A DECISION-SUPPORT MANAGEMENT SYSTEM DESIGNED FOR *EUDONTOMYZON DANFORDI* REGAN, 1911 POPULATION OF UPPER TÂRNAVA MARE RIVER

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The ADONIS: CE free software has been used for one protected fish species, *Eudontomyzon danfordi* Regan, 1911, to create and adapt an on-site (upper Târnava Mare River) support-system model for local management decision-making. Habitat requirements and indicators of good protection condition have been examined, pressures and threats to these fish species have been identified, and management proposals have been recommended. This adapted management system permits an on-site and species applicable management elements implementation for the local lotic habitats recovery.

Keywords: Carpathian lamprey, habitat requirements, human impact, management, Transylvania, Romania.

INTRODUCTION

The waters of Romanian Carpathians high-medium altitude streams and rivers are generally of excellent to very good and good characteristics where the human impact is not critical (Breabăn & Romanescu, 2014; Romanescu *et al*., 2016).

Nowadays, fish are one of the most worthwhile conservative and economic animal groups which are influenced by both natural conditions and a high number of human activities effects (Lenhardt *et al*., 2016; Radhi *et al*., 2017; Năstase & Oţel, 2017; Khoshnood, 2017; Balasaheb *et al*., 2017; Florea, 2017).

The European Union component states gave their agreement in 1992 for the Habitats Directive, to admit different species of European Community concern to prosper, in compliance with the responsibility to protect the species and habitats belonging to this Directive (Annex 2), by conserving their status (*, 1992).

This aim of this study was to develop a model for a management tool for one of the most valuable conservation fish species of the Târnava Mare upper sector, the Carpathian lamprey. In nature protection, modelling is regularly used to obtain a "general image" of distinctive systems and/or actions within certain areas. The components of the modelling process support discerning distinguishable levels of

species and their habitat management. The use of ADONIS: CE free software, can design models that support a local adapted management structure. The models target three central functional areas, relevant for environment protection: 1) to validate the existing state, 2) to determine the consequences of changing, and 3) to recommend a programme to improve the actual state in a needed way. In the end, different diagrams can be produced to reveal the significant elements of management. (Hall & Harmon, 2005)

MATERIAL AND METHODS

The streams and rivers of the Târnava Mare Watershed occupy the interior area of the Romanian Carpathians. With a watershed of 3,606 km^2 and a length of 221 km (Badea *et al*., 1983), Târnava Mare River is one of the principal rivers of Transylvania.

Eudontomyzon danfordi Regan, 1911 (Fig. 1), is one of the most elusive protected fish species of the Romanian Carpathians; usually specific designed management plans for this species populations are missing, introducing the need for new management elements (Bănăduc, 2011).

Fig.1. *Eudontomyzon danfordi*.

The condition of this fish species population was evaluated based on elements containing: the dimension of fish populations; the dimension of the population distribution in the researched area; the balanced distribution of the sampled individuals in age categories; and maximum and minimum numbers of this fish species in fish communities. The habitat necessities, pressures and threats on *Eudontomyzon danfordi* were researched in relation with their ecological status, the relations among them and the conservation context of this species.

A flexible management model was created to bring together a fitting management plan that would determine the preservation of the researched fish species, with an accent on needed processes. The ADONIS: Community Edition (ADONIS: CE) free software, produced by the Business Object Consulting (BOC) Group, was used in this study. This free software is in an advantageous form of ADONIS with some restrictions (compared to the commercial version). It uses a Business Process Model and Notation (BPMN), a standardized modelling terminology that holds up recognizable processes structure. ADONIS:CE is commonly used as an access point to Business Process Management. These processes can be modelled using compatible notation. (**)

RESULTS AND DISCUSSION

IDENTIFIED HUMAN PRESSURES AND THREATS

In the researched upper Târnava Mare River sector, from its springs area to downstream Zetea Dam lake, based on the Biotic Integrity Index for Carpathian river assessment score values (Bănăduc & Curtean-Bănăduc, 2002) the local Carpathian lamprey ecological state varies significantly, this index scores vary from 45 – excellent (excellent, comparable to pristine conditions, exceptional assemblage of fishes) to 10 – poor (very few species and individuals present, tolerant species dominant).

In the studied area, the following significant pressures and threats on *Eudontomyzon danfordi* were identified, as a cumulative result the local natural fish associations of the trout lower zone and grayling and Mediterranean barbel zone were partially changed or replaced by modified fish association (Bănărescu, 1964; Bănăduc, 2005) condition induced by the human impact. These principal pressures and threats are: the typical habitats change or loss, the lotic system sectors continuum fragmentation provoked by the hydrotechnical works, the disorganized and sometimes lawless stocking and restocking, poaching, the organic pollution of water, the logging of lotic systems riparian trees vegetation, and the expansion of some invasive/more tolerant fish populations (*Squalius cephalius*, *Gobio gobio, Barbus meridionalis*, etc.), species that are not naturally a prey target for *Eudontomyzon danfordi*.

IDENTIFIED SPECIFIC REQUIREMENTS

The researched fish species required: relatively high level of water sectors; relatively variable water flow sectors; relatively fast speed of water flow sectors; relatively moderate to low speed water flow sectors; cold water; oxygenated water; stones/rocky river bed sectors; sandy-muddy river bed sectors; heavy shadowed banks (Bănărescu, 1969).

Last but not least, the lack or low basin lotic systems sectors connectivity, chaotic restocking, poaching and non-native species presence have highly negative importance.

PROPOSED SPECIFIC HABITAT INDICATORS

In the researched mountain river sectors, the principal habitat indicators are recommended in this paper as argumentation for the presence/absence and relative abundance of *Eudontomyzon danfordi*: relatively high level of water (70%); relatively variable water flow (70%); relatively fast speed of water flow (60%); relatively moderate to low speed water flow (40%); cold water (90%); oxygenated water (90%); stones/rocky river bed (70%); sandy-muddy river bed (30%); heavy shadowed banks (90%); lotic systems connectivity (100%); chaotic stocking and restocking (0%); poaching (0%); non-native fish species presence (0%).

MANAGEMENT MEASURES

According with this suggested model we proposed that the most influential management elements are: preservation of the lotic systems natural hydrology, preservation of the natural morphology of the lotic system and its banks; no riverbed mineral exploitation should be allowed in the studied area; preserving the vegetation of the basin on the banks riverine valley slopes; a ban on the disposing of any type of waste in streams and rivers; keeping a permanent high/medium level of the water on river sectors markedly in drought cold and/or warm seasons based on avoidance of high water derivations; decreasing water organic pollution.

All the hydrotechnical works should have species adapted fish pass facilities, stocking and restocking should be rigorously guarded from the scientific point of view, poaching should be banned, and non-native species should be diminished or eradicated through targeted fishing.

ADJUSTED MODEL FOR THE SITE MANAGEMENT

The modeling of the species *Eudontomyzon danfordi* was designed using three processes (Fig. 2): the presentation of the species *Eudontomyzon danfordi* (Fig. 3), the possible habitat indicators (Fig. 4) and the management measures to be taken for the species to ensure its existence (Fig. 5).

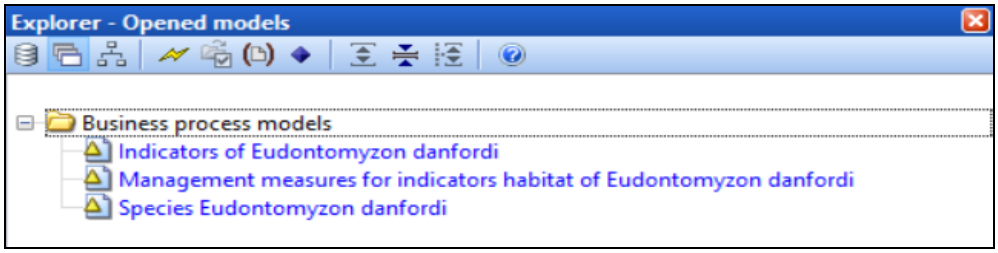

Fig. 2. The processes of *Eudontomyzon danfordi* model.

MODEL DESCRIPTION

The process from which it was started is "Species *Eudontomyzon danfordi*" (Fig. 3), which specifies: habitat type, critical habitat requirements, pressures and threats from people, as well as possible indicators measured and analyzed on the ground (they were modelled as a sub process to understand and visualize them more easily). After the indicators have been completed, a decision is made to check whether the indicators ensure the favorable conservation status of the species. If it is fulfilled, the Yes branch of the decision (variable: Favorable_conservation_state='YES', probability: 0.15%) then follows the activity "Human pressures and threats" and the process is closing. If the conservation status is not favorable, the No branch (variable: Favorable_conservation_state='NO', probability: 0.85%), then return to the activity "Specific requirements" and once again go through the "Indicators of *Eudontomyzon danfordi*" subprocess.

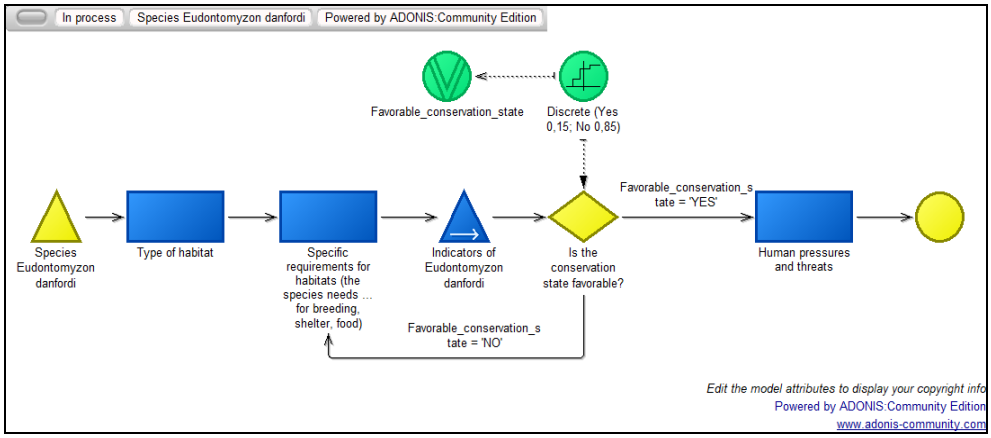

Fig. 3. *Eudontomyzon danfordi* species – basic process.

The "Indicators of *Eudontomyzon danfordi*" sub process (Fig. 4) goes through all the indicators outlined above and highlights through decisions the likelihood that

they will meet the favorable conservation status of the *Eudontomyzon danfordi* species. The percentage was determined by field measurements, comparing the current state with favorable conservation status. If we go through all the decisions on the "YES" branch (selection of variables: probability: probability:

High_level_of_water='YES',	probability:	0.71%;
Natural_relatively_cool_water='YES',	probability:	0.66%;
Stones_rocky_river_bed='YES',	probability:	0.85%;
Sandy_mud_river_bed='YES',	probability:	0.99%;
Heavy_shadowed_banks='YES',	probability:	0.55%;
Lotic_systems_connectivity='YES',	probability:	0.02%;
Non_native_fish_species='YES',	probability:	0.50%)

then the species is in a favorable conservation status and the process ends with the "Implementation of an integrated monitoring system" activity.

If the indicators do not fulfill the favorable conservation status, the branch of "NO" (variables:

High_level_of_water='NO',	probability:	0.29%;
Natural_relatively_variable_water_flow=' NO',	probability:	0.29%;
Natural_relatively_fast_speed_water_flow=' NO',	probability:	0.15%;
Natural_relatively_moderate_to_low_speed_water_flow=' NO',	probability:	0.25%;
Natural_relatively_cool_water=' NO',	probability:	0.34%;
Natural_relatively_oxygenated_water=' NO',	probability:	0.34%;
Stones_rocky_river_bed=' NO',	probability:	0.15%;
Sandy_mud_river_bed=' NO',	probability:	0.01%;
Heavy_shadowed_banks=' NO',	probability:	0.45%;
Lotic_systems_connectivity=' NO',	probability:	0.98%;
Chaotic_restocking=' NO',	probability:	1%;
Poaching=' NO',	probability:	1%;
Non_native_fish_species=' NO',	probability:	0.50%),

then the "Management measures" subprocess (Fig. 5) is called, after which it returns to check the indicator, forming a loop. It can only come out of the loop when that indicator ensures the conservation status of the species.

The last subprocess (Fig. 5) is structured using ten activities presenting the management measures that should be considered for the welfare of the *Eudontomyzon danfordi* species. These have been outlined above.

Concluding, the model of *Eudontomyzon danfordi* species provides the presentation of the species characteristics, the visualization of the collected data, shows the possible habitat indicators and their percentage, as well as the management measures that should be taken into account for species preservation. An overview of the model can be seen in Fig. 6.

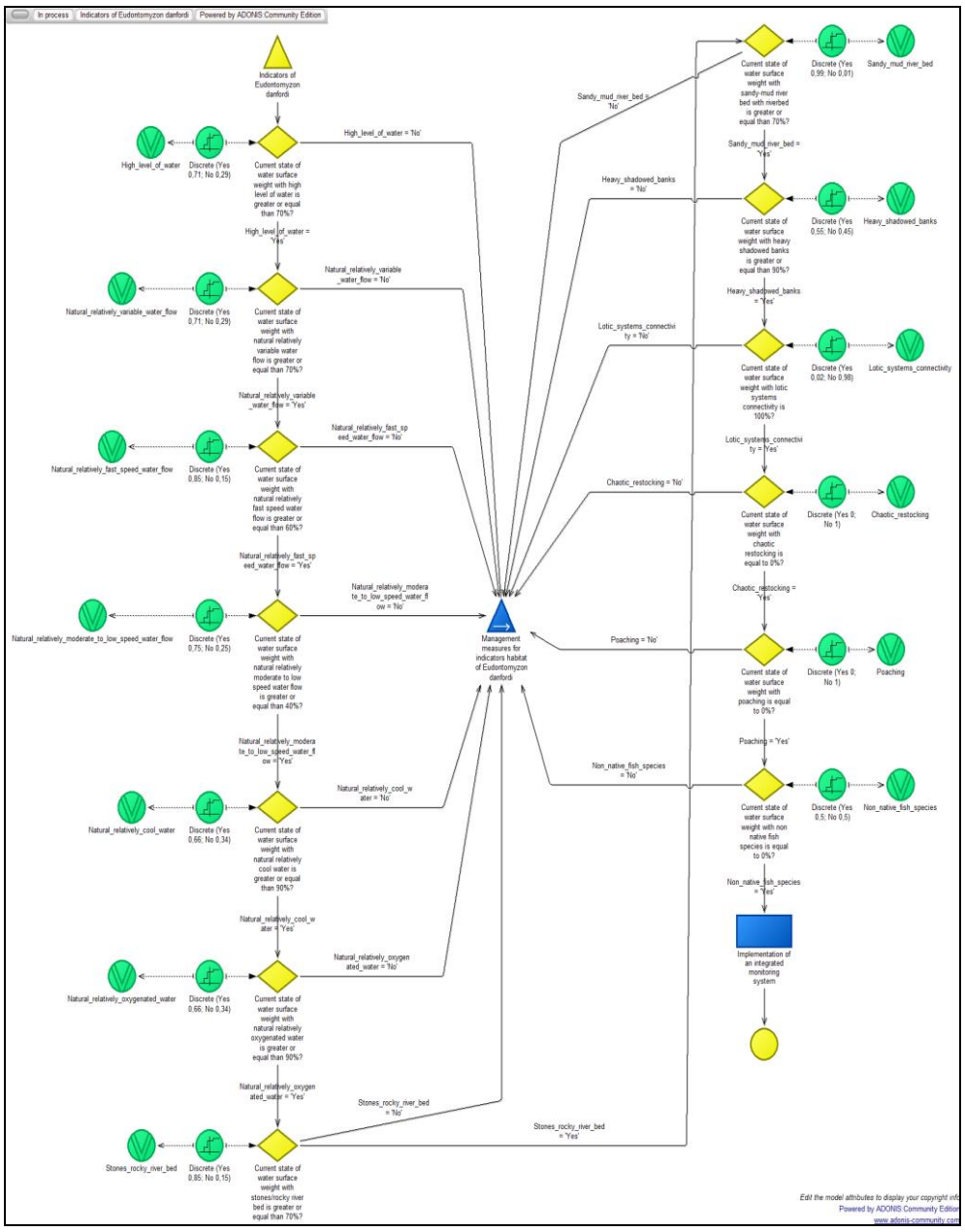

Fig. 4. Critical requirements
for *Eudontomyzon danfordi* species – subprocess.

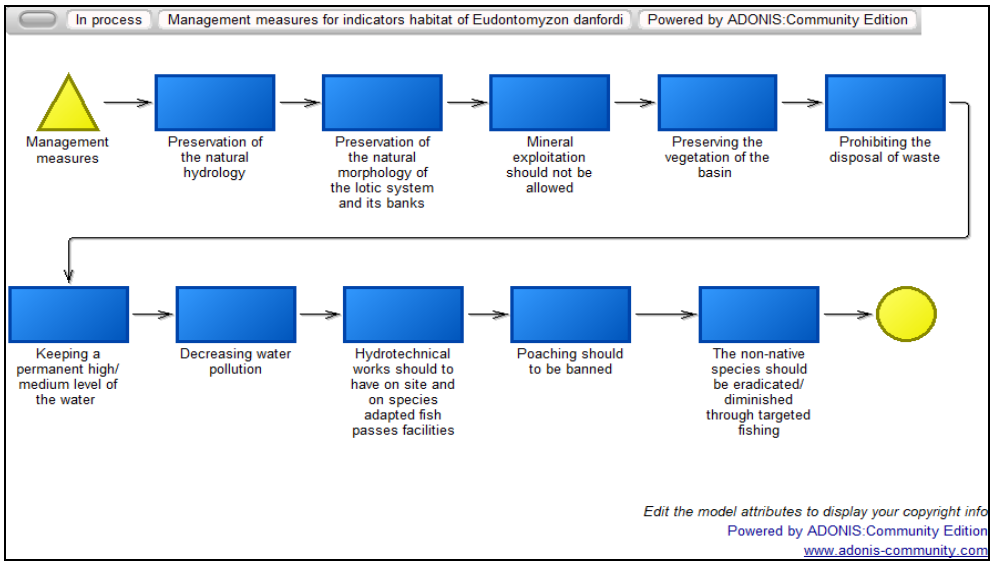

Fig. 5. Management measures for indicators of *Eudontomyzon danfordi* – subprocess.

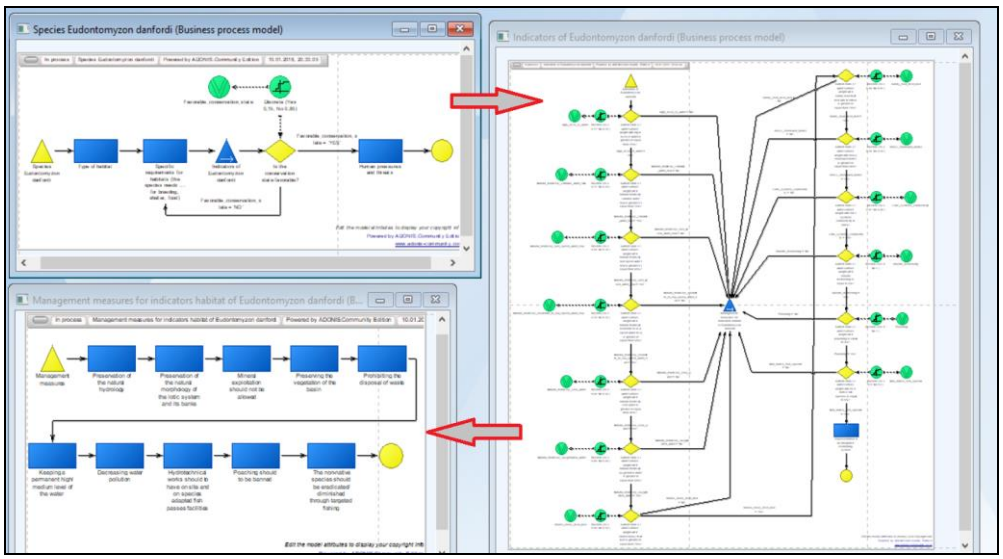

Fig. 6. Overview of *Eudontomyzon danfordi* model.

CONCLUSIONS

The preeminent pinpointed pressures and threats on *Eudontomyzon danfordi* researched populations ecological status in upper Târnava Mare River are change or loss of typical habitats, lotic system sectors continuum fragmentation, fish stocking and restocking, poaching, pollution, logging, and invasive/more tolerant fish species.

Necessary management measures for *Eudontomyzon danfordi* are: preservation of the natural hydrology and geomorphology; no riverbed mineral exploitations; vegetation protection; a ban on the disposing of any type of waste in streams and rivers; keeping a permanent high/medium level of the water on river sectors; decreasing water pollution. All the hydro technical works should be adapted with local fish fauna passes upstream and downstream; stocking and restocking should be rigorously scientifically supervised, poaching should be banned, and the non-native species should be diminished by targeted fishing.

The ADONIS: CE software was used in this research to design a management model for *Eudontomyzon danfordi*, a valuable fish species from conservation point of view. This management model contains the main requirements for lotic habitat, and the indicators that highlight good ecological conditions – the management measures, and the threats and pressures which influence this fish species. We advocate that this management instrument be used to design a much complex management model for all the fish fauna in the region.

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*** http://ec.europa.eu/environment/water/water-framework/index_en.html
*** http://www.boc-group.com/products/adonis/bpmn-method/

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