VIŞEU RIVER WATERSHED (MARAMUREŞ, ROMANIA) ECOLOGICAL MANAGEMENT PROPOSAL

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ABSTRACT: The impetus for such work has arisen from hydrobiologists' major concern over the continuous declining quality of lotic systems as complex resources. The Vişeu River watershed benefited in the last decade from complex biological and ecological assessments and monitoring, a fact which recommends it as a good area for management plan implementation. The approach used for this watershed management can be used as a model for other similar Carpathian watersheds of conservation interest. For this watershed under study, two management zones were revealed: I. Zones which should be managed for biodiversity conservation - Vaser Watershed, upper Ruscova Watershed, upper Vişeu River and Vişeu River Gorge. In these areas the natural structure of the habitats and of aquatic communities are still existing, as well as the natural dynamics of ecologic processes. Also present here are aquatic protected species like *Hucho hucho, Thymallus thymallus, Cottus gobio* and *Cottus poecilopus*; II. Zones where resources should be used in a sustainable way - zones in which resources and lotic ecosystem services can be used within the limits of self-regulation and self-support of the ecologic systems.

1. INTRODUCTION

The impetus for this type of work has arisen from the major concerns of hydro-biologists regarding the continuous declining quality of lotic systems as complex resources in Romania over the past seven decades.

In any historical period and in almost all geographic regions, rivers were a priceless resource, but always were utilised by people with divergent interests, different methods and with significantly different spatial and temporal effects.

From the perspective of human socio-economy, lotic ecosystems offer resources (water, substratum like building materials, biological resources) and services (absorption - recycling of residues of human activities, through the natural cleaning processes). For the sustainable management of hydrographical basins, an assessment of their capacity for support and self-regulation is necessary.

Assessment of lotic systems should be the main action that scientists undertake to understand and document their status, causes and effects, and trends. The second step, management, is of interest not only to researchers but also to local and regional public authorities for environmental protection, local and regional public administrative authorities, physical and juridical persons, consultative councils, other local stakeholders and mostly the Maramureş Mountains Nature Park and Maramureş Mountains Natura 2000 site administration. The third step is to check, validate, improve and extend all the obtained results based on data analyses obtained thtough integrated monitoring.

The Vişeu River watershed (Fig. 1) is situated in the Maramureş Depression, in the north-west of Romania, near the border with Ukraine and belongs from the administrative point of view to the Maramureş County. With a 1606 km 2 surface it is delimited in the north and east by the Maramureş Mountains, in the south by the Rodnei Mountains, and in the south-west and west by the Maramureş Hills. The lowest altitude of the Vişeu River basin is 303 m at the confluence between Vişeu River and Tisa River, and the highest altitude is 2303 m in the Pietrosul Rodnei Peak in the Rodnei Mountains. (Posea et al., 1980; Posea, 1982; Chiş, 2008).

The source of the Vişeu River is in Prislop Pass (1.416 m altitude) and flows into the Tisa River, near the Valea Vişeului locality, at 330 m altitude. The Vişeu River collects its water from the Maramureş Mountains, Rodnei Mountains and Maramureş Hills, its hydrographical basin surface being of around 1.600 km2 and the river length over 80 km. In the upper part, from the spring and to Moisei locality, the riverbed has high inclination (20 - 50 m/km) and the river name on this sector is called Borşa or Vişeuţ. From Moisei locality, the Vişeu River enters the Maramureş Depression where the valley becomes large, and in some areas becomes narrow forming gorges like Rădeasa Gorge (between Moisei and Vişeu de Sus), Oblaz Gorge (between Vişeu de Jos and Leordina) and Vişeu Gorge (between Bistra and Valea Vişeului localities). The Vişeu River waters are high in spring (39.4%) then start to decrease till the summer when

they reach 27% of the annual total flow, in the autumn 18.6%, the lowest flow being registered in winter 15%. In January the measurements prove the fact that at Bistra is flowing only 4.5 % of the annual volume, in comparison with the neighbour Iza River where the minimum is registered in September (2.9%). The Vişeu River basin is developed mainly in mountainous areas (67 %), a fact which induces a high density of the hydrographic net (0.7 - 1 km/km2) and one of the highest specific flows in the country, due to the high precipitation of over 1.100 mm/year. In the upper part, the tributaries which spring in the Rodnei Mountains, have their origin in the glacial relief and have a high flow, the approximate flow being of 5 m3/s. The main tributaries in the Rodnei Mountains are: Valea Fântânilor (Length = 7 km), Valea Negoiasa (L = 6 km), Valea Repedea (L = 10 km), Valea Pietroasa (L = 7 km), Vremeşu, Pârâul Hotarului, Valea lui Dragoş (L = 11 km) and Izvorul Negru (L = 7 km). From the Maramureş Mountains the right side tributaries are: Hăşmarul Mic, Cercănel (L = 11 km), Ţâşla (L = 20 km), Vaser (Surface = 422 km2, L = 52 km) which have a flow of 9 m3/s and contribute 27% to the total debit of the Vişeu River, Ruscova (S = 435 km3; L = 39 km) have a flow of 11.3 m3/s, Frumuşeaua (L = 14 km) and Bistra (L = 9 km). From the Maramureş Hills the left side tributaries are small and have insignificant flows: Drăguiasa, Bocicoi, Spinului, Plăiuţ, Neagră and Luhei. In the Rodnei and Maramureş mountains are many cascades and falls: Cailor Cascade, Cimpoiasa Valley falls, Repedea Valley falls, Izvorul Verde (Rodnei Mountains) Valley and Criva Valley falls, Tomnatic Valley Cascade, Bardău area falls (Maramureş Mountains). (Diaconu, 1971; Ujvari, 1972; Posea et al., 1980; Roşu, 1980; Posea, 1982; Staicu et al., 1998; Chiş, 2008).

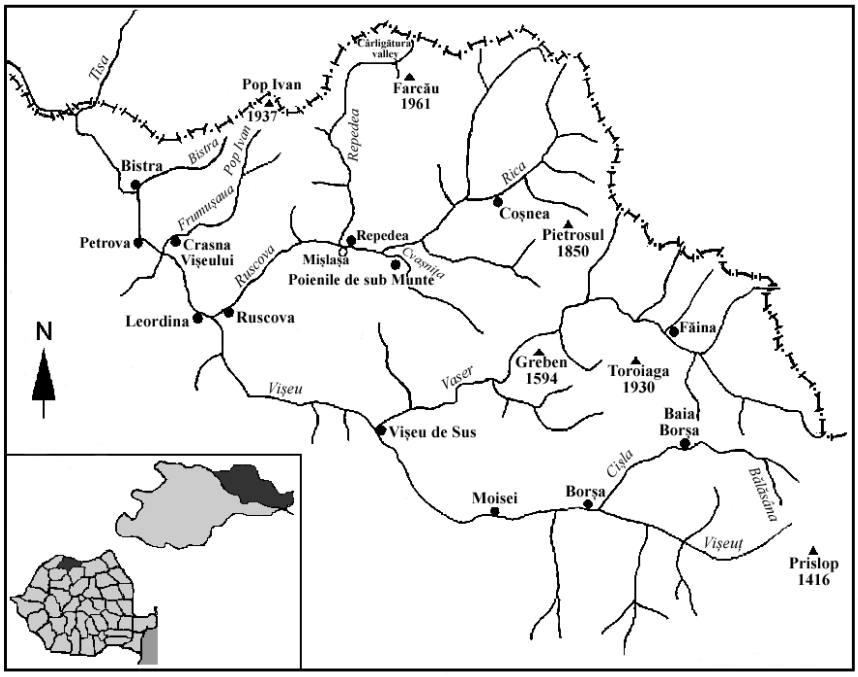

Figure 1. The Vişeu River watershed.

The geographic area described benefited in the last decade from complex biological and ecological assessments and monitoring, a fact which recommends it as a good area for implementation of a management plan, regarding the Vişeu River watershed.

The studied area is part of the Maramureş Mountains Nature Park and of the Maramureş Mountains Natura 2000 site. This work aims to sustain this protected area's ecological quality management and sustainable development, and the results obtained are offered to this protected area administration.

The watershed under study is dominated by forestry/small rural localities and agriculture/industry/medium sized localities.

Although the macroinvertebrate communities and fish communities may have a high degree of natural variability, they can be useful indicators of the status/health of aquatic ecosystems (Chapman 1992, Knoben et al. 1995, Hellawell 1986, De Pauw, Hawkes, 1992, Curtean-Bănăduc 2000, Karr 1981, Moyle & Herbold 1987, Bănăduc & Curtean-Bănăduc 2002). Also, it is recommended that macroinvertebrates and fish be given consideration in biological water-quality surveys of streams because they generally are regarded by the public to

be ecologically relevant, and they are in direct relation to legislative mandates because of concerns over human health and endangered species. Analysis of these taxonomic groups is essential for establishment of lotic system management (Curtean-Bănăduc & Bănăduc 2001).

The dimensions of this river basin, its natural and economic importance, and variable and aggressive types of human impact, justify such a study for this specific area.

In the last few decades human impact has heavily increased, causing visible disruption to the ecological functioning of the river, and research was needed to assess and monitor the apparent ecological effects, to find new management actions for the new situation, and to predict some aspects of the lotic system's future evolution.

In spite of the fact that the rivers of this basin were, are and will be very important in the urban and rural development, and in the development of the economy of Borşa, Moisei, Vişeu de Sus, Vişeu de Mijloc, Vişeu de Jos, Leordina, Ruscova, Repedea, Poienile de sub Munte, Petrova, Crasna Vişeului, Bistra localities by serving as the main water supply, and the important human impact that it has to be expect, it is seldom acknowledged that this area was not subjected to integrated studies till the present. The lately studies (Curtean-Bănăduc, 2008; Bănăduc, 2008; Cogălniceanu, 2008 Sîrbu et al., 2008 Oloşutean and Ilie, 2008) reveal the fact that in the Vişeu River watershed there are still lotic sectors which shelter aquatic species and communities of conservation interest, sectors in which the ecological processes were not affected by human activities - for these zones protection measures are needed.

Specialists of "Lucian Blaga" University of Sibiu, Faculty of Sciences, Ecology and Environment Protection Department, together with other collaborators, chose to allocate important resources to the ecological assessment of the Vişeu River Watershed, in the 2004 - 2008 period, and at its end a scientific volume coming into being.

As a result of this work, the presence of a varied types of human impact in the Vişeu River watershed environment has been documented (Danci, 2008; Sîrbu et al., 2008; Gheoca et al., 2008; Oloşutean & Ilie, 2008; Pârvu, 2008; Curtean-Bănăduc, 2008; Bănăduc, 2008; Cogălniceanu, 2008; Kovács, 2008), and an obvious necessary objective for the future was identified related to a better understanding of the dynamics of proper management of the Vişeu Watershed rivers, as a catalyst for the enhancement and protection of wildlife habitats in the area, and which induce actions to improve water quality for different human uses and wildlife, and to facilitate discussion on the future human impact on this watershed.

This study based on the benthic macroinvertebrates, fish, habitat conditions and local human impact, and intends to provide an identification and evaluation of the responsible causal factors and of the alternatives, which can gain consensus in a strategy for developing a sustainable management plan for the river, for mitigating human impact and controlling its effects on environment, public health and welfare, including remedial objectives and response actions.

Data generated during this phase filled previously existing data gaps in order to provide a comprehensive understanding based on which the possible remedial alternatives for the human and ecological risk situations was evaluated. The biological assessment was used to characterize the response of the aquatic environment to multiple disturbances, considering that the integrity of the biota inhabiting the river ecosystems provides a direct and integrated measure of the integrity or health of the river.

In the end, with these offered alternatives, a specific case proposal is developed, concerning the Vişeu River basin natural resources and conservation, restoration and management of ecosystem services.

The assessments of the river's ecological state and the emerging problems identified, led to the selection of river sectors in terms of different specificity and priority for receiving an efficient specific management, based on specific goals, quantifiable objectives and actions.

2. METHODS

The identification of management areas and objectives was made starting with highlighting the present ecological status of the different river sectors in correlation with utilisation of lotic and terrestrial riverine ecosystems resources and services. Also the areas which sheltered aquatic species, communities and habitats of conservation interest were identified, which as a consequence should be managed for their protection.

For the assessment of the ecologic state of different river sectors, the structure of benthic macroinvertebrate and fish communities was analysed in 26 lotic sectors (Fig. 2) selected according to valley morphology, confluence with the main tributaries, and human impact types and degrees on the river sectors - hydro-technical works, pollution sources, and overexploitation of the river

bed mineral resource and riverine land use (Curtean-Bănăduc, 2008).

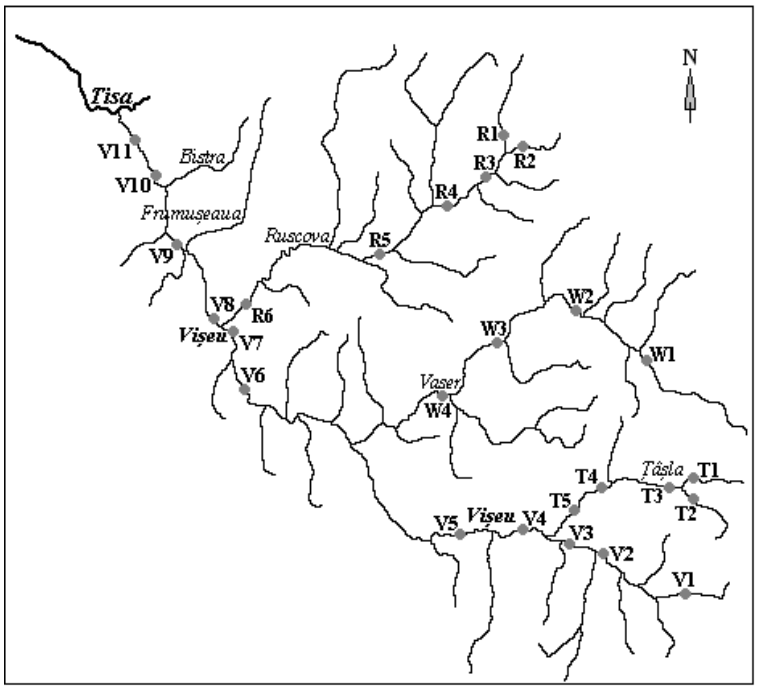

Figure 2. The Vişeu River basin sampling stations (V1-V11, T1-T5, W1-W4, R1-R6) layout.

The presence and the effects of the human impact relative to a reference ecological state, was analysed in terms of relative biologic integrity - the biotic integrity index adaptation for a Carpathian (first-second order) river assessment (Bănăduc and Curtean-Bănăduc, 2002), on the diversity of fish communities and on the structure and diversity of benthic macroinvertebrate communities and the specific diversity of orders Ephemeroptera, Plecoptera and Trichoptera (Curtean-Bănăduc, 2008). The fish and benthic macroinvertebrate communities' diversity was quantified with the Simpson heterogeneity index (Krebs, 1989).

For the physical assessment of the habitat, a visual-based habitat approach was used (Roth at all, 1996, Infante at all, 2009). The habitat descriptors were: river substrate type, diversity of pools, riffles, runs and bend, channel modification (river banks with a natural dynamic, modified river banks, river banks embanked with stones and/or wood, river banks embanked with concrete, mineral substratum exploitation, mineral substratum exploitation and embankment), bank vegetation (coniferous forest, deciduous forst, mixed forest, alders and willows, alders, willows, willows and coniferous, grass, no vegetation on the banks).

Also the type of the riverine use was considered (200 m from the river banks): in natural/semi-natural regime, forest exploitation, agricultural lands, locality, mining exploitation, mining waste deposits.

For the classification of the river sectors considered, cluster analysis was used based on biotic integrity index, benthic macroinvertebrate communities diversity, habitat descriptors and riverine land use.

3. RESULTS AND DISCUSSIONS

In the studied area were identified 14 fish species, and in the benthic macroinvertebrates structure were identified 10 orders: Tricladida, Basommatophora, Haplotaxida, Hydracarina, Amphipoda, Ephemeroptera (24 species), Plecoptera (18 species), Trichoptera (19 species), Coleoptera and Diptera.

Based on the structure of benthic macroinvertebrate communities and fish communities (Curtean-Bănăduc, 2008; Bănăduc 2008) and on the cluster analysis (highlighting of lotic sector similarities, Fig. 3) correlated with the different types of resources utilisation, the following management areas were highlighted.

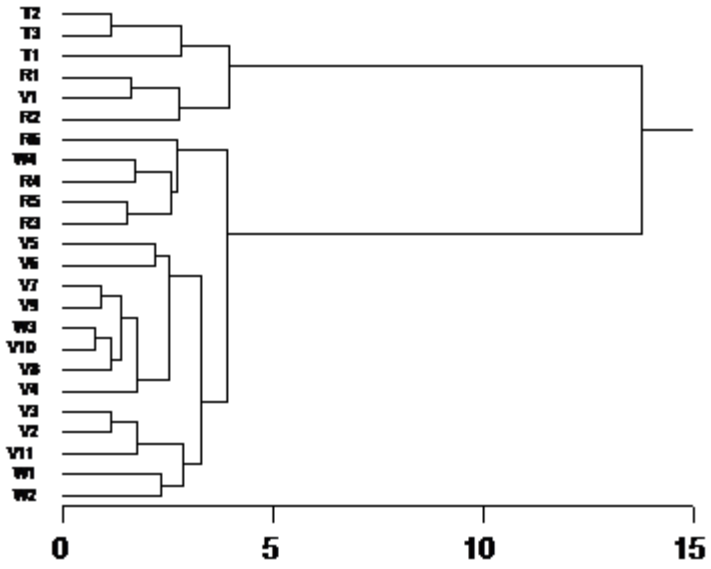

Figure 3. River sector groups as a function of the biotic integrity index, benthic macroinvertebrates diversity, fish diversity, habitat descriptors (diversity of pools, riffles, runs and bends, river substrata type, channel modification, bank vegetation) and riverine land use (euclidian distances, V1 - V11, T1 - T3, W1 - W4, R1 - R6; sampling stations)

Upper Vişeu River - river springs to the confluence with Ţâşla River (V1, V2, V3)

This sector varies from a torrential to a mountainous river appearance, between 50 cm to 6.5 m riverbed width, and the depth between 20 cm to 70 cm. The river bed varies from sectors with rocks, boulders and pebbles with dead tree trunks and coniferous forest on banks to sectors with cobbles, boulders and strips of coarse sand with willows and coniferous trees on the banks.

Its present ecological status, based on the aquatic communities present there, can be considered as an almost natural one in its upper part but negatively impacted in its lower part due to the Borşa resort area (water quality modifications induced by waste waters and non-native fish species escaped from a fish farm).

This entire sector should be returned to a natural condition through proper management because it should reduce as much as is possible the much accentuated negative effect of the downstream confluence with the Ţâşla tributary! In this respect: no other hidrotechnical works should be added to those which already exist now, the river should be isolated from the escaped fish species of the local fish farm, the Borşa Resort should implement a proper waste water canalisation and cleaning system. A permanent integrated monitoring system should be also implemented.

Middle Vişeu River 1 (Borşa - Vişeu de Sus localities, V4, V5).

On this sector the Vişeu is a mountainous river, with high liquid discharge and speed, the substratum is formed of rocks, boulders and pebbles; and in the quasi-lenitic areas are sandy patches. On the river banks are sectors with willow and alder trees which alternate with sectors with no trees. The maximum width of the minor river bed varies between 6 and 10 meters, the maximum water depth varies between 35 and 80 cm.

This low/medium sector ecological state is determined mainly by the high negative impact of the Ţâşla River basin which accumulates significant local, urban and industrial impact.

For its ecological restoration, not only is implementation of proper management actions needed on this sector, but also in the upper Vişeu River sector, and especially in the Ţâşla River basin, in an integrated manner. This river sector management should include the implementation of a proper waste water canalisation and cleaning systems and an integrated monitoring system. The river substratum and the banks should not be changed, and the associated natural processes supporting the ecosystem services should not be affected. The permanent high rate of illegal fishing should be stopped through real administrative measures. The selective collection of the solid wastes should also be a main task in the area.

Middle Vişeu River 2 (Vişeu de Jos - Bistra localities, V6, V7, V8, V9).

This river sector is meandered with willows on the banks. The medium width of the minor river bed varies between 20 and 40 m, the average water depth varies between 40 cm and 1.80 m. The substratum is formed of pebbles and cobbles covered with a thin layer of mud, boulders, course sand.

This sector's medium ecological state is determined mainly by the upper Vişeu River's ecological problems (including the Ţâşla tributary basin), by its riverine localities waste waters and also by the exploitation of mineral resources in the river bed, all of which are compensated in a significant degree by the Vaser, Ruscova and Frumuşeaua tributaries good and relatively good resources of water and biodiversity, including the self cleaning processes.

Starting with this point of the analysis it the need becomes obvious for an integrated management plan for all the Vişeu River basin! This river sector management should include also the implementation of a proper waste water canalisation and cleaning systems and an integrated monitoring system. The river substratum and the banks should not be changed, and the associated natural processes supporting the ecosystem services should not be affected. The selective collection of the solid wastes should also be a main task in the area. The permanent high level of illegal fishing should be stopped through real administrative measures.

Lower Vişeu River (Bistra Village - confluence with Tisa River sector, V10, V11).

This sub mountainous river sector has a heterogeneous substratum formed of rocks, pebbles, gravel, sand and mud, with a water velocity between two and four meters per second, the lowest Vişeu River basin lotic sector. As a consequence its ecological status is a sum of the upstream good water quality inputs, bad water quality inputs, natural self-cleaning processes and human impact presence on this river sector.

Based on the ecological demands characteristic for all invertebrate and vertebrate species of conservation interest identified in the area, a series of problems and restrictive factors were identified here: in spite of the fact that due to the natural self-cleaning processes present in the middle Vişeu River, the low water quality of its upstream and middle sectors recovery is a significant one, the water quality here cannot be considered a pristine one; in the context of the warming climate and the aggressive deforestation in large surfaces of this basin, the changing (warming) of water temperature will affect the mainly cryophilic species / associations; eutrophication, linked with higher and higher seasonal and diurnal oxygen variations especially in the middle sector of the Vişeu River, is also a limiting factor for the species with certain high demands in this respect on the lower sector, too; in spite of the fact that this area is a protected one, illegal over-fishing here is very accentuated, with nets, electricity, natural and/or synthetic substances, dung forks, etc.; the spawning areas for different key species are not completely known and proper protection cannot be assured for them; the status of trophic resources for fish (benthic macroinvertebrates) was not included in integrated studies until now. Here river sector management should include implementation of a proper waste water canalisation and cleaning system and an integrated monitoring system. The river substratum and the banks should not be changed or over-exploited, associated natural processes supporting the ecosystem services should be not affected and the excessive illegal fishing should be stopped! No important water extractions and hydro-technical constructions should be allowed in the area and on these sector tributaries. The good quality of this sector can be maintained and improved only if the whole basin will have an integrated management plan successfully implemented. The permanent high illegal fishing should be stopped through administrative measures.

Ţâşla River (T1, T2, T3, T4, T5)

This sector varies from a torrential creek to a mountainous river appearance, with a natural substratum formed of rocks, boulders, cobbles and pebbles but with a modified structure of the river bed in some sectors (the banks are embanked with concrete, stones or wood). The average riverbed width varies from 50 cm to 4.5 m and the average depth from 15 to 25 cm.

The main and serious ecologic problem of the Ţâşla River is also one of the main problems for the Vişeu River, old mining exploitations (Cd, Cu, Zn) and mining waste deposits, to which should be added the presence in the proximity of the river of the non-ecologic waste deposit of the Borşa locality and illegal waste water discharges and the mineral resources exploitation from the river bed. The whole Vişeu River basin needs a determined ecologic management elements regarding the Ţâşla River basin, consisting mainly of: isolation of mining exploitations and wastes (mining and urban) deposits, implementation of a proper waste water canalisation and cleaning system in the Borşa locality, ecological restoration of the river substratum and banks in its lower sections. If this approach will be adopted, the colonisation with valuable species will happen in a medium period of time in natural way from the nearby lotic systems (Vişeuţ, Vişeu and its near tributaries). This area is the main hotspot of the Vişeu River basin, regarding

ecologic restoration of its natural/semi-natural status.

Vaser River (W1, W2, W3, W4)

A typically mountainous river with a river bed varying between 4 to 12 m and an average water depth between 40 and 60 cm. The substratum is formed of rocks, boulders and pebbles; sometimes sand and mud. On the river banks are alder trees and willows. Upstream on the valley slopes are coniferous species and in the lower sectors deciduous species.

In spite of the fact that this basin is relatively isolated concerning human settlements and roads, railway access and important forestry exploitation impact here made from this river, it enjoys only a good ecological status not a pristine one as at a first look can be expected.

The forestry activities which cause direct harm to the river and creek beds due to the transport of logs on them and indirect harm due to the increased and not natural siltation processes should be the main management issues in the Vaser Basin. Illegal fishing is also a main topic of concern here, especially in the middle-lower sectors.

Ruscova River (R1, R2 , R3, R4, R5, R6)

Typical river bed for a big mountainous river. The average minor river bed varies between 1 and 12 m in the studied sectors, the average water depth varies between 25 and 65 cm), the substratum formed of boulders, rocks, pebbles. On the river banks and in the river bed are logs and deposits of sawdust. In the slow moving water sectors the boulders are covered with a thin layer of mud and some with moss. On the banks the natural succession from upstream to downstream is coniferous/mixed/deciduous forests with alder and willow trees in the middle-lower sectors.

The forestry activities (clear felling of mountain slopes, illegal sawdust deposition in the rivers and on river banks) and the illegal discharges and depositations of rural solid and liquid wastes should be the main targets for this watershed management activities, to which should be added the permanent high illegal fishing countermeasures.

Special management requirements for aquatic species of highly conservative interest in the area

The management of fish species for stabilizing their populations, increasing their numbers and biomass represents in fact species protection and conservation. Due to the fact that it is not possible to provide universal management guide-lines which would fit all the fish species of conservation interest in all the upper, middle or low stretches, several different conservation management approaches were used as below.

Hucho hucho (Linnaeus, 1758)

The Hucho hucho, is the largest, exclusively riverine and anadromous species, which can be found in Europe in Danube, Volga and Pechora basins, unfortunately in the last decades the regress continued and in the present only data exist about few such lotic systems with this species, Vişeu River being one of these last valuable lotic systems (Bănăduc, 2008).

The management related with this highly endangered species, of the lower Vişeu River basin should include: maintaining of the relatively high and constant water flow; forest water retention capacity should be encouraged by the appropriate forestry management in all the basin; no hydro-technical works should be allowed to be built on the Vişeu River basin in the future; no important water captures should be allowed for hydro-technical works in the neighbouring watersheds; the water quality in the streams should be improved everywhere in the basin where it is a necessity, through (quantitative and qualitative) cleaning activities, canalisation of villages, sawdust management and avoidance of river bed alteration; stopping illegal fishing and forbidding legal fishing for the Danube salmon; the lower gorge sector of the Vişeu River, including the confluence area, should have a highly restricted protection regime not only for Danube salmon but for all the local fish species (as trophic resources) and for the trophic resources of benthic macroinvertebrates; the aquaculture of Danube Salmon and the artificial stocking and restocking of water bodies of interest should be initiated.

Thymallus thymallus (Linnaeus, 1758)

With a former relatively large European distribution, this non-migratory fish has in the present a rather disrupted distribution, as a consequence of the last decades decrease of water quality and man-made transformations of natural and semi-natural habitats. This trend was identified also in the Romanian Carpathians.

The Vişeu River basin can act like a complex sanctuary for this species if the following management elements will be implemented in the upper stretches of this basin: stopping illegal fishing, stopping the legal fishing of this species one year out of every two years, significant decrease of physical

and chemical pollution; no hydro-technical works should be allowed to be built; eliminating illegal deposits of saw dust in the river bed and on the banks.

Cottus gobio (Linnaeus, 1758) and Cottus poecilopus (Heckel, 1836)

These related species (mostly the first one), formerly occurred in the majority of the waters inhabited by the brown trout (C. g. from the north of Spain throughout Europe and to the east; C. p. northern and central Europe). In the last decades the decline was a significant one, also in the Romanian Carpathians in which the Vişeu River basin can act like a complex sanctuary for this species (UNDP Project 042/2007).

The management related with these protected species, of the Vişeu River basin should include: significant decreasing of physical and chemical pollution; no management actions for trout fishing in the upper lotic systems; no natural and/or semi-natural riverbed modifications; no hydro-technical works should be allowed to be built on the Vişeu River basin in the future; eliminating illegal deposits of saw dust in the river bed and on banks; the identification and strict protection of habitats for spawning, hiding and feeding; deeper pools should be available for winter season.

4. CONCLUSIONS

The approach used for this watershed management can be used as a model approach for any other similar Carpathian watershed of conservation interest.

This approach should be based on extensive and intensive biological and ecological data, obtained and checked / monitored at least along a medium period of time (ten years).

From the perspective of management objectives and measurements required, in the Vişeu River watershed two management zones can be revealed:

I. Zones which should be managed for biodiversity conservation - Vaser Watershed, upper Ruscova watershed, upper Vişeu River, Vişeu River Gorge. In these areas the natural structure of the habitats and the aquatic communities, and the natural dynamic of the ecologic processes, are still existing,. Also present are aquatic protected species like Hucho hucho, Thymallus thymallus, Cottus gobio and Cottus poecilopus.

II. Zones where the resources should be used in a sustainable way – zones in which resources and lotic ecosystems services can be used within the self-regulation and self-support limits of these ecologic systems.

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