THYMALLUS THYMALLUS (LINNAEUS, 1758), ECOLOGICAL STATUS IN MARAMUREŞ MOUNTAINS NATURE PARK (ROMANIA)

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ABSTRACT

Thymallus thymallus is considered a species of significant protective importance within the Vişeu Watershed. The state of habitats characteristically inhabited by *Thymallus thymallus* within the Maramureş Mountains Nature Park is balanced between reduced (one third of the lotic sectors where the species was identified), average (one third) and good (one third). The excellent conservation status is currently missing for populations of this fish in the Vișeu Basin.

Human impact types identified as contributing towards the decreasing state of *Thymallus thymallus* habitats and therefore populations in the studied area in comparison with its natural potential are: poaching, minor riverbeds morphodynamic changings, solid and liquid natural flow changes, destruction of riparian trees and bush vegetation, habitat fragmentation/isolation of population, organic and mining pollution, and displaced fish that are washed away during flood periods in the lotic sectors uniformized by humans.

RESUMEN: Estado ecológico de *Thymallus thymallus* (Linnaeus, 1758) en el Parque Montañas Maramureș (Rumania).

Las características del habitat de *Thymallus thymallus* dentro del Parque natural Montañas Maramures es un balance entre estados degradado (un tercio de los sectores donde se ha identificado a la especie), promedio (un tercio) y bueno (un tercio). Para las poblaciones de este pez en la cuenca Vișeu, a la fecha, no existe un estado excelente de conservación.

Los impactos humanos que reducen las poblaciones de *Thymallus thymallus*, en relación con su potencial natural son: pesca ilegal, cambios morfodinámicos menores en las cuencas fluviales, cambios en el flujo natural de sólidos y líquidos, fragmentación de hábitat/aislamiento de poblaciones, contaminación orgánica y de minería y pérdida de peces durante los periodos de inundación en los sectores loticos que han sido uniformizados.

REZUMAT: *Thymallus thymallus* (Linnaeus, 1758), situația ecologică în Parcul Munții Maramureșului (România).

Starea habitatelor caracteristice pentru *Thymallus thymallus* din Parcul Natural Munții Maramureșului oscilează între precară (o treime din sectoare în care specia a fost identificată), medie (o treime) și bună (o treime). Statutul de conservare excelent lipsește pentru moment la populațiile acestei specii în zona de referinţă – Bazinul Vişeului.

Tipurile de impact antropic identificate a fi responsabile de înrăutățirea stării habitatelor populației de *Thymallus thymallus* în zona studiată, comparativ cu potențialul său natural, sunt: braconajul, modificări ale morfodinamicii albiei minore, modificări ale debitelor naturale solid și lichid, distrugerea vegetației arbustive și arboricole ripariene, fragmentarea habitatelor/izolarea populațiilor, poluare organică și cu ape de mină, evacuarea peștelui în perioadele de inundații în sectoarele lotice uniformizate antropic.

INTRODUCTION

The mountainous water is usualy of high quality in the condition of modest development of anthropic activities (Romanescu, 2016), activities which should be assessed in the local conservation issues context.

Stream and river ecosystems of the Maramureș Mountains Nature Park mostly belong to the Vișeu River basin and very little to the Bistrița Aurie Basin (Fig. 1), in the northern part of Romania. The Vișeu Basin is bound by the Maramureș Mountains in the northeast, by the Maramureș Hills in the west and southwest, and by Rodna Mountains in the south. The lowest area of this basin is at 303 m above the sea level at the point of confluence of the Tisa and Vișeu rivers, while the highest area reaches 2,303 m altitude in the Pietrosul Rodnei Peak in the Rodna Mountains. Due to the tectonic, geological, and geographical diversity within this basin (karst, exokarst, glacial relief forms, etc.), the studied area is diversified in landscapes, inevitably having a high diversity of biotopes, biocoenosis, and among other elements ichtyocoenosis. (Curtean-Bănăduc et al., 2008; Bănăduc et al., 2011)

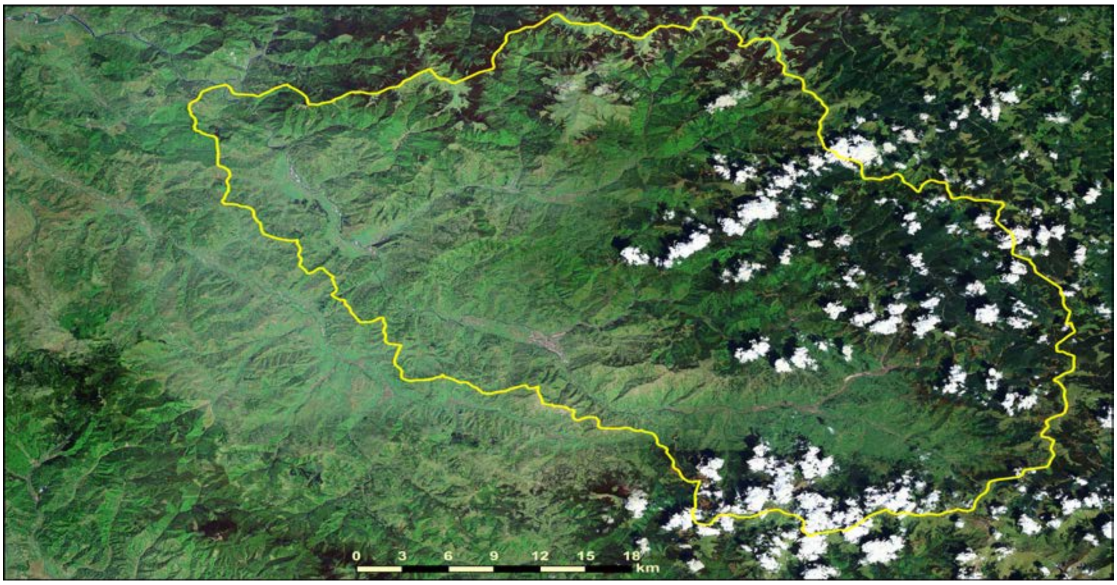

Figure 1: Vișeu River basin.

The Vişeu River is a second degree tributary of the Danube River, streaming into the much larger Tisa River. It has a length of 80 km and a multiannual average flow of 30.7 m^3/s at its end near the confluence with Tisa. The spring area is placed in Prislop Pass (1,416 m) and it stream into Tisa River in the proximity of Valea Vișeului Village, the basin covering 1,606 km^2. In its upper sector, from springs area to the Moisei locality, the Vișeu River has a relatively considerable abruptness (20-50 m/km) and is named Borșa or Vișeuț. The Vișeu enters at Moisei in the Maramureș Depression where the river valley is broader, even if some narrow gorge-like passages exist: Rădeasa Gorges between Moisei and Vișeu de Sus, Oblaz Gorges between Vișeu de Jos and Leordina, and Vișeu Gorges between Bistra and Vișeului Valley. The Vișeu River hydrography is of Eastern-Carpathian-Moldavian kind in its upper sector and of Eastern-Carpathian-Transylvanian type in its lower part. Its discharge is significant in the springtime (39.4% of the annual discharge) afterwards declining in the summer (27% of the annual discharge) likewise during the autumn (18.6% of the annual discharge) and with its lowest period during wintertime (15% of the annual discharge). (Curtean-Bănăduc et al., 2008; Bănăduc et al., 2011)

Due to fact that the Vişeu Basin is located for the most part in mountainous areas (67%) induce a significant density of the hydrographic network (0.7-1 km/km^2) and to one of the biggest specific discharges in Romanian territory, as a result of rain and snowfall of over 1,100 mm/year. In the upper sector, the tributaries formed in the glacial-type Rodna Mountains, have a discharge of approximative five m^3/s. The most substantial Rodna-originating tributaries of Vişeu are: Fântânilor Valley (seven km length), Negoiasa Valley (six km), Repedea Valley (10 km), Pietroasa Valley (seven km), Vremeșu Valley, Hotarului Stream, Dragoș's Valley (11 km) and Izvorul Negru (seven km). From the Maramureș Mountains, the right side tributaries are: Hășmașul Mic, Cercănel (11 km), Țâșla (20 km), Vaser (52 km in length and catchment area of 422 km^2, with an average flow of nine m^3/s contributing by 27% to the total flow of Vişeu), Novăț (16 km, 88 km^2 tributary of the Vaser), Ruscova (39 km in length and 435 km^2 catchment area, average discharge of 11.3 m^3/s), Socolău (13 km in length and 72 km^2 catchment area, tributary of the Ruscova), Repedea (19 km in length and 87 km^2 catchment area, tributary of the Ruscova), Bardi (11 km in length and 32 km^2 catchment area, tributary of the Ruscova), Covașnița (11 km in length and 34 km^2 catchment area, tributary of the Ruscova), Frumușeaua (14 km in length) and Bistra (nine km in length). From the Maramureș Hills originate the left-side tributaries, small and with insignificant water input: Drăguiasa, Cocicoi, Spinului, Plăiuț, Neagră and Luhei. (Curtean-Bănăduc et al., 2008; Bănăduc et al., 2011)

In the Vişeu River watershed, the water feature is influenced in some areas in a natural way by the existence of mineral springs (around five in Maramureş Hills; about six in Rodnei Mountains, and 150 in Maramureş Mountains) with a rather diverse content (ferrous, bicarbonate, sulphurous and saline) (Curtean-Bănăduc et al., 2008).

In the Maramureş and Rodnei mountains the streams and rivers are occasionally obstructed by considerable waterfalls and successions of rapids, we remark the most important of these waterfalls from the Maramureş Mountains: Criva, Tomnatic and Bardău, and from the Rodnei Mountains: Cailor, Cimpoioasa Valley, Repedea Valley and Izvorul Verde. Lentic water ecosystems also occur. Glacial lakes from Rodnei Mountains are placed at an altitude over 1,900-1,950 m and were formed at the heels of some deposits: Iezer Lake, Gropi Lake, Buhăiescu Lake, Rebra Lake, Negoiescu Lake and Cimpoieş Lake. The local wetlands are eutrophic and oligotrophic marshes: Strungi, Tăul Obcioarei, Tăul Ihoasa, Jneapănul Hânchii, Pietrosul Barcăului, Tăul Băiţii, Preluca Meşghii, Vârtopul Mare, Tăul cu Muşchi and Bedreasca. The lakes from Maramureş Mountains are Lutoasa, Bârsănescu, Budescul Mare, Măgurii and Vinderel. On the Vişeu River valley near Petrova locality, there are some small bodies of water/ponds. (Curtean-Bănăduc et al., 2008; Bănăduc et al., 2011)

The variety of aquatic and semi-aquatic habitats and their linked endangered, rare and endemic species from Vişeu Watershed are heterogeneous and very valuable under preservation context. The fish species of this area are no exception, as recorded by various ichthyologists rather constant over more than a century of specific research (Bănărescu, 1964; Staicu et al., 1998; Curtean-Bănăduc et al., 2008). Around 50% of the local fish species are of significant protective importance.

Thymallus thymallus (Linnaeus, 1758) is one such fish species of preservation importance, where populations within the Vişeu Watershed have declined. The distribution and abundances of this endangered taxa are relatively unknown and specific information for the a proper management is highly needed.

MATERIAL AND METHODS

Research on populations of *Thymallus thymallus* within the Maramureşului Mountains Nature Park was accomplished in January – July 2015, consisting of 370 sampling sectors (Fig. 2; Tab. 1). This research included population mapping, evaluation of the current preservation status, and identification of factors responsible for the current declines in populations.

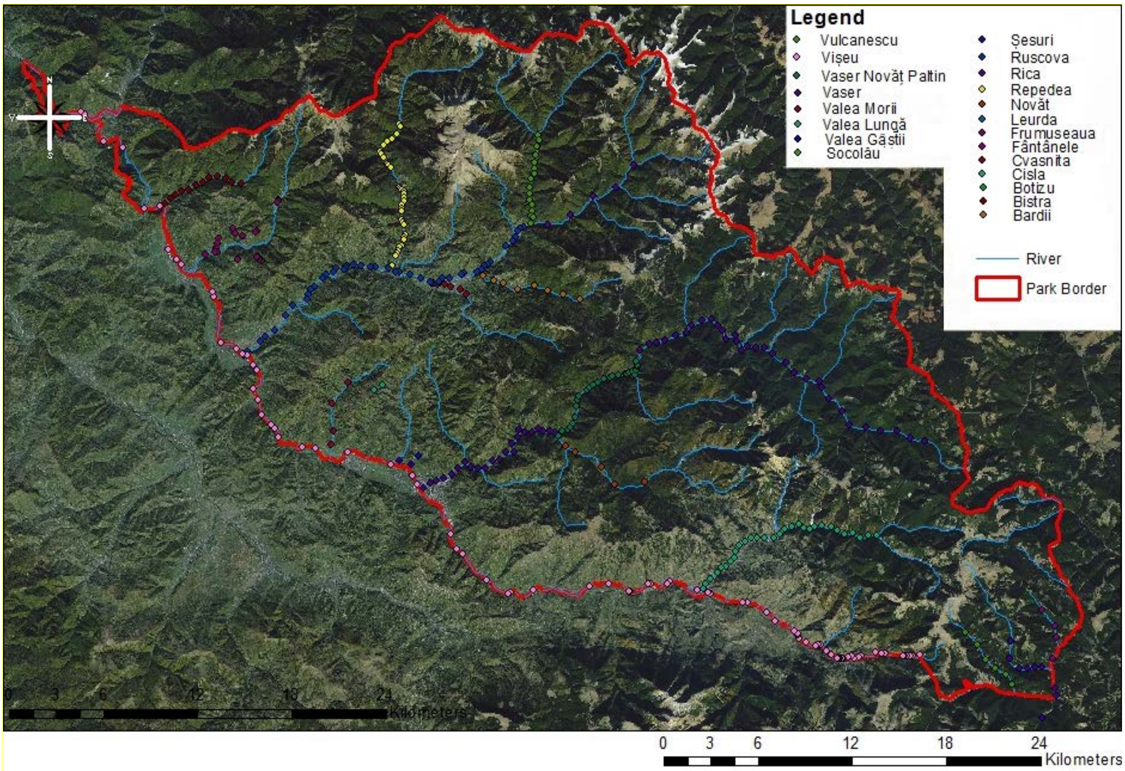

Figure 2: Locations of the 370 sampling stations (GIS support – Danci O.).

To evaluate the conservation status and population decline of *Thymallus thymallus* within the Maramureşului Mountains Nature Park, quantitative samples were collected from sampling stations of approximately three kilometres between two consecutive sectors on all watercourses with appropriate habitats for this species. The locations of the sampling stations allows the evaluation of the effects of human influence on the target populations, including the biotope situation transformation, presence of substratum exploitation, pollution sources, hydrotechnical works, and last but not least chaotic recreational fishing and poaching.

Quantitative sampling of fish fauna was accomplished by the electronarcosis, per unit of time and effort per section (two hours on Vişeu River, one hour on Ruscova River, 30 minutes on the other rivers of the references zone), on five longitudinal sections of 100 m length. After species identification and counting individuals, fish were immediately released in their natural habitat.

The number of individual fish caught in the unity of time and effort can be converted through correspondence in the following categories: (C) – common fish species, (R) – rare fish species, or (V) – very rare fish species, according to the guidelines for Natura 2000 standard data form filling, “In mammals, amphibians, reptiles and fishes, no numeric information can be indicative and then the size/density of the population is evaluated as (C) – common species, (R) – rare species, or (V) – very rare species”.

The criteria used to evaluate the population status are the following: balanced distribution of individuals by age classes, population size, distribution areal size and the percent of fish individuals of the species of interest in the structure of fish communities.

According to the Natura 2000 guidelines, standard data form filling the following criteria "The conservation degree of specific habitats" contain subcriteria: i) the degree of conservation of the habitat features which are important for the species; ii) possibilities for recovery.

The criteria i) need a comprehensive assessment of the characteristics of the habitat regarding the needs of the species of interest. **"**The best expertise" is used to rank this criterion in the following way: I. elements in excellent condition, II. well preserved elements, III. elements in average or partially degraded condition.

In the cases in which the subclass I is granted "I: elements in excellent condition" or "II: well preserved elements," the criteria B (b) should be classified entirely as "A: excellent conservation" or "B: good conservation", regardless of the other sub-criterion classification.

In the case of this sub-criterion ii) which is taken into account only if the items are averagely or partially degraded, an evaluation of the viability of the analysed population is necessary. The obtained ranking system is: I. easy recovery; II. restoration possible with average effort; III. restoration difficult or impossible.

The combination practiced for classification is based on two sub-criteria: A – excellent conservation = elements in excellent condition, regardless of classification of recovery possibility; B – very good conservation = well preserved elements, regardless of classification of recovery possibility; B – good conservation = elements in average or partially degraded condition and easy to restore; C – average or reduced conservation = all other combinations.

In every sampled area, were evaluated: condition, pressures/threats of habitats and populations of interested fish species.

The sampling sections to assess fish population and the conservation status of *Thymallus thymallus* in the monitoring area occurred in sectors where these populations are constant, with a favourable conservation status and well preserved characteristic habitats, as well as river sectors located at the limit of the dispersion area for this species, which include sectors under human impact that can endanger the studied populations condition – the so called Representativity Criteria.

The economical criterion was treated for constituting the monitoring sectors, in this manner an average number was set to supply the needed data for the management decision mechanism in order to be able to conserve a favourable status for the interest fish species in the research area.

Thymallus thymallus (Linnaeus, 1758), Actinopterygii – Salmoniformes – Salmonidae – Thymallinae (Fig. 4), was found in the researched area in the last century (Bănărescu, 1964; Staicu et al., 1998; Telcean and Bănărescu, 2002; Bănăduc et al., 2012; Homei, 1963).

The two sections of the body are evenly convex or, the dorsal one, slightly more convex; the maximum height is located in the insertion of the dorsal or in front of the first quarter of the dorsal. The eyes, placed in the anterior part of the head, look sideways. Interorbital space, convex. Small nostrils, at an equal distance from the tip of the snout and from the anterior margin of the eye. Small mouth, subterminal, transversal, protractile; its opening located anteriorly from the nostrils. The rear edge of the upper jaw reaches far below the anterior margin of the eye, insertion of the mandible behind the middle of the eye. Margins of jaws, straight and sharp. Teeth small, pointed, arranged in a single row on the intermaxillary, maxillary and dental; a group of tiny teeth on prevomer and palate. Wide gill openings, brachial membrane fixed by isthmus only with the anterior end. Dorsal margin rounded anteriorly, straight posteriorly. Posterior radials of the dorsal fin slightly longer than the anterior ones but strongly inclined backwards so that the fin height decreases slightly toward the rear. Pectorals sharp, ventral fins rather rounded. Anal margin anteriorly convex, slightly concave posteriorly. Ventral fins are inserted under the posterior side of the dorsal; anal fin behind the posterior tip of the dorsal and ventral fins, and the adipose fin above the posterior half of the anal. Caudal deeply cupped. Lateral line complete, almost straight. The scales well fixed, absent on the head, on the pectoral base, isthmus and irregular areas of the anterior part of the body ventral side. Ventral scales small. Head and backside are brown, body sides yellowish with a metallic luster or silvery with purple reflections, ventral side silvery white, sometimes reddish. On the sides of the anterior body half a series of dots or thin strips dark brown, very obvious and persistent. Dorsal dark, with a series of brick-red spots and black, less displayed like longitudinal stripes. Caudal gray, with reddish or blueish tint, and brown spots. Pectorals yellowish, purplish-pink ventrals and anal pink-violaceous. It can reach 30-35 cm, up to 50 cm in length. (Bănărescu, 1964)

RESULTS

The lotic sectors where the species *Thymallus thymallus* (Fig. 3) was found during the research are shown in table 1 (Fig. 4), for each such sectors the catch index values were specified (individuals number per time and effort unit).

Figure 3: *Thymallus thymallus* (Linnaeus, 1758).

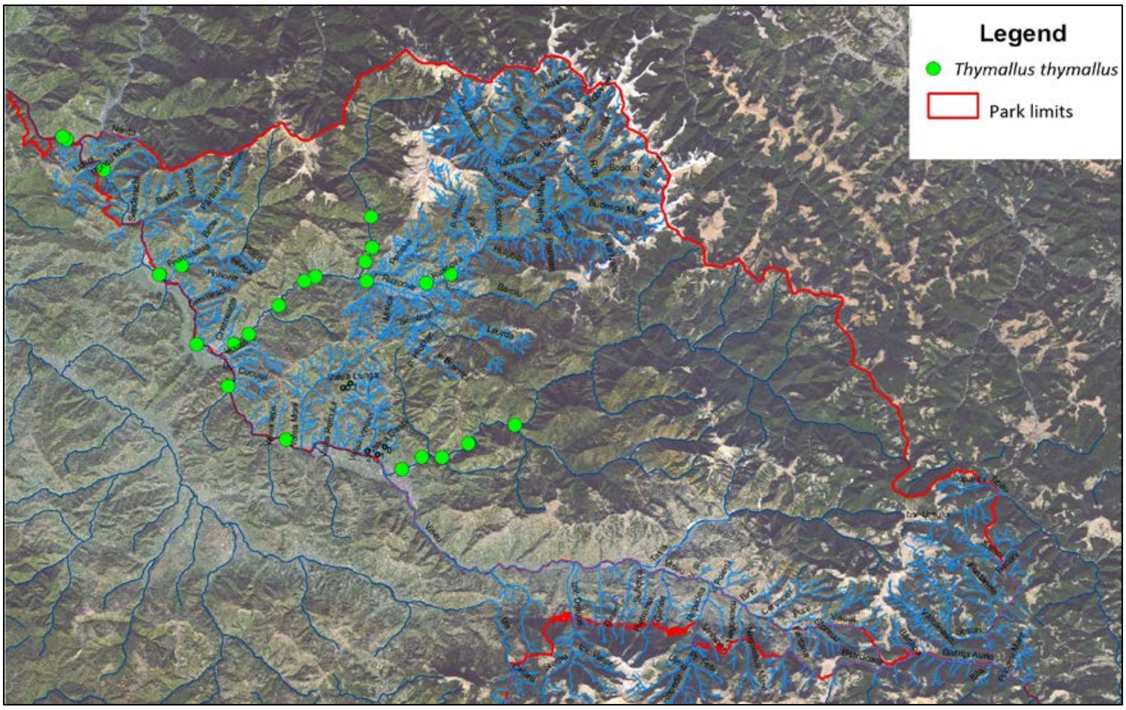

Figure 4: *Thymallus thymallus* sampling stations location (GIS support – Danci-Kast O.).

Table 1: *Thymallus thymallus* sampling points in Maramureș Mountains Nature Park.

No. crt.	River	Station code	Lat. (N’)	Long. (E’)	Catch index no. ind./100 m × 30 min	Characteristic habitat state
1.	Vișeu	56	47 43 55,5	24 20 02,7	1	reduced
2.	Vișeu	62	47 45 53,3	24 16 53,9	1	reduced
3.	Vișeu	68	47 47 24,0	24 15 12,6	1	reduced
4.	Vișeu	71	47 49 57,1	24 13 09,3	2	reduced
5.	Vișeu	76	47 53 47,4	24 10 06,8	7	good
6.	Vișeu	78	47 54 53,0	24 08 06,6	5	good
7.	Vișeu	79	47 54 58,8	24 07 54,2	1	reduced
8.	Ruscova	7	47 50 03,2	24 28 46,7	1	average
9.	Ruscova	12	47 49 43,0	24 27 28,3	5	average
10.	Ruscova	21	47 49 46,7	24 24 16,7	7	good
11.	Ruscova	29	47 49 55,6	24 21 31,7	6	good
12.	Ruscova	32	47 49 45,4	24 20 56,8	3	average
13.	Ruscova	38	47 48 51,2	24 19 35,0	1	average

Table 1 (continued): *Thymallus thymallus* sampling points.

No. crt.	River	Station code	Lat. (N’)	Long. (E’)	Catch index no. ind./100 m × 30 min	Characteristic habitat state
14.	Ruscova	41	47 47 47,4	24 17 58,4	1	reduced
15.	Ruscova	43	47 47 25,6	24 17 12,2	1	reduced
16.	Repedea	18	47 52 08,7	24 24 28,7	3	good
17.	Repedea	25	47 51 00,3	24 24 33,4	4	good
18.	Repedea	30	47 50 29,6	24 24 11,5	2	good
19.	Vaser	42	47 43 49,4	24 29 46,9	1	good
20.	Vaser	46	47 43 18,4	24 28 23,2	6	average
21.	Vaser	49	47 43 18,9	24 27 17,6	5	average
22.	Vaser	52	47 42 52,6	24 26 15,2	2	average
23.	Frumușeaua	18	47 50 17,0	24 14 21,6	1	reduced
24.	Novăț	32	47 44 31,2	24 32 16,2	1	average

DISCUSSION

Based on the present research results, correlated with *Thymallus thymallus* species biological and ecological necessities, some risk elements were diagnosed (pressures and threats): poaching, minor riverbed morphodynamic changes, liquid and solid natural flow disruption, destruction of riparian vegetation, and habitats/fish populations fragmentation.

Poaching. During the field research chaotic recreational fishing and poaching was observed with electricity from vehicles accumulators and from other categories of rechargeable devices. Poachers were seen during their activities also using diverse substances (natural and/or synthetic) to slaughter fish and gather them downstream. By questioning many people who live in Maramureș Mountains Nature Park, at least from these sources poaching is a somewhat constant activity around the year in the Vișeu River basin. The inability to stop this anomaly may cause a decline in the number of *Thymallus thymallus* individuals.

Minor riverbed morphodynamic changings. Characteristic diverse microhabitat and habitat necessities for this species, in accordance with its life cycle stages, include a natural variability of riverbed morphodynamics. Dams, dikes, sills, changed riverbeds, roads in riverbeds, riverbed mineral exploitation (Fig. 5), changed dynamics of liquids and solids flow, etc., all contributed towards modifying the natural morphodynamics of major and minor riverbeds. These changes also affected the habitats and/or microhabitats needed for the life cycle stages of the *Thymallus thymallus*, which could contribute towards the decline in abundances of this species.

Watercourse obstructions, and water resource development activities on the studied watercourses (for example: dams, dikes, high sills, microhydropowerplants, modifications in the riverbeds, water extractions, riverbed mineral overexploitations, etc.) should not be admitted by the Park Administration without an appropriate/explicit ichthyologic study for this valuable fish species.

Figure 5: Overexploitation of minerals in the banks and terraces of the lower Vișeu River.

Solid and liquid and natural flow changings. The modification of natural flow and riverine morphology prevent the generation of specific microhabitats, habitats, and environmental conditions necessary for the continued presence of *Thymallus thymallus*. These changes to the riverbed natural morphodynamics may be contributing towards the decreasing population size of this fish species. Atypical events, where water turbidity is artificially increased due to careless forestry activities within the vicinity of riverbeds, are examples of activities causing disturbance to the natural balance of the solid and liquid flow.

The solid and liquid natural flow can be preserved as similar as desirable to the natural condition if the riverbed gravel exploitations and/or forestry practices do not significantly disturb the watershed capacity to have a proper self-sustainable function. This can be accomplished by coordinating the human activities with the periods of the year when the natural circumstances are very much alike to those to be generated (e.g. high water turbidity). Proposed in-channel structures and modifications, such as dams, thresholds (Fig. 6) embankments, crossings, water extractions, bank modifications and roads in the waterbed (Fig. 7), thalweg changes by exploitations of construction materials from the riverbed, etc., should be not allowed by the administrator of the protected site without the consent of experts studying the species, based on the integration of the identified local stress factor and the biological and ecological needs of the fish species of interest. In this peculiar case, no crossing should be higher than 15 cm in the shallow water sectors and dry season. We also propose the monitoring of the forestry regulation surveillance containing the boycott of dragging and storage lumber through/in the lotic systems. We also suggest the inspection of the development works for lumber storage and exploitation terraces, (Fig. 8) and the compulsory demand to fast reforestation. In this situation, the rotation of forest exploitations in the sub-basins of the Vișeu Basin is desirable.


Figure 6: Concrete threshold of three m height, with no fish ladder on the upper Vişeu River.


Figure 7: Frumuşeaua River concrete riverbank/completely modified and road in the riverbed.

Figure 8: Logs transported and deposited on the Vaser River banks and in the riverbed.

Figure 9: Destroyed riparian vegetation on the Ruscova River islet.

Destruction of riparian trees and bush vegetation. The clearing and destruction of riparian and islet vegetation (Fig. 9) can cause a reduction in the abundances of fish species, including the *Thymallus thymallus*, due to alterations in the in-stream microclimate and changes to trophic resources (Curtean-Bănăduc et al., 2014). Where feasible, arboreal and shrubs riparian vegetation must remain undamaged.

Habitat fragmentation/isolation of populations always leads to genetic isolation, reduced gene diversity, inbreeding, and local or regional extinction. Unobstructed upstream and downstream movement, including connectivity of the diverse sub-drainage basins of the Vișeu Basin, is a very critical element for the management of this species.

We propose considering the potential investments situated on the streams and rivers courses carefully, as some developments may weaken or interrupt water course connectivity, not only by making diversified crosswise barriers in the riverbed, but also by diminishing the water flow or draining of some river sectors.

Pollution caused by mining activities. The historical pollution generated by heavy metal mining activities in the Țâșla River basin are not influencing only the Țâșla River habitats and species but also the downstream habitats and species of the upstream Vișeu River. The effect of the meteoric washing waters of the abandoned mine galleries and greened refuse heaps is rated as considerable on the Țâșla River and important on the upstream Vișeu River.

The effects of meteoric waters washing the abandoned mine galleries and rehabilitated refuse heaps can be considerably diminished by isolating/filling the old mine galleries and by insulating (not greening) the refuse heaps from the water courses in the Țâșla River basin.

Combined human impacts affect numerous lotic sectors in the area of interest (Figs. 10 and 11), and consequently the studied fish species in the area compared to its natural potential.

Minimal management elements that should be enforced in the researched area include: development of lotic systems buffer zones; wise management of water use; wise management of sewage and waste water and surface water pollution; adapt to the local conditions of the hydroenergetic use of streams and rivers; enforcement of integrated water management at the Vișeu Watershed level; create ecological networks; streams and rivers connectivity restoration; back specific high scientific quality assessments and monitoring and basin integrated management oriented research.

Organic pollution is an old persistent problem, where sewage and wastewater treatment is simultaneously connected with the farm activities, in the majority of the Vișeu Basin, principally on the Vișeu River (Curtean-Bănduc, 2008), which is a lasting stress source for fish populations. Complete sewage systems must be created in the Vișeu Watershed and the wastewaters of all the localities alongside the main water courses must be properly treated.

Displacement of fish washed away during flood periods in the human uniformized lotic sectors. In the lotic sectors uniformized by humans, fish are washed away in flood periods. In these sectors shelters should be created with a maximum high of 15 cm.

A **diet overlapping** among *Thymallus thymallus* and *Salmo trutta* (Kruzhylina and Didenko, 2011) can be another local pressure on the European Grayling populations, but such studies in the research area are still needed.

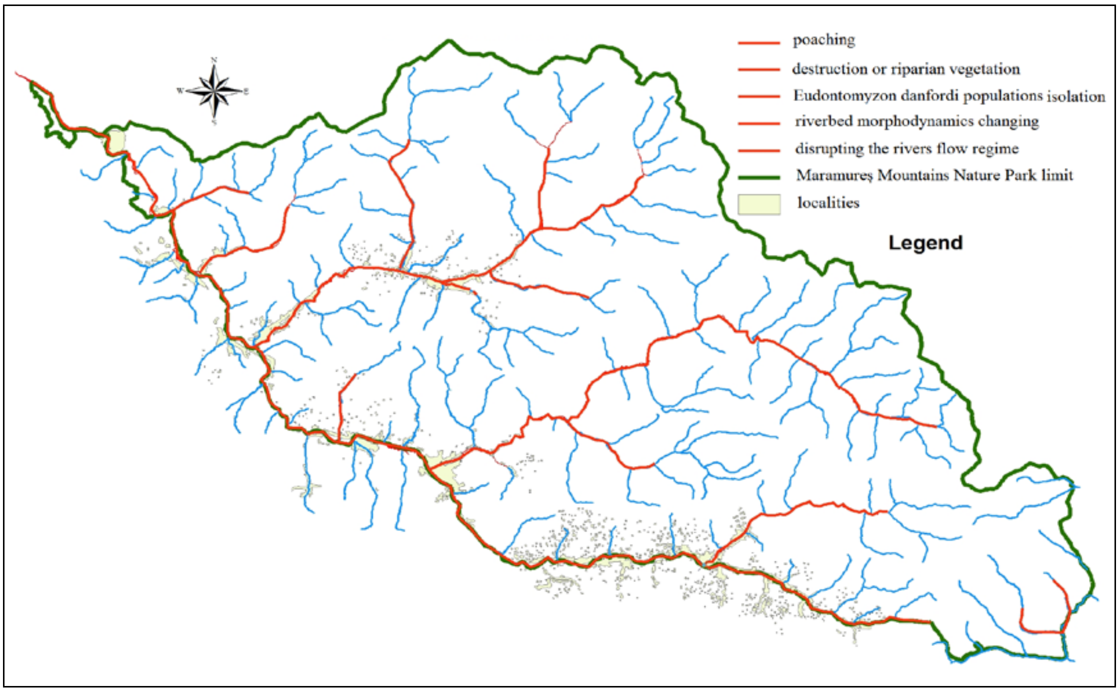

Figure 10: Diagnosed mixed pressures and threats for *Thymallus thymallus* in the studied area (GIS support – Danci-Kast O.).

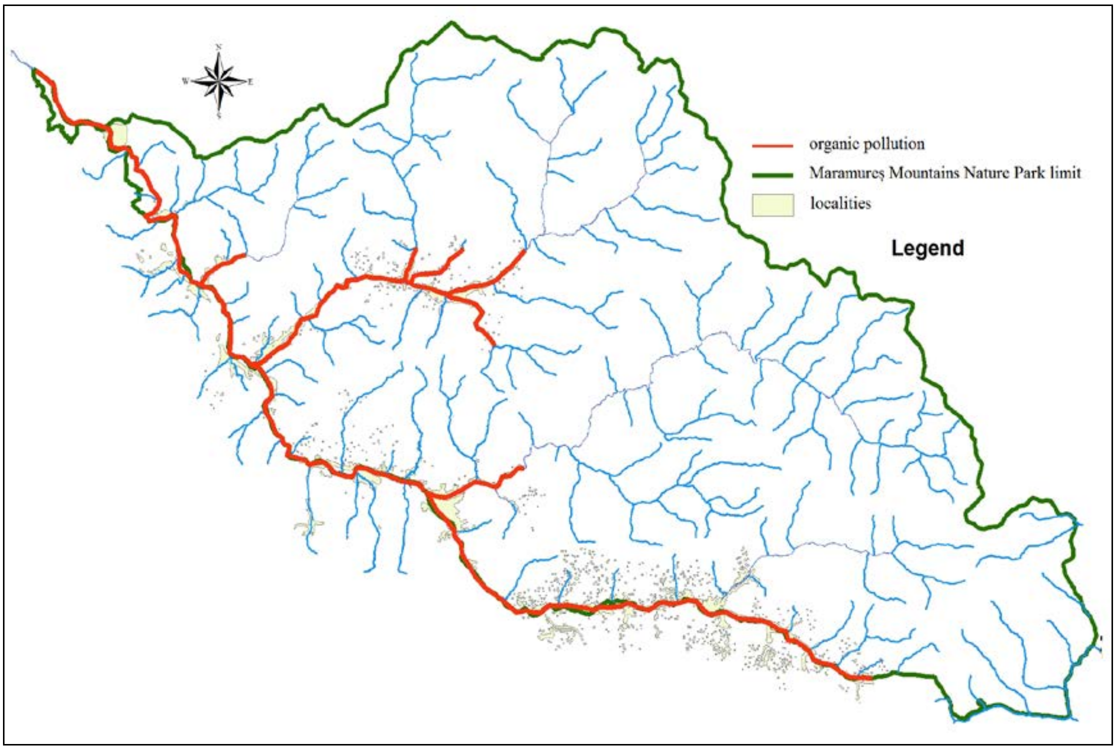

Figure 11: Lotic sectors influenced by organic pollution (GIS support – Danci-Kast O.).

CONCLUSIONS

Thymallus thymallus from the researched area has stable populations but not achieve their natural potential due to anthropic activities, in the following basins: Vișeu – middle and lower sectors, Ruscova – middle and lower, Vaser – middle and lower, Frumușeaua – lower and Bistra – lower. The preferred habitat for this species is large enough within this area to preserve the actual average state of the Grayling studied populations.

Thymallus thymallus can be considered in the present as a relatively rare species in the studied area and there where a specificaly low abundance was registered exist a suplementary limitation on their use for restorative goals.

The conditions of the Vișeu and Frumușeaua lotic systems are the most degraded, and do not meet the habitat quality requirements of *Thymallus thymallus* species.

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