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Historical development of floodplain forests in the Upper Moravian Vale (Vrapač National Nature Reserve, Czech Republic)

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ABSTRACT: The paper deals with historical development of floodplain forests in the area of Vrapač National Nature Reserve in the floodplain of the Morava River (Protected Landscape Area Litovelské Pomoraví, Czech Republic). The aim of this paper is to contribute to a better understanding of the anthropogenic influences that have over centuries led to the present state of floodplain forests in the study area. Thus, it will be possible to define more efficiently the management plan of this floodplain forest ecosystem.

Keywords: floodplain forest; historical development of forests; coppice-with-standards; national nature reserve; forest management

The floodplain forests of Central Europe represent a specific forest geobiocoenoses, the species diversity of which is closely connected with the ecotope, consisting of Quaternary river floodplain, regular or irregular flooding, and a high level of subterranean water in the first half of the vegetation period (Mezera 1958; Vašíček, Prax 1983; Penka et al. 1985, 1991). The main characteristics and functions of floodplain forests in Europe are in particular: high production of biomass, high level of biodiversity, protection of rivers against erosion and pollution, high number of natural preserves, both recreational and aesthetic functions of the landscape, significant source of water vapours in the landscape and retention space in the case of floods (Klimo, Hager 2001).

The floodplain forests within Europe are ranked (Gutzweiler et al. 1990) as endangered biotopes. For example, as a result of changes related to water management on the upper Rhine between the years 1955 and 1957, only 1% of the area with near natural communities was preserved in the river floodplain. The degree of ecological stability of forest ecosystems in the floodplain of the Morava River serious dropped in the 19th and 20th century (Kiliánová 2001). This ecologically undesirable state has lead to the presently preferred renaturalization of the floodplain, i.e. an expansion of the area in which natural fluvial processes and associated biota are restored (Dister et al. 1990).

To define an optimal management scheme for floodplain forest geobiocoenoses it is essential to know the history of its formation and development *in sensu* (Vrška et al. 2006). The historical development of floodplain forests in the Czech Republic (including the former Czechoslovakia) was examined e.g. by Nožička (1957), Krejčíř (1959), Prudič (1982), Putík (1984), Hošek (1985), Horák (1992) and Novotný (2000). An interesting method of studying the historical development of floodplain forests based on a combination of historical map analysis and the findings of a fossil mollusc in the area of the Danube basin was published by Pišút and Čejka (2000).

Based on the historical development of the floodplain forest ecosystem in the National Nature Reserve Vrapač (Litovelské Pomoraví) the aim of this paper is to try to contribute to a better understanding of the anthropogenic influences that have over centuries led to the present state of the geobiocoenoses.

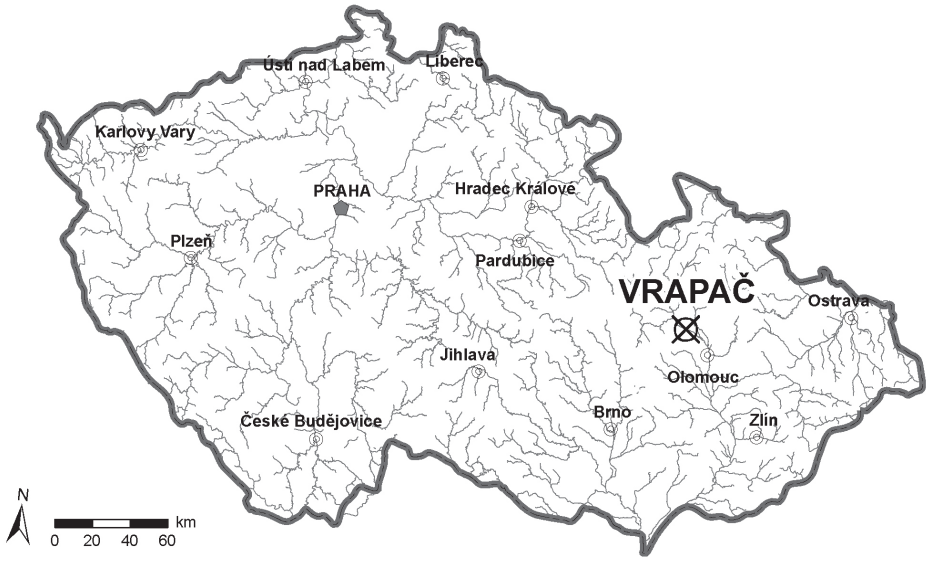

Fig. 1. Vrapač National Nature Reserve in the Czech Republic

Thus, it will be possible to define more efficiently the management policy and care plan concerning this reserve which is a model floodplain forest locality (Simon 2008).

MATERIAL AND METHODS

Study area

The floodplain forest locality Vrapač is protected in the same way as the National Nature Reserve of the same name, which is located in the first zone of the protected landscape area Litovelské Pomoraví. The area is located in the Upper Moravian Vale, 2 km eastward of the town of Litovel, at an altitude of 235 m, quadrate of mapping organisms 6268, coordinates 17°02'E, 49°42'N (Fig. 1). The total area of the reserve is 80.69 ha. From a biogeographic view, the area in question belongs to the Litovel bioregion (Culek 1996) and to Growing Forest Area No. 34 – Upper Moravian Vale (Burian et al. 1999). From the geomorphological aspect, the Vrapač reserve belongs to the West Carpathians, the Upper Moravian Vale complex and Middle Moravian floodplain subcomplex. The floodplain terrace of the Morava River is predominantly formed of gravel and sand originating from Wurm and Holocene, with the thickness of 4–6 m. The sand gravel layer is covered by a layer of flood loam that is up to 3 m thick. The subsoil of the terrace consists of gravel and sand sediments coming from the Mindel-Riss Interglacial. In the subsurface of the quaternary sediments, Neogene (Pliocene and Miocene) sediments can be found in some places to be up to 250 m thick. The floodplain terrace itself is covered by the Holocene flood loams – Fluvisols. They are loamy to loamy clay, viscous to very viscous, wet, and well-provided with nutrients. The reaction of the soil is neutral to slightly alkaline. The accumulation of humus soil is regularly interrupted by floods with subsequent deposit of flood sediments of various origins. The prevailing form of humus is mull. From the climatologic aspect, the Vrapač reserve area is located in the warm climatic region (T2). This region is characterized by long, warm and dry summer, slightly warm to warm spring and autumn and short, dry winter with only very short-term snow coverage. Selected climatic characteristics: the average annual air temperature 8.4°C (Olomouc 1961–2000), the average annual precipitation amount 586 mm (Litovel 1961–2000). The water relations within the Vrapač reserve are determined by the Morava River which markedly winds in this area and by branching, it forms so-called inland river delta. Another important water stream in the area is the right arm of the Morava River, Malá Voda.

The prevailing forest vegetation is associations of the alluvial hardwood forest of the second forest altitudinal zone, the dominant geobiocenes of which are *Ulmi-fraxineta carpini superiora* (Buček, Lacina 1999) in the floodplain of the Morava River, the natural (non-regulated) bed of which borders the reserve from the north. Detailed studies have been carried out concerning the geomorphological development of the anastomosis river system in this area (Kirchner et al. 1999; Šindlar et al. 2003). More detailed descriptions of the reserve area and its biota can be found e.g. in the following works: Montágová (1998), Poprach (2000) and Machar (2001). The historical development of the forests in the area of Litovelské Pomoraví was described by Hošek (1981, 1985). A geobiocoenological research of the Vrapač reserve was carried out by Lacina (1999), the impact of cloven-hoofed game on the forest ecosystem

was studied by Čermák and Mrkva (2006), the proposal of the forest ecosystem management in the Vrapač area based on the natural models of richly structured forests at present times was published by Simon et al. (2007).

Sources and data analysis

In addition to the above listed literature, the following documents were used as information sources concerning the historical development of the forests in the area in question: historical maps and documents from the State Archives in Opava, Janovice branch office; vertical aerial photography of the area in question from the years 1938, 1953, 1990 and 2006; data from the forest management plans from the archives of Forest Management Institute (FMI), Brandýs nad Labem, Olomouc branch office and from the archives of the Administration of Litovelské Pomoraví Protected Landscape Area (PLA).

HISTORICAL DEVELOPMENT OF THE FLOODPLAIN FOREST GEOBIOCOENOSES

Forest development in the Vrapač area from the Primeval Age till the end of Middle Ages

There are no direct data available for the analysis of the state of floodplain forests in the Vrapač area from the Neolithic Age till the end of Middle Ages. However, fairly extensive palaeobotanic data from the nearby archaeological locations (Fig. 2) allow to carry out an approximate reconstruction of the presumed ecosystem state in the broader area. The most serious problem concerning the interpretation of these data is a missing detailed evaluation. There is an older pollen analysis available concerning the period of late Glacial Age/Early Holocene, which concerns the moors in the Černovír area, ca 20 km southwest of the Vrapač area (Opravil 1983). Based on it, it is possible to reconstruct in the floodplain the presence of moors with sedge and reed stands, the prevailing woody species pollen is *Pinus sylvestris*. Otruba (1928) published a study on the herbal macro-remains from the area of Olomouc – Lazce, which were obtained in the 20s of the previous century during gravel-sand mining. According to the re-evaluation carried out by Opravil (1983), a floodplain forest consisting of oak and elm accompanied by ash may be reconstructed for the older Subatlantic. The presence of the pine and other heliophilous species implies that the forest was not closely connected. The research of the large Neolithic settlement near Mohelnice (Tichý 1977) on the loess blanket of a terrace closely adjacent to the Morava floodplain, 8 km northeast of the Vrapač area, enabled the following reconstruction of vegetation character: on the loess of the terrace above the floodplain, at the time of the arrival of Neolithic agriculturists, a mixed Atlantic oak grove developed from which associations of oak-hornbeam groves with rich incidence of mesophilic and xerophilic plant species developed. On the surface of the floodplain, a loosely connected alluvial hardwood forest (*Ulmenion* association*)* was to be found. In the depressions and arguably also at the river banks, an alluvial softwood forest was to be found, although only rarely (*Salicion albae* association). At the nearby village of Moravičany, there is a burial ground situated at the edge of the loess terrace above the floodplain belonging to the Lusatian culture (end of the Bronze Age), i.e. from the period of presumed extensive settlement of the floodplain (Poláček 1999). The loess was populated with oak-hornbeam forest and bush associations. The vastly prevailing oak allows to assume that the species also grew in the adjacent floodplain together with elm (Opravil 1999).

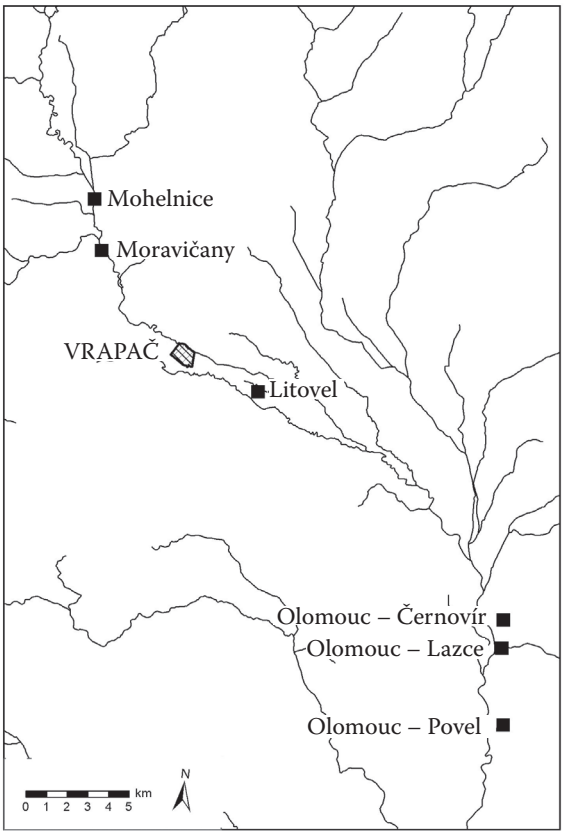

Fig. 2. Archaeological localities in the vicinity of Vrapač National Nature Reserve

For the reconstruction of the vegetation in the period of early Middle Ages, the findings from the Slavonic ancient settlement Olomouc – Povel may

be used, which was built on a terrain elevation of the rugged gravel surface of the Morava River floodplain towards the end of the 7th century AD. At the base of the elevation, there was an old river channel in which plant macro-remains were being deposited over a longer period of time (presumably in the course of more than one hundred years), from which especially very well-preserved leaf blades stand out (Bláha unpublished). According to an analysis carried out by Opravil (1999), there were willow trees (*Salix triandra, S. alba)* in the vicinity of the dead channel and a floodplain hardwood forest nearby, which surely was loose with regard to the nearby settlement. In the reconstructed association of the hardwood forest, the following tree species prevailed: common oak (*Quercus robur*), white elm (*Ulmus laevis*), field elm (*Ulmus carpinifolia*), European hornbeam (*Carpinus betulus*), small-leaf linden (*Tilia cordata*); as accompanying species, the following occur: durmast oak (*Quercus petraea*), common ash (*Fraxinus excelsior*), Norway maple (*Acer platanoides*), English hawthorn (*Crataegus oxyacantha*), wild pear *(Pyrus pyraster*), summer lime (*Tilia platyphyllos*), accompanied by hazel (*Coryllus avellana*) in areas with sufficient light, dogwood (*Corpus sanguinea*) and American elder (*Sambucus nigra*). It may be assumed that at the elevated places of river terraces, these "ulmi" merged into an oak-hornbeam forest (*Querceto-Carpinetum).* The analysis of fossil flora implies that the hollow rugged gravel-sand surface of the floodplain prevailed till the early Middle Ages. The floodplain was not burdened with heavy floods and was well passable. The surface of the floodplain was covered by loose stands of non-flooded hardwood forest, which were subjected to the continuous and heavy impact of anthropogenic pressures (source of wood, extensive grazing and acorn collection, browsing etc.). The floodplain, as well as the river, served as an important communication means within the area. Around the river, as well as around the dead channels, there were narrow bank stands consisting of willows, alders and poplars. At the loess edges of the floodplain, there were loose oak-hornbeam forests. At the time of the Great Moravia, there were extensive "urban" type settlements; in the vicinity of the Vrapač location, it was e.g. Great Moravian fortified settlement in Moravičany at the forks of Morava and Třebůvka Rivers.

From the beginning of flood loams till the first forest regulation

The main period of the flood loam sedimentation at the Upper Moravian Vale began no sooner than at the turn of Early and High Middle Ages (Opravil 1999). The flood loams evened the originally rugged gravel-sand surface. The alluvial hardwood forest consisting of loose *Ulmi-fraxineta* gave way to *Fraxineta populi* and stands of softwood forest that are able to cope with floods. During this period, the forests were utilized for grazing and wood collection (Novotný 2000). In the 13th century, a royal city of Litovel was set up at the river island next to the already existing fishermen settlement. The town of Litovel was set up on a "board" from large oak boards and beams that were anchored in the ground by means of oak stills. The area of the alluvial forest in Litovelské Pomoraví was significantly diminished by uprooting during the 12th century and at the turn of the 14th and 15th century, thus giving rise to an increased amount of agricultural land at the point when new villages belonging to the town of Litovel were set up. The floodplain was gradually covered with flood loam layers that were several meters thick, with the settlements being quickly relocated at the edges of the floodplain where they would be safe from floods. Within the floodplain, there remained only small settlements consisting mainly of fishermen, which in modern times served as a basis for the present villages (Hynkov, Střeň, Sedlisko). The importance of fishing for the life of local inhabitants is also indicated by the instructions that were issued in 1681 by the Prince Karl Eusebius of Liechtenstein for the Úsov dominion. An interesting clause concerning otter hunting can be found in the document – hunting of these was allowed, nevertheless, the take had to be submitted to the forest office immediately. Disobedience of this rule was punished with a heavy penalty.

The floodplain forests in the Vrapač locality became a part of a dominion administrated from the Úsov castle in the 14th century. In 1598, this dominion was acquired by marriage by the Prince Karl of Liechtenstein, who owned the dominion until the state confiscation in 1945. The dominion of Úsov (a forest complex called Doubrava – Oak Grove) served as an important hunting district to the whole family of the Prince, which contributed positively to the preservation of their original state. The oldest documents date from 1577, when 3 beavers, 16 wild boars, 3 roe deer and 1 wolf were caught by the Holy Roman Emperor Rudolf II. Already at that time, the forests of the Úsov dominion were heavily used for grazing, which is apparent from the documents of the forest administration office from 1664, where not only entries for wood sale appear, but also those concerning grass and grazing. The incidence of the deer is documented by a bill from 1709 in the City

Table 1. Summary of hunter kill in the dominion of Úsov in the period 1694–1728

Year	Wolf	Wildcat	Fox	Marten	Polecat	Beaver	Otter
1694	3	1	22	3	1		
1700	1						
1701						3	
1708	2	4	64	9			
1709	5	1	37	3			
1728		2	53	3	3		1
Total	11	8	176	18	4	3	1

(Source: State Archives in Opava, Janovice branch office, according to Hošek 1985)

book of Litovel, where the deposited deer hides are recorded, including one that had been heavily damaged by wolves. The records of the game kill for 1,728 in the whole domain state: 14 deer, 124 does, 11 calves, 45 roe deer, 15 (wild) boars and 24 piglets, 24 hares, 94 pheasants, 2 grouses, 7 partridges, 6 ducks, 2 woodcocks, 21 snipes, 1 stock dove and 2 fieldfares (Hošek 1985). An overview of the "vermin" game kill based on the records of fur stock for the years 1694–1728 is presented in Table 1. Towards the end of the 17th century and throughout the 18th century, the form of forest management settled on the model of composite forest: coppice with a rotation period of ca 40 years with seed trees of oak supplemented with elm, ash, hornbeam and beech.

Period from 1769 till 1872 (meadows and composite forest)

In 1769, the first forest management measures were taken that belong to the oldest ones carried out in Moravia. The management plan was drafted by Baron de Geusau, coming from Baden, on the basis of prescribed cutting. The forest was managed as coppice with seed trees with the rotation period of 40 years. For the especially loose stands and where the good reproduction capacity following regular

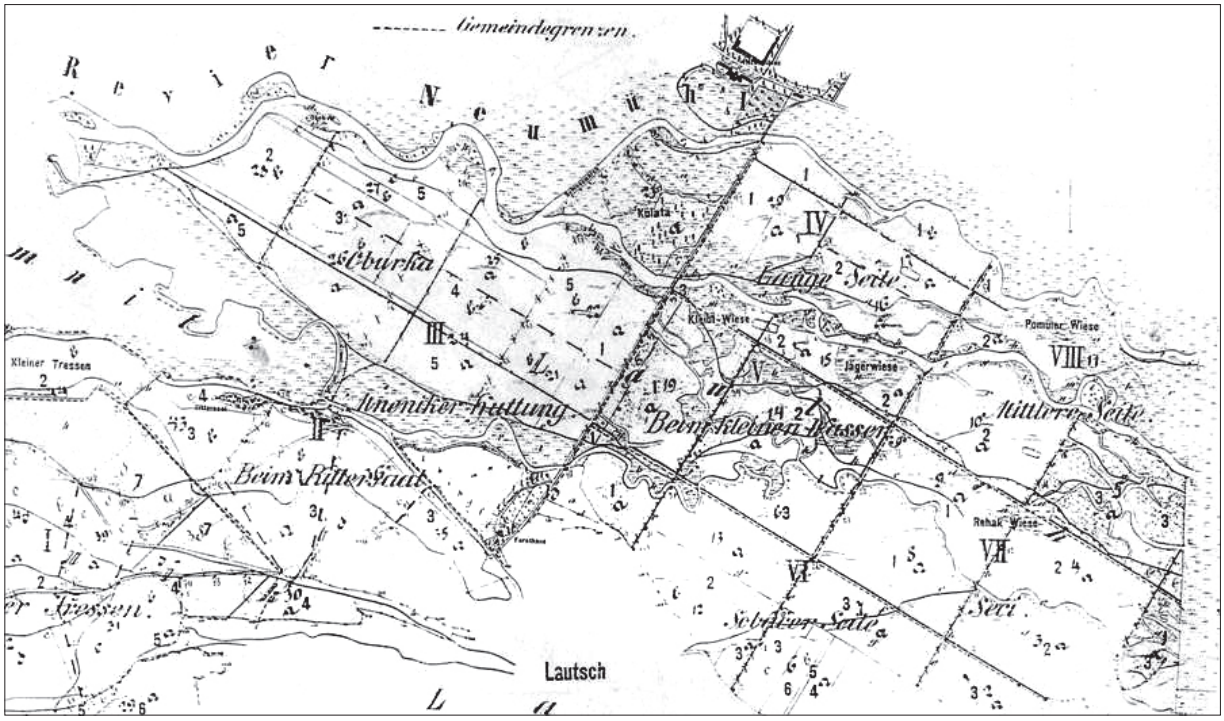

Fig. 3. Part of the forest management map of forest district Mladeč (Lautsch) for the period 1892–1901, original at a scale of 1:7,200. We can see the meandering Morava River and its branches and regular network of boundary lines of forest roads, which has persisted up to the present day. In the upper middle of the figure there is a plot of hunting lodge Nové Zámky near Litovel, in the upper left corner the Řimice dam is situated next to an island in the river

cutting could not be presumed, artificial regeneration by means of acorns and birch and lime seeds was prescribed. The total area of forests within the dominion (6,000 ha) was divided by means of roads and shooting areas into several districts with each district consisting of several tracks. The Vrapač locality belonged to the Mladeč district (named after a nearby village), which was divided into 36 tracks. The present area of the National Nature Reserve Vrapač consisted of 4 tracks: *Vrapač, U staré střelnice, U bobřích staveb, U novozámecké hospody*. However, only a small part of those tracks was covered by forest (Vrapač track: 1/14, the other three tracks: 1/5 to 1/4 of the total area), the majority of the area was covered with meadows with single standing trees (Hošek 1981). In 1769, the forest in the area of the present Vrapač reserve was a 20-years old coppice with the species composition consisting of lime, poplar, hornbeam, and alder with the seed trees of oak, hornbeam, and elm.

Further, although only imprecise information on the forest state is provided by the forest face from so-called Josephian cadastre from 1784, according to which there are 504 acres (i.e. 292 ha) of seed trees of oak, elm, ash, and hornbeam and further 120 acres (70 ha) of soft coppice of poplar, lime, and alder in the area between the villages of Mladeč and Nové Zámky. The significantly larger proportion covered with seed trees in comparison with the coppice can be explained by the fact that the "seed trees" area also included meadow and grazing land. The large meadows (presumably used for extensive grazing) were gradually turned into forests (naturally as well as artificially), which lead to the gradual expansion of the forest area within the area of the present Vrapač Reserve at the end of the 18th century and in the course of the 19th century. However, some of the initial meadows have remained until present. Large areas of meadows were preserved along the Morava River between the Vrapač track and the west edge of the town of Litovel until the 50s of the last century. The plan drafted by de Geusau was used until 1825, when a new forest management plan for the whole dominion of Úsov was drafted by the forest master František Ondřej Pavlík. In the area of the Vrapač locality, the prevailing type was coppice consisting of birch, lime, hornbeam, and alder, with the occasionally occurring elm, oak, lime and ash seed trees. For the seed trees, the rotation period of 200 years was defined. It is presumed that larger-scale harvesting of old seed trees took place within the area of the Mladeč district between the years 1785 and 1825 (Hošek 1981). Next to the present Vrapač Reserve, a game park for deer and fallow deer with a total area

Table 2. Historical species composition in the Vrapač National Nature Reserve in the period 1852–1980

Year	Norway spruce	Pedunculate oak	European hornbeam	Lime	Black alder	Elm	European ash	European aspen	Birch	Maple	Red oak	Walnut	Willow	Poplar
1852	–	12.4	–	22.2	17.8	11.1	21.8	6.6	3.3	2.6	–	–	–	0.7
1872	–	16.9	–	29.2	8.0	5.8	34.6	2.4	1.5	0.5	–	–	0.4	0.7
1892	–	32.2	2.6	9.2	9.5	4.6	40.0	–	0.5	1.4	–	–	–	–
1906	0.1	46.8	2.7	8.1	5.8	4.1	31.3	0.1	0.4	0.6	–	–	–	–
1925	–	51.6	8.9	4.4	2.0	2.5	28.8		0.5	1.3	–	–	–	–
1937	0.1	42.5	9.2	6.4	3.4	2.2	30.4	0.3	0.7	4.0	–	0.4	–	0.4
1970	–	35.7	4.9	9.2	4.7	1.1	38.2	–	–	2.9	–	–	–	2.0
1980	–	31.5	7.0	7.0	4.3	0.1	40.7	–	–	6.1	1.2	0.2	0.1	2.1

(Source: State Archives in Opava, Janovice branch office, according to Hošek 1985)

Table 3. Proportions of age class areas in the Vrapač National Nature Reserve in the period 1852–1980

Year	Age class areas								Area (ha)
	clear-cut areas and meadows	1–40	41–60	61–80	81–100	101–120	121–140	141–160	
1852	38.30	38.30	1.96						78.56
1872	2.86	21.64	50.02	3.68					78.20
1892	38.88	0.52	34.71						74.11
1906	51.43	11.77	1.70	12.23					77.13
1925	11.66	63.20			2.27				77.13
1937	7.39	9.01	57.70			2.41			76.51
1970	10.75	4.87	7.34	2.41	52.67	1.51			77.23
1980	8.02	6.00	7.03		53.28		1.82	1.08	77.23

(Source: State Archives in Opava, Janovice branch office, according to Hošek 1985)

Table 4. Removals in the Vrapač National Nature Reserve in the period 1877–1929

	Main felling	Tending felling	Felling total
Average annual felling (m^3)	596	50	646
Average annual clear-cut area (ha)	7.9	0.7	8.6
Felling total (m^3) in 1877–1929	28,025	2,371	30,396

(Source: State Archives in Opava, Janovice branch office, according to Hošek 1985)

of 450 ha was set with a rotation period of 100 years (due to interests related to game management). The game park was fenced with a stone wall (that has survived in places until the present). The game park was abolished in 1850 due to the excessive damage caused by the game, and the fallow deer was wiped out. The process of turning the meadows in the Vrapač area was presumably finished by that time, indicating that the area covered by forests was the same as at present.

In 1846, another management procedure of the forests in Úsov area was carried out, the result of which was a new division principle of the forests of the whole dominion based on the forest paths of prevailingly geometrical shapes (Fig. 3). This division net has been preserved until the present time and still functions as the basis of the present division of the forest. As new measures, improvement cutting and the precise recordings of harvest cutting were introduced. The next forest management principles were introduced in 1852, consisting of the so-called Saxon method. The annual prescribed cut for the Mladeč district of the total area of 286 ha was 1,108 fathoms of wood, i.e. 2,230 m^3 (see Table 4). The forest in the Vrapač area is described as coppice with seed trees, with vastly prevailing stands younger than 40 years (Table 3). The species composition – see Table 2. In 1850, the forest administration office was moved from Úsov to the hunting lodge Nové Zámky near Litovel (Fig. 3). Since then (1852), the forest management procedures were carried out every ten years. In 1861, large clear-cut areas were recorded within the Mladeč district, namely 62 ha (the state of the Vrapač course see Table 3). The whole management concept remained unchanged, based on the composite forest principle.

From 1872 to 1945 (high forest, private property)

The important milestone in the management of Úsov forests came in 1872, when measures drafted by the forest management office belonging to the Lichtenbergs came into force. Because the extracted coal became the main energetic source, the demand for fire wood was decreasing, causing its price to decrease, too. As a result of these economic changes, the sprout based system ceased to be an efficient means of forest management and the coppice forest concept became inadequate. Consequently, forest management became oriented towards the production of timber, for which the high forest concept is especially suitable. As Table 3 demonstrates, as early as in 1872, a substantial proportion of the forests in

Table 5. Reforestation in the Vrapač National Nature Reserve in the period 1877–1893

Year	Reforestation (ha)	Filling of blanks (ha)	Sowing (kg)			Planting (number)			
			pedunculate oak	European ash	maple	pedunculate oak	European ash	maple	black alder
1879	8.9		1,200	62	20				
1881	9.5		8,600						
1882		1.0					500	100	
1884		1.0				1,300	2,100		1,200
1885	0.9		1,400						
1885		2.0				2,500	3,100	200	3,500
1886		2.3	100						2,200
1887		2.2				1,900	5,800	1,000	
1888		4.0				2,200	14,400	1,400	2,200
1889	4.6					3,000	21,000		
1889		0.6				500	1,500		900
1890		1.8				2,000	5,300		1,400
1891		2.7				600	8,100	4,300	
1892	2.6					500	10,000	3,300	
1893		1.5				5,800	1,400	300	

(Source: State Archives in Opava, Janovice branch office, according to Hošek 1985)

the Vrapač area already consisted of stands older than 40 years, which indicates that the process of turning the coppice (low forest) into the high forest by means of keeping the coppice until it reached the so-called false trunk state was already in progress. To this end, the rotation period in the Mladeč district was extended to 60 years. In addition to the indirect coppice conversion, direct conversion of coppice to high forest by means of clear-cutting was carried out. According to the new regulation rules, after the coppice clearance the coppice and the bracken had to be removed regularly, with the subsequent reforestation of the resulted clear-cut area. For reforestation, the seeding or planting of strong, transplanted plants was used, which was supplemented with the planting of oak, ash, alder or maple saplings (Table 5). In cases when a natural self-seeding of ash or oak occurred, the area was to be fenced in order to protect it from browsing (Hošek 1985). It is presumed that most of the high forest floodplain stands forming the present Vrapač reserve developed at that time. According to the forest management plan, the forest formation was defined as "stem-wood with seed trees" with a rotation period of 60 years. In the Vrapač area, the annual prescribed cut was defined to be 519 m^3 of wood (Table 4). This was to be accomplished by means of clear cutting, but two or three years before that, the seeding of acorns was carried out. After the clear cutting, the artificial regeneration by means of planting saplings was carried out in the areas where the acorns seedings had not been successful (Table 5). The last forest management procedure in accordance with the Saxon method was carried out in 1892, keeping the rotation period at 60 years, due to the fact that older stands were virtually non-existent.

In 1895, the senior forest councillor Julius Wiehl was called to manage the forest property of the house of Liechtenstein. He promoted the concept of a forest serving the general well-being and saw the aim of forest management as the provision of the maximum economic gain possible (Hošek 1985). The high standards of forest management at that time are documented by the forest office Nové Zámky taking part in the world exhibition in Paris in 1900. The influence of Wiehl's concept is apparent in the management principles introduced in 1906, drafted in accordance with the stand management. A part of the forest management plan in 1906 was a detailed geodetic survey of the forests which resulted in the production of basic management, stand and also plastic maps. It was unambiguously stated that it is necessary to put an end to the coppice based management and to manage the forests as high forest in future. Transforming coppice to high forest proceeded as follows: in the autumn before the cut, the areas of the coppice were seeded with acorns and then the area was illuminated in lines in the course of 2–3 regeneration interventions. The final cutting of the remaining stands was carried out in at least two

other interventions. At that occasion, approximately 50% of the oaks were chosen that were protected as seed trees until the next cutting took place. The more mature oak seed trees were consistently protected and they were cut only in exceptional cases after a thorough consideration with regard to the actual demand for good-quality wood selection. At the places where acorn seeding was not successful, saplings were planted after the clearance had been carried out. The principles for the conversion of coppice to high forest were drawn in detail; the indication of the trees to be cut was carried out by the forest master in summer when the trees were fully leaved. The direct conversion of the coppice was often combined in a complicated way with the indirect conversion by means of reservation of chosen sprout tree groups. During the tending of stands younger than 40 years, at least two thinnings were carried out, in the course of which oak was preferred. Outside the damp areas, the larch originating in the Jeseníky Mountains was also preferred, the additional introduction of which was recommended by J. Wiehl. Although oak is considered to be the main species of the floodplain forest, other allochthonous species were also introduced: the red oak and the black walnut. J. Wiehl considered 120 years to be the optimal rotation period for the floodplain forest; however, due to the lack of sufficiently old stands, the rotation period in the Mladeč district was kept at 60 years. The prescribed cut was determined by means of volume regulation; in the case of improvement cutting, the so-called thinning quotient was used and the thinnings were to be realized based on the actual needs at the first place. The forest management plan from 1920 increases the rotation period to 80 years. The forest management plan from 1906 was kept almost unchanged till the end of the private forest property in 1945, when forests were confiscated by the state.

From 1945 till the declaration of the reserve

Based on the forest management plan from 1949, the rotation period was increased to 100 years with regard to the increase in areas with older stands. Furthermore, general regeneration by means of shelterwood cutting was introduced. The same principles were followed in the management plan from 1960; in 1970, the stands in the present Vrapač Reserve were included in the working circle of high forest with a rotation period of 120 years. There was no harvest cutting prescribed. In 1977, the then District National Committee in Olomouc and the Forest Enterprise in Litovel approved the intention of setting up a Vrapač nature reserve. Subsequently, the forest management plan from 1980 is in line with the requirements for nature preservation defined by the state consisting of the exclusion of harvest cutting in the area of the reserve under consideration. From that time on, the foresters were patiently waiting for the declaration that would officially establish the reservation. Unfortunately, at the end of the 80s, a mighty common oak was cut down illegally near the winding of the river, which was presumably the oldest live representative of the species in the area of Litovelské Pomoraví. The trunk of the tree fell into the river and was gradually covered with gravel-sand deposits. The stump remained at the river bank until it was swept into the river along with the bank during the floods in 1993. The reserve was officially declared no sooner than in 1989; in 1992, it was administratively included in the "National Nature Reserve" category.

HISTORICAL CHANGES IN THE RIVER SYSTEM

In order to learn the historical changes of the river system in the area of Vrapač National Nature Reserve, a historical map analysis was carried out (Jindrová 1991; Kirchner et al. 1999; Machar 2001), as well as an analysis of aerial photographs from 1937, 1953 and 1990.

The analysis showed that the pattern of the meandering river bed of the Malá Voda River, beginning at the Řimice dam, was pictured virtually without changes in its geomorphological shape since 1774. The shape of the Malá Voda River meanders was stabilized for at least 200 years, until the straightening of the river bed that accompanied the building of a highway leading from Olomouc to Mohelnice in the 70s of the last century. Similarly, the system of intermittent river arms (so-called "smohy") has virtually remained without changes in pattern for one century at least. For example, the so-called Řehákova smoha, an intermittent river arm in the northern part of Vrapač National Nature Reserve, has been mapped in the same shape since 1834 until present. The historical map analysis shows that no new intermittent river arms have developed in the course of the last 200 years.

The reasons for the long-term stabilization of the river system were especially ascribed (Kirchner et al. 1999) to the fact that the Malá Voda River was, at least since the 14th century, used extensively to drive water mills. Due to a significant number of water mills, it was necessary to ensure stabilized (steady) flow rates in the Malá Voda River from the Řimice dam, where the Malá Voda River begins. The old-

est written proof regarding the dam reconstruction dates from 1407 when the wood for the reconstruction was supplied from the royal forest Dúbravy by Margrave Jošt. The way of water distribution among the individual river arms at the Řimice dam as well as the obligations of the millers to maintain the dam were stated in writing in the so-called Contract of Řimice drafted in 1474 and approved by the King Vladislav Jagello. This water distribution system among the millers functioned perfectly until 1856, when the first disputes among the millers concerning water distribution were recorded (Kauerová 2000). In 1811, the owner of the Úsov dominion Eusebius Liechtenstein had a small building of Temple of Friendship built at the rock above the dam in memory of the Řimice contract.

In contrast to the above described, significant dynamic changes in the meandering were traced in the main river bed of the Morava River. The historical maps originating from the 3rd military mapping, perambulated at the time of the First Republic of Czechoslovakia, clearly show that in the area of the present large meander at the northwestern border of the Vrapač National Nature Reserve, the river arm was straight prior to WW II. Similarly, in the aerial photography of the area from 1937, there are no signs of meandering. However, the aerial photography from 1953 clearly shows a distinctive meander arch. It is to be presumed that the development of this meander was triggered by the straightening of the Morava River bed that was a part of the flood control related changes of the river bed in the area above Litovel that were carried out in the 30s of the last century (Kirchner et al. 1999). At present, meander development is still in progress, it has been going on for almost 60 years and has not been completed yet.

The head deep erosion of the river bed in the area of the artificially straightened part of the Morava River above Litovel is probably the cause of a gradual decease in some of the intermittent river arms (the so-called "smohy") that originate in the main stream of the Morava River in the area of Vrapač. The recess of the Morava River into its own bed by means of the head erosion causes the upstream parts of the intermittent river arms to be ca 2–3 meters higher than the average water surface level in the river for most of the year. As a result, the intermittent water arms cease to communicate with the main water stream and the water can penetrate into the intermittent river arms virtually only when exceptionally heavy floods occur. The periodical river streams are not flushed regularly during the yearly spring floods and they gradually decay by means of spontaneous succession (a process of land-filling).

DISCUSSION

The landscape of the floodplain was subjected to intensive settlement during prehistoric times and later until the High Middle Ages (an overview see Poláček 1999) and at the same time, it represented an important communication and migration area (Jankovská 2001). There are no doubts that the anthropogenic factors have influenced the formation and development of forest ecosystems in the floodplain in a significant way (see e.g. Rybníček 2001).

The grazing was an important impact on the historical development of European lowland forests (Vera 2000). The fact that the formation and development of the floodplain forest ecosystems is anthropogenically conditioned leads to their understanding as so-called archeocoenosis (Řehořek 2001). The understanding of the floodplain forest as anthropogenically formed geobiocoenoses with an exceptionally high biodiversity is in line with the presented results of the historical analysis of the floodplain forest in the Vrapač National Nature Reserve. The present state of the species-rich geobiocoenoses of the floodplain forest in the Vrapač National Nature Reserve area corresponds to the definition of *natural forest* (Vrška, Hort 2003). The real natural state of the floodplain forest geobiocoenoses in Europe is not known, furthermore, their truthful picture could be obtained only in the course of several centuries as a strictly non-interventional geobiocoenological floodplain forest reserve were to be set up as defined by Prof. Zlatník (Zlatník 1968) with a sufficiently large area of floodplain forest that would be capable of spontaneous evolution (Vacek 2003), in a floodplain area with the intact fluvial-seral section of floodplain biotopes. The area of Litovelské Pomoraví is well-suited for such an experiment (Machar 2001).

CONCLUSION

The archaeological and palaeobotanical data obtained in the areas of the Morava River floodplain in the area of Vrapač suggest that the development of the present ecosystems in the area in question began in the period of large-scale sedimentation of flood loam in the Early Middle Ages. Approximately in the middle of the 18th century, the major part of the floodplain area, where the Vrapač National Nature Reserve is located, consisted of meadows with single standing trees and smaller areas of coppice forest. The meadows that were presumably intensively used for grazing were gradually turned into forests, so that in the 18th century, the forest became the prevailing

landscape matrix. Till 1872, the floodplain forests were managed as a coppice-with-standards with a rotation period of coppice of 40 years; with the seed trees of oak and less frequently also of other trees. Since 1872 the composite forest was purposely turned into high forest. During the artificial regeneration, the oak (*Quercus robur*) has been purposely preferred as the main commercial species. The present richly structured stands of the floodplain forest in the Vrapač locality, protected as a National Nature Reserve, are a result of intensive forestry activities and much credit is to be given to the foresters for having preserved it in the present state. Although the Morava River, which forms the northern border of the reserve, is not regulated by technical means, it is very strongly influenced anthropogenically, similarly like the dynamics of the whole river system in the floodplain of the Vrapač locality.

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Historický vývoj lužních lesů v Hornomoravském úvalu (Národní přírodní rezervace Vrapač)

ABSTRAKT: Příspěvek se zabývá historickým vývojem lužních lesů v oblasti Národní přírodní rezervace Vrapač v údolní nivě řeky Moravy (Chráněná krajinná oblast Litovelské Pomoraví, Česká republika). Cílem práce je přispět k lepšímu porozumění antropogenním vlivům, které v průběhu několika staletí utvářely současný stav lužních lesů ve studované oblasti. To by mělo umožnit lépe formulovat plán péče o ekosystém lužního lesa.

Klíčová slova: lužní lesy; historický vývoj lesa; sdružený les; národní přírodní rezervace; lesnický management

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