantee sufficient competition against weeds, dense, mixed plantings should be composed ideally of 5-10 % dominant plants, 20-40 % companion plants and at least 50 % ground coverers. Furthermore, scattered plants can be added abundantly. Sown Hemi parasites support the visual effect during the first three to five years, until the vegetation cover is too competitive and the nutrient content has declined to a lower level. These species behave more or less as R-strategists (Grime, Hodgson & Hunt, 1986) but improve the display during the starting phase of a fen-planting, similar to other short lived species like *Dianthus superbus* and *Lychnis flos-cuculi*. *Gentiana sino-ornata*, *Fritillaria meleagris* and *Iris setosa* subsp. *canadensis* should be used on sites with a higher nutrient level and planted about 10 to 20 cm above water level. A site along streams or flushed marginal zones could also be beneficial for a healthier growth.

Site 2 was invaded by *Solidago* seeds from a neighbouring brown field, causing the time intensive demand for weeding. All facilities showed a clearly declining pressure of weeds over the years. With the increased coverage of the intended species and the stabilizing of a low nutrient level, the maintenance workload seems to decline significantly.

Table 2: Recommended species for marginal zones of intensively filtered swimming ponds

Species	tested in site number	vitality valuation (average over all tested facilities)	design function (following Borchardt, 1996)					recommended habitat			
			dominant plant	companion plant	ground cover	scattered plant	sown species	bog (between Sphagnum)	bog (acid substrate)	transition bog (neutral)	fen (lime con-taining substrate
Allium angulosum	1	7				●				●	●
Allium suaveolens	1, 2, 3, 5	9				●				●	●
Andromeda polifolia	1, 4, 6	8		●				●	●		
Arnica montana	1, 4	8		●					●	●	
Aster nemoralis	1, 2, 4, 6	8				●		●	●	●	
Cardamine pratensis	1	6		●		●				●	●
Carex davalliana	1, 2, 3, 5	9			●						●
Carex diandra	1, 2, 7	7	●	●						●	●
Carex flava subsp. *flava*	1, 2, 3, 4, 5	8		●						●	●
Carex viridula	1, 2, 3, 5	8			●					●	●
Castilleja miniata	1	7 s					●			●	●
Cypripedium reginae	1, 4	5	●							●	●
Dactylorhiza Hybrids	1, 2, 3, 5	8				●					●
Darlingtonia californica	1, 2, 6	7		●				●	●		
Dianthus superbus	1, 2	8 s				●				●	●
Drosera anglica	1, 2, 4	7 s				●	●		●		
Drosera rotundifolia	1, 2, 4	8 s				●	●		●		
Epipactis palustris	1, 2, 5	9		●						●	●
Erica tetralix	1, 2, 4, 6	9		●				●	●		
Eriophorum latifolium	1, 2, 3, 5	8	●	●						●	●
Gentiana asclepiadea	1, 2, 3, 5	7	●							●	●
Gentiana pneumonanthe	1, 2	5				●				●	
Gladiolus palustris	1, 2, 3, 5	9				●					●
Helonias bullata	1, 6	5				●			●	●	
Iris sibirica	1, 2, 3, 5	5	●							●	●
Ledum groenlandicum	1, 4, 6	8	●	●				●	●		
Lythrum salicaria 'Robert'	1	6	●							●	●
Menyanthes trifoliata	1, 6	6		●		●				●	
Narthecium ossifragum	1, 4, 6	8		●				●	●		
Parnassia palustris	1, 2, 3, 5	7				●	●			●	●
Pedicularis sceptrum-carolinum	1, 2, 3	7 s					●			●	●
Pinguicula grandiflora	3	8				●				●	●
Pogonia ophioglossoides	1, 4	9				●		●	●		
Primula frondosa	1, 2, 3, 5	7				●				●	●
Rhinanthus serotinus	1, 2	7 s					●			●	●
Rhynchospora alba	1, 2, 4, 6	8				●			●	●	
Sarracenia flava	1, 4	6	●					●	●		
Sarracenia purpurea	1, 2, 4	7		●					●	●	
Schoenus ferrugineus	2, 3, 5	8		●	●						●
Schoenus nigricans	2, 3, 5	8	●								●
Sphagnum capillifolium	1, 6	7				●		●	●		
Sphagnum palustre	1, 2, 4, 6	9				●		●	●		
Sphagnum squarrosum	1, 2, 4, 6	9				●		●	●		
Swertia perennis	1, 3	7	●							●	●
Tofieldia calyculata	1, 2, 3, 5	8		●							●
Trichophorum alpinum	1, 2, 3, 6	7		●		●				●	
Vaccinium oxycoccus	1, 2, 4, 6	9			●			●			
Zigadenus elegans	1	7	●							●	

Legend of vitality valuation:	1 = unsatisfactory growth, hardly flowering, heavy deficiency symptoms 3 = weak growth / flowering, beginning deficiency symptoms, 5 = moderately weak growth / flowering, no deficiency symptoms, 7 = moderately vigorous growth, plants thrive and flower satisfactory, 9 = very vigorous growth, best developing plants, s = short lived plants (life span 1 - 4 years)
further species with vitality ratings > 5, not listed above are: *Adenophora liliilolia, Bartsia alpina, Bletilla striata, Carex capillaris, Carex echinata, Drosera binata, Mimulus primuloides, Nardus stricta, Pedicularis palustris, Trichophorum caespitosum, Vaccinium macrocarpum*	

Conclusions

Randomly mixed selection of suitable grasses and forbs can thrive and develop to exciting visual effects when they are composed in appropriate ratios. From a bather's point of view, it is wonderful to experience colourful flowering orchids and other perennials as well as insectivorous plants. Between a ground cover vegetation of low growing grasses (*Carex davalliana, C. viridula, Schoenus ferrugineus*) these gems thrive well with low maintenance requirements if planted in adequate densities and mixtures. This design concept can be recommended for private swimming ponds that are nutrient poor, if nurseries are able to provide the adequate plant material in the future. Current trials at Anhalt University in Bernburg aim to optimise the combination of filter systems and plantings.

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Summary

On six test sites, 74 species from poor fen, transition bog and acid bog communities were examined to determine their suitability for marginal zones of intensively filtered swimming ponds. After six to nine years of evaluation, a list of 48 recommended plants was developed which includes the ratings of vitality, proposed design functions and plant habitats. The results lead to a highly recommendable design concept for private swimming ponds with oligotrophic water.

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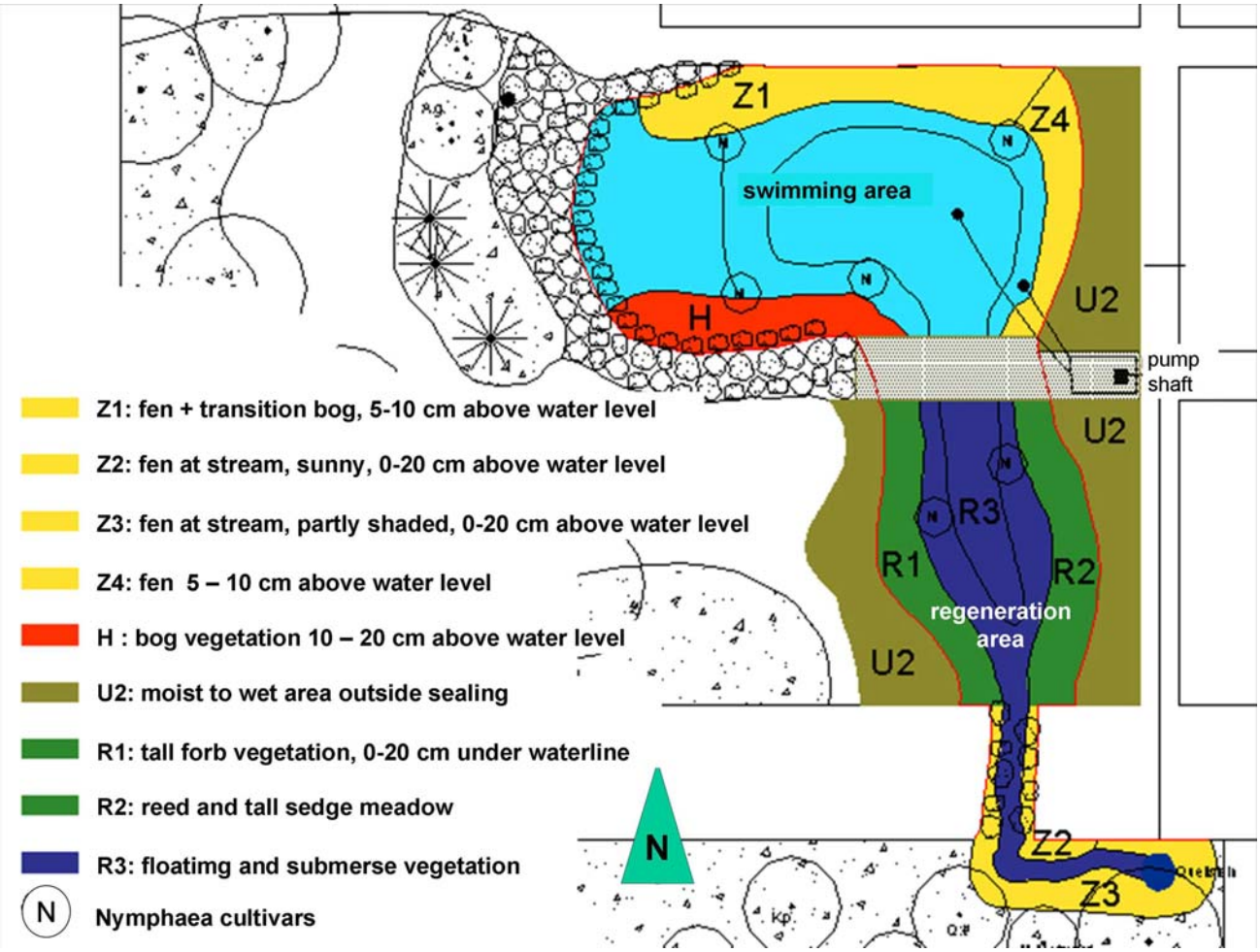

Figure 1: planting zones of test site 1 (private swimming pond in Staßfurt)

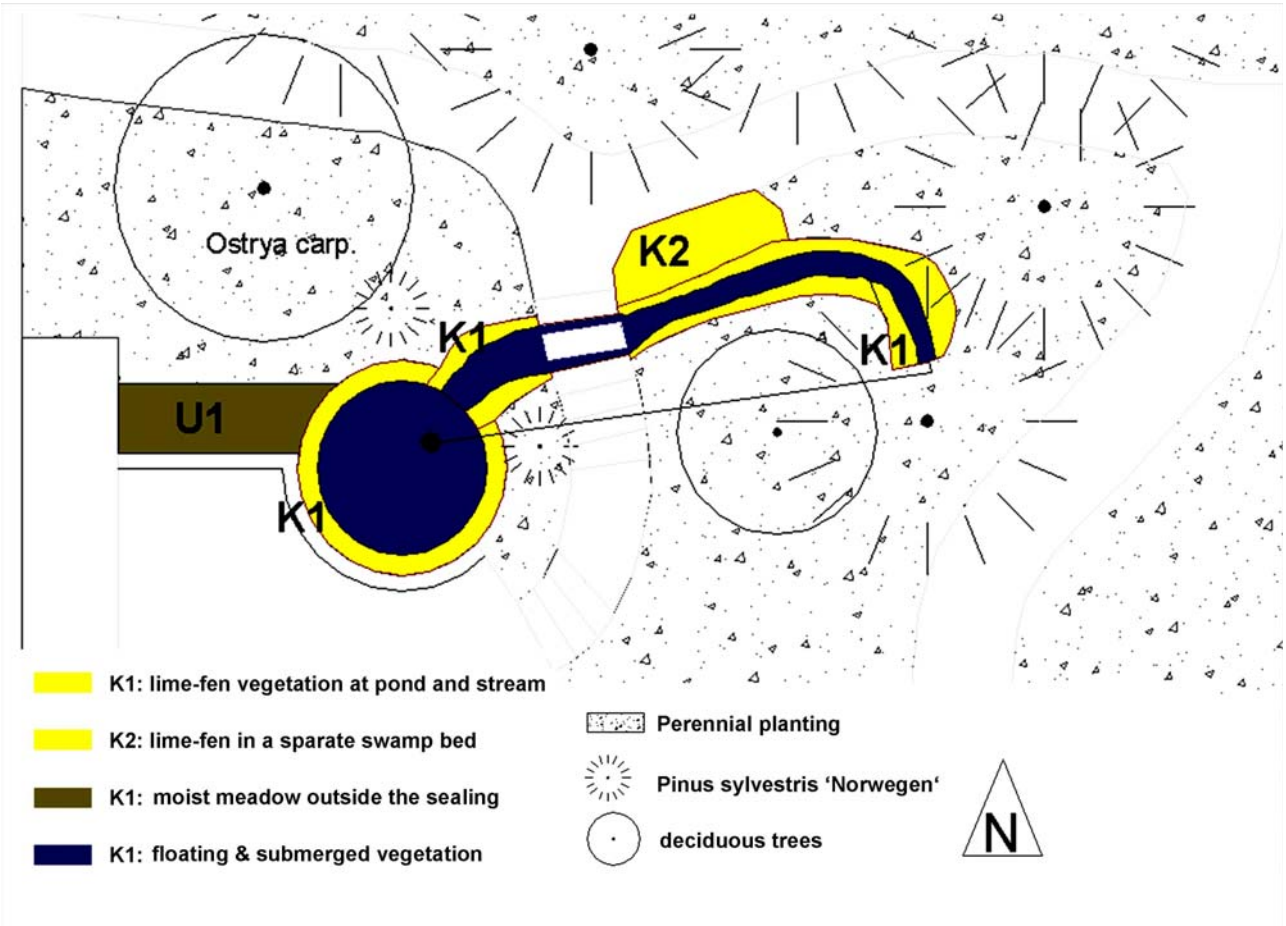

Figure 2: planting zones of test site 3 (ornamental pond in Staßfurt)

Figure 3: marginal zone of the private swimming pond in Staßfurt (test site 1). Plants from acid bogs and transition bogs like *Sarracenia flava* thrive. The hemi parasitic *Castilleja miniata* attracts with its orange inflorescences, presumably tapping the roots of *Lythrum salicaria* 'Robert'. In the background *Eriophorum latifolium* seedheads are floating above the fen-zone.

Figure 4: *Dactylorhiza* Garden-Hybrids thrive and spread well between low growing *Carex davalliana* and *Carex viridula*.

Figure 5: The autumn display of the marginal fen zone of site 1 is dominated by the light pink flower-balls of *Allium suaveolens*.

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