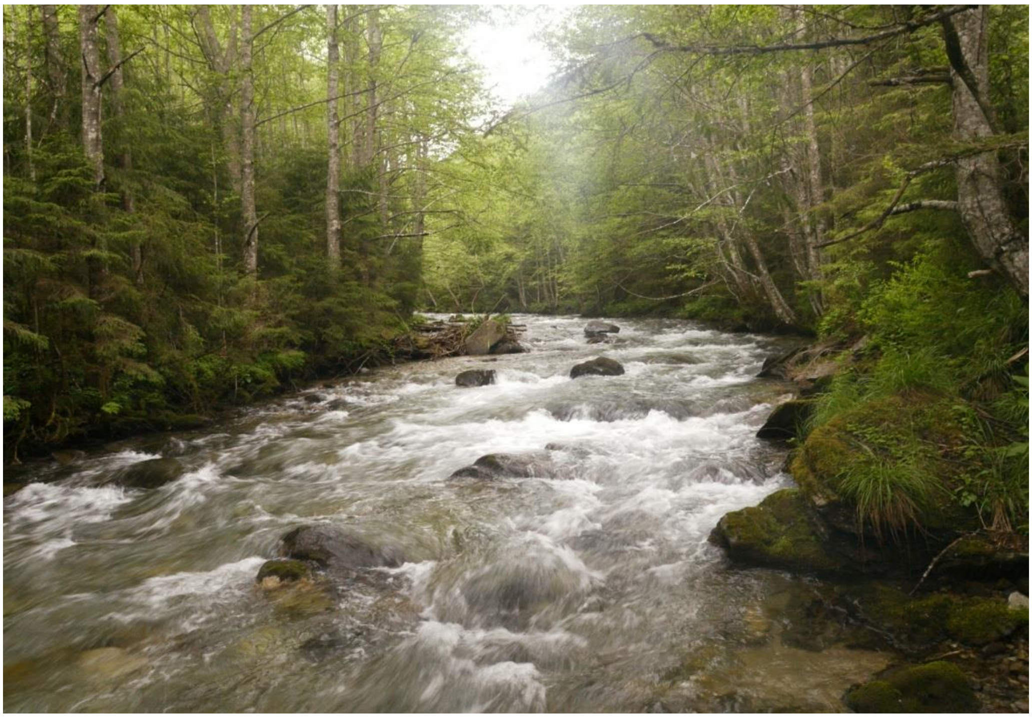
Ecological state assessment of the Upper Dambovita River basin



8/11/2013

Final report

Assessment of the ecological state (habitat classification, condition of fish stocks, structure of benthic macro-invertebrate community, physico-chemical water analysis), identification of the anthropogenic disturbance structures and recommendations for restoring the ecological condition of the Upper Dambovita river system.

Societatea Ecologica pentru Studierea si Protejarea Florei si Faunei Salbatice AQUATERRA

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Ecological state assessment of the Upper Dambovita River basin

FINAL REPORT

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Contract responsible: Lect. Dr. Craciun Nicolae

This survey is part of the LIFE+ project “Ecological restoration of forest and aquatic habitats in the Upper Dambovita Valley, Muntii Fagaras” (LIFE11/NAT/RO/823).

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SUMMARY

This study aims to assess the ecological state of the Upper Dambovita river basin by identifying the aquatic habitats, determining the condition of fish stocks, analysing the structure of the benthic macro-invertebrate community, conducting a physico-chemical water analysis, and identifying the most problematic anthropogenic disturbance structures that impact the integrity of the river system. In addition, it outlines clear recommendations to restore function and ecological condition of the water system and consults on the elaboration of a plan for a future aquatic monitoring scheme to go along with any restoration work.

We made this assessment between September 2012 and June 2013, with several field trips in all four seasons. Sampling for all relevant taxonomic groups was done in 19 sampling stations above and below the Pecineagu Lake. We used standard methods, such as electro-fishing and rheophile nets for capturing fish, and Surber dredges for collecting macro-invertebrates. Based on the field data we calculated different ecological indices and modelled a pollution gradient along the Upper Dambovita River. In addition we mapped and classified aquatic habitats according to the Romania's Habitats Book, based on the present flora.

The Dambovita River in its upper course, is a beautiful river, with a wild natural course, with a relatively low anthropic impact, and no village or rural community in the watershed. We identified 12 aquatic habitats in the Dambovita basin, out of which 5 are of high conservation value, including the Natura 2000 priority habitat *7220 Petrifying springs with tufa formations.

Water analysis revealed low turbidity and a slightly acid pH value in some areas due to both, natural and anthropogenic factors. Dissolved oxygen levels in the Dambovita River are very good, yet the presence of organic matter coming from woody debris on the slopes limits the oxygen saturation capacity. Also the micro-biological analysis shows an increased number of bacteria colonies and high nitrate levels in some parts of the river, indicating the presence of some organic pollution sources, originating from forestry and grazing.

The fish community of the Upper Dambovita River consists of brown trout (*Salmo trutta fario*) and European bullhead (*Cottus gobio*), that are common almost along the entire river, and Common minnow (*Phoxinus phoxinus*) and Mediterranean Barbell (*Barbus meridionalis petenyi*), that are present only below the Pecineagu dam. However, trout stocks are low, and the lack of adults indicates that increased fishing, both legally and illegally, is a major threat. Another factor that impedes the development of a healthy unaffected fish population, is the presence of concrete dams, built for adjusting the river flow. These dams cause a severe habitat fragmentation by blocking the micro-migrations of trout and bullhead, which are crucial for foraging and breeding.

From an ecological point of view, aquatic habitats in the Dambovita basin show a very high biodiversity, based on a rich phytoplankton, the trophic source for several consumer levels. Where the riverbed is wider, and the river splits into two branches, aquatic invertebrates are well represented, especially stoneflies, dragonflies, and diptera. Caddiesflies and mayflies dominate in adjacent habitats (dead arms, elbows, pools and ponds). The adjacent micro-habitats are also safe breeding places and refuges for different species of newts and frogs, and the listed medicinal leech.

Although the entire area is uninhabited, economic activities are taking place and affect to some degree the ecological balance of the aquatic system. Especially deforestation alongside riverbeds

and bad exploitation practises destroy the natural vegetation. Clearings, followed by heavy rains, lead to erosion and wash the mull into the water, resulting in changes in water acidity, reduced transparency and oxygen concentration, and increased concentration of ammonia and hydrogen sulphide. Anaerobic decomposition of wood waste heavily affects water quality. Besides habitat fragmentation, the dams also alter the species composition of the system, since deposits of silt and organic matter upstream of a dam affect the chemical characteristics of the water. Also, installing sheep pens close to the river (as in Valea Vladului) results in an impairment of water quality as the manure is getting washed away. We also have evidence that fish poaching with toxic substances and self-made high voltage installations took place in certain river segments and eliminated the adult fish population.

In order to restore the ecological condition of the Upper Dambovita River and to counteract a loss of fish populations, we strongly recommend to open the waterways either by demolishing the dams, or, if this is not feasible, to install modern fish ladders on the sides of the concrete dams. At the same time, re-stocking of the Upper Dambovita River with trout and bullhead shall be considered, together with a ban on fishing for a period of 5-7 years and a strict control of poaching. The success of aquatic habitat restoration depends on applying a good management plan in the future and monitoring its efficiency long-term. The findings of this research can be considered in the future as a reference, as this is the first study integrating all taxonomic groups in this area.

Ecological state assessment of the Upper Dambovita River basin

FINAL REPORT

INTRODUCTION

General frame of the assessment

In this paper we assessed the current situation of ichthyofauna from the upper hydrographic basin of Dambovita river and its tributaries from the upper course, from its sources to the lake Pecineagu, on a total length of about 45 km. Besides ichthyofauna biodiversity, we wanted to assess the biodiversity of aquatic and shore microhabitats existing in the hydrographic basin and, with a special interest in those of community interest or habitats and species (zoobenthos, aquatic invertebrates, aquatic flora, phytobenthos and amphibians) regarded nationally threatened, vulnerable or very rare. Finally, we will characterise the ecological status of the present aquatic habitats and their conservation state.

This study and inventory of biodiversity from aquatic habitats was conducted in two periods:

- Autumn – Winter 2012 (September – October – November – December)
- Winter – Spring – Summer 2013 (March – April – May – June)

Presentation of EU policies regarding surface water management

The new **EU Water Framework Directive** has the following key aims:

- expanding the scope of water protection to all waters, surface waters and groundwater
- achieving "good status" for all waters by a set deadline
- water management based on river basins
- "combined approach" of emission limit values and quality standards
- getting the prices right
- getting the citizen involved more closely
- streamlining legislation

The outline below shows how these elements are made operational within the Directive.

A single system of water management: River basin management

The best model for a single system of water management is management by river basin – the natural geographical and hydrological unit – instead of according to administrative or political boundaries. Initiatives taken forward by the States concerned for the Maas, Schelde or Rhine river basins have served as positive examples of this approach, with their cooperation and joint objective-setting across Member State borders, or in the case of the Rhine even beyond the EU territory. While several Member States already take a river basin approach, this is at present not the case everywhere. For each river basin district – some of which will traverse national frontiers – a "river basin management plan" will need to be established and updated every six years, and this will provide the context for the co-ordination requirements identified above.

Co-ordination of objectives – good status for all waters by a set deadline

There are a number of objectives in respect of which the quality of water is protected. The key ones at European level are general protection of the aquatic ecology, specific protection of unique and valuable habitats, protection of drinking water resources, and protection of bathing water. All these objectives must be integrated for each river basin. It is clear that the last three – special habitats, drinking water areas and bathing water – apply only to specific bodies of water (those supporting special wetlands; those identified for drinking water abstraction; those generally used as bathing areas). In contrast, ecological protection should apply to all waters: the central requirement of the Treaty is that the environment be protected to a high level in its entirety.

Surface water

Ecological protection

For this reason, a general requirement for ecological protection, and a general minimum chemical standard, was introduced to cover all surface waters. These are the two elements "good ecological status" and "good chemical status". Good ecological status is defined in Annex V of the Water Framework Proposal, in terms of the quality of the biological community, the hydrological characteristics and the chemical characteristics. As no absolute standards for biological quality can be set which apply across the Community, because of ecological variability, the controls are specified as allowing only a slight departure from the biological community which would be expected in conditions of minimal anthropogenic impact. A set of procedures for identifying that point for a given body of water, and establishing particular chemical or hydromorphological standards to achieve it, is provided, together with a system for ensuring that each Member State interprets the procedure in a consistent way (to ensure comparability). The system is somewhat complicated, but this is inevitable given the extent of ecological variability, and the large number of parameters, which must be dealt with.

Chemical protection

Good chemical status is defined in terms of compliance with all the quality standards established for chemical substances at European level. The Directive also provides a mechanism for renewing these standards and establishing new ones by means of a prioritization mechanism for hazardous chemicals. This will ensure at least a minimum chemical quality, particularly in relation to very toxic substances, everywhere in the Community.

Other uses

As mentioned above, the other uses or objectives for which water is protected apply in specific areas, not everywhere. Therefore, the obvious way to incorporate them is to designate specific protection zones within the river basin which must meet these different objectives. The overall plan of objectives for the river basin will then require ecological and chemical protection everywhere as a minimum, but where more stringent requirements are needed for particular uses, zones will be established and higher objectives set within them.

There is one other category of uses which does not fit into this picture. It is the set of uses which adversely affect the status of water but which are considered essential on their own terms – they are overriding policy objectives. The key examples are flood protection and essential drinking water supply, and the problem is dealt with by providing derogations from the requirement to achieve good status for these cases, so long as all appropriate mitigation measures are taken. Less clear-cut cases are navigation and power generation, where the activity is open to alternative approaches (transport can be switched to land, other means of power generation can be used). Derogations are provided for those cases also, but subject to three tests: that the alternatives are technically impossible, that they are prohibitively expensive, or that they produce a worse overall environmental result.

Physical, geographical and biological presentation of the Upper Dambovita basin

The upper course of Dambovita consists mainly of two large tributaries: Valea Vladului, which has the springs in the Fagaras Mountains at an altitude of about 1,800 m and Valea Otic, with sources in Iezer - Papusa Mountains (Fig. 1 and Annex 1). Confluence of the two rivers with an approximately equal flow (Valea Vladului slightly bigger, however as flow is about 55-60 % of the total flow at the confluence) increases the riverbed width and decreases the flowing speed.

The Iezer – Papusa Massif is bounded by the valleys Raul Doamnei and Dambovita, and stands as a relatively isolated block up to almost 2,500 m altitude. The more than 12 km long ridge falls in the deep saddles of Mezei and Otic, before it connects to the main ridge of Fagaras Mountains. The ridge runs almost continuously from west to east, and reduces itself schematically to a large ridge amphitheater open to the south, on both sides of the Targului's River and Campulung's small depression. The overall features of the Iezer-Papusa massif repeat, in small-scale, the relief features of the Meridionali Carpathians: strong and short falls to the north, gentle and prolonged falls to south. In its upper portion, the Dambovita River represents the northern and eastern frame of this mountain massif.

The Fagaras massif measured from East to West in a straight line is approximately 70 km in length and extending about 45 km in width from North to South. From above it looks like a huge backbone, with rib-like ridges like stretching to the North and South. Ridges from the North are much shorter and more abrupt than those of the South, which are very long and smooth. In the East the Fagaras Mountains are bounded by the Barsa Groşetului and Dambovita rivers. To the North a large tectonic step drops to the Fagaras Depression, where on a distance of only 8 – 10 km altitude difference reach over 2,000 meters. To the South, the mountains decline less pronounced, on a distance of 30 – 40 km. The total area covered by the Fagaras Mountains is more than 2,400 km^2, containing more than 150 peaks with heights over 2,300 m and eight peaks over 2,500 meters. The Fagaras Mountains have a rich hydrographic network.

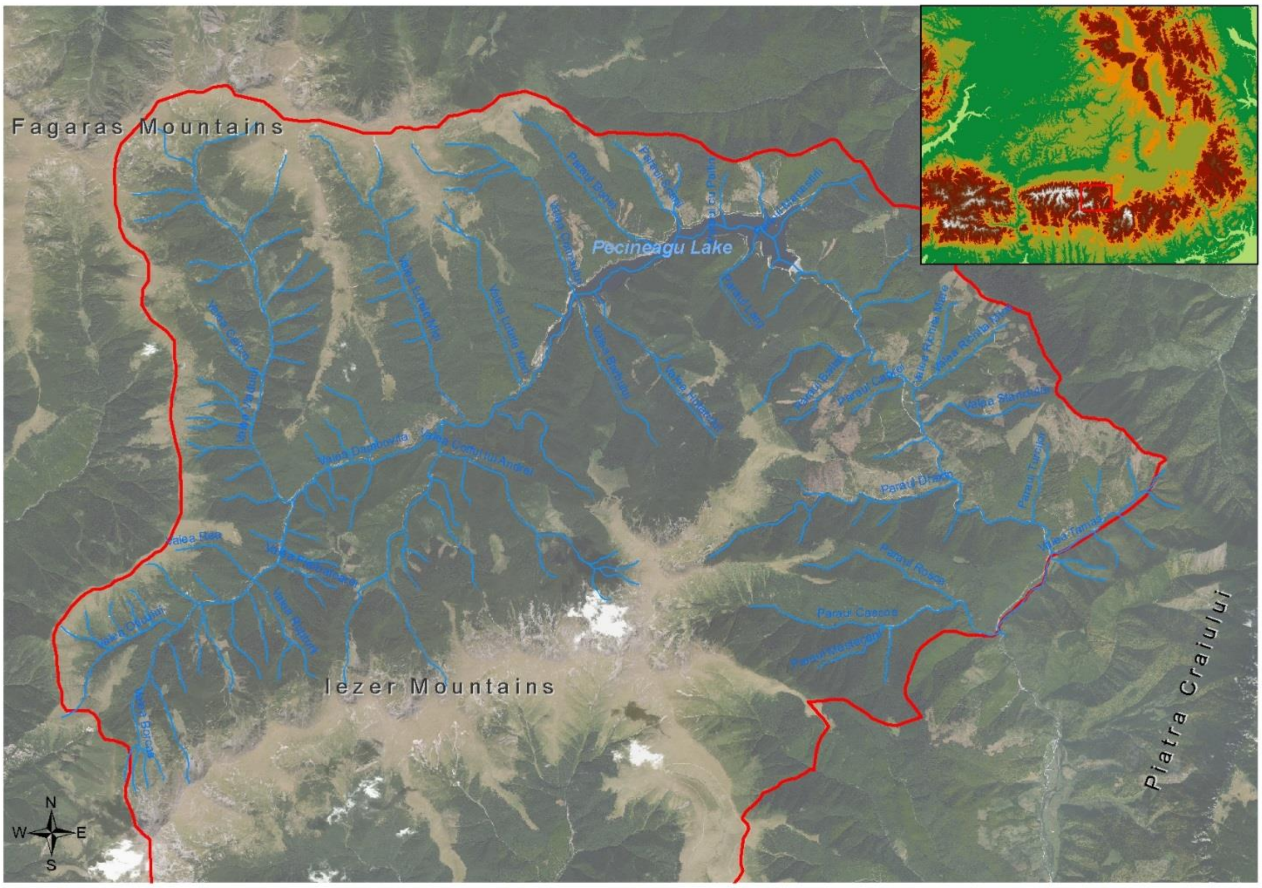


Fig. 1. Map of the study area – upper sector of the hydrographical basin of Dambovita.

Valea Otic and Dambovita

Otic creek springs from Iezer-Papusa massif, beneath the eastern slopes of Curmatura Oticului, and has a length of about 3 km. The estimated watershed is about 3 – 4 square kilometers containing four small tributaries. Otic creek flows into the Boarcas creek, and after another 3.5 km joins Valea Vladului from the Fagaras Mountains, such forming the Dambovita River. In the first twenty kilometres the river is getting bigger due to one larger tributary creek, Coltilor valley, a large basin gathering a whole bunch of streams and glacial buckets. The river then unexpectedly turns from the northeast to the southeast, receiving waters from three major valleys (Barbului, Dracsinului and Cascoe). Still wide open and stabilizing the course to the south, the Dambovita River gets on the right Clabucetul valley, before it breaks through successive rows of gorges in the picturesque karst landscape of the Rucar-Dambovicioara area. Except Clabucet valley, all mentioned tributaries are strongly marked by glaciations: short, grouped in clusters, or isolated in large independent valleys around Papusa.

Valea Vladului

Valea Vladului, a tributary of Dambovita, springs in the Fagaras Mountains, close to Bratila Peak (alt. 2,274 m). Compared to the northern slopes of the Fagaras Mountains, where waters are relatively short and with a low flow, cutting deep and narrow valleys, the southern slope rivers are longer and with a higher flow. Valea Vladului has a watershed estimated at about 20 square kilometres. The river flows from North to South in two smooth bends on a length of 8 km before it joins Valea Otic from the Iezar-Papusa massif, together forming Dambovita River.

Climate

Both massifs have a harsh climate, with sub-polar characteristics. Temperature decreases with increasing altitude. Mean annual value of the ridge area is -2 Celsius degrees. Temperature ranges from +20 to -38 Celsius degrees with small differences pertaining to the altitude (highland areas are the coldest), orientation (temperatures being lower on northern and eastern slopes) and gravitational movement of air that causes, especially in winter, surprising temperature inversions. Winds that dominate the region are from the West and Northwest, their maximum intensity being developed in areas above 1,800 m, where in exposed areas wind speed often reaches values of 25-30 m/sec. Cloud coverage of the sky is particularly high in these massifs; the number of cloudy days passes 200 in the central-high nucleus, lowering in the forested parts. Due to its location in the path of dominant winds, the annual average of rainfalls is high, exceeding 1,300 mm on ridges and northwest slopes. Rainfalls are more numerous in early summer and then begin to decline tending to a minimum between August and September, when the atmosphere is drier and clear. In June and July, large variation of vaporization from the first half of the day causes strong convective cloudiness that triggers, often unexpectedly, violent thunderstorms. Above 1,800 – 2,000 m altitude, a thick layer of snow covers the massifs almost permanently between November and April, being kept longer in sheltered corners and with northern and north-eastern orientation.

Fauna

Covering a large range of altitudes these mountains are characterised by a rich fauna, both in the subalpine areas, mostly covered by vast forests, as well as in the alpine areas. Among mammals, Brown bears (*Ursus arctos*), wolves (*Canis lupus*) and lynx (*Lynx lynx*) are common on the large predator side, whereas the ungulates are represented by wild boar (*Sus scrofa*), red deer (*Cervus elaphus*), roe deer (*Capreolus capreolus*), and, in higher altitudes, chamois (*Rupicapra rupicapra*). The marten family is represented by pine marten (*Martes martes*), which can be found all over the forested areas, otter (*Lutra lutra*), polecat (*Mustela putorius*) and weasels. Red fox (*Vulpes vulpes*) and wildcat (*Felis silvestris*) complete the carnivore order. Among rodents, the red squirrel (*Sciurus vulgaris*) and the edible dormouse (*Glis glis*) can be encountered regularly as well as several species of forest mice.

Birdlife is diverse with several woodpecker species, raven (*Corvus corax*), red crossbill (*Loxia curvirostris*), finches, rock wagtail (*Motacilla cinerea*), eagle owl (*Bubo bubo*), dipper (*Cinclus cinclus*), Ural owl (*Strix uralensis*), capercaillie (*Tetrao urogallus*), honey buzzard (*Pernis apivorus*), falcons, and golden eagle (*Aquila chrysaetos*), to name only some representatives.

Reptiles are represented by lizards (*Lacerta sp.*) and snakes, among which we recall the common viper (*Vipera berus*), present mostly close to open and sunny places. Among the amphibians, frogs (*Rana sp.*) are most widespread, but also salamanders (*Salamandra salamandra*) are teeming through carpets of dead foliage and small puddles are inhabited by different newt species.

Characteristic fish species in the mountain rivers are bullhead (Cottus gobio), in the high segment and trout (Salmo trutta fario) in the medium segment.

Particularly numerous insects include ants, bumblebees and forest wasps, dragonflies, locusts, grasshoppers and beetles: ladybirds (*Coccinella septempunctata*) – invader in some summers, and in the lower lands dung beetles (*Geotrupes sp.*), spruce bark beetle (*Ips typographus*) and great capricorn beetle (*Cerambix cerdo*). From the diurnal butterflies we mention peacock-eye-of-the-day (*Vanessa io*), small tortoiseshell (*V. urticae*), common brimstone (*Gonepterix rhamni*), copper butterfly (*Lycaena sp.*), etc. Twilight or nocturnal butterflies are very numerous – from Death's-head Hawk moth (*Acherontia atropos*), with wingspan of 12-13 cm, and up to countless moths, some with dimensions in the range of only several millimetres.

Flora

The vegetation coat of these two mountain massifs is very rich and varied. Throughout the forested area, the lower floor is represented by beech forest (*Fagus sylvatica*), which hosts as the main accompanying species hornbeam (*Carpinus betulus*), mountain maple (*Acer pseudoplatanus*) and birch (*Betula pendula*). All throughout this floor, in sheltered areas, the fir (*Abies alba*) appears and – very rarely – the transparent foliage and silhouette of larch (*Larix decidua*). Many shrubs are growing in beech forests, most commonly mountain elder (*Sambuccus racemosa*), raspberry (*Rubus idaeus*) and blackberry (*R. hirtus*). A rich herbaceous flora covers the soil of this level, being advantaged by the great brightness of beech foliage. Among the "spring" species – we mention violet crocus (*Crocus heuffelianus*), Easter flower (*Anemone nemorosa*) and primula (*Primula elatior*). Among the graminae, characteristic for beech pastures are tall hair grass (*Festuca altissima*) and wind grass (*Agrostis tenuis*). Hearths of ferns occupy either sunny places (navalnicul: *Pteridium aquilinium*) or shadow areas (*Dryopteris filixmas*). Also, in shaded areas, many weeds cover the ground: dead nettle (*Lamium sp.*), Yellow Balsam (*Impatiens noli-tangere*), Heartleaf Oxeye (*Telekia speciosa*), peach-leaved bellflower (*Campanula persicifolia*, the biggest from our country) and willow gentian (*Gentiana asclepiadea*).

The spruce area (*Picea abies*) climbs up to 1,650-1,800 m, and forms a narrower belt than the previous level of beech forests. Spruce level is limited at the top by a characteristic transition strip (the low-density limit area), in which the specimens appear isolated or in rare clumps, with tattered treetops and grown like a "flag" – pointing to the dominant wind direction. Often, the discontinuous edge of this level is united and covered by dwarf pine (*Pinus mugo mugo*) and a creeping juniper (*Juniperus sibirica*) usually spread over large areas. Sporadically – in upper parts of Valea Vladului – the Swiss pine (*Pinus cembra*) can be found and small groups of Scotch pine (*P. sylvestris*) appear in several groups in the lower parts of Dambovita. Forwarding up to the lower alpine area we meet various species of flowers, some beautiful and more interesting than others: cowberry, bellflowers, gentians, forget-me-not, mountain pansy (*Viola lutea*), orange hawkweed (*Hieracium aurantiacum*), Edelweiss (*Leontopodium nivale)*. In mid-June, up in the alpine, rhododendron blooms (*Rhododendron kotschy*), intertwined with *Vaccinium* species and grasses, such as bristle grass (*Nardus stricta*). Often met is the monk's hood (*Aconitum tauricum*), with each flower of characteristic shape, like a helmet with visor lifted. Along rocky gullies, elastic branches of mountain alder (*Alnus viridis*) form elegant arches of leaves – this shrub being among the few that survive avalanches. Along the highest peaks (upper alpine floor) vegetation rises only slightly above the ground, leaving "fat" herbs of the genera *Sedum* or *Saxifraga*) and almost always brightly colored flowers: *Ranunculus montanus*, Mountain thyme (*Thymus alpestris*), Trumpet gentian (*Gentiana kochiana*), Glacier carnation (*Dianthus gelidus*), Dwarf willow (*Salix herbacea*), Snowbell (*Soldanello sp.*), and many more. In the lower and wet lands – we meet pearl-soft swabs of Hare's tail (*Eriophorum vaginatum*) and rigid tufts of Three-leaved Rush (*Junous trifidus*). Finally, in shady places, on land or on felled beech trunks, a great variety of mushrooms is occurs, usually at the beginning of each fall.

Previous biodiversity research in the Dambovita area

Ichthyofauna of the Dambovita River was target of several research projects by Acad. Petru M. Banarescu during 1951-1964, the period in which he wrote the volume “Romanian Fauna”, Pisces-Osteichthyes, Volume XIII. Fish fauna also was studied in research contracts during construction of the Pecineagu dam by Acad. Petru M. Banarescu, Victoria Tatole and collaborators of the Institute for the Study and Design for Hydropower Bucharest (Bucharest ISDH). During 1996-1997, the undersigned and collaborators, conducted a series of studies in Dambovita hydrographic basin, especially downstream of the dam, for publication of the fish situation at that time, including two environmental impact studies on dams made during communism (dams Voina and Schitul Golesti).

It appears that ichthyofauna situation in the past was better than the present, due to a lower human impact: different kind of forest management with little clear-cutting; no hydro-technical constructions; grazing on valleys was strictly prohibited and was respected by farmers who grow sheep; fish poaching activities were discouraged by the control authorities and sanctions were applied by Romsilva.

Also, research on aquatic insect species like zoobenthic caddisflies, were conducted by Lazar Botosaneanu, eminent Romanian zoologist (1978), who established a foundation for ecological zoning of mountain water on habitats, in all the mountains of the world, during 1982-2004, working at the Institute of Zoology from Amsterdam, Netherlands.

The Plecoptera order, including insects with larval stages that live in water, under rocks and show sharp claw-feet to protect themselves and to not be drawn by currents from rocks, were studied in Dambovita river by Bela Kiss, author of “Romanian fauna”, Volume VIII - Plecoptera (1974) and by Prof. I. Ciubuc, from University of Bucharest, Faculty of Biology, Zoology station Sinaia, of Bucharest University.

In recent years the flora and fauna of Dambovita hydrographic basin were studied by young PhD students, who meanwhile have become specialists in taxonomy, especially in the field of botany. Lichens were studied by Maria Bocila, which conducted a PhD thesis and an extensive work with lichens from Fagaras and Iezer-Papusa mountains.

METHODS

Field methods used in the assessment of the lotic system

For this assessment we used three different field methods:

Electro-fishing

Electric fishing seeks to interfere with neural transmission path of the central nervous system and muscles of fish. By blocking the internal signal and overcoming this by the artificial neural signal, electric fishing redirects the neural signal and the muscle reaction. Fishes can pass through electric barrier undisturbed if they are oriented in the proper position. Fish have a nervous system similar to other vertebrates. In the dorsal part, nerves exiting the spinal cord enter the myomere. In front of the head is a negative charge which would explain why fish are attracted by the anodes. Length and orientation of nervous fibres play a crucial part – the electric current being more powerful as these fibres are longer and crossed transverse by electric field lines. Fish orientation in the electric field determines how this is affected, and the strongest effect is when the fish is placed perpendicular to the field lines and head facing the anode.

Once inside the electric field, fish behaviour will depend on the spatial position of the fish at baseline. The reaction that is expected is swimming involuntarily in a predictable direction (toward the anode). If the force of muscle contractions is too large spinal injuries may occur. Electric fishing is size selective: larger fish tend to be more vulnerable due to electrical gradient, voltage head to toe. A big fish crosses more field lines than a small one (Fig.2). There is an important difference between dimensional selectivity, efficiency and mortality catches. While the capture efficiency increases with fish length, mortality depends mainly on the length and pulse frequency response.

Reversible fishing by electroshock differs fundamentally from so-called "electric fishing" practiced by poachers. Because they use alternating current or pulse frequencies above 50 Hz, fish and other aquatic organisms are killed without discrimination.

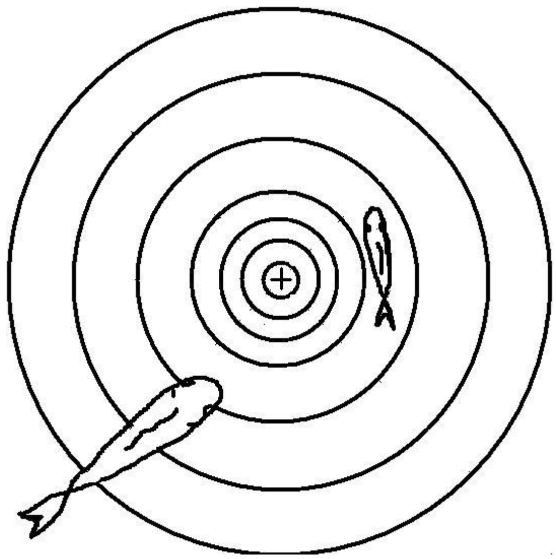


Fig. 2. The effect of electric current is stronger if the fish is larger and closer to the anode.

Fishing with rheophile and small nets

The method of fishing with rheophile nets, model Acad. Petru M. Banarescu, and small nets, is used efficiently in all streams and rivers, even in very large rivers, if biology of rheophile fish species is well known. For small streams, using only one rheophile net is sufficient, because the width of 1 to 1.3 meters placed across the stream ensures catching almost all fish, even though the river has a width of 1.5-2 meters. The nets were placed in the deepest portion of the sampling site, on one side remaining 10-20 cm on the bank at a water depth of 5-10 cm, where no frightened fish can escape, and on the other side of the net the fisher, standing in an open angle of 180 degrees can cover another 40-50 cm of river edge, which is usually the deepest. Though this fishing method can be done by one person, we did it with two people: one person was holding the net and carefully fished the entrance, and the second person, from a distance of 3-8 meters upstream, used a wooden stick of 2-4 meters to scare the fish. In 80-90% of cases, fish will swim downstream as a defence response. It is therefore necessary that the fisher stands in the middle of the river and makes sure fish are leaving the shelters. The time between the fisherman stirring with a stick that scares the fishes and the moment when the ichthyologist will raise the net should be 2-3 seconds, but no longer than 5-6 seconds, because if rising the net is delayed, fish learn the place and discover that this is a trap. Simultaneously they discover in only 6-7 seconds the escape route, which is the same as the entrance into the net. We installed a net in the same place 2-3 times before moving upstream to the next place.

There are some species of very small fish, such as members from the *Cobitidae* family (especially juveniles), that live submerged on sandy or muddy substrate, where electro-fishing is generally inefficient, leaving electrocuted fish on the shore. A very effective way for catching these fish is dredging with rheophile nets that catch all these fish. For catching juveniles of 1-2 cm, we sewed a mesh of 2-3 mm on the bottom of the substrate side of the rheophile net.

Fig. 3. Electro-fishing and fishing with rheophile nets in Valea Vladului.

Bio-monitoring

Given the specific local conditions we considered that the most appropriate evaluation methods are those based on monitoring biological indicators, bio-monitoring. Biotic indices based on aquatic invertebrate fauna are a useful tool for assessing the human impact on a river system. The main advantage is that the effects of changes are felt by the resident biotic community a long time and can thus be detected between periods in which discharges are occurring in riverbed, interventions are made or other temporary disruptions are happening.

In these rivers with high slope and rapid flow, impacts detectable by chemical analysis disappear relatively quickly, within a few hours, especially after rains, thus being very difficult to put the existence of an abnormal chemical parameter into evidence.

As the main method of analysis we used Biotic Normalized General Index, a method that is successfully used by environmental agencies in many European countries. Biological methods for assessing the quality of the aquatic environment have the following advantages:

- aquatic macro-invertebrates have a great natural diversity, about 150 families, 700 genera and over 2,000 species, many of which are acting as indicators for certain types of changes in the environment
- aquatic macro-invertebrates have a relatively short lifespan (1-5 years), thus changes can be detected, changes that cannot be assessed by instant analysis
- assessment is done at various levels of the system, like producers, primary and secondary consumers and decomposing organisms
- relative simplicity of sampling and preservation methods

These qualities have made the so-called "biotic index" to be increasingly used by institutions with responsibilities in the field of water and environmental protection.

BIOTIC NORMALISED GENERAL INDEX

The Biotic Normalised General Index (BNGI) shows the degree of development of aquatic invertebrates to a specific station or section of a body of water. The index enables objective classification of biogenic qualities of aquatic systems: natural, modified or synthetic, polluted to different degrees (Verneaux 1982). This method accurately identifies the following types of disturbances:

- Classic organic dominant-pollution.
- Changes of physical factors, the nature of the substrate, flow rate, etc.

SAMPLING

Since for all biological evaluation methods it is essential to collect the material, the invertebrate samples in a standardized way to minimise errors, we harvested each sample by combining material from eight subsamples taken so as to cover all habitat types present in the station.

The sampling table allows sampling of habitat subtypes according to the "hospitality" for their benthic fauna. This standard operating protocol is designed to avoid neglecting a habitat type during sampling or failing to sample taxa with particular preferences. The purpose of the sampling protocol is to obtain a more complete list of taxa and avoid errors due to operating mode.

THE SAMPLING PERIOD

Sampling was made at least two times, during low flow months, in summer and late autumn.

CHOOSING POINTS FOR SUBSAMPLES

Each habitat can be characterised by two variables: the natural substrate and the speed.

The dominant substrate types were considered, significant in size, even if not the most "welcoming" for benthic fauna. In case of uniform substrates due to hydro facilities we increased diversity by sampling in the same type of substrate, but looking at areas with different flow rates.

Flow speed was assessed with a flow-meter or by float method. For practical reasons the float method, although rudimentary, is easy to use and provides sufficiently accurate information for our needs.

TOOLS FOR SAMPLING

Harvesting was done with a modified Surber dredge, which provides quantitative collection of biological material from equal surfaces. Surber dredges consist of a metal frame aluminium profile with a trapezoidal opening and have a limitation restricting the sample surface at 500 square centimetres, which means 0.2 square meters. This limitation has two wings that prevents scattering of the material on the substrate outside the filter bag. The mesh used is Nytal, with a 250 microns thick wire and eye dimensions <300 μ (Fig.4).

In our case, samples were collected from 19 sampling points. Subsequently, in the laboratory the material was sorted and identification of the biological material was carried out at least to the family level. On the basis of a taxa list obtained, classification into a quality category was made:

- Pollution intolerant (1): these organisms are highly sensitive to pollution. (e.g.: stonefly or alderfly larvae)
- Semi-pollution intolerant (2): these organisms are sensitive to pollution (e.g.: dragonfly larvae or crawfish)
- Semi-pollution tolerant (3): these organisms will be found in clean and slightly polluted waterways. (e.g.: snails or black fly larvae).
- Pollution tolerant (4): these organisms will be found in polluted, as well as clean aquatic ecosystems (e.g.: leeches, bloodworms)

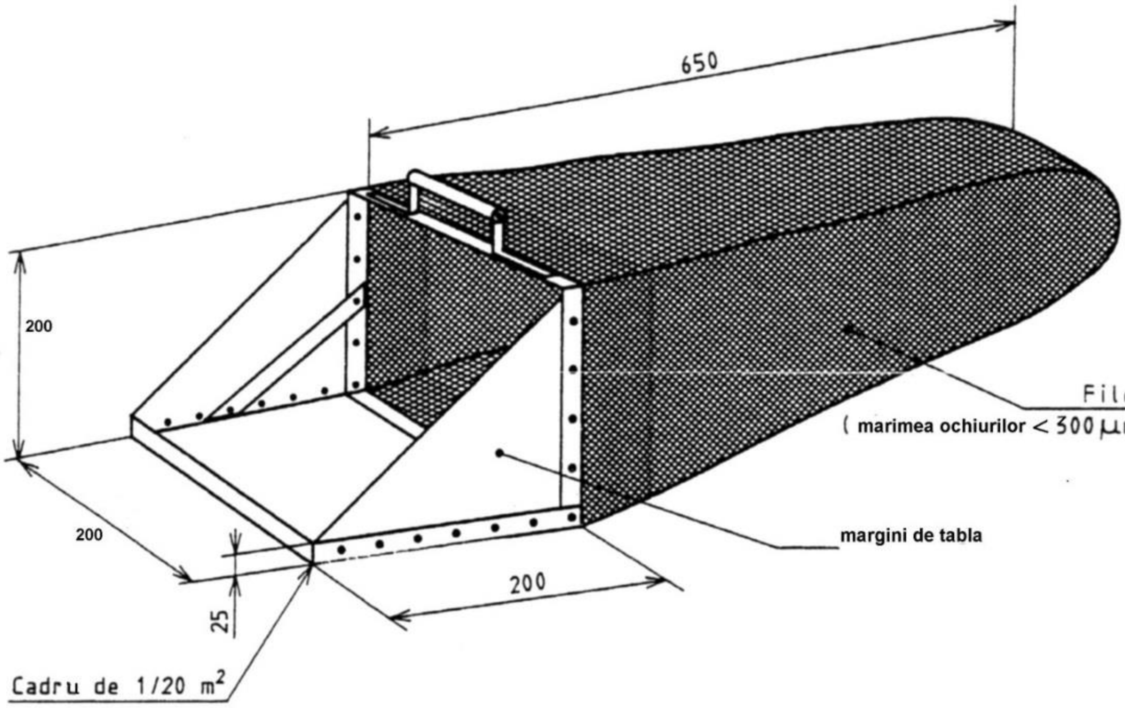


Figura A.1 : draga «Surber»

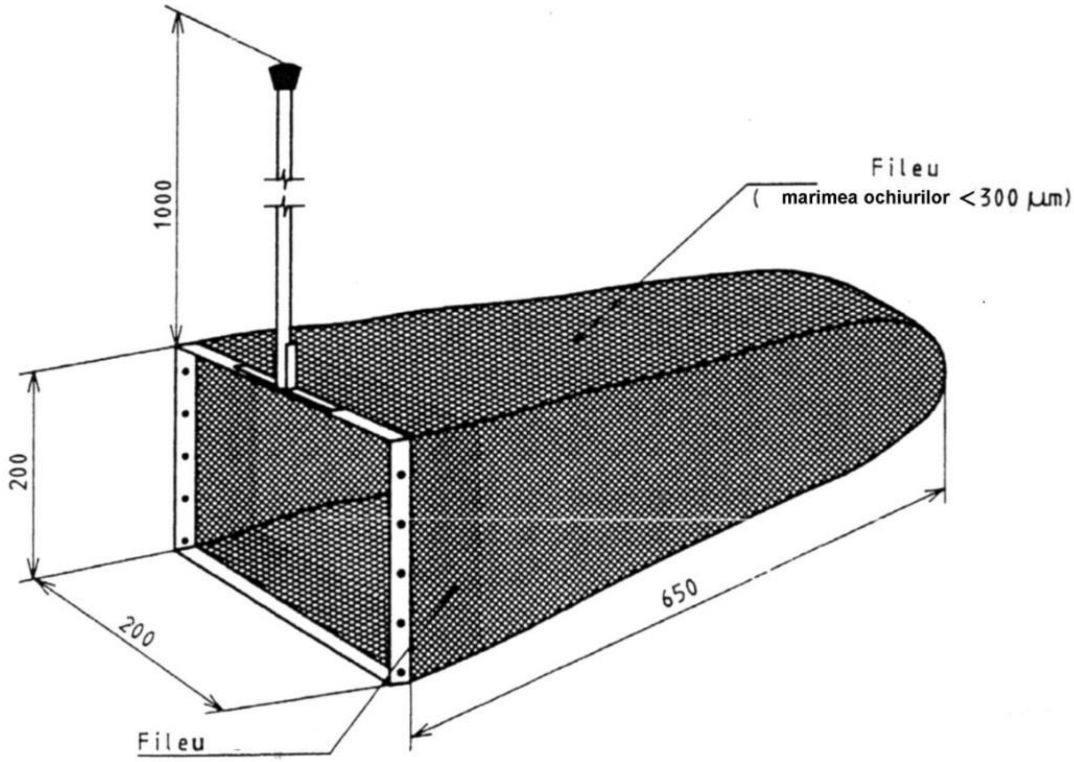


Figure A.2 : draga simpla «haveneau»

Fig. 4. Modified Surber dredge used for sampling.

Geographical data processing

To obtain spatial data we used handheld GPS receivers to map sampling sites, locations of certain habitat types, and human impact parameters (shepherd camps, forestry cabins, logging sites, etc.). After the field work, corrections of GPS errors were made on the basis of 2010 ANCPI ortho-photographic maps. On this basis, also water courses were digitised semi-automatically. For digitised cartography, ArcMap10 and Global Mapper software proved useful, while for 2D modelling we used RSIMgui 2D and specific scripts (Python, Java, MatLab and PHP).

For modelling the pollution gradient along the Dambovita River, we made use of an existing numerical model, adopted according to the necessities. The model assumes the linear interpolation of two points with known values through increasing or decreasing gradient expression, this expression depending on input values. Beside the main model, for the model used in this analysis another 2 variables were added, representing the absolute incline of the place and possible external influences (on DEM basis).

Absolute slope influences the speed of linear dispersion of the pollutant (if the slope is higher the dispersion is faster and vice versa). The possible external influences affect the pollutants dispersion, being very important in this model, facilitating the linear interpolation because of the added values where there are influences but measurements couldn't been made, the pollution gradient ranging from the ideal case of increasing or decreasing between two points with a known value (for example, based on this model, we could have obtained between two points with known values, a decrease, then an increase and again a decrease, this being caused by an external source).

Practically, with the help of a Python script, a polynomial interpolation was made in ArcMap10, on the basis of a "border" (the river itself), and the obtained values from water samples taken from each stations. The output file was exported as an ASCII-raster file, including, for each pixel, the defined domain between border points and x, y, z information.

Mathematically, the results can be expressed like this:

$$Tvsd = \Sigma 1 \cup \Sigma 2 \cup \Sigma 3 \cup \Sigma 4 \cup \Sigma 5$$

$$\Sigma 1 = \{P \mid Vp\ (a1.....an);\ P \in D1\}$$

$$\Sigma 2 = \{P \mid Vp\ (b1.....bn);\ P \in D2\}$$

$$\Sigma 3 = \{P \mid Vp\ (c1.....cn);\ P \in D3\}$$

$$\Sigma 4 = \{P \mid Vp\ (d1.....dn);\ P \in D4\}$$

$$\Sigma 5 = \{P \mid Vp\ (e1.....en);\ P \in D5\}$$

Tvsd = total values spatial distribution

Σ1…Σ5 = total range between stations

P = points

Vp = points values

Using DEM, the absolute slope was calculated for each known point. With a compiled ArcMap tool the gradient dispersion was calculated according to the slope, so if the slope increases with 0.5 degrees, pollutant dispersion is higher in connected points with 5%, and if the slope decreases with 0.5 degrees, dispersion is lower with 5%.

Gds= P1 (∓5o … ∓ no) => Dx= P1 (∓ 5% …∓ n %)

TGds = {p / v (a1+a2+a3+…an) OR/AND p /v (- a1-a2-a3-…an)}

Gds = pollution gradient dispersion considering slope
P1 = point 1 slope value
Dx = dispersion in point x
P = points
A1…an = point 1…point n
V = values

For the second variable, we calculated the area of each surface that has an influence on the degree of water pollution, such establishing an importance relation of the surface to the absolute area (if the influence area is bigger, the pollution is increased and vice versa).

Ins= {P / Iv (f…..fn) P∈D }

Ins = influence surfaces
P = points
D = domain computation
Iv = Influence

The output interpolation file was imported into RSIM, software that uses memory models, where a new distribution model was executed, on the basis of border values, a model that was created through modifications of existing memory models. Using PHP, MatLab we compiled a script that modifies the raw data according to the variables expressed in the upper part of the text. Practically, for each defined point x, y (obtained through the first Python script) a rewriting of the information z (that contains the absolute value of the pollutant) was made, considering the slope evolution and influence surfaces.

Mathematically, this can be expressed as follows:

R1 = {(TVSD ∩ Gds) ∪ (TVSD ∩ Ins)} ∪ {TVSD ∋ (Gds ∪ Ins)}

Tvsd = total values spatial distribution
Gds = pollution gradient dispersion considering slope
Ins = influence surfaces

Laboratory analysis and statistical data analysis

Analysis of water samples

Water transparency was measured with a Secchi disk at a depth of 70 cm - 1 m. We also measured water temperature in summer and in winter, and water pH. Surface water samples were taken from six locations in the study area and were collected in adequate conditions and recipients.

The microbiological (total number of colonies at 37°C, total coli-form bacteria, faeces coli-form bacteria, enterococci) and physico-chemical water analysis (Chemical Oxygen Consumption (CCO-Mn), Nitrites ($NO2^-$), Nitrates ($NO3^-$)) were realised at the National Institute for Research and Development of Industrial Ecology - ECOIND Bucharest, Podu Dambovitei street, 71-73, area 6, zip code 060652, Bucharest, e-mail: ecoind@incdecoind.ro; web: www.incdecoind.ro and at National Institute for Research and Development in Environmental Protection (INCDPM) - BUCHAREST, Spl. Independentei No. 294, sector 6, PC 060031, Bucharest, Romania, E-mail: tociucarmen@yahoo.com.

Cluster analysis of aquatic habitats from the study area

Collection stations were taken in agreement with the beneficiary, only in the upper course of the river, on the main tributaries (Valea Vladului, Valea Otic) that have the largest flows, on which human impact is marked by deforestation even in the stream’s bed and where in the past a rich ichtyofauna was present. Other tributaries, with a low flow (Valea Barbului, Coltii lui Andrei, Berevoiu, Lutele, Tamas) do not present, nor had a permanent ichtyofauna in the past, but probably only during trout migration for breeding in September-October.

In order to conduct the cluster analysis, MVSP version 3.22 software was used (Multi Variate Statistical Package), developed by Kovach Computing Services.

For the analysis we considered the most common fish species typical for upland aquatic rheophile habitats, typical invertebrates (caddiesflies, Heteroptera, aquatic beetles) and amphibians, strictly related to Dambovita and its tributaries or adjacent dead arms, flowing immediately into the mainstream.

Generally these dead arms and small ponds, with clean water and high flow rates are directly related to the main course. Therefore their fauna had been identified, because their habitats are in continuity with the riverbed, juvenile ichthyofauna being present in them.

The *Jaccard index* (Caenotic affinity index, Q) highlights the affinities between the species of a given group in a biocenosis, based on common preferences for the same environmental conditions of life. The index enables highlighting characteristic species (indicator), these having the highest affinity. To estimate the caenotic affinity of representatives of a group identified in a specific area we calculated the affinity of each species with all others. Jaccard's formula is:

$Q = c / a + b, c * 100$

a = the number of samples in which species A is found, whether or not also species B is found;

b = the number of samples in which species B is found, whether or not also species A is found;

c = number of samples in which there are both species found.

Species that have values ranging from 70.1 to 100% are considered edifying for that biocenosis. The Jaccard index can be expressed graphically in a matrix as the percentage of affinity between the investigated species, pair wise or as a dendrogram, which reflects how the investigated species are grouped according to common affinities for the same habitat.

The *Sorensen specific similarity index* (rS) expresses the degree of similarity of communities from different habitats, pair wise, in terms of common species. This index is estimated by Sorensen's index values.

$rS\% = 2 x c / a + b \times 100$

a = the number of species in habitat A

b = the number of species in habitat B

c = the number of common species in the two habitats

The Sorensen specific similarity index can be graphically expressed in a matrix, as the percentage of similarity between investigated habitats, pair wise or as dendrogram, which shows how the investigated habitats are grouped according to the degree of similarity.

Field data was accumulated in a Microsoft Excel database, representing the number of species and individuals of each species collected or observed in each station from the 19 collection stations (Fig. 5 and Annex 2).

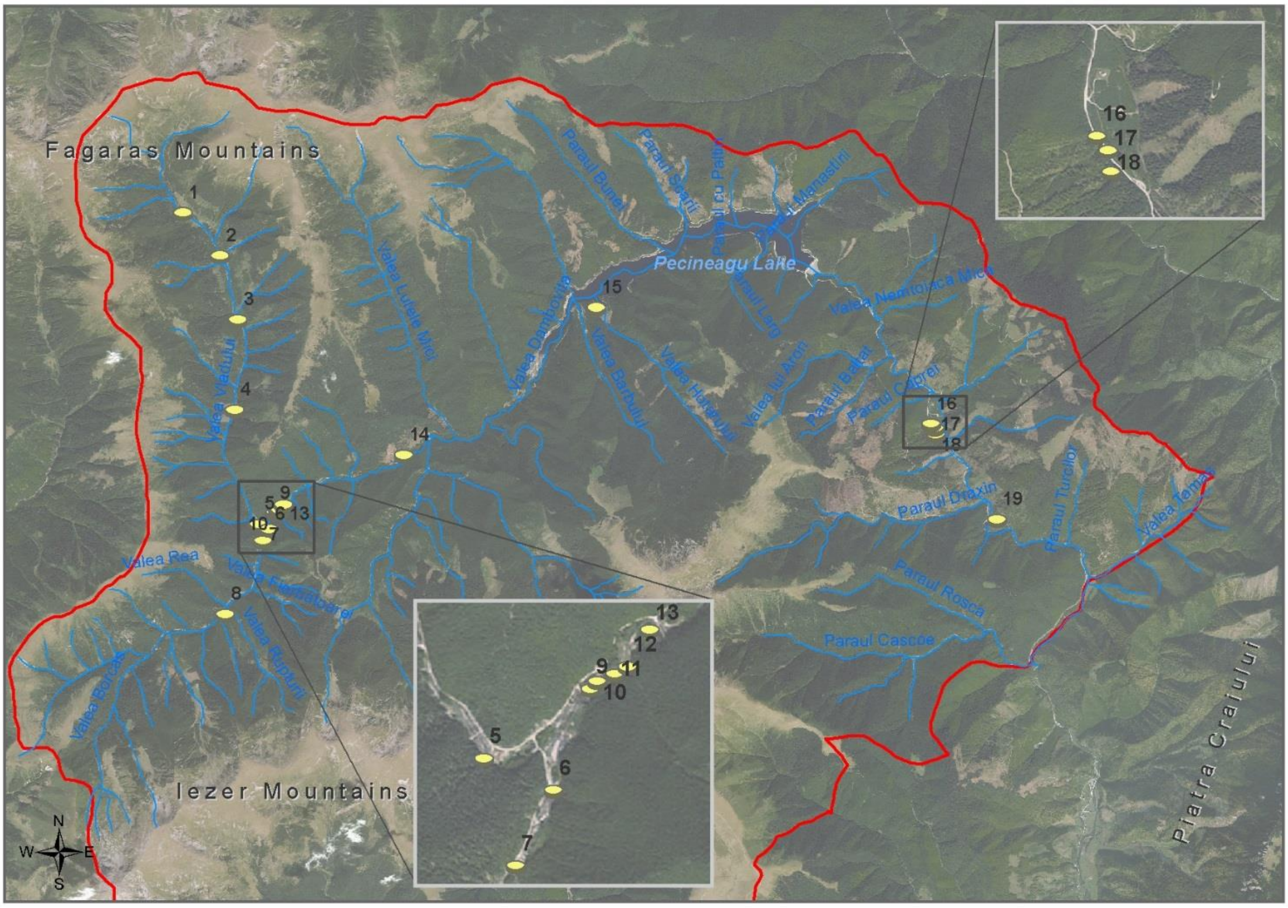


Fig. 5. Distribution of sampling stations for fish, amphibians, reptiles, and invertebrates in the Dambovita basin.

Analytical Ecological Indices

Numerical abundance (A) represents the absolute number of individuals of a species present in a given area. The value of abundance gives us the possibility to characterise present species as rare, less rare, abundant or very abundant (Simionescu, 1984).

Constancy (C) expresses the occurrence continuity of a species in a given habitat. It is a structural indicator because it shows how much of a given species is participating in the population structure (biota). The higher the value, the better a species is adapted to the environment.
Constancy is calculated by the formula:

CA = species constancy

A = number of samples in which the species A is found
N = total number of analysed samples

Depending on the value of this indicator, we can distinguish the following constancy classes (Varvara et al., 2001):

- incidental species: C1 = 1–25%
- accessory species: C2 = 25.1 to 50%
- constant species: C3 = 50.1 to 75%
- euconstant species: C4 = 75.1 to 100%

Dominance (D) shows the relationship between the number of a given species and the sum of individuals of other associated species. This index expresses the relative abundance and is an indicator for productivity because it indicates the percentage of participation of each species for achieving the total biomass. Dominance is calculated by the formula:

DA = A species dominance
nA = total number of individuals of the species A found in the analysed samples
N = total number of individuals of all species present in the analysed samples

The following classes of dominance are distinguished (Varvara et al., 2001):

- D1 – subrecedent species – below 1.1%
- D2 – recedent species – between 1.1 to 2%
- D3 – subdominant species – between 2.1 – 5%
- D4 – dominant species – between 5.1 – 10%
- D5 – eudominant species – more than 10%

Synthetic ecological indexes

Synthetic ecological indexes aggregate the values of some analytical indicators or introduce into calculation more parameters.

Ecological significance index (W) represents the relationship between the structural indicator, constant (C) and the productive indicator – dominance (D), reflecting more eloquent the position of a species in the biocenosis and is calculated by the formula:

CA= constancy of species A
DA= dominance of species A

We distinguish the following value classes (Varvara et al., 2001):

- W1 – accidental species with values below 0.1%
- W2 – with values ranging from 0.1 to 1%
- W3 – accessory species (accompanying species)with values between 1.1 – 5%
- W4 – with values between 5.1 – 10%
- W5 – species characteristic (constant and euconstant) for the cenosis with values above 10%

List of field trips

Field data was collected during five field trips:

- 1st to 3rd October 2012: Valea Otic, Valea Vladului, main Dambovita
- 24th to 26th November 2012: Valea Otic, Valea Vladului, main Dambovita
- 13th to 15th April 2013: Valea Otic, Valea Vladului, main Dambovita, big pond near Valea lui Aron
- 21st to 22nd May 2013: Valea Vladului, main Dambovita, Tamas
- 1st to 3rd June 2013: : Valea Vladului, Otic, Colţii lui Andrei, Cascoe, Tămaşului, Baltatul, Pecineagu lake tail, Barbului, Dracsin, Berevoiu, Lutele Mari, Lutele Mici, Comisului, Aron, Richita, Ivan, Hotarului

RESULTS

Classification and description of inventoried habitats of the Upper Dambovita River

Habitat classification is based on the book "Romania's Habitats" (Donita, N., et al.), which is the first attempt to give a unitary description of the main types of habitats that can be found in Romania. Most of these habitats were included in several habitats classification systems used at European level, like CORINE (1991), PALAEARCTIC HABITATS (1996, 1999) and EUNIS. Wherever practicable, the authors established correspondences with the major European habitat classification systems, i.e. NATURA 2000, EMERALD, CORINE, PALAEARCTIC HABITATS and EUNIS. The code of habitat types contains the capital letter "R" (for Romania) and four numbers. The first two numbers represent the codes of PALAEARCTIC HABITATS subclasses, while the last two numbers represent the running number of habitats in the respective subclass. The numbering of habitats starts with those located at the highest altitudes, habitat names are mentioned as a whole, using three characteristic elements for the natural habitats:

- Land cover type (i.e. forests, scrubs, grasslands, communities of marshes, rocks, sand dunes or water bodies, etc.)
- geographic domain where it occurs (i.e. South-East Carpathian, Dacian, Moldavian, Pannonic, Danubian, Westpontic, Pontic-Sarmatic, Balkanic)
- plant species characteristic to the habitat type

Since there are not enough data about microbiological and fauna components of the ecosystems, characterisation of biocenosis has been done on the basis of flora since this represents a very stable skeleton and is the main producer of ecosystems, determining the occurrence of consumers.

The habitats have been described as follows:

- Code and name
- Correspondence with NATURA 2000, EMERALD, CORINE, PALAEARCTIC HABITATS and EUNIS classifications
- Correspondence with plant association classification and, in case of forests, with forest ecosystem types
- Distribution in Romania
- Approximate area
- Sites description: altitude, climate, relief, substrate, soils
- Community structure
- Flora composition
- Conservation value

We have identified 12 aquatic habitats in the hydro-graphic basin of Dambovita (Fig.5 and Annex 3). Their description and their correspondence to the European classification systems are presented below:

R5409 Southeast Carpathian oligotrophic swamps with Rhynchospora alba and Sphagnum cuspidatum

R5410 Southeast Carpathian mesotrophic swamps with *Carex echinata* and *Sphagnum recurvum*

R5416 Southeast Carpathian communities of springs and streams with *Saxifraga stellaris*, *Chrysosplenium alpinum* and *Philonotis seriata*

R5417 Fontina Southeast Carpathian communities with *Cratoneuron commutatum* and *Cratoneuron filicinum*

R5418 Fontina Southeast Carpathian communities with *Philonotis seriata* and *Caltha laeta*

R5419 Springs and streams Southeast Carpathian communities with *Doronicum carpaticum*, *Saxifraga aizoides*, *Chrysosplenium alpinum* and *Achillea schurii*

R5420 Fontina Southeast Carpathian communities with *Cardamine opizii*

R5421 Southeast Carpathian communities of springs and streams with *Chrysosplenium alternifolium* and *Cardamine amara*

R5422 Southeast Carpathian communities of springs and streams with *Glyceria nemoralis*

R5423 Southeast Carpathian communities of springs and streams with *Carex remota* and *Caltha laeta*

R6105 Southeast Carpathian communities of siliceous half-fixed grunting with *Saxifraga bryoides*, *Silene acaulis* and *Veronica baumgarteni*

R6112 Southeast Carpathian pioneer mountain communities of mobile or semi-fixed grunting with *Thymus comosus*, *Galium album* and *Teucrium montanum*

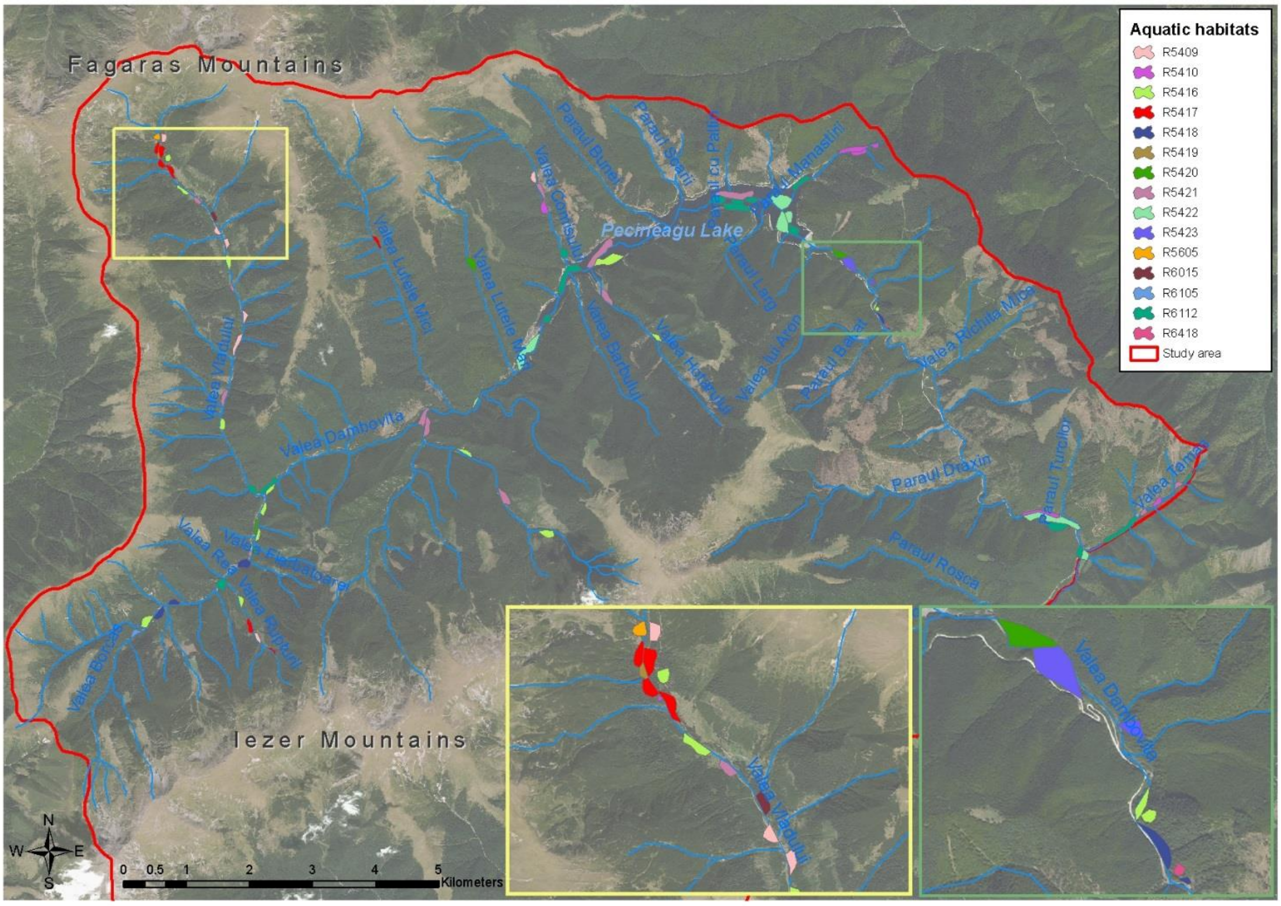


Fig. 5. Distribution of aquatic habitats in the Upper Dambovita basin.

R5409 **Southeast Carpathian oligotrophic swamps with *Rhynchospora alba* and *Sphagnum cuspidatum***	
present in Valea Vladului, in spring area, Valea Otic, on the riverbed gravel terraces, in dead arms and around springs in the forest and also in the spring area of the tributary creeks	
NATURA 2000	7150 Depressions of peat substrates of the *Rhynchosporion*
EMERALD	!54.6 White beak-sedge and mud bottom communities
CORINE	54.6 Beak-sedge quaking bogs
PAL.HAB 1999	54.6 White beak-sedge and mud bottom communities
EUNIS	D2.3H Wet, open, acid peat and sands, with *Rhynchospora alba* and *Drosera*
Plant associations	*Sphagno cuspidati – Rhynchosporetum albae* Osvald 1923, em. Koch 1926
Distribution	Southern Carpathians: Fagaras basin; Western Carpathians: Bihor Mountains
Surface	10-50 ha
Location	Altitude: 520-1050 m. Climate: T = 7-5 Celsius degrees, P = 700-1050 mm; Relief: plain land in mountain depressions. Substrate: acid. Soils: histosoils. Soil of these locations is a meso-oligotrophic peat, characterized through a strongly acidic pH (4.2 to 5.2) and high total nitrogen content.
Structure	Typically oligotrophic habitat, on negative lands, where water is surfacing in rainy months. Floristic composition of the habitat is characterized by a series of species that present a high coverage and frequency. Herbaceous layer is developed, high of 10-20 cm; to mention: *Drosera rotundifolia*, *Carex limosa*, *Rhynchospora alba*. Two sub-associations were mentioned: • *typicum* (Osvald. 1923) Dierssen et Reichelt 1988, which includes phytocoenosis from the Bihor Mountains, poor in class characteristic species *Scheuchzerio – Caricetea nigrae*, but are at the same time very rich in oligotrophic species characteristic for *Sphagnetalia* order; • *caricetosum echinatae* Coldea 1981, signaled in Fagaras basin and with differential species like *Carex echinata*, *Carex lepidocarpa*, *Carex fusca* and *Agrostis canina*. Muscles layer is dominant, sometimes with large coverage; to mention: *Sphagnum cuspidatum*, *Sphagnum contortum*, *Sphagnum magellanicum*.
Conservation value	high, priority habitat
Floristic composition	Prominent species: *Rhynchospora alba*, *Sphagnum cuspidatum*; characteristic species: *Rhynchospora alba*, *Carex limosa*, *Carex diandra;* other important species: *Carex nigra*, *Scheuchzeria palustris*, *Juncus alpinus*, *Eriophorum gracile*, *Menyanthes trifoliata*, Carex lepidocarpa, *Eriophorum vaginatum*, *Andromeda polifolia*, *Empetrum nigrum*, *Oxycoccus microcarpus*, *Polytrichum strictum*. Glacial relict species:*Rhynchospora alba*

R5410 **Southeast Carpathian mesotrophic swamps with *Carex echinata* and *Sphagnum recurvum***	
found in the spring area of Valea Otic and Valea Vladului; in this habitat dominating aquatic bryophyte species are *Drepanocladus fluitans* and *Aulacomnium palustre*, *Sphagnum sp.* and *Agrostis canina* and species of the Poaceae family	
NATURA 2000	–
EMERALD	54.4 Acidic fens
CORINE	54.4 Acidic fens
PAL.HAB 1999	54.42 Black-white-star sedge fens
EUNIS	D2.22 *Carex nigra*, *Carex canescens*, *Carex echinata* fens
Plant associations	Carici echinatae - Sphagnetum Soo (1934) 1954 (Syn.: Caricetum stellulatae Csürös et al. 1956; Carici echinatae - Sphagnetum (Balázs 1942; Soo 1955)
Distribution	Eastern Carpathians: Gutai, Caliman, Dornelor Depression, Blejoaia swamp, Bistrita Mountains, Harghita Mountains, Giurgeului Depression, Comandau, Lacul Negru (Vrancea County). Meridional Carpathians: Godeanu Mountains, Tarcu. Western Carpathians: Bihor Mountains (Valea Iadului, Izbucul Mare, Valea Iedutului), Valea Sebesului, Gilau Mountains, in the mountain and subalpine region
Surface	200-500 ha
Location	Altitude: 700-1500 m; Climate: T = 7.0 to 3.0 Celsius degrees, P = 850-1200 mm; Relief: flat or slightly sloping land, mountain depressions. Substrate: acid. Soils: histosols, with a pH ranging from very acidic up to acid (pH 5 to 5.2); Content in organic matter is variable (35.4 to 82.5%)
Structure	Oligo-mesotrophic habitat present in small clumps or on larger surfaces from the crossing swamps of the entire Carpathian chain. Because of the high environmental acidity, species are well represented by typical oligo-trophic elements, characteristic for order *Sphagnetalia fusca*. The following sub-*associations can be distinguished:* • *typicum* Soo (1934) 1954 (Syn.: *Caricetum echinatae sphagnosum* Balázs 1942); • *pedicularietosum limnogenae* Coldea 1973, with differential species like *Pedicularis limogena*, *Luzula sudetica* and *Leontodon autumnalis*; • *nardetosum strictae* Lupsa 1971; • *carici stellulatae-sphagnetosum* (*recurvi*) *palustris* Coldea 1981; • *sphagnetosum* (*magellanici*) Coldea 1981. We mention that in the herbaceous layer, prominent species achieve the highest coverage and in the moss layer, *Sphagnum recurvum* reaches coverage of up to 60%
Conservation value	very high in habitats where *Ligularia sibirica* is present (DH2)
Floristic composition	Prominent species: *Carex echinata*, *Sphagnum recurvum*; characteristic species: *Carex echinata*, *Carex rostrata*, *Carex nigra ssp nigra*, *Eriophorum scheuchzeri*; other important species: *Drepanocladus exannulatus, Drepanocladus fluitans, Pedicularis limnogena, Valeriana simplicifolia, Carex canescens, Agrostis canina, Aulacomnium palustre, Sphagnum warnstorfii, Sphagnum subsecundum, Carex*

	magellanica, Sphagnum teres, Menyanthes trifoliata, Eriophorum angustifolium, Calliergon stramineum, Ligularia sibirica, Pedicularis palustris, Dactylorhiza maculata, Pedicularis sceptrum-carolinum, Drepanocladus revolvens, Drepanocladus vernicosus, Juncus alpinus

Fig. 6. *Saxifraga stellaris*

R5416 Southeast Carpathian communities of springs and streams with *Saxifraga stellaris*, *Chrysosplenium alpinum* and *Philonotis seriata*	
present in the springs of Valea Otic, even in forests and the area under the rocks with groundwater to the surface as springs or even dead arms; In the Valea Vladului this habitat is present both in the formation area of the river from many sources, on land with slopes of 30-70 degrees inclination, on small areas of 15-20 square meters, easily drained, and larger surfaces, when the relief has slopes of 5-10 degrees inclination (trays under rocks - glacial moraines)	
NATURA 2000	-
EMERALD	54.1 Springs
CORINE	54.11 Soft water springs
PAL.HAB 1999	54.11124 Alpine *Philonotis - Saxifraga stellaris* springs
EUNIS	C2.11 Soft water springs
Plant associations	*Chrysosplenio alpini - Saxifragetum stellaris* Pawl. et Walas 1949 (Syn.: *Philonotido - Saxifragetum stellaris* Boscaiu 1971, *Epilobio anagallidifolii-Saxifragetum alpini* Rejmánek et Rejmánková 1979) Swertio punctate - Saxifragetum stellaris Coldea (1995 - 1996) 1997
Distribution	Eastern Carpathians: Rodna. Meridional Carpathians: Iezer - Papusa, Fagaras, Cindrelului, Retezat, Tarcu, Godeanu. Western Carpathians: Bihor Mountains, Cucurbata Mare, in lower alpine and subalpine level
Surface	small surfaces, around water (<100 ha)
Location	Altitude: 1,400-2,200 me; Climate: T = 3.6 to -1.30 Celsius degrees, P = 1,100-1,450 mm; Relief: subalpine valleys, on slopes with small angle; Substrate: acid or alkaline. Soils: acid hydrisoils to slightly acid (pH 5.0 to 6.8); moist up to wet
Structure	Spring habitat (along springs and streams) with hydro - hygrophilous character. Herbaceous layer is well developed, 12-15 cm high, *Chrysosplenium alpinum* and *Saxifraga stellaris* prevailing, that achieve an average coverage of 35 - 50%. Moss layer, sometimes with large covering, up to 50%. The appreciable presence of *Philonotis seriata* species in Carpathian phytocoenosis led to their reporting to the association *Philonotido-Saxifragetum* Horv. 1949, but this does not justify in terms of the flora
Conservation value	reduced
Floristic composition	Prominent species: *Saxifraga stellaris*, *Chrysosplenium alpinum*. Characteristic species: *Saxifraga stellaris*, *Chrysosplenium alpinum*. Other important species: *Caltha laeta*, *Cardamine opizii*, *Chrysosplenium alternifolium*, *Cardamine amara*, *Saxifraga aizoides*, *Silene pusilla*, *Epilobium nutans*, *Epilobium alsinifolium*, *Bryum pseudotriquetrum*, *Brachythecium rivulare*, *Saxifraga heucherifolia*, *Scapania undulata*, *Deschampsia caespitosa*, *Chaerophyllum hirsutum*, *Stellaria nemorum*, *Viola biflora*, *Veratrum album*, *Aconitum tauricum*, *Juncus triglumis*, *Swertia punctata*

R5417 Southeast Carpathian springs communities with *Cratoneuron commutatum* and *Cratoneuron filicinum*	
Most common type of habitat in both streams (Otic and Valea Vladului), both in the spring area and below (7-10 km downstream). *Saxifraga stellaris* and *Cardamine amara* associations are found even below, but not with all habitats present. It has a larger spreading on lands with gravel deposits and even in the low slope spruce forested area and many springs. In the formation perimeter of Valea Otic this habitat is widespread, not being found in the last 2 km before the confluence with Valea Vladului, probably due to habitat changes caused by hydro dam made in the past, which have changed the hydrology of the valley and led to clogging of the riverbed upstream of the dams and the formation of deposits of organic and organo-mineral on banks that are improper for installing these habitats. It is dominant both in wet shore habitat associations, in dead arms, waterfalls, submerged or partially rotten wood, above the water, in high humidity, but also on the rocks (saxicolous moss), where core moss, alone or in association, is *Cratoneuron sp*	
NATURA 2000	* 7220 Petrifying springs with tufa formations (*Cratoneurion*)
EMERALD	54.12 Hard water springs
CORINE	54.12 Hard water springs
PAL.HAB 1999	54.1221 Hard water bryophyte springs, 54.12241 *Cochlearia pyrenaica* calcareous springs
EUNIS	C2.12 Hard water springs
Plant associations	*Cratoneuretum filicino - commutati* (Kuhn 1937), Oberd. 1977 (Syn.: *Cratoneurum commutatum*, Puscaru et al., 1967), *Cochleario pyrenaicae - Cratoneuretum commutati* (Oberd., 1957), Th. Müller 1961 (Syn.: *Carici flavae - Cratoneuretum cochlearietosum pyrenaicae*, Stefureac 1972)
Distribution	Eastern Carpathians: Maramures Mountains (Sâlhoi), Obcinile Mestecanisului (Rachitisul Mare), Rodna (Piatra Rea, Rebra Peak, Batrana - Fundul Rapilor, Gasetel valley - Rebra valley, Izvorul Fantanii, Corongisul Mare, Lala valley), Bistrita Mountains (Neagra Brostenilor la Cristisor). Meridional Carpathians: Bucegi, in mountain areas and subalpine level
Surface	small surfaces around water ($<$100 ha)
Location	Altitude: 900-2,100 m. Climate: T = 3.5 to -1.50 Celsius degrees, P = 950-1,425 mm; Relief: subalpine and mountainous valleys. Substrate: alkaline, limestone. Soils: eutricambosoils, hydrisoils, eu-mesobasic soils, pH 7 to 7.3
Structure	Hydrophilic habitat and pronounced heliophile, along the streams and springs; Herbaceous layer is poorly developed, with a height of 12-30 cm. Among the species that contribute to the geographical differentiation of phytocoenosis from the Romanian Carpathians, we mention: *Chrysoplenium alpinum*, *Achillea schurii*, *Silene pusilla*. In the groups where characteristic species *Cochlearia pyrenaica* (var. borzeana) is present, it makes a 40-60% average coverage. Moss layer is dominant, sometimes with a big covering, up to 80%, where the characteristic and edifying species *Cratoneuron commutatum* achieves an average coverage of 40%. *Cratoneuron filicinum*, *Bryum pseudotriquetrum*
Conservation value	very high, priority habitat
Floristic composition	Prominent species: *Cratoneuron commutatum*, *Cratoneuron filicinum*. Characteristic species: *Cratoneuron commutatum*, *Chrysosplenium*

alpinum, *Cochlearia pyrenaica*. Other important species: *Silene pusilla*, *Pinguicula vulgaris*, *Saxifraga stellaris*, *Caltha laeta*, *Chrysosplenium alternifolium*, *Cardamine amara*, *Saxifraga aizoides*, *Epilobium nutans*, *Epilobium alsinifolium*, *Bryum pseudotriquetrum*, *Philonotis calcarea*, *Deschampsia caespitosa*, *Crepis paludosa*, *Chaerophyllum hirsutum*, *Stellaria nemorum*, *Viola biflora*. Endemic species: *Achillea schurii*

Fig. 7. Habitat at the confluence of Valea Vladului and Valea Otic.

Fig. 8. *Caltha laeta*

R5418
Southeast Carpathian springs communities with *Philonotis seriata* and *Caltha laeta*

Typical throughout the upper course, but more frequent in the Valea Vladului springs and at a single point in the dead arm area from Valea Otic, where *Cardamine opizii* species is present.

NATURA 2000	–
EMERALD	54.1 Springs
CORINE	54.11 Soft water springs
PAL.HAB 1999	54.1112 *Philonotis-Saxifraga stellaris* springs
EUNIS	C2.11 Soft water springs
Plant associations	*Philonotido - Calthetum laetae* (Krajina 1933) Coldea 1991 (Syn.: *Calthetum laetae* Krajina 1933, *Calthetum palustris* Borza 1963 n.n.)
Distribution	Eastern Carpathians: Rodnei; Southern Carpathians: Bucegi, Piatra Craiului, Fagaras, Retezat, Cindrelului, Tarcu, Godeanu, Western Carpathians: Apuseni (Vladeasa, Cetatile Radesei); in subalpine level
Surface	small surfaces around the water (about 100 ha).
Location	Altitude: 1,300-2,000 m. Climate: T = 4.0 to 0.00 Celsius degrees, P = 1,100-1,400 mm; Relief: subalpine valleys, sloping terrain, little rough. Substrate: acid, crystalline shale. Soils: hydrisoils, with short profile (15-25 cm), well supplied with water, pH 4.3 to 5.1
Structure	Spring habitat. In phytocenosis, characteristic species *Philonotis seriata* and *Caltha laeta* achieve 50% coverage. Herbaceous layer is 10-20 cm high, in which the presence of several peaty species such as *Carex nigra ssp dacica*, *Carex echinata*, *Juncus filiformis* and *Valeriana simplicifolia*, indicates the sindynamic evolution of these species towards the vegetation groups of *Caricetalia nigrae* order as the process of peat forming is amplified. Moss layer coverage is sometimes large, up to 70%; we mention especially *Philonotis seriata*
Conservation value	reduced
Floristic composition	Prominent species: *Caltha laeta*, *Philonotis seriata*. Characteristic species: *Philonotis seriata*, *Chrysosplenium alternifolium*, *Cardamine opizii*. Other important species: *Saxifraga stellaris*, *Cardamine amara*, *Glyceria nemoralis*, *Silene pusilla*, *Epilobium nutans*, *Epilobium alsinifolium*, *Scapania undulata*, *Stellaria uliginosa*, *Philonotis fontana*, *Deschampsia caespitosa*, *Crepis paludosa*, *Angelica sylvestris*, *Veronica beccabunga*, *Chaerophyllum hirsutum*, *Stellaria nemorum*, *Viola biflora*, *Veratrum album*, *Aconitum tauricum*.

R5419 Springs and streams Southeast Carpathian communities with *Doronicum carpaticum*, *Saxifraga aizoides*, *Chrysosplenium alpinum* and *Achillea schurii*	
found on gravel terraces from Valea Otic, in highlands brightly lit, without wood vegetation, on minimum 20-30 square meters	
NATURA 2000	* 7220 Petrifying springs with tufa formations (*Cratoneurion*)
EMERALD	54.12 Hard water springs
CORINE	54.12 Hard water springs
PAL.HAB 1999	54.1226 Eastern Carpathian leopardsbane communities
EUNIS	C2.12 Hard water springs
Plant associations	*Doronico carpatici – Saxifragetum aizoidis* Coldea (1986) (Syn.: *Saxifragetum aizoidis* auct. rom. *Saxifragetum aizoidis* Boscaiu 1971 non Horvat 1935; *Saxifragetum moschatae-aizoidis* Boscaiu 1971).
Distribution	Eastern Carpathians: Rodnei (Piatra Rea, Pintu Mic-Puzdrele stream, Caldarea Aniesul Mare, Caldarea Galatiul, Cobasel valley, Corongisul Mare, Cormaia Peak, Cabana Puzdrele, Cailor Mountain). Southern Carpathians: Fagaras, Retezat, Tarcu (Sadoveanu Peak, Groapa Bistrei, Obarsia Hidegului), Godeanu Mountains (Curmatura Paltina); in mountain region
Surface	small, around water (about 100 ha)
Location	Altitude: 980-1,900 m. Climate: T = 5.5 to 1.00 Celsius degrees, P = 1,000-1,350 mm; Relief: mountain valleys. Substrate: limestone. Soils: moist eutri-cambisoils, pH = 6.8 to 7.1
Structure	Hygro-heliophile habitat located on the edge of streams that drain through grunting and limestone slabs. Herbaceous layer is dominant, 15-30 cm high. Prominent and characteristic species *Saxifraga aizoides* and *Doronicum carpaticum* achieve coverage between 35-55%. In Retezat Mountains, an important role has the Carpatho-Balkan species *Saxifraga heucherifolia*. Often, stages of transition are formed, due to increased drainage of the substrate of these Fontina communities and that of the *Saxifragetum moschatae-aizoidis* association Boscaiu 1971 from the grunting. Extended arcto-alpine disjunction of the species *Saxifraga aizoides* area is an argument for the preglacial origin of these groups of plants. Moss layer is quite diverse and is represented by: *Cratoneuron commutatum*, *Cratoneuron filicinum*, *Bryum pseudotriquetrum*, *Philonotis calcarea*.
Conservation value	very high, priority habitat, endemic in south-eastern Carpathians
Floristic composition	Prominent species: *Saxifraga aizoides*, *Doronicum carpaticum*. Characteristic species: *Saxifraga aizoides*, *Doronicum carpaticum*. Other important species: *Saxifraga stellaris*, *Caltha laeta*, *Chrysosplenium alternifolium*, *Cardamine amara*, *Epilobium nutans*, *Epilobium alsinifolium*, *Deschampsia caespitosa*, *Crepis paludosa*, *Silene pusilla*, *Pinguicula vulgaris*, *Chaerophyllum hirsutum*, *Stellaria nemorum*, *Viola biflora*. Endemic species: *Achillea schurii*, *Doronicum carpaticum*, *Chrysosplenium alpinum* (subendemic)

Fig. 9. *Cardamine opizii*

Fig. 10. Ritro-rheophile habitat with springs and dead arms with *Veronica anagallis – aquatic.*

R5420

Southeast Carpathian springs communities with *Cardamine opizii*

present in the Valea Vladului stream springs, mostly in springs and in one single place in a pond from Valea Otic, situated about 2 km upstream of the confluence with Valea Vladului	
NATURA 2000	–
EMERALD	54.1 Springs
CORINE	54.11 Soft water springs
PAL.HAB 1999	Alpine 54.11124 Alpine *Philonotis-Saxifraga stellaris* springs
EUNIS	C2.11 Soft water springs
Plant associations	*Cardaminetum opizii* Szafer et al. 1923
Distribution	Eastern Carpathians: Rodnei. Meridional Carpathians: Fagaras, Retezat, Tarcu, Godeanu Mountains; in sub-alpine level
Surface	small, around water (about 100 ha)
Location	near sources of subalpine level, in places sheltered from winds, sometimes reaching in contact with cenosis erected by *Saxifraga stellaris*. Altitude: 1,440-1,860 m. Climate: T = 3.0 to 1.50 Celsius degrees; P = 1,200-1,350 mm; Terrain: mountainous valleys. Substrate: acid or base and crystaline shale. Soils: mesobasic hydrisoil, with short profile (15-25 cm), well supplied with water, pH 5.5 to 7
Structure	Neutrophile habitat or weak acidophilus. Hygrophile vegetation communities have been described in the Tatras, studied thorough by Krajina (1933), which has established the cenotaxonomic position in relation to other associations from the alliance. Later it was reported by A. Borza (1934) in Retezat Mountains, where it has a wide spread. Linking the population of *Cardamine opizii* with that of *Cardamine amara* raises difficulties in distinguishing these associations by that of *Cardaminetum amarae* (Rubel 1913) Br.-Bl.1926 described in the Alps. Herbaceous layer is well represented, 10-30 cm high, most commonly present species being: *Chrysosplenium alpinum*, *Saxifraga heucherifolia*, *Doronicum carpaticum*. Moss layer is dominant with high coverage, up to 60%.We mention the species: *Philonotis seriata*, *Brachythecium rivulare*
Conservation value	reduced
Floristic composition	Prominent species: *Cardamine opizii*. Characteristic species: *Cardamine opizi*, *Philonotis seriata*, *Chrysosplenium alpinum*, *Chrysosplenium alternifolium*, *Cratoneuron commutatum*, *Doronicum carpaticum*. Other important species: *Saxifraga stellaris*, *Caltha laeta*, *Epilobium nutans*, *Epilobium alsinifolium*, *Deschampsia caespitosa*, *Silene pusilla*, *Chaerophyllum hirsutum*, *Stellaria nemorum*, *Viola biflora*, *Aconitum tauricum*. Endemic species: *Doronicum carpaticum*

R5421
Southeast Carpathian communities of springs and streams with *Chrysosplenium alternifolium* and *Cardamine amara*

Frequently especially in Valea Otic, in Valea Vladului in the middle course and in Valea Vladului springs, where sometimes *Cardamine opizii* is found, together with *Cardamine amara*	
NATURA 2000	–
EMERALD	54.1 Springs
CORINE	54.11 Soft water springs
PAL.HAB 1999	54.11124 Alpine *Philonotis-Saxifraga stellaris* springs
EUNIS	C2.11 Soft water springs
Plant associations	*Chrysosplenio – Cardaminetum amarae* Maas 1959, including subassociations: *stellarietosum uliginosae* Sanda et al. 2001 (syn. *stellarietosum alsini* Ratiu et Gergely 1975), *circaeetosum lutetianae* Mass 1959, *chrysosplenio rdaminetosum* Lungu 1971 and *plantaginetosum gentianoides* (Borza 1959) Dragulescu 1986 (syn. var. geogr. *dacica – plantaginetosa gentianoidis* Borza 1959)
Distribution	Eastern Carpathians: Rodnei Bistrita Mountains, Bistrita Aurie, Calimani Mountains (Rachitis Peak, Gurghiului Valley), Harghita Mountains, Govora Mountain, Mures Gorge (Salard Valley). Southern Carpathians: Zănoaga, Siriu Mountain, Postavaru, Piatra Craiului, Fagaras, Retezat, Tarcu, Godeanu Mountains, Lunca Berhinii, Parâng Mountains, Cibin Mountains, Cindrelului Mountains. Western Carpathians: Mesesului Mountains, Vladeasa Mountain, (Iadului Valley, Iedutului Valley, Sebiesului Valley), Ploplis Mountains, Sebesului Mountains (Sebesului Valley, Draganului Valley); in the mountain region
Surface	small, around the water (about 10 ha)
Location	common around springs from the mountain valleys, both from the beech forests level, as well as in that of spruce forests. Altitude: 500-1,550 m. Climate: T = 8.0 to 3.10 Celsius degrees; P = 800-1,200 mm. Substrate: acid or alkaline. Soils: hydrisoils moderate to weak acid (pH 5.0 to 6.8), moist up to wet.
Structure	Spring sciafil habitat. Herbaceous layer is well developed, 12-15 cm high, dominated by *Cardamine amara* and *Chrysosplenium alternifolium*. In the lower mountain level we distinguish a sub-association with *Impatiens noli-tangere* and in the upper mountain level, the differential species is *Chaerophyllum hirsutum*. Along with increasing altitude, composition of these communities is contaminated with more species from the order *Adenostyletalia*. Moss layer is sometimes present with large coverage, up to 40%. We mention: *Philonotis seriata*, *Philonotis fontana*, *Brachythecium rivulare*
Conservation value	moderate
Floristic composition	Prominent species: *Chrysosplenium alternifolium*, *Cardamine amara*. Characteristic species: *Chrysosplenium alternifolium*, *Chrysosplenium alpinum*, *Philonotis seriata*, *Carex remota*. Other important species: *Saxifraga stellaris*, *Caltha laeta*, *Glyceria nemoralis*, *Epilobium nutans*, *Epilobium*

	alsinifolium, *Stellaria uliginosa*, *Epilobium palustre*, *Deschampsia caespitosa*, *Crepis paludosa*, *Saxifraga heucherifolia*, *Chaerophyllum hirsutum*, *Stellaria nemorum*, *Impatiens noli-tangere*, *Tozzia alpina*. Endemic species: *Barbarea lepuznica*

Fig. 11. *Cardamine amara*

Fig. 12. Habitat with *Carex sp.*

R5422 **Southeast Carpathian communities of springs and streams with *Glyceria nemoralis***	
This habitat is found only in Valea Otic, where some oligotrophic ponds are formed between toplices from the terraces of gravel and coarse silt and fine sands, where species *Glyceria nemoralis* is found, together with green algae (*Spirogyra sp.*, *Chara sp.*) and cyanobacteria (*Nostoc sp.*)	
NATURA 2000	–
EMERALD	54.1 Springs
CORINE	54.11 Soft water springs
PAL.HAB 1999	54.11 Soft water springs
EUNIS	C2.11 Soft water springs
Plant associations	*Alchemillo mollis – Glycerietum nemoralis* Popescu et Sanda 1998 (Syn.: *Glycerietum nemoralis* Sanda et al. 1994)
Distribution	Eastern Carpathians: Siriu Mountain (Izvorul Bradului). Meridional Carpathians: Bucegi Mountains (Busteni, Azuga Valley) in the mountain region
Surface	small, around the water (about 1 ha)
Location	Altitude: 900-1,000 m. Climate: T = 6 to 5.50 Celsius degrees; P = 950-1,000 mm Terrain: mountain valleys in small depressions. Substrate: acid and crystalline shales. Soils: hydrisoils, with high humidity, pH = 6
Structure	Cryo-hydrophilic habitat located in the fir-beech forests level, in small depressions from the edge of the forest roads. Herbaceous layer is dominant, 15-30 cm high, with abundant species of Alno-Padion and Fagetalia, such as: *Carex remota*, *Cardamine pratensis*, *Rumex sanguineus*, *Carex sylvatica*. The permanent course of the mountain streams determines settling of a large number of mezohygrophile elements including: *Veronica beccabunga*, *Epilobium palustre*, *Stellaria nemorum*, *Mysotis scorpioides*, *Ranunculus repens*, *Poa trivialis*. Moss layer is less represented
Conservation value	reduced
Floristic composition	Prominent species: *Alchemilla mollis*, *Glyceria nemoralis*. Characteristic species: *Alchemilla mollis*, *Glyceria nemoralis*. Other important species: *Deschampsia caespitosa*, *Silene pusilla*, *Epilobium nutans*, *Crepis paludosa*, *Veronica beccabunga*, *Epilobium palustre*, *Rumex obtusifolius*, *Stellaria nemorum*

R5423
Southeast Carpathian communities of springs and streams with *Carex remota* and *Caltha laeta*

Habitat found on the terraces of Valea Otic, where it is met in one single place, along with the habitat type R5422

NATURA 2000	–
EMERALD	54.1 Springs
CORINE	54.11 Soft water springs
PAL.HAB 1999	54.111 Soft water bryophyte springs
EUNIS	C2.31 Soft water springs
Plant associations	*Carici remotae – Calthetum laetae* Coldea (1972) 1978 (Syn.: *Carici remotae – Cardaminetum amarae* Dihoru 1964, *Calthetum palustris* Borza 1934, *Caltheto – Ranunculetum* (Resm. et al. 1971) Resm. et Ratiu 1978).
Distribution	Eastern Carpathians: Maramures Mountains, Mures Gorge, Gurghiului Valley, Siriu Mountain. Southern Carpathians: Azuga Valley, Cheile Dâmbovicioarei – Brusturet. Western Carpathians: Plopis Mountains, in the mountain region
Surface	small, around the water (about 10 ha)
Location	from the inferior and midst mountain level. Altitude: 500–950 m. Climate: T = 8.0 to 5.60 Celsius degrees; P = 800–925 mm; Relief: mountain valleys. Substrate: acid and crystalline shales or slightly alkaline. Soils: mesobasic hydrisoils, with short profile, well supplied with water, pH = 5–6
Structure	Habitat along the streams, well differentiated in terms of flora. Herbaceous layer is dominant, 10–20 cm high, some hydrophilic species of *Glycerio–Sparganion* alliance and *Molinietalia* order are present. Characteristic and diagnostic species *Carex remota* indicates a glaciations process of soil, as the process of soil formation progresses. In these locations groups with *Caltha laeta* and *Carex remota* are progressing to *Calthion* alliance. Moss layer is well represented by *Cratoneuron commutatum*, *Brachythecium rivulare*.
Conservation value	moderate and high in habitats where the species *Ligularia sibirica* is present (DH2)
Floristic composition	Prominent species: *Carex remota*, *Caltha laeta*. Characteristic species: *Carex remota*, *Cratoneuron commutatum*, *Chrysosplenium alternifolium*. Other important species: *Ligularia sibirica*, *Cardamine amara*, *Glyceria nemoralis*, *Stellaria uliginosa*, *Epilobium palustre*, *Crepis paludosa*, *Chaerophyllum hirsutum*, *Doronicum austriacum*

R6105 **Southeast Carpathian communities of siliceous half-fixed grunting with *Saxifraga bryoides*, *Silene acaulis* and *Veronica baumgarteni***	
found in Valea Vladului, in the middle course, with rock habitats and waterfalls in riverbed, where, on the side slopes, with 80-90 degrees inclination, is present this type of habitat to the river bed	
NATURA 2000	8110 Siliceous screes of the montane to snow level (*Androsacetalia alpinae* and *Galeopsetalia ladani*)
EMERALD	61 Screes
CORINE	61 Screes
PAL.HAB 1999	61.11522 Southern Carpathian saxifrage-speedwell screes
EUNIS	H2.31 Alpine siliceous screes
Plant associations	*Saxifrago bryoides - Silenetum acaulis* Boscaiu et al. 1977 *Veronico baumgarteni - Saxifragetum bryoidis* Boscaiu et al., 1977
Distribution	Southern Carpathians: Retezat Mountains (peaks: Custura, Gruiul, Judele, Muchia Ascutita, Bucura, Peleaga, Papusa, Pietrele) in the alpine level
Surface	very small (about 10 ha)
Location	Altitude: 2,000-2,200 m. Climate: T = -0.5 to -1.50 Celsius degrees; P = 1,350-1,450 mm. Relief: grunting and smashed rocks. Substrate: small shales, granite. Soils: skeletal lithosoils in places with big snow accumulations during the winter
Structure	Cryo-nival habitat, that vegetates under extreme conditions. Herbaceous layer: prominent species *Saxifraga bryoides* and *Silene acaulis* makes a medium coverage of 35%. On the other hand, the two characteristic species: *Saxifraga bryoides* and *Veronica baumgartenii* form unfinished phytocenosis. The most common accompanying species are: *Saxifraga pedemontana ssp cymosa*, *Doronicum carpaticum*, *Poa laxa*, characteristic taxa of the order *Androsacetalia alpinae*. Being in contact with *Salicion herbaceae* alliance groups in their composition often occur many characteristic species such as: *Luzula alpino-pilosa*, *Festuca picta*, *Taraxacum alpinum*, *Soldanella pusilla*, *Chrysanthemum alpinum*. The habitat may present floristic similarities with the one mentioned in Bucegi Mountains, named *Silene acaulis - Minuartia sedoides* and *Geum reptans - Oxyria digyna.*
Conservation value	important, endemic habitat
Floristic composition	Prominent species: *Saxifraga bryoides*, *Silene acaulis*, *Veronica baumgarteni*. Characteristics species: *Silene acaulis*, *Poa cenisia ssp. contracta*, *Veronica baumgarteni*. Other important species: *Saxifraga pedemontana ssp. cymosa*, *Geum reptans*, *Oxyria dygina*, *Saxifraga carpatica*, *Poa psychrophila*, *Saxifraga androsacea*, *Soldanella pusilla*, *Luzula spicata*, *Gentiana frigida*, *Senecio carniolicus*. Endemic species: *Doronicum carpaticum*.

R6112 Southeast Carpathian pioneer mountain communities of mobile or semi-fixed grunting with *Thymus comosus*, *Galium album* and *Teucrium montanum*	
This kind of habitat is present in Valea Otic, on gravel terraces and rock blocks, already seeded with juvenile spruce. It seems to be a transitional habitat that will be replaced with spruce and alder (*Alnus incana*) habitats in the next 30 years. Indicator plant species for this habitat are: *Teucrium montanum*, *Galium album* and *Thymus comosus* (mountain thyme).	
NATURA 2000	8120 Calcareous and calcshist screes of the montane to alpine levels (*Thlaspietea rotundifolii*)
EMERALD	61 Screes
CORINE	61 Screes
PAL.HAB 1999	61.242 East Carpathian calcareous screes
EUNIS	H2 Screes
Plant associations	*Thymo comosi – Galietum albi* Sanda, Popescu 1999 (Syn. *Thymetum comosi* Pop et Hodisan 1963 *Galietum erecti* Pop et Hodisan 1964 *Teucrietum montani* Csürös 1958) *Galio-Hirundarietum* Dihoru 1975 (Syn. *Vicetoxicetum officinalis* Schwick 1944 p.p.)
Distribution	Eastern Carpathians: Siriu Mountain. Meridional Carpathians: Bucegi Mountains; Talmaciu-Podul Olt, Leaota Mountain (Cheile Rudaritei, Cheile Cheii, Cheile Dâmbovitei); Grohot Massif. Western Carpathians: Apuseni Mountains (Cheile Bulzesti, Cheile Runcului), Iadului Valley, Râmet, Sighistelului Valley, Scărita Belioara Mountain, Craciunesti, Vadu Crisului, Valea Ascunsa.
Surface	small (100 – 500 ha)
Location	Altitude: 310-1,400 m. Climate: T = 9.0 to 3.50 Celsius degrees; P = 700 -1,100 mm. Relief: Slopes with large to medium tilt. Substrate: fine grunting, with a high rate of soil formation (1), on the semi-fixed fine grunting from the foot of cliffs (2) are installed first on mobile grunting, rarely being encountered on the fixed ones (3) or are developing on the accumulation of gravel, the result of crushed rocks at the base of cliffs, at an altitude above 1,000 m (4). Soils: lithosoils, pH = 5.8 to 7.5
Structure	(1) *Thymetum comosi* Pop et Hodisan 1963. Thermophilic habitat. Herbaceous layer coveres a large number of species, and the most common are: *Teucrium chamaedrys*, *Viola jóoi*, *Sedum hispanicum*, *Geranium robertianum*, *Hieracium pilosella*, *Festuca cinerea*. This indicates the evolution of the association towards xerophilic meadows. The group was described from the Apuseni Mountains (Buzesti keys and Runcului keys). (2) *Teucrietum montani* Csûrös 1958. Thermophilic habitat, that features southern elements, and the most representative are: *Achillea crithmifolia*, *Orlaya grandiflora*, *Sanguisorba minor*, *Salvia verticillata*, *Cnidium silaifolium*, *Stachys recta* and, in some locations, *Ceterach officinarum*. It is known from the West of Southern Carpathians and the Apuseni Mountains. (3) *Galietum erecti* Pop et Hodisan 1964. Pioneer habitat. Herbaceous layer – in which the cover performed by *Galium album* is relatively high (60-70%), although

	the floristic composition is not well defined, being a pioneer group. In addition to characteristic species from *Teucrion montani* alliance, also grow: *Acinos alpinus ssp. majoranifolius*, *Cardaminopsis arenosa*, *Silene heuffelii*, *Minuartia verna*, *Cytisus nigricans*, and from the class characteristic species we note: *Scutellaria altissima*, *Lamium maculatum*, *Phyllitis scolopendrium*, etc. Presence in *Galium album* phytocoenosis of dried meadows (*Festuco-Brometea*) and forests (*Querco-Fagetea*) characteristic species is explained by their vicinity and which, as the substrate enriches in organic material, it creates conditions for installation of species with larger ecological requirements. (4) *Galio - Hirundinarietum* Dihoru 1975. In *Vicetoxicum officinale* groups and *Galium album* also participates: *Geranium robertianum*, *Festuca rupicola var. saxatilis*, *Verbascum lychnitis*, *Fragaria vesca*, *Sedum telephium ssp. maximum*, *Poa nemoralis*, *Origanum vulgare*, *Luzula luzuloides*. Species entering in phytocenoses structure are very heterogeneous, containing plants that live on rocks, in the forest and even on meadows.
Conservation value	large, endemic habitat
Floristic composition	Prominent species: *Thymus comosus*, *Galium album*, *Teucrium montanum*. Characteristic species: *Thymus comosus*, *Gymnocarpium robertianum*. Other important species: *Erysimum odoratum*, *Cardaminopsis arenosa ssp. borbásii*, *Melica ciliata*, *Origanum vulgare*, *Geranium robertianum*, *Senecio rupestris*, *Moehringia muscosa*, *Vincetoxicum hirundinaria*, *Acinos alpinus*, *Asplenium trichomanes*, *Poa nemoralis*, *Cystopteris fragilis*, *Sedum album*. Endemic species: *Campanula carpatica*, *Silene nutans ssp. dubia*, *Thymus comosus*, *Viola jóoi*
Selected literature	Csürös 1958; Pop I. et Hodisan 1963, 1964, 1967, 1969; Pop I. et al. 1964; Boscaiu et al. 1966; Suteu St. 1968; Schneider-Binder E. 1970; Dihoru 1975; Suteu et Faur 1977; Ratiu O. et al. 1984; Pop I. 1971; Diaconescu F. 1973; Sanda et al. 1996; Alexiu 1998; Coldea 1991; Coldea et al.1997; Sanda et al. 2001; Sanda 2002

Fig. 13. Association of *Thymus sp.*

Water analysis

The measurement of water transparency revealed a maximum transparency in Dambovita river water. Turbidity is very low, being represented by organic detritus, humus, resins from the trees near the water and lichens present on rocks that detach and enter in the water body. Water temperature is 7 degrees Celsius in winter and 12 to 13 degrees Celsius in summer. Water pH is 7 (neutral) in the confluence of Otic-Valea Vladuluis and 6.4 (slightly acid) on Valea Vladului, due to both natural (present microhabitats with *Sphagnum sp.*) and anthropic factors, like water pollution and grazing along the stream.

Table 1. Variations of dissolved oxygen in the sampling stations during cold and warm seasons.

Sampling station	Date			
	25.11.2012		01.06.2013	
	Temperature °C	Dissolved oxygen (mg/l)	Temperature °C	Dissolved oxygen (mg/l)
1	3	10,33	7	10,21
2	4	10,16	7	10,04
3	4	10,11	7	10,07
4	4	9,67	7	9,64
5	4	9,34	8	9,25
6	4	9,10	8	9,14
7	4	8,92	8	8,79
8	5	9,96	8	9,77
9	5	9,87	8	9,71
10	5	8,93	8	8,81
11	5	8,87	8	8,62
12	5	8,84	8	8,53
13	5	8,91	9	8,45
14	5	8,78	9	8,39
15	5	8,63	9	8,41
16	5	8,79	9	8,25
17	5	8,45	9	8,31
18	6	8,12	11	7,85
19	6	8,05	13	7,81

Oxygen is the most important element to aquatic organisms (hydrobionts). The oxygen source for water is atmospheric air and the amount of dissolved oxygen depends on the difference between the partial pressure of oxygen dissolved in the 2 environments. Solubility of oxygen is influenced by the absorption coefficient, the content of dissolved salts in water as the temperature is in inverse proportion to the amount of dissolved oxygen. Another oxygen source results from the process of photosynthesis provided by hidrobionts such as vegetable cryptogame phytoplankton and aquatic macrophytes. Oxygen can also come from the reduction of oxides. Dissolved oxygen increases more in mountain rivers flowing over rapids and waterfalls and also in water basins that are rich in vegetation, leading even to water saturation of oxygen. Dissolved oxygen variation is in direct correlation with temperature (see Table 1), water flowing speed, the slope, number of rocks from the major riverbed, that allow increasing of water contact surface with the atmosphere during flow, and dissolving of a greater oxygen quantity, up to saturation, according to water temperature. Variations are also determined by: the amount of organic matter, supply of rivers with water less oxygenated, pollutant waste discharge, resulting in destruction of photosynthetic producers, the degree of turbulence of the water, oxygen consumption through hydrobionts breathing.

Dambovita River shows an optimum amount of dissolved oxygen in water to allow the development of hydrobionts (Tab. 1). For some oxiphilic crenobiont species, like salmonids, the oxygen is a limiting factor in their spread. Reaching the oxygen saturation capacity is yet limited by the presence of organic matter coming from the slopes, especially in Dambovita valley, where there are very many woody debris, foliage, herbaceous dried plants in different degradation stages, from mull to modder.

Table 2. Results of microbiological water analysis.

Executed test	Measure Units	Sample value	Test method
Total no. of colonies at 37°C	UFC/cm^3	>300 (492)	SR EN ISO 6222/2004
Total coliform bacteria	No./100 cm^3	130	ISO 9308/2-1990
Fecal coliform bacteria	No./100 cm^3	49	ISO 9308/2-1990
Enterococci	No./100 cm^3	<2	SR EN ISO 7899-2/2002

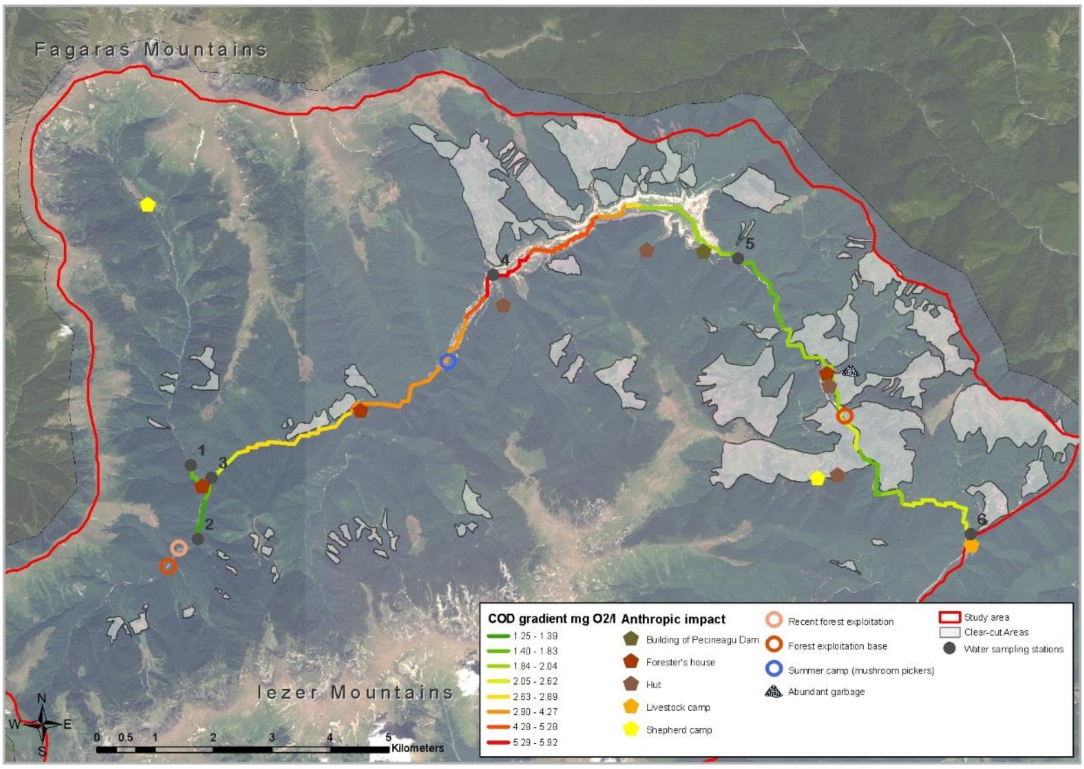
Results marked with "<" represent values under the detection limit of the method used

From Table 2 we can observe that, although the sampling station should be very clean and the water should be almost pure microbiologically, the bacterial colonies are numerous. Partially this is because of an increased human activity, especially in summer, when numerous mushroom pickers stay for extended periods of time in the area. The main source of water pollution, however, remains forestry and grazing.

Table 3. Results of the physico-chemical water analysis.

	Quality indicators		
Water sample station	**Chemical Oxygen Consumption (CCO-Mn) mg O_2/l**	**Nitrites (NO_2^-) mg N/l**	**Nitrates (NO_3^-) mg N/l**
1	1,51	< 0,001 (0,0004)*	0,0929
2	1,19	< 0,001 (0,0004)*	0,1559
3	1,83	< 0,001 (0,0004)*	0,0998
4	12,50	<0,001 (0,0004)*	3,1500
5	1,59	< 0,001 (0,0004)*	0,3620
6	2,62	0,0019	0,2975

Through these activities, two types of pollution occur – inorganic pollution, with petroleum products, especially fuel and motor oils from trucks that carry exploited wood outside of the forest and organic pollution, with sheep or cow faeces that are washed away by the rain and drain into the water. This activity can cause the nitrate level to increase. Nitrites (NO_2^-) are undetectable in most samples, but nitrate (NO_3^-) levels are increased in some areas, most probably due to human activities (Tab. 3). The amount of consumed oxygen can be explained by the presence of bacteria. Although the dissolved oxygen is normal for stream water, the consumption of oxygen is bigger, mainly due to metabolism processes of bacteria. The modelled pollution gradient along the Dambovita River and a good visualisation of possible pollution sources are presented in Figures 14 –16 (and in Annex 4 – 6) for each of the determined physico-chemical indicators (chemical oxygen consumption, nitrites, nitrates).



Note: throughout the survey period, the artificial Pecineagu Lake was drained and the Dambovita River was flowing in its original riverbed.

Fig. 14. Modelling of the chemical oxygen demand (COD) in the upper course of the Dambovita River.

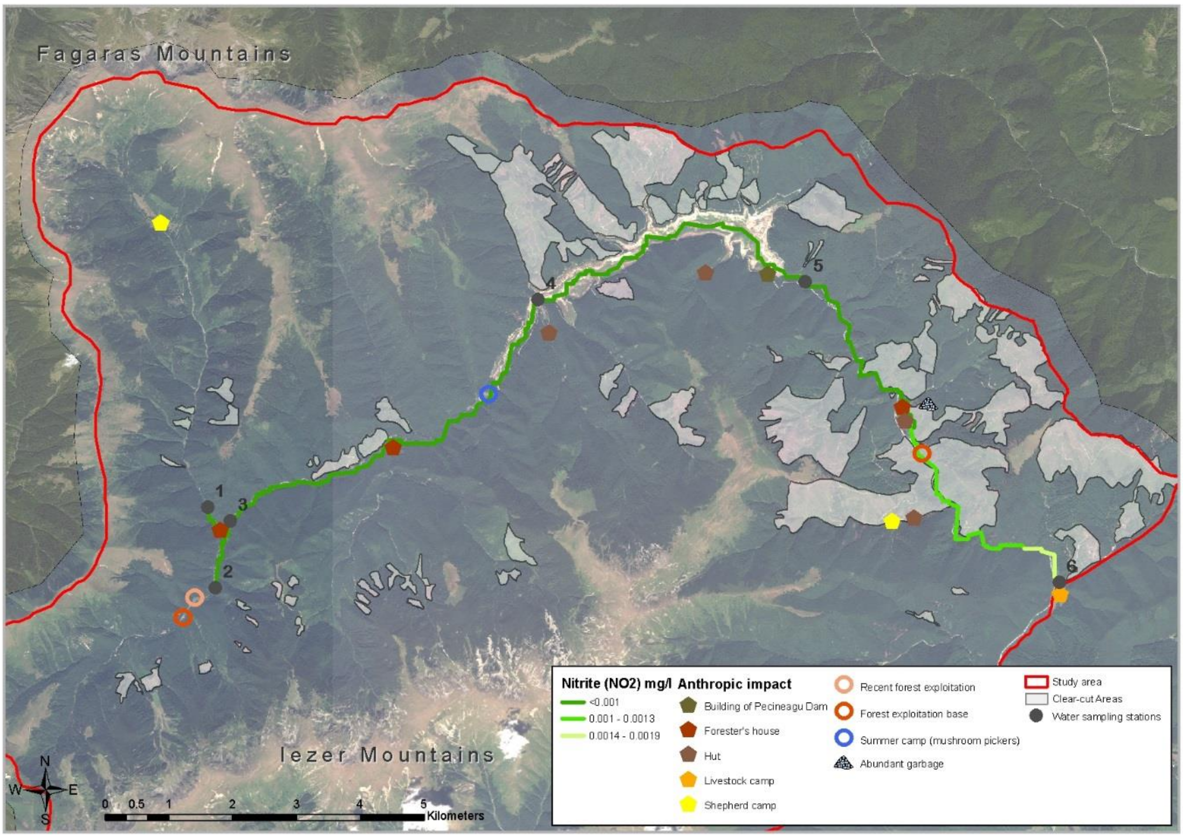


Fig. 15. Spatial distribution of nitrite (NO2) in the Upper course of the Dambovita River.

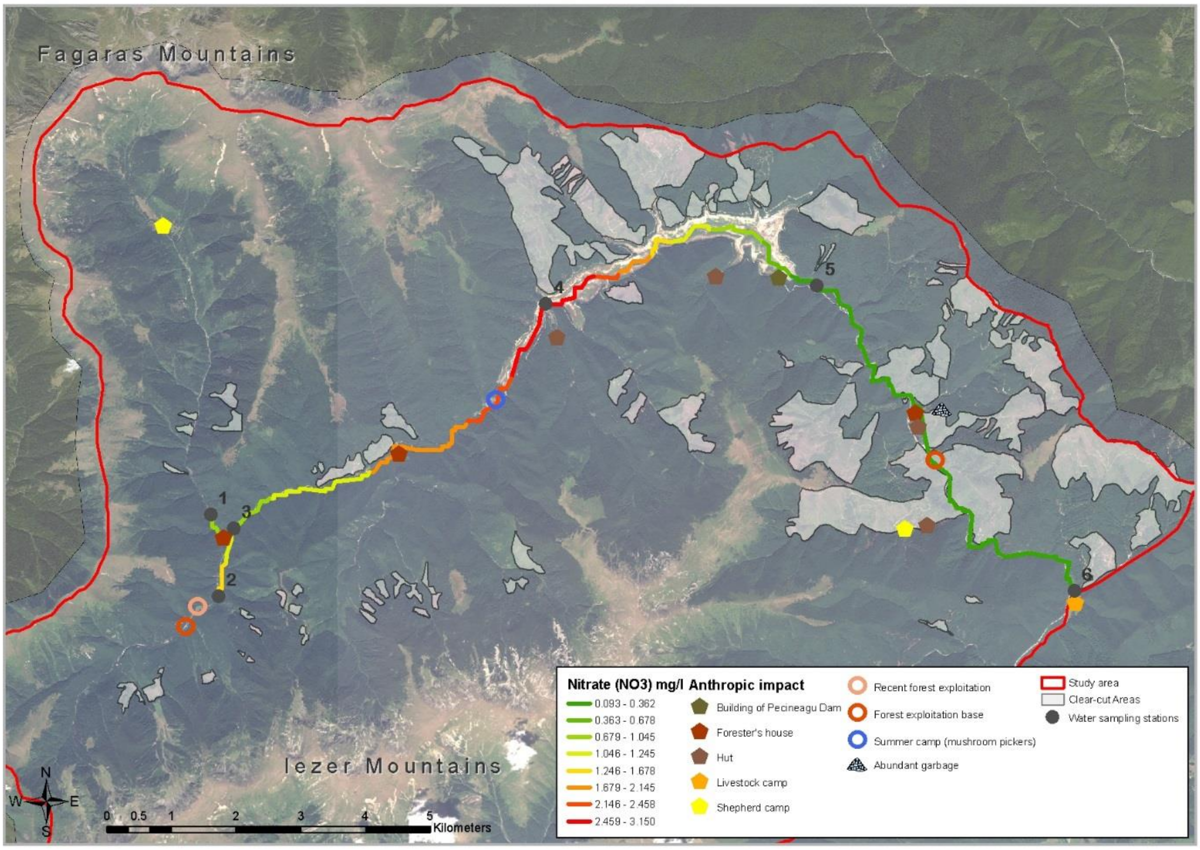


Fig. 16. Spatial distribution of nitrate (NO3) in the Upper course of the Dambovita

Quantitative and qualitative structure of all important taxonomic groups

A list of all species identified during the field study of this assessment is presented in Annex 7. Table 4 presents the absolute abundance of species collected in the 19 different sampling stations along the Upper Dimbivota River.

Cluster analysis

Aquatic habitats in the upper Dâmboviţa are closely related to each other, due to the geographical orography of the valley (deep bed of Dâmboviţa and tributaries, very little or no floodplain, microhabitats like oligotrophic ponds are very small, but with powerful springs, with high flow, dead arms, that flow after a short route into the main course). These habitats and microhabitats inhabit a temporary fish fauna: in spring and summer, ponds are refuges for trout and bullhead juveniles; they show a rich invertebrate fauna, which represents the food for trout and bullhead. In early spring these microhabitats are used for breeding amphibians (newts and frogs) until June-July and also tadpoles are present here. This is why we can say that, in terms of characteristics, these habitats and microhabitats do not have a hydrological border between them, having the same physical and chemical characteristics of water and same biodiversity composition, the only differences being those related to water flow and speed of the currents.

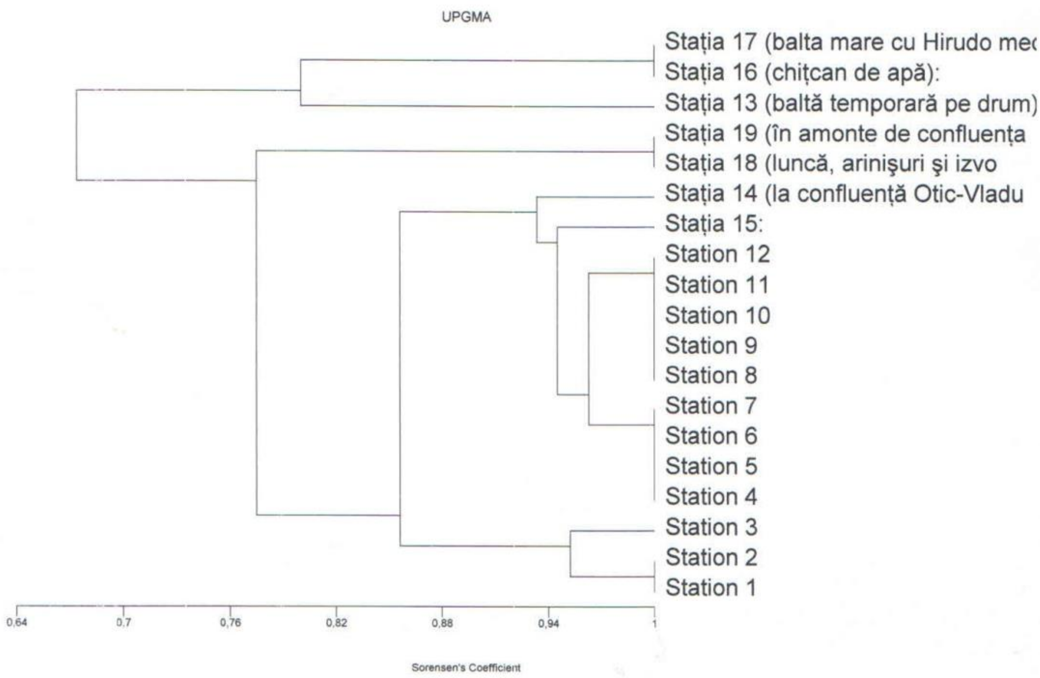


Fig. 17. Sorensen coefficient for all sampling stations along the Upper Dambovita River.

From the Sorensen index (Fig. 17) we can observe that stations show a high degree of similarity with each other, namely presenting the same species in most stations, which although few in number, are present with maximum frequency in the samples revealed in the field. Maximum similarity appears between stations 16 and 17, 19 and 18, 12, 11, 10, 9, 8, then between stations 7, 6, 5, 4, and stations 2 and 1, between which there are no differences, so the similarity is maximum, equal to 1. These stations have the same species and, in general, have the same ecological indices (density, frequency). In terms of habitat, physico-chemical factors are constant, completely unchanged, all the way between these stations. A certain difference between these groups of stations exists and it is determined by the existence of some clear hydrological barriers: the hydro dams from Dâmboviţa and tributaries, the great dam Pecineagu, that definitely separates the upper course from the lower course, where stations 17, 18 and 19 are present, which have larger differences in terms of habitat and species composition, but also in their density and frequency compared to stations upstream Pecineagu lake. Stations 13, 16 and 17 differ more in species, due to having some adjacent microhabitats (pools, warm water bodies, oligotrophic ponds, and springs) and high differences in the plant biodiversity. Stations 8, 9, 10, 11, 12 are virtually identical in composition of species.

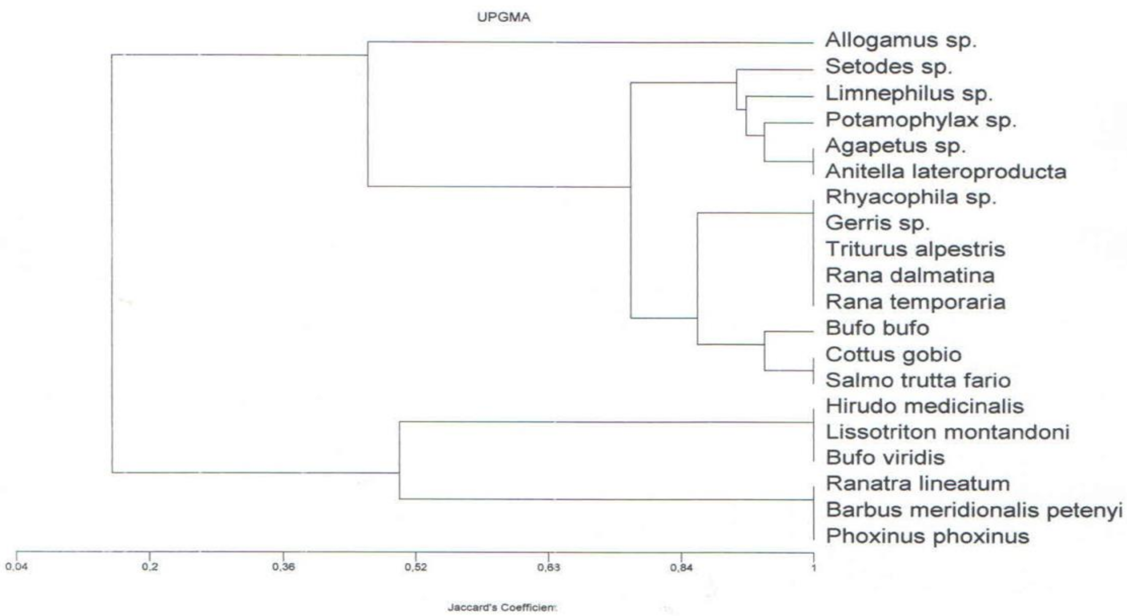


Fig. 18. Jaccard index for species samples in the Upper Dambovita River.

The index of cenotic affinity (Fig. 18) was calculated in order to analyse the affinity in between species, which is due to the common preferences for certain habitat characteristics, especially to abiotic environmental conditions. Species having maximum cenotic affinity (1) are always found together and they give maximum stability to zoobenthic and ichthyofaunistic communities, respectively the steady ecological state, which is generally required for all aquatic species. It is apparent that one single species, *Allogamus sp.* (order Trichoptera), is less associated with other species, meaning that it is less linked to these habitat types.

Table 4. Absolute abundance of species collected in the different sampling stations.

	Sampling station																			
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	***Total***
Ichtyofauna																				***233***
Phoxinus phoxinus																		5	8	*13*
Barbus meridionalis petenyi																		4	5	*9*
Salmo trutta fario				2	3	1	4	4	5	8	12	9	7	8	12	14	7	9	12	*117*
Cottus gobio				1	1	2	1	2	3	1	4	7	3	2	8	12	14	17	16	*94*
Amphibia																				***2.656***
Rana dalmatina	1	3	8	4	7	2	5	7	19	8	3	5	18	3	1	2	6	7	3	*112*
Rana temporaria	5	7	8	25	34	5	9	25	34	10	86	114	248	321	89	27	48	15	18	*1.128*
Bufo bufo			3	2	4	8	7	15	24	18	26	34	45	68	72	85	69	74	96	*650*
Bufo viridis																4	7	9	14	*34*
Triturus alpestris	5	9	6	12	18	26	18	46	53	68	12	18	28	37	74	82	78	67	62	*719*
Lissotriton montandoni																2	3	6	2	*13*
Hirudinida																				***9***
Hirudo medicinalis																4	2	1	2	*9*
Hemiptera																				***146***
Gerris sp.	1	4	3	8	3	7	18	4	7	14	22	5	2	1	4	16	3	4	17	*143*
Ranatra lineatum																		2	1	*3*
Trichoptera																				***7.391***
Rhyacophila sp.	23	68	115	240	26	18	45	350	267	485	563	14	24	57	69	72	41	86	37	*2.600*
Anitella lateroproducta	12	11	3	47	23	26	48	142	12	16	48	38		132	29			15	12	*614*
Agapetus sp.	18	17	15	28	73	26	15	114	237	82	74	18		145	134			27	14	*1.037*
Limnephilus sp.	1	16	2	18	16	22	12	32	11	12	37	21			18			24	39	*281*
Potamophylax sp.	24	39	31	87	92	74	123	578	423	93	42	24	79	143	201			28	131	*2.212*
Setodes sp.	22	31	18	72	98	28	27	49	13	91	14	9		24				12	7	*515*
Allogamus sp.								18	12	8	34	14			19			14	13	*132*

Ichtyofauna

The fish community of the Upper Dambovita River consists of four different species: Brown trout (*Salmo trutta fario*) being the most common one (Fig. 19), followed by European bullhead (*Cottus gobio*). Common minnow (*Phoxinus phoxinus*) and Mediterranean Barbell (*Barbus meridionalis petenyi*) were found only at two sampling stations (18 and 19).

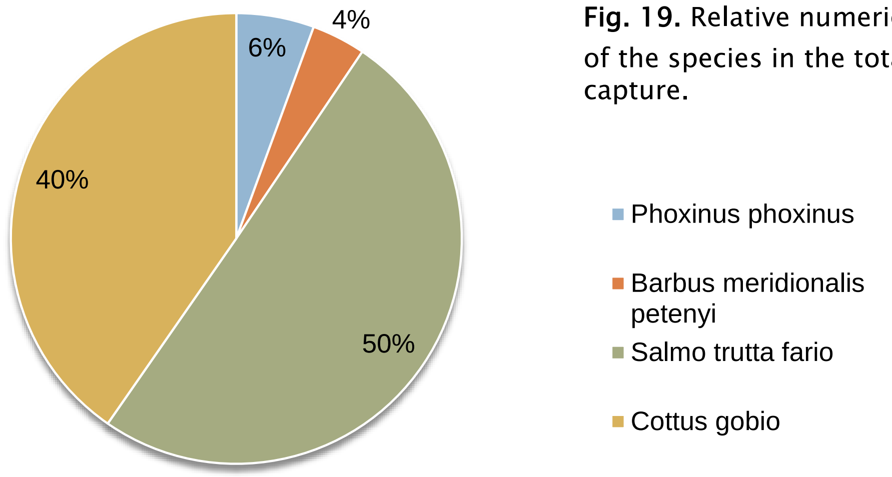


Fig. 19. Relative numeric abundance of the species in the total fish capture.

Fig. 20. : Brown trout (*Salmo trutta fario,* left) and European bullhead (*Cottus gobio*) are the most common fish species found in the Upper Dambovita basin.

Table 5. Quantitative and qualitative structure of ichtyofauna from the 19 sampling stations.

Species	Collecting stations	No. of individuals	Length (cm)/weight (g)
Phoxinus phoxinus	**Station 19:** Alt. 875 m	8	8 cm/7,2 g, 9,1 cm/8,9 g, 5,3 cm/ 4,2 g, 6,8 cm/5,7 g, 9,4 cm/9,1 g, 7,8 cm/ 6,9 g, 8,7 cm/8,3 g , 8,5 cm/8 g
	Station 18: Alt. 969 m	5	8,2 cm/7,4 g, 8,9 cm/8,2 g, 4,3 cm/3,2 g, 4,8 cm/3,9 g, 6,4 cm/5,6 g
Barbus meridionalis petenyi	**Station 19:** Alt. 875 m	5	15,6 cm/65,3 g, 17,8 cm / 71,2 g, 19 cm / 78,4 g, 16 cm / 58,3 g, 14,3 cm / 35,4 g
	Station 18: Alt. 969 m	4	18,3 cm / 71,2 g, 19,6 cm / 74,8 g, 13,4 cm / 48,5 g, 14,8 cm / 56,2 g
Salmo trutta fario	**Station 4:** Alt. 1,326 m	2	6,3 cm/ 8,9 g, 5,4 cm / 7,2 g
	Station 5: Alt: 1,268 m	3	10,2 cm / 13,4 g, 8,3 cm / 11 g, 7,5 cm / 9,6 g
	Station 6: Alt. 1,387 m	1	8,2 cm / 10,4 g
	Station 7: Alt. 1,255 m	4	7,5 cm / 9,4 g, 11,2 cm / 13,5 g, 9,8 cm / 11,7 g, 6,1 cm / 8,7 g
	Station 8: Alt. 1,253 m	4	5,7 cm / 6,4 g, 7,6 cm / 9,3 g, 7,9 cm / 9,8 g, 12 cm / 15,4 g
	Station 9: Alt. 1,235 m	5	8,3 cm / 7,8 g, 9,3 cm / 10,4 g, 5,5 cm / 7,2 g, 9,4 cm / 10,3 g, 8,7 cm / 9,8 g
	Station 10: Alt. 1,230 m	8	6,7 cm / 8,9 g, 7,5 cm / 9,4 g, 6,5 g / 9 g, 7,8 cm / 9,9 g, 9,7 cm / 12,1 g, 10,3 cm / 13,4 g, 9,1 cm / 11,8 g, 10,5 cm / 9,7 g
	Station 11: Alt. 1,225 m	12	6,3 cm / 8,2 g, 6,5 cm / 7,4 g, 8,5 g / 9,7 g, 6,8 cm / 7,9 g, 8,7 cm / 11,2 g, 12,3 cm / 15,4 g, 16,1 cm / 21,8 g, 12,5 cm / 11,7 g, 7,7 cm / 9,4 g, 12,6 cm / 14,3 g, 5,9 cm / 6,8 g, 11 cm / 12,4 g
	Station 12: Alt. 1,249 m	9	7,2 cm / 9,1 g, 13,2 cm / 16,5 g, 9,5 cm / 10,4 g, 8,1 cm / 9,2 g, 7,3 cm/ 8,2 g, 7,4 cm / 6,2 g, 14,2 cm / 17,4 g, 8,5 cm / 11,2 g, 8,5 cm / 10,6 g
	Station 13: Alt. 1,178 m	7	14,1 cm / 19,8 g, 10,5 cm / 9,7 g, 15,7 cm / 21,4 g, 11,2 cm / 13,3 g, 6,9 cm / 7,8 g, 10 cm / 15,4 g,

Species	Collecting stations	No. of individuals	Length (cm)/weight (g)
			12,1 cm / 15,2 g
	Station 14: Alt. 1,156 m	8	12,3 cm / 11,2 g, 8,1 g / 9,3 g, 8,4 cm / 9,2 g, 13,1 cm / 17,8 g, 11,5 cm / 10,2 g, 7,4 cm / 8,2 g, 5,7 cm / 6,1 g, 10,3 cm / 13,4 g
	Station 15: Alt. 1,272	12	8,2 cm / 10,1 g, 9,1 cm / 10,5 g, 7,5 cm / 6,4 g, 7,1 cm / 8,2 g, 9,3 cm/ 10,2 g, 9,4 cm / 7,9 g, 12,2 cm / 14,5 g, 8,9 cm / 10,4 g, 8,4 cm / 9,6 g, 11,2 cm / 13,4 g, 8,3 cm / 9,7 g, 7,6 cm / 9,3 g
	Station 16: Alt. 1,217 m	14	9,2 cm / 10,1 g, 11,2 cm / 14,5 g, 9,4 cm / 12,4 g, 8,3 cm / 9,6 g, 9,1 cm/ 11,4 g, 6,7 cm / 7,2 g, 13,2 cm / 15,4 g, 9,5 cm / 11,6 g, 14,7 cm / 20,6 g, 10,9 cm / 11,7 g, 13,7 cm / 19,5 g, 7,9 cm / 9,8 g, 10,2 cm / 12,4 g, 12,3 cm / 16,2 g
	Station 17: Alt. 1,220 m	7	6,9 cm / 7,4 g, 13,4 cm / 15,6 g, 9,2 cm / 11,2 g, , 12,7 cm / 14,3 g, 7,6 cm / 10,3 g, 6,5 cm / 7,1 g, 10,7 cm / 12,3 g
	Station 18: Alt. 969 m	9	7,2 cm / 8,9 g, 11,5 cm / 12,7 g, 9,3 cm / 10,4 g, 7,3 cm / 7,9 g, 8,7 cm / 9,8 g, 9,8 cm / 12,7 g, 6,9 cm / 8,2 g, 8,4 cm / 9,3 g, 7,8 cm / 9,2 g
	Station 19: Alt. 876 m	12	13,1 cm / 17,8 g, 10,8 cm / 12,7 g, 15,7 cm / 21,3 g, 11,6 cm / 14,9 g, 9,8 cm / 10,8 g, 13,6 cm / 15,3 g, 12,7 cm / 15,5 g, 8,1 cm / 7,5 g, 9,2 cm / 10,9 g, 5,8 cm / 7,4 g, 9,7 cm / 10,8 g, 9,7 cm / 10,3 g
Cottus gobio	Station 4: Alt. 1,326 m	4	10,3 cm / 15,4 g
	Station 5: Alt. 1,265 m	1	12,4 cm / 18,2 g
	Station 6: Alt. 1,378 m	2	11,6 cm / 17,3 g, 9,7 cm / 13,9 g
	Station 7: Alt. 1,255 m	1	14,1 cm / 19,2 g
	Station 8: Alt. 1,253 m	2	13,5 cm / 18,7 g, 10,7 cm / 16,1 g
	Station 9: Alt. 1,235 m	3	12,9 cm / 17,6 g, 9,8 cm / 15,7 g, 10,9 cm / 16,3 g

Species	Collecting stations	No. of individuals	Length (cm)/weight (g)
	Station 10: Alt. 1,230 m	1	8,2 cm / 10,4 g
	Station 11: Alt. 1,225 m	4	12,1 cm / 15,6 g, 10,8 cm / 15,9 g, 9,5 cm / 13,1 g, 8,7 cm / 11,9 g
	Station 12: Alt. 1,249 m	7	8,9 cm / 12,6 g, 13,8 cm / 20,7 g, 7,9 cm / 10,8 g, 10,1 cm / 12,9 g, 11,8 cm / 17,9 g, 13,5 cm / 19,1 g, 6,7 cm / 9,8 g
	Station 13: Alt. 1,178 m	3	7,4 cm / 10,2 g, 8,6 cm / 12,3 g, 10,4 cm / 13,2 g
	Station 14: Alt. 1,156 m	2	12,5 cm / 17,8 g, 14,3 cm / 19,2 g
	Station 15: Alt. 1,271 m	8	10,1 cm / 13,2 g, 11,8 cm / 16,4 g, 7,5 cm / 9,1 g, 8,4 cm / 10,2 g, 11,9 cm / 16,6 g, 9,6 cm / 15,3 g, 10,6 cm / 14,3 g, 11,4 cm / 17,2 g
	Station 16: Alt. 1217 m	12	8,7 cm / 12,2 g, 12,8 cm / 18,5 g, 8,9 cm / 11,3 g, 9,1 cm / 11,9 g, 10,8 cm / 16,9 g, 12,5 cm / 18,1 g, 6,3 cm / 7,8 g, 10,1 cm / 13,6 g, 12,8 cm / 17,9 g, 9,2 cm / 12,6 g, 9,7 cm / 13 g, 11,3 cm / 14,4 g
	Station 17: Alt. 1220 m	14	9,2 cm / 11,3 g, 12,8 cm / 17,1 g, 7,2 cm / 8,9 g, 8,5 cm / 10,4 g, 10,9 cm / 15,3 g, 9,7 cm / 12,1 g, 10,7 cm / 13,2 g, 13,4 cm / 18,9 g, 12,5 cm / 17,6 g, 11,8 cm / 16,5 g
	Station 18: Alt. 969 m	17	7,5 cm / 11,4 g, 10,8 cm / 16,3 g, 10,9 cm / 12,5 g, 12,1 cm / 13,9 g, 13,8 cm / 18,9 g, 14,5 cm / 20,1 g, 6,7 cm / 8 g, 12,1 cm / 15,6 g, 13,5 cm / 16,9 g, 9,4 cm / 11,6 g, 9,4 cm / 13,2 g, 12,7 cm / 16,2 g, 7,8 cm / 10,5 g, 8,3 cm / 11,4 g, 13,4 cm / 15,2 g
	Station 19: Alt. 875 m	16	9,7 cm / 13,2 g, 12,4 cm / 18 g, 8,3 cm / 10,3 g, 9,2 cm / 12,9 g, 11,5 cm / 15,9 g, 12,7 cm / 18,3 g, 6,8 cm / 9,8 g, 12,1 cm / 13,7 g, 12,4 cm / 16,5 g, 9,1 cm / 12,3 g, 9,2 cm / 12,8 g, 10,7 cm / 14,3 g, 7,2 cm / 10,9 g, 8,5 cm / 12,1 g, 12,2 cm / 12,9 g, 8,7 cm / 11,6 g

From table 5 we can see that common minnow and barbell are represented only in the two sampling stations 18 and 19, in the area between Tamas and Draxin, below the big Pecineagu dam. Both, brown trout and bullhead are common along the entire length of the river with the exception of the upper part of Valea Vladului (sampling stations 1 to 3).

Table 6. Ecological indices of fish populations in the upper course of the Dambovita

Species	Absolute Abundance (A)	Constancy (C)		Dominance (D)		Ecologic semnification index (W)	
	%	%	Class	%	Class	%	Class
Phoxinus phoxinus	6	10,52	C1	5,57	D4	5,9	W4
Barbus meridionalis petenyi	4	10,52	C1	3,86	D3	4,1	W3
Salmo trutta fario	50	84,21	C4	50,21	D5	42,2	W5
Cottus gobio	40	84,21	C4	40,34	D5	33,9	W5

Table 6 shows the ecological indeces for the fish populations in the upper Dambovita River. With an ecological semnification index of over 20%, brown trout and bullhead are ruling species; common minnow is considered a complemantary species and barbell an associated species in the fish community of the Upper Dambovita River.

Structure of invertebrate communities, phytoplankton and zooplankton

Flowing waters represented by springs and tributaries of the upper Dambovita to the tail of Pecineagu lake are characterised by a number of physical and chemical constants: small amount of nutrients, high concentrations of oxygen, sediment, mostly made of gravel, rocks, boulders and less sand, fast course with waterfalls, large water flow rate, low concentrations of nitrite, nitrate and organic matter, low water temperature, even in summer, slightly acid pH. Pelitic sediments are extremely rare, occurring especially in areas of accumulation from the lake tail and during floods, at the confluence of the tributaries with the main river, or in elbows and behind dams, these deposits of mud and fine sands actually having an artificial origin (anthropogenic effect). Under these circumstances a shore flora installed, typical for eco-tone habitats or interference habitats between terrestrial habitats from the main riverbed and lotic ritrorheophile habitats.

Where the riverbed is wider (at the confluence of the main tributaries - valleys Vlad, Otic, Coltii lui Andrei Berivoiu) these shore and elbow habitats are accompanied by other habitat types. Due to widening of the valley, where the groundwater is near the surface, streams, large springs, small or large oligotrophic ponds, brooks, and dead branches formed, or the river split into two branches delimiting small islands, and areas with alder vegetation. These small, lotic, ritro-rheophile aquatic habitats, but also limnic, smaller or larger oligotrophic ponds are very important for the hydrobiological dynamics of large ritro-rheophile habitats, because they allow the reproduction of amphibians (salamanders, newts, frogs) and aquatic invertebrates, especially from the orders Odonata, Heteroptera, Diptera (*Anopheles sp.*), Trichoptera, and Plecoptera.

In these habitats, we also find a rich phytoplankton, which is almost entirely missing in lotic ritro-rheophile habitats. Phytoplankton found in the samples can only originate from small oligotrophic ponds, springs, and dead branches, where it developed and then was driven downstream, by the normal flow of the river or during floods. Here also some exuberant development of phytoplankton occured, represented by Chlorophiceae (spring-summer), Cyanophiceae (summer), Characeae (Chara sp. - summer - fall), Diatoms, Bacillariophyceae (autumn - winter). Therefore, stones from oligotrophic ponds, and dead branches, have a thicker plant bioderma, in which sometimes even red algae (*Batrachospermum moniliforme, Anabaena flos aquae*) or green macrophytic algae (*Cladophora sp., Cladophora sericea, Spirogyra sp., Mougeottia sp.*) can be found.

On stones from lotic rheophile habitats with a really fast flow and large boulders, colonies of other algae apart of diatoms aren't found, but on the opposite side of the stream current flow or under rocks, where no current is present and colonies can adhere directly, with the mucilaginous layer to the surface of rocks. Here they are, in fact, the food of aquatic insects from the orders Plecoptera - *Perla marginata, Perla sp.* and Trichoptera - *Agapetus sp., Anitella lateroproducta, Lymnephillus sp., Potamophylax sp., Setodes sp., Alogamus sp.*.


Fig. 21. Caddiesfly larvae in cases of rock fragments and plant material (left). Right, adult *Perla sp.* from the Plecoptera order.

In the thick layer of vegetable bioderma, fixed on the upper and lower part of the stones from these microhabitats, colonies of micro and macroinvertebrates develop, being represented by protozoa (class Euglenophyta - *Euglena viridis, Euglena gracilis*, class Cilliata - *Paramecium sp.*, *Colpidium sp.*, *Colpoda sp., Stentor sp., Stentor polymorphus, Vorticella nebulifera*). In these habitat types, on their side, on rocks, dominant are species from Cyanophiceae, genus Croochoccus (*Chroococcus turgidus*, *Chroococcus macrococus*, *Tetrapedia trigona*, *Hydrococcus sp.*) and species from Nostocales order - *Nostoc verucosum*, *Nostoc gelatinosum*, *Nostoc paludosum*, *Anabaena flos - aquae*. In the water of this oligotrophic ponds unicellular algae are found - Chlorophyceae, order Volvocales (*Chlamydomonas sp., Chlainomonas sp., Eudorina sp., Chlorosphaera sp.*), ord. Chlorococcales (*Pleurococcus vulgaris* - Pleurococcaceae family, *Chlorella vulgaris, Chlorella faginea* - Chlorellaceae family, *Oocystis lacustris, Scenedesmus quadricauda* - Scenedesmataceae family, *Coelastrum sphaericum* - Choelastraceae family.

In these types of oligotrophic ponds, with substrate made of stones, components of phytoplankton or hydrobionts that form the bioderma on which sometimes freshwater macrophytic algae are attached, grow very well, considering the large amount of oxygen dissolved, minerals in optimal proportions, but also a slight acidic pH (6.8 to 7) and very high transparency of water, which promotes photosynthesis process. Also, the excess of nutrients is provided by the past year detritus of alder and willow, which is readily biodegradable, compared to other types of litter and that releases the necessary minerals for the development of phytoplankton and phytobenthos (algal periphyton). Quantitatively, phytoplankton biomass is much lower than that of phytobenthos, but in summer and autumn a macrophyte development can be noticed in the form of green algae (*Spirogyra sp., Zygnema sp., Oedogonium sp.*). In these ponds, communities of aquatic macroinvertebrates develop such as *Sympetrum sp.* from the Odonata order, whose larval stages stay up to 6 years in water, adults appearing in the sixth year. These larvae are predators, feeding on frog tadpoles, newts, and salamanders. Multiplication rate of phytoplankton is highest in July and August in these ponds, and that of algal periphyton or phytobenthos during August to November, especially when cryophilic diatoms are developing.

Shellfish are underrepresented in these habitats, meeting only one species of Cladocera or daphnia (*Daphnia pulicaria*), which is typical for these mountains ponds. This species of Daphnia is considered the most cryophilic of all species of cladocerans, being met even north of the Arctic Circle, in Feno - Scandinavia and Svalbard archipelago.

Amphibian fauna from the upper course is dominated by *Rana temporaria*, representing about 90% of all individuals. In the oligotrophic swamps we can meet frequently the species *Triturus alpestris*, *Rana temporaria* and rarely *Bombina variegata* or *Bufo bufo*.

Fig. 22. Male and female alpine newt (*Triturus alpestris*) during mating season.

Cryophilic per se, also moss species develop here, such as species of the genus *Drepanocladus sp.* and *Fontinalis antypiretica*, considered as being the largest aquatic moss, destined for very cold water habitats.

Fig. 23. Fontinalis antypiretica

In general, these habitats are considered cryophilic habitats, with cold waters, and its associated species, both, flora and fauna, occurring relatively few in number. From an ecological point of view they are considered stenotope species (species that don't support large variations of physical and chemical factors). Also, these stenotope species are per se cryophilic (cold water species) and oxyphilic (they require large amounts of dissolved oxygen in water) and therefore try to avoid habitats with high amounts of organic matter and thick mud sediments where nitrites are transformed into nitrates by consumption of dissolved oxygen from the water. In parallel such ponds are characterised by an excess of ammonia, which is highly toxic for these stenotope - oxyphilic species.

We also found some extremely rare plants that are representative species for Natura 2000 Habitats: *Caltha laeta, Caltha palustris, Saxifraga stellaris, Cardamine amara, Cardamine opizii*. Therefore, we conclude that these habitats are extremely vulnerable, occupying small areas of 10-20 square meters or 2,000 square meters. They should be preserved and no anthropogenic influences should be put on them, such as dragging of wood in the riverbed with heavy forest tractors.

In the lower course of the Dambovita River, downstream of the dam to the confluence with Tamas tributary, we noticed a decrease in oxygen concentration and a neutral, slightly alkaline pH (7.4), both in the main course and in accompanying aquatic habitats. We also found an exuberant development of algal periphyton, especially during summer and autumn, a higher density of herpetofauna, represented by amphibians, but also a higher density of fish and aquatic macroinvertebrates. Lotic ritro-rheophilic habitats downstream of Pecineagu dam and limnic habitats, represented by oligotrophic ponds, bends, meanders, dead branches, springs, brooks, small tributaries, show a richer fauna of aquatic macroinvertebrates and a more variated flora, macrophytes plants, and algae. Also, the amount of produced biomass or biological productivity of phytoplankton, phytobenthos and zoobenthos is much higher than in the upper course. A greater wealth of diatoms, both in number of species and also, as thickness of mucilaginous layer, which indirectly leads to an increased number of free zoobenthonic protozoa (*Paramecium sp., Vorticella sp., Colpidium sp., Colpoda sp.*), free turbellaria worms (*Dendrocoelum lacteum, Dicrocoelum lanceolatum*, which feed on them), Tubificidae (*Limnodrilus sp., Tubifex sp.*), and caddisflies

(*Anitella sp., Rhyacophila sp., Agapetus sp., Limnephilus sp., Setodes sp., Potamophylax sp., Allogamus sp.*). These colonies have high densities on the inferior side of the stones.

If in the upper part of the river, caddisflies colonies under rocks are between 65-70 and 145 individuals in size, in the lower part of the river their frequency is higher, with colonies under large rocks counting 187 to 235 individuals. This shows that there is a greater amount of detritus and diatoms, both free and fixed, which serve as food. Also, the number of free caddisflies individuals (*Allogamus sp.*, making their houses from stones and pieces of wood), is higher in the lower part of the river.

Due to a higher biomass productivity consisting of algal periphyton and protozoa, as well as microzoobentos, and free worms (Oligochaeta and Turbellaria class), ritro-rheophilic lotic habitats downstream of Pecineagu dam show a richer fish fauna. Here we noticed a larger number of trout and bullhead juveniles than in the upper course, probably because of the plentiful food available. Caddisflies in the larval stage are common and serve as food for trout and bullhead. As adults, when executing their breeding flight above the water, they represent together with dragonflies and adult mosquitoes the favorite food of trout. Aquatic oligochaeta species, both in larval and adult stages (*Limnodrilus sp.*, *Tubifex sp.*, Turbellariata order species such as *Dendrocoelum sp.*), are the favorite food for newly hatched juveniles of trout and bullhead up to 3-4 weeks of age; later on they accept bigger feed, such as larvae of caddisflies, dragonflies and other insects. Therefore, juveniles of trout and bullhead were found more frequently in the lower part of the river.

Microstational aquatic habitat conditions do not change on this route, instead there are dimples, big bottom sediments with pelitic deposits, 70-80 cm thick that resulted from clays, driven on slopes, with litter excess, raw humus, undecomposed and decomposed humus, mull and moder. These organic matter is subject to anaerobic fermentation from sulfur-oxidising bacteria (*Thyobacillus denitrificans*), resulting in conversion of nitrites to nitrates with an excess of ammonia production. These phenomena are more obvious here than in the oligotrophic swamps from the upper course.

Fig. 24. Carpathian newt (*Lissotriton montandoni*).

Adjacent muddy marshes, with thick sediments on the bottom are populated by mosquito larvae (*Culex sp.*, and *Anopheles sp.*). In these ponds, the pleuston is well represented and is consisting of *Gerris sp.*, Heteroptera order, and other aquatic predators (*Ranatra linearis*, *Notonecta glauca*, *Notonecta sp.*, aquatic red mites from the Acaria order). During spring we found an abundance of the frog species *Bufo bufo*, *Rana dalmatina* and *Bombina variegata*, as well as two newt species – *Triturus alpestris*, and especially *Lissotriton montandoni*, which is found more frequently in the study area.

Categories of anthropogenic disturbance structures and activities that impact the natural state of Dambovita

Dambovita River, in the first 20 km from its source waters to Lake Pecineagu is a beautiful river, with a wild natural course, with a relatively low anthropic impact at first sight, and no village or rural community in the watershed. Although the entire area is uninhabited, economic activities taking place in the area affect more or less intensively the ecological balance and aquatic fish communities, as well as the health of fish habitats. We identified the following threats for the aquatic species, habitats, and biodiversity in the hydrographic basin of Dambovita:

1. Deforestation or abusive deforestation like clearcuts on slopes, and cuts being made in major river beds, changes the composition of the naturally installed vegetation (trees, shrubs, herbaceous carpet). Besides, clearcuts have quite a number of negative environmental effects such as washing the fertile horizon A (mull and moder – or raw humus decayed and decomposed) by torrential rains and storing it under rocks, resulting in severe changes of water chemistry (pH changes from 4 – 4.5 to 7.5 – 8.3), reduced transparency, increasing concentration of ammonia, hydrogen sulfide, carbon dioxide, decreasing oxygen concentration. Species of hydrobionts sensitive to a lack of oxygen are disappearing, while the production capacity of biomass and biological productivity of aquatic communities decreases. Accumulation of organic detritus under rocks and in deep lakes affects or leads to mortality of caddisflies or plecoptere communities, and other species of hydrobionts (Ephemeroptera, worms from Tubificidae family) found in the Dambovita area.

Fig. 25. Alluvial muds washed down from a clearcut after heavy rainfall.

2. Tree branches, sawdust and other wood waste in the upper river bed gets submerged under rocks and banks after being washed away by torrents, which leads to damming of the river

and the formation of alluvial deposits. Through anaerobic decomposition, water quality in aquatic habitats of the upper Dambovita is heavily affected.

3. Hydro dams cause habitat fragmentation and prevent upstream migration of fish. Besides, dams affect the physical and chemical characteristics of the aquatic habitats by anaerobic fermentation in deposits of silt and organic matter upstream of the dam (anaerobic decomposition with excess production of methane, ammonia, hydrogen sulfide, carbon dioxide, etc.). This is altering the species composition of aquatic habitats; species sensitive to a lack of oxygen are replaced by other species found below or by bacteria and phytobenthal cyanobacteria, and diatom species.

4. Installing sheepfolds close to the creek in Valea Vladului and depositing piles of manure that get washed away and quickly reach river water, results in impairment of water quality by accumulating nutrients in excess, containing nitrogen, phosphorus and potassium.

5. Burning dry wood vegetation near the water in inappropriate places and forbidden places (Valea Otic, Valea Vladului, Dambovita Valley).

6. Changing the course of the river and river drainage into another arm with the scope to poach fish on dried arms (Valea Otic).

7. Poaching fish with banned toxic substances, pesticides, or self-made instalations with high power electricity. We found evidence of this in certain sectors of the Dambovita river (downstream), where we fished only yearling fish, which indicates that no more than one year ago poaching took place on this river segment resulting in a total elimination of adult fish.

8. Secondary forest roads and skidding tracks, built without considering the slope or contour lines, cause severe erosion and draining of the heavy podzolic loamy soil into the river, such reducing water quality.

9. Dumping waste in the river bed, often resulting from forest exploitation activities (mineral and organic waste, motor oil from forest tractors, lubricants, fuels, strong acids from used batteries, plastic and metal waste disposal into the river etc.) represents a serious threat.

10. Sport fishing – as fish populations of the river is currently very small, sport fishing must be banned for a period of 6-8 years, until it has recovered.

11. Paved waterfalls with heights greater than 40 cm (for trout) are harmful because they do not allow upstream migration of juvenile trout and bullhead.

12. Destruction of dwarf mountain pine trees in the alpine zone (activities undertaken by shepherds), especially in Valea Vladului, exposes the humus on slopes, which is being drained into the river bed during heavy rainfalls.

13. Erosion of the banks due to flooding after trees have been cut in the valley bottoms (spruce, alder, willow, and sycamore).

14. Disrespecting the forestry and timber transport regulations (trucks carrying heavier loads than roads can endure) leads to damaged roads and more repair works per year. During these repair-works more fine sediments are being washed into the river, having a permanent negative human impact on aquatic habitats.

Additional possible threats for the integrity of the studied habitats are:

- People temporarily settling in the valley for mushroom picking, where they also perform illegal fishing.
- Livestock husbandry above the carrying capacity of alpine grassland habitats can lead to increased surface gully erosion (snow melting, heavy rain). Excessive trampling damages the grass layer and storm water drains horizon A and B soils into the river bed. Also abusive grazing during summer in the valley bottoms or near the bed springs (Valea Vladului, Valea Otic) is detrimental.
- Grassland or forest fires.
- Tourists and workers camping in inappropriate places.
- Storage of organic household waste or burying waste instead of collecting and disposing it from the area (both organic and inorganic).
- Construction of new roads near the water or even in the water.
- Exploitation of river stone and quarries.
- Cutting undergrowth vegetation and forest species considered worthless from a silviculture point of view (willow, alder, sycamore, aspen and shrubs: wreath – *Spiraea ulmifolia*, *Vaccinium myrtilus*).
- Execution of new hydro-power works or repairs of dams and paved waterfalls.
- Illegal deforestation not followed by re-planting works or natural seeding (clearcuts of more than 0.5 ha and a lack of natural seed trees makes natural regeneration impossible).

CONCLUSIONS FOR THE OVERALL INTEGRITY OF THE RIVER SYSTEM

The upper course of Dambovita shows only two species of fish (trout and bullhead) and a population naturally very rich in terms of biomass, zoobenthic animals of all species described and determined.This leads to the conclusion that in the past, probably 50-80 years ago, trout and bullhead populations were very high. However, due to the changing anthropogenic impact throughout the 20th century, it is hard to compare the nowadays situation with the real situation from the distant past. Trout stocks now are very low, young individuals from the summers 2012 and 2013 prevail, while adults are obviously being fished legally or semi-legally. From our research we found that the close season for fish is not respected, fishing during the mating season is common, and a too large number of fishing permits are issued, far beyond the natural carrying capacity of these aquatic habitats. Fish poaching is increased in the upper course of Dambovita. Besides traditional pastoralism, which per se represents a major risk factor for fish poaching, this year also mushrooms gatherers build a temporary camp in the valley and increased the pressure on the fish stock. The Roma population totalled about 550-600 people; even at a minimum estimate of 10% potential poachers, this far exceeds the capactiy of such habitats.

Bullhead and trout habitats in the Dambovita River nowadays are fragmented by dams located on the major tributaries (Otic and Valea Vladuluis). Due to fragmentation, fish micro-populations upstream of the dam disappeared, since micromigration for feeding and reproduction, typical to all rheophilic species of fish including trout and bullhead, is not possible.

Downstream of the dam towards Tamas valley, also other species were fished, such as minnow (*Phoxinus phoxinus*) and barbel (*Barbus meridionalis petenyi*). Two species we fished in previous surveys (1997-2000), more precisely chub (*Leuciscus cephalus*) and grayling (*Thymallus thymallus*), both fry and juveniles, could not be found anymore during this recent study. Most likely these have vanished due to poaching. Grayling occurred naturally in Dambovita, as revealed by studies of Peter Bănărescu during 1952-67 and was also re-stocked by Romsilva (the Romanian State Forest Administration) in the 1960ies, since self-repopulation from the Arges River (confluence with Dambovita River in the lowlands, about 40 km downstream of Bucharest) was impossible after the glaciation. However, this re-stocking obviously did not result in achieving a stable population, the species having disappeared completely due to natural and artificial causes (poaching, overfishing, brutal washing of hydroelectric turbines and waste disposal in the river fairway, discharge of waste and oils, lubricants used in maintenance and repair of industrial hydromechanic aggregates, directly into the river).

From an ecological point of view, aquatic habitats from Dambovita basin show a very high biodiversity in number of species. The most important thing is that in the composition of the zoobenthos, probably due to its high trophic source, caddisflies and ephemeroptera insects dominate in adjacent habitats (elbows, dead arms, and pools in riverbeds connected by small arms with the main course). Here we meet both adults and larvae of aquatic insects in specific limnic habitats of hill or plain hill area (hemipteres species - *Gerris lacustris*, *Notonecta glauca*, *Nepa cinerea*, 2 species from the Dytiscidae family; Odonata - *Scempetrum sp.*).

These adjacent microhabitats are also safe breeding places for all species of newts and frogs found in the valley (Order Urodela and Anura). The density of adult frogs (*Rana temporaria*, *Bufo bufo*) is very high, exceeding the carrying capacity of the habitat (narrow valley, few breeding places, steep slopes, and swamps only in the valley, in the riverbed). In these habitats, huge gatherings of adult males and females occur in spring (especially *Rana dalmatina*, which represents 80% of all reported clutches). Much of *Rana dalmatina* adults, however, fall prey to multiple predators (otters, water shrew, buzzards) or are run over by timber transporters, as they reproduce in temporary ponds formed on access roads in early spring before full melting of the snow. In the study area we also found the presence of a newt species less known for the Dambovita area, namely *Lissotriton montandoni*, which appears in smaller populations than *Triturus alpestris*, but is mixed with it in the same breeding places. Most of them come out of hibernation later (second half of April), but reproduction continues in aquatic habitats about 4 weeks longer than *Triturus alpestris*. We found *Lissotriton montandoni* only downstream of the Pecineagu dam towards Tamas valley, in all collecting and exploring stations, but could not yet confirm the species upstream of the dam.

Small ponds function as temporary refuges for many species of worms – Turbelariata, Annelida (*Limnodrilus sp.*, Tubificidae; *Hirudo medicinalis*, Hirudindae, the medicinal leech, which is also listed on Annex V of the Habitats Directive).

We also confirmed some bird species that are strictly related to the trout zone of a river, such as water blackbird (*Cinclus aquaticus*), white wagtail (*Motacilla alba*), and yellow wagtail (*Motacilla flava*). *Motacilla flava* is most common with a frequency of about one pair per 50 meters river section, *Motacilla alba* occurs with one pair each 100–150 meters, and *Cinclus aquaticus*, with a lower frequency. For example, between the Tamas valley and Pecineagu dam we estimate a population of about 20 individuals for *Cinclus aquaticus*. We also encountered kingfishers (*Alcedo atthis*), a species listed on the Annex I of the Birds Directive, in the segment below the dam. Due to silt deposition, some large natural ponds were formed (0.5 ha), downstream from the dam Pecineagu in the Richita area and upstream of the dams of the Otic, Berevoiu, Lutele, Valea Vladuluis. These dams keep limnic habitats that have a low water flow upstream, but large areas, providing a rich food source for fish, and waterfowl. We already found dozens of pairs of breeding ducks (about 30 individuals), which nest in the neighborhood of these ponds because these contain the food source for adults and for juveniles.

On the mammal side, we identified water shrew (*Neomys fodiens*), which is present in large numbers, nesting in burrows near the water on the banks. A high frequency of water shrew reflects a high density of its favorite food (plecoptera, caddisflies, and juvenile amphibians). Due to timber exploitation throughout the past 50–80 years, the riverbed of Dambovita, both upstream and downstream of the Pecineagu dam, contains a lot of silt with plant debris (leaves, branches, logs), forming multiple alluvial deposits. Their density (one alluvial deposit per 10–100 m) is a big advantage, representing refuges for small rodents that feed on succulent hygrophilic plants (*Arrheathrium elatus*, *Dactylus glomerata*, *Agrostis tennuis*). Worth mentioning is also the presence of otter (*Lutra lutra*) all along the surveyed river course. Considering the extremely low fish population in the valley, especially upstream of the dam, we believe the otter uses a variety of other food sources such as amphibians, reptiles, aquatic birds, snails, and slugs, which are plentiful along the valley. We found traces of a feast – partially eaten frogs, frog limbs in ponds close to Otic, which could not be consumed by anything else than otters.

MANAGEMENT RECOMMENDATIONS

Modifications of current river disturbance structures

The main issue regarding the fish community in the upper course of Dambovita is represented by fragmentation of habitats due to the presence of concrete dams build for adjusting the flow of the river. These dams block the micromigration paths for breeding and feeding of fish and make the development of a healthy unaffected fish population improbable. Especially the dams in the upper valley, on the tributaries Otic and Vlad, are in urgent need of ecological reconstruction. Dams that were made in the past have the disadvantage that they completey cut off different river stretches, their original purpose being to prevent erosion of the riverbed and deepening of the tributaries and the main river.

This habitat fragmentation reduces fish population virtually to zero. It is known that fish species from the mountains (trout, bullhead) need to take daily micromigrations (in daytime or night time) on river segments of at least 700-1,000 meters for foraging. The distance increases after each flood, when water flow is higher and zoobenthos and phytobenthos gets destroyed. It takes about 2 to 3 weeks for it to regenerate and therefor fish need to undertake longer migrations to meet their nutritional needs.

In this respect, demolishing the dams and opening the waterways would make a tremendous difference. An alternative measure, if dams cannot be demolished, is to build fish ladders on the sides of the concrete dams. An example of an efficient fish ladder on the side of a concrete dam is given in Fig. 26.

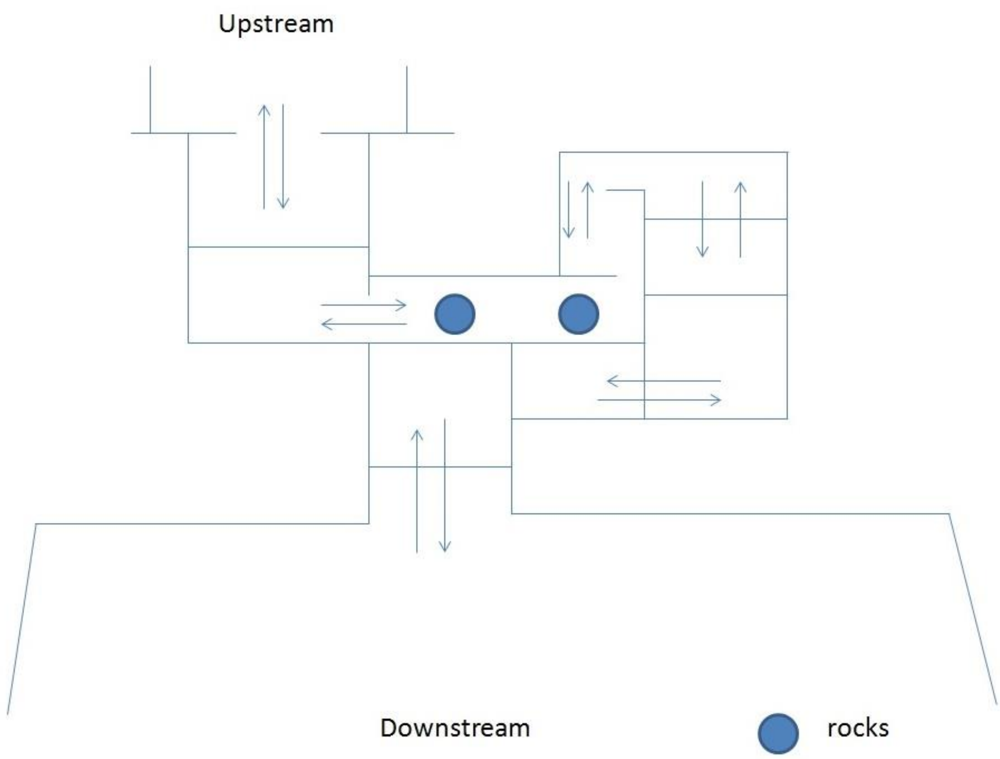


Fig. 26. Model of a fish ladder on the side of a large concrete dam.

As an alternative, a slit can be cut in the initial dam (Fig. 27), right in the middle, so that during floods, the high water flow will not affect the banks through hydro erosion. The slit will be cut horizontally with a pneumatic pick by a team of workers, from the top till near the bottom of the dam, at a height of about 40 cm. The slit will not be cut all the way down to prevent hydrological erosion upstream and downstream of the dam, and even of the dam foundation, during a flood. This way, upstream of the dam all young alders already installed, are protected from flooding and drying.

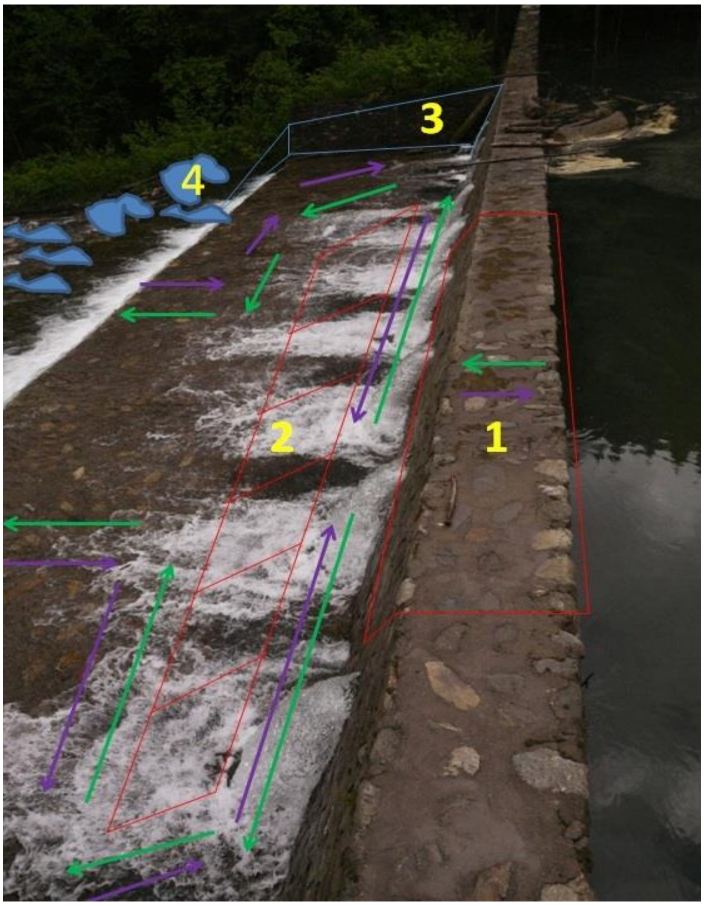


Fig. 27. Model for the ecological reconstruction of a dam with fish ladders

1. Breaking the dam site and digging a slit with a width of 3m, down to about 40 cm above the dam base.

2. Installing a concrete wall, anchored to existing structures, to prevent destructive effects of floods. The wall is trapezoidal with the base much wider than the hight of 30 cm.

3. Installing a side wall to protect the banks from flooding and to redirect the water to the center of the river course.

4. Rocks gathered with an excavator and installed below the slab of the dam, to increase the water level and allow fish migration.

The material resulting from the slit can be used for the trapezoidal wall (2) provided at one meter downstream of the slit and the old dam. The dam site will be reinforced with anchors to ensure resistance to floods. Formworks are made, achieving a trapezoidal shell with sides (base or bottom width = 70 cm, h = 50 cm, width = 40 cm). The total length of the dam will be 10 meters, placed symmetrically to the slit, so that water will flow through the small waterfall of 40 cm, then go left and right to bypass the high trapezoidal weir. A detour will be created, 3.5 m to the left and 3.5 m to the right, that will force the water flow to the edges of the banks, from where the water will be forced back (3) to the center of the riverbed. Right below the slab of the dam, a group of large boulders (4) will be installed, which ensure raising of the water level by 15 -20 cm. This will allow fish to move among boulders, to jump the slab of 10-15 cm, to move upstream through the dam, bypassing the central trapezoidal wall on the left or right side, and swimming upstream through the slit (purple arrows).

In Figure 28 we present how the fish ladder will look like after a few months to 1 year, when the dam will be filled with sediments, especially rocks and cliffs, on the hydrologic flow paths to the left and right, so fish can move downstream and upstream on this very easy route, no longer being forced to climb waterfall thresholds higher than 10-15 cm.

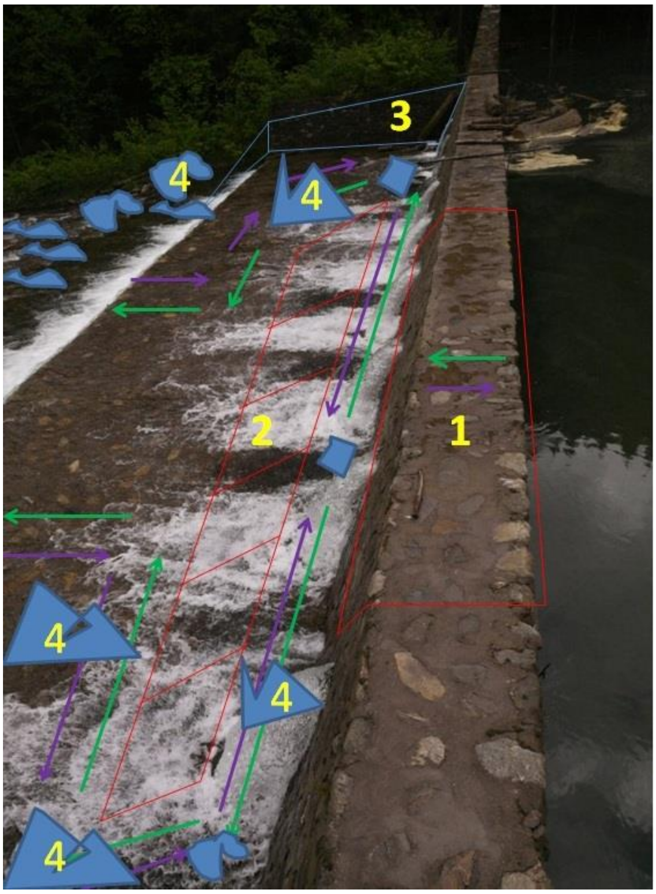


Fig. 28. Model of a dam with fish ladders, filled with rocks and gravel

Water paths along the left and the right walls (3) have filled up with sediments and boulders (4), allowing easier upstream migration for fish.

Note that the sketches presented here are two very effective fish ladders, done with minimal costs and by avoiding major changes to existing dams. We could also specify other models, but these seemed most appropriate.

It is necessary to execute these works in the late summer or fall, to minimize the environmental impact on invertebrate communities and especially aquatic macroinvertebrates, fish, and other types of zoobenthos and phytobenthos, knowing that in the late summer and fall Dambovita and its tributaries flow is constant and smaller.

Budget for ecological reconstruction of a dam with fish ladders

We made a cost estimate at minimal prices, based on the experience of such work for an aquaculture research station (Table 7). In general, the profit for the company that builds has to be added (if subcontracted), which is 40-70% of the materials and raw labor price, plus taxes and charges. The budget shall be multiplied by the number of existing dams on Vlad and Valea Otics, which finally results in the total costs for ecological restoration and rehabilitation of the Upper Dambovita River by the use of fish ladders.

Table 7. Budget for the presented reconstruction of one dam with fish ladders.

Position	Items	Costs (RON)
1. Organisation of construction site	travel, equipment, materials, delimitation of the camping area, temporary materials from warehouse and staff organisation (short auto-container – 10 m length), ecological toilets setup, placement of boxes and containers for recovery of mineral, solid, liquid, organic and recyclable waste; equipment: 1000 kg concrete mixer, 2 large rigs, 50 kW power generator, welding machine, electrodes, etc	
2. Necessary materials	1,000 to 1,100 kg reinforced concrete 12, 14, 16 mm x 2.72 RON / 1 kg	2.992
	8 Buzau meshes, 3x2 m, rebar diameter of 6-8 mm = 150 RON x 8	1.200
	150 cement bags x 20 RON / bag	3.000
	3 tippers á 16 tons ballast x 3,000 RON / transport from downstream Rucar, Campulung Muscel area, Targului river	9.000
	formworks made of standard OSB materials (or prefabricated formworks) – 40 sheets of 20 mm thick OSB sheathing, which can be used at all dams = 119 RON / piece	4.760
	2 sqm straightedges 10x10 cm x 4 linear meters x 500 RON / sqm	1.000
	Nails, wires, screws	3.000
3. Stones for cyclopean concrete	found in the river or on the roadside from landslides (rocks, debris) – only labor and fuel costs for staff = about 4,000 RON / dam (approximately 55-60 tons of stone / dam).	4.000
4. Wood material	beams of 8x8 cm x 4 m = 5 square meters x 500 RON / sqm	2.500
Construction material costs		*31.452*
5. Staff	8-10 consecutive working days x 8 people x 180 RON / gross salary / day	14.400
Partial gross budget (material and workers)		*45.852*
6. Material transportation, etc.	10% of total costs of construction materials	3.145
7. Other unforeseen expenses	10% of the partial gross budget	4.585
8. Administrative and accounting expenses	5 % of the partial gross budget	2.293
Total gross budget per dam		***55.875***

Materials from the area will be used – stone debris from the edge of the access road, also realising the road decongestion, harvesting a portion of the alluvial deposits of gravel from elbows to avoid affecting the water canal. Harvesting is done where the terrain allows entering of the machines (bulldozer, excavator, trailer, tractor, harvesting stone outside of the water, only from the shores and from alluvial deposits, upstream and downstream of the dam where the stone is necessary).

Advantages of this kind of dam reconstruction are:

- The disappearance of the complex fragmentation and restoring the continuity of fish populations and their communication through upstream and downstream migration of the fish for feeding and reproduction.
- Increased biomass production and biological productivity of fish and aquatic biomass in general, from all aquatic rheophile and shore habitats from the upper basin of Dambovita.
- The anti-erosional effect – the primary reason for which the dams were built by the Romanian Water Authorities – is not reduced and therefore the stability of roads isn't at risk.
- This reconfiguration doesn't threat the dams, but on the contrary, strengthens natural hydrotechnical erosion by torrents, floods or frost, as the water speed is reduced, especially in the middle of the riverbed, both near the dams and inbetween them, on the entire length of the river. The riverbed isn't deepened this way and the banks of the riverbed sectors between two dams aren't eroding.
- No polluting materials result.
- The vegetation state of the alders is stabilized.

Site specific recommendations to combat water pollution

Applying the following set of measures can eliminate water pollution, also considering a touristic use of the area:

- Abusive grazing in the valley should be forbidden.
- The logging companies, to avoid that debris is being washed away by the rain and ends up in the water, should clear forests from woody vegetation debris.
- Access for a large number of vehicles should be controlled and any toxic waste resulting from the maintenance of vehicles (oils, lubricants, fuels, strong acids from used batteries, plastic and metal waste) must be collected in containers that are taken to special waste disposal sites.
- Access into the valley during mushroom season, should be controlled by releasing permits for those involved in this activity. Thus, it is easier to identify fish poachers or other activities that lead to water pollution.
- Severe control actions should be undertaken, to fight poachers that fish with toxic substances or pesticides.

- Special areas for tourists and campers should be designated to minimise uncontrolled tourism and the number of tourists camping in unauthorized places, especially near the water.
- Sewers for toilets must be build in a rich humus soil, not rocky and not near streams or springs, as this can affect the quality and health of aquatic habitats.
- People should be warned about burning dry wood vegetation near the water by information panels installed in camping places and places with high visibility.
- The use of fertilizers on alpine lawns (complex fertilizer type substances, nitrogen, phosphorus, potassium), which increases the concentration of nutrients in the water, must be forbidden.
- Manure shall be spread immediately rather than stored in piles in the upper areas of Valea Vladului and Valea Otic, where erosion and rainfall leads to draining of the waste into the water.

Re-stocking fish populations

Due to the low fish populations in the Upper Dambovita River, caused by habitat fragmentation and overfishing, we recommend re-stocking fish populations above the Pecineagu dam together with a ban on fishing for a period of 5-7 years. Restocking with trout and bullhead shall be done annually for a minimum of 5-7 years, not with large quantities of fish, but distributed in many restocking stations (at 200 m distance from each other for bullhead, and 400-500 m distance for trout).

Trout can be obtained either by purchasing from Romsilva trout breeding locations in the area, or by fishing and/or electro-fishing in other rivers of the hydrological basin of the Arges river basin, which belong to the same subpopulation. It is crucial for the juveniles to be at least one year old, since chances of juveniles to reach maturity rise from 0.01% for individuals below one year of age to 25-33% for fish over a year. About 60-70% of juveniles are falling prey to natural predators (fish eating birds, otters, etc.). Restocking with trout shall mainly be undertaken on the larger tributaries (Vladului, Otic, Barbului, Coltii lui Andrei, Berevoiu), after re-arranging the dams.

For the less mobile bullhead, adults shall be released in the waters upstream of the lake and along Valea Otic and Valea Vladului, with 5-6 individuals / location, locations be separated by a distance of 200 m only. Downstream of the dam it is not necessary to restock with bullhead, as the population can be considered sufficiently numerous and in ongoing growth. We found about 30 juveniles or adults of at least10 cm in the rheophile river segment, which translates into a population in good condition and capable of self-reproduction. Therefore, we believe it is justified to harvest a supply of juveniles and adults (60-70) for repopulation measures upstream of the dam.

MONITORING PLAN

Monitoring habitats and species

Methodology

Each of the areas surveyed will have adequate, specific protocols. Protocol development will be based on detailed literature documentation, specialist's consultation and also own experience and shall be preceded by a preparatory stage, including a:

- specialised scientific documentation on the general morphological, cytological, sociological and eco-physiological characteristics of the studied species
- technical documentation on the methodology of taxonomical, chronological, sociological and ecological investigation
- thorough review of the scientific literature on the natural and socio-economic status of the territory studied (upper course of Dambovita)
- purchase of reagents, equipments, materials and adequate logistics, expected to be used in the field and laboratory investigations
- consultation of specialists who have done some investigation in the territory

There should be a clear delineation of the territory to be investigated, also considering the general location, as well as geological and topographical details. Transects need to be established in a way that they cross all vegetation types equally, and that the most specific habitats and main areas under obvious zoo-anthropogenic influence, are covered. Distances between transects will be set according to the map scale, the degree of vegetation variation, size, and diversity of pollutants.

Field protocols shall be developed that allow an assessment of habitat's size and conservations status, population size of certain species, anthropogenic influences, etc. by recording following data:

- Number of species per square meter
- Number of individuals (juveniles, in bloom, stage of boost)
- Coverage
- Layering of vegetation
- Plant associations
- Richness of the site
- Rare plants present on the site
- Alien plants present on the site
- Anthropic influences (tourism, construction, collection of forest fruits)
- Diseases
- Site Sketch (drawn directly in nature)
- Climate data

The field research has to be conducted by specialized staff and needs to be supported by detailed maps, photo-cameras, GPS, vehicles and fuel.

Monitoring fish species

Community structure

Fish communities relate to the relative abundance of each species of fish in a multi-species assembly. Relative abundance is measured by the number of fish caught per sampling unit, but sometimes measurements based on weight are used. A community of fish includes virtually all fish using a defined area at a time. The best method of measuring the fish community structure is the one that obtains the largest sample and which is the least selective (catches species in proportion to their occurrence in the sample). In general there is no method good enough to meet both criteria, and therefore community trend analysis usually includes several methods. When comparing samples from different habitat types, one has to keep in mind that major differences in the efficiency of the methods used in different habitats might occur.

Relative abundance can be determined for all specimens regardless of size, or can be determined separately for adults and young-of-the-year by using pre-defined length categories for each species. The relative abundance is measured in units suitable for the method used and is always linked to taxonomic identification and the group described. The term relative stresses the fact that any method used is somewhat selective and produces a biased view of true abundance. In trend analysis, developing standardized methods minimizes this bias.

Species diversity refers to the total number of species taken during a pre-defined unit of effort and is a component of the total diversity of the fish community. Because the sample species richness increases with increasing sampling effort, comparing estimates requires either constant sampling effort or formal estimation methods. Depending on the value of the ecological significance index (W), species of fish in a pool are divided into:

- ruling species (W5> 20)
- characteristic species (non-dominant – indicators) (10 <W5 <20)
- complementary species (companion – dominant) (5 <W4 <10)
- associated species (subdominant) (1 <W3 <5)
- accidental species (0.1 <W2 <1) (W1 <0.1)

Population structure

The population structure refers to the distribution of individuals of a single species among size or age groups. Usually, it is recommended that the population structure analysis be based on a large number of specimens (≥ 200). Population structure data are obtained from routine monitoring and sampling.

Distribution size of a species is a valuable index for a variety of population characteristics, including growth, mortality and birth rates. Evaluation of the distribution size requires the setting of total size categories (TL). During measurements, the specimens are cataloged according to the total length recorded. Categories are marked as the lower limit of length. For example, fish in category 9 have a total length between 90 and 99 mm, and fish in category 40 are between 400 and 420 mm TL.

Sampling

To monitor fish, biological material sampling stations will be fixed, both downstream and upstream, to cover the full range of ecological preferences of fish species in the area. The main method used for non-destructive sampling of fish is by *electro-fishing*. Electroshock devices emit a low current that stun the fish for a short period of time, in which they can be caught. After 10 minutes the fish will return to their normal activity. In order to carryout electro-fishing in large bodies of water, such as a lake, high power electroshock devices (> 10kW) with a greater range are needed. Besides this method, nets and rheophile nets will be used for catching fish. To get a complete picture of the composition and diversity of ichthyofauna, fishing will be made randomly at different depths.

Another method of capturing fish is by running out large and small *hoop nets*. Large hoop nets have seven rings of fiberglass and a length of 4.8 meters, whereas small hoop nets have seven rings and a length of 3 meters. The first ring is 1.2 meters in diameter (or 0.6 m in small nets), and each successive ring decreases by 2.5 cm by the end of the net. The mesh size is 3.7 cm (or 1.8 cm) and is coated with a protective layer. Black aperture is set on the second ring and the ring number 4. Aperture number 2 has a circumference of 35 meshes (rep. 28 in small nets) and aperture number 4 has a circumference of 26 meshes (resp. 22). The nets are launched in pairs; both placed in the same layer of the habitat, with the open end downstream and with the smaller mesh facing the shore. Water depth should be sufficient for the entire net to be submerged. Each hoop net is anchored using ropes of 14-60 m tied to a pole or anchor. Where current velocity is not sufficient to keep the hoop net open, a rope of 15 m is tied to it to keep it open. A marking may be attached to the rope, to facilitate observation and recovery of the nets. Hoop nets are baited with 3 kg of forage soybean, 1 kg placed in a mesh bag of 1.9 cm in the back end of the nets, and 2 kg placed in the front. The standard unit of effort is placed-day (number of 24 hours-days the nets were set, multiplied by the number of nets). A standard release lasts 48 hours, after which the set-up is recovered using a hook that rises from the water rope tied to the net's mouth.

Seining is used to collect small fish in shallow water areas. The standard unit of effort is the catch net, the time required for the catch is not recorded. Seine dragging nets are made of braided 3 mm nylon mesh, are 10.7 m long and 1.8 m high, with a bag measuring 0.9 square meters located in the center and two on the sides. Seines can be coated with a protective layer, as long as it does not affect their flexibility. These nets are used along shorelines, in waters with depths less than 1.2 meters. The upstream end is anchored to the shore, while the other end is perpendicular to the shore, forming an arc of 90 degrees in the downstream direction. This movement will sweep an area of approximately 4.6 - 5.2 meters in diameter. Slow movement is to ensure, so that the bottom line remains in contact with the substrate and stays afloat at all times. The use of seines in an area involves taking at least two samples - one of the most upstream section and one downstream at the lowest point - but it is recommended to make four sampling using nets. The data from each sample are recorded separately.

Trawling can be done at fixed sampling locations in unstructured river channels. This method is mainly used to collect small fish. The standard unit of effort is a 350 m long haul. Trawling nets are 4.8 m wide and 4.5 m long and made of # 9 nylon mesh of 18 mm diameter. The trawl bag is made of # 18 nylon mesh and contains a liner of 1.8 to 3 mm diameter mesh. Rafts are equally spaced at 0.91 meters along the top. Leads of 4.8 mm are bonded along the bottom. Trawls are pulled downstream with a moderate speed, so that the lower end is in contact with the bed of the river. The time needed to cover the distance of 350 m is reported as the sampling time in minutes. Trawling on a sampling site usually consists of at least 6 hauls; data from each haul is recorded separately.

Gillnets are primarily used to increase the sample of highly riparian areas. The standard unit effort using gill-nets is one 24-hour day. Gillnets are about 90 m long and are made of 4 monofilament mesh panels of 22.86 meters. The panels have a depth of 2.44 m. Each panel is formed of a different mesh size. Table size is 10.2, 15.2, 20.3 and 25.4 cm. Tables 10.2 and 15.2 cm are transparent monofilament braided # 8 nylon. The top line consists of floating, foam-core rope and the bottom line is a lead core rope. It may be necessary to add additional lead to the lead rope for sinking the nets. Gill-nets can be placed either perpendicular or parallel to the shoreline. Generally it is preferred o place them perpendicular, but sometimes this can be inefficient, especially if the flow rate of the water is very high.

Methods for testing

Starting in 1993, the monitoring effort initiated by LTRMP (Long Term Resource Monitoring Program) for ichthyofauna is based on a stratified random sampling model (Gutreuter, 1993). This method facilitates clear predictive estimates of relative abundance and other statistical methods (Cochran, 1977). It is also suitable for the interpretation of tests of hypothesis based on predictive models.

Sampling layers

There are nine sampling layers that are defined on the basis of enduring morphological and physical features, called "aquatic areas" (Gutreuter, 1992). The terminology used here is consistent with that in Wilcox (1993), except where noted. Transient features, such as vegetation, forms the basis of many species, important habitats, but proved to be too short-lived to serve as the characteristics of the sample layer. Important transient features are recorded when sampling. Sampling strata are defined as follows:

A. Main channel border-unstructured area (MCB-U). An unstructured main (navigation) channel border area is that aquatic area between the margins of the main navigation channel and the nearest natural shoreline areas (island or mainland). An unstructured shore area is important because it is a great coat and promotes many riparian species.

B. Main channel border wing dam area (MCB-W). A main (navigation) channel border-wing dam area is a localized portion of main navigation channel border area in which a wing dam is the predominant physical feature. Wing dams are artificial structures that act to restrict flow to the navigation channel and are usually constructed of rock.

C. Side channel border (SCB). A side channel border is the border of all secondary and tertiary channels (Wilcox 1993) that have terrestrial margins and carry flow downstream through the floodplain (and hence have measurable current velocities) at normal water elevations. Side channels are important because they are lotic areas that are relatively unaltered and isolated from navigation traffic.

D. Tailwater zone (TWZ) is defined as the area immediately downstream of the dam, comprising the area of "jump drowned", an area where erosion occurs due to the presence of the dam bottom of the water. These areas provide unique conditions that act to concentrate fish, including large coastal species. Because these areas are small and are of particular interest, sampling methods is carried out permanently fixed sites existing in these areas.

E. Backwater, contiguous-offshore (BWC-O). These are areas adjacent to water bodies that have some communication with the main navigation channel, but are separated from it by a terrestrial area.

F. Backwater, contiguous-shoreline (BWC-S). These are areas of standing water, as described in the previous paragraph, which are located at a distance of 50 m from land.

G. Impounded-offshore (IMP-A). Impounded areas are usually large, mostly open-water areas located immediately upriver from locks and dams. An offshore impounded area is that portion of the impounded area more than 50 m from the nearest shoreline.

H. Impounded-shoreline (IMP-S). Impounded shoreline areas are those portions of impounded area that are within 50 m from the nearest shoreline.

I. Main channel trough (CTR). The main channel trough is the thalweg or navigation channel within the main channel. This channel is usually identified as the area between the navigation buoys.

J. Tributary mouth (TRI). The tributary mouth is the portion of a tributary stream that is within the floodplain of a large river.

Data collection and processing

Data processing consists essentially in preparing a comprehensive list of existing fish in the study area. For each species of Community Interest (Table 8), threats and their impact shall be observed and noted.

Table 8. Target species for monitoring.

Scientific name	Annex of Habitats Directive and OUG 57/2007	Population size	Conservation state
Barbus meridionalis petenyi	II	-	B
Phoxinus phoxinus	II	-	B
Cottus gobio	II	-	B
Salmo trutta fario			

Fish species, which will be given special attention during monitoring, are presented in the table below. Also, the general data structure and composition of fish fauna will be noted, as well as the establishment and development of risk populations, to develop appropriate management and conservation measures.

Monitoring insect species (Entomofauna)

Terrestrial and aquatic environments are populated by insects in all stages of development. The objective is to provide methods given standardized data about the distribution and relative frequency of species present. Standard collection methods are namely:

- Mowing the herbaceous layer/shrub with entomological nets
- Striking branches and collecting the entomological umbrella
- Installation of Barber traps with preservative solution (5% formaldehyde, ethylene glycol, brine)
- Installation of baited traps, depending on the species
- Collection of the substrate with tweezers
- Night collection with light source
- Other methods

To get a complete picture of the composition and distribution of entomofauna in the study area sampling will be done randomly. Samples collected will be stored by specific methods groups, in principle in a liquid medium. Data processing consists essentially in preparing a comprehensive list of existing insect species in the study area. For each species of Community Importance and/or under EU protection, threats and their impact will be marked the observed.

The following protocol provides a consistent and effective method of obtaining the distributional data, both space and time, as the detection / non-detection, as well as information on the status conditions of potential habitat for all species of insects.

Main monitoring method

Sampling along *transects* is the standard method used in the inventory of coeloptera species. Typically, they are composed of linear paths, which cross an area considered representative for monitoring local populations. They may be homogeneous when compiling a uniform habitat or heterogeneous, in the case of a complex habitat. Transects can be either the 10 or 20 carried out by sweeping the entomological fillet at a beat frequency of 1 per step along a line, or to the location of the traps at various distances Barber (20 - 50 cm up to 1 m).

There are many techniques for insect inventories (e.g. different types of traps, etc....), each having advantages and disadvantages related to the species collected, applicability to different types of habitats and assumptions from which it starts. Using several methods of collection will result in better characterization of present insect communities. However, transects are the most widely used method over a wide range of habitats due to the simplicity of its implementation.

As sample units we recommend using visual transects of 10 ha hexagons (Fig. 29). A big surface area of the sample unit has been chosen to allow observation of a wide variety of insects. On a big surface, a variety of microhabitats are included, such increasing the chance of detection and mapping of the representative entomofaunistic assemblies.

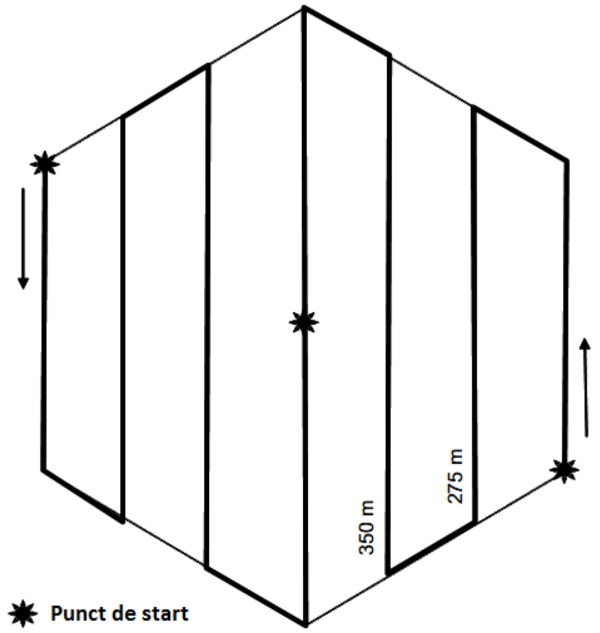


Fig. 29. Starting points of the 10 ha polygon and transects to be followed.

Each transect has a spacing of 50 m, and the distance along the entire hexagon is 2,400 m. Starting point of the study is randomly selected along transects, and the starting points of further studies will be selected to be on transects opposed to the first, covering a larger area of habitat. Periodically, to properly browse transects, observers may consult the compass.

Monitoring along transects of the hexagon will take about 8 hours, usually between 7:00/9:00 to 18:00/20:00, which is the period when the expected insects are active and visible. However, during the summer with high temperatures, or for some species, individuals are more active in the morning, at sunset or are completely nocturnal. Data collection at night is more dangerous and less feasible, but can be used as a secondary method, with good results in certain families (e.g. Dytiscidae and Carabidae).

Each sample unit will be visited at least four times per month in the period from March to September, for a total of 28 visits per year, maximizing the number of species and individuals collected. If time allows, it is good to make additional visits to obtain more detailed and better accuracy of predictions.

The observer looks at a distance of 1m from each side of the transect, but can also leave transects to look for favorable habitats adjacent to a distance of 10 meters either side of the transect. For each catch/catch set there shall be attached Information such as hour, type of substrate (plants, rocks, logs, soil), meteorological conditions, ambient temperature, substrate temperature (optional), and location along the transect. Dead animals found will be collected and preserved. D

Data analysis consists of creating species lists for each collection point along all field activities and estimating the proportion of all monitoring points in the study area, using the probability of presence and detection as parameters in a maximum likelihood model. For this analysis programs like PRESENCE and/or Maxent will be used. Species detection data will be compiled to create a register of detection for each species. Detection records consist either of a "1" for the entire sample unit (regardless of the number of detections) or a "0" if there is no detection.

Additional monitoring methods

Other study methods are represented mainly by increasing the number of transects to increase the likelihood of catching and trapping, which may show species that were not collected during the performance transects. Nocturnal seizures can be used to collect different species difficult to collect.

Additional visits may lead to the detection of more species or species habitats and / or areas that have not been previously found. If there is time, it is recommended at least 1-2 additional visits for each sample area. Extra time will be dedicated to each point with the highest potential habitats for species presence. An additional search time per visit may be beneficial in areas with rich entomofauna.

Nocturnal collections may be used as additional approach to increase the potential for the detection of night active species. One can either use transects or fixed, white screen light source traps of various types.

Terrestrial traps (Barber traps) are commonly used to capture a wide variety of terrestrial animals (both vertebrate and invertebrate small) and are especially effective in the study area communities. However, the implementation of these kinds of methods is effective only in the areas of good habitat, which is a time-consuming process. In order to increase the attractiveness different types of bait can be used.

In so far as it may consider appropriate, *Malassez traps* can be placed, in order to increase the probability of collection of species otherwise difficult to collect by other means. Placing traps can be done immediately after snowmelt. The data collection period using the trap should not be less than 10 to 14 days.

Expected outputs

- Development of distribution maps of species occurring within the protected area
- Calculation of the estimated populations of the species, where possible, using specific software.
- Designation of areas of high importance for the survival of insect populations, of breeding areas and designation of wintering (hibernacule) areas - if applicable.

- Determination of anthropogenic pressures in the area and the degree to which each of them jeopardizes the species.
- Formulation of recommendations for reducing pressure on natural populations and conservation measures.
- Creation of a database.

Period of fieldwork

Field visit for entomofauna inventories of the area will be made only during the warm season (spring-summer-autumn; see Tab. 9). During this time at least 4 visits per month shall be scheduled, each for 2 days, accumulating eight days of work per month.

Table 9. Optimal periods for insect and fish fauna monitoring.

Study group	Month										
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Insects					X	X	X	X	X			
Fish			X	X	X	X	X	X	X	X		

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ANNEX