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The fluvial functioning index: an ecological assessment applied for river restoration

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ABSTRACT: The Fluvial Functional Index (FFI) is a method that allows the collection of information about the main ecological characteristics of watercourses, and is able to find functional aspects and interrelations between eco-topes. Through the description of morphological, structural and biotic parameters of the fluvial ecosystem, it is possible to determine the associated functionality of the river. The method gives completely different information from other methodologies that are applied using i.e. biotic indices, chemical and microbiological analysis etc.).

The IFF has been applied by the ecologists of the Environment Agency on the main rivers of the Province of Trento. The results had been used for the new Provincial Plan for Water Resources Utilisation.

The process of data collection and analysis leads from ecological assessment to water course restoration planning. Application of the FFI of the main provincial rivers has resulted in a map identifying three different ecological river types:

1. “adequate ecological quality”: zones with high value which are defined by an ecological discontinuity or by a no-fluvial influence distance.

2. “ecological altered strips”: 30 meters wide along the river with restoration possibility

3 “high urbanised strips” compromised and almost impossible to restore.

KEYWORDS: River ecology, river restoration, river assessment, water management

1 Introduction

An integrated approach for sustainable use and protection of water resources is a key element of effective water policies including those set out by theEC Water Framework Directive 2000/60 (1).

A holistic and integrated vision of the river environment is also crucial to successful river restoration (2). The Fluvial Functional Index (FFI) is a tool that can aid an integrated assessment of the rivers is, and is now largely applied in Italy. This paper aims to give on overview of the FFI and its possible application for the river restoration purposes.

2 The fluvial functional index

2.1 Brief history

The FFI is a further development of the Riparian and Environmental Inventory (RCE) 1 and -2 (3), created by Peterson from the Institute of Limnology at Lund University (4). RCE-I was initially created for collecting information about the sides and banks of

rivers. After many field applications, it was recognised that this method could be adjusted to evaluate the whole river ecosystem quality.

Building on the RCE method, the FFI method was developed. The first FFI manual was issued in 2000 by the National Environmental Protection Agency and widely disseminated in Italy through training courses organised by the Provincial Protection Agency of Trento (North of Italy) (3).

2.2 The method principles

The FFI method allows the collection of information about the main ecological characteristics of the water course and captures co-functional aspects and interrelations between eco-topes within en eco-mosaic.

The FFI assesses the most important ecological characteristics of the river. This evaluation is carried out by identifying river stretches in the field that can be considered homogeneous. For each stretch a FFI form, which is divided in 14 questions, is filled in (tab. 1a and 1b). There are 4 possible responses to each and for each answer there is a fixed score.

There is a progression apparent in the sequence of the questions. The first four concern the bank vegetation, the extent of the riparian area and the land use pressure. The next two questions refer to the physical and morphological structure of the banks, due to the importance of the role that these have for the conservation of the water quality characteristics.

Questions 7 to 11 are about the structure of the river bed, identification of the features related to the capacity of the river to be self-purification). These five questions facilitate the comprehension of the characteristics that influence the biological composition of a particular habitat; identify the elements which characterize the static and dynamic morphology of the ecosystem (e.g. the succession of meanders**,** riffles, pools; presence of back waters**,** point bars, islands, bank features; the nature and size of non-living particles; (granulometry of a different nature and size); depositing and erosion processes).

The last three questions evaluate some key biological characteristics of the river ecosystem: periphyton, macrophytes and macrobenthos, and the state of the coarse particulate organic matter. This, normally called CPOM, is considered to be the energy input contributing to the trophic web of the ecosystem. The fact that there only two questions reserved forthe biotic aspect should not be taken as an underestimate of its importance, but rather as the balancing of the information contributing towards the assessment of the quality of the whole aquatic ecosystem and its surroundings.

2.3 Functioning level calculation

The final score, called FFI value, is the sum of the answer scores, and classifies river stretches surveyed into in 5 levels of functionality. Level 1 is the best and Level 5 the worst situation. There are also boundary levels (i.e. Level 3-4). The conversion table from FFI value to functionality level is shown in the following table (tab 2).

Tab 1 Conversion table for the fluvial functioning levels

LEVEL	SCORE	JUDGEMENT	COLOUR
I	261-300	excellent	
I-II	251-260	excellent-good	
II	201-250	good	
II-III	181-200	good-fair	
III	121-180	fair	
III-IV	101-120	fair-poor	
IV	61-100	poor	
IV-V	51-60	poor-very poor	
V	14-50	very poor	

FFI FORM

Basin…….Stream name……..

Location……..

Stretch (metres)…….. width (metres)…… altitude……

date ……record no…… photo no……

code……..

Tab 1a: The FFI form, question 1 to 6

Bank	Left		Right
1) Land use pattern of the surrounding area			
Undisturbed forests, woods and/or natural wetlands	**25**		**25**
Meadows, pasture, woods, a few areas of arable and uncultivated land	**20**		**20**
Mainly seasonal cultivation and/or mixed arable and/or permanent cultivation	**5**		**5**
Urbanised area	**1**		**1**
2) Vegetation of primary perifluvial zone (fluvial zone around watercourse)			
Arboreal riparian formations	**30**		**30**
Shrub riparian formations (shrubby willow thicket) and/or reeds	**25**		**25**
Non-riparian arboreal formations	**10**		**10**
Made up of non-riparian or herbaceous or absent shrub species	**1**		**1**
2b) Vegetation of secondary perifluvial zone			
Arboreal riparian formations	**20**		**20**
Shrub riparian formations (shrubby willow thicket) and/or reeds	**15**		**15**
Non-riparian arboreal formations	**5**		**5**
Made up of non-riparian or herbaceous or absent shrub species	**1**		**1**
3) .Extention of the perifluvial vegetation zone			
Perifluvial vegetation zone >30 m	**20**		**20**
Perifluvial vegetation zone 5-30 m	**10**		**10**
Perifluvial vegetation zone1-5 m	**5**		**5**
Perifluvial vegetation zone absent	**1**		**1**
4) Continuity of the perifluvial vegetation zone			
Continuous perifluvial vegetation without gap	**20**		**20**
Perifluvial vegetation zone with gap in vegetation	**10**		**10**
Frequent gaps or only continuous and consolidated herbaceous vegetation	**5**		**5**
Soil without or with thin herbaceous vegetation	**1**		**1**
5) Water conditions of the river bed			
Width of the annual peak flow bed less than three times than the wet river bed		**20**	
Annual peak flow bed more than three times than the wet river bed with discharge fluctuations with seasonal variation		**15**	
Annual peak flow bed more than three times that of the wet river bed with discharge fluctuations with frequent variation		**5**	
Wet river bed non-existent or almost non-existent or presence of impermeabilisation of the river bed		**1**	
6) **Stream bank structure**			
Bank with arboreal vegetation and/or stones	**25**		**25**
Bank with grass and shrubs	**15**		**15**
Bank with a fine grassy layer	**5**		**5**
Bare banks	**1**		**1**

Tab 1b: The FFI form, question 7 to 14

7) Retention structures of trophic matter			
River bed with large boulders and/or old trunks firmly embanked or presence of reeds or hydrophyte strips	**25**		**25**
Boulders, cobbles and/or branches present with depositing of sediment or scarce and not extensive reeds or hydrophyte	**15**		**15**
Retention structures free and mobile during flooding or absence of reeds	**5**		**5**
River bed with sandy sediment without algae or smooth artificial profile with uniform current	**1**		**1**
8) Erosion			
Little evident and not important	**20**		**20**
Only at bends and/or narrow passages	**15**		**15**
Frequent with cutting of the banks and of roots	**5**		**5**
Very evident with undercutting of banks and landslips or presence of artificial intervention	**1**		**1**
9) Cross-section			
Natural		**15**	
Natural with some artificial intervention		**10**	
Artificial with some natural elements		**5**	
Artificial		**1**	
10) Stream bottom			
Diversified and stable		**25**	
Movable in stretches		**15**	
Easily moveable		**5**	
Cemented		**1**	
11) Riffles, pools or meanders			
Clearly distinguished and recurrent		**25**	
Present at different distances and at irregular intervals		**20**	
Long pools which separate short riffles or vice versa, few meanders		**5**	
Meanders, riffles and pools absent, straightened path		**1**	
12) Vegetation in the wet river bed			
Periphyton only noticeable on touching and/or low covering of macrophytes		**15**	
Periphyton visible and/or small covering of macrophytes		**10**	
Periphytion fair, presence of filamentous algae and/or monotonous macrophytes		**5**	
Periphyton thick and/or macrophytes relatively unvaried		**1**	
13) Detritus			
Presence of leaves and woods, vegetable fragments recognisable and fibrous		**15**	
Leaves and woods scarce, vegetable fragments fibrous and pulpy		**10**	
Pulpy fragments		**5**	
Anaerobic detritus		**1**	
14) Macrobenthonic community			
Well structured and diversified, appropriate to the fluvial type		**20**	
Sufficiently diversified but with altered structure as compared to that expected		**10**	
Poorly balance and diversified with a prevalence of taxa tolerant of pollution		**5**	
Absence of a structured community, presence of a few taxa all relatively tolerant of pollution		**1**	
Total Score			
Fluvial Functioning Level			

2.4 The FFI mapping

The FFI results are mapped in order to view directly the functionality level of each river stretch. An example is given in figure 1.

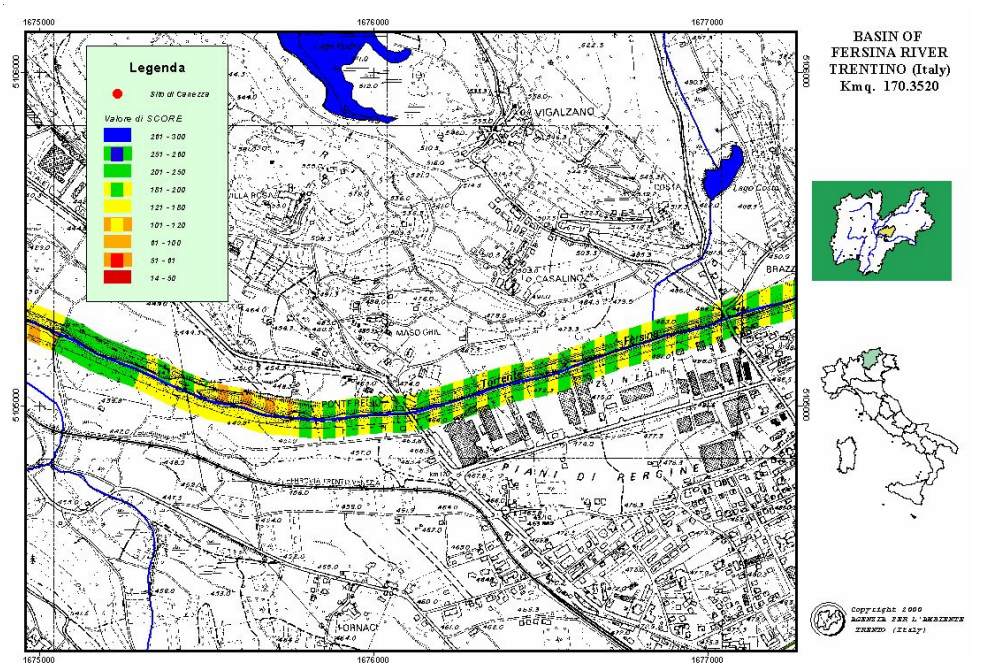


Fig. 1 An example of the FFI applied to the River Fersina in Trentino (North of Italy). The different colours show different functional levels.

3 FFI and river restoration: a practical example

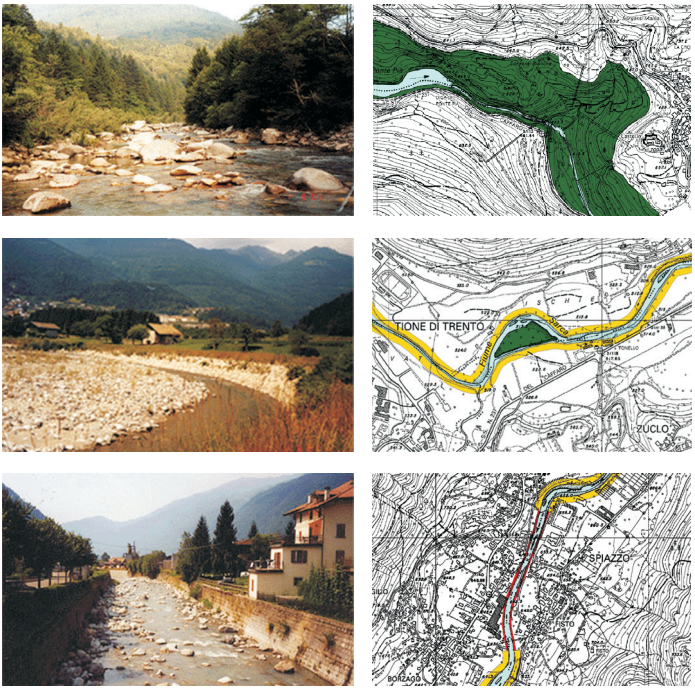
The FFI has been applied by the ecologists of the Environment Agency on the main rivers of the Province of Trento. The final results and maps had been used by an inter-disciplinary team to draw up the new draft Provincial Plan for Water Resources Utilisation, which is now under approval. This plan will effect the water management of the entire province for the next years (how many)including also opportunities to restore rivers and their flood plains.

Through the FFI different functional zones along the main provincial rivers had been identified. This zoning process was based on field data and lead from a simple ecological assessment to integrated water course planning. The result was a final document which includes a map that identifies three different river area types with different restoration potential (Fig 2):

3. "adequate ecological quality": zones with high ecological value which don't need specific restoration actions. These areas, identified by an ecological discontinuity or by a no-fluvial influence distance, must be preserved and protected.
4. "ecologically altered strips": 30 meters wide strips along the river with restoration possibility. In these areas further new urban and agricultural development schemes

will not foreseen. The strips guarantee an adequate space for restoring the river and the floodplain. This is also very important for flood protection in order to maintain an area where the rivers can expand freely in high flows.

5. "highly urbanised strips": these are severely compromised and almost impossible to restore. In there strips restoration opportunities are greatly reduced.



"adequate ecological quality": polygons defined by an ecological discontinuity or by a no-fluvial influence distance. This areas will be protected by further human intervention

"ecological altered strips" (yellow line) with restoration possibility, 30 meters wide

"high urbanised strips" (red line) compromised and almost impossible to restore

Fig 2: Examples of the potential restoration areas derived using the Fluvial Functional Index

4 Conclusion

From the experience gained in Italy, the FFI method can be a useful tool for targeting river restoration schemes as it :

- is able to identify the most fragile or altered features of the river ecosystem.
- can be a valid way to identifying the most suitable areas for river restoration
- can be use to assess pre-scheme river restoration state and to forecast possible post scheme scenarios, verifying how the fluvial functional index can change according the objectives of the project

The FFI has also the advantage of being a rapid and low cost method. The estimated cost for 1 km of FFI is about 250 euros. The FFI method, proposed by National Environmental Protection Agency of Italy, is indicated as best practice by WFD Common Implementation Strategy- Working Group 2.7. It appears in Annex III (Summary of factsheets on current monitoring) of the final draft of Guidance on Monitoring for the Water Framework Directive (15th november 2002).

The FFI manual (in Italian) is downloadable for free at: http://www.provincia.tn.it/appa/Pubblica/FrPubbl.htm

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