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Floodplain forests influenced by construction of the Gabčíkovo dam

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1. Introduction

Floodplain forests are one of the main ecosystems on the Danube plain influenced the whole biota, mainly in the interdike space. Its existence is unceasingly made dependent upon hydropedological regime, created by the Danube river in dependence on fluvial Quarternary complex, filling up majority of Tertiary pan. Essential part of this filling up are created by gravelly sands. Its thicness is different. Near Bratislava it is 12 - 15 m, in direction of the main channel increases and the most thickness reaches at Gabčíkovo (about 600 m). Lower thickness of gravelly sands decreases and from Kližská Nemá to our border is again only 8 - 15 m. Different thickness of sediments was made dependent upon also by gradient curve of the river. Concerning upper part of the main channel, it means from Bratislava to Hamuliakovo is the inclination of the Danube cca 0.2 %, from Hamuliakovo to Palkovičovo it is only 0.06 %. Therefore the upper part is typical by erosion of the bottom, which is involved by construction of dams in Austria and German part of the Danube river. Sudden decreasing of the Danube curve at Palkovičovo made dependent upon deposit of born sediments, lowering of channel speed and by that creation of system of the additional arms and islands. This part represents on Slovak, but also Hungarian territory unique naturel region of the floodplain biom, creating variegated mosaic of bank, aquatic and marsh communities and semiterrestric vegetation and fauna of floodplain forests. Beneath Palkovičovo the Danube spilled even at moderately discharges, it sediments deposited near banks, unceasingly increased, therefore the Danube flows here at present on gravel range elevated over surrounding terrain.

Different thickness of the river-bed, different thickness of sediments of gravelly sands with meso-, but mainly microrelief define different thickness of the ground water level. It oscilation during vegetation season, but also during the whole year together with floods was and is a limiting, structure - creating factor of tree and herb layer of floodplain ecoystems. Unneglected is also further component of the hydropedological regime and it is soil, mainly it texture and structure. Degree of nutrient supply of these soils has almost in all types global significance, because of there are soils very rich to nutrients. Specificness of soils in Danube's floodplain forests against other middle - european forests is in heigh contents of $CaCO_3$, coming from alpine affluents of the Danube (Lech, Isar, Inn, Traun and Ens).

Floodplain forests of the Danube plain are at present only rest of their origin occurrence. Their highest content is at present on the territory of direct inundation (interdike space). Protected antiflooded dikes established from surface loams, obtained from material pits (holes) have such soil - mechanical qualities, that enable relatively quick infiltration of floodet waters even through its body. Besides that, the line of dikes often crosses dead arms filled by Histosols and muddy sediments whitch after pressing of dike body, have spoots, in whitch water filters through even behind dikes. Therefore the occurrence of floodplain forests behind dike space is not exception. Floodplain forests here are widened also on such stands, where gravel benchs climb up to soil surface (upper part of the Danube plain) and create absolute forest soil, unsuitable for other activity (a.g. agriculture).

Present extend of floodplain forests estimates to 14,000 ha on the Slovak territory. It is 10,356 ha on the territory influenced by construction of variant "C", it means from Bratislava to Palkovičovo. For construction of the Gabčíkovo dam was seized about 3,200 ha of floodplain forests. Considerable extact of forests mainly between the power channel and the old river - bed of the Danube it requires separate (managed) water regime. Therefore it is very important to take appropriate attention to relation of the Danube water dam and floodplain forests with their whole biota.

Authors of this report aimed at comparison of state to the end of fifties and before damming up the Danube river , it means to the end of 1990. Fifties represent such state of biota on this territory, which enforced by the construction of the antiflooded dikes at the both Danube banks, finished approximately 100 years ago. Arised interdike space signified essential change , mainly in the hydropedological regime of the territory. Floods, which before the construction of the antiflooded dikes, covered the whole Danube plain up to the Small Danube were limited only to interdike territory. However its frequency was higher and its intensity was essentially enlarged. It came to the change of origin conditions, and biota accepted this change.

Regulations of the Danube river - bed bottom joined with posibility to make navigable the Danube river also at lower water weir as protected antiflooded measures after catastrophic floods in 1954 and 1965 had further interference to the hydropedological regime. It came to essential deepening of the Danube river-bed bottom and by means of that, also to decreasing of the ground water level, mainly in the upper part of the Danube plain. Part of side - arms was set aside the main channel, further had lowered wateriness. Of course, floodplain forests reacted to the lowering of the ground water level. Assembling of xerophilization on origin ecosystems caused the lowering of floodplain trees vitality and gradually came to the disintegration of forest stands. Various cultivar euro - american poplars began to plant on such places , which signified essential change of these ecosystems. Changes of terrestic conditions in floodplain forests, also changes of water environment in the side - arms touched to all organisms. It signified in vegetation lowering of extent of the most humid types of flora, in fauna lowering of the number of aquatic and bog organisms.

Autors of this report have to state, that the knowledge about floodplain forest biota and their following water and bog stands, from the point of view above - mentioned changes is considerable interspaced. The most knowledge is about vegetation, which first reacted to the changing of the hydropedological regime. Besides that, forestry practice was forced to adapt the regeneration of forest to changed conditions, which preceded also more detailed scientific research.

Faunistic knowledge are the most elaborated from the aquatic environment. Only some groups of terrestric animals are elaborated, more detailed view to the whole territory was obtained already in the begining of monitoring in floodplain forests, it means since 1990.

Autors of this report are convinced that , phytoenvironment is the main, determing part of the biota. The dynamics of organisms depends on it changes. Therefore, as an essential part regard the evaluation of floodplain forests state as planary the most important ecosystem of the territory influenced by construction of the Gabčíkovo dam.

All considerations and evaluations concerning with influence of the Gabčíkovo dam to the floodplain forest ecosystems come out from legalized factors, that by deepening of the Danube came to essential raising of the ground water level. It is possible to state, that by construction of the Gabčíkovo dam was renewed the hydrological situation from the end of fifties, then the period before it rapidly decline. It means that also for floodplain forests arised environment, which allows gradual return to origin conditions. To evaluate the changes which are at present or will be renewing of these conditions is impossible during such short period.

I. PHYTOCENOLOGICAL AND FLORISTIC CONDITIONS OF FLOODPLAIN FORESTS

2. Floodplain forests to the end of fifties

Floodplain forests of the Danube plain, their structure, soil - ecological qualities and syntaxonomic value were scientifically defined in 1958 (Jurko, 1958). Foundations for their characteristic were obtained in 1953 - 1956, it means in period, where expressive regulations of the Danube river-bed bottom finished after catastrophic floods in 1965 only in a very small scale touched to floodplain forest ecosystems. Therefore is possible this state to consider as "starting-point". Even if definition "origin forest", "origin vegetation", is impossible to use for the Danube floodplain forests in that period, because of man unceasingly interfered to their tree and stand structure (establishment of protected antiflooded dikes from Bratislava to Mošoni arm is dated already since 1235 - 1370), but they had decisively natural character. Therefore it is possible to call them "natural floodplain forests". Only slightly were there small forests with introductive trees (*Junglans nigra*, *Ailanthus*, *Robinia* and others). Until fifties were the beginning of more extensive plantation of euro - american poplars and their cultivars.

According to frequency and intensity of floods, height of the ground water level and soil qualities it is possible in floodplain forests of the Danube plain to the end of fifties to distinguish these vegetation units of floodplain forests:

NATURAL FORESTS

a) Willow - poplar forests (soft floodplain forests) SALICI - POPULETUM. These forests settled all stands lowest located to the ground water level, regularly, even several times up to year flooded, as also elevated aggregated ramparts with light soils, exposed to destructive effect of flooded waters.

b) Ash - poplar forests (transitional floodplain forests FRAXINO - POPULETUM as transitional type between willow - poplar and ash - elm floodplain forest. Floods influence these stands at least once per year. Ground water level is about 80 - 120 cm under surface.

c) Ash - elm forests (hard floodplain forests) - FRAXINO - ULMETUM widened on higher terraces, rarely flooded, the ground water level is about 100 - 230 cm under surface.

d) Elm - oak forests - ULMO - QUERCETUM as the driest type of floodplain forests, which arised on high terraces of the river, however flooded only in catastrophic floods.

e) Xerophilous danube forest steppes - CRATAEGETUM DANUBIALE. Represent shrub bioms of hawthorns and low shrubs, between of which occurs non - forest xerothermophilows vegetation. Their occurrence is mainly on gravel benchs, thickness of which only sometimes enables supply of the rhizosphere by the ground water.

SECONDARY FORESTS

f) Poplar monocultures - to the end of fifties were planted only on the clear cuttings, without areal soil preparation. There were planted almost on the all stands after natural forests, mostly on the stands after willow - poplar floodplain forests.

g) Black locust forests - CHELIDONIO - ROBINIETUM, BROMO - ROBINIETUM. as small woods scatered mostly in the interdike space, in the inundation territory only mixed tree

h) Plantation of walnuts, cultivated for commercial purposes, rarely also black walnut stands, mainly in the upper part of the Danube plain.

i) Stands of *Ailanthus glandulosa*, very scatered, planary without significance

Majority of these stands did not manifest some structural changes with relations to decrease of ground water level to the end of fifties, even if in that period evidentially decreased, mainly in the upper part of the Danube river. The whole territory was influenced by unexpected dying out of elm (*Ulmus minor*) caused by graphiosa. During 1957-1963 died out almost all stands and older individuals of this tree in floodplain forest of the whole Pannonia plain. There were some information (experimentally uncomfirmed) that it is a consequence of the ground water level decrease.

Plantation of poplars, mainly euro - american species resp. cultivars (*Populus x* aamericana cultivars "I-214", "Robusta", Blanc du Poitou" and others) began in the end of fifties. Areal soil preparation before their planting equalized differences in soil qualities, but also in their localization to the ground water level.

According to previous materials (forest menagement plan, Forest Work Bratislava and Dunajská Streda) was planted in period of fifties about 1,200 ha cultivar poplars.

State of vegetation to the end of fifties is presented on phytocoenological map (scale 1:50,000). The map takes to the consideration only basic syntaxonomic units of the Zürich - Montpellier School-association, which is considerable simplication of real variability of vegetation. For example, only willow-poplar floodplain forest (association Salici - Populetum) has four lower units - subasociations representing a great variability of environmental differences and by that also floristic specifity. There are such different biotops like e.g. planted bottom of died arms with water above soil surface and Gleysols on one side and elevated aggregated rampart with sandy Fluvisols on the other side.

From the general look at to the phytocoenological map, it is possible to state, that about 1960 were in these forests with almost equal area distributed all types of floodplain forest. Especially we want to call to relatively big area of the wideness of ash-elm forests (association Fraxino - Ulmetum), trees of which, as we will stress in further part, mostly suffered by decrease of the ground water level caused by regulations of the Danube river-bed.

In the upper part of the Danube plain had quite high distribution about 1960 also willow - poplar floodplain forests (association Salici-Populetum). While in the surroundings of Podunajské Biskupice willow - poplar stands disappeared, on the other hand, in low part (Palkovičovo - Gabčíkovo) came out in these vegetational types only to insignificiant changes.

3. VEGETATION OF FLOODPLAIN FORESTS BEFORE CONSTRUCTION OF THE GABČÍKOVO DAM

Regulations of the river-bed bottom on the upper part of the main channel (under from Bratislava) caused considerable deepening of the Danube bottom during last century , but mainly after catastrophic floods in 1954 and 1965. To the erosion of the river-bed bottom helped also numerous energetic dikes on the Austrian and German part of the Danube river as also the cleaning plant of waste waters in Vienna. Together with deepening of the bottom came out also to decreasing of infiltration to the basement of the Žitný ostrov (island) which had consequence - decisive lowering of the ground water levels. It is asserted, that besides older regulations of the river-bed bottom only last regulations caused decrease of the ground water levels about 2 meters (during 1960 - 1970). Such decrease, mainly on gravel substrate signified "tearing" ground water level from soil profile, and, regarding that root system of trees and also herbs remained dependent on only to rain fall water. Majority of trees, but first of all poplar (*Populus alba*), ash (*Fraxinus angustifolia*), but also oak (*Quercus robur*) reacted to this situation by essential lowering of increments, or died up. Together with dying out of elm caused by graphiosa remained numerous stands interspaced or completely destroyed.

Artificial reforestation of such damaged forests was solved differently. Either it was realized by means of planting cultivar poplars, or planting of trees resisting to drought like e.g. pine

(*Pinus nigra*), ash (*Fraxinus exelsior*), birch, limetree and others. Unfortunately, regarding to decrease of rainfalls during vegetation season, not even this artificial reforestation was succesful. Plantations of cultivar poplars (euro - american) obtained by that higher extent.

As for as reforestation of forest was realized by plantation way on the upper part of the Danube plain - it means on places with uneffective ground water level - it is impossible to have a reservation against it. However, such way was realized also in stands, in which the hydropedological regime was not essentially destroyed. It is estimated, that according to artificial reforestation of floodplain forests on the Danube plain, cultivar poplars prevail up to 80 % above origin trees.

It is necessary to stress, that monoculture stands of cultivar poplars require for their succesful development (increment) lighting of almost all circle of crown. Such state is possible to reach by light felling, by which is enlightened total crown cover of trees. In such way to the stand penetrates enormous amount of light, which helps again to a group development of neophytic herbs (*Solidago serotina, S. canadensis, Aster novi-belgii, A. lanceolatus, Impatiens glandulifera* and others), which completely change reduce natural values of origin floodplain forests.

By consequence of above - mentioned decrease of the ground water levels came to the end of eighties, it means before construction of the Gabčíkovo dam, to extensive changes in several natural communities of floodplain forests. It is possible to characterise as follows:

a. Destruction up to disappearing of ash-elm (association Fraxino - Ulmetum) and elm-oak (Ulmo - Quercetum) communities in the upper part of the Danube plain. In these stands, which remained (e.g. in the State Nature Reserve Kopáč at Podunajské Biskupice) came gradually to dying out of tree crowns - mainly oaks, poplar (*Populus alba*), ash (*Fraxinus angustifolia*) - and to their gradual change by succesion to xerophilous danube forest steppes, represented by association Crataegetum danubiale.

b. Essential reduction of willow-poplar floodplain forest up to their disappearing in the upper part of the Žitný ostrov (island).

c. Reduction of ash-poplar floodplain forests (Fraxino - Populetum) in the low part of the territory (Bodíky - Palkovičovo).

d. Exchange of natural floodplain forest to monocultures of cultivar poplars on about 80 % of extent and their devastation by neophytic species

e. Natural floodplain forests with their previous "origin phytocoenoses" were preserved only in the low part of the territory (surroundings of Bodíky and Palkovičovo) and there are willow-poplar forests (Salici - Populetum) and partially also in the upper part (Podunajské Biskupice) associations Ulmo - Fraxinetum, Ulmo - Quercetum, Crataegetum danubiale. The extent of natural floodplain forests is estimated to the end of eighties to 20 %.

4. EXPECTED INFLUENCE OF FLOODPLAIN FOREST PHYTOCOENOSES BY CONSTRUCTION OF THE GABČÍKOVO DAM

Foresight of changes in composition of floodplain forests after construction of the Gabčíkovo dam is very hypothetic. It results, first of all, from considerable change of existing vegetation, which, as we mention in previous chapter, is different from it origin state. Besides that, our ideas about future state of the ground water level after construction of water dam, even of numerous prognoses, cannot intercept the whole mosaic of amplitudes, to which approach ecosystems of floodplain forest with their trees and others coenobionts. The more so does not exist any analogous models with which it should be possible to compare the territory. There are only several data about changes of floodplain vegetation after lifting of ground water level in the Danube floodplain forest near Offingen (SEIBERT 1975), on the Rhine river (HUGIN 1981), wether certain abstractions from DISTER (1988) and ELLEMBERG (1988). From our sources, there are contributions dealing with production ability, ecophysiological functions, transpiration, distribution of root system of some trees and herbs of floodplain forest (KUBÍČEK et al. 1989), however more complete experiences from such changes for comparison or prognosis we have not.

The decisive factor for existence of floodplain vegetation, as we stressed above on several places, is the whole-year dynamics of the ground water level. This one with relation to microrelief is the only accepted criterion at the evaluation of impact of construction of the Gabčíkovo dam to floodplain vegetation (see JURKO 1976, Figure.1).

Assumed changes described by hip scheme are related to situation after lowering, or increasing of the ground water level against situation to the end of fifties. It is assumed, that these changes run over by developed succesion during differently long time according to types of floodplain forest. Forest manager can, on the base of future microregionalisation, to help this succession, of course, only in tree composition.

If we take to the consideration these prognoses, it was possible to expect that almost whole extend of willow - poplar (Salici - Populetum) and ash-poplar (Fraxino - Populetum), covering the area between right-bank line of the power channel and old river-bed of the Danube, will be gradually changed by influence of floods absence and decrease of the ground water level, to the more humid type of hard floodplain forest (ash - elm, Fraxino - Ulmetum). This succesion, wether supported exchange would be quite unprobable with regard to fallow of Gleysol horisons of these soils. Present solution, representing watering of the dead arms by water from the power channel and simulation of floods this risk dicreases, untill completelly eliminates.

Briefly described estimated changes after construction of the Gabčíkovo dam are as follows:

a) Exchange of humid willow-poplar forests (Salici - Populetum) to mesophilous types of ash-poplar forest (Fraxino - Populetum) under Gabčíkovo dam and smaller enclaves of forests on the left bank of the power channel. Exchange is neacessary to help to forest manager in tree composition.

b) Exchange of humid elm-ash forests (Ulmo - Fraxinetum) and drier types of ash-poplar forest (Fraxino - Populetum) to willow-poplar stands along to whole length of swelling up, mainly in lowered microrelief shapes. Exchange also with help of forest manager.

c) Changes of the driest types of ash-elm (Fraxino - Ulmetum) and elm-oak (Ulmo - Quercetum) forests even if expected swelling up will touch only some part of stands. In such places, where the ground water level in relation to thick gravel substrate will not be able to swell up to rhisosphere, will be necessary forest trees, mainly tree layer to renew by artificial reforestation.

Summing up, wether evaluation of expected changes of phytocoenoses by influence of Gabčíkovo dam construction it is possible to become generalized this situation and to point at already proved increasing of water level in the Danube river. Following lifting of the ground water level as also watering of the arm system on the right bank of the power channel under Dobrohošť together with simulated floods, creates such hydropedologic situation what was on this territory in the end of fifties. It means in that time, when floodplain forests had natural character with more-less origin phytocoenoses. However changes which arised during last thirty years, it means till damming of the Danube river mainly existence of poplar monocultures with weed, neophytic flora in herb layer, will this restitution process considerable complicate up. The whole renaturation of floodplain forests after Gabčíkovo dam constuction requires complex project.

5. FLORA OF INFLUENCED TERRITORY

The Danube plain belonges from phytogeographical point of view to region of pannonic flora (Pannonicum), to it lowland region (Europannonicum). Floristically is very rich. It includes almost one third of Slovak flora richness. First of all, there are thermophilous species, majority of which reaches in our country the north border of their occurrence. In numerous dead arms occurs aquatic and bog flora with rare to scarce species from which numerous requiure extraordinary attention. There are several very interesting species from conservancy view - point on the sedge meadows. In floodplain forests are also occur some trees giving their specific syntaxonomic value different from other middle-european floodplain forests. On the high laying gravel sediments of the Danube accumulated cone near Bratislava occur special community of xerophilous danube forest steppes with shrubby hawthorns and low oaks, among which exists non-forest xerothermophilous vegetation with numerous scarce plants. On the Danube plain ocur also sandy flora, among which are many species protected by law, also rare and threatened ones. On the old aggregated rampart in agriculture landscape were preserved special elements of thermophilous flora which indicate their scientific value. Specifity of flora in this territory confirm also pannonian endemits and subendemits including more than ten species.

Our information about the Danube plain flora are almost complete. There were included to the results of research taking to consideration the Gabčíkovo dam construction in 1986 (BERTA et al. 1986). There were obtained data about occurrence more than 1, 000 species of plants, of which 196 were indicated as scarce and threatened with proposal of their protection. From this territory were described by detail algological research 40 new species of algae with new genera.

For higher plants, found out in the territory was defined the degree of threatenless (MAGLOCKÝ 1983). From the total number of 1,000 species where placed in order number of categories as follows (Figure 3):

category A III; missing taxons, 3 species (0.3%)
category B III; endemic taxons, 4 species (0.4%)
category B I; endemic and subendemic taxons,3 species(0.3%)
category C I; critical threatened taxons,13 species(1.3%)
category C II; very threatened taxons, 30 species (3.0%)
category C III; threatened taxons, 39 species (3.9%)
category C IV; scarce taxons, 58 species (5.8%)

Protection of given species and their populations do not guarantee their success. Therefore for the protection of pannonic genofound were suggested certain measures (BERTOVÁ et al, 1986) such in order to by GD construction came out only to minimal losses. First of all it was the wideness of number of protected regions, which together with existing nature reserves will protect general environmental conditions including this vegetation, of which common part are given species populations. On the line Bratislava - Hrušov there are 9 small-areal protected regions (soft floodplain forests of Bratislava, floodplain forests of Podunajské Biskupice, Klokočový háj (wood) at Petržalka, Ostrovné lúčky at Rusovce, Biskupické rameno (arm), part of forests districts Topoľové, Borové, Bajdel and Kalinkovo). In the line of the interspace dike there are other region (Dunajská Sihoť (island), Šulianske ramená (arms), Kráľovská lúka, Bodícke ramená (arms), Bačianske ramená (arms) at Baka). In the line Gabčíkovo - Palkovičovo there is Istragor ostrov (island) and Riečica ostrov (island). For these regions was elaborated proposal of its management regime and degree of protection.

Even of this protected arrangements, by GD construction already came out to perceptible interference to floristic genofund, and in the first place, to lowering of numerous populations areals by occupying of soil (forest also non - forest) find for the Hrušov dike, the power and flowing channel, sluice channels with regulated and other objects.

Futher future of flora, similarly than phytocoenological units, after GD construction is possible to foresee only hypothetically. Majority of floodplain forest species will develope on stands, which will be after increasing or decreasing of the ground water level (territory of the left bank of the Hrušov dike and the power channel) floristically changed by succession (Figure 1). Non forest species, mainly of aquatic and bog biotops, which by arising ecological conditions will be similar to its origin claims. Scheme of exchange of such biotops presents Figure 2.

Extraordinary attention will be necessary to devote after GD construction mainly these species: *Staphyllea pinnata*, *Astragallus asper*, *Galanthus nivalis subsp. imperata*, *Spiranthes spiralis*, *Orchis coriophora*, *Leucojum aestivum* and *Trapa conicarpa*. The last one is a new species for Slovak flora and it occurrence was recorded in the dead arm near Kráľovská lúka (Bodíky).

II. FORESTRY VIEW TO FLOODPLAIN FORESTS

6. CHARACTERISTICS OF GROUPS OF FOREST TYPES IN INFLUENCED TERRITORY

Forests in the territory which influences GD construction are presented on the map of groups of forest types (ZLATNÍK 1959) in scale 1 : 50,000. This map was elaborated on the base of these maps (made in Forest Project Institute at Piešťany):

-map of forest types from forest stand maps in scale 1:10,000

-map of management sets of forest types in scale 1:25,000

Regarding to, that used maps are utilizing in forest practice, presented map of groups of forest types is new, origin and represents the state of forests in this territory before starting GD construction. Groups of forest types (ZLATNÍK 1959), as higher mapping unit, best comply to given aim, more precisely characterize basic ecological condition of forests and are relatively better comparable also with vegetational units of the Zürrich-Montpellier school.

Forests in the territory which will influenced by GD consruction is possible from typological point of view to divide to these groups of forest types:

a) CORNETO-QUERCETUM, cornel-oak forests (CoQ)

There are stands on drier substrates, characterized by occurrence of thermophilous trees and rich shrub layer. They occur only in a very small extent on shallow, light soils on gravel terraces with very deep located ground water. There are vegetational types from loosening shrubs with steppe stand, through forest steppe with various degree of tree cover, which have relatively low growth. Characteristic feature is there the lack of water, which determines the occurrence of xerophilous and thermophilous vegetation. On the light soils is typical slow changes to group of forest types QUERCETUM (oak forests) and on gravel terraces with higher soil deep are also occur unmapping areas of group of forest types ULMETUM (elm stands) with prevailing low oak (*Quercus robur)*; elm *(Ulmus carpinifolia)* after graphiosa calamity almost completely disappeared. The main tree was originaly oak (*Quercus pubescens*), at present it is oak (*Quercus robur*) and in a smaller scale lime tree (*Tilia cordata*) and maple (*Acer campestre)*. From higher shrubs the most typical species is cornel (*Cornus mas*) mainly on lighter places and other shrub species bearing drought and warm: *Ligustrum vulgare, Cornus sanguinea, Crataegus oxyacantha, C. monogyna, Berberis vulgaris* and others. In herb layer prevailing xerothermophilous grasses. In this case it goes about scarce forest community, significant as from botanical, as from zoological point of view, however from view of timber production, has not any significance. There are protected forests, not managed. Total area of these communities (including oak and elm stands) was before GD construction about 185 ha, mainly in Podunajské Biskupice and Rusovce regions.

b) ULMETO-FRAXINETUM CARPINEUM, elm-ash forests with hornbeam (UFrc) - hard floodplain forests

This group of forest types occur mainly on relative elevations on gravel terrains or on continous areas on flat terrains, even quite far from the main channel with lower ground water level. Water supply of the soil profile in essential scale depends on that fact, wether the ground water level influence at least temporary the active soil profile.

From trees had in origin stand prevalence oak (*Quercus robur*) with elm (*Ulmus carpinifolia*) however oak was in majority harvesting and elm liquidated by graphiosa. At present prevails ash (*Fraxinus angustifolia*) with mixture of oak, poplar (*Populus alba*), lime tree, maple, only rarely hornbeam (*Carpinus betulus*). Shrub layer is very rich, creates more-less continuos layer,occur mainly *Corylus avellana, Cornus sanguinea, Euonymus europaea* and others. Herb layer is mainly on places with low covering of shrub layer, prevailing mainly nitratophilous species. Extent of these forests before construction was 3,380 ha, but the major part from this extent occur besides the interdike space in region Rusovce and Čuňovo.

c) ULMETO- FRAXINETUM POPULEUM, elm-ash forests with poplar (UFrp)
- transitional floodplain forests

This group by character of environment borders with willow-alder forests (SAL) Dividing border is given it occurrence on areas not-flooded by surface water, covers only localities moistened by the ground water, which in time of spring surface floods climbs up to soil surface (or on surface), but does not sediment fine layer of mud.

In origin stand was dominated elm together with ash, oak and *Ulmus laevis*, to which were mixed domestic poplars (*Populus alba*, *P. nigra*) and aspan (*Populus tremula*). At present in that group prevailing cultivar poplars, only less are distributed domestic poplars, willow and oak. Shrub layer is created mainly by *Padus racemosa*, *Sambucus nigra*, *Cornus sanguinea*, *Euonymus europaea* and other shrubs bearing wetting up. Herb is rich on species with presence of numerous nitratophilous herbs.

Present stands on these areas are in majority stands of cultivar poplar, because of here are optimal conditions for cultivating of qualitative timber (wood). Prevails short catting cycle (about 30 years) and mostly are distributed cultivars like "Robusta", "I 214", "Blanc du Poitou" and "Virginiana de Frignicourt".

d) QUERCETO-FRAXINETUM, oak-ash forests (QF) - transitional floodplain forests

Existence of this group of forest types is felt dependent on higher to highest ground water level, incidentally periodic floods. It covers flat terrains, in macrorelief also in microrelief slightly subsided, every year mainly in spring flooded by surface water. Optimum of wideness has this group on the alluvium of the Danube river. It creates, by character of environment, transition between UFrp and SAL. Decisive soil-created factor are spring floods, which bring fine layer of mud.

Dominanting element in origin stand was oak (*Quercus robur*) with mixture of ash, domestic poplars and aspan. Now, similarly than in previous group UFrp prevail above-mentioned cultivar poplars, which have here optimal production conditions. Shrub layer is not so rich as in previous group with regard to longer lasting floods. Herb layer is indeed dense, but with low qualitative distribution of species.

The extent of transitional floodplain forests (UFrp and QFr) is in the territory of GD construction the highest - 5,482 ha and they are widened mainly in the inundated region of the Danube river.

e) SALICETO-ALNETUM, willow-alder forests (SAL) - soft floodplain forests

This group considerable influence ground water level and regular long-termed floods, what has a decisive influence on it wideness. Although by soil types is this group considerable various, by selection of tree, which is possible to cultivate in it, is sufficiently unify.

Horizontal distribution of this group concentrates on the Danube alluvium, directly on the banks or in the dead arms, often flooded. With regard to such terrain distribution soil types are gravel (shallow banks), often without normal soil profile, to Gleysols, Histohumic Gleysols, Humic Gleysols (dead arms), usually with short oxidation horizon.

Origin stand preserved more-less origin feature, prevail willows (*Salix alba, S. fragilis*) with mixture of domestic poplars and alder (*Alnus glutinosa*). On the places from the main chanell is alder more frequent, with mixture of willows and domestic poplars. At present occur also cultivar poplars, mainly on drier places. Herb layer has dominanting distribution first of all bog species, requiring permanent humid soils and suffering lack of soil air.

The extent of soft floodplain forests was before GD construction about 1,309 ha, mainly in the inundation region of the Danube river, in the line Šamorín - Palkovičovo.

7. POTENTIAL DISTRIBUTION OF GROUPS OF FOREST TYPES BEFORE AND AFTER CONSTRUCTION OF THE GABČÍKOVO DAM (GD)

Construction of the Gabčíkovo dam and tending the Danube river to the power channel will signify even if establishment of hydrotechnical objects to alleviation some negative consequences, certain change of the hydrological regime in the Danube floodplain forests. It is very likely, that further development, resp. changes of present floodplain forests will depend on, first of all, mean discharge, resp. height of water level during vegetation period in the old river-bed of Danube. From this point of view is important to compare potential distribution of group of forest types before and after GD construction, because of it comes to certain differentiation of the Danube floodplain forests on what will be necessary to take into consideration in future, not only as for their production function (planting of cultivar poplars, in several cases compensation of soft to hard floodplain forests), but also non-production functions (recreation, landscape protection, soil protection and others).

First of all is necessary to express, that in the territory of GD construction is not possible to say about origin tree composition of floodplain forest, because of already longer time before construction came to the exchange of the main trees, mainly in transitional and soft floodplain forests with preferring, resp. introduction of cultivar poplars. To the given fact influenced in certain scale also other changes, deepening of the Danube river-bed after gravel harvest in sixties and practically complete disappearing of elm after graphiosa calamity.

First so-called profit forms of poplars began to plant in the surroundings of the Danube in the end of the 19. century. Their plantations were joined with establishment of the antiflooded dikes. Later, mainly after 1918 began to establish in great deal stands of new cultivars of euro-american poplars (Monilifera, Robusta, Serotina), in which was continued also later. Plantation of poplar stand acquired dimension mainly beginning of sixties. Present floodplain forests of the Danube river including arm system between Dobrohošť and Palkovičovo are created prevailing (about 80 %) from above-mentioned artificially cultivated euro-american poplar with prevalence of cultivars "I-214" and "Robusta". With regard to this fact it is possible to characterize also changes in distrtbution of groups of forest types before and after GD construction (Table 1, Figs. 4,5,6). Before construction had the highest distribution two groups of forest types - in the upper part of territory ULMETO-FRAXINETUM CARPINEUM (32.6 %) and in the interdike space ULMETO-FRAXINETUM POPULEUM (38.6 %), which together with QUERCETO-FRAXINETUM (14.3%) creates group of transitional floodplain forests which was widened on more than half of the territory. Relatively high percentage covered also soft floodplain forests-SALICETO-ALNETUM, mainly in the low part and only small percentage other forests, extreme stands in the upper part of the territory near Podunajské Biskupice and Rusovce (1.8 %).

After building measures connecting with GD construction and the power channel (variant C) the extent of floodplain forests was lowered approximately to 30 % which had impact also to distribution of groups of forest types (Figs.5,6). The extent of hard floodplain forests was lowered from 32.6 % to 25.6 % and extreme stands (Corneto-Quercetum) from 1.8 % to only 0.4 %. On the other hand the share of soft but mainly of transitional floodplain forests icreased about 3, resp. 7 %. It means about such floodplain forests, where are prevailingly planted cultivar poplars.

As can be seen also from presented sketch and Table 2, the highest changes occured in the upper part of GD construction up to Dobrohošť and relatively without change remained forests in the interdike space. In the upper part essentially increased percentage of hard floodplain forests (91.3 %) and decreased percentage of transitional floodplain forests which together with soft floodplain forests create at present only 1 % from the total extent against almost one third before construction. On the other side, on the territory of the interdike space of derivate part of the Danube river are mostly distributed transitional floodplain forests, which cover 81 % and soft floodplain forests 19 % from total area; hard floodplain forests and cornel-oak forests in the inundation region of derivate part missing. Although is necessary to notice, that general tendency is the change of communities from more humid to drier ones also without impact of GD construction. It is obviously caused by limited transport of flooded sediments and decline of the Danube river-bed.

Finally it is possible to state, that preservation of present ecological (growth) conditions in the region of the Danube area system will depend on namely mean height of water level in old Danube river-bed, which is possible to maintain on the certain height e.g. by means of small dams. It is real assumption, that establishement and working of removed object beneath Dobrohošť enables floods of the Danube arm system and close stands and provides suitable condition for their development.

If we allow, in conection with GD construction, possibility of certain forestry risk, it is first of all risk of lowering stand area of cultivar poplars and not a risk connecting with rescue of the Danube floodplain forests genofund. On the other hand, in connection with certain slighty becaming dry of several stands we can realy calculate with reversibility of floodplain forests development from present stands of cultivar poplar to stands which will be closer to origin forest communities. However it is necessary to stress, that changes caused by GD construction and watering of the power channel is imposible to record in such short time (almost year), but for such observation or research will be necessary essentially longer time period (minimum 5-10 years)

8. COMPOSITION OF TREES AND THEIR GROWTH CONDITIONS

Until second half of the 19. century was the territory flooded by flood waves of the Danube river much more extensive than at present. Flood waves were not so high and therefore in this territory prevailed drier forest communities, while transitional and soft floodplain forests occured on less scale in terrain lowerings, extensive were bogs and aquatic ecosystems.

After establishment of both-side antiflooded dike in the second half of the 19. century flooded waves (up to exceptions) came only to the interdike space. Flooded wave was therefore higher than recently and reached in the interdike space also these localities on which before establishement of dikes did not come. In this way increased in the interdike space - against previous conditions - area of humid and more humid types of floodplain forests. Floods were in the interdike space more frequent, increased the level of flood waves and such way were worse conditions for broad - leaved trees, which occur at present in the interdike space essentially less than in the past. Prevail here therefore soft deciduous trees (poplar, willow). Exception are forests beneath Bratislava (so-called upper part), where terrain is elevated and floods were rarer, there are oak and stands.

Stands of cultivar poplar began to plant after 1938, in higher extent after 1950. According to forest management plan elaborated for 1951, in that period, state forests (non-state forests are not included), on the right and left bank of the Danube river (from Bratislava to almost Komárno), it means the territory of GD construction, is distribution of main stand trees given in Figure 7. In tree composition prevail trees typical for transitional and soft floodplain forests and there are: domestic poplars (*Populus alba* 22 %, *P. nigra* 5 %) cultivar poplars (20 %), willow (16 %), alder (7 %), trees typical for hard floodplain forest (oak, ash, elm) covered approximately 20 % of total area.

Essential changes in tree composition were not even by forest management plan from 1965, when were included to the evidence also further areas of forests in this territory (non-state forests). Difference in tree composition of both terms (1951, 1965) is very small (Figure 7).

Change of tree composition became in later years, mainly in the upper part and namely by means of mutually uncoordinated hydrotechnical measures in seventies (unproportionale deepening of the Danube river-bed, in average about 1.5 m, setting aside of Biskupice arm, establishment of hydraulic shade near Slovnaft, right-bank narrow wall about suburb of Petržalka, construction of water sources and others). It caused drying up about 500 ha of floodplain forests. Forests which remained in this region languished, disintegrated their structure and new planted stands only lived poorly. In that period began cutting in stand, which were on the base of administrative decisions permanently taken out from forest management fund, it means distribution of trees was changed in forest management districts. It concerns to main forest management district Rusovce, where was decisive movement in success of hard floodplain forest trees (oak, hornbeem), while in the low part (forest management district Gabčíkovo and Šamorín) remained high share of transitional and soft floodplain forest trees. However decisive share have cultivar poplars, which at present cover 61-65 % of total area of both forest management districts (Gabčíkovo and Šamorín). Relatively small reduction of stand area in consequence of GD construction was on Gabčíkovo, but on Šamorín came to big-areal unforestation on the region of present Hrušov dike, power channel and other building areas. Survey about tree composition in forest management districts Rusovce, Šamorín, Gabčíkovo is given in Figures 8,9,10, survey about stand areas, growing stocks and annual harvestings is in Table 3. The base were accessible data from forest management plans.

On the left side of the Danube river, in recent interdike space (from Bratislava to Hrušov dike) stand are not flooded till 1975. There are such changed hydropedological conditions, that forest ecosystems are depended on only rainfall water. Bad, unsuitable growth condition for floodplain forests after all and for transitional floodplain forests mainly, it is possible to prove by documentary evidence on this territory by following scientific information:

a) Table 4 shows distribution of stand bonity with main stand trees cultivar poplar and oak. In the upper part of territory has oak, as tree less pretentious to moisture, prevail bonity degrees +1 to 3, while cultivar poplar, as typical tree of transitional floodplain forests pretentious to soil moisture, prevail bonity degrees 4 to 7, bonity degree +1 to 1 does not occur.

b) Figure 8 presents distribution of trees in forest management district Rusovce, where absolutely prevail trees with more modesty pretentious to soil moisture.

c) Also evaluations of majority of stem analyses, made on mean trees on monitoring areas in the upper part in 1991 confirmed radical decreasing of diameter increment, resp. breadth of year-rings already before 6-14 years, it means since 1986-1978. Consequences of interferences to the hydropedological conditions were visible already in that years. It was ascertained on 11 from 12 monitoring areas in the upper part, and it without respect to tree species (Table 5).

d) Bad state of these monitoring areas confirmes also loss of leaves in tree crowns, which was estimated e.g. in August 1991 to 10-60 %; in 1992 were losses of leaves yet higher, caused by extreme summer drought.

After watering and working of the Hrušov dike the ground water level is in this region in deep 1-3 m under soil surface. By this way was reached renaturation or at least partial renaturation of the hydropedological conditons.

It is possible to prove by documentary evidence by preliminary scientific information (based only on observations in summer 1993) about leaf area index of monitored forest ecosystems in given territory, as also by loss of leaves in observed terms (annually about August,15.) in 1991, 1992 and on the other side in 1993 , it means after GD construction. Leaf area index, as important production-ecological characteristic defines the vitality of forest stand, at which gives the area of all tree and shrub leaves in relation to stand area.

Example:

Monitoring area 19, forest district Rusovce (region Podunajské Biskupice)

Leaf area index in 1991 - 1.70 $ha.ha^{-1}$

in 1993 - 3.02 $ha.ha^{-1}$

While leaf area index in 1991 was extremly low, in 1993 decisive increased (even value 3.02 $ha.ha^{-1}$represents only about half value of leaf in healthly floodplain forest ecosystem).

Other example from monitoring areas in forest district Rusovce (region Čuňovo, Rusovce):

Mean loss of leaves in August		
	willow	poplar, ash, *Acer negundo*
1992	32%	46%
1993	15%	26%

In soft floodplain forests (willow) which suffered by lack of moisture in previous years, the ground water level is closely under soil surface, in part of stand climbs above it surface. In this forest ecosystem crowns of trees dried and loss of leaves was at several individuals of *Acer negundo* in August 1992 about 80-90 %. In 1993 was ascertained in the same individuals, in the same terms loss of leaves only 0.1 %, it became global restoring of all tree species and the ground water level climbed up above surface in terrain lowerings.

Low part of the territory (from Dobrohošť to Palkovičovo) was possible - from the watering and working of GD - to consider as region with suitable hydropedological conditions. In that part came to creation of such situation, mainly by establishment of the dike system in the second half of the 19.century. Growth conditions were mostly suitable for poplars and willows, while trees of hard floodplain forest (oak, ash) were replaced by high-productive planting of cultivar poplars. These trees gradually replaced, in a high degree, also stands of domestic poplars. These conditions shows also Table 4, where in more suitable bonity degrees are approximately 70 % of poplar stands.

Advantage of planting cultivar poplars confirms also tree composition in forest management districts Gabčíkovo and Šamorín. High production (also more than 20 $m^3.ha^{-1}.year^{-1}$) and short cutting period suported exchange of origin floodplain forests to intensive managed monocultures of cultivar poplars.

After working of GD (knowledge are from the only vegetation season 1993) and watering object of the arm system to action,on the majority of monitoring areas are not visible negative changes of vegetation in the low part. We judge in this way from the global look at on all growth forms of forest ecosystems, in which are located monitoring areas. Leaf area index is proportionate, green, leaves are damaged mostly only mechanically (leaf-eating insect, hail in July, 19 ,1993). Loss of leaves was not possible to observe, on the other hand, the state of majority of trees on monitoring areas and also in the other stands was good to very good. Meanwhile is impossible to express about diameter increment resp. it casual reduction.

In the vegetation season 1993 were in bad to very bad state stands, located close to the main channel of the Danube river (drainage of ground waters to river-bed of the Danube) as also in region above watering object of the arm system (triangle: Danube river-bed-chanel resp. dike-arm watering by watering object). Against previous years in that region comes to rapid negative reaction of all occured trees, which reacted to lack of moisture, caused by decrease of the ground water level, by untimely yellowing of leaves (starting in May 1993), loss of leaves already in soon summer and drying up of crowns, sometimes died also some individuals (mainly willows and poplars).

Finaly, summing up this part dealing with forestry view to floodplain forests (chapters 5-7) it is possible to state as follows:

a) Hydropedological conditions improved for proportionale development of such groups of forest types, which prevailed to the end of fifties by means of permanent increasing of the ground water level which were reached by damming of the Danube river and construction of the object for watering arm system beneath Dobrohošť.

b) In tree composition of floodplain forest, which were gradually replaced to monocultures of cultivar poplars, is possible to calculate with wideness of hard floodplain forest trees (oak,ash) with mixture of domestic poplars after GD construction.

c) It comes to decisive , evident decrease of diameter increment of trees (proof on 11 monitoring areas from total number 12) in consequence of long-termed decrease of the ground water level.

d) Negative conditions in production-ecological characteristics of floodplain forests before GD construction confirmes also lowering of leaf area index. In 1991 was this index 1.77 $ha.ha^{-1}$, while alredy in the first year after damming up to 3.02 $ha.ha^{-1}$.

e) Monitoring of forest ecosystems confirmed decisive loss of leaves before damming of the Danube river (60-80 %), while after following increasing of the ground water level loss of leaves varies between 0-10 % (1993).

f) Renovation of forest ecosystems occupied for construction of the Hrušov dike and reconstruction of stands damaged by lack of water beneath watering object of the power channel is possible to decrease by artificial reforestation, which is preliminary planned on area about 570 ha from total occupied area 3,270 ha.

g) Prediction of changes dealing with growth conditions of trees after GD construction is possible after longer time period (5-10 years).

III. FAUNA OF THE TERRITORY INFLUENCE BY CONSTRUCTION OF THE GABČÍKOVO DAM (GD)

9. GENERAL REMARKS

Inland delta of the Danube river is defined as flat territory on the alluvial sediments along the main channel with net of it additional arms and standing waters. Inland delta is created on the boundary of ritoral and potamal of the main channel on the breaks with sudden change of the stream speed. This hydrological-geomorphological situation makes dependent upon existence of varied scale of aquatic ecosystems. For terrestric part of the inland delta is characteristic high ground water level and regular seasonal floods making dependent upon existence of floodplain forests. Another typical feature of the inland delta is existing of rich scale of ecotons, transitional zones in hydric and terrestric cycle of ecosystems as also between both cycles. This all creates conditions for rise of the territory with extraordinary biodiversity. For the inland delta is also characteristic high primary and secondary production of biomass, made dependent upon, besides other, by import of anorganic and organic nutrients by floods. Determining factor of ecological system of the inland delta is water regime of the main channel, arm system and ground waters.

While aquatic animals and their communities were more intensively studied mainly in period of last forty years, terrestric fauna was observed only marginally. Starting-point for knowledge of aquatic fauna is monographic study written by Dudich (Dudich in Liepolt, 1967; including Russev's addition) in which are summarized also more detail data by Brtek and Rothschein (1964). This survey of danube aquatic fauna, with regard to, that in survey is asserted only given national part of the Danube river (Hungarian, Slovak, Austrian and so on) as also to time, which elapsed since publishing that book, it is necessary to applicate it to the territory of GD with certain reserve. Such summarized survey for terrestric fauna does not exist; elaborated were only several animal groups (e.g. birds, mammals; Brtek unpubl.) From this reason it is not always possible to state and judge changes, which became during the whole period of GD construction. Situation changend after that, when in 1990 began regular monitoring of biota, within the frame of which is observed also fauna and taxocoenosis of most important groups.

10. AQUATIC FAUNA

Aquatic habitats represents varied scale of conditions for the life of aquatic fauna from waters of eupotamon type through parapotamon, plesiopotamon up to paleopotamon. In comparison with terrestric represents water environment more homogenous system in which are not usually rapid topic oscilations than in terrestric ecosystems. With regard to that fundamental differences among eupotamon on one side and parapotamon, plesiopotamon on the other side, aquatic fauna and communities are evaluated in two parts.

10.1. Zoobenthos and zooplankton of the main channel (eupotamon)

In the periphyton of the main channel are distributed mainly *Flagellata: Bodo spp., Rhynchomonas spp., Anthophysa spp., Codonosiga spp.), from Metazoa, Nematoda, Rotatoria, Oligochaeta, Gastrotricha, Tardigrada* and others (Ertl, 1970).

Situation in the main channel was not essentially changed in monitoring years. Number of *Flagellata* relatively decreased, what means that self-cleaning processes develope more intensively against stream. Monitoring was tended mainly to *Ciliata*. The main channel of the Danube river is indicated by relatively poor but stabile community of *Ciliata* which create mainly euryecal and bacterial species. In relatively small number are distributed mainly planktonical species.

Saprobity varied in 1990 - 1991 between 2.5 - 3.0. In 1992 was assertained increasing, saprobity was between 2.6 - 3.3.

These values had minimal changes during year.

Community of *Ciliata* and other groups of microzoobenthos is during year dependent on the height of water level. Besides current changes in physical-chemical and trophic conditions (speed of stream, turbulency, increasing of mud content and other) we assertained after floods in this part of the Danube river phenomenon of individuals inactivation. In 1991 was maximal discharge (joined with floods of the inundation territory) in July, in 1992 in May what manifested always by finding of inactivated individuals in samplings of next month. This phenomenon we explain by increasing number of flooded sediments in which are probably toxic substances. This phenomenon did not discover in the arms.

It is possible to state that in other period of the year goes about communities of stabilizied microzoobenthos with inclination to increasing saprobity to the end of vegetation season, it means in September to November.

Macrozoobenthos has in the main channel unified character, in regard to exist some differences there are more on quantitative level, what can be caused by variability of substrate or local differences in discharge. In the whole this part are absent outflow of waste waters and soiling from Bratislava does not reflect on the composition of fauna. The littoral zone where organisms find a firm base has a richer benthic fauna, represented by *Gastropoda*, *Bivalvia*, *Isopoda* and larvae of further insect groups, such as *Ephemeroptera*, *Plecoptera* and *Trichoptera*. The biomass of the zoobenthos here reached a mean of 15 $g.m^{-2}$.

In the benthos are distributed as reophilous form (*Ancylus fluviatilis*, *Amphipoda*) as ubiquistic species living also in standing waters (*Bithynia tentaculata*, *Dreissena polymorpha*, *Dendrocoelum lacteum*, *Eunapius fragilis*). High number reached pontocaspic *Amphipoda: Dikerogammarus haemobaphes* and *D. villosus* and *Ancylus fluviatilis*. On the lowest monitoring station near Sporná Sihoť was occured, by the consequence of lowering of stream speed, as littoral element *Lithoglyphus naticoides* (quantitative sampling in 1992 was misssing). In the littoral of the main channel prevailed from *Amphipoda* species *Dikerogammarus haematobaphes* and *Corophium curvispirum*. From *Oligocharta* there were species from *Naididae* and *Stylodrilus heringianus (Lubriculidae)*, rarely occured species from *Tubificidae*. In comparison with previous years increased occurrence of species *Hypania invalida*.

Declination of essential part of danube waters from the main channel was manifested by expressive decrease of filtrators (mainly from order *Trichoptera*). In the part of Danube (Dunajské Kriviny) this fact could be expected. Lowering number of discharge means lower supply of bioseston to this ecosystem and in the sense of river condition of the Danube river in the upper Austria. Similar fact we recorded also in Danube near Sporná Sihoť (part with origin discharge). Therefore these data will be necessary to authenticate.

Planktonic zoocenozes of flowing waters are generally poorer in species and have a small diversity. In samples occured taxons which are characteristic for littoral zone. In potamoplankton of the main channel were ascertained together six species *Copepoda*, of which the most frequently dominated *Acanthocyclops robustus*. Species composition of taxocoenoses *Copepoda* was practically the same as in previous years. Against previous years is composition of zooplankton without more important changes. The mean annual values of the biomass of zooplankton in the main channel near Gabčíkovo (r.km 1815-1821) amount to 0.2-0.8 $g.m^{-3}$ of wet weight. As a rule, the greatest share in these yearly means of biomass goes to the *Protozoa* (40-80 %), and the rest to *Rotatoria* (11-56 %) and *Crustacea*, i.e. *Cladocera* and *Copepoda* (2-6 %) (Vranovský 1974a, 1974b, 1985, etc.).

10.2. Zoobenthos and zooplankton of the arm system

In the principal arms of the inland delta between Hrušov and Gabčíkovo, the zooplankton has approximately the same species composition as the main channel. Differences, however, exist in the quantitative representation of the various species and higher taxons, and also in the overall biomass of zooplankton. At times of a more protracted intensive discharge through the arm systems, their zooplankton resembles also from the quantitative aspect that of the main channel. In seasons of a slower discharge or its cessation during the warm part of the year, there is an increase in abundance and biomass of limnetic rotifers (*Polyarthra vulgaris*, *Keratella cochlearis*, *Brachionus calyciflorus*, *Synchaeta pectinata*, *S.oblonga*, or some further species of genera *Asplanchna* etc.), cladocerans (*Bosmina longirostris*, *Diaphanosoma brachyurum*, *Moina micrura*, and also of *Daphnia cucullata*) and copepods (especially *Thermocyclops oithonoides* and *Eudiaptomus gracilis*). At the same time the share of Protozoa declines and that of Rotatoria and Crustacea increases and this simultaneously with an increase of the overall biomass of zooplankton. The yearly mean biomass of zooplankton in the arms is usually 3-15 times higher than in the main channel - the biomass of Rotatoria being up to 30-fold and that of Cladocera up to 180-fold higher (Vranovský op.cit.). In general it may be stated that the mean annual values of the biomass in short arms of a predominantly eupotamic character, are low.

Species composition and distribution of microzoobenthos is current in such type of waters. The whole arm system presents a high potential of self cleaning processes in the whole arm system of the Danube river. All asserted arms except Kráľovská lúka are strongly dependent on the ground water level and mainly in autumm are without water, again except Kráľovská lúka. This locality we consider as a rest of a typical dead arm of danube system, which remaindes as the only in origin state. It is interesting, that level after spring filling up by higher water weirs only gradually and slowly decreases and not even in very dry year, as was 1992 arm did not remain without water, did not dry up either at that time, when rapidly decreased ground water after watering of the power channel to the hydroelectric plant of Gabčíkovo. Even of these changes in observed years, community of microzoobenthos did not change and remained stabile (Figure 11). From this reason we consider this locality as a remarkable refuge of the Danube microfauna and surely it would require certain degree of protection.

In arm system was saprobity in monitoring years about 2.6 - 3.1, when arms drying up in the second half of the year saprobity index increases. In dead arms (e.g. Kráľovská lúka) are developed communities of microzoobenthos typical for standing waters with high diversity: saprobity index varies between 2.4 - 2.8 with increasing tendency to the end of season, what is normal phenomenon. It did came to changes during monitoring years.

Asserted conclusions, coming up from monitoring are not in contradiction with ascertained data about microzoobenthos. In the inundation territory are distributed water areas of temporary character (drying up) up to permanently watered biotops of lake or from time to time discharging arms. In the arms lying in the inundation territory, conditions of benthic fauna both qualitatively and quantitatively in dependence on character of the arms. In strongly running arms (eupotamon) the zoobenthos biomass has almost the same values as in the main channel (6.5 $g.m^{-2}$ - Ertlová 1970).

In arms of the parapotamon type, three types of benthic communities occur in dependence of on the nature of the substrate: a community of the gravel-type substrate, a community settling on aggregations of *Dreissena polymorpha* and a community of the muddy substrate. The various communities differ by their species composition and also by their population density. The mean annual abundance of zoobenthos on a gravel substrate without Mollusca attains 280-1,259 ind.m^{-2}, with a biomass of 2.06-10.78 g.m^{-2}. Typical representatives in this substrate are *Chironomus gr.fluviatilis*, *Chironomus gr.plumosus*, *Chironomus gr.reductus*, *Procladius* sp. (Chironomidae), *Psammoryctides barbatus*, *Potamothrix moldaviensis*, *Limnodrilus hoffmeisteri* (Oligochaeta). The mean annual abundance was in the range 915-2,487 ind.m^{-2}, with a biomass 9.41-19.07 g.m^{-2}, excluding *Dreissena polymorpha* whose abundance fluctuated between 188 and 1,322 ind.m^{-2} and biomass between 715 and 2,751 g.m^{-2}. Typical representatives are *Criodrilus lacuum. Rhynchelmis limosella*, *Potamothrix vejdovskyi*, *Potamothrix moldaviensis*, species of the genus *Limnodrilus*, *Psammoryctides barbatus*, *Stylodrilus heringianus*, *Tubifex tubifex* (Oligochaeta), *Dikerogammarus haematobaphes* (Amphipoda and *Erpobdella octoculata* (Hirudinea). The mean yearly abundance of zoobenthos in a muddy substrate amounted to 323-1,167 ind.m^{-2}, the biomass to 4.74-9.74 g.m^{-2}. Typical species are *Limnodrilus hoffmeisteri*, *Limnodrilus udekamianus*, *Tubifex tubifex* and *Potamothrix moldaviensis* (Oligochaeta), *Chironomus* gr. *fluviatilis* (Chironomidae) (Šporka 1979).

In the littoral of type plesiopotamal on the gravelly-sand bottom were species composition varier, occured besides species from Tubificidae also species from Naididae, it means species feeding on plants, while in swampy bottom prevailed species from Tubificidae, causually amphibiotic species of Enchytraeidae and species *Eiseniella tetraedra*. Increase of number mainly phytophilous species of Chironomidae shows gradual change of several arms from the type plesiopotamon to paleopotamon what connects with loss of its contavt with the main channel in consequence of it deepened. In the arms of the plesiopotamon type the highest values of zoobenthos biomass in the littoral inside growths of submerged macrophytes amount to 24.6 g.m^{-2}, on the other hand, in the medial zone where the bottom is made up of muddy sediments they reached 1.6 $g.m^{-2}$ only (Nagy, Šporka 1990). In benthic fauna of the arms, the dominant position is occupied by Oligochaeta (species of the family Tubificidae) and Chironomidae larvae (species of the Chironomus genus).

In the arms outside the floodplain (paleopotamon) the mean yearly abundance of zoobenthos ranges around 7,190 $ind.m^{-2}$. Typical representatives of the benthos community are Chaoboridae and Chironomidae larvae (Ertlová 1963).

In all types of waters are dominant group of microbenthos Mollusca, mainly Gastropoda. There are mainly species dependent on standing waters: *Lymnaea stagnalis, L.auricularia, L.palustris, Planorbarius corneus, Planorbis planorbis, Viviparus acerosus, Valvata piscinalis*. There are among them as euryec species widened on the majority types of waters (*L. stagnalis, P. corneus*) as also species with local occurrence: *P.carinatus, V.contectus, L.turricula, Gyraulus laevis*. From other groups of microzoobenthos in littoral of areas, type parapotamal occured as the same species than in the main channel *Corophium aurispinum, Dikerogammarus haematobaphes, Hyphania invalida*, species of Naididae and *Stylodrillus* Psammoryctides and Potamothrix.

From the point of view of saprobity evaluation on the base of permanent benthic fauna it is possible to confirm the condotions about water saprobity in the main channel had in all cases betamesosaprobic character. In the arms of parapotamal type prevailed betamesosaprobity even if occured also alfa-mesosaprobity. In the arms of plesiopotamal type against that prevailed alfamesosaprobity. Here is however, necessary to take to consideration, that it goes about standing water, where is sufficiency of organic matter in the bottom, which is settled by species preferring this substrate *Limnnodrilus hoffmeisteri, Limnodrillus claparedeanus*).

In zooplankton was accertained on monitoring localities in 1992 a higher number of taxons Copepoda and phytophilous planktonic Cladocera. As possible explanation of that and several others differences against previous years comes to consideration permanent deepening of the Danube river-bed mainly in last years. It consequences certainly accelerate the process of narrowness and earthiness of the arms. More expresive manifestation of taxons, characteristic for littoral cover by macrophytea, resp. for periodically drying of small water basins in 1992 in comparison with last year can be also connected with flood of the whole delta in 1991, after which followed relatively less- water year 1992. It is not supposed, that observed changes should be connected with GD construction, reso. with it working up. Own development of GD construction namely to the end of October 1992 after all or almost after all influenced the hydropedological regime of monitoring part (r.km. 1,840-1,815).

In the arms aquatic fauna in comparison with previous yers manifested only unexpensive changes of the species spectrum. Aquatic communities we consider as a little demaged although processes of the arm succession develope comparitively quickly therefore its natural dynamics is missing.

10.3. Ichtyofauna

With regard to known relations of ichtyofauna and ichtyocoenoses to the main channel of the Danube river and arm system of the inland delta, we present date about them separately.

10.3.1. Development and state

The fishfauna of the Slovak-Austrian, Slovak and the Slovak-Hungarian part of the Danube is well known. Altogether one species of cyclostomes and 68 species of fish has been recorded in this stretch of the river. The present number of fish occurring here amounts to 52 native and 13 introduced species. The impact of man, such as hydraulic engineering measures and overfishing eliminated such species as *Huso huso, Acipenser stellatus, A.nudiventris,* and also the migrating race of *A.gueldenstaedti* from this stretch of Danube; all of them were extinct before (BALON,1966) Deepening of the Danube bottom during past three decades and the subsequent change of the floodplain hydrology are the main reasons of the decline of some, particularly phytophilic species (*Cyprinus carpio, Abramis sapa, Carassius carassius, Scardinius erythrophthalmus, Tinca tinca*) and some of them are facing the danger of extinction (e.g. the native wild carp). The last evaluation of the conservancy status of the fishes in Slovakia (HOLČÍK, 1989) shows that most threatened fish species is just from the Danube river. From 56 native species recorded in this stretch of Danube 4 are now extinct (7.1 %), 3 (5.4 %) are endangered, 5 (8.9 %) vulnerable, 3 (5.4 %) rare and 23 species of fish (41.1 %) need further information to be exactly classified (Figure 12).

On the other hand, there have been accidental or intentional introductions of 13 species of fish. However, their abundance and economic contribution is quite low except of *Ctenopharyngodon idella, Hypophthamichthys molitrix* and *Aristichthys nobilis.*

Species diversity and population density of the Danube fish fauna differs according to the type of habitat (Figure, 13) Eupotamon (main channel of river and its anabranches permanently connected with the main channel upstream and downstream respectively) harbours 64 species but their ichtyomass is rather low as has been estimated to about 36 $kg.ha^{-1}$ only. Parapotamon (the side arms permanently connected with the main channel) is inhabited by 37 species with ichtyomass around 292 $kg.ha^{-1}$. In plesiopotamon (permanent or temporary standing water bodies that were formerly side arms) 4-26 fish species occur, the ichtyomass of which is 598 $kg.ha^{-1}$ in average, while in the paleopotamon (permanent standing water bodies left when the river changes its channel) only 1-4 species occur with ichtyomass fluctuating around 300 $kg.ha^{-1}$ in average. Both the species and quantitative composition of the fish communities in this stretch of Danube are subject to continuous change depending on the seasons and natural fluctuations of the discharge.

In the time of high water weirs have arms the function of refuge for fishes migrating from higher arm systems and stretches of the main channel, but contemporary also function of one from the spawning of inundation, from where fishes emigrate during higher water weirs of Danube to other, mostly lower arms and stretches of the main channel.

10.3.2. Trend of changes of ichtyofauna during monitoring

In 1991 was ascertained, that the changes of water weir in numerous arm are considerable later than changes in the main channel, which recently manifested during several hours, which powers the process is at present considerable rapid with regard to poor rainfall and extreme warm vegetation period in 1992, and, at present also by that in the old river-bed of Danube after working of GD in the end of 1992, is discharge cca 400 $m^3.s^{-1}$. Several arms are not filled up from this source by water such as in the past, on the contrary, the old river-bed of the Danube partially causes drainage effect.

Above asserted factors and intensive fishing mainly predators and economically valuable fish species lowering species diversity of the ichtyocoenoses. We can observe increase of relatively number of ecologically plastic, eurotopic species (*Rutilus rutilus*), introduced (*Lepomis gibbosus*) and expansive species (*Carassius auratus*). Lowering is relatively number of threatened species, which also in the past belonged to recedentic species. At *Cyprinus carpio* and *Stizostedion volgense* is this state caused by probably fishery pressure, at threatened species (*Gymnocephalus schretzer*) and scarce species (*Abramis sapa*) hindering of arm communication with other waters of the inundation territory.

During monitoring in 1991 was recorded in the main channel more abundant occurrence of fish species pretentious to the quality of water as *Cottus gobio, Salmo trutta.* In the whole inundation is visible retreat of several fish species as for example *Esox lucius, Silurus glanis* but also further mainly phytophylic fish species. Asserted knowledge, however, does not come from comparison of two monitoring years, but from long-termed work of scientists in the inundation. Above-mentioned species evidently by gradual changes on the Danube regime, which connect with more expresive deepening of it levels in last decades, lose substrate for reproduction. The second aspect, which evidently contributes also to retreat, mainly nutrically valuable fish species, are evident deviations from rules of sport fishing. Mainly in last period here comes to collective utilizing of the whole scale of non-rule possibilities of fishing.

Arms communicated with the main channel are indicated by high abundance mainly juvenelle ichtyocoenose. They represent at high water weirs in spring month suitable spawning for prevailing part of the Danube ichtyofauna. So for example the Medveďovské rameno (arm) is known by spawning of critically threatened species *Cyprinus carpio*, from threatened species *Stizostedion volgense* and from rare species *Abramis ballerus.* In connection with earthiness and diminution of level area comes in arms to changes, which threaten this its function.

10.3.3. Fishery

Danube and the adjacent waters from the fishery point of view is given by the greatest wealth of fish species, as well as by the high productivity of waters permitting high catches. This high productivity is conditioned by the existence of the inland delta here which serves as a feeding and reproducing base to fishes, further as a refuge during high water levels and provides conditions for wintering to the great majority of Danube fishes.

The ichtyomass attains various values in dependence on the type of habitat. The highest values were found in the arms of the inundation territory, lower in waters outside the floodplain and the lowest within the mainstream itself.

Until 1987 fishing in the Slovak stretch of the Danube was carried out in the form of both commercial and sports fishing. Catches made in the Slovak stretch of the Danube river during 1976 to 1991 shows an average of 129.6 t of fish were caught. About 90 % of the catch come from the arms systems. There exists a positive relationship between quantity of the catch and the hydrological regime and the length of communication between the main channel and the system of arms. From the economically valuable fishes, the following were involved in the total catch for the period studied: carp - 10 %, pike - 8 %, zander - 6 %, barbel - 3 %, wels - 2 %, grasscarp - 1 %.

11. TERESTRIC FAUNA

Terrestric fauna essentially less known than aquatic one. Permanently were observed only some groups of special interest as for example ectoparasites exept terrestrial mammals. Existing knowledge are therefore are uncomplete, which is possible to prove by documentary evidence on the example of *Aranea*: from the Danube inland delta is known occurrence of 108 species, in Jur peat-bog (CARICI ELONGATAE - ALNETUM) were ascertained 271 species. Similar situation we can assume at all *Evertebrata*. More complete knowledge has brought monitoring of Danube delta biota going on since 1990. Existing knowledge confirm expected assumption, that terrestric fauna is a typical in floodplain forests resp.the other communities. A characteristic feature of habitats of the floodplain forests and wetlands is the presence of hydrophilic, hygrobiontic, but also some eurybiontic species. Some of them occur solely in these types of habitats and may thus be considered to be indicators of floodplain forests or wetlands.

Thus the number of species of *Collembola* occurring only in a floodplain forests and in wetlands 9, of *Acarina* 30 and 15 respectively, of *Araneae* 36 and 2 resp., of *Chilopoda* 12.

The number of species, their abundance and the overall population density are affected by the hydrological regime. A rise of the ground water and floods result in decrease of the overall abundance and exert a strikingly inhibitive effect on penetration of xerophilous species whose population density rises in periods of years with a lowered ground water and absence of floods, or also in consequence of human impact (e.g.cutting of floodplain forests).

Altogether there occur about 120 species of *Carabidae* and about 200 species of *Staphylinidae*. This number of species in a concrete undisturbed site fluctuates within the limits of 33 - 45 species of *Carabidae* and between 30 - 55 species in *Staphylinidae*. This number of species is approximately 1.5 - 2 times higher than in the natural mesohygrophilous deciduous forests at the comparable elevations. On all monitoring areas were ascertained during monitoring decrease of the number in given groups of soil *Acarina* in 1990-1992. This reduction of number concerned of majority taxons of *Acarina*, mostly it was manifested at dominant groups. At the same time was lowered also species spectrum. In the case of other monitored group *Chilopoda* were not manifested essential changes of species spectrum or composition of taxocoenoses during monitoring. Decrease of abundance of hygrophilic species in 1992 evidently connects with extreme low rainfalls and global decrease of the ground water level. Similar situation was recorded at geobiontic species from *Curculionidae (Coleoptera)*, whose abundance and diversity is except extreme drought influenced also by floods. This trend was not manifested at further group *Collembola* (Fig. 15). Well indicator of the biota state are buterfly species (*Rhopalocera*). Totally were ascertained in studied territory about 61 butterfly species from *Zygaenoidea* and *Papilionoidea*(Fig.16). The most number of species was recorded on monitoring areas with prevailing xerothermophilous vegetation (Rusovecké ostrovy - 50 species, Ostrovné lúčky - 45 species, Ostrov Kopáč - 42 species). Xerothermophilous species (*Minois dryas*, *Arethusana arethusa*, *Zygaena punctum*, *Satyrium spini*) reached increasing of their number in dry and warm summer 1992. Two mostly xerothermophilous species (*Satyrium spini* and *Melitaea cinxia*), known from the nearest surroundings widen their areal near the main channel and settle on the xerothermophilous stands.

From the point of view of buterfly species occurrence in studied territory in 1992, aridization was most manifested on three monitoring areas near Bratislava, where was ascertained 9-11 xerothermophilous buterfly species. On the other monitoring area is their number lower and mostly is their occurrence felt dependent on ecotons.

On the base of more-years research of buterfly species in the region of the main channel manifest tendence of increasing of xerothermophilous species number with exception of 1991 where after floods in summer period came to more extensive increating of number at important bioindicator of moisture stands-*Lycaena dispar*.

Eleven species and klepton of amphibians on the territory of the Žitný Ostrov (island). Seven of these species are protected in Slovakia, 2 species are entered to the category critically endangered (E), and 7 species to vulnerable (V) species. Salamanders are represented by species *Triturus vulgaris* and *Triturus cristatus dobrogicus*. Frogs are represented by 8 species and one klepton (*Rana esculenta*). Amphibians suffered considerable losses due to the destruction of their habitats and the excessive chemization in agriculture and forestry.

From the reptile group, 9 species live on the Žitný Ostrov (island) area, 7 of them are protected in Slovakia . Three species are listed in the category of endangered (E) and 4 in vulnerable (V). One species of turtles occurred here (*Emys* *orbicularis*); its autochthonous occurrence at the present time has not been confirmed and it has probably disappeared from this territory. Three species of lizards occur here; the species *Lacerta agilis* is relatively abundant, *L.viridis* is rare and *L.vivipara* is seen occasionally at one locality. Snake species *Natrix natrix* and *N.tessellata* are bound to an aquatic environment. *Coronella austriaca* and *Elaphe longissima* have been found only as less abundant ; *E.longissima*, whose occurrence in the inland delta was recorded only exceptionally , has not been found at all over the past years.

At present a total of 210 bird species have been listed in Žitný Ostrov (island); from these, 132 species are nesters and 78 non-nesters, occurring only during migration and hibernation. From this number, 171 species are protected by law, 11 species belong to the category endangered (E) species, 44 to vulnerable (V), 21 to rare (R) and 16 to indeterminate (I) species.

Human impact has influenced number of species and abundance of bird populations. As the most important factors, one may consider a change in the hydrological regime, interventions into the arms systems, replacement of the original forests with plantations of monocultures (poplar and willow), removal of bush growths, old hollow trees, an intensive timber extraction. As a result of this, nesting possibilities have been reduced for aquatic birds, hollow nesters and species building their nests in greater heights. Simultaneously, feeding possibilities for some species have diminished, explicitly for insectivores and those feeding on fish, as well as those feeding on shrub berries and tree seeds in winter. The cutting mode of timber extraction creates only small enclaves of older forests which then attract an unnatural nest concentration. As regards nesting, poplar monocultures are of less significance than the original forest (Fig. 17). Finally this led to a change of the origin species composition, as also of the abundance of the different species. In the past, several bird species have ceased nesting on the territory (e.g. *Haliaetos albicilla, Phalacrocorax carbo, Falco cherrug, Crex crex, Numenius arquata, Sterna albifrons)*; the abundance of several species has decline (e.g. *Botaurus stellaris, Ixobrychus minutus, Rallus quaticus, Porzana parva, Otis tarda, Coracias garrulus, Upupa epops, Anthus campestris*); some bird species that had not nested here in the past, now do so (e.g. *Cygnus olor, Larus ridibundus, Netta rufina, Anas crecca, Aythya ferin, A.fuligula*) and the abundance of some bird species has increased (e.g. during hiberantion *Fulica atra, Larus canus*). During monitoring period, substantial changes in species composition of bird fauna was registered (Fig. 18).

From the total of 49 species of mammals living on the territory of Žitný Ostrov (island), 15 are protected in Slovakia. In the Red Data Book for the ČSFR, one species is listed in the category of extinct (E), 4 are in endangered (E), 11 in vulnerable (V), 2 in rare (R) and 2 in indeterminate (I) requiring further attention.

From mammals the beaver (*Castor fiber*) deserves special attention. This species has been exterminated on the territory in the second half of the 19th century. It again reached the Slovak stretch of the Danube from Austria (where it had been introduced) in the middle of eighties. At present two small colonies of beavers occur near Gabčíkovo.

Fauna of micromammals is in floodplain forest (generally in middle-europaen conditions) represented (70-100%) from three dominant species: *Sorex araneus, Apodemus flavicollis* and *Clethrionomys glareolus*. Absolute number of these three dominant species and their mutual ratio say much more about feeding value of the locality. All three asserted species are more-less dependent on the humidity of environment. *Microtus arvalis* is widened with wideness of cultural steppe. Remarkable is occurrence of relict species *Pitymus subterraneus*, which is very sensitive to human impact.

An altered water regime may heavy affect some species of vertebrates directly dependent on water environment, e.g. *Triturus cristatus* and *T.vulgaris, Lutra lutra, Castor fiber, Rana ridibunda, R.dalmatina, Bombina bombina, Pelobates fuscus, Bufo bufo, Bufo viridis, Hyla arborea, Rana arvalis, R.lessonae, R.esculenta, Natrix natrix, N.tesselata*. Disappearance of wetlands and moist grasslands may cause extinction of the species *Microtus oeconomus*.

As a result of changes in exploatation of the floodplain and increased cutting of old trees with hollows, all the bat species are endangered and some of them may disappear altogether from this territory. But also further groups will be threatened (e.g. *Martes martes, Sciurus vulgaris, Nyctereus procyionides*) which use tree hollows as their dens.

12. SUMMARY OF FAUNISTIC KNOWLEDGE

Aquatic and terrestric fauna of the Danube inland was formed as zoocoenosa of cyclic climax ecosystem. In consequence of hydrotechnical interferences (regulation of navigation line, cutting of arms) and deepening of the Danube river-bed was changed the hydrological regime of the delta with following changes in communities - without respect of GD construction. In water biocoenoses were manifested some elements of transition of the arm system parts from parapotamon to plesio- up palaeopotamon with following adaptive successional changes of planktonic also benthic communities. Changes in watering of the arms to the main channel contemporary marked deterioration of conditions for reproduction of fishes and cutting of arms lost significance as refuges of fishes during flood and as places for wintering. In terrestric ecosystems in consequence of the ground water level decrease was manifested the decrease of the density of hydrophilic species and penetration of euryc and xerophilous species. Incontestable influence to the changes of terrestric zoocoenoses composition had change of origin flooplain forests to monocultures. These changes manifested without direct dependence on GD construction, partialy is possible to consider about undirect connections (cutting of timber). Asserted changes would be continued further without GD construction, its intensity would depend on speed and intensity of changes in the hydrological situation.

In consequence of construction were liquidated communities on the areas occupied by building activities. This changes are definitive. After declining of essential part of discharge from the main channel in stretch Hušov-Palkovičovo came - in consequence of the level decrease - to the single die off fishes and species expressively felt dependent on water stream, which in the main channel and permanently discharged arms created ritralic communities. These communities are able gradually to renew on the base of the assumption, that in the main channel will be created suitable hydrological conditions.

Terrestric communities of animals did not recorded up to this time such drastic changes as aquatic communities; in consequence of the ground water level decrease and also by drainage effect of the main channel on some places (e.g. Dunajské Kriviny) will come to gradual degradation of communities against changes of aquatic communities, slower and towards hydrological changes phasely moved.

For preservation of ecological functions of the inland delta of the Danube river is necessary to preserve present arm system, to fill it by sufficient amount of water permanently to simulate floods, to increase water level in the main channel under the pupose of decreasing of drainage effect, to provide discharge and speed of stream for renewing of torenticolic communities, to provide communication of the arm system and the main channel with respect to renew and preservation of ichtyofauna. These conditions are in a great deal begun to fulfill by damming of the Danube river and watering of the arm system.

IV. CONCLUSIONS

This report is tending to evaluation of impacts caused by the construction of the Gabčíkovo dam to the territory of floodplain forests on the line Bratislava-Palkovičovo. Judges their phytocoenological (syntaxonomical) composition, data about the state of flora and it threateness, evaluates forests from forestry view-point and finally summarizes known results about fauna in this territory.

Evaluation of the floodplain forests conditions and following biotops is related to certain time period, in which were carried out essential changes in the hydropedological regime on the Danube plain.

The oldest part of the territory development, it means up to the establishment of the antiflooded dikes could not be judged, because of from that period there are almost no data. But it was a serious interference influencing the intensity of floods and the hydropedological regime of the whole territory. From origin ecosystems already arised first replaced biocoenoses and it mainly in the interdike space but also in the inland of the plain. During more than 100 years were here created specific conditions to which the whole biota was adapted to. The conditions of the first replaced biocoenoses lasted until the end of fifties, where further antiflooded measures, joined with deepening of the river-bed bottom, setting aside of the side arms and establishment of unpenetrated walls of banks caused the decrease of water level in the Danube river system, but also the ground waters. Erosion activity of the Danube river beneath Bratislava, supported by water constructions on the Danube also in it Austrian and German stretch, lasted to the damming of the Danube in November 1992.

This second period dated by years 1960-1992 signified serious deterioration of life conditions of floodplain forest not only in the upper part, but also in the line Šamorín-Palkovičovo, especially in the interdike place of the Danube river. The decrease of the ground water level in the upper part of the

Danube plain was so intensive, that came to its "tearing off" from soil profile. Forest trees reacted on that fact by lowering of increment, high loss of the leaf area, drying up of more pretentions trees and finally by disappearing of the whole nature biocoenoses. The lack of moisture touched also fauna because of to drier conditions reacted also animals. Hygrophilous species decreased and xerothermophilous increased. This fact confirm also results of monitoring made in last two years (1991-1992).

Authors of this report endeavoured to evaluate the state of biota to above-mentioned two time period as follows:

- The state of floodplain forests and their biota to the end of fifties, concretely to 1960
- The state before damming of the Danube river, it means since 1960-1992.

It is necessary to state, that such procedure could not be used at all judging particles of the biota. With such accent was elaborated phytocoenological map of forest communities (1:50,000) and the map of group of forest types (1:50,000). Also development of tree composition could these time stages to respect. Data about flora and fauna even if summarize all present known organisms could not be evaluated from this aspect.

Prognosis of the floodplain forests development and their biota after damming the Danube river (October 1992), even if there are the first knowledge from the observations in 1993, can be understood only hypothetically. Monitoring of the territory, which has began in 1990, observes impact of the GD construction in the whole scale. The first consequences will be possible to generalize already after 4-5 years.

In spite of that it is possible to come out of the assumption, that by the increasing of the ground water level as also watering of the arm system of the right-side part of the power channel, considerable part of biotops will gradually turn by successive way to "origin state", it means to such, what had been to the end of fifties.

On the base of long-termed knowledge of the floodplain forests development, including their following biotops, and evaluation of all present inforamation authors of this report judge the situation as follows:

a) By finishing of the construction of the antiflooded dikes along the main channel of the Danube river came up to the first change of the natural floodplain forests.

b) In these changed condition was created approximately during 100 years replaced variant, which characterized "natural floodplain forests" with specific biotops of the water and arm system.

c) By antiflooded measures after catastrophic floods in 1954 and 1965 as also by finishing of water constructions on Austrian and German stretch of the Danube river came out to the further decisive changes in the hydropedological regime with tendency of rash decrease of the ground water levels.

d) The decrease of the ground water levels caused gradual drying off floodplain forests finishing especially in the upper part (beneath Bratislava) by disintegration of stand. Reforestation was not able by origin floodplain trees, but was realised by preferring of cultivar poplars.

e) The arm system by the water decrease lost the contact with the Danube waters, was earthed by bog vegetation. The whole environment will have xerothermophilous trend of development, what was reflected also on change of fauna and flora (decreasing of hydrophilous species, increasing of xerothermophilous ones).

f) By lowering of the extent of water areas, shortening of period its wateriness, came to disintegration of reproducing conditions for domestic ichtyofauna (decrease of spawning areas). Lowering of fishes species diversity is except that caused by unruled forms of fishing.

g) By establishing of poplar monocultures from the half of fifties up the damming of the Danube river came to the exchange of natural forests to managed forests. Managed monocultures before damming of the Danube river covered about 80 % and natural forests only 20 % from the total area.

h) Also in managed poplar monocultures, with regard to the decrease of the ground water level, came to the lowering of timber increment and decisive loss of leaves.

i) Gaining of the optimal timber increment in monocultures was possible to reach only by coming in light to the whole crown of cultivars. Increasing of the light intensity in field layer made dependent upon weeding by neophytic plants. It came to the devalvation of natural values also of these replaced ecosystems.

j) By weeds devastated herb layer of monocultures became as the centre for widening of neophytic species also to natural forests.

k) By disintegration of natural floodplain forests, diminished trees which by their specifity (type of crown, bark, hollow) rendered nesting and other life conditions of fauna, which missing in cultivar poplars monocultures. In consequence of that numerous number of fauna species were lost from territory. Lost of nesting conditions touched also of the bats.

l) Changed environment of the herb layer rendered the other character of trophic conditions for animals. Besides that marked essential deterioration of nutric conditions for hoof animals (mainly deer ones).

From about-mentioned results, that the total development of floodplain forests was in unsuccess of their origin (natural) state during 1960-1992

It came following changes by the construction of water dam :

a) Permanent occupation of floodplain forests on the areas of the Hrušov dike, power and flowing off channel, penetrated channels and other various building and communicating objects, which is estimated to 30 % of the total area (area of floodplain forests from Bratislava to Palkovičovo 10,700 ha, occupied 3,276 ha).

b) Lowering of the arela (local area of wideness) for origin fauna and flora on the permanent occupied territory.

c) Change of floodplain forests stand composition beneath watering of the Hrušov dike to the object of watering the system of dead arms.

d) Disintregation of small forests enclaves in the inland for decrease of ground humidity along the left bank of the power channel.

e) Single dying of fishes and further particles of fauna after turning aside of the essential part of discharge to the power channel (old main channel of the Danube river).

f) Deterioration of life conditions for deer animals by cutting of migrated ways by the Hrušov dike and the power channel for nutric worthy food (inland agricultural landscape).

Above-mentioned negative changes is possible to reconcile by following measures:

a) Planting of new stands on recent building areas, which is preliminary planned on the area of 570 ha, what means lowering of forests occupied by GD to the mark of 25 % (accepted project).

b) Reforestation of already established "Ornitological island" about area 2.3 ha in the Hrušov dike by origin floodplain trees; increase possibilities for nesting of aquatic birds (accepted project).

c) By planned reconstruction of the small forests enclaves by artificial reforestation.

Positive consequences:

Damming of the Danube river and watering of the system of dead arms including simulation of floods enables gradual return of the ecological conditions in floodplain forests and their following biotops to the conditions of the end of sixties. It means the stabilization of these ecosystems, to which could not come without the Gabčíkovo dam construction.

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VI. ENCLOSURES

Table 1

Changes in distribution of groups of forest types and its tree composition before and after constructionof the Gabčíkovo dam

groups of forest types	distribution (planary and percentage) of groups of forest types			tree composition	
	before construction	after construction	difference	origin	present
Corneto - Quercetum (CoQ)	185 ha 1,8%	30 ha 0,4%	155 ha	oaks, limetree, cornel, (elm)	oak, limetree, maple, cornel
Ulmeto - Fraxinetum carpineum (UFrc) hard floodplain forests	3,380 ha 32,6%	1.833 25,6%	1,547 ha	elm, oak, ash, domestic poplars, limetree, maple, (hornbeam)	ash, oak, maple, domestic poplars, cultivar poplars, limetree
Ulmeto - Fraxinetum populeum (UFrp)	4,000 ha 38,6%	2,850 ha 39,7%	1,150 ha	elm, oak, ash, domestic poplars, aspan,	cultivar poplars
Querceto - Fraxinetum (QF)	1,482 ha 14,3%	2,850 ha 39,7%	1,150 ha	oak, ash, domestic poplars, aspan,	cultivar poplars
total area of transitional floodplain forests	5,482 ha 52,9%	4,236 ha 59,0%	96 ha		
Saliceto - Alnetum (SAL) soft floodplain forests	1,300 ha 12,7%	1,077 ha 15,0%	232 ha	willows, alder, domestic poplars,	willows, alder, domestic poplars, cultivar poplars,
TOTAL	**10,356 ha**	**7,176 ha**	**3,180 ha**		

Table 2

Changes of typological characteristics in upper part of the Gabčíkovo dam and in interdike space of derivate part of the Danube river (in % of total area)

groups of forest types	upper part		interdike space	
	1976	1990	1976	1990
soft floodplain forests	1,45	0,95	18,00	19,00
transitional floodplain forests	32,12	0,15	79,00	81,00
hard floodplain forests	60,86	91,29	3,00	0,00
other forests	5,57	7,61	0,00	0,00

Table 3

Stand area, stand growing stock and annual harvesting in the Gabčíkovo dam territory

	years	stand area ha	stand growing stock total (m^3)	stand growing stock per ha (m^3)	annual harvesting m^3
upper part Rusovce	1976 - 1985	from 3,206 to 2,875 up to 1,624	78,571	—	24,903
	1986 - 1995	1,633	179,129	110	3,760
low part Šamorín	1972 - 1981	to 2,788	428,684	153	23,950
	1982 - 1986	1,807	297,116	164	21,312
	1987 - 1991	1,802	215,882	119	12,972
	present	1,492	—	—	—
low part Gabčíkovo	1972 - 1981	2,204	326,217	148	22,403
	1982 - 1986	2,035	268,598	131	20,200
	1992 - 1994	2,063	313,576	152	25,000

Table 4

Distribution of stand bonity with main tree (cultivar poplar and oak) in 1990

	bonity class	distribution of stands in bonity classes (% of area)	
		cultivar poplar	oak
upper part	from +1 to 1	0 .00	21 .82
	2 to 3	15 .57	67 .99
	4 to 5	31 .84	8 .19
	6 to 7	40 .63	2 .00
	8 to 9	11 .95	0 .00
low part	from +1 to 1	22 .06	oak has very small distribution bonity was not ascertained
	2 to 3	34 .07	
	4 to 5	24 .72	
	6 to 7	11 .11	
	8 to 9	8 .04	

Table5

Mean annual increment of thickness (in breast hight) and tree hight of samples on permanent monitoring areas

	parameter	1991		1992	
		variation interval	mean	variation interval	mean
upper part monitoring areas 13 - 24	mean annual increment of thickness (in cm)	0.2 - 2.4	0.96	0.2 - 0.8	0.52
	mean annual increment of hight (m)	0.1 - 0.9	0.58	——	——
low part monitoring areas 1 - 12	mean annual increment of thickness (in cm)	0.2 - 2.6	1,31	0.4 - 1.3	0,87
	mean annual increment of hight (m)	0.1 - 3.5	1,32	0.0 - 2.2	0,7

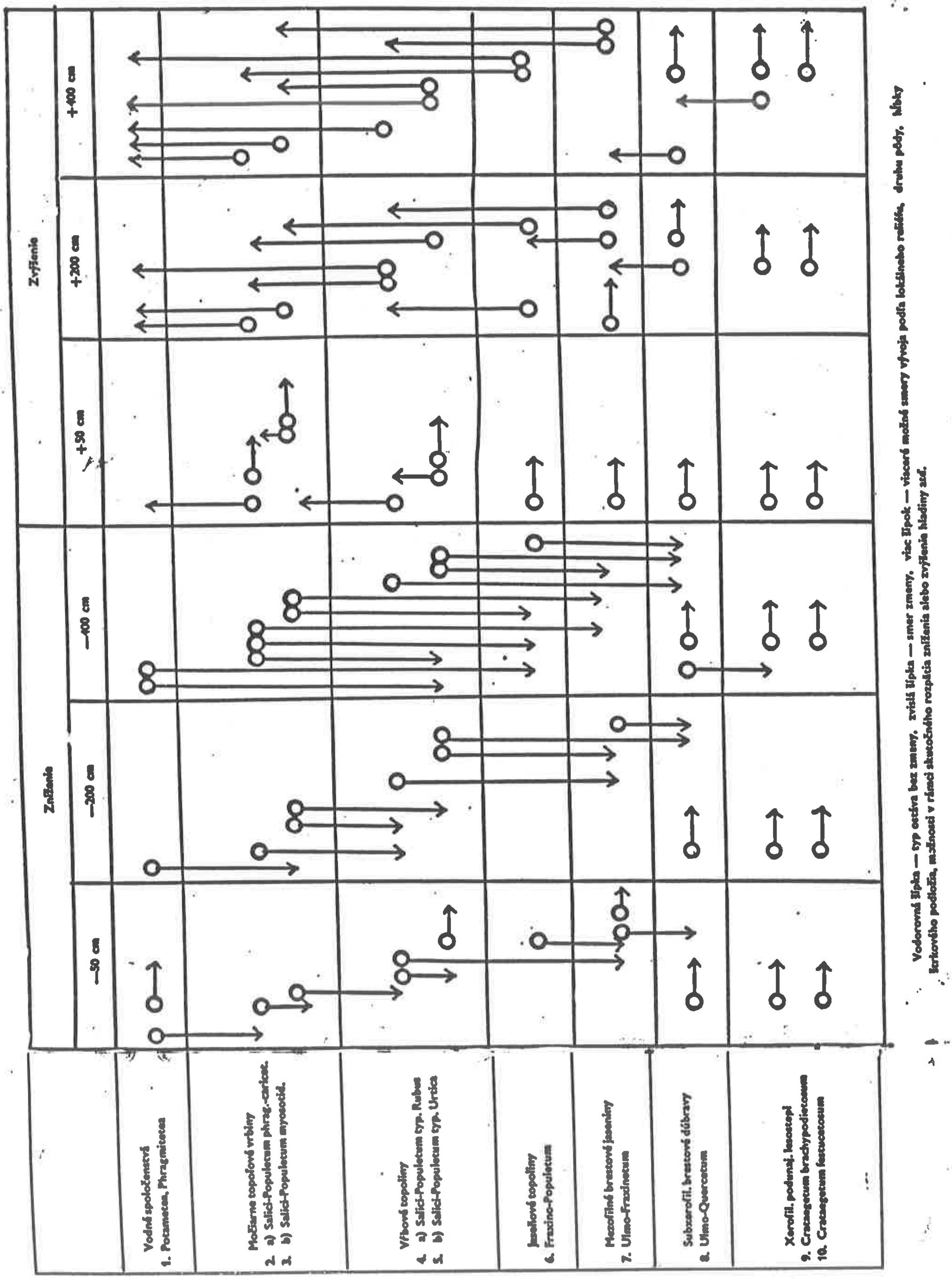


Figure 1: Supposed changes of floodplain forests phytocoenoses after lowering or increasing of the ground water level (JURKO, 1976)

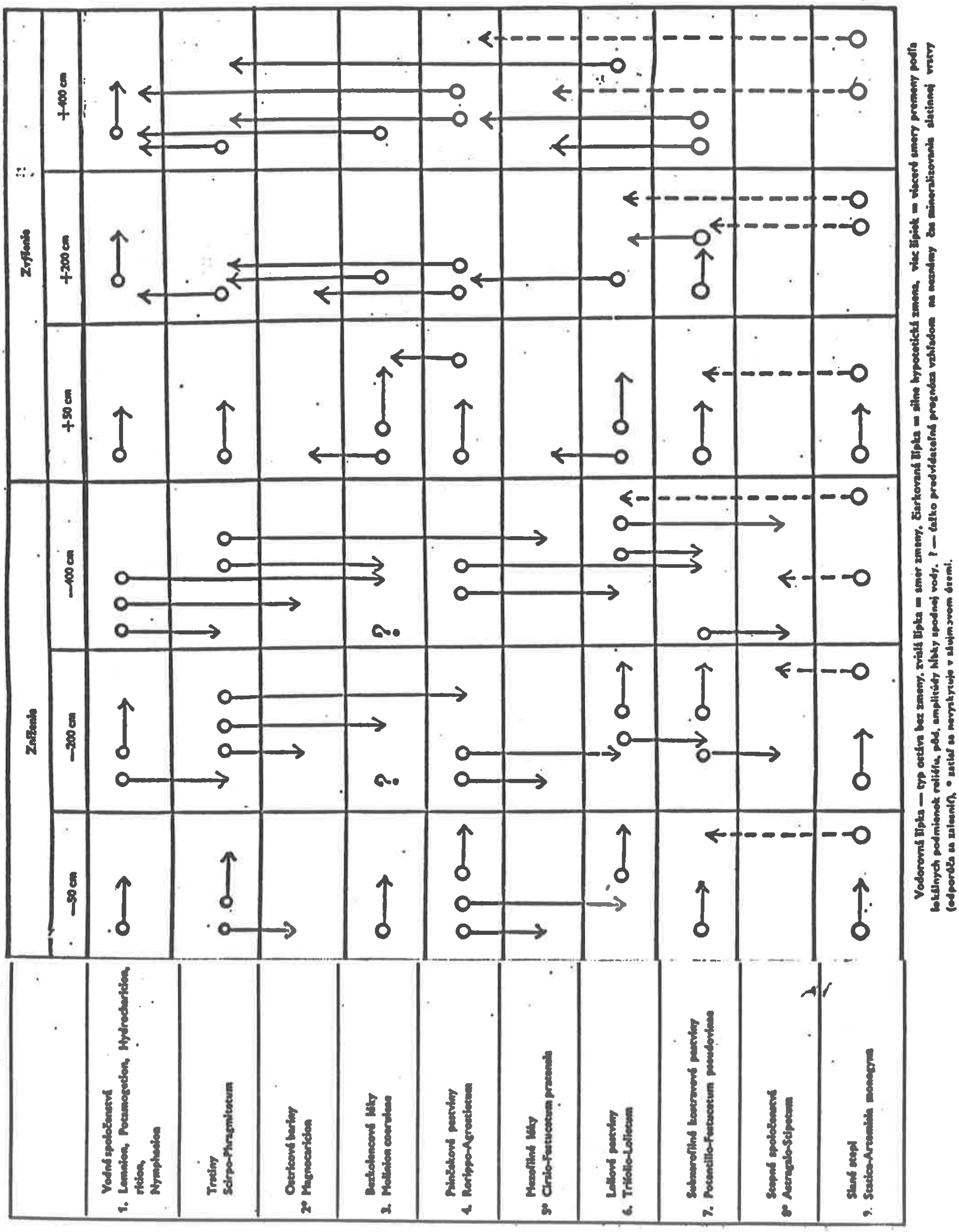


Figure 2: Supposed changes of the phytocoenoses of the grassy succession serie after lowering or increasing of the ground water level

SITUAČNÝ NÁČRT LESOV ZABRATÝCH VÝSTAVBOU VODNÉHO DIELA GABČÍKOVO

SKETCH OF FORESTS OCCUPIED BY CONSTRUCTION OF THE GABČÍKOVO DAM TERRITORY

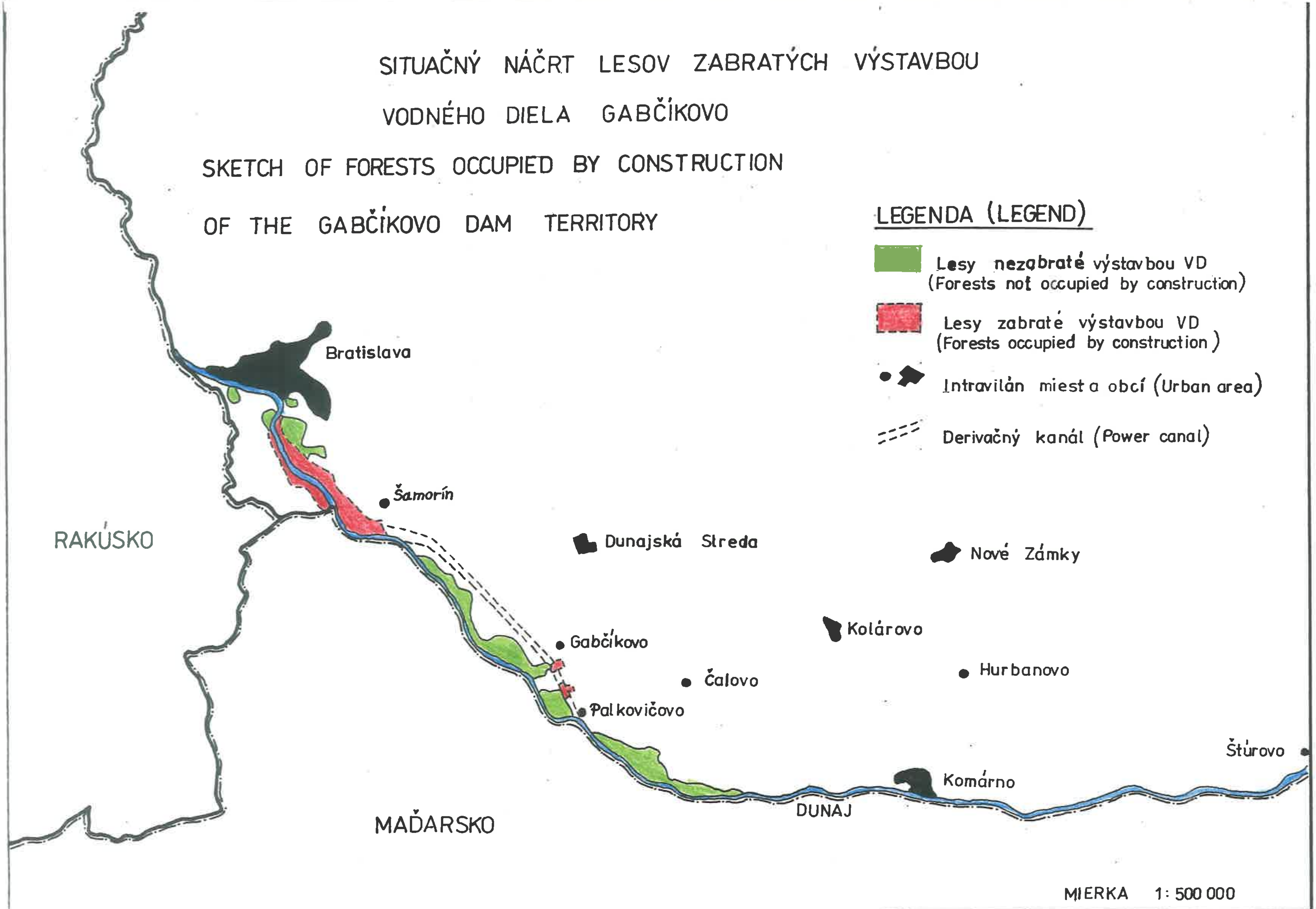


Figure 3

Number of species according to degree of threatenless of plant genofund in the Gabčíkovo dam territory (by Maglocký 1983)

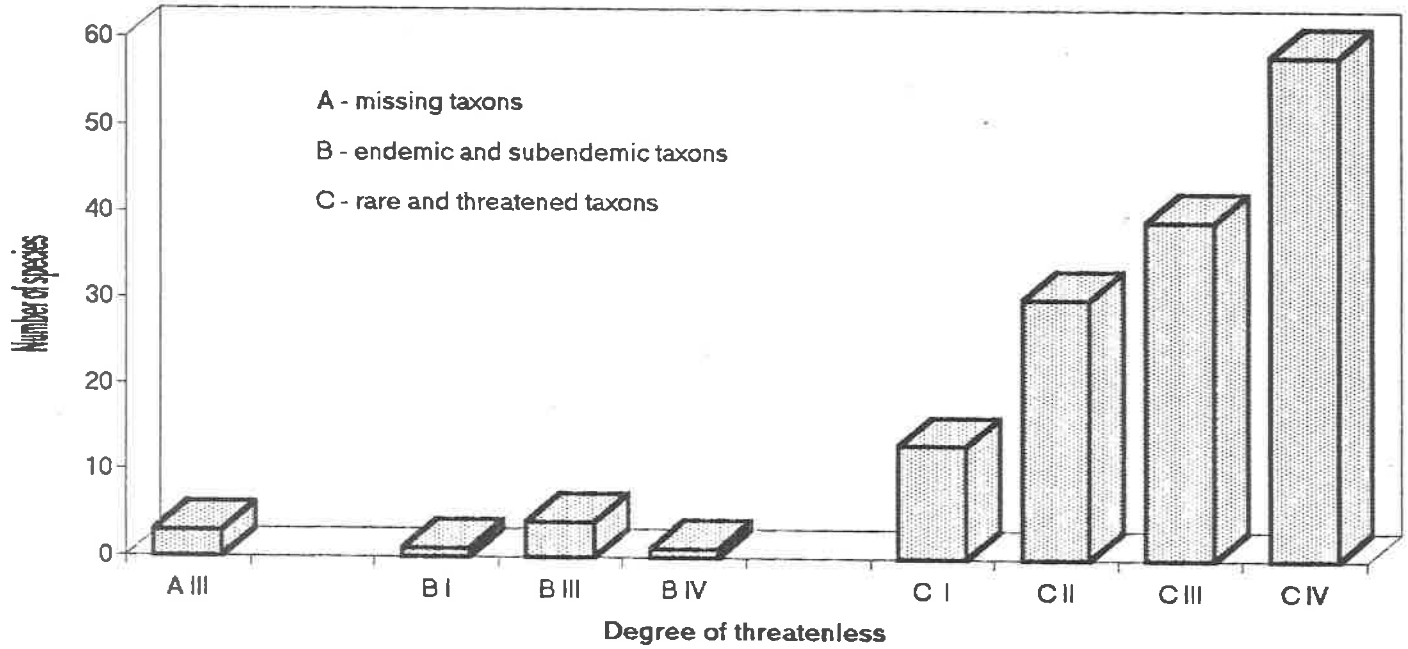
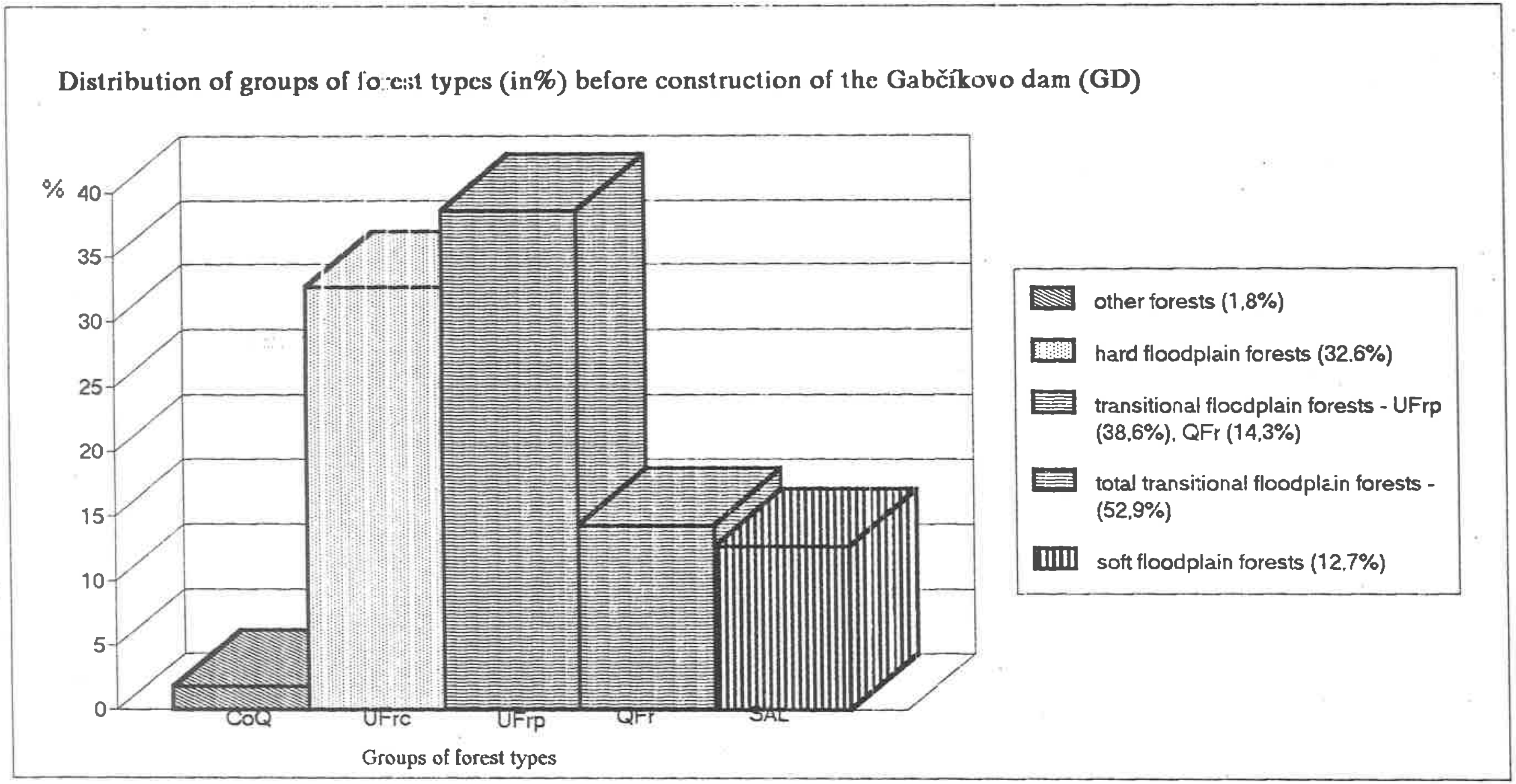


Figure 4



Distribution of groups of forest types (in%) before construction of the Gabčíkovo dam (GD)
%
40
35
30
25
20
15
10
5
0
CoQ
UFrc
UFrp
QFr
SAL
Groups of forest types
other forests (1,8%)
hard floodplain forests (32,6%)
transitional floodplain forests - UFrp (38,6%), QFr (14,3%)
total transitional floodplain forests - (52,9%)
soft floodplain forests (12,7%)

Figure 5

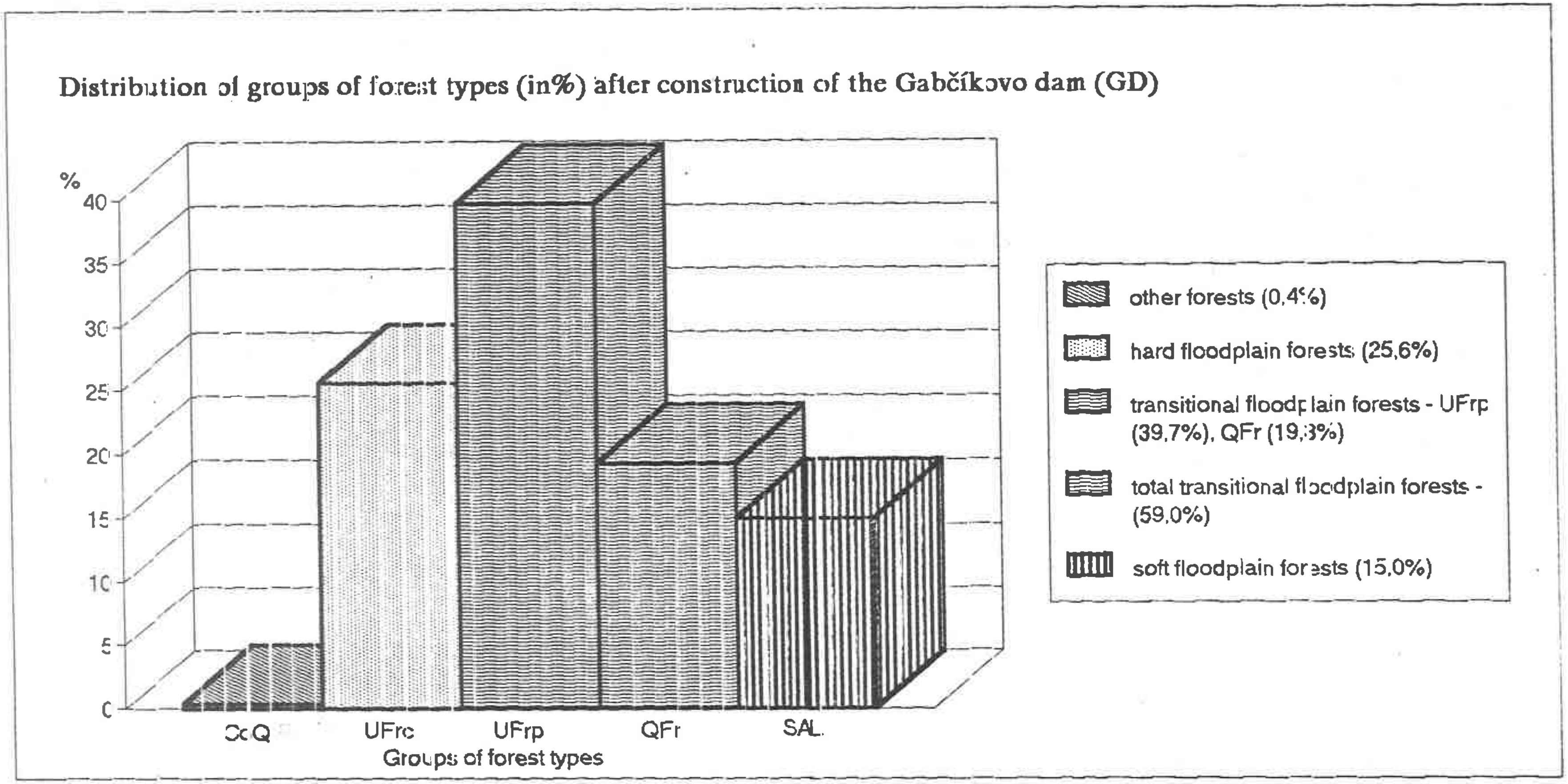

Distribution of groups of forest types (in%) after construction of the Gabčíkovo dam (GD)
%
40
35
30
25
20
15
10
5
0
CcQ
UFrc
UFrp
QFr
SAL
Groups of forest types
other forests (0,4%)
hard floodplain forests (25,6%)
transitional floodplain forests - UFrp (39,7%), QFr (19,3%)
total transitional floodplain forests - (59,0%)
soft floodplain forests (15,0%)

Figure 6

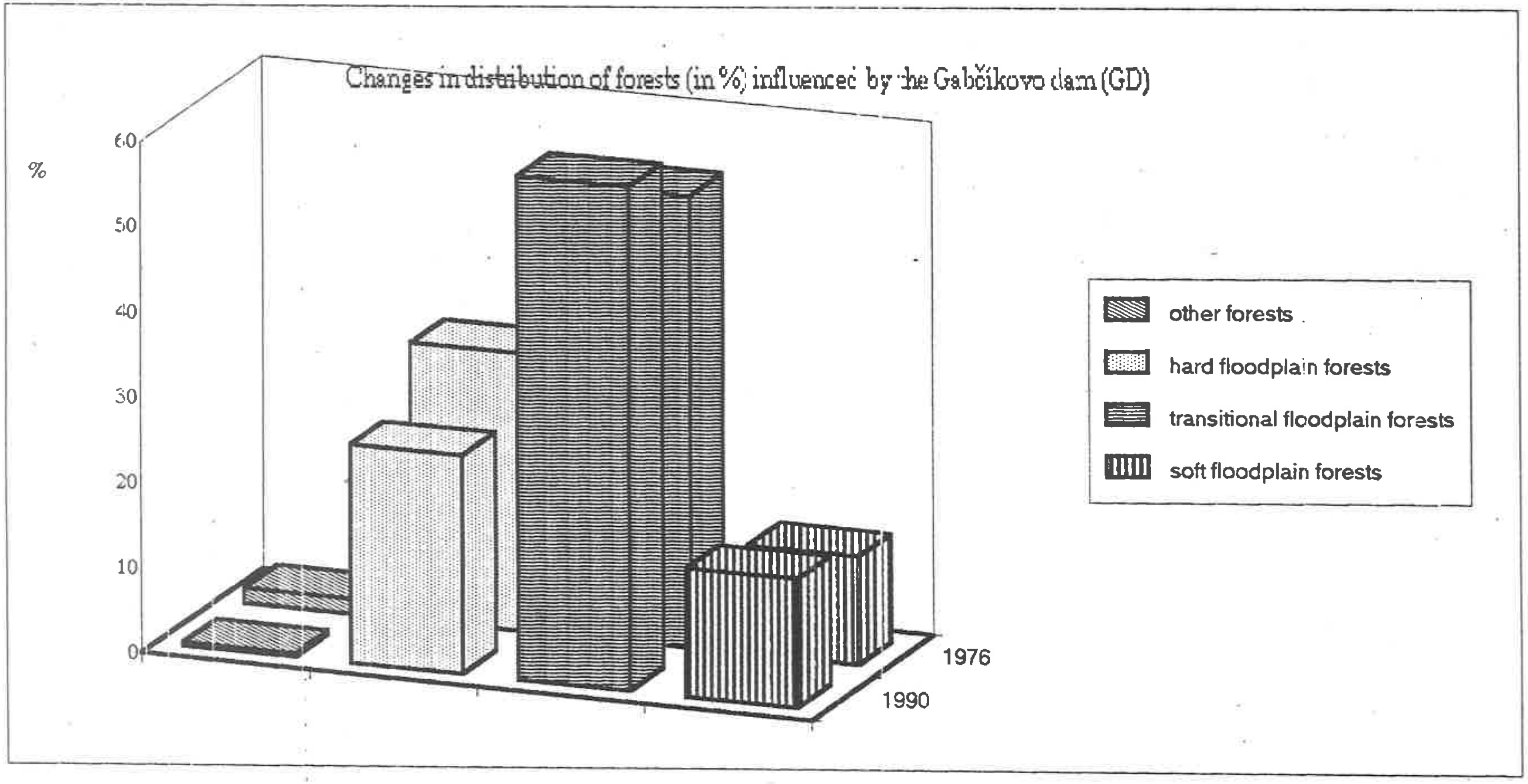

Changes in distribution of forests (in %) influenced by the Gabčíkovo dam (GD)
%
60
50
40
30
20
10
0
1976
1990
other forests
hard floodplain forests
transitional floodplain forests
soft floodplain forests

Figure 7

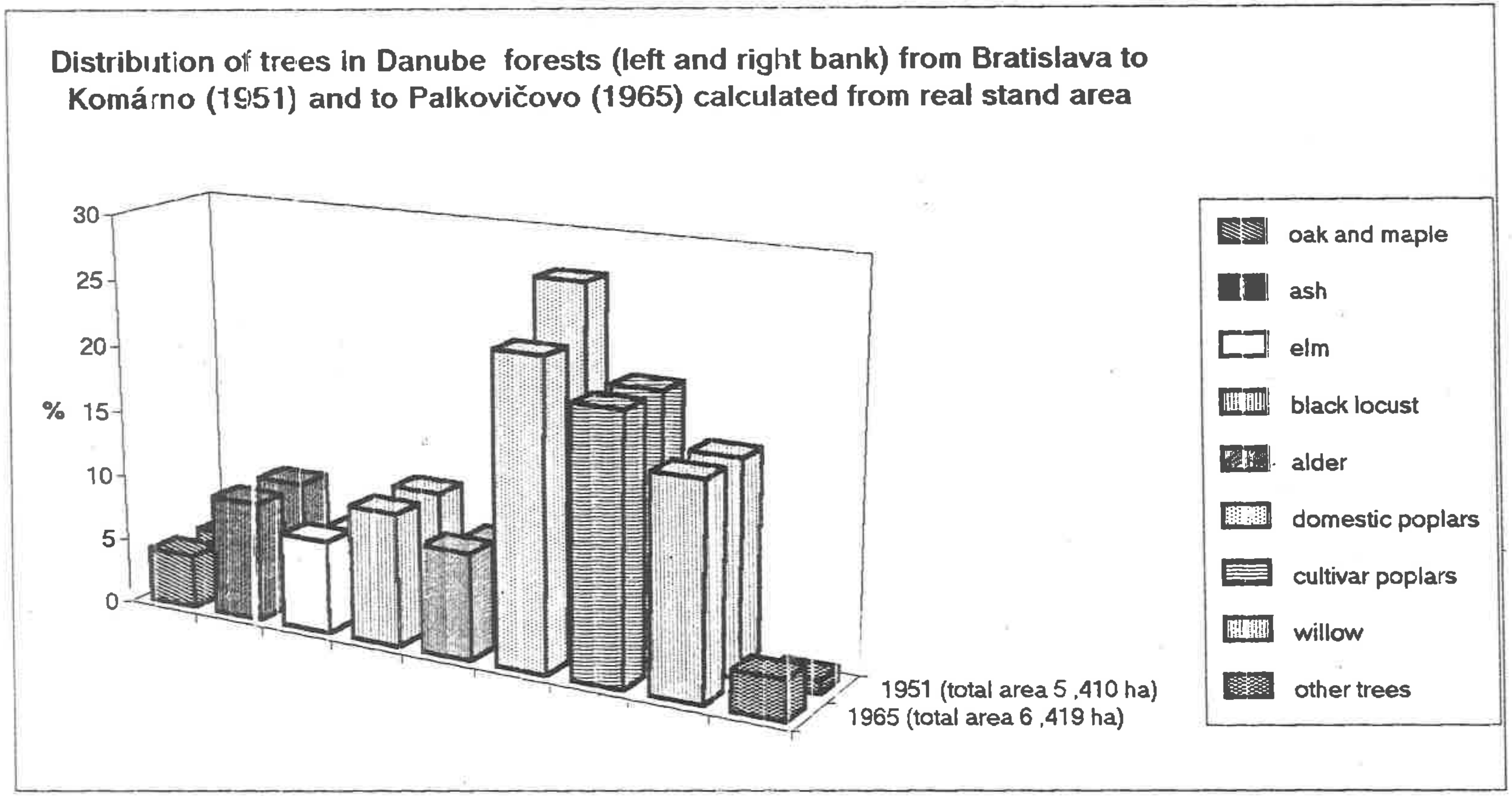

Distribution of trees in Danube forests (left and right bank) from Bratislava to Komárno (1951) and to Palkovičovo (1965) calculated from real stand area
30
25
20
% 15
10
5
0
1951 (total area 5 ,410 ha)
1965 (total area 6 ,419 ha)
oak and maple
ash
elm
black locust
alder
domestic poplars
cultivar poplars
willow
other trees

Figure 8

Upper part - Distribution of trees in forest district Rusovce calculated from real stand area

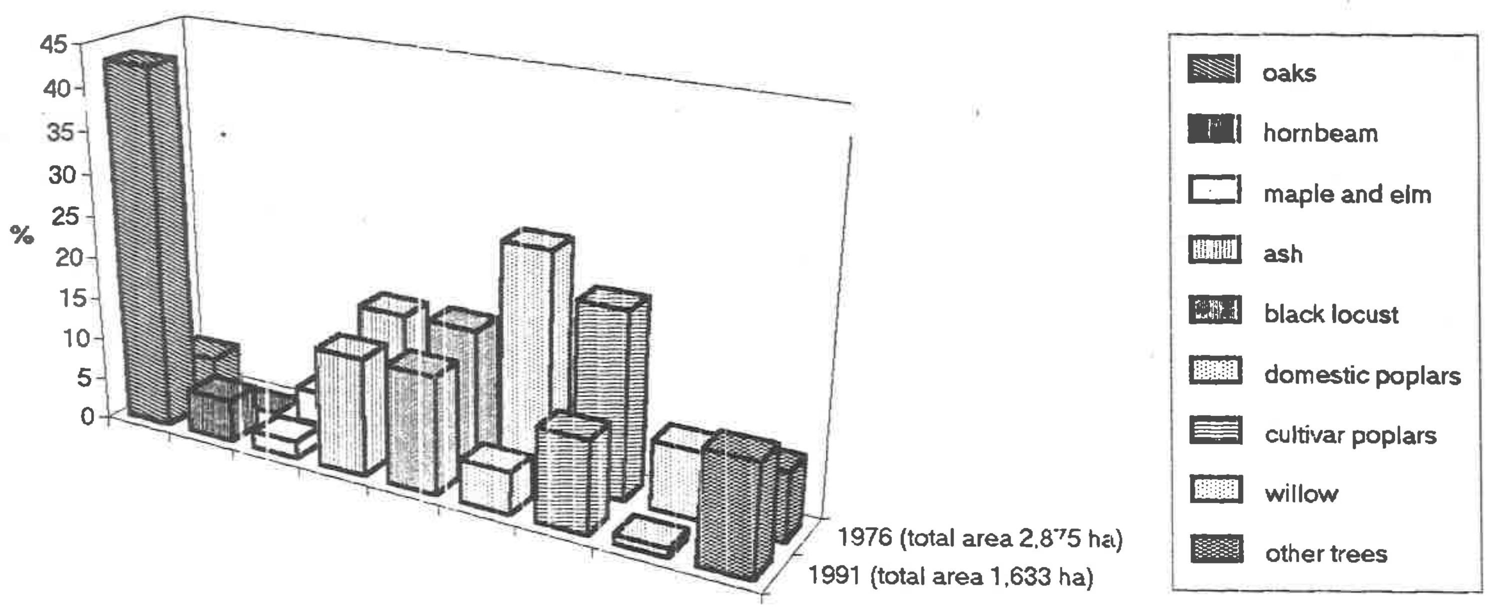


Figure 9

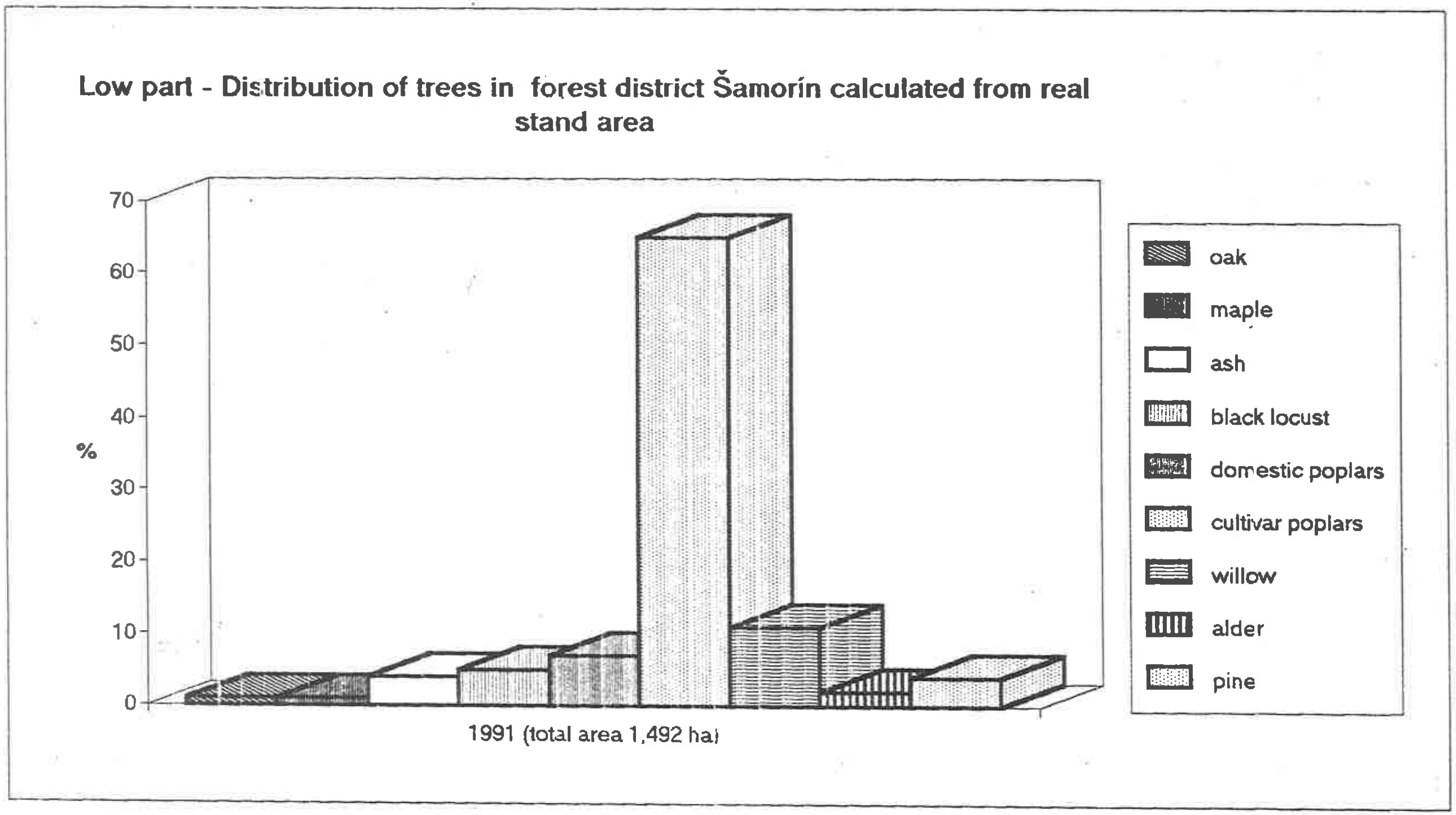

Low part - Distribution of trees in forest district Šamorín calculated from real stand area
%
70
60
50
40
30
20
10
0
1991 (total area 1,492 ha)
oak
maple
ash
black locust
domestic poplars
cultivar poplars
willow
alder
pine

Figure 10

Low part - Distribution of trees in forest district Gabčíkovo calculated from real stand area

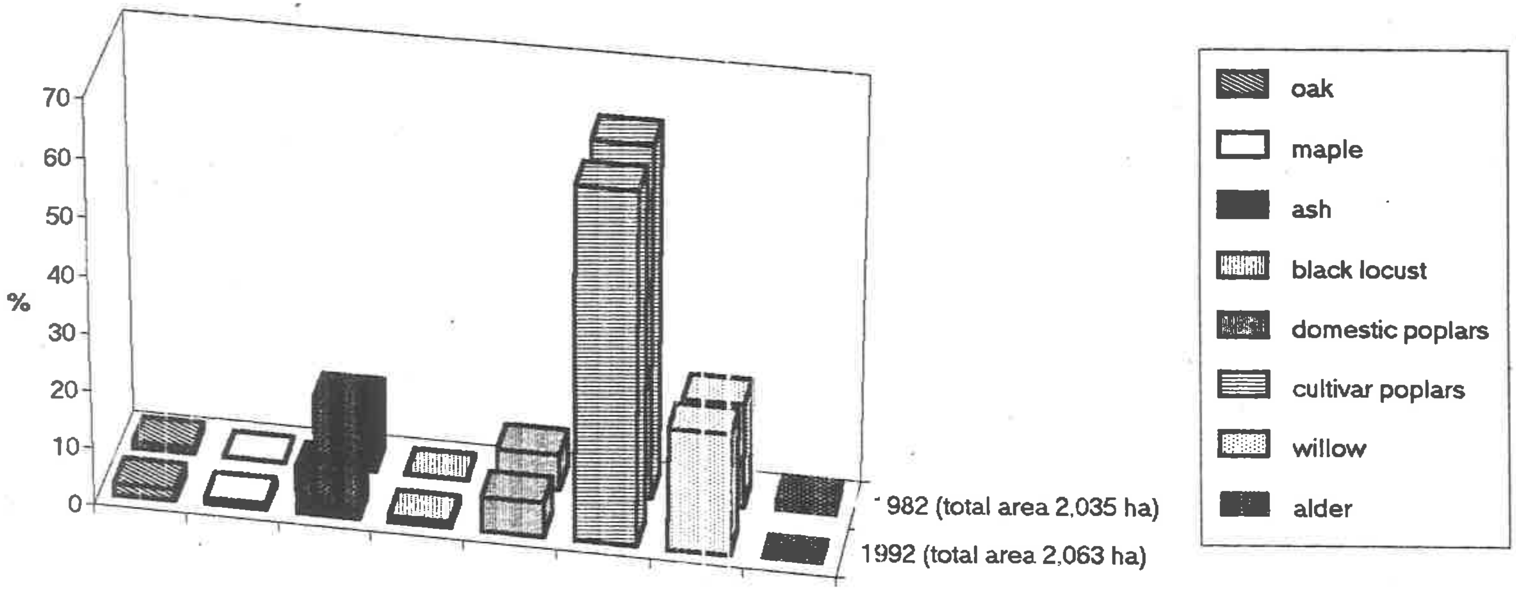


Figure 11

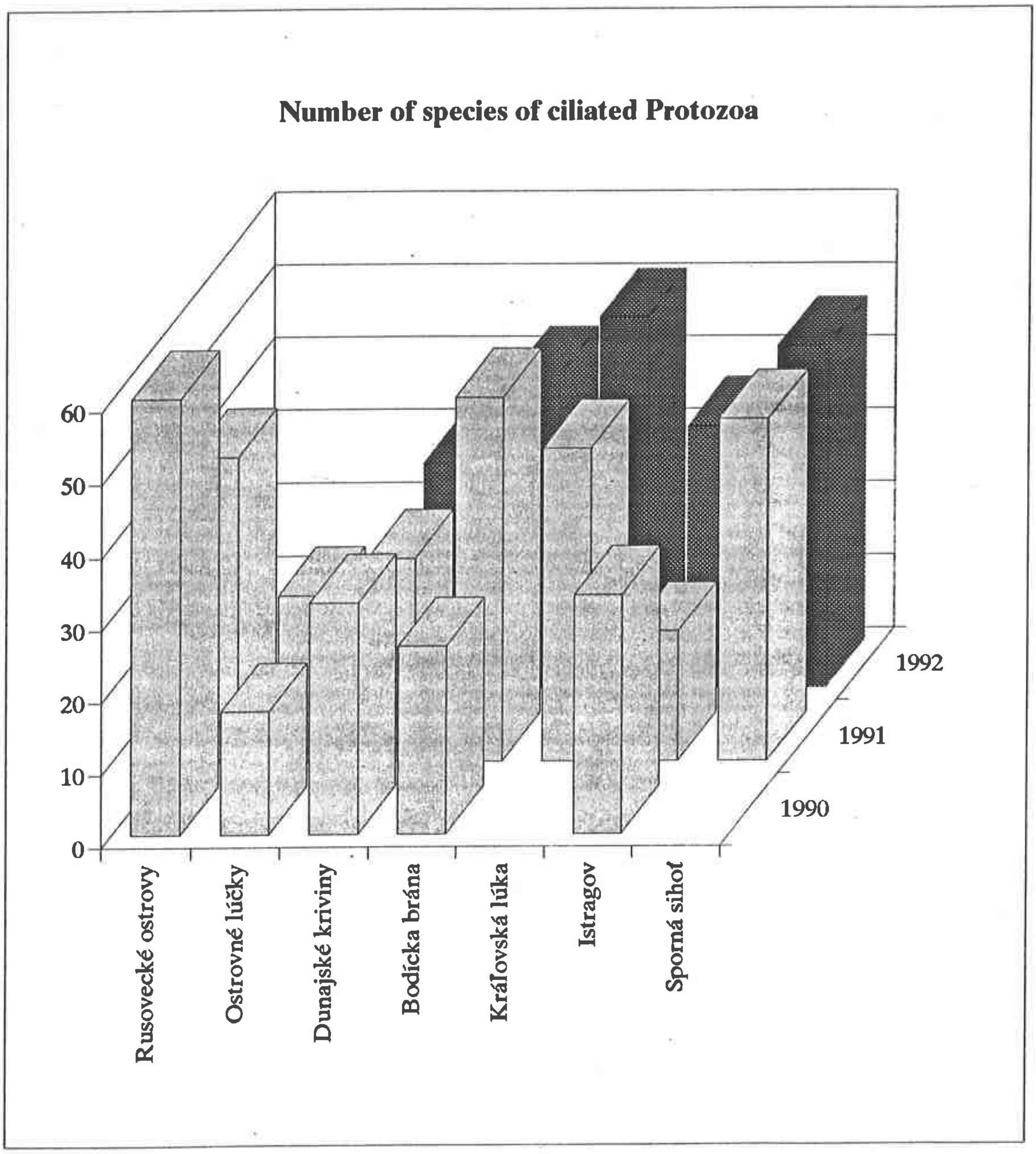

Number of species of ciliated Protozoa
60
50
40
30
20
10
0
1992
1991
1990
Rusovecké ostrovy
Ostrovné lúčky
Dunajské kriviny
Bodícka brána
Kráľovská lúka
Istragov
Sporná sihoť

Figure 12

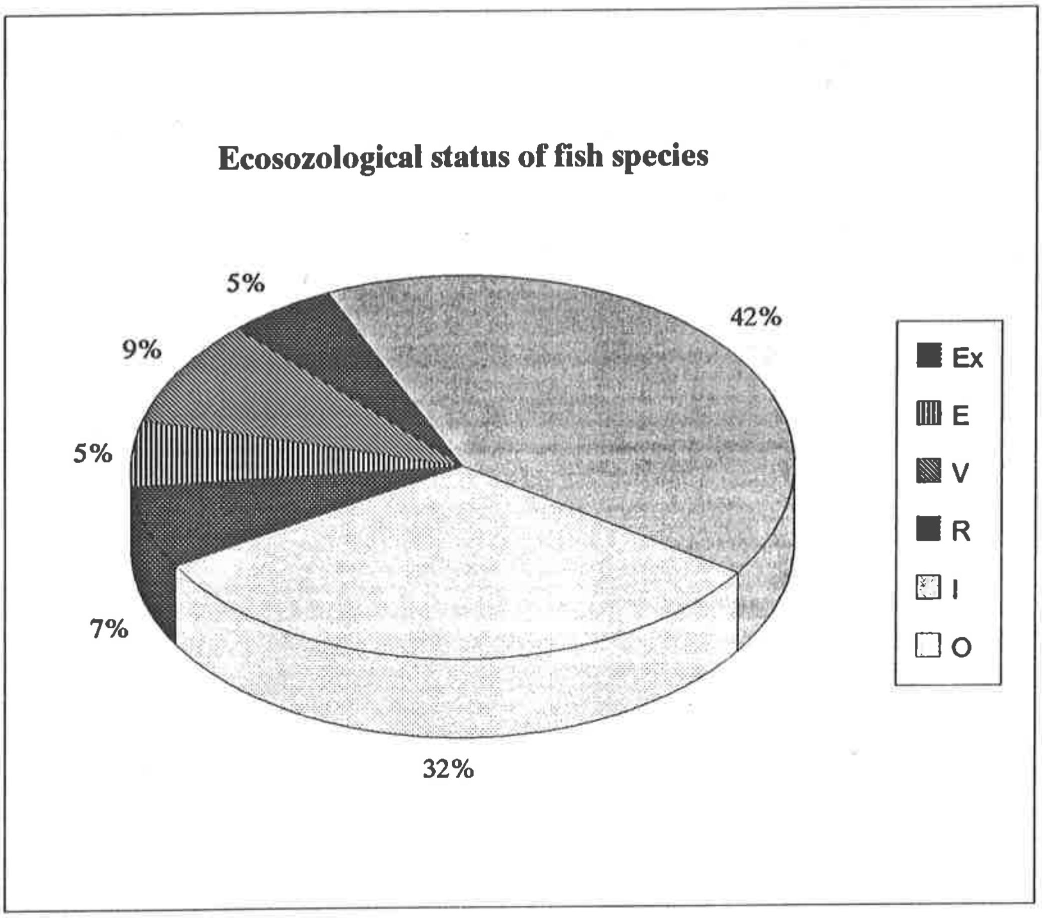
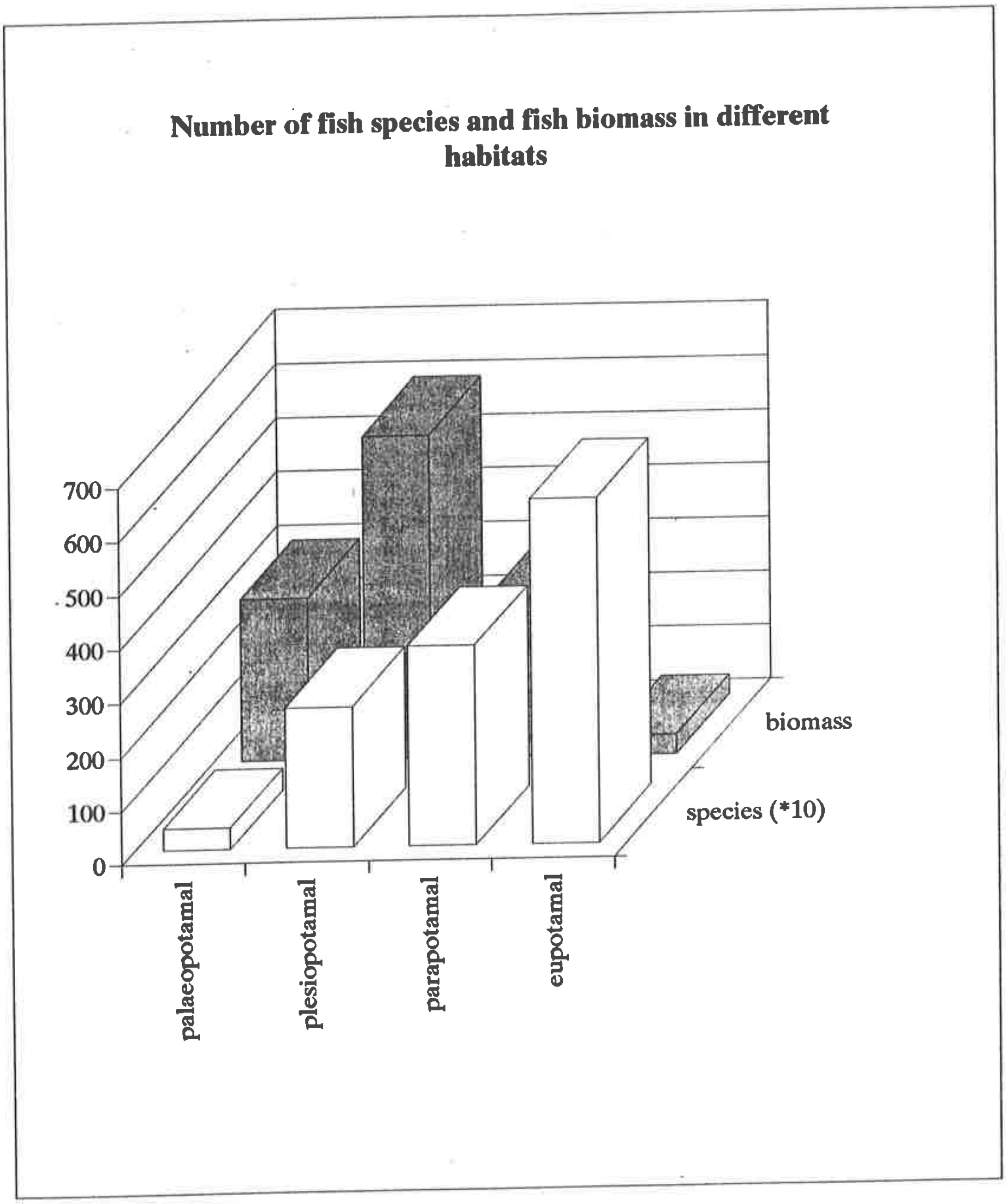
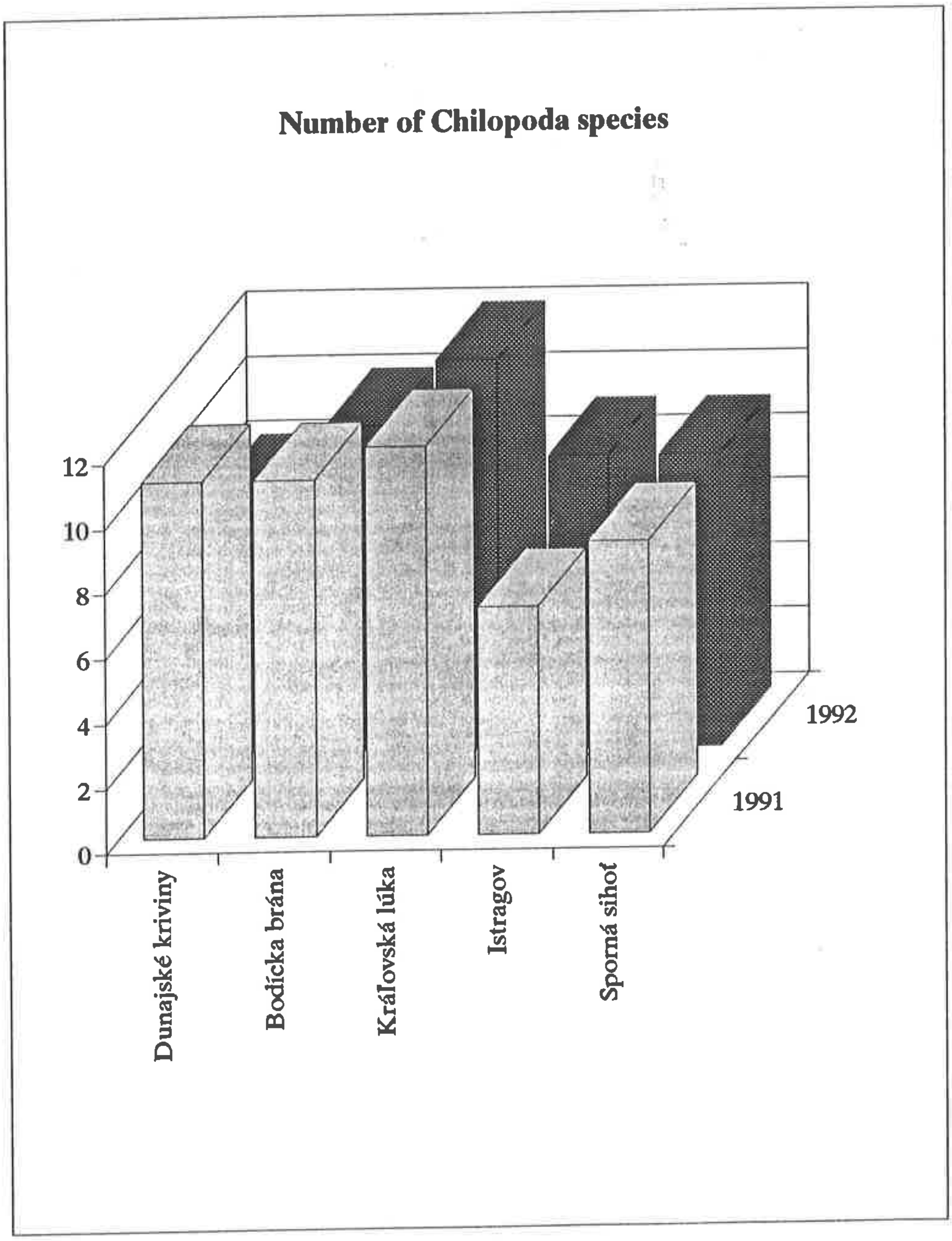


Figure 13



Number of fish species and fish biomass in different habitats
700
600
500
400
300
200
100
0
palaeopotamal
plesiopotamal
parapotamal
eupotamal
biomass
species (*10)

Figure 14



Number of Chilopoda species
12
10
8
6
4
2
0
1992
1991
Dunajské kriviny
Bodícka brána
Kráľovská lúka
Istragov
Sporná sihoť

Figure 15

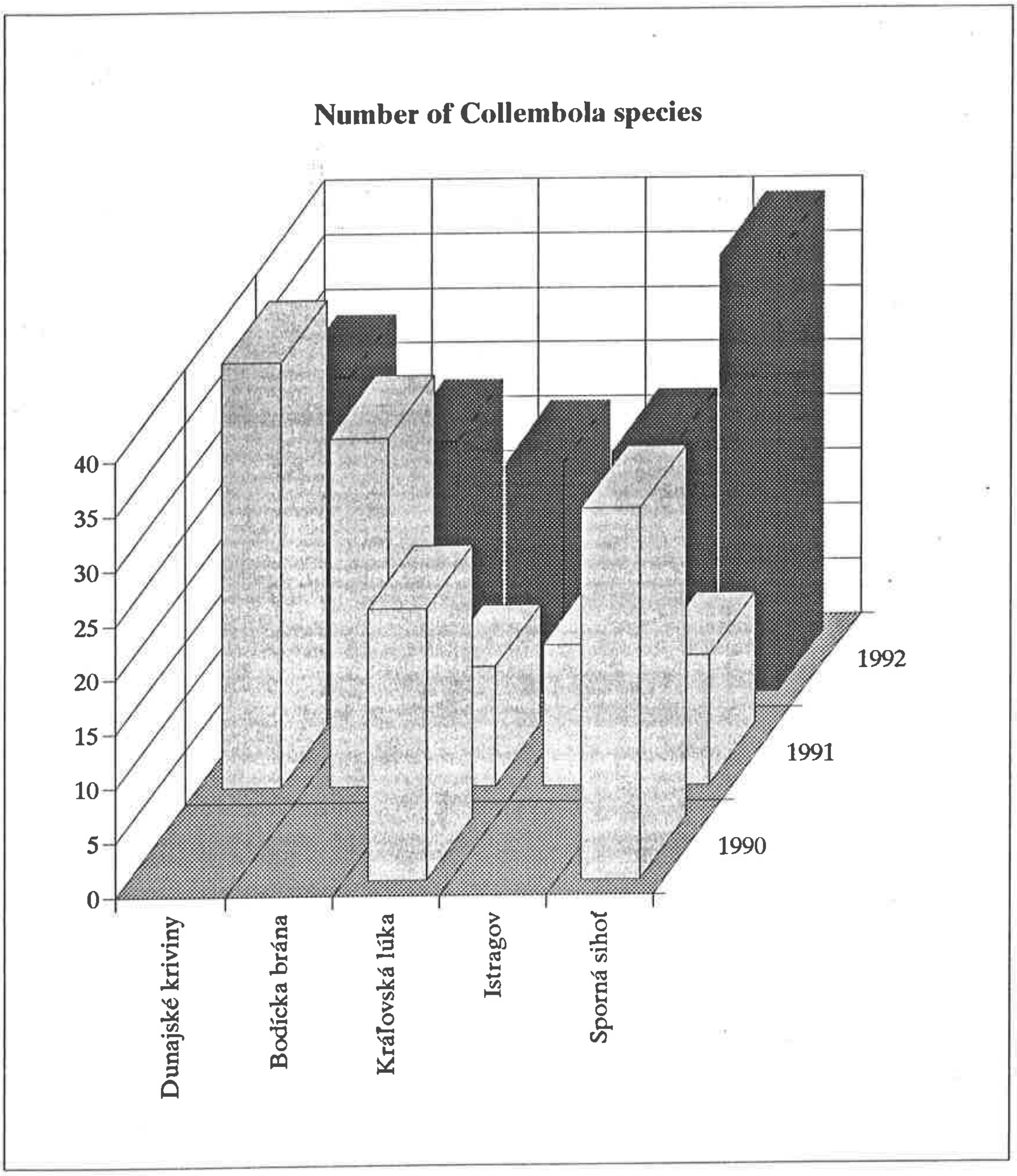
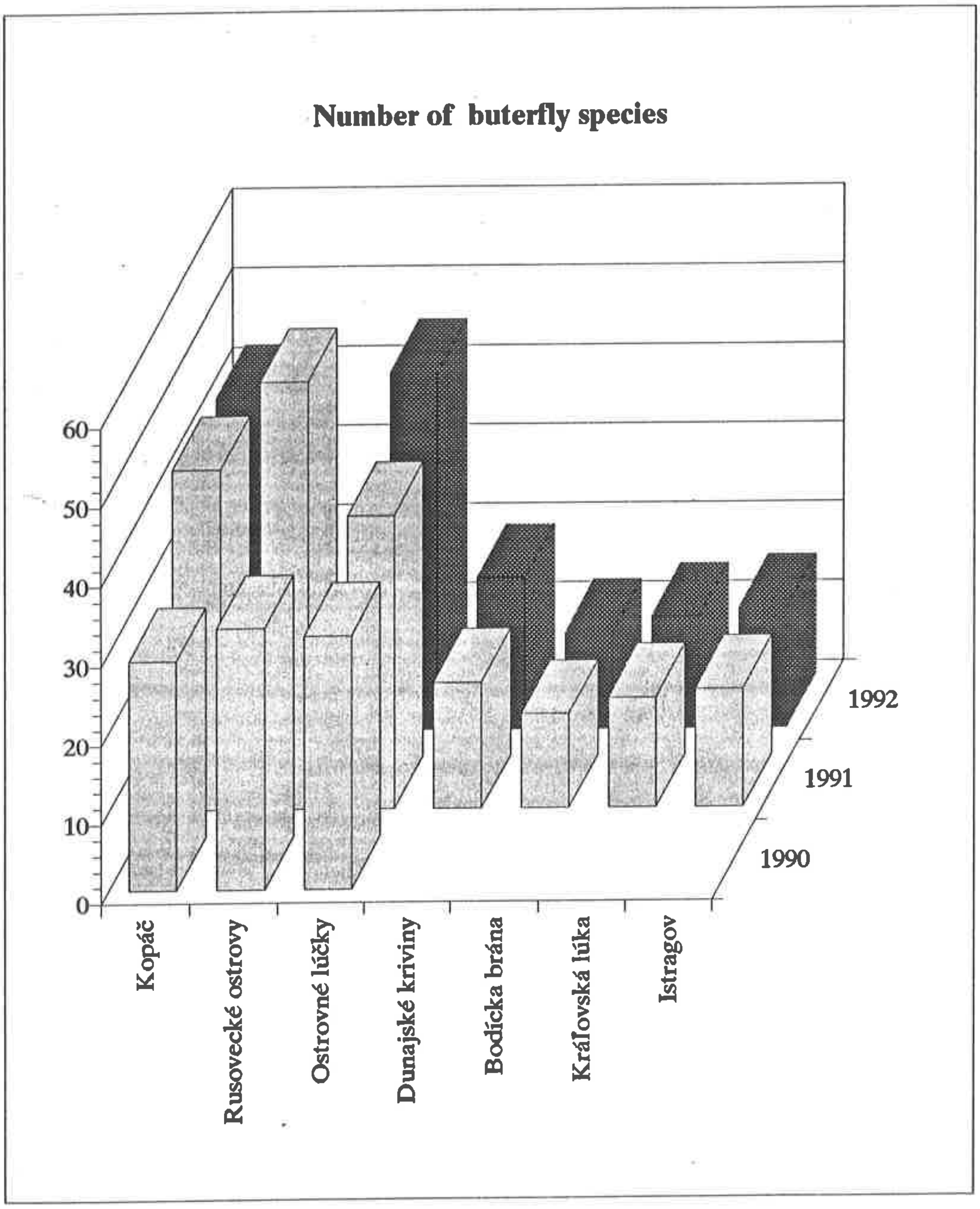

Number of Collembola species
40
35
30
25
20
15
10
5
0
Dunajské kriviny
Bodícka brána
Kráľovská lúka
Istragov
Sporná sihoť
1990
1991
1992

Figure 16



Number of buterfly species
60
50
40
30
20
10
0
1992
1991
1990
Kopáč
Rusovecké ostrovy
Ostrovné lúčky
Dunajské kriviny
Bodícka brána
Kráľovská lúka
Istragov

Figure 17

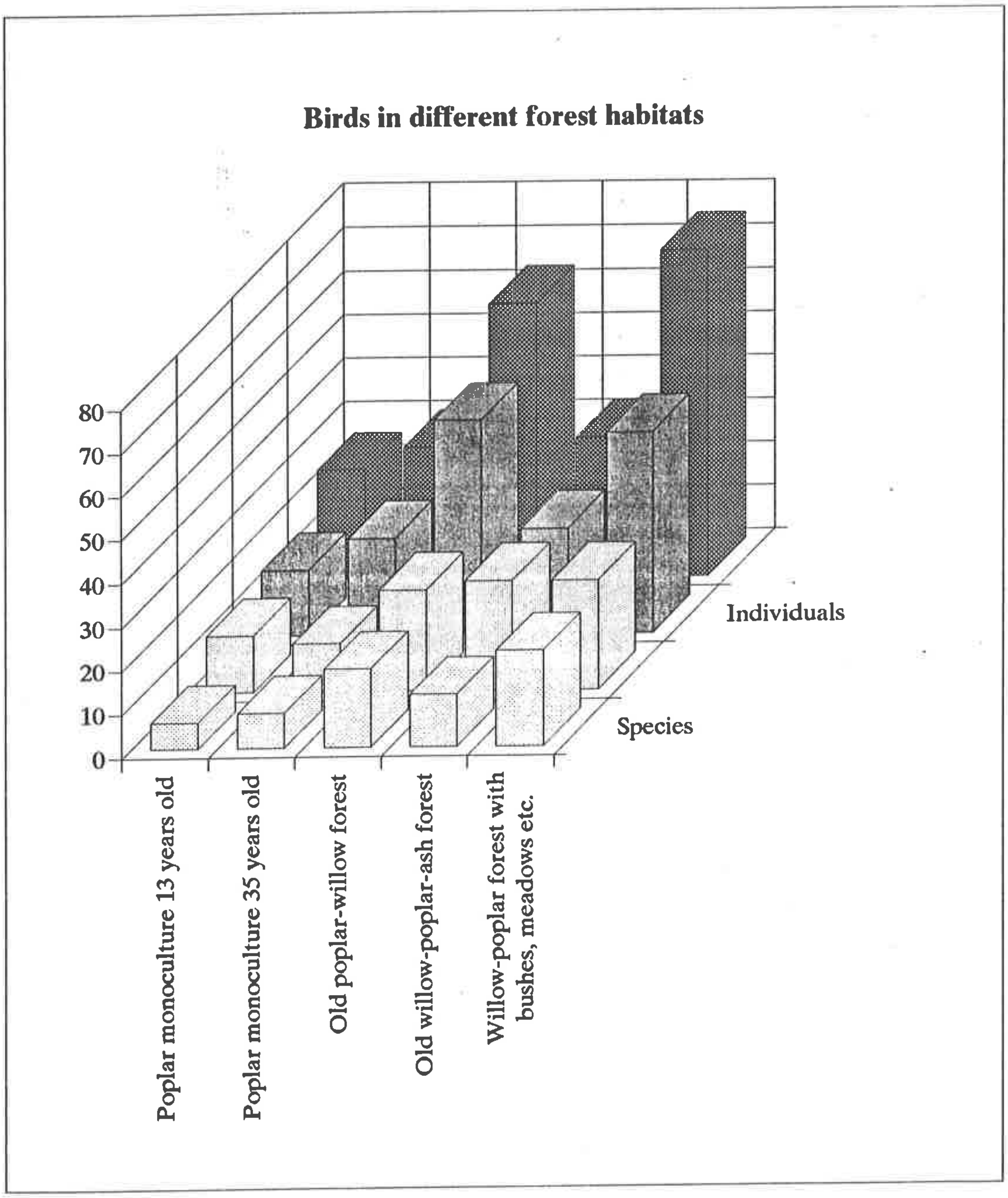
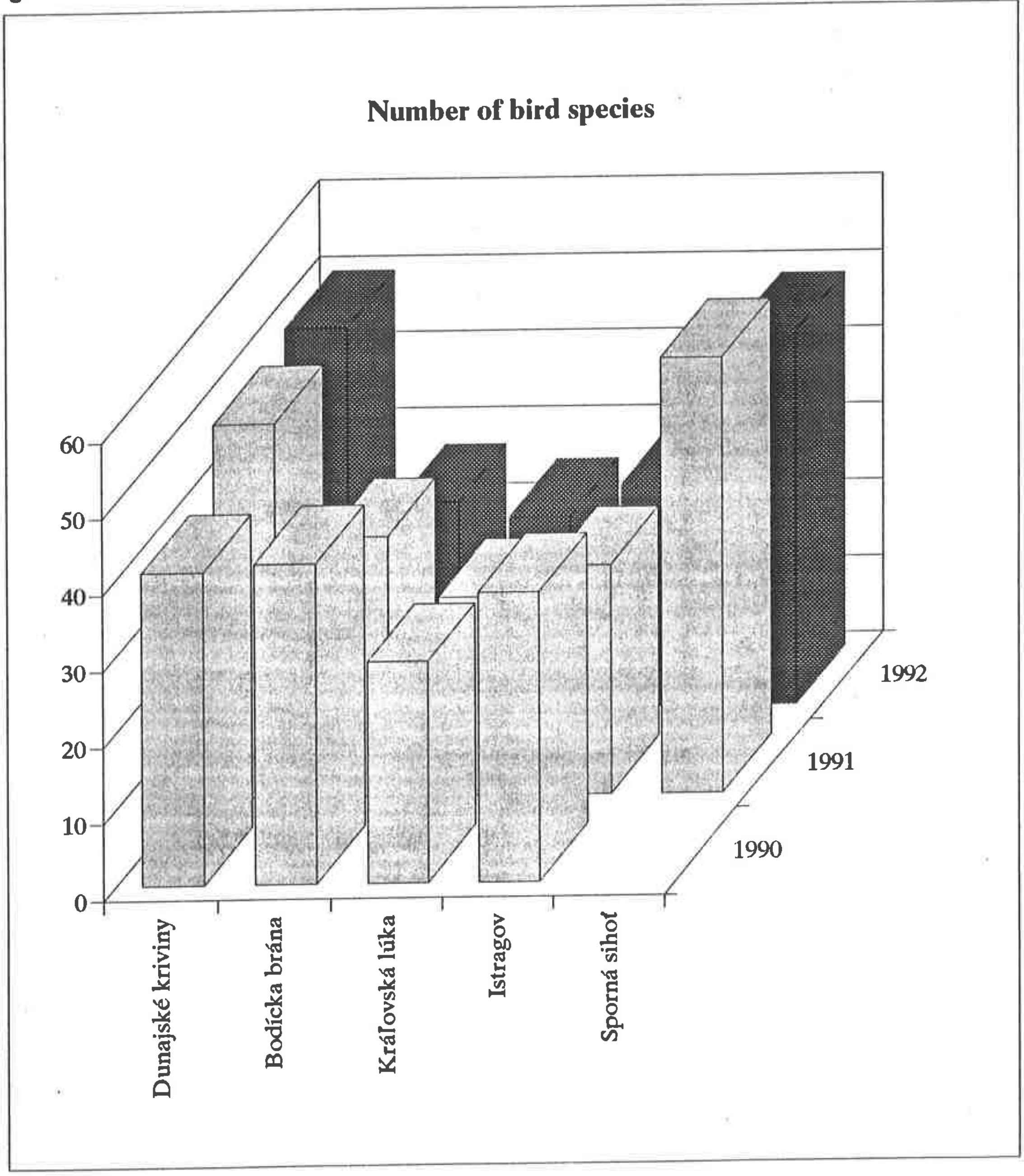

Birds in different forest habitats
80
70
60
50
40
30
20
10
0
Individuals
Species
Poplar monoculture 13 years old
Poplar monoculture 35 years old
Old poplar-willow forest
Old willow-poplar-ash forest
Willow-poplar forest with bushes, meadows etc.

Figure 18


Number of bird species
60
50
40
30
20
10
0
1992
1991
1990
Dunajské kriviny
Bodícka brána
Kráľovská lúka
Istragov
Sporná sihoť

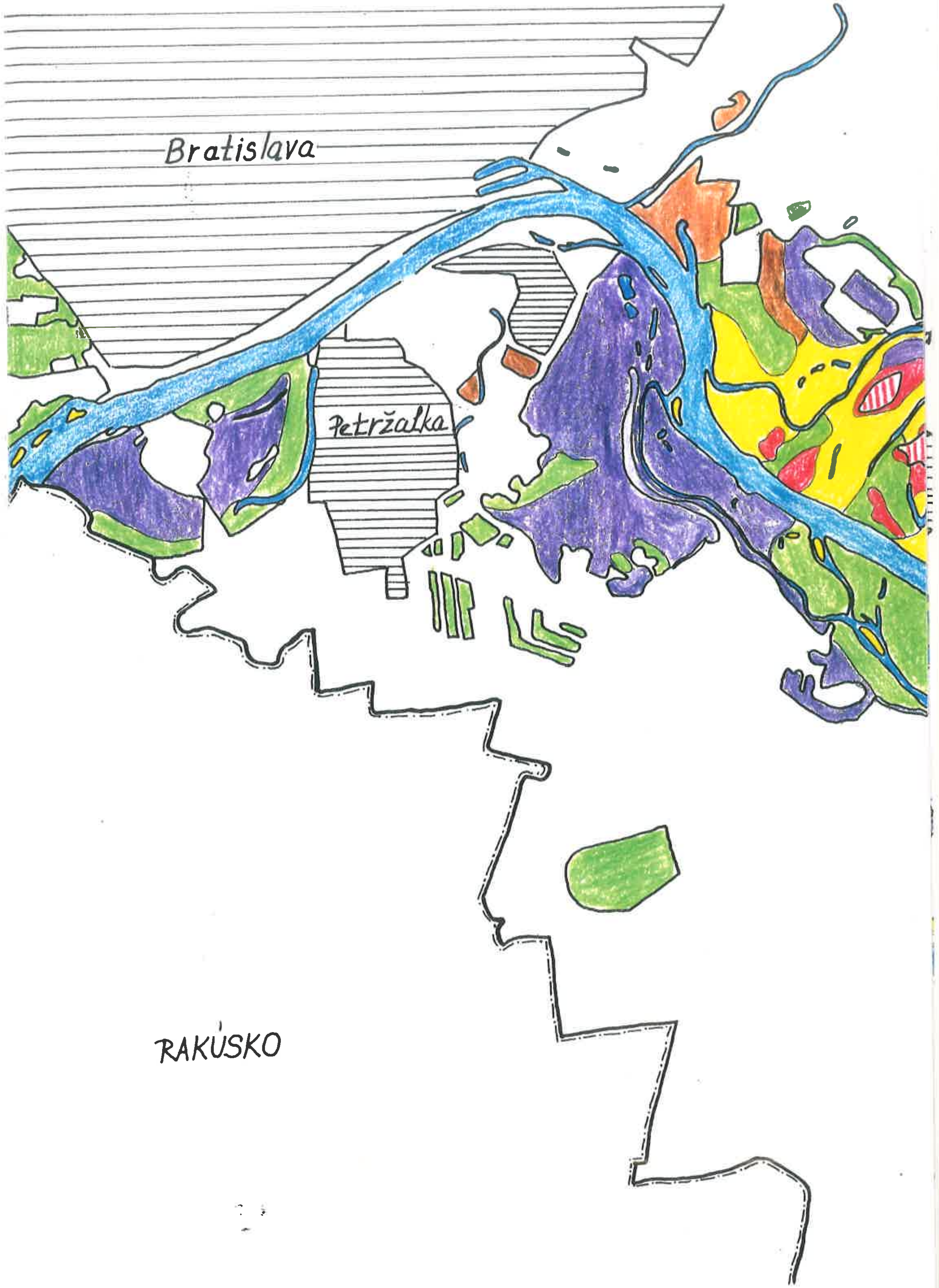
PHYTOCOENOLOGICAL MAP OF FLOODPLAIN FORESTS IN THE GABČÍKOVO DAM TERRITORY

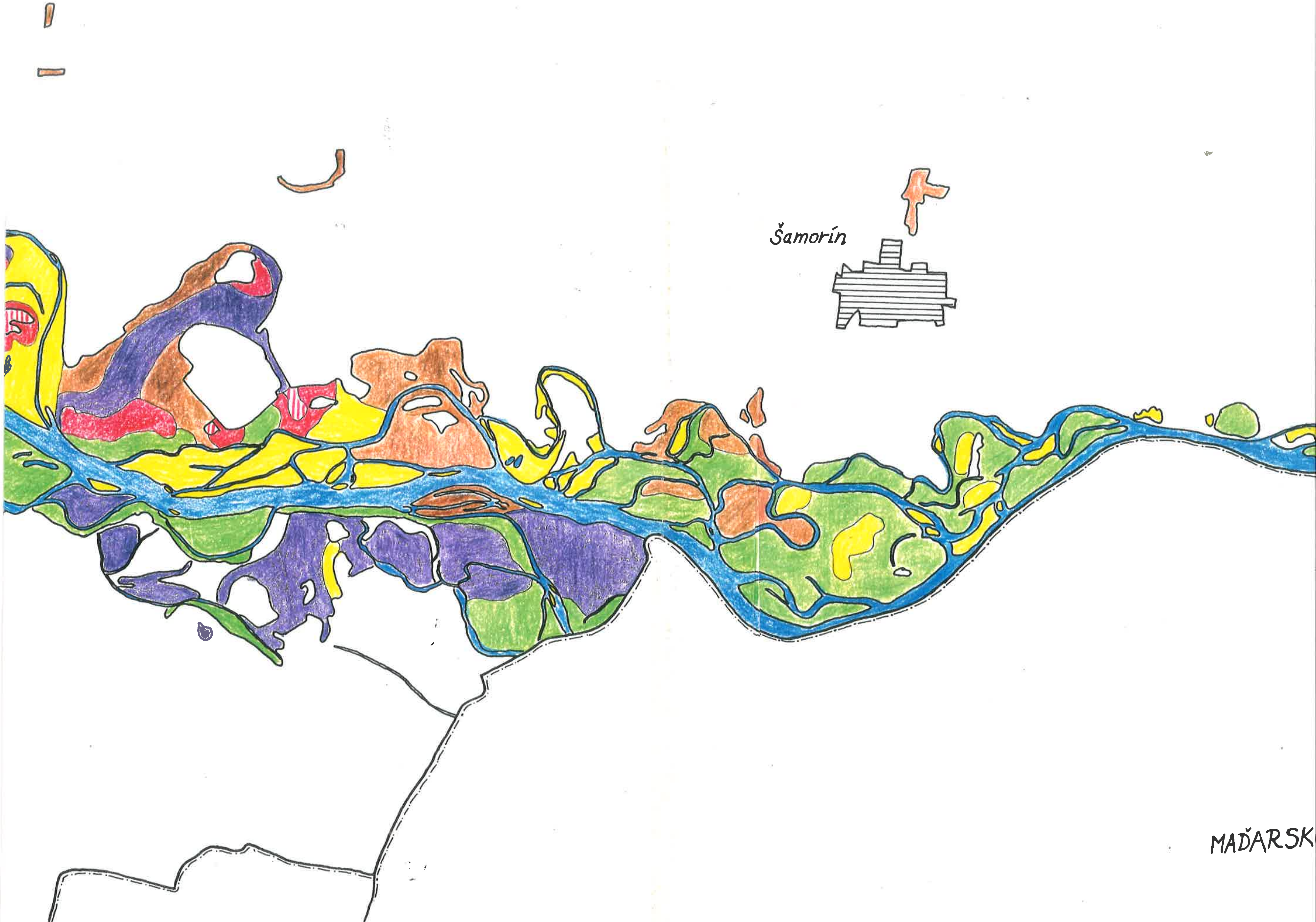
Condition in 1960 year

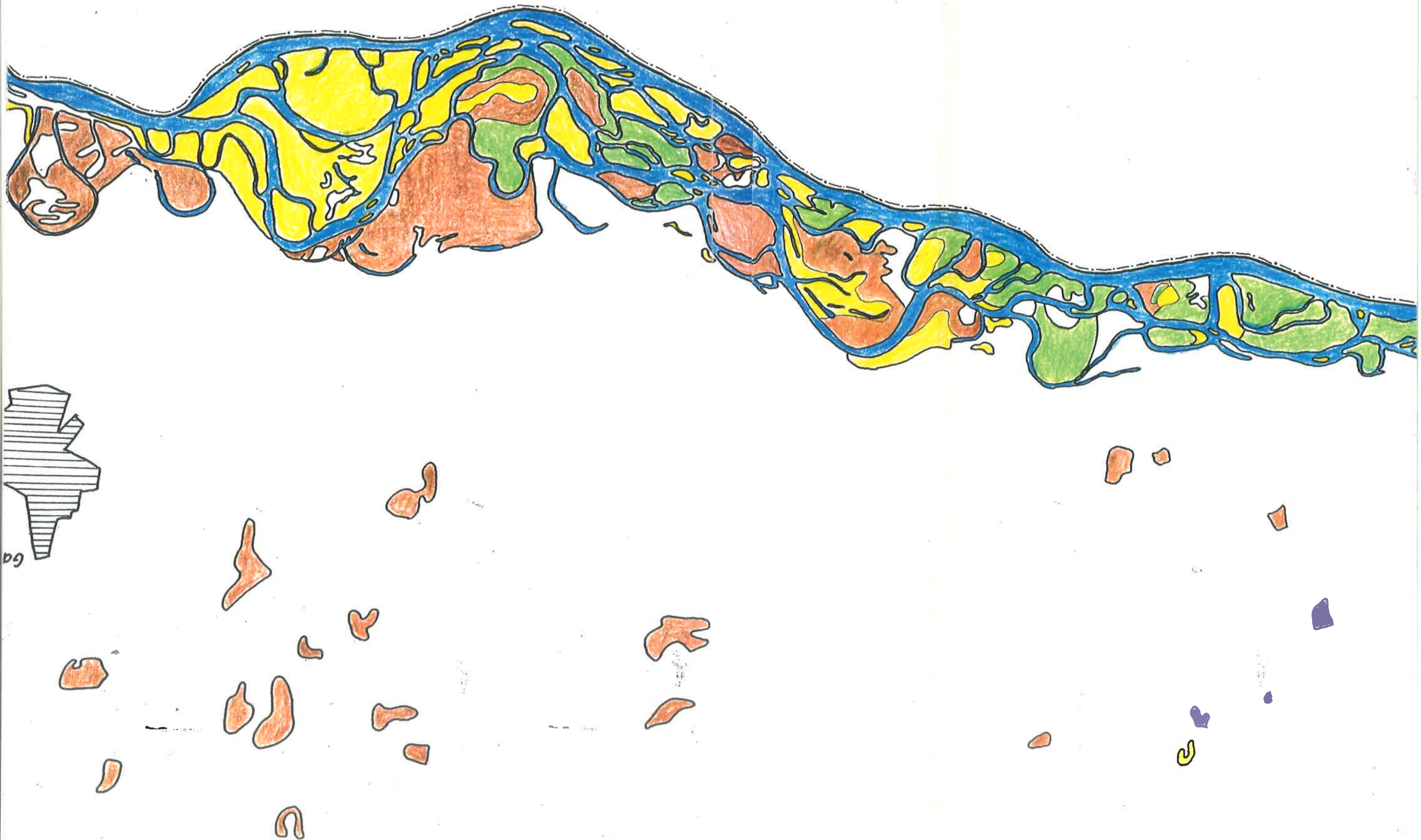
SCALE 1 : 50,000

LEGEND (PHYTOCOENOLOGICAL UNITS - BRAUN - BLANQUET SCHOOL)

- SALICI - POPULETUM willow - poplar floodplain forest
- FRAXINO - POPULETUM ash - poplar floodplain forest
- ULMO - FRAXINETUM elm - ash floodplain forest
- ULMO - QUERCETUM elm - oak floodplain forest
- CRATAEGETUM DANUBIALE BRACHYPODIETOSUM xerophilous danube steppe - forest
- CRATAEGETUM DANUBIALE FESTUCETOSUM xerophilous danube steppe - forest
- water area
- state boundary
- urban area




Šamorín
MAĎARSK




bčíkovo
Palkovičovo

MAP OF GROUPS OF FOREST TYPES IN THE GABČÍKOVO DAM TERRITORY

Condition in 1960 year

SCALE 1 : 50,000

LEGEND

QUERCETUM oak forest

CORNETO - QUERCETUM oak - cornel forest

ULMETO - FRAXINETUM CARPINEUM elm - ash floodplain forest with hornbeam

ULMETO - FRAXINETUM POPULEUM elm - ash floodplain forest with poplar

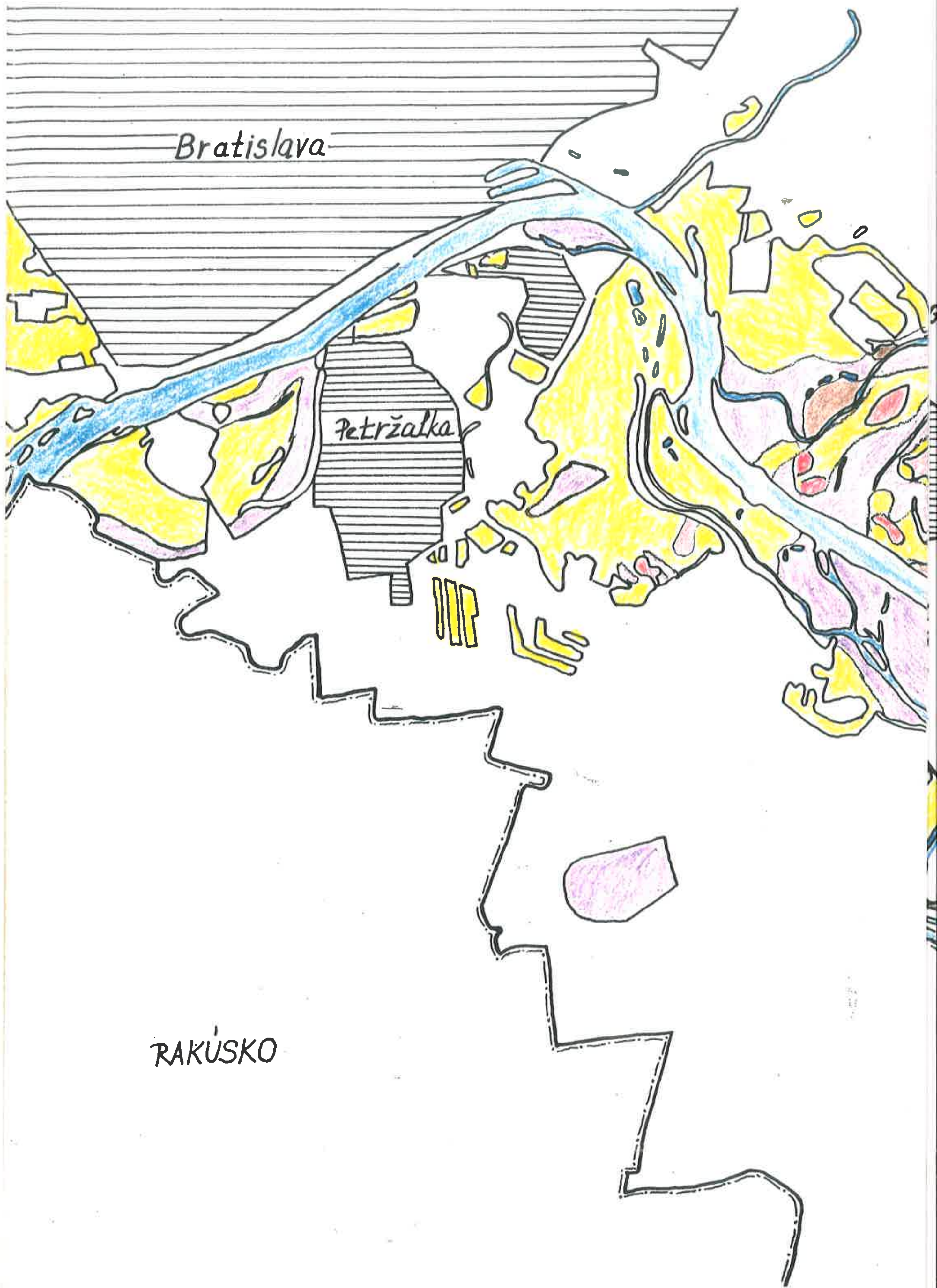
QUERCETO - FRAXINETUM oak - ash floodplain forest

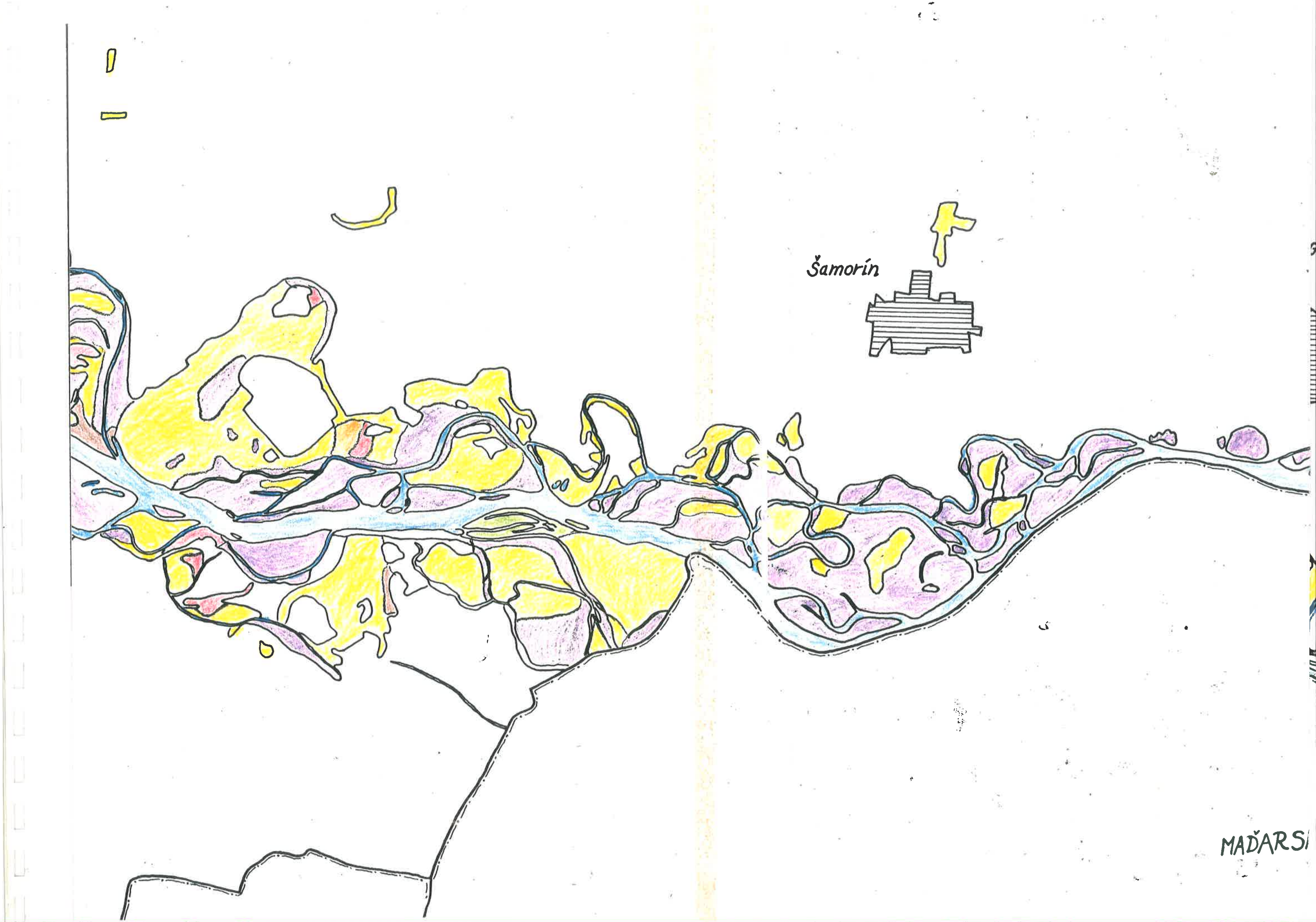
SALICETO - ALNETUM wilow - alder flodplain forest

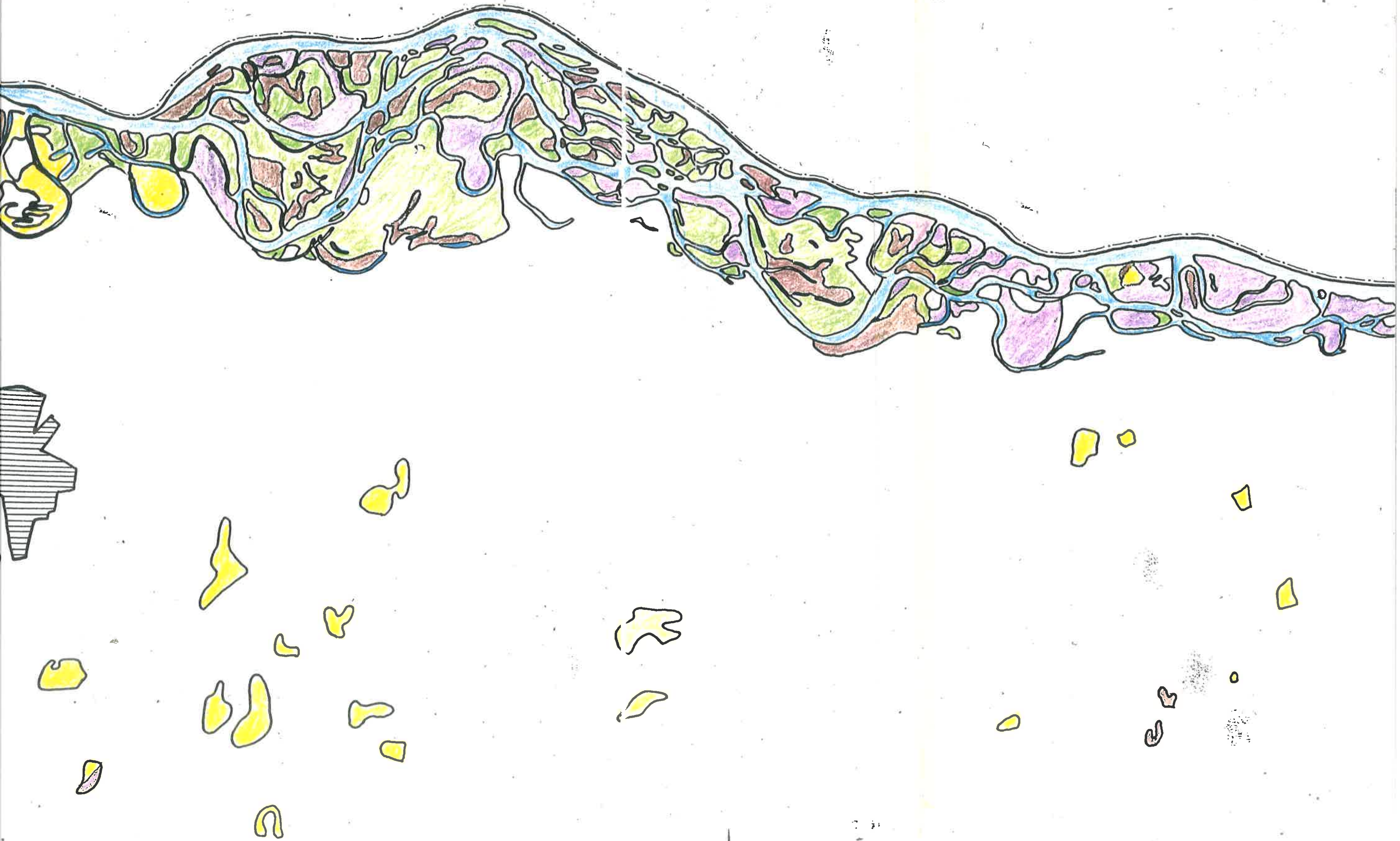
water area

state boundary

urban area




Šamorín
MAĎARS




abčíkovo
Palkovičovo