K A N I T Z I A
Journal of Botany

Kanitzia 11: 67-84. Szombathely, 2003

FORMATION AND EVOLUTION OF NATURAL SOFTWOOD STANDS WITH RESPECT TO WATER DYNAMICS.
EXAMPLES FROM THE LOIRE, RHINE, ELBE AND DANUBE RIVERS

ERIKA SCHNEIDER
WWF-Auen Institut, Josefstrasse 1, 76437 Rastatt, Germany

Abstract
Schneider E. (2003): Formation and evolution of natural softwood stands with respect to water dynamics. Examples from the Loire, Rhine, Elbe and Danube rivers. - Kanitzia 11: 67- 84.
The paper shows the ecological conditions necessary for a natural tree regeneration in floodplains. The hydrological and morphological dynamics play an essential role in this respect. Examples from floodplains on the Loire, Rhine, Elbe and Danube rivers verify the development of pioneer softwood floodplain species, mainly of black poplar *(Populus nigra)* and white willow *(Salix alba)*. It should be noted that of pioneer tree development possibilities are severely restricted because of the reduction in natural habitats. The problem is important in several aspects e.g. calls the attention to the consequences of river training management done in the past. From the point of view of nature protection, this is why they deserve to be given highest consideration.
Key words: softwoods, floodplains, Salicion albae, natural regeneration, nature protection, European rivers

Introduction

Softwood forests of European rivers showing a predominance of white willow *(Salix alba)* have been subsumed in an alliance that R. Soó was the first to call *Salicion albae* in 1930. The alliance of white willow forests comprises various willow communities. Among these, the white willow community *(Salicetum albae* Issl. 1926.) is the most common and occurs in different forms along various European rivers. In the central and lower Danube basin, the white willow community was also described as *Salici-Populetum* Soó s.l. (1927) 1946 in order to highlight the remarkable role of the black poplar *(Populus nigra)* in the structure of the community.

For most European rivers, the loss of morphodynamics as a consequence of their training entailed a strong reduction in natural softwood stands, most of those being composed of white willow *(Salix alba)* and black poplar *(Populus nigra)* as well as other willow species. Nowadays, on these regulated rivers, only a few and small-scale softwood stands still belong to those dependent on the river dynamics. It is crucial for their presence that due to the dynamics the sites remain free of vegetation. Whenever the newly created sand and gravel banks stand higher than the lower vegetation limit, it then allows the settlement of a large diversity of pioneer species both under the herbaceous storey and the ligneous plants. Then, the first plants to settle are those whose seeds are transported by the river and that could germinate on the substratum.

The two dominant species of softwood stands, white willow *(Salix alba)* and black poplar *(Populus nigra)* require very specific conditions for germination. The same applies to other willow species such as purple willow *(Salix purpurea)*, the almond-leafed willow *(Salix triandra)* and the common willow *(Salix viminalis)*. They only germinate on more or less vegetation-free grounds when enough moisture is supplied. Given that the seeds can germinate within only a few days, these specific germination conditions have to be present immediately after seed transport has occurred. Such conditions, however, do not appear every year so that natural regeneration of these species may require several vegetation periods. When then natural germination usually occurs on a large scale. This is why willow stands in floodplains are all about the same age and a distinct delimitation according to the different age classes may be observed (SCHNEIDER 1992).

In both the floodplain's cross and longitudinal sections, the repartition of softwood stands corresponds to river dynamics and consequently to the deposited sediments of different sizes (cf. DISTER et al. 1989, DISTER 1995). The inundation height does not play a major role in the development of this type of forest. It merely decides, together with the habitat and competition factors, which among the willow and poplar species that have arrived by water or by air will survive (cf. DISTER 1995).

Whereas on the Loire and the Allier rivers, thanks to a distinct morphodynamics, the softwood stands are largely present on the river banks and the islands, the conditions are less favourable on other rivers such as the Rhine, the Danube, in particular the Upper Danube, and the Elbe due to the influence of man. Comparative studies documented commonalties, although differences between stands and river stretches, in the formation and development of natural softwood stands along the various rivers. These white willow and black poplar forests, developed without man's intervention, are actual pristine forests that, with the pioneer vegetation of the river bed during low-water time, attain the highest rank of naturalness (see also DISTER 1980).

The Loire river

As a consequence of the dynamics of their habitats, pioneer herbaceous and ligneous communities dominate the overall picture of vegetation on the Loire river and its tributary Allier (cf DISTER et al. 1989, LOISEAU & FELZINES 1995, SCHNEIDER 1996). They do not merely develop on sites situated directly over or below the mean water level, but even reach far beyond these. At higher flood levels, sands can be transported to the highest points of the islands and into nearshore floodplains situated 2 to 3 m over mean water level. Here they allow settlements with pioneer species. For the higher habitats, succession rapidly develops into sound hardwood floodplain forest communities. Flood duration however is a limiting factor in the lower situated sites, where merely communities adapted to these conditions can survive.

On the gravel banks, pioneer bushes consisting primarily of purple willow *(Salix purpurea)*, *Salix purpurea x viminalis* and black poplar *(Populus nigra)* do do develop.

In later succession phases the predominance of black poplar *(Populus nigra)* increases. It finally becomes the essential component, together with a few other ligneous species, of the softwood forests in very dynamic and coarse-grained habitats (cf. DISTER et al. 1989, SCHNITZLER 1996).

The white willow *(Salix alba)* dominates in habitats with decreasing dynamics and smaller grain sized substratum. It covers the whole range from dynamic sandy habitats usually situated directly on the river to the loamy banks of old channels that are flooded over a long period. It usually appears together with velvet osier *(Salix viminalis)*, almond-leafed willow *(Salix triandra)* and, in places, adventitious ash-leafed maple *(Acer negundo)* (cf. BRAQUE & LOISEAU 1980, DISTER et al. 1989).

The white willow regeneration of different age classes studied near Château sur Allier distinctly shows, that the development of the stands does not necessarily correspond to the annual succession of vegetation periods. Regeneration-free years do definitely occur in between (cf. fig. 1). Along, and almost contemporaneously, with the dominant white willow *(Salix alba)*, a number of ephemeron pioneer species appeared on the habitats of the willow re-generations of the lag period studied fourteen years ago in 1989: *Corrigiola littoralis*, the goose-foot *Chenopodium ambrosioides* and pusley *(Portulaca oleracea)* (see table 1).

Similar examples could be found for places with significant black poplar germination, the regeneration of which was studied from 1988-91 (table 1, sample number 3) and was continued in the following years. They developed almost without exception on, gravel-sand virgin soils, although partly silt. In late May 1991 one could find characteristic species on sludgy soils on comparable habitats situated on the Allier river near Apremont: *Polygonum lapathifolium*, *Veronica peregrina*, *Illysanthes gratioloides*, *Pulicaria dysenterica* and *Gnaphalium uliginosum*, the latter being very abundant. In places where softwoods spread and tree vegetation develops, ephemeron pioneer species are suppressed through competition and alternating lighting conditions. They do however prevail in the low water bed (cf. LOISEAU & BRAQUE 1972).

The Rhine river

Natural habitats for the development of black poplar and white willow stands have become rare along the Rhine. Comparative maps of the historical development of river sections distinctly show the loss of sand banks, which offer favourable conditions for pioneer settling (GÜNTHER-DIRINGER & MUSALL 1989, GÜNTHER-DIRINGER 1990).

Nowadays, adequate habitats for possible natural softwood regeneration, especially white willow and black poplar, are limited to very few natural riparian areas along the Rhine, to some islands and to old channels. On a near natural river bank of about 700 m included in the Nature Reserve Kühkopf-Knoblochsaue (Upper Rhine, Hessen) regeneration of softwood stands have been documented (BAUMGÄRTEL & ZEHM 1999). The stands with white willow *(Salix alba)*, black poplar *(Populus nigra)*, purple willow *(Salix purpurea)* and common willow *(Salix viminalis)* are developed above the mean water level. This site appears to be the only place where natural black poplar regeneration occurs on the Upper Rhine (BAUMGÄRTEL & ZEHM 1999).

Given their fine substratum, the old channels connected to the river dynamics are only favourable to white willow regeneration. In these places falling water levels uncover humid sand and sludge areas between the water and the existing herbaceous vegetation. This is the case in summers with low precipitation and extremely low water levels, especially if water levels remain, with small fluctuations, below the mean water level until autumn. Such conditions were found on the Kühkopf in the Nature Reserve Kühkopf-Knoblochsaue (areas Schlappeswörth, Krönkes island) (cf. DISTER et al. 1992a). In the autumn of the respective years one could already observe willow regeneration of about 30 to 40 cm. This was the case in the years with poor precipitation from 1989 to 1991 (Er. SCHNEIDER, DISTER & SCHNEIDER 1994, BAUMGÄRTEL & ZEHM 1999, ZETTL 2002, fig. 2). In the past it was also proved by Dister (1980), both for the Kühkopf and the Lampertheimer Altrhein.

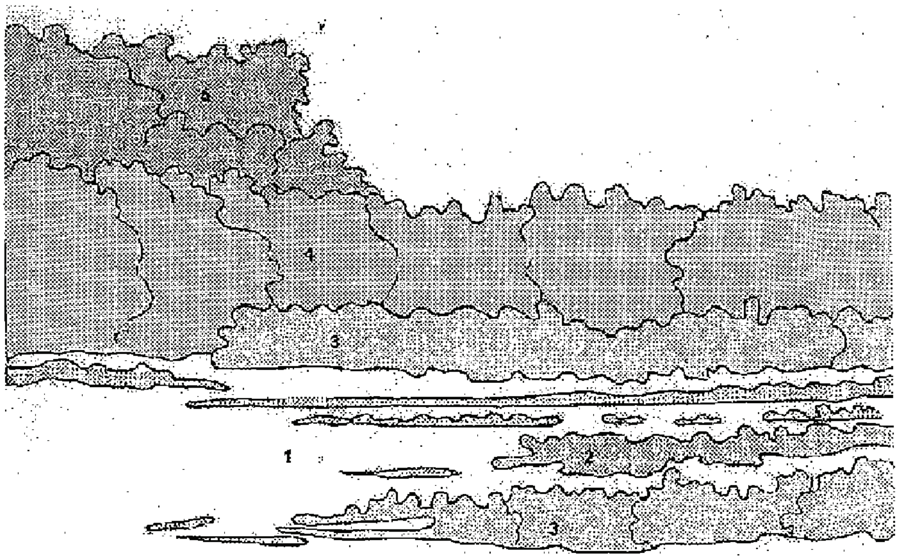

Fig. 1 - Regeneration of white willow stands on the Allier river/France:
1 - one year old regeneration, 2: second layer two years old regeneration,
3: third layer, three years old regeneration, 4: fife years old regeneration,
5: seven years old regeneration.

Widespread willow and black poplar regeneration on the hardwood floodplain level could be documented in the natural reserve Kühkopf-Knoblochsaue after a dam breach caused an inundation in 1983. A 4 hectare pioneer area developed. The fine sized sand that had been washed out did not spread evenly across the area, but formed levees starting star-shaped from the scour lake. Between the levees there was a thin or no sand cover. On the uncovered soil, rudder vegetation had already developed in 1983 and on the thin sand layer a widespread black poplar and willow regeneration (mostly white willow) appeared.

The colonisation of black poplar and willow seedlings on the sand clearly showed the former drift lines of longer lasting water levels at the moment of slowly retreating floods. This is where anemochorous seeds were deposited by the wind. The sand levees however remained almost vegetation-free. In the autumn of their germination year, 1983, the poplars were about 50 cm high, and the following autumn (1984) they were already as high as a man. One year later (1985), black poplars and white willows formed a dense coppice, except on the sand levees, even though they were subject to extreme browsing. Single hardwood floodplain seedlings of tree and shrub species could already be found in late 1984: ash *(Fraxinus excelsior)*, sycamore maple *(Acer pseudoplatanus)*, dogwood *(Cornus sanguinea)* and hawthorn *(Crataegus monogyna)* (cf. cf. DISTER et al. 1991, DISTER et al. 1992 b, SCHNEIDER 2001). Generally, the development may be divided into two phases that may be derived from the species' distribution with respect to height classes. They can be identified by today's 20 year-old black poplar and white willow stands on the one hand and by the hardwood forest species on the other hand and reflect the real character of this habitat (BAUMGÄRTEL& GRÜNEKLEE 2002, SCHNEIDER 2001).

In grasslands on the hardwood forest level, a regeneration of white willow and poplar frequently occurs where the activity of wild boar has created virgin soils. Under adequate moisture conditions the anemochorous willow and poplar seeds germinate together with other herbaceous pioneer species. Such developments could be documented frequently on the northern Upper Rhine in the Nature Reserve Kühkopf-Knoblochsaue (cf. Er. SCHNEIDER, DISTER & SCHNEIDER 1994, SCHNEIDER 2002).

Other, secondary areas that have been created by sand and gravel extraction offer the prerequisites for the regeneration of softwood species. They have been observed on broad areas on the 'Schafkopf' near the Iffezheim hydro-electric plant (Rastatt county, middle Upper Rhine). Pioneer stands of *Epilobium angustifolium* and *Scrophularia canina* settled here along with purple willow *(Salix purpurea)*, the white willow *(Salix alba)* and black poplars *(Populus nigra)*. Given the lack of natural water level fluctuations and substratum dynamics, the softwood stands of these habitats show other characteristics to those that are subject to natural river dynamics. With progressing regeneration they become less characteristic of floodplain communities.

The Elbe river

The softwood stands on the Elbe river presently exist only as disjointed fringes or groups of trees along the banks, scours and temporarily inundated flood channels. Despite alterations caused by river engineering measures such as groins, in Saxony-Anhalt on the central Elbe, one may still find fairly dynamic habitats that are favourable to the regeneration of willow species and black poplar. Depending on flow conditions, different grain sizes are deposited forming gravel and sand banks (cf. JÄHRLING 1993). Smaller grain sizes are deposited in the area with very low flow velocity between the groins. Pioneer tree vegetation settles on the virgin soils appearing in the riparian zone up to below the mean water level (cf. HENRICHFREISE 1996). Both black poplar, rare on the Elbe (Landesamt für Umweltschutz Sachsen-Anhalt 1992), and white willow found favourable regeneration conditions during the 1993 vegetation period, as water levels remained below the mean water level throughout the summer. On the coarse-grained substratum near the natural reserve Bucher Brack, both black poplar (cf. fig. 4) and white willow could regenerate (Schneider, unpubl.). Whereas black poplars require the coarse-grained substratum of the Elbe banks, the white willow also finds adequate regeneration possibilities along the flood channels.

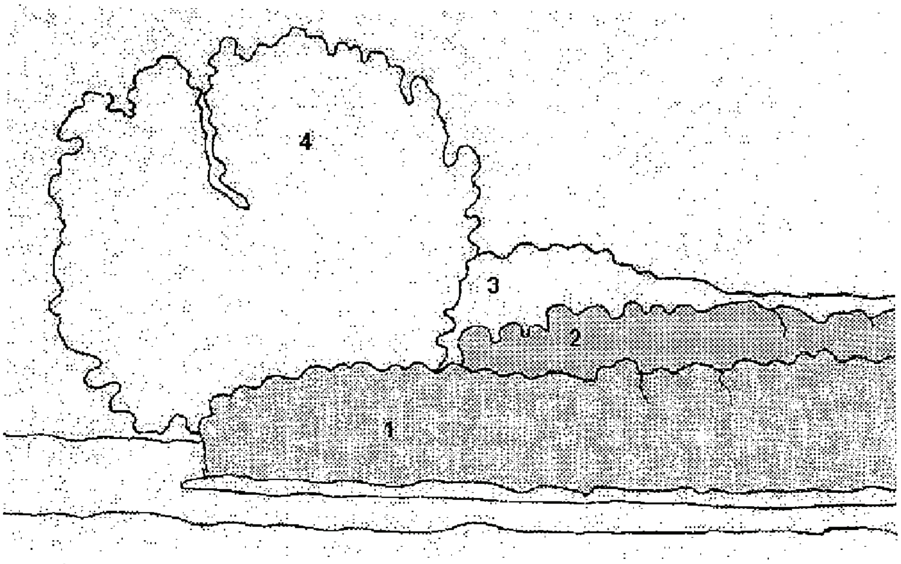

Fig. 2 - Regeneration of white willow stands on the old branch Krönkes, Nature Reserve Kühkopf-Knoblochsaue, Northern Upper Rhine/Hessen:
1: first layer: two years old regeneration, 2: second layer four years old regeneration (sampling in 1994), 3:poplar.

The natural development of pioneer tree stands on gravel banks may still be observed on the Mulde, a left-hand tributary of the Elbe (cf. EICHINGER 1992). On the gravel banks upstream the Mulde reservoir near Eilenburg, a series of different development phases may be found, with reedgrass *(Phalaris arundinacea)* and purple willow *(Salix purpurea)* having been the first to settle on the gravel banks (SCHNEIDER 1993, unpublished). They lower the flow velocity so that even smaller grain sizes may be deposited. This soil provides favourable conditions for black poplar, almond-leafed willow *(Salix triandra)*, basket willow *(Salix viminalis)* and white willow *(Salix alba)*. The white willow occurs together with pioneer species such as *Rorippa amphibia*, *Ranuculus* *scelerathus, Alopecurus geniculatus, Chenopodium rubrum* and other species.

The Danube

The Danube's training and reduced morphodynamic processes provide adequate conditions for a natural development of pioneer species only on certain sections, in particular on the Middle and the Lower Danube. In eastern Bavaria, on the Straubing-Vilshofen section, one may observe the development of pioneer stands, mainly almond-leaved willow *(Salix triandra)* and the basket willow *(Salix viminalis)* (cf. SCHREINER 1985), and sometimes white willow (cf. AHLMER 1989). Downstream Vienna a pioneer vegetation respective of the grading may also be found on larger spots on gravel banks that are created and recreated by the water (cf. DISTER 1985). Pioneer bushes of grey willow *(Salix elaeagnos)* characteristic of upland alluvial deposits, purple willow *(Salix purpurea)*, black poplar *(Populus nigra)* and white willow *(Salix alba)* may be observed there. In the pannonic region there are additional pioneer alluvial tree species such as white willow and black poplar *(Populus nigra)*, increasingly also white poplar *(Populus alba)* (cf. DIHORU, CRISTUREAN & ANDREI 1973). The latter mainly appears downstream the Iron Gate whereas black poplar, if compared to white poplar, plays a less important role on some stretches of the Lower Danube. On some of the islands of the Lower Danube for example islands upstream the towns Giurgiu and Calarasi, regeneration of black poplar could be observed on sandy areas on a large scale also on some of the Lower Danube tributaries.

In the Drava mouth region, the Kopacki Rit, gallery-like terraced white willow fringes grow along the drift line of the old channels. For longer lasting low water levels, as occurred in 1990, white willow seeds also germinate below the mean water level on dried up, scoured areas. They form ephemeron therophyte fields together with species such as *Dichostylis micheliana, Heleochloa alopecuroides, Cyperus fuscus, Gnaphalium uliginosum* (table 2). They do not survive there however, the flood duration acting as a limiting factor in this area (SCHNEIDER 1990, unpublished).

Even though the loss of floodplain sites considerably limits the conditions required for softwood regeneration on the Lower Danube, one may find broad softwood re-generations on the islands (fig. 5). This development is connected to morphodynamic processes, i. e. sedimentation and the active formation of islands. These processes constantly uncover new areas for pioneer vegetation settlement. On differently aged islands situated on the Danube between Milka island (=Ostrov) and Vardim island (near Belene/Svistov on the Bulgarian and Zimnicea on the Romanian side), and also on islands near to Calarasi the development of softwood floodplains may be observed from the first settlements to the mature classes and the transition to hardwood floodplain forests *(Querco-Ulmetum)*. As soon as the banks reach over the lower vegetation limit, the white willow regeneration germinates provided the sand banks are uncovered to coincide with the moment of seed drift.

The sediments that are held back by vegetation bring about a further elevation of the islands. On these somewhat higher situated spots, pioneer trees, such as white willow, settle, as well as almond-leafed willow *(Salix triandra)*, the tamarisk *(Tamarix* *ramosissima)* and the white poplar *(Populus alba)*. Black poplar *(Populus nigra)* is less important (cf. ZANOV 1992). Young willow stands form on the new sediment banks that appear along the islands and lead to their extension. The continuous elevation of the islands gradually offers the conditions for hardwood forest settlements as can be found on the Bulgarian Vardim island. The 1944 forest management plan showing exclusively white willow stands on Small Vardim island, shows, when compared to a recent map, that the development from a white willow to a hardwood floodplain forest with elms and oaks as well as soil flora characteristic of the hardwood floodplain forest with Leucojum aestivum took place over a period of about 50 years.

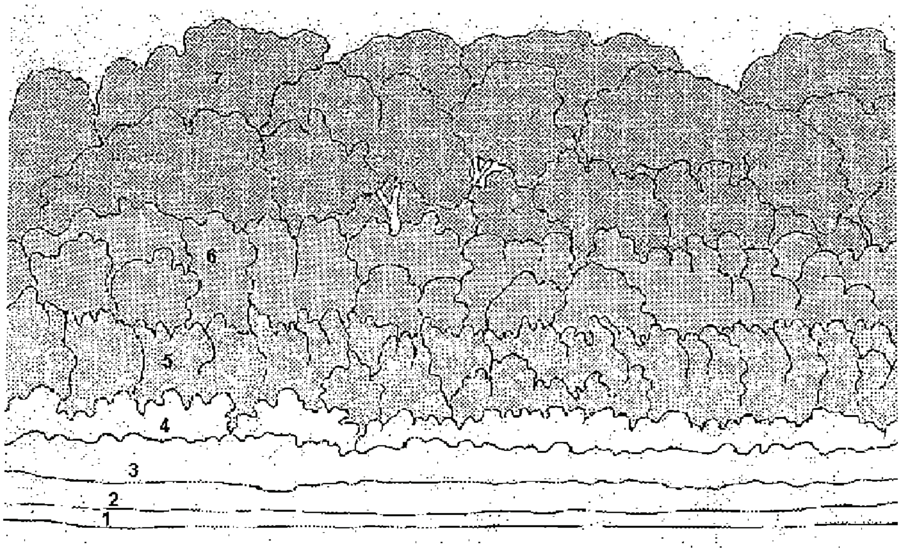

Fig. 3 - Schematic view of regeneration of a white willow gallery forest in the Danube Delta/Chilia branch:
1: open river bank without vegetation during low water level, 2: therophyte communities (Nancyperion), 3: tall herbaceous vegetation with Aster lanceolatus and Cyperus serotinus with poor willow specimens, 4: regeneration of white willow one year old, 5: regeneration of white willow two years old, 6: regeneration of white willow four years old, 7: white willow regeneration six years old

Generally, the white willow forests on the Lower Danube stand out for two different variants, the herbaceous storey indicating the different flood duration (cf. DONITA, DIHORU & BINDIU 1966, SCHNEIDER 1991, 2003). Poorly structured white willow floodplain forests with few species, tree layers consisting exclusively of white willows and shrub layers lacking of species will stagnate in places where inundation lasts six months and more. The herbaceous storey mainly consists of moisture indicators and species that are well adapted to fluctuating water levels (cf. SCHNEIDER 1991). The structure of the white willow forest changes in places where the flood duration does not exceed four months/year. A softwood floodplain forest develops with white willow, white poplar *(Populus alba)*, black poplar *(Populus nigra)* and grey poplar *(Populus canescens)*.

White willow completely dominates on newly created virgin soils with fine grain sizes, in the Danube Delta (table 3). Here one may observe the development of terraced white willow gallery forests (fig. 3). When the banks are uncovered at the moment of seed drift, a dense fringe of young willow stands, called 'renisuri', develops along the drift line of the larger and smaller Delta arms (SCHNEIDER 2003). If comparable conditions arise in the following vegetation periods, such fringes appear again and again on the new sediments. This is how terraced willow fringes appear parallel to the river bank and are finally transformed into a dense white willow gallery forest, the structure and species composition of which depends on the height and duration of the inundation (cf. DONITA, DIHORU & BINDIU 1966, SCHNEIDER 1991). As sign for changed water dynamics and sedimentation processes with evolution of new river banks, the regeneration of white willow can be observed also in the restoration areas Babina, Cernovca and Fortuna as well as in the area of the cutted meanders of the Sf. Gheorghe branch of the Danube Delta. In the first phase of sedimentation *Butomus umbellatus* occurs frequently followed by the white willow (table 3).

The white willow and black poplar forests mentioned above that emerged on natural habitats without the intervention of man are actual pristine forests that, together with pioneer vegetation of ephemeron species in the low water bed, reach the highest degree of naturalness (cf. DISTER 1980). Their development and survival depend on the water level and substratum dynamics, and on erosion and accretion. They stand at the beginning of a whole series of developments and are the prerequisite for the natural development of floodplain forests. Because they have considerably decreased throughout Europe, they deserve special attention from the point of view of nature conservation.

Table nr. 1 Willow and black poplar regeneration on the Loire and Allier rivers

Number of survey	1	2	3	4	5	6	7	8
Size of sample	2	4	4	2	1	2	4	4
Covering degree %	60	65	70	20	60	40	20	20
Salix alba	.	**4.5**	**4.5**	.	.	.	.	.
Salix purpurea	**4.5**	.	.	.	.	.	.	.
Populus nigra	**1.5**	.	**2.5**	**2.5**	**4.5**	**3.5**	**2.5**	**2.5**
Phalaris arundinacea	+	+	.	.	.	.	.	.
Rorippa amphibia	+	+	.	+	+	.	.	.
Rorippa sylvestris	+	+	.	+	+	.	.	.
Corrigiola littoralis	.	1.5	.	.	.	+	+	+
Chenopodium ambrosioides	.	+	.	.	.	.	+	+
Portulaca oleracea	.	+	.	.	+	+	+	+
Gnaphalium uliginosum	.	.	+	.	.	+	+	+
Spergularia rubra	.	.	.	.	.	.	+	+
Chenopodium polyspermum	.	.	.	.	+	+	.	.
Pulicaria vulgaris	.	.	.	.	+	+	.	.

Further species with + in one survey:
Artemisia vulgaris, Galium aparine, Malachium aquaticum, Plantago lanceolata (1);
Amaranthus chlorostachys, Barbarea vulgaris (6);
Bidens frondosa, Chenopodium rubrum, Digitaria sanguinalis (7);

Place and data of survey taken:
1: Port Barreau/Allier, gravel bank, 6.6.1990;
2: Château s. Allier/Embraud, silty sand, 27.6.1989;
3: Charité s. Loire/Pasy, less silty sand, 29. 6. 1989;
4: Mündung von Le Vielle Allier/Le Brochet, gravel bank, 7. 5. 1990;
5: Bec d'Allier, more or less silty fine-grained gravel, 15. 10.1988;
6: Bec d'Allier, gravel and fine-grained gravel, slightly silty, 15.10.1988;
7, 8 : Mars s. Allier, silty sand, 24. 6. 1988.

Table nr. 2

Pioneer vegetation (Nanocyperion) with white willow (Kopaciki Rit)

Number of sample	1	2	3	4	5	6
Covering degree	60	35	45	45	50	45
Size of sample in square m	4	2	4	4	6	4
Dichostylis micheliana	3.5	1.5	1.5	2.5	1.5	2.2
Lythrum tribracteatum	+	+	+	1.5	+	+
Limosella aquatica	+	2.4	1.5	1.4	+	1.4
Gnaphalium uliginosum	1.5	1.5	+	1.5	+	2.5
Cyperus fuscus	+	.	.	+	1.3	+
Heleochloa alopecuroides	.	+	1.5	.	2.4	.
Chenopodium rubrum	+	+	+	+	+	+
Rorippa amphibia	2.5	+.5	1.4	1.3	1.4	1.3
Salix alba	+	**1.5**	**2.4**	**1.5**	**2.5**	+
Rorippa sylvestris	.	.	+	.	.	+
Echinocloa crus-galli	+	.	.	.	+	.

Place and data of sampling: Kopacki Rit, 4.10.1990

Table nr. 3: White willow regeneration in the Danube Delta															
Number of sample	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Surface of sample	25	25	25	25	25	25	20	25	16	20	15	20	20	15	25
Covering degree %	80	65	50	95	95	100	85	90	85	90	90	90	60	85	85
Salix alba	**4.5**	**4.5**	**3.5**	**5.5**	**5.5**	**5.5**	**4.5**	**5.5**	**3.5**	**5.5**	**5.5**	**5.5**	**3.5**	**4.5**	**4.5**
Populus alba	.	.	.	+	.	.	+		.						.
Solanum dulcamara	.	.	.	.		.	.		.	+		+			+
Calystegia sepium	.	.	.	2.5	+		+		.						.
Butomus umbellatus	1.2	+	1.3	.		+	.	+	.	+	+		1.3	2.5	2.4
Rorippa amphibia	.	.	.	.	.	+			.		+	+	+	1.3	+
Bolboschoenus maritimus	2.2	.	1.5	.	2.4	.	.	+	.				2.3		
Lycopus europaeus	+	+	+	1.3	1.4	2.5	1.5	+	.		+				+
Mentha aquatica	.	.	.	+		2.5	2.4	+	.	+					+
Phragmites australis	.	.	.	+	.	+	1.3	1.2	+		+			+	.
Stachys palustris	.	.	.	+	.		+		.		+				+
Rumex hydrolapathum	.	.	.	.	.	+	+	+	+						+
Rumex limosus	..	+	+	.	+	+			.						
Iris pseudacorus	.	+	+	.	.		.		.						
Schoenoplectus lacustris	+			+	.	.	.		.						
Typha angustifolia	.	.	.	.	.	.	.	+	.	.	+	+			.
Cyperus glomeratus									2.5						
Cyperus serotinus									3.5						
Lemna minor	.	.	.	.	.	.	.	+	.	+	+	+			
Salvinia natans	.	.	.	.	.	.	.	+	.	.	+	+			
Ceratophyllum demersum									+			+			+
Agropyron repens	.	.	.	2.2	.	+	.		.						
Poa palustris		1.5		.	.	.	.		.						
Xanthium strumarium	.	+	.	.	.		.		.				+		
Bidens tripartita	.	.	.	.	.	.	+		+				+		

Species presents in one sampling (+):
Tamarix ramosissima (2); Alopecurus geniculatus, Althaea officinalis, Lythrum salicaria, Malachium aquaticum, Salix cinerea (7); Amorpha fruticosa, Galium palustre (8); Chenopodium rubrum, Cirsium arvense, Gnaphalium uliginosum (9); Sparganium ramosum (11); Alisma plantago-aquatica, Cyperus flavescens, Echinocloa crus-galli, Polygonum lapathifolium (13); Oenanthe aquatica, Phalaris arundinacea (14);

Place and data of sampling:
1, 2, 3: restauration area Babina/Danube Delta, pumping station near to canal CC1, 28.06.1997;
4, 5, 6, 7: restauration area Babina/Danube Delta, near to the pumping station, 5.6.1998;
8: restoration area, Babina/Danube Delta, near to the pumping station and to canal CC1, 24.6.1999;
9: restauration area Babina, southern part of the main canal CC1, 6.10.2001;
10, 11, 12: Rotund lake, Fortuna area/Danube Delta, 9.10.2001;
13: Fortuna polder area, canal C1, 30.06.2000;
14: Canal S 20, Fortuna polder area/Danube Delta, 6.10.2001;
15: Rotund lake, Fortuna polder area/Danube Delta, 6.10.2001.

Fig. 4. Pioneer stages of black poplar on the Elbe river, Nature Reserve Bucher Brack, upstream the town Tangermünde/Sachsen Anhalt June (1994).

Fig. 5. Pioneer stages with white willow (foreground) and black poplar on a young Danube island near to the Calarasi/Romania (June 2002).

REFERENCES

AHLMER, W. (1989): Die Donau-Auen bei Osterhofen. Eine vegetationskundliche Bestandaufnahme als Grundlage für den Naturschutz. – Hoppea, Denkschr. Regensb. Bot. Ges. 47: 403-503.

BAUMGÄRTEL, R. & W. GRÜNEKLEE (2002): Sukzession nach Dammbruch auf ehemaligen Ackerflächen in der Rheinaue : Ergebnisse nach 17 Jahren ungestörter Sukzession auf der Rheininsel Kühkopf.– Natur und Landschaft, 77, 6:: 269-288, Verlag Kohlhammer GmbH, Stuttgart.

BAUMGÄRTEL, R. & A. ZEHM (1999): Zur Bedeutung von Fließgewässer-Dynamik für naturnahe Rheinufer unter besonderer Betrachtung der Schwarzpappel (Populus nigra) und Sandrasen.– Natur und Landschaft, 74, 12: 530-535, Verlag Kohlhammer GmbH, Stuttgart.

BRAQUE, R. & J.-E. LOISEAU (1980): Forȩts alluviales interessantes du cours moyen meridien de la Loire et de l'Allier. – Colloques phytosociollogiques, IX: Les forȩts alluviales: 601-605, Strasbourg.

DIHORU, GH., I. CRISTUREAN & M ANDREI (1973): The vegetation between Mraconia Valley and Dubova Depression in the Danube Defile.– Acta bot. Horti Bucurestiensis 1972-1973: 353-423.

DISTER, E. (1980): Geobotanische Untersuchungen in der hessischen Rheinaue als Grundlage für die Naturschutzarbeit.-- Dissertation Georg-August Universität Göttingen, pp. 170.

DISTER, E. (1985): Auenlebensräume und Retentionsfunktion.- in: Die Zukunft der ost bayerischen Donaulandschaft, Laufener Seminrabeiträge ANL Laufen/Salzach, 3: 74-90.

DISTER, E. (1995): Die Ökologie der Flußauen und ihre Beeinträchtigung durch den Verkehrswasserbau.– Das 2. Elbe-Colloquium: 56-64, Hersg. Michael Otto-Stiftung für Umweltschutz, Edition Arcum.

DISTER, E., P. OBRDLIK, E. SCHNEIDER, ER. SCHNEIDER & E. WENGER (1989): Zur Ökolo gie und Gefährdung der Loire-Auen.- Natur und Landschaft, 64, 3: 95-99.

DISTER, E., ER. SCHNEIDER, H.-G. FRITZ, E. FLÖßER, E. SCHNEIDER & S. WINKEL (1991): Erfassung der Sukzession auf den aufgelassenen Ackerflächen des Kühkopfs im NSG "Kühkopf-Knoblochsaue".– WWF-Auen-Institut, Rastatt; Gutachten im Auftrag des Hessischen Ministeriums für Landesentwicklung, Wohnen, Landwirtschaft, Forsten und Naturschutz.

DISTER, E., H.-G. FRITZ, K. GUTZWEILER, P. OBRDLIK, EB. SCHNEIDER & ER. SCHNEIDER (1992 a): Gutachten zur Renaturierung hessischer Auengebiete konkretisiert am Beispiel des Naturschutzgebietes Kühkopf-Knoblochsaue.-WWF-Auen-Institut im Auftrag des Landes Hessen.

DISTER, E., ER. SCHNEIDER, E. SCHNEIDER, H.-G. FRITZ, S. WINKEL & E. FLÖBER (1992 b): Großflächige Renaturierung des "Kühkopfes" in der hessischen Rheinaue -

Ablauf, Ergebnisse und Folgerungen der Sukzessionsforschung.– Beiträge der Akad. für Natur- und Umweltschutz Baden-Württemberg, 13 b: 20-36.

DONITA, N., GH. DIHORU & C. BINDIU (1966): Asociatii de salcie (Salix alba L.) din luncile Câmpiei Române.– St. si Cercet. de Biol. Seria Bot. (Bucurestl), 18, 4:341-353.

EICHINGER, E. (1993): Naturschutzgebiet "Muldeaue nördlich Eilenburg".– Gutachten im Auftrag des Staatlichen Umweltamtes Leipzig.

GÜNTHER-DIRINGER, D. (1990): Landschaftshistorische Entwicklung des Gebietes zwischen der Staustufe Iffezheim und der Renchmündung. – Karte, WWF-Auen-Institut.

GÜNTHER-DIRINGER, D. & H. MUSALL (1989): Landschaftshistorische Entwicklung der Rastatter Rheinaue. – Karte, FH Karlsruhe, Studiengang Kartographie.

HENRICHFREISE, A. (1996): Uferwälder und Wasserhaushalt der Mittelelbe in Gefahr.- Natur und Landschaft, 71, 6: 246-248.

JÄHRLING, K.-H. (1993): Struktur der Elbaue in Sachsen Anhalt. – Information STAU - Staatliches Amt für Umweltschutz Magdeburg, pp. 43.

Landesamt für Umweltschutz Sachsen-Anhalt, Edit. (1992): Rote Liste der Farn- und Blütenpflanzen des Landes Sachsen-Anhalt.- Berichte des Landesamtes für Umweltschutz Sachsen-Anhalt, 1: 44-61.

LOISEAU, J.-E. & R. BRAQUE (1972): Flore et groupements végétaux du lit fluvial dans le bassin de la Loire moyenne. – Etudes Ligeriennes, 11: 99-167.

LOISEAU, J.-E. & J.-C. FELZINES (1995): Etude, évaluation et evolution de la végétation naturelle du cours oriental de la Loire. – C. R. Acad. Agric. Fr., 81, 1: 83-98.

SCHNEIDER, E. (1991): Die Auen im Einzugsgebiet der unteren Donau. – Laufener Seminarbeitr. 4/91: 40-57, Akademie Natursch. Landschaftspfl. (ANL), Laufen/Salzach.

SCHNEIDER, E. (1992): Chap. 8 Vegetation.- in: Conservation Status of the Danube Delta. – Environmental Status Reports 4: 75-88, IUCN East European Programme.

SCHNEIDER, E. (1996): Pioniervegetation kurzlebiger Arten an der mittleren Loire und dem unteren Allier.- Braunschweiger Geobotanische Arbeiten: Ufervegetation von Flüssen. Tagungsbericht des Braunschweiger Kolloquiums über Ufervegetation und -flora von Flüssen (24.-26 November 1995): 309-322.

SCHNEIDER, E. (2001): Restoration of floodplain meadows and forests. Results of 15 years of monitoring in natural and controlled succession on re-flooded areas in the Natura Reserve Kühkopf/Knoblochsaue/Upper Rhine. – River Restoration in Europe. Practical Approaches, Conference on River Restoration, Proceedings: 197-199, Wageningen.

SCHNEIDER, E. (2002): Vom Acker zur Auenwiese. 20 Jahre Grünlandsukzession auf dem Kühkopf. – 50 Jahre Naturschutzgebiet Kühkopf-Knoblochsaue: 43-49, Regierungspräsidium Darmstadt.

SCHNEIDER, E. (2003): Les forȩts alluviales du Danube.- in : Les forȩts riveraines des cours d'eau. Ecologie, fonctions et gestion. – Centre Nationale de la Recherche Scientifique, in printing.

SCHNEIDER, ER., E. DISTER & E. SCHNEIDER (1994): Erfassung der Sukzession auf den aufgelassenen Ackerflächen des Kühkopfs im NSG "Kühkopf-Knoblochsaue".- Gutachten WWF-Auen-Institut, Rastatt im Auftrag des Hessischen Ministeriums für Landesentwicklung, Wohnen, Landwirtschaft, Forsten und Naturschutz, pp- 101.

SCHNITZLER, A. (1996): Comparison of landscape diversity in forests of the upper Rhine and the middle Loire floodplains (France). – Biodiversity and Conservation 5: 743-758.

SCHREINER, J. (1985): Die Donauniederung zwischen Regensburg und Vilshofen - Landschaft, Pflanzen und Tiere.- in: Die Zukunft der ostbayerischen Donaulandschaft, Laufener Seminrabeiträge ANL Laufen/Salzach, 3: 9-15.

ZANOV, Z. I. (1992): Zalivnite goru po Dunavskoto proretschie na Bulgaria (Flooded forests in the Bulgarian Danube floodplains).- Isd. na Bulgarskata Akademia na naukite (Bulgarian Academy of Science), Sofia, pp. 155.

ZETTL, H. (2002): 50 Jahre: Ein Spaziergang durch Zeit und Raum. - 50 Jahre Naturschutzgebiet Kühkopf-Knoblochsaue: 10-17, Regierungspräsidium Darmstadt.

ENTSTEHUNG UND ENTWICKLUNG NATÜRLICHER WEICHHOLZBESTANDE IN ABHANGIGKEIT VON FLUSSDYNAMIK

(Zusammenfassung)

Die Arbeit zeigt die ökologischen Bedingungen auf, unter denen natürliche Gehölzverjüngung in Flußauen stattfinden kann. Dabei spielen hydrologische und morphologische Dynamik eine ausschlaggebende Rolle. Anhand von Beispielen aus Auengebieten an Loire, Rhein, Elbe und Donau wird die Entwicklung von Pioniergehölzen der Weichholzaue, vor allen von Schwarzpappel *(Populus nigra)* und Silberweide *(Salix alba)* belegt. Es wird darauf hingewiesen, daß die Entwicklungsmöglichkeiten von Pioniergehölzen durch den Rückgang natürlicher Standorte sehr stark eingeschränkt sind. Aus Sicht des Naturschutzes verdienen daher die Pioniergehölze dieser Arten höchste Beachtung.

TERMÉSZETES PUHAFALIGET-ÁLLOMÁNYOK KIALAKULÁSA ÉS FEJLŐDÉSE A VIZDINAMIKÁVAL KAPCSOLATBAN

(Összefoglalás)

A dolgozat a természetes ártéri erdők regenerálódásának ökológiai folyamatait vizsgálja. Az európai folyóparti puhafaligetekben megfigyelhető elsősorban a fehérfűz elterjedése és dominanciája, mely alapján Soó megalkotta a Salicion albae szüntaxont. Az állományok szerveződésében a morfológiai és hidrológiai dinamika fontos szerepet játszik. A puhafaliget állományok kialakulásában és fejlkődésében fontos szerepet töltenek be a pionír ártéri fajok közül főleg a fekete nyár *(Populus nigra)* és a fehér fűz *(Salix alba)*, ezek fejlődését értékelte a szerző a Loire a Rajna, az Elba és a Duna folyók árterein. A vizsgálatok alapján megfogalmazódott azon következtetés, hogy az ártéri pionír fa-fajok terjeszkedése nagyon is behatárolt tekintettel a természetes élőhelyek fokozatos visszaszorulása miatt. Mindezekért természetvédelmi szempontból fokozott figyelmet érdemelnek.

K A N I T Z I A
Journal of Botany

Kanitzia 11: 85-96. Szombathely, 2003

DISTRIBUTION PATTERNS OF HIMALAYAN BALSAM (IMPATIENS GLANDULIFERA ROYLE) IN AUSTRIA

ANTON DRESCHER[1], BOHDAN PROTS[2]
[1]*Institute of Botany, Karl-Franzens-University, Holteigasse 6, A-8010 Graz, Austria, e-mail: anton.drescher@kfunigraz.ac.at*
[2]*Institute of ecology of the Carpathians, National Academy of Sciences of Ukraine, Kozelnytska Str. 4, Lviv, 79 026, Ukraine, e-mail: bprots@hotmail.com*

Abstract
Drescher A., Prots B. (2003): Distribution patterns of Himalayan Balsam (Impatiens glandulifera Royle) in Austria. – Kanitzia 11: 85-96.
The distribution patterns of the highly invasive neophyte *Impatiens glandulifera* Royle in Austria are presented. The invasion dynamics of the species are characterised by historical reconstruction. The ecological preferences in altitude and habitat type are elucidated. The possible future expansion and the role of the different dispersal agents are discussed.
Key words: plant invasion, distribution patterns, mapping, dispersal agents, Impatiens glandulifera Royle, Austria
Nomenclature: Adler, Oswald & Fischer (1994)

Introduction

For thousands of years, people have introduced plant species, intentionally and unintentionally, into regions outside their original distribution area. Many of these species provide great benefit to society. Most of our major food crops have been introduced from other countries, and many other non-native species cause no problems in their new environment. However, the invasive alien species (including the so-called 'problem plants') cause big environmental problems world-wide (DI CASTRI & GROVES, 1990; DE WAAL & al., 1994; WADE & al., 1994; MOONEY & HOBBS, 2000). Many of them have become agricultural weeds, others have invaded native ecosystems by outcompeting native plants.

Himalayan balsam, *Impatiens glandulifera* Royle (Balsaminaceae), is one of these species. It is the tallest spontaneous annual plant in Europe, which makes it a strong competitor (GRIME, 1979). It is able to replace the native flora in invaded sites and may cause many problems for nature conservation along riversides (PERRINS & al., 1990).

Himalayan balsam was first introduced into Europe in 1839 when seeds from Kashmir (Western Himalayas) were sent to the Royal Botanic Gardens in Kew (England) by DR. ROYLE. The first records of naturalisation on the British Isles were noticed in 1855 (Middlesex and Hertfordshire) and 1859 (near Manchester). Up to now *I. glandulifera* spread throughout 26 countries of Europe between 40° and 65° N latitude, the Russian Far East, Japan (DRESCHER & PROTS, 2000; Fig. 1, improved), and the USA (RICE, 1998).