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Cycling of Elements and Some Ecological Effects of Water Management Measures in the Region of Floodplain Forests of Southern Moravia

Emil Klimo & Ferdinand Vašiček

The scientific project of floodplain forest ecosystem studies in the region of South Moravia, some results of which are presented here, was motivated by a need to learn, above all, the changes in the moisture regime of an environment created by technological interference in the landscape and the effects on production, structures, processes and functions of significant terrestric and water ecosystems.

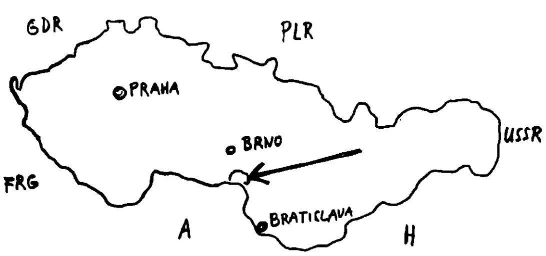

Figure 1

Extensive water management and land reclamation measures have been evoked by state efforts with the purpose of flood protection, rationalization of management and increase of agricultural production, improvement of conditions in frequently flooded lowland forests and a total increase of the socio-economical level of the highly productive, prevailingly agricultural landscape of Southern Moravia. The realization of this project brought about the elimination of uncontrolled inundations of the Dyje and Morava rivers, which caused great damages on agricultural and forest cultivated land every year. The meandering water courses are being straightened; river beds are being deepened; the level of the river bottom regulated and levees are being built in addition to discharge channels, weirs, drop spillwas and irrigation and drainage systems, pumping stations and extensive retention reservoirs with systems for the distribution of irrigation water over an area of about 40 thousand hectares of agricultural land. The reservoirs have caused water quality change in water courses below them. Because of the exacting demands and expenses for the technical work involved (solving complex construction as well as modification of the whole landscape) its realization has been under supervision and sponsorship of the Czechoslovakian government.

The scientific project, realized as a multidisciplinary research project (at the same time as Unesco-MAB 2 project No. 86) encompassed a very broad scale of productional and ecological studies aiming at ascertaining changes in ecological stability and the balance of terrestrial and aquatic ecosystems, at the adaptability of plant and animal populations to the new conditions reigning and at gaining information for the rational use of natural resources in view of the new ecological situation.

As a result of this scientific project some valuable information was gathered, not only on the functioning of forest ecosystems, but also of grass ecosystems (mostly cultivated) and of ecosystems of water reservoirs and streams. The basic scientific approach here was a study of structure and biomass of primary and secondary producers, physiological processes in plants, decomposition processes, reserves and balance of bioelements, transformation processes and solar energy; attention was also paid to air pollution, recreation, gamekeeping and possibilities of multipurpose exploitation of forest and to perspective forms of management and usage of forest, field, meadow and water ecosystems. The project has come to an end and some of the research results have been published by Elsevier Publishing House in the book „Floodplain Forest Ecosystem 1" The second part, mainly presenting the results from the period after water management measures, is in press.

Climate

The climate of the region, according to long-term statistics (1901 - 1950), is slightly warm, of the dry and subhumid type with an average yearly temperature of 9° C and an annual precipitation of 524 mm. A climatic diagram of this period does not note any significant precipitation deficit. The water balance of floodplain forests has not been determined by the climate. Rhizosphere has been saturated mostly by underground and flood waters.

The period after cessation of the floods and the lowering of the underground water table was drier and warmer as a whole. Over a period of ten years after the regulation measures, there was a precipitation deficit from May to July and again from August to September for a period of 5 and 7 months respectively. These periods could be consequently regarded as less favourable for a moisture regime of the given region in comparison to long-term statistics. At the same time vegetation became more dependent on precipitation.

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Moisture Regime

Changes in the underground water table due to water management measures showed the following effects: The inundations were eliminated and the subsequent lowering of the underground water table (maxima on the average 50 - 60 cm and 30 - 45 cm in the lower courses of the Dyje and Morava rivers respectively, table 1 and 2); the seasonal dynamics remained basically the same but there was a shortening of periods of high states of underground water. Seasonal dynamics of underground water during regular floods were characterized by a regular river flooding for several days to weeks. The minimal water table levels were e.g. 147 and 205 cm in the year 1970 and 1971 respectively. The period from 1973 - 1982 can be characterized by a drop of maximal underground water table on the average of 90 cm (fluctuation 45 - 130 cm) and minimal underground water table by 207 cm (fluctuation 170 - 240 cm).

Table 1

Concentration of elements and pH of water in the river Dyje and of groundwater (period 1972-1974 – mg · l^{-1})

	River	Ground water
pH	7,1	7,2
N	2,3	1,0
P	0,8	0,7
K	8,0	1,5
Ca	**54,8**	**63,4**
Mg	17,8	18,2
Na	20,9	**31,6**
C	9,9	8,8

Table 2

Uptake of water by floodplain forest
(Prax, Čermák 1980)

16 %	from the soil profile (spring reserves of water in the rhizosphere)
14 %	from percolation
70 %	from groundwater

Dynamics of Soil Moisture

During the flooding period the soil moisture is a little higher but not very different in comparison to the period without floods. A significant difference can mainly be seen in the content of gravitational water. When comparing soil moisture in the time periods between 1970 -1981 and 1971 1982 which were climatically similar, it was found that the period following technical measures and the lowering of the underground water table did not produce any great difference in the reserves of capillary soil water in the soil profile. It was found that the duration of the higher underground water level in the soil profile (manifested by a higher saturation of the capillary zone) is decisive for the height of the reserve of the capillary soil water. The quick rise and drop of underground water level play here a lesser role. From evaluation of soil water reserves, in comparison to hydrolimits of the field water capacity and wilting point in the period 1979 - 1982, it can be concluded that on the investigated area of a middle moisture gradient there was a sufficient reserve of the soil water for transpiration of the forest stand during every vegetation period. Relatively little favourable moisture conditions occurred in 1980 when a considerable drop of soil water was registered and its reserve, at a depth of only 0 50 cm, in the period from August to October reached the values of wilting point. The course of the soil moisture storage also shows a considerable significance of soil profile resaturation during the winter and early spring.

Changes of soil moisture in the catchment areas of water supplies under floodplain forests are most significant. There is a continual drop of the underground water table up to a depth of 5 - 6 m under the soil surface. The tree rhizosphere is saturated only with precipitation water. Soil moisture has reached critical conditions, especially in places with less shallow sediments of heavy deposits with original types of Ulmeto-Fraxinetum carpinetum when in the end of the vegetation period the whole profile dries up to values around wilting point. The pumping of water by water plants from beneath the floodplain forests resulted in a change from the original floodplain moisture regime to a deficient evaporational moisture regime.

The Soil Properties in the Sample Area

Soils of the floodplain forest may be classified into the group of alluvial soils, viz. paternia and vega (according to KUBIENA, 1953).

Table 3

The description of the soil profile
according to PELÍŠEK (1976) is as follows:

Depth (cm)	Description
0-1	leaf litter and mull A_0
1-8	dark-grey clay loam, crumby structure, slightly moist
8-50	grey-brown clay soil with ferruginous mottles, fine block soil structure, moist, rather compact
50-95	black-grey clay, rather compact and tight (fossil A horizon)
95-115	light grey-brown, mottled, clay loam, moist, tight, larger ferric patches
115-130	sand-gravel terrace, enriched with loamy soil from the upper horizon, blue-grey colour

The main rooting zone in the profile occupies the layer up to 50 cm, a lower density of roots occurs up to 100 cm; most of the herb-layer roots are in the top 10 cm.

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The soils of the study area have a heavy texture with a high proportion of clay particles (ca. 60 %). This fact corresponds with the value of cation exchange capacity which is affected in the top horizons by a high content of organic coloids. The pH value, which ranges from 6.2 to 6.4 in the topsoil horizons and is equal to 7.2 in the subsoil horizons, assumes base saturation of the soil exchangeable complex. The derived V values range from 70 to 88 %.

Table 4

Soil texture and exchangeable soil absorption complex (according to PELÍŠEK, 1976)

Depth (cm)	Soil texture %				Exchangeable sorption complex		
	0.01 mm	0.01-0.05 mm	0.05-0.1 mm	0.1-2 mm	CEC / X 10^2	S / $mol\ g^{-1}$	V / %
1-8	62-65	18-22	4-6	8-10	45.6	33.3	73.4
8-50	64-67	18-20	3-5	7-10	36.0	22.9	71.9
50-75	61-65	18-20	3-5	8-12	32.0	28.0	79.7
75-95	58-60	19-21	6-8	10-14	35.0	32.3	88.5
95-115	55-58	18-20	8-10	10-14	36.7	22.5	86.7

Chemical Properties

The amounts of nutrients present in the soil profile are given in the following table. The amount of nutrients present in the main rooting zone shows a different rank order of element totals (K, Ca, N, P) as compared to the available elements (determined by 1 % citric acid) - Ca, N, K, P. A high amount of potassium is present in the non-available form. In general, the profile is rich in nutrients, due to enrichment of the nutrient content as a result of floods and atmosphere and to the rapid cycle of nutrients between the stand and the soil.

Sampling of the properties of the top layer in the sample area (25 samples randomly distributed for determining available nutrients - K, Ca, P in 1 % citric acid, pH, humus, N-total, N-available) indicated considerable heterogeneity. The following table shows ranges for each of these properties.

Table 6

The range of soil properties in the top layer

Soil property		Range
pH		5.5-6.8
Humus (%)		16-21
Ca	(x 10^2 mg g^{-1})	57-286
K	(x 10^2 mg g^{-1})	8-25
P	(x 10^2 mg g^{-1})	4-17
Total N	(x 10^2 mg g^{-1})	500-800
Available N	(x 10^2 mg g^{-1})	14-26

The uneven distribution of data is caused by the heterogeneity of alluvial deposits and by the variability of stand composition. These results in different litter composition and in various rates of decomposition and nutrient release from the forest vegetation as well as in an uneven distribution of the shrub and herb layer in this stand.

Cycling of Mineral Nutrients

Cycling of nutrients within a given ecosystem may be studied at different time-intervals. Most studies published recently have related these cycling values to the interval of one year. For some ecosystems, a heterogeneous development of some components of nutrient cycling is typical. This also applies to the majority of forest ecosystems. For example, the cycling of elements within the ecosystem under study was strongly affected by high inputs of elements resulting from regular floods and mud sediments rich in nutrients on the soil surface. Although this process has been interrupted by technical improvement of the water regime, it still affects the level of primary production and thus results in a greater turnover of individual nutrients, especially nitrogen.

The position of the investigated floodplain forest ecosystem within the landscape has also gradually changed. The neighbouring grassland and forest

Table 5

The supply of carbon and nutrients in the soil profile (after PELÍŠEK, 1974)

	Depth (cm)	Total supply (kg ha^{-1})					Mobile sypply (kg ha^{-1})			
		C	N	P	K	Ca	N	P	K	Ca
Zone of intensive rooting	1-8	50,335	4,297	853	12,159	6,226	73,4	19,4	66,9	1,363
	8-50	96,365	10,549	4,100	109,205	38,638	500,0	59,7	104,8	5,164
	1-50	146,700	14,846	4,953	121,364	44,864	573,4	79,1	171,7	6,527
Zone of poor rooting	50-75	34,106	3,774	1,637	51,431	22,835	219,3	26,7	46,8	2,451
	75-95	27,155	2,687	1,393	49,340	25,855	219,3	24,0	46,7	2,410
	95-115	18,896	2,632	2,055	75,761	27,631	256,3	85,3	52,8	2,633
	50-115	80,157	9,093	5,085	176,532	76,321	695,4	136,0	146,3	7,494
Total	1-115	226,857	23,939	10,038	297,896	121,185	1,268,8	215,1	318,0	14,021

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ecosystems have been changed, step by step, into intensively cultivated agroecosystems, with high inputs of fertilizers. As a result, the floodplain forest has assumed the character of a corridor ecosystem, with typically high inputs of elements transported from neighbouring ecosystems.

Our study was oriented to the evaluation of the present situation in element-cycling.

Concentration and supply of elements

The estimation of the concentration and reserves of elements was focused on both trees and undergrowth (i.e. shrubs and herbs).

Attention was also paid to the evaluation of some changes in concentration of elements depending on the role of some phytomass components in the ecosystem, or of those depending on the development of stand phytomass during the growing season.

According to the total supplies of individual elements in the phytomass of trees, shrubs and herbs of the ecosystem under study, it could be concluded that the floodplain forest ranks among the temperate ecosystems with the highest supplies of nutrients in the standing biomass, and that in the case of some elements, the supplies are similar to those of tropical forests.

As far as the total reserves of major bioelements in the phytomass of the stand (i.e. trees, shrubs, herbs) are concerned, Ca showed the highest values (viz. 2,233 kg ha^{-1}) followed by N, K, Mg and P.

Table 7

Concentration of nutrients in the aboveground and underground parts of Cornus sanguinea L. biomass (% of dry matter)

	N	P	K	Ca	Mg	Ash matter
Buds	5.018	0.884	1.741	1.117	0.312	7.619
Leaves	2.367	0.272	1.390	2.554	0.630	11.409
Fruits	1.275	0.323	1.312	0.276	0.116	3.850
Petioles	1.267	0.222	2.084	0.850	0.211	6.726
Annual shoots	1.720	0.322	0.774	0.936	0.253	4.614
Twigs < 5 mm	0.930	0.192	0.516	0.641	0.149	6.160
Twigs 5-10 mm	0.825	0.144	0.165	0.459	0.100	2.845
Trunk: wood	0.614	0.084	0.160	0.182	0.050	1.703
Trunk: bark	1.556	0.222	0.714	0.218	0.143	6.955
Roots ≤ 1 mm	1.275	0.188	0.664	0.799	0.419	7.523
Roots 1-2 mm	0.878	0.171	0.387	0.638	0.235	3.927
Roots 2-5 mm	1.008	0.169	0.277	0.513	0.166	2.995
Roots 5-20 mm	0.993	0.167	0.246	0.404	0.134	3.199

Table 8

Vertical distribution of nutrient reserves in the floodplain forest ecosystem (kg ha^{-1})

	N	P	K	Ca	Mg
Tree crown, branches and leaves	473	41	219	619	45
Trunks	1,044	42	358	1,326	81
Shrubs (aboveground part)	55	8	26	31	9
Herbs (shoots)	22	4	47	21	5
Total	1,594	95	650	1,997	140
Surface humus, annual mean	99	6	18	75	15
Roots: trees, shrubs, herbs	210	34	84	240	52
Nutrient reserves: rhizosphere	14,846	4,953	121,364	44,864	
Reserves: without rhizosphere	9,093	5,085	176,532	76,321	
Plants total	1,804	129	734	2,233	192
Soil total	24,038	10,044	297,914	121,260	
Total	25,842	10,173	298,648	123,493	

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As to the vertical distribution, the highest supplies of nutrients were accumulated in tree stems and order of elements was as follows: Ca, N, K, Mg and P. The same sequence in the accumulation of nutrients was also found in tree crowns. In the aboveground part of the shrub layer, this sequence was a little different: the highest reserves were of N, followed by Ca, K, Mg and P. In the above-ground part of the herb layer, the highest reserves were of K, followed by N, Ca, Mg and P.

In roots, the following order of nutrient supplies was found:

trees, Ca, N, K, Mg and P;
shrubs, N, Ca, K, Mg and P;
herbs, K, N = Ca, Mg = P.

On the basis of the results obtained, it can be concluded that herbs are very important for the cycling of potassium, the supplies of which exceeded those observed in the shrub layer. This importance is further increased by the regular input of potassium onto the soil due to the decomposition of annual plants.

The vertical distribution of individual elements within the floodplain forest ecosystem is presented in the preceding table. It can be seen that there are relatively high reserves of elements in the phytomass of the stand and high reserves of bioelements in the soil. High supplies of e.g. nitrogen resulted from a long-term, positive balance of nitrogen in the floodplain forest conditioned by an import of flood sediments into the ecosystem. This means that the reserves of elements in the soil also represent a precondition of high stability of the floodplain forest ecosystem under conditions of intensive timber harvesting from this ecosystem and improvement of the water regime.

Surface Humus, its Structure and Development during the Year

In the floodplain forest ecosystem under study, the surface humus represents an important dynamic component. It is of mull type and is characterized by marked changes in total mass and concentration of nutrients during the year. However, the heterogeneous species composition of the stand is also very important because it forms a mosaic of surface humus with different properties. This results in the formation of a relatively high heterogeneity of the soil surface layer.

To characterize the spatial variability of surface humus, three plots with different species compositions of the stand were selected, viz:

Plot I: with dominating *Quercus robur* L.

Plot II: with dominating *Quercus robur* L. and *Cornus sanguinea* L. undergrowth

Plot III: with dominating *Fraxinus excelsior* L.

Dead organic matter was sampled on plots of 1 m^2 on 1st December 1972, 1st April 1973, 1st July 1973 and 1st October 1973. Leaves and detritus (indefinable organic residues) were held to be the main criterion for changes occurring in the course of the decomposition of surface humus. The mass of dead wood was of a random character.

The maximum average supply of litter on the soil surface (i.e. leaves and detritus) was 6,200 kg ha^{-1}; the maximum value was found on Plot II (Quercus robur L. and Cornus sanguinea L.), viz. 7,400 kg ha^{-1}

The total reduction of litter reserves up to 1st April 1973 amounted to 2,800 kg ha $^{-1}$, i.e. 45 % of the reserves found on 1st December 1972. The corresponding values observed on 1st July 1973 and 1st October 1973 were 3,700 kg ha^{-1} (60 %) and 4,300 kg ha^{-1} (69 %), respectively. The minimum reserve of leaves and detritus was 1,900 kg ha^{-1}

On studying changes in leaf reserves, the following patterns were obtained on the individual plots:

Plot I
Leaf reserves on

1 Dec. 1972	2,500 kg ha^{-1}	100 %
1 Apr. 1973	1,600 kg ha^{-1}	decreased by 36 %
1 July 1973	1,400 kg ha^{-1}	decreased by 44 %
1 Oct. 1973	1,100 kg ha^{-1}	decreased by 56 %

Plot II
Leaf reserves on

1 Dec. 1972	4,200 kg ha^{1-}	100 %
1 Apr. 1973	2,000 kg ha^{1-}	decreased by 52 %
1 July 1973	1,700 kg ha^{1-}	decreased by 59 %
1 Oct. 1973	1,200 kg ha^{1-}	decreased by 71 %

Plot III
Leaf reserves on

1 Dec. 1972	4,70 kg ha^{-1}	100 %
1 Apr. 1973	2,000 kg ha^{-1}	decreased by 57 %
1 July 1973	0,000 kg ha^{-1}	decreased by 100 %
1 Oct. 1973	0,000 kg ha^{-1}	decreased by 100 %

As indicated, there was a fairly significant unevenness in the rate of litter decomposition on the soil surface under dominating *Fraxinus excelsior* L. and *Quercus robur* L.

The total changes occurring in nutrient supplies in the litter during the year are given in a table. (compare table 11)

In the period of maximum reserves of nutrients, N had the highest values, followed by Ca, K, Mg and P, i.e. 143, 99, 24, 21 and 9 kg ha^{-1}, respectively (table 9). The maximum change in nutrient supplies was observed in the period from 1st December 1972 to 1st April 1973, i.e. in the spring season. The sequence of nutrients was the same in the period of minimum reserves, viz. N(36 kg ha^{-1}), Ca (17 kg ha^{-1}), K (7 kg ha^{-1}), Mg (4 kg ha^{-1}) and P (2 kg ha^{-1}).

Table 9

Changes in nutrient reserves in Ao horizon during the year
(Kg · ha^{-1})

	1. Dec. 1972	1. Apr. 1973	1.July 1973	1. Oct. 1973
N	143	59	56	36
P	9	4	5	2
K	24	10	9	7
Ca	99	62	38	17
Mg	21	10	7	4

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Table 10

Nutrient reserves in various parts of trees.

		Leaves	Annual shoots	Branches 2-5 cm		Trunks	
				bark	wood	bark	wood
OAK	N	**3,56**	**1,71**	**1,08**	0,51	**0,71**	**0,34**
	P	0,17	0,10	0,09	0,08	0,03	0,01
	K	0,69	0,35	0,39	0,29	0,14	0,07
	Ca	**0,82**	**1,29**	**2,38**	0,38	**2,85**	0,04
	Mg	0,22	0,19	0,10	0,05	0,09	0,02
ASH	N	2,68	1,10	0,89	0,63	0,59	0,27
	P	0,34	0,15	0,06	0,04	0,03	0,02
	K	**2,24**	0,81	0,56	0,18	0,57	0,27
	Ca	**2,26**	0,79	1,27	0,24	1,95	0,08
	Mg	0,51	0,17	0,08	0,04	0,11	0,03
LIME	N	2,76	1,82	1,44	1,15	0,82	0,30
	P	0,34	0,20	0,11	0,06	0,08	0,01
	K	1,47	0,60	0,40	0,22	0,49	0,11
	Ca	1,75	1,97	1,51	0,24	1,25	0,10
	Mg	0,24	0,25	0,11	0,06	0,14	0,02

Input of Nutrients into the Soil

The input of elements into this ecosystem by way of atmosperic precipitation also contains elements of flying dust and dry deposits and shows a considerable variability in a given region due to local and global influences of industrial and managerial activities. This factor may have a positive, but also a negative effect on ecosystem components. The input of precipitation water hitting tree crowns and furthermore on penetrating through the canpoy and by stemflow onto the soil surface contains a considerable amount of calcium and phosphorus, entering into it due to liming on neighbouring fields. Data from literature and the found values of incoming compounds into the ecosystem in the region of upper levee of the Nové Mlýny dam are markedly lower (The Nové Mlýny dam: N 21.0, P 2.1, K 5.3, Ca 10.6, Mg 2.0 kg ha^{-1} $year^{-1}$).

In this floodplain forest ecosystem the most important component for the input of nutrients into the soil is surface humus, created by litter fall of relatively quick decomposing organic matter. Another component of nutrient transport into root zone are nutrients from dead mineralizing roots and uptake of nutrients from uderground water and from mineral substrate by weathering processes (table 10). All in all, there is yearly input into the soil per ha of 260 kg Ca, 112 kg N, 104 kg K, 61 kg Mg and 21 kg P. Extraordinarily significant is here the input of potassium from litter fall of the shrub and herb layer. (table 11)

Relatively high migration value in lysimetric waters has calcium (125 kg ha^{-1} $year^{-1}$), in water caught under surface humus (table 12). Otherwise calcium strongly migrates in the soil profile.

Table 11

Total input of nutrients into the soil (Kg · ha^{-1} · $year^{-1}$)

	N	P	K	Ca	Mg
Litterfall: trees	76,5	11,2	30,8	152,4	26,0
Dead roots	13,0	1,5	7,0	20,0	
Litterfall: shrubs, herbs	18,0	4,3	**43,2**	18,3	4,3
Precipitation	**5**	4	23,0	**70,0**	31
Total input	112,5	21,0	104,0	260,7	61,3

Table 12

Migration of nutrients from the surface humus layer into soil profil (Kg · ha^{-1} · $year^{-1}$)

		Released from A_0 hor	Acum. in A	migrat. into soil prof.
C	Kg	155,8	110,2	45,6
	%	100	**70,7**	29,3
N	Kg	20,6	4,3	16,3
	%	100	21,0	**79,0**
P	Kg	8,1	7,4	0,7
	%	100	**91,3**	8,7
K	Kg	72,5	58,5	14,0
	%	100	**80,7**	19,3
Ca	Kg	125,4	53,0	71,7
	%	100	42,8	**57,2**
Mg	Kg	46,3	18,3	28,0
	%	100	39,5	**60,5**
pH		6,9		7,0

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Potassium and phosphorus are more significantly accumulated in the surface horizon, while nitrogen and magnesium considerably migrate into the middle part of the soil profile. Lysimetric waters have, with regard to a high portion of calcium, a neutral reaction. Leaching of nutrients in the soil profile has even an opposite flow direction due to fluctuating underground water table.

Uptake of nutrients from Soil by the Forest Stand

Uptake of nutrients from soil by the forest site has been calculated per ha and year to be approximately 265 kg Ca, 224 kg N, 129 kg K, 24 kg Mg and 18 kg P. (table 13)

Table 13

Uptake of nutrients by the forest stand (Kg · ha^{-1} · $year^{-1}$)

by:	N	P	K	Ca	Mg
Trees	178	11	67	220	13
Shrubs	24	3	13	23	6
Herbs	22	4	49	22	5
Total	224	18	129	265	24

The input/output relation of elements shows a passive balance of N, K and Mg. This disproportion is balanced above all by compounds released from animal component, from weathering processes and from underground water. A highly active balance of nutrients has been caused by inputs of elements from fluvial deposits during periods of flooding. After water management measures this supply of nutrients has dropped. Therefore it can be presumed that after water management measures the floodplain forest ecosystem, from the balance of nutrients point of view, will not be highly active but balanced and stable without significant tendency of lowering fertility, if the present regime of underground water dynamics is maintained.

Reaction of Primary Producers

Herb layer reacted the most quickly and the most evidently to changes of ecological conditions after water management measures. In conditions e.g. of middle moisture gradient the maxima of aboveground phytomass decreased by about 60 - 70 %.

The proportion of species populations in the middle moisture gradient strongly changed. Species bound to early floods disappeared within 2 years after their discontinuance. Species bound to a high soil moisture with perennial underground organs successively lowered their vitality and disappeared only after 8 - 10 years after flooding ceased. The group of species bound to a high underground water table significantly lowered its production and density dropped to ca. 20 % of the original number. At the same time the frequency of species bound to relatively drier conditions in floodplain forests (fresh moisture) gradually increased.

From the point of view of succession change indexes, diversity index increased after the technical measures, characterizing a shift of the community from the ecological viewpoint from wetter to drier while indices of community maximal diversity decreased, which expresses a decrease in species diversity of the community. This is in accordance with results of the species density and dominance study; decrease even in relatively small degree of dominance signals subduing of dominants expressiveness whereas changes of equitability.

The shrub layer in the middle moisture gradient reacted to the change of moisture conditions by an increased mortality. The layer significantly decreased in canopy and leaf area index (LAI) and originally sharp boundaries between structurally different groups diminished. In former, long-term

Table 14

Year	Duration of flood: Date	Duration of flood: days	Height of flood water above soil surface	Underground water table maximum: Height cm	Underground water table maximum: date	Underground water table minimum: Height cm	Underground water table minimum: date	Maximal state of herb above-ground biomass kg ha-1 of dry matter
1970	25.3.-2.5	37	+ 15	+ 15	1.4.	-170	15.10.	1 453
1971	28.3 - 7.4	10	+ 5	+ 5	3.4.	-205	20.9.	1 323
1972	28.4-1.5	4	+ 1	+ 1	1.6.	-46	2.10.	1 168
	28.5. - 4.6.	6						
1973				-45	2.5.	-205	15.7.	1 043
1974				-140	5.4.	-230	?	983
1075				-102	1.4.	-230	?	
1976				- 97	4.6.	-218	17.9.	717
1977				- 73	24.2.	-211	3.10.	
1978				- 98	18.4.	-232	28.9.	
1979				- 95	11.4.	-215	18.9.	640
1982				- 67	10.1.	-204	5.-25.9.	503

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inundated areas of more wet types the shrub layer has increased its coverage after water management measures.

The tree layer did not show either significant structure changes or an increased dying back. The main tree species - European ash and English oak - kept seasonal dynamics of diameter increment reaching its maximum in June. Increment depressions revealed especially poplar, European ash and willow but not on all sites. English oak also did not show significant changes in increment and in most cases revealed only a greater dependency on atmosperic precipitation.

Changes in diameter increment in a long-term sequence (approximately since the year 1900) with all species at different moisture conditions showed considerable variability and periodical increment depressions and peaks in ca. 5 to 9 year intervals (a sinusoidal course). No ambiguous conclusion on changes of diameter increment in the period after 1972 (cessation of floods) can be drawn from the investigations up til now. It seems that poplar and oak reacted to higher precipitation in 1975 also by increasing of increment and European ash manifested itself by a several year depression of increment without significant increasing of diameter increment in the year 1975. But similar situations of depressions and rises of diameter increment can be found regularly with all tree species and in the past in times of frequent floods and higher reserves of available water in rhizosphere. Cycles of changes in diameter increment can be evoked also by other factors than by soil moisture, e.g. by damages from graduating phytophagous insects and their feeding, by temperatures, by changes in radiation, etc. Thus, it was not possible, based on hitherto investigations, to draw univocal conclusions on changes of the diameter increment. They call for broader sets of experimental material.

From among other reactions of plants to changed conditions, transpiration of mature oak trees and of some components of shrub and herb layers has been studied. In the period of floods and immediately after their cessation, transpiration of oak, measured in conditions of medium moisture gradient, was rather high and corresponded with unlimited conditions of water reserves in soil. The concrete values of water consumption recalculated from the measured sample trees to the whole stand according volume of „derbholz" reached in climatically wetter years as much as 250 mm and in climatically drier years up to 460 mm. Magnitude of transpiration in individual years has been proportional to evaporation demands of atmosphere and in favourable conditions approached to 70 % of the potential evapotranspiration.

After cessation of floods transpiration of the tree layer began to drop. After the first 5 years there was but only slight drop which, in the next 5 years, became more expressive. It has shown that this drop was not caused (compared to potential evapotranspiration) by climatic conditions but by changes of conditions in the system soil-tree. The drop of minimal demand of stand for soil and underground water signalized after water management measures a gradual adaptation of trees to changed moisture conditions.

The measured transpiration drop in the ten-year-period after cessation of flood did not show on the average critical values, it signalized only lowering of reserves ensuring stability of the given system and consequently a higher degree of endangering in case of climatically drier years.

Reaction of Secondary Producers

Study results of different synusia of animals revealed their sensible reaction to moisture changes. The studied groups of insects and spiders changed as follows:

Number of species (especially hygrophilous) dropped with the exception of harvestmen (Opilionidea) which are connected to original surface and formerly they were endangered by floods; number of individuals dropped, as well as number of eudominant species. Several species formerly dominant lost their position in the community, some of them disappeared completely; similary as with herb species, lowering of species diversity occurred.

In species spectrum with synusia of small mammals there was a decrease in the group of insectivora and increase of seed-eating species. Species diversity dropped slightly and equitability increased. Number of hygrophilous species decreased and species typical for drier conditions in forests and for individual trees again increased.

Synusia of blood-sucking arthropods, present in large numbers before technical measures, reacted very significantly. Occurring of a drier environmental gradient helped to limit formerly usual mosquitoes plagues. But on the other hand there was a development of ticks *(Ixodes ricinus)* in such places where this species did not exist before (places with regular floods). The group of mosquitoes laying eggs on wet soil has been reduced mostly. Creation of new large water surface influenced development of mosquitoes laying eggs on water table, from which the most abundant species are of genera Anopheles. From among other genera of blood-sucking insects, black flies and horse flies were hit the least by technical measures. It can be presupposed that neither the group of biting midges has been considerably reduced by the technical measures.

Finally, it is necessary to add that the more detailed analysis and the total extent of studies within the scientific project of floodplain forests of South Moravia are beyond possibilities of this information. Those interested are kindly asked to refer to the prepared publication „Floodplain Forest Ecosystem 2" which contains broad facts to the question of ecological consequences of a large-scale technological manipulation of a natural landscape.

Anschrift der Verfasser:
Emil Klimo und
Ferdinand Vašiček
Institute of Forest Ecology,
University of Agriculture Brno

Czechoslovakia

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Autor(en)/Author(s): Klimo Emil, Vasicek Ferdinand

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