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Floodplain forests of Litovelské Pomoraví and their management

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ABSTRACT: The paper characterizes the natural conditions and current state of floodplain forests in the area of Litovelské Pomoraví and proposes the protective management of the area in accordance with the European Natura 2000 system. The paper describes the geographical location and the natural conditions of the area of interest (climate, geology, geomorphology, hydrology and flood regime, soils, and vegetation). Six groups of geobiocene types were identified, classified and described in detail. Assessment of the ecological stability of the forest stand was carried out using biogeographical differentiation of the landscape and the outline of the forest ecosystem management is drawn based on the differentiation of the protected landscape area into zones with various levels of protection.

Keywords: alluvial landscape; anthropogenically conditioned state of geobiocoenoses; dynamic fluvial seral series of floodplain geobiocoenoses; protected landscape area; forest management; Natura 2000

The floodplain forest is a natural formation that is very rare in Europe, appearing in the area of its potential natural existence of alluvial landscape only in a historically limited extent. In the usually extensively deforested and agriculturally exploited landscape of the current alluvia, the preserved remains of floodplain forests present extraordinarily valuable refuges of biotic diversity and entail irreplaceable importance for the ecological stability of the entire alluvium and wider river basin. Unlike the other Central European landscapes, where even under changes of biocoenosis the permanent ecological conditions of biotopes remain unchanged, the floodplain forests in valley alluvia are typical with their long-term continuous development of ecotopes and mutually conditioning complexly linked succession processes of biocoenosis. Owing to fluvial landscape forming processes, the protection of the ecological alluvium phenomenon necessitates the preservation of natural development dynamics of landscape forming fluvial processes. The international importance of floodplain forests as an endangered type of vegetation is emphasized by the Ramsar Convention, the European ecological network (EECONET) as well as the system of European important natural regions (Natura 2000). The Central European floodplain forests represent specific forest geobiocoenoses, species (the diversity of which closely depends on the ecotope consisting of quaternary river alluvium), regular or irregular inundations and high level of groundwater in the first half of the vegetation period.

METHODS AND MATERIALS

Based on geobiocoenological transects (Machar 2001), a method of biogeographic differentiation of the landscape from a geobiocoenological perspective (Buček, Lacina 1995) was used to determine ecologically important segments of floodplain forests in the area of interest, the Litovelské Pomoraví Protected Landscape Area (PLA). When processing the in-field analysis, a fluvial seral series of alluvial biotopes (Machar 2001) was identified in Litovelské Pomoraví, which is a landscape-related and ecological characteristic of an alluvial plain (Buček, Lacina 1994). The forest stands in the various segments were analyzed for their degree of ecological stability according to Míchal (1994) and the level

Table 1. Degrees of naturalness of forest stands in the Litovelské Pomoraví PLA

Degree of naturalness of forest stands	Proportions of trees in natural species composition
1st degree	90–100
2nd degree	50–89
3rd degree	20–49
4th degree	2–19
5th degree	1

of naturalness (Table 1) by comparing the actual and natural species composition according to forest types. By overlapping the layers of ecologically significant segments and the forest stands with the highest level of naturalness and ecological stability, taking into account other area-related nature preservation interests (various categories of small areas with special protection, areas with endangered species of plants and animals, biotopes significant from the aspect of the Natura 2000 system), while respecting the general principles (Moucha 1999, 2004; Anonymous 2004), two graded zones of preservation of the floodplain forest in the PLA have been distinguished: the core zone, covering the ecologically most significant segments of fluvial seral series biotopes and the economic zone, where ecologically appropriate forest management is allowed. A proposal of forestry management was drawn for both parts, respecting the principles of sustainable forestry management (cf. Plíva 2000). Subsequently, all the defined requirements of nature preservation are expressed with the help of forestry terminology and realized in the Protected Landscape Area management plan.

Geographical delimitation of the area in question

The Litovelské Pomoraví PLA is situated in the western part of the Czech Republic (Fig. 1). The area consists of a 5–6 km wide and 30 km long zone of the alluvial plain of the Morava River north of Olomouc in the region of Central Moravia. The total area of the Protected Landscape Area amounts to 96 km^2. The town of Litovel, which was set up on a river island in the 13th century, is situated approximately at its centre (17°02'E, 49°42'N).

NATURAL CONDITIONS

Climate

The area of interest is situated in a warm climatic region with long and dry summer, warm to slightly warm spring and autumn, and short dry winter with minimal snow coverage. The average length of the vegetation period is 172 days (Quitt 1975). The average annual air temperature (Olomouc 1961–2000) is 8.4°C, the average annual precipitation amount

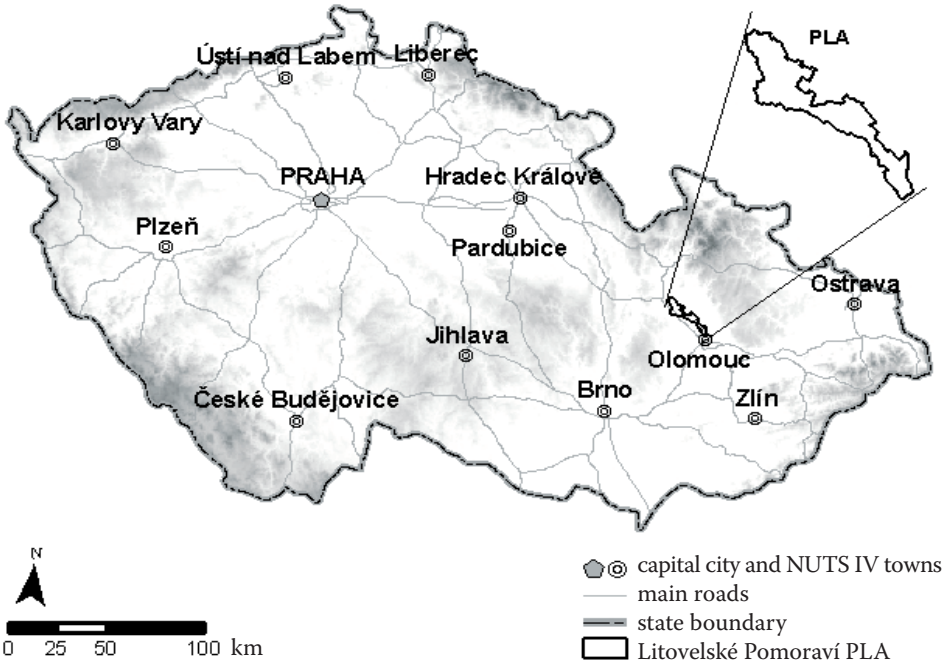

Fig. 1. Geographical location of the Litovelské Pomoraví PLA in the Czech Republic

(Litovel 1961–2000) is 586 mm, in the vegetation period it is 310–490 mm (Hadaš 1997).

Geomorphology, geology and hydrology

Litovelské Pomoraví is situated at the point of contact of two geomorphological areas (The Czech Highlands and The Western Carpathians) in the Upper Moravian vale that belongs to the subprovince of Outer Carpathian depression (Czudek 1997). The geological bed of the Upper Moravian vale is formed by Neocene sea and lacustrine sediments that are up to 250 m thick in places (Panoš 1991). To the west of Litovel, a phenomenon of so-called buried carst can be observed, where the alluvial river sediments cover shallowly positioned and strongly carstified Devonian limestone with subterranean rivers. The Quaternary valley terrace of the Morava River consists of pit-run gravel coming from the Würm period and 4–6 meters thick alluvia. These are covered by recent alluvial soil layers that are up to 3 meters thick. Several levels of river terraces forming the edge of the bottomland can be distinguished.

The basic geomorphological feature of the bottomland in Litovelské Pomoraví is the unusually thick river net and its pattern. It forms the "nervation" of mutually connected canals (partly meandering) that are pertinently called an "inland river delta". The basic form is forked, consisting of active or empty canals of the main channel of the Morava River and its side streams, meanders in various developmental stages, connecting and compensating channels. The canals are sunk deeply into the sediments themselves. Recent geomorphological research (Kirchner, Ivan 1999) discovered the presence of a special type of river net, so-called anastomosis, which had not been previously described in the Czech Republic. Anastomosis river beds develop in the consolidated argillaceous sand sediments and one of their main features is their stability, i.e. minimal side drifting (meanders do not move in the direction of the river flow).

The anastomosis river system of the Morava River in Litovelské Pomoraví is characterized by the dominant meandering main stream of the Morava River with a system of side canals (popularly known as "smoha") with relatively narrow canals. The side canals are flooded periodically during spring (exceptionally also during summer) floods. At the beginning of summer, the side canals gradually dry; remains of the flood water stay in the deepest parts for a few weeks longer in the form of so-called periodic ponds that are very important biotopes for crustaceans (*Lepidurus apus, Siphonophanes grubii*). The natural depressions of the alluvial plain as well as the main canal are sunk into the upper layer of gravel sand that is found under the flood loam, enabling the tight hydraulic connection of subterranean water in the alluvium with the water of the main stream. During great floods when the alluvium is flooded up to the edge of the first low terrace, the flood water may infiltrate around the edge to the gravel sand and significantly increase the groundwater resources. This hydraulic connection of alluvium groundwater with the river is, however, locally influenced by interference related to water management, in particular by flood bank systems.

Pedology

The valley terrace of the Morava River is covered by Holocene alluvial soil, Fluvisols. The accumulation of vegetable soil is regularly interrupted by floods and by the subsequent sedimentation of flood soils of various characters, depending on their origin. There is a constant pedogenetic process of the sedimentation of fluvial soil in the regularly flooded parts of the floodplain forest in Litovelské Pomoraví. The soil is superior and rich in nutrients, causing the steady production of biomass in the floodplain forest (Kulhavý, Sáňka 1998). The predominant soil type of the alluvium is cambial Fluvisol; at the places with secondary loess it is a pseudogley brown earth. A detailed investigation of the soils in the area was carried out by Hruška (1952), who determined 26 territorial soil types in a seemingly uniform area, proving significant variance of the alluvial plain in a relatively small area. A more recent pedological description of the area was carried out by Šarapatka (1991).

Vegetation and biogeographical conditions

The whole area belongs to the 2nd altitudinal zone according to Zlatník (1976). From the aspect of regional phytogeographic division (Skalický 1988), the floodplain forests of Litovelské Pomoraví belong to the phytogenetic area Pannonian Thermophyticum, Haná phytogeographic district, the Upped Moravian vale sub-district. The position of the area, in the vicinity of the Czech and Moravian Mesophyticum, results in significant species richness of vegetation. Due to the Morava River, the flora of the floodplain forest displays numerous subalpine and alpine species (*Veratrum lobelianum* and others). Phytocoenologically, the whole area is an floodplain hardwood forest, with prevailing elm-oak wood of the *Querco-Ulmetum* association (Rybka 2001). Biogeographically, the area in question belongs to

the Litovel bioregion (Culek 1996), with the fauna typical of Central European floodplain forests and their ecosystems, i.e. periodic ponds and various types of riparian wetlands. The prevailing biotopes surveyed for Natura 2000 are floodplain hardwood forests of plain rivers (Table 4).

ECOSYSTEMS OF FLOODPLAIN FORESTS IN LITOVELSKÉ POMORAVÍ

Historic development of the floodplain forest

The floodplain forest in the alluvial plain of the Morava River was already exposed to human interference in the Neolithic, mainly due to its location in the middle of the agriculturally cultivated lands of Haná. The floodplain forest was significantly affected by the deforestation of subalpine and alpine areas in the River Morava basin at the beginning of the Middle Ages. This caused fluctuations in the river flow and led to frequent floods as well as to extensive sedimentation of flood soils. Throughout the Middle Ages, livestock (especially pig) grazing was common in the floodplain forest. The water regime of the floodplain forest area in question was significantly affected by human activities related to water management: the building of dams (since the 14th century), stream regulation for mill races, the building of flood banks and the regulation of some parts of the stream. The current area of the floodplain forest was preserved only due to the unmanageable strength of the regular flooding that the inhabitants faced by building soil dams around the forest complex, which thus became a floodable zone.

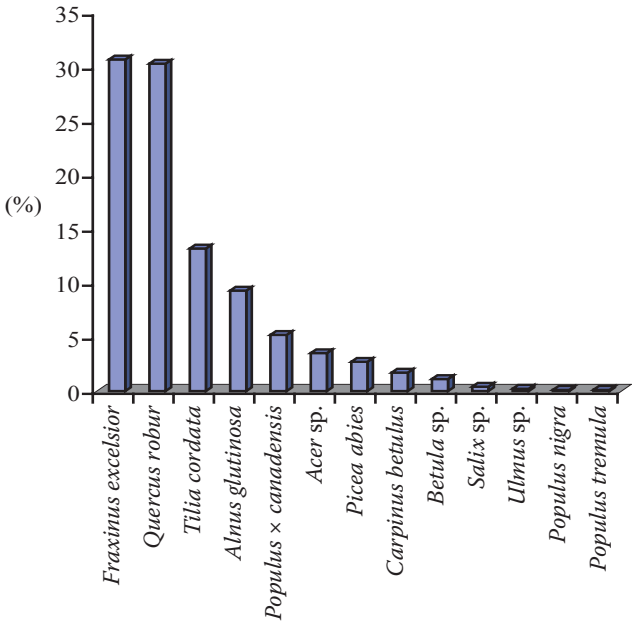

Fig. 2. The present species composition of floodplain forests in the Litovelské Pomoraví PLA

The historical development of the floodplain forest in Litovelské Pomoraví can be clearly traced, since the 16th century, through entries in the account books of the owner of the area (the town of Olomouc). At that time, the town received a significant income from revenues for oak wood; in the years rich in acorns, the income generated by their sale could be twice as high as the income from the sale of wood. This allows to assume a high proportion of oaks in the floodplain forest at that time. In the 17th century, harvesting numbers were approximately 0.5 m^3/ha. The forest served as a complement to agricultural

Table 2. Forest site type groups (FSTG) in the Litovelské Pomoraví PLA

FSTG	Forest site type (FST)*	Proportions of FSTG in the PLA (ha)	Proportions of FSTG (%)
Elm floodplain forest (1 L)	1 L 2	1,656.61	71.0
	1 L 3	85.62	3.6
	1 L 4	82.08	3.4
	1 L 5	68.97	2.8
	1 L 9	315.22	13.5
Poplar floodplain forest (1 U)	1 U 1	56.54	2.4
	1 U 2	1.79	0.1
Salix alderwoods (1 G)	1 G 1	11.78	0.5
	1 G 2	18.23	0.8
	1 G 3	4.09	0.2
	1 G 5	39.96	1.7

*Characterization of FST cf. Burian et al. (1999) and Machar (2001)

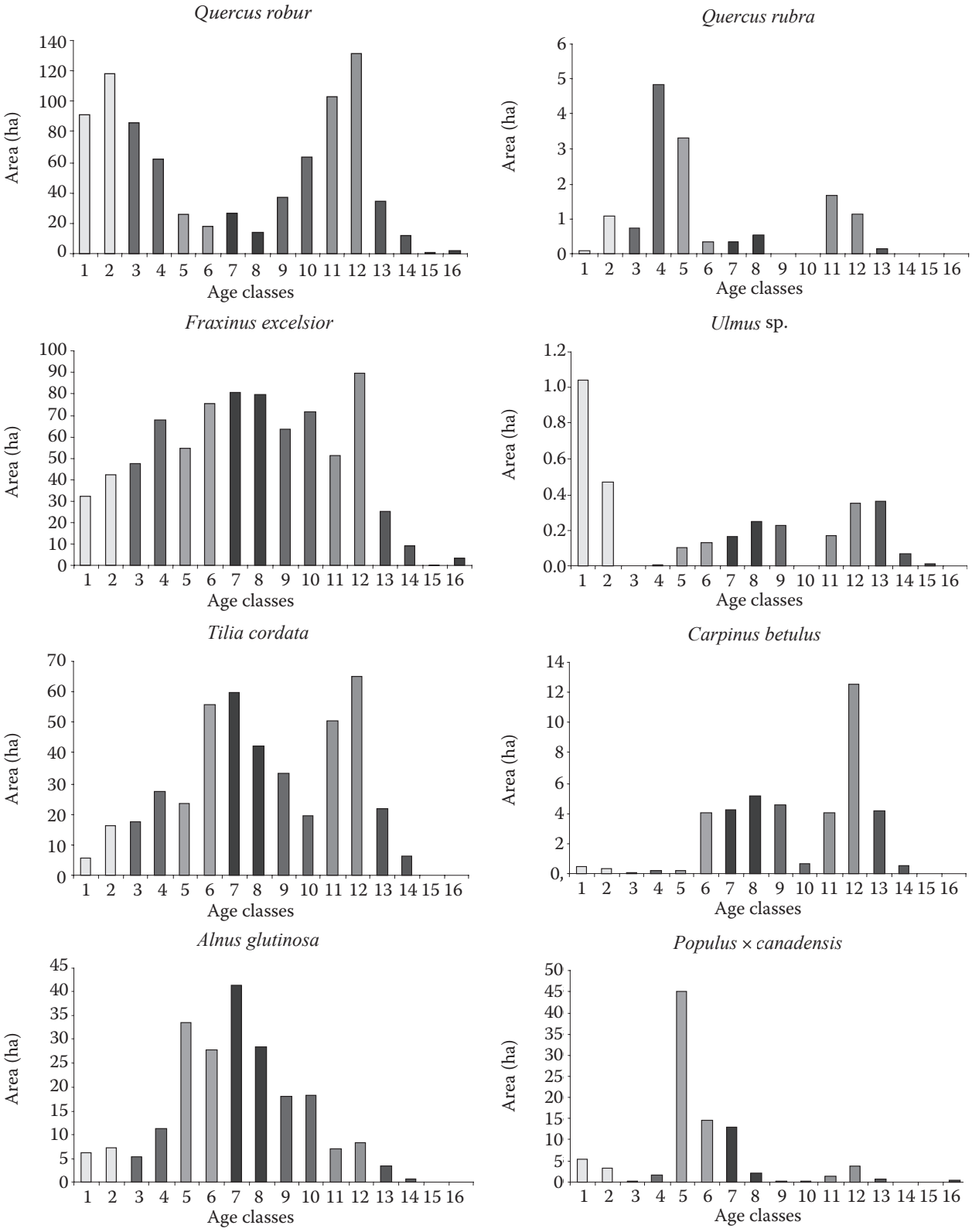

Fig. 3. Trees in the age classes of floodplain forests in the Litovelské Pomoraví PLA

activities; apart from extensive acorn harvesting, the forest was used for grazing until it was legally abolished in 1850. The planned forestry economy dates from 1754, when the geodetic location of the forests belonging to the town was done. The net of forest paths set up at that time has remained virtually without change to the present day. The forest management plan was based on the forest being managed

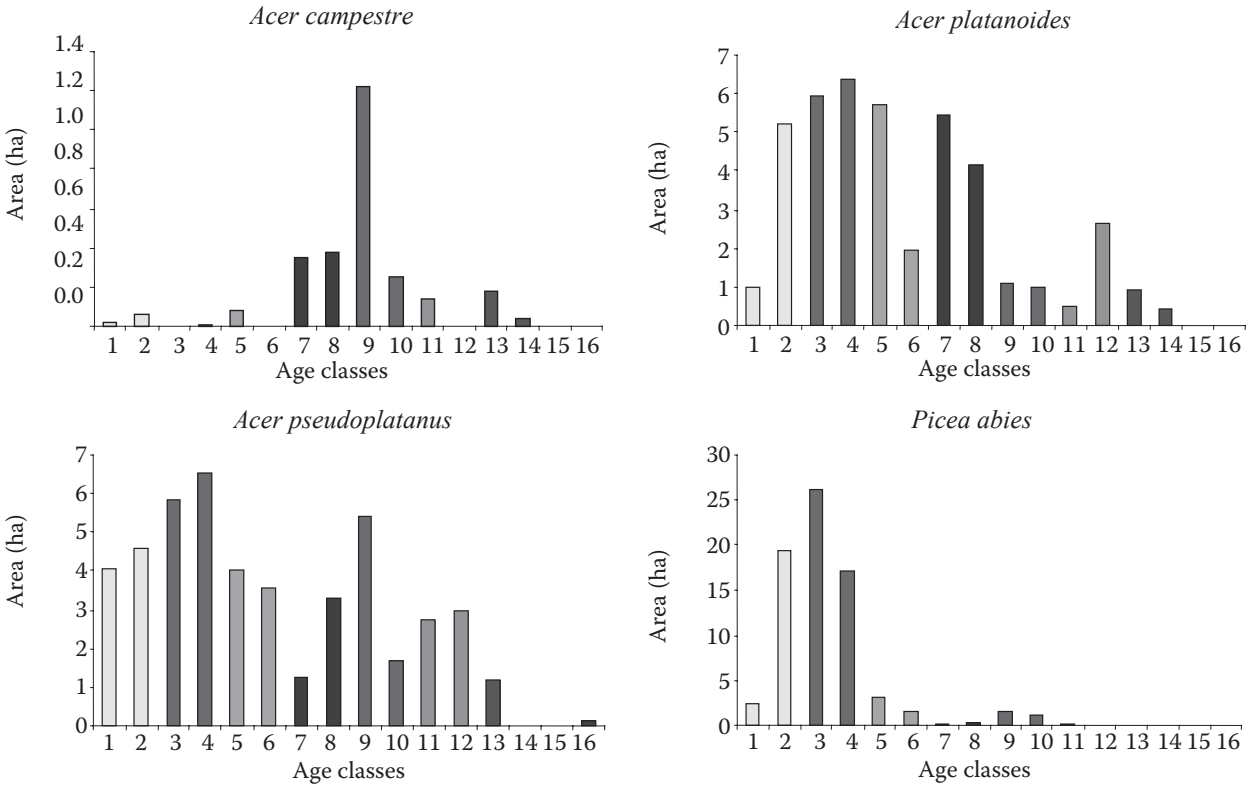

Fig. 3 to be continued

under systems involving coupes. The floodplain forest was cultivated for more than two centuries as a mixed wood, with directed cultivation based on seed trees and a rotation period of 25–35 years. The cultivation was extensive, including the artificial replacement of stands (for example, when reforestation took place in the area of Horka between 1869 and 1939, more than 1.5 million transplants were planted, of them 27.5% were oak, 23.5% ash, 27.6% alder, 11.6% birch, 1.4% locust, 0.9% both elm and maple, 1.2% poplar and 0.4% larch). This type of forest management prevailed virtually unchanged until the forced takeover of the town property by the state in 1950 that was followed by major changes aimed at changing the then composite forest to a broadleaved forest. The most problematic intervention into the floodplain forest in the area of Litovel in the recent history was the establishment of a large pheasantry Střeň-Březová in 1962 with an area of 1,340 ha. To this end, the category of a special assignment forest was set up, and the forest management was strictly governed by the large-scale breeding of pheasants (setting up of artificial non-stocked forest land, extensive planting of conifers, etc.). When the area was declared a PLA in 1990, the priorities of forest management were reconsidered and the pheasantry was closed down in 1994.

Forest site type groups

On the basis of a typological survey carried out by the Forest Management Institute (Burian et al. 1999), the floodplain forests of Litovelské Pomoraví were assessed as belonging to the 1st forest vegetation zone. In this zone, the forest site type groups dependent on water prevail (elm alluvium – 80%, poplar alluvium – 15%). An overview of forest types and their representation in the floodplain forest of Litovelské Pomoraví are presented in Table 2.

Type and age structure of the forest geobiocoenosis

The type structure of the forest geobiocoenosis in Litovelské Pomoraví is relatively diverse. The English oak (*Quercus robur*) is a dominant species in the floodplain forest of Litovelské Pomoraví, followed by the European ash (*Fraxinus excelsior*) and a number of other broadleaved species (*Tilia* sp., *Acer* sp., *Salix* sp., *Alnus glutinosa, Carpinus betulus,* and others). The *Ulmus* family (all three types) is also relatively common; the elm trees in the area have a strong tendency of natural reproduction, especially near the water streams. Older representatives of *Populus nigra* are quite rare; therefore, a special preservation

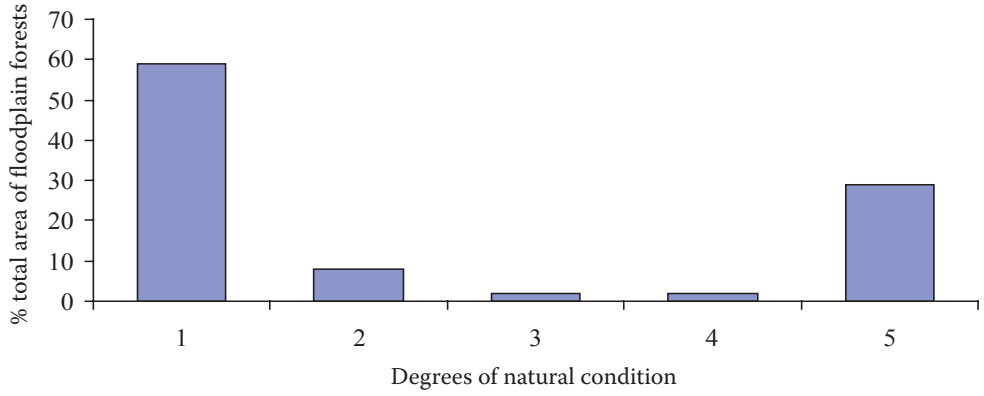

Fig. 4. Proportions of the degrees of naturalness of floodplain forests in the Litovelské Pomoraví PLA

program has been undertaken (Mottl, Dubský 1993). A significant part of the floodplain forest ecosystem is formed by shrubs (*Padus racemosa, Evonymus europaeus, Sambucus nigra, Ribes nigrum* and others). The diversity of the species composition of the forest is shown in Fig. 2, the representation of the main species of the forest according to age classes is shown in Fig. 3. This figure shows the even distribution of *Fraxinus excelsior*, which has optimal growth conditions in the forest. The incidence of *Quercus robur* exhibits significant deficiency in the 5th to 8th age class, which can be explained by a period of decreased interest in its planting in the second half of the last century. The high incidence of English oak in the older age classes can be explained by a high level of biomass of the so-called seed oaks in the floodplain forest. The significantly high incidence of elm species (*Ulmus* sp.) in the first two age classes is a proof of its high natural reproduction capability after recurrent tracheomycotic diseases. The hornbeam (*Carpinus betulus*) also has a capability of natural reproduction, often in the form of coppices in the sub-storey of the driest parts of the forest. The existence of spruce monocultures in the lower age classes (1st–4th) can be ascribed to the recently closed pheasantry (see Fig. 3). The monocultures of needle-leaved species in a regularly flooded area are exceptionally ecologically unstable and their further cultivation and planting in the areas with high occurrence of broadleaves is unreasonable as well as incompatible with the aim of the PLA. Therefore, the spruce monocultures are being gradually transformed to broadleaves by immature harvesting. Another ecological problem is caused by smaller areas with monocultures of allochthonous broadleaves (*Quercus rubra* – Fig. 3). The occurrence (however low) of *Q. rubra* in the first age class makes it clear that this allochthonous species has an undesirable natural reproduction ability in an floodplain forest. The high occurrence of hybrid poplar monocultures (*Populus* × *canadensis*) in the fifth age class is a result of so-called "forestry poplar mania" after the fashion of Soviet agriculture in the 1950s. At present, those considered mature are harvested and substituted with the geographically local species of *Populus nigra*. Geographically allochthonous species are not planted in the PLA at present and their occurrence is gradually reduced depending on the capabilities of the forest industry.

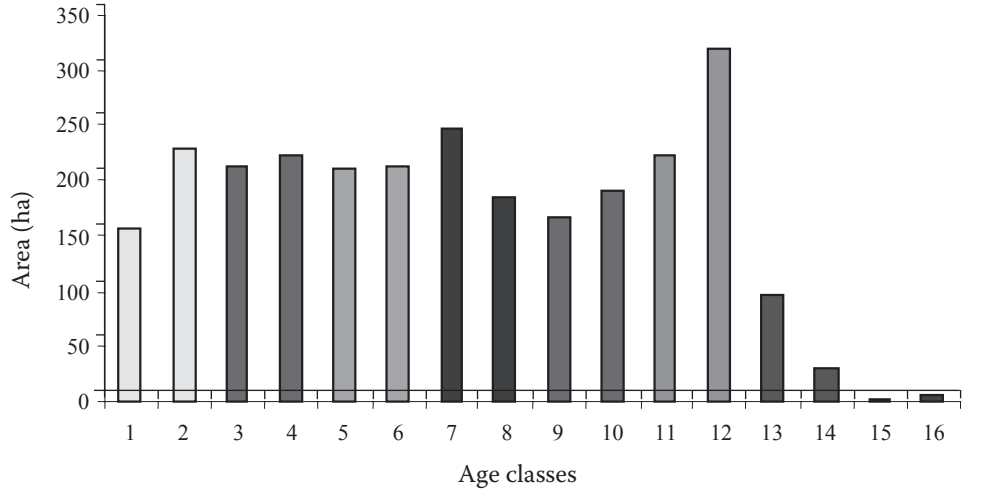

Fig. 5. Proportions of age class areas of floodplain forests in the Litovelské Pomoraví PLA

Table 3. Groups of geobiocene types (GGT) in the Litovelské Pomoraví PLA

Abbreviation of GGT	Name of GGT*	Proportions of FST in the PLA (ha)	Proportions of FST in the PLA (%)
A B-C 5a	*Saliceta albae* sup.	86.18	3.6
2 B-C (4) 5a	*Querci roboris-fraxineta* sup.	302.83	12.9
2 C (4) 5a	*Ulmi-fraxineta populi* sup.	340.13	14.5
2 BC-C (3)4	*Ulmi-fraxineta carpini* sup.	1,512.33	64.6
S BC 5b	*Alni glutinosae-saliceta* sup.	98.52	4.4
2 B-C 5a-5b	smohy	350 km	

*Characterization of GGT cf. Machar (2001)

When comparing the natural and actual species composition (Machar 2001), it is clear that the floodplain forest in this area exhibits a high degree of naturalness. The degree of naturalness for age classes is shown in Fig. 4. A low degree of naturalness at the site of nettle poplar carr (1U1) is caused by a high intensity of planting hybrid poplar monocultures (cf. Machar 2001). There is a high level of naturalness at the site of the most common forest type (ashweed elm carr, 1L2), where 57% of the covered area (i.e. 1,492 ha) falls under naturalness degree 1.

The age structure of the Litovelské Pomoraví forest is slightly irregular from the aspect of "forest age classes" (Fig. 5). Ecologically negative is above all the absence of the older age classes from the 12th class on, i.e. only a small number of exceptionally old and over-mature trees which are significantly important for the biodiversity of the forest biogeocoenosis. The age diversity within the stand groups is, however, exceptionally high. So-called storey stands account for ca 14% of the floodplain forest area. In the forest management plan, stands which had been managed as coppice-with-standards forest and at the time of indirect transformation to high forest (ca 50 years ago) its lower coppice storey was intentionally kept, are also described as storey stands (i.e. stands with two or more sharply differentiated layers). Due to the fact that it is this type of composite forest that is closest by its character and wood composition to the current ideal of ecologically stable and highly aesthetic floodplain forest (Míchal 1992), the remains of this type of stand are valued highly from the aspect of nature preservation.

Geobiocoenological characteristics

According to the geobiocoenological typology, the floodplain forests of Litovelské Pomoraví belong to the 2nd altitudinal zone (in contrast to the forestry typology – cf. Burian et al. 1999). Six groups of geobiocene

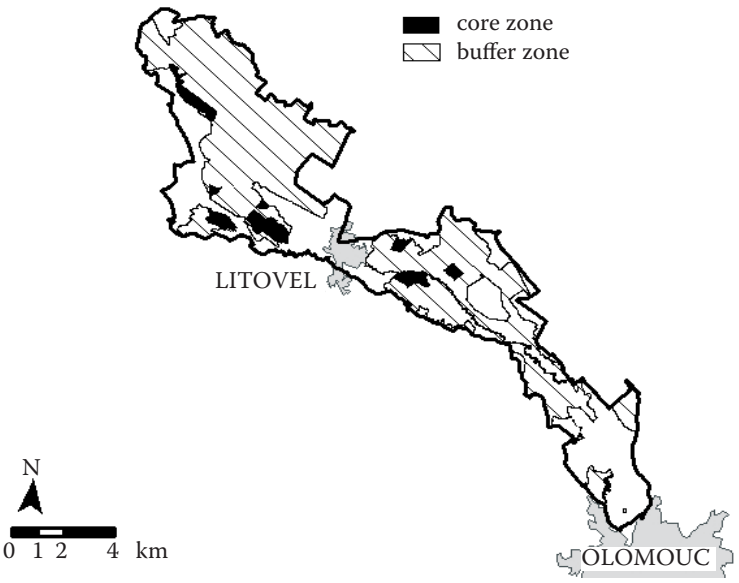

Fig. 6. The zonation of floodplain forests in the Litovelské Pomoraví PLA

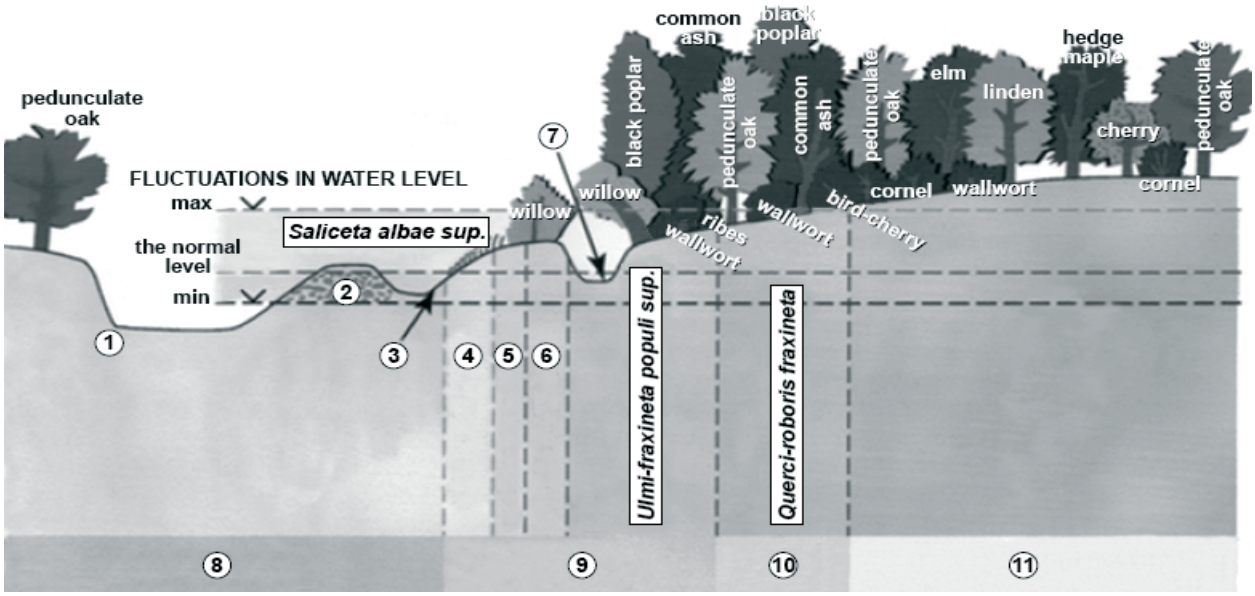

Fig. 7. Fluvial seral series of floodplain biotopes in the Litovelské Pomoraví PLA: 1 – stream bank erosion, 2 – gravel river island, 3 – sand river drift, 4 – muddy river bank with *Bidens* sp., 5 – gravel river bank with *Phalaris arundinacea*, 6 – willow scrub of loamy and sandy river banks, 7 – side arm of river, 8 – main river bed, 9 – frequent floods, 10 – occasional floods, 11 – habitats out of floods

types (STG) (Table 3) were identified, classified and described in detail (Machar 2001). In the area of the floodplain forest of Litovelské Pomoraví the individual STG form so-called fluvial seral series of alluvial biotopes (cf. Buček, Lacina 1994) (Fig. 7).

Within the fluvial seral dynamic section of alluvial biotopes, the initial alluvial community usually consists of white willow, with a significant proportion of high stands on the newly created edatope of alluvial deposit on the banks or river islands (they emerge closely after or together with the herb community of the phytocoenological coalition of *Phalaridion arundinaceae* and the natural seeding of *Salix purpurea*). Communities of white willow of a higher class (v.s.) are dependent on relatively "young" alluvial deposits that are, in turn, highly and directly dependent on the dynamics of the water stream.

The willows are followed by *Querci roboris fraxineta* of the higher class which exhibit numerous specimens of subalpine plants species. The *Querci roboris fraxineta* are usually found within ecotopes based on gley Fluvisol soils, the particles of which are heavy; the soil is regularly flooded and the gley horizon is situated 50–150 cm below the surface. The soils are usually rich in minerals, especially in the azotic ones, therefore the forest communities are usually above average in productivity. The floods usually last for 15–30 days (Maděra et al. 1999). With the naturally close examples of this STG, the main stands are the English oak (*Quercus robur*) and the common ash (*Fraxinus excelsior*) with the presence of white elm (*Ulmus laevis*),

Table 4. Natural habitat types in the framework of the Natura 2000 network in the Litovelské Pomoraví PLA

Code of the Natura 2000 network	Natural habitat
6410	*Molinia* meadows on calcareous, peaty or clayey-silt-laden soils *(Molinion caeruleae)*
6510	Extensive hay meadows of the plain to submontane levels (*Arrhenatherion, Brachypodio-Centaureion nemoralis*)
9170	*Galio-Carpinetum* oak hornbeam forests
91E0	Mixed ash-alder floodplain forests of temperate and Boreal Europe *(Alno-Padion, Alnion incanae, Salicion albae)*
91F0	Riparian mixed forests of *Quercus robur, Ulmus laevis* and *Ulmus minor*, *Fraxinus excelsior* or *Fraxinus angustifolia*, along the great rivers of the Atlantic and Middle-European provinces *(Ulmenion minoris)*

Table 5. The species of European Communities interest in the framework of the Natura 2000 network in the Litovelské Pomoraví PLA

Code of the Natura 2000 network	Species
1337	*Castor fiber*
1166	*Triturus cristatus*
1188	*Bombina bombina*
1061	*Maculinea nausithous*
1308	*Barbastella barbastellus*
1060	*Lycaena dyspar*
4056	*Anisus vorticulus*
1355	*Lutra lutra*

Table 6. The species of birds of European Communities interest in the framework of the Natura 2000 network in the Bird Area Litovelské Pomoraví

Species
Kingfisher (*Alcedo atthis*)
Middle Spotted Woodpecker (*Dendrocopos medius*)
Collared Flycatcher (*Ficedula albicollis*)

black poplar (*Populus nigra*) and common alder (*Alnus glutinosa*). With dry types, maples are often present; in the case of naturally close examples it is the sycamore maple (*Acer pseudoplatanus*).

At a greater distance from the water stream, *Ulmi-fraxineta* of a higher class are to be found, usually on lighter, sandy and well-aerated soils (subtype arenic Fluvisol), often on natural levées. Here, the floods usually last only for 1 to 2 weeks in a year, during which typical regular sedimentation of light suspended solids on the surface of the terrain takes place. In the naturally close segments in the main tree layer, the black poplar (*Populus nigra*), common ash (*Fraxinus excelsior*) and elms (*Ulmus* sp.) prevail, followed by the English oak (*Quercus robur*), common alder (*Alnus glutinosa*) and willows (*Salix* sp.). The character of *Ulmi-fraxineta populi* is slightly distorted by the prevailing hybrid poplars (*Populus* × *canadensis*). However, in the monocultures at mature cutting age (40–50 years), aged specimens of the former *Populus nigra,* and at the edge of the communities that are situated near the river, specimens of aged tree willows (*Salix alba, Salix fragilis*) together with a weakly developed sublayer of vital specimens of common bird cherry (*Padus avium*) and black elder (*Sambucus nigra*) are to be found. In some cases, the fragments of *Ulmi-fraxineta populi* only verge the winding of the river.

The prevailing STG in the floodplain forests of Litovelské Pomoraví are *Ulmi-fraxineta carpini* v.s. of a higher class in the driest part of the alluvium out of the reach of regular floods. They are to be found on Fluvisol soils rich in minerals with favourable humification. The groundwater level varies dynamically, however, water is supplied to the rhizosphere by means of capillary rise. Due to this fact, humification is favourable. For the stand layer with a predominance of English oak and common ash, the presence of the yoke elm is typical (*Carpinus betulus*) for the type of composite forest, it is usually of cop-

Table 7. National natural reserves (NNR), natural reserves (NR) and natural monuments (NM) in the Litovelské Pomoraví PLA

The name of reserve	Type	Area (ha)	Predominant habitat
Ramena řeky Moravy	NNR	71.19	meandering river and ash-alder floodplain forests
Vrapač	NNR	80.69	floodplain forest
Litovelské luhy	NR	344.45	floodplain forest
Hejtmanka	NR	38.34	floodplain forest
Panenský les	NR	15.90	floodplain forest
Kenický	NR	11.15	floodplain forest
U Zámecké Moravy	NM	1.36	floodplain forest
Častava	NM	7.32	alluvial lake
Daliboř	NM	3.36	alluvial meadows
Novozámecké louky	NR	25.75	alluvial meadows and ash-alder floodplain forests
V Boukalovém	NM	1.18	wetland
Kurfurstovo rameno	NM	5.02	side arm of river and willow stands
Plané loučky	NR	20.12	alluvial meadows, wetlands and alder floodplain forests

pice origin in the sublayer, and the sycamore maple (*Acer pseudoplatanus*) found in both the layer and the sublayer. Older specimens of white elm (*Ulmus laevis*) are rather rare at this time.

The mosaic of fluvial series biotopes is complemented by alder bushes of a higher class at those sites which are constantly soaked with stagnant water. This type of STG is to be found in small mosaic-shaped fragments (at places, areas of several m^2 only) in the matrix of *Ulmi-fraxineta populi* or *Ulmi-fraxineta carpini*. The soils are predominantly waterlogged gley; in the case of larger STG, stagnant water may occur throughout the year, giving rise to small hydrobiocoensis with a high level of biodiversity. Due to a lack of soil aeration, intensive reduction processes take place in the soil. In the stand layer of naturally close segments, common alder (*Alnus glutinosa*), white willow (*Salix alba*) and crack willow (*Salix fragilis*) predominate. In the areas that are subject to forest management, it is sometimes possible to increase the occurrence of common ash (*Fraxinus excelsior*) although it is usually very demanding. The stands are often naturally loose and even missing around permanent water sites. This fact often leads to concern on the side of foresters who tend to improve and amend the "disintegrated" stands.

The fluvial series is complemented by a newly defined STG called "smoha" side canals (Machar 2001), which forms a transition from geobiocoenosis and hydrobiocoenosis. The "smoha" is a meandering and forked river arm that forms a complex anastomosis river system of bird-foot like water streams together with the permanently flooded water streams. The historical comparative studies in the area of Litovelské Pomoraví (Kirchner, Ivan 1999) proved that the "smoha" side canals arise in the anastomosis river system from originally permanently flooded river arms by means of seral land-filling. At a microrelief view, "smoha" side canals exhibit a highly differentiated bottom (which is also added to by e.g. trees and branches fallen into the river bed), which leads to the formation of pools after a drop in the flood level. These pools, so-called biotopes of alluvial periodic

Table 8. Management of the core zone in the Litovelské Pomoraví PLA

Zone of graded PLA preservation	I (core zone)
Characteristics of the area	Geobiocoenoses of various types of floodplain forest in various seral stages from willow bushes on fluvial deposits to the *Ulmi-fraxineta carpini* stands belonging to the first degree of naturalness. Active fluvial processes and dynamics of Fluvisol development.
Basic aims of care for the area	Protection of representative samples of fluvial seral series of alluvial biotopes. Protection of dynamics of landscape-ecological processes in an alluvial plain of a large river. Long-term aim: Geobiocoenological "natural" laboratory enabling the study of natural development of various types of alluvial geobiocoenoses.
Area	390 ha
Legal protection	National nature reserve
Natura 2000	Core area of the bird area and an important locality on the European level
Territorial system of ecological stability	Core area of supra-regional biocentre
Forest category	Forestry with a special assignment due to nature protection
Agricultural wood shape	Coppice with standards and high forest
Agricultural way of management and its form	Selective – individual selection, group selection when reducing geographically allochthonous woody species
Desired species composition	In accordance with the respective geobiocene types
Rotation period	Physical age – differentiated according to the space-forming tree species
Reproduction period	Continuous
Basic management principles	Natural development of the geobiocoenosis without intervention.
Game management	Feeding of game excluded. Intensive hunting of cloven-hoofed game.
Deviations from the model	Selected stands with a composite forest character should be continuously managed with the aim of preserving this ecologically desirable stand state (reproduction period 15–30 years, leaving seed trees of English oak 15–20 trees per ha until the ultimate end of the life cycle). Removal of obstacles in the Morava River channel arising from fallen trees into the river bed. Maintenance of forest roads, bridges and pipe culverts in a proper state. Active reduction of geographically allochthonous woody species. Active removal of alien plants.

Table 9. Management of the buffer zone in the Litovelské Pomoraví PLA

Zone of graded PLA preservation	II (buffer zone)
Characteristics of the area	Floodplain forest rich in species, age structured.
Basic aim of the care for the area	Continuous production of wood mass while respecting the principles of environmentally friendly forestry management. Planting of multi-storeyed and species-rich stands, with English oak and common ash in the main storey and rich sub-storey.
Area	1,955 ha
Legal protection	Zone II of the protected landscape area
Natura 2000	Bird area, sites important at the European level
Territorial system of ecological stability	Supra-regional biocentre
Forest category	Production forest
Agricultural wood shape	High forest (storeyed)
Agricultural management and its form	1. System involving coupes with shelterwood cutting to support the natural regeneration of ash (clear cutting of maximum area of 1 ha with consistent leaving of seed trees in the regenerated area; the minimum number of seed trees being 10 trees/ha) 2. Selective (group selection)
Desired species composition	According to the respective agricultural type. Introduction of geographically allochthonous woody species is excluded.
Rotation period	With oak seed trees (minimal number: 10 trees/ha), the rotation period is extended till the end of the life cycle.
Reproduction period	According to the respective agronomical stand type.
Course of reproduction	Where the group selection is realized, the regeneration elements (gaps) should be inserted into the natural regeneration points. Where regeneration by clear cutting is realized, oak seed trees should be left in place (minimally 10 trees/ha).
Plantation	Artificial planting of English oak and natural reproduction of common ash (floodplain hardwood forest) and black poplar (floodplain softwood forest) by means of large saplings in those areas where reproduction is ensured by means of clear cutting, acorn seeding should be used. The natural reproduction of the woody species in the substoreys should be encouraged: lime, hornbeam, maple, alder, willow.
Stand tending	Consistent protection by means of fencing to protect from the game. Check of the fen-cing state after each flood. Use of natural sprouting capacity to create the lower storey.
Forest protection	
Improvement of land	Maintenance of the flow capacity of the periodical river channels (maintenance of bridges and pipe culverts in the forest roads). Systematic drainage of the forest is excluded. Systematic preparation of the soil during stand regeneration is excluded.
Game management	Intensive hunting of cloven-hoofed game. Do not establish the special assignment forest category in order to set up a pheasantry.
Deviations from the model for composite forest	Continuous management in order to preserve this ecologically desirable forest state (reproduction period 15–30 years, leaving seed trees of English oak 15 to 20 trees/ha until the end of the life cycle).
Deviations from the model	1. Small-scale natural monuments: plan of care. 2. Seed trees intended for reproduction should be preferably chosen from English oak, alternatively from viable ash or elm specimens. 3. In a good year for English oak seeding, the promising areas of self-seeding should be fenced immediately and consistently protected against weeds. 4. Selected specimens of older trees with hollows (nesting places), indicated with nature protection, should be left in place permanently. 5. Stands with a willow alder carr character: elimination of hybrid poplars at the mature cutting age, otherwise without intervention, if possible exclude the development of cleared areas. 6. Bank protection stand: intensive health-based selection, protection of rare woody species (black poplar, elm). 7. Former hunting specific non-stocked forest land: reforest, in parts leave in the form of meadows.

pools house specific zoocoenoses. The best known, although not dominant, specimens of periodic pool fauna are two species of critically endangered crustaceans: the fairy (*Siphonophanes grubii*) and tadpole shrimp (*Lepidurus apus*). The optimal state for the zoocoenoses of the periodic pools is the early seral stages (their seral aging is hindered by repeated distribution by flooding). During greater floods, new "smoha" side canals (and periodic pools) are created in the alluvium. Seral extinction by means of gradual filling (or when the disturbance element – the floods – is no more in effect), the biotopes of the periodic pools undergo a transition from the early seral stage to the final stages of extinction (both periodic pools and their zoocoenoses disappear). It is, therefore, apparent that the active dynamics of the river and its system is a precondition for the preservation of the biodiversity of the alluvial periodic pools.

Nature protection

Natura 2000

Thanks to their specific biodiversity, the floodplain forests deserve priority nature preservation at the European level. Within the framework of the Natura 2000 system, Litovelské Pomoraví was included in the national list of important sites at the European level (EVL) and delimited as bird area. The overview of the species and biotopes important at the European level and being subject to protection as important locations at the European level is shown in Tables 4 and 5, and bird species important at the European level – subject to protection in a bird area are given in Table 6.

Other specific interest related to nature preservation

The floodplain forest of the area of interest forms a part of the internationally important wetlands of Litovelské Pomoraví, protected by the Ramsar Convention (Chytil 1999). Virtually the whole area of the floodplain forests belongs to a supra-regional system of ecological landscape stability (Burian et al. 1999). An overview of individual small areas in the floodplain forest in the area of interest that enjoy special protection, its categories and areas are shown in Table 7.

Management and zonation of the floodplain forest ecosystem

The delimitation of both zones of graded nature protection in the floodplain forests in the area of interest is shown in Fig. 6. The first zone of graded nature protection (the core zone) represents the ecologically most important segments of the fluvial seral series of alluvial biotopes and is formed by continuous complexes of nature-close forest stand with the 1st degree of naturalness and a high level of ecological stability. The stands in the core zone are subject to thoroughly specific management, carried out by means of detailed plans of care regarding the individual specially protected areas (Table 8). The minimal area (cf. Vacek 2003) of one segment of the core zone is 30 ha; this is due to presumed management in future in the course of which the geobiocoenosis will be left to evolve naturally as so-called geobiocoenologic reservation. The fluvial processes in the core zone (erosive and accumulative geomorphological processes in the water streams, development of meanders, changes in the locations of the canals) are in no way anthropologically influenced.

The second zone of graded nature protection (the protected zone) covers floodplain forests where the concerns related to nature preservation are carried out in accordance with the principles of sustainable forestry (Table 9). In the protected zone, aquaculturing interventions in the dynamics of the fluvial processes are allowed only in the case of necessary flood measures (maintenance of the protective banks, maintenance of flow profiles under bridges). All the above stated principles of management related to both zones are incorporated in the actualization of the plan of care of the PLA and subsequently taken over and incorporated in the applicable forestry-agricultural plan.

CONCLUSION

The essence of the protective management of floodplain forests in Litovelské Pomoraví is the knowledge and identification of the fluvial seral series of alluvial biotopes. The entirety of this series of the alluvial biotopes and its seral development are dependent on the continuous impact of the fluvial processes in the area of the alluvium (movement and branching of the canals, floods and sedimentation processes, etc). The preservation of biodiversity of the area of the alluvial plain is conditioned by the functioning of the natural fluvial processes related to landscape enhancement. The entire dynamic fluvial seral series of the alluvial biotopes cannot, therefore, be preserved and protected otherwise than through territorially differentiated protection of the natural dynamics of the fluvial processes within the area.

References

ANONYMOUS, 2004. Rámcové zásady lesního hospodaření pro typy přírodních stanovišť v území soustavy Natura 2000 v ČR. MŽP ČR, Planeta, *12*: 24.

BUČEK A., LACINA J., 1994. Biogeografické poměry. In: KOLEKTIV, Vybrané fyzickogeografické aspekty pro revitalizaci nivy Dyje v úseku VD Nové Mlýny – soutok s Moravou. Brno, Ústav geoniky AV ČR: 46–98.

BUČEK A., LACINA J., 1995. Diferenciace krajiny v geobiocenologickém pojetí a její aplikace v krajinném plánování při navrhování územních systémů ekologické stability. Zprávy ČBS Praha, *30*: 92–102.

BURIAN J. et al., 1999. Oblastní plán rozvoje lesů – PLO 34 Hornomoravský úval. Brandýs nad Labem, ÚHÚL, pobočka Olomouc: 256 + příl.

CULEK M., 1996. Biogeografické členění ČR. Praha, Enigma: 347.

CZUDEK T., 1997. Reliéf Moravy a Slezska v kvartéru. Brno, Sursum: 213.

HADAŠ P., 1997. Klimatické poměry. In: KLIMO E. et al., Posouzení stavu a možností dalšího sledování vývoje lužních lesů Litovelského Pomoraví. Brno, MZLU, LFD: 8–11.

HRUŠKA B., 1952. Stanovištní půdní typy v lužních lesích Hornomoravského úvalu a jejich význam pro lesní hospodářství. Brno: 184 + příl.

CHYTIL J. et al., 1999. Mokřady ČR – přehled vodních a mokřadních lokalit ČR. Praha, MŽP a Český Ramsarský výbor: 327.

KIRCHNER K., IVAN A., 1999. Anastomózní říční systém v CHKO Litovelské Pomoraví. In: Geologické výzkumy na Moravě a ve Slezsku v roce 1998. Brno, ČAV, *VI*: 19–20.

KULHAVÝ J., SÁŇKA M., 1998. Půdní monitoring v CHKO Litovelské Pomoraví. Litovel, Správa CHKO LP: 15.

MADĚRA P. et al., 1999. Dřeviny lužních lesů České republiky. Živa, *XLVII*: 64–66.

MACHAR I., 2001. Krajinně-ekologická studie lužních lesů Litovelského Pomoraví. [Dizertační práce.] Brno, MZLU, Ústav ekologie lesa LDF: 155 + příl.

MACHAR I., 2007. Lužní lesy. Dynamická stabilita geobiocenóz. Olomouc, ČSOP a UP v Olomouci: 111.

MÍCHAL I., 1992. Obnova ekologické stability lesů. Praha, Academia: 169.

MÍCHAL I., 1994. Vymezování a navrhování územních systémů ekologické stability v lesích. Praha, MŽP ČR: 33.

MOTTL J., DUBSKÝ M., 1993. Záchrana genofondu domácího topolu černého modelovým řešením návratu jeho reliktní populace do ekosystému lužního lesa. Průhonice, VÚOZ: 32.

MOUCHA P., 1999. Zásady začleňování lesů v chráněných krajinných oblastech do zón odstupňované ochrany přírody a principy hospodaření v nich. In: MOUCHA P. (ed.), Přírodě blízké hospodaření v lesích chráněných krajinných oblastí. Sborník ze semináře 30. 3. 1999 v Průhonicích. Praha, SCHKO ČR a ČLS: 41–46.

MOUCHA P., 2004. Péče o lesní porosty v ptačích oblastech Natury 2000. Sborník referátů. Praha, Česká lesnická společnost: 48.

PANOŠ V., 1991. Fyzickogeografické charakteristiky území. In: ŠARAPATKA B. (ed.), Oborový dokument Chráněné krajinné oblasti Litovelské Pomoraví. Olomouc, Univerzita Palackého: 12–64.

PLÍVA K., 2000. Trvale udržitelné obhospodařování lesů podle souborů lesních typů. Brandýs nad Labem, ÚHÚL: 34 + příl.

RYBKA V., 2003. Vegetace Litovelského Pomoraví. In: ŠAFÁŘ J. et al., Chráněná území ČR – Olomoucko, svazek VI. Agentura ochrany přírody a krajiny ČR a EkoCentrum Brno: 361–363.

QUITT E., 1975. Klimatické oblasti. In: Pedogeografická mapa, rekonstrukční mapa přírodních pedogenetických asociací, list Olomouc. Brno, Geologický ústav ČSAV: 27.

SKALICKÝ V., 1988. Regionálně fytogeografické členění. In : HEJNÝ S., SLAVÍK B. (eds), Květena ČSR 1. Praha, Academia: 103–121.

ŠARAPATKA B., 1991. Pedologie. In: ŠARAPATKA B. (ed.), Oborový dokument Chráněné krajinné oblasti Litovelské Pomoraví. Olomouc, Univerzita Palackého: 64–121.

VACEK S., 2003. Minimum area of forest left to spontaneous development in protected areas. Journal of Forest Science, *49*: 349–358.

ZLATNÍK A., 1976. Přehled typů geobiocénů původně lesních a křovinných v ČSSR. Zprávy GgÚ ČSAV v Brně, *13*: 55–64 + příl.

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Lužní lesy Litovelského Pomoraví a jejich management

ABSTRAKT: Příspěvek charakterizuje přírodní podmínky a současný stav lužních lesů v oblasti Litovelského Pomoraví a prezentuje návrh jejich managementu v souladu se zájmy ochrany evropské soustavy Natura 2000. Je popsána geografická lokalizace a přírodní podmínky zájmového území (klima, geologie, geomorfologie, hydrologie a vodní

režim, půdy, vegetace) a ochranářský statut území. Metodou biogeografické diferenciace krajiny v geobiocenologickém pojetí a analýzou stupňů přirozenosti lesních porostů je zhodnocen stupeň ekologické stability lesních porostů a na základě rozčlenění chráněné krajinné oblasti do zón odstupňované ochrany přírody jsou zpracovány zásady managementu lesních ekosystémů.

Klíčová slova: krajina údolní nivy; antropogenně podmíněný stav přírodě blízkých geobiocenóz; dynamická fluviální sukcesní série geobiocenóz lužního lesa; chráněná krajinná oblast; management lužního lesa; Natura 2000

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