Landscape planning and biodiversity conservation of river habitats require vegetation analysis and mapping: the case of Cilento National Park (Italy)

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Abstract: - Riparian and freshwater ecosystems are strongly endangered throughout Europe as they suffer the ongoing human pressure, habitat destruction, pollution and eutrophication. Monitoring species and habitats is essential to address conservation efforts and to evaluate the results of restoration actions. In this context we present the main results of a two-year (2010-2011) research project funded by the Cilento and Vallo di Diano National Park, focused on riparian habitat and vegetation mapping. Vegetation Mapping was performed within a 300 m width buffer along the main water bodies of the National Park; it was based on 2005 digital aero-images and GIS assisted; field surveys were stratified on water bodies, environmental unit and vegetation physiognomy and recorded using GPS with 2-5 m precision. We collected 273 relevès and detected 748 taxa of vascular plants (approx.1/3 of the overall regional flora) with several new findings for Cilento and Campania Region. A not negligible amount of these are alien species showing an invasive behavior in riparian habitats. 27 Natura 2000 habitats were identified accounting to 45% of the mapped area. The project results could contribute to assess the reference conditions of Southern Italian Peninsula water bodies to answer to the European Water Framework Directive (WFD 2000/60 CE). Furthermore they represent a first step of monitoring actions of species and riparian plant communities of the National Park that are essentials to address conservation efforts and to evaluate the results of management and restoration policies, as explicitly requested by art. 11 of Habitats Directive.

Key-Words: Habitat Directive, phytosociology, river ecology, vegetation mapping

1 Introduction

Freshwater ecosystems cover about only 0,8% of the Earth's surface, nevertheless, approximately 6% of all species lives in these systems. Despite they provide a large amount of services and goods [1], freshwater ecosystems are strongly endangered [2,3] due to the ongoing human pressure, as pollution, eutrophication and habitat depletion [4,5].
Thus, in the European Union, several freshwater habitats are included in the Habitat Directive (92/43 CEE Annex 1) and protected as Sites of Conservation Interest (SCI) within the Nature 2000 network. In order to supervise habitats subjected to environmental changes, monitoring actions of species and plant communities are essential to address conservation efforts and to evaluate the results of restoration policies [6], as explicitly requested by art. 11 of Habitats Directive. Furthermore, all European countries should assess the ecological status of their inland water bodies according to the European Water Framework Directive (WFD 2000/60 CE).
In this context, species and plant communities should be used as biological indicators of habitat conservation status, as a matter of fact that anthropogenic factors influence the structure, composition and vegetation pattern of the river ecosystems.

2 Problem Formulation

The plant communities that grow along rivers are closely related to abiotic processes and there are dynamic relations between physical process, fluvial forms and biotic structures. Understanding these associations is crucial for scientific aims and for practical management of riverine environments. Thus, for a reliable evaluation of the conservation status of such habitats we have to disentangle the variance in species assemblage and communities structure due to either environmental factors or habitat degradation.

In the Southern Italian peninsula, despite the importance of an appropriate knowledge about freshwater ecosystems, it is crucial to implement the effectiveness of conservation policies, the data regarding riverine flora and vegetation is scanty, and appropriate monitoring programs on freshwater ecosystems are still lacking [7,8]. In particular, in the Cilento National Park there are not specific studies about vegetation ecology and assessment of river habitats. In this context we present the main results of a two-year (2010-2011) research project, funded by the Cilento e Vallo di Diano National Park, focused on riverine habitats. In this project, we performed a phytosociological analysis and ecological characterization of riparian and aquatic vegetation and a detailed habitat and vegetation mapping followed by a land quality assessment.

3 Problem Solution

3.1 Study area

The Cilento and Vallo di Diano National Park (Campania, southern Apennine) is one of the widest Italian National Park, stretching between 40°00′ and 40°30′N and 14°50′ and 15°0′E (Fig. 1), with a total area of 178,172 ha (EUAP 2003), reaching with its buffer zone about 300,000 ha (Fig. 2) .

Altitudes range from sea level to Mt. Cervati (1898 m). Two bioclimatic zones are present: the Mediterranean along the coast and hills and the temperate zones prevailing in the mountain and inner areas. Precipitations vary from 730 to 1700 mm year^{-1}, depending on altitude, with a peak in winter and a period of aridity in summer. The geological nature of the rocks is dominated by limestone and silicoclastic substrata of "Flysch of the Cilento", wherein the main river basins (Alento, Calore, Mingardo, Bussento) are established. Olive orchards and sclerophyllous mediterranean vegetation prevail along the coast, whereas forest landscape is dominant in the inner area (mainly

Figure 1: location of the Cilento and Vallo di Diano National Park in Italy

represented by *Quercus cerris* or *Fagus sylvatica* woods) with a not negligible amount of riparian forest dominated by *Salix alba*, *Populus nigra*, *P. alba* and *Alnus glutinosa*. An analysis of some aspects of Cilento's vegetation can be found for example in [9,10,11,12].

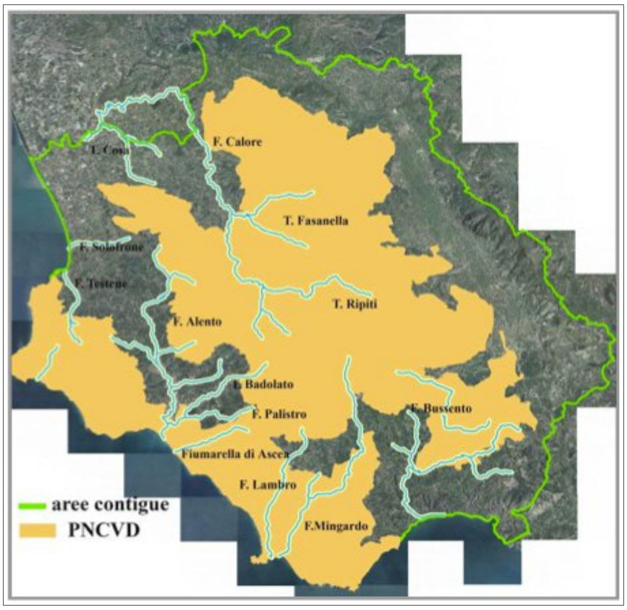

Figure 2: The main rivers of the Cilento and Vallo di Diano National Park (PNCVD) and its contiguous areas extension (green line)

3.2 Data and Methods

Vegetation Mapping was performed, within a 300 m width buffer from the river banks, along the main water bodies of the Cilento National Park; contiguous areas were also considered. Main water bodies surveyed and mapped in this study were: Calore, Alento, Lambro, Mingardo and Bussento river (Fig. 2). Photointepretation was based on 2005 digital aero-images of Campania Region and GIS assisted (Fig. 3); minimum mapping unit was set at 0,5 ha. Map legend has a hierarchical structure that complies with the framework defined in the European CORINE Land Cover project.

Vegetation survey was performed using plot based relevès, collected according to Braun-Blanquet method [13] and was stratified on water bodies, environmental unit [14] and vegetation physiognomy. Each plot was localized using GPS, with 2-5 m accuracy.

Vascular plants nomenclature follows Conti et al. [15] except for some taxa (e.g. *Quercus*, *Pyrus*) that are according to Pignatti [16]. Life forms and chorological categories for plant species were derived from Pignatti (1982). Alien taxa status (except *P. orientalis*) referred to Celesti et al. [17].

Species composition and relative abundances were analyzed using JUICE program [18]. Cluster analysis was performed using the modified TWINSPAN procedure [19] and 'Total Inertia' as a measure of cluster heterogeneity. Ordinations were performed using a Non-metric Multidimensional Scaling (NMDS) and Bray-Curtis similarity to reveal the main pattern of ecological variation within the identified plant communities. The syntaxonomical classification of homogenous groups of relevès was performed up to association level. Nomenclature of syntaxa was in accord with the International Code of Phytosociological Nomenclature [20], whereas phytosociological terms agree with Poldini & Sburlino [21]. Species to syntaxa attribution and vegetation classification of higher syntaxa accord to Rivas-Martinez et al. [22] and more recent specific literature, e.g. [23,24,25]. Correspondence between syntaxa and Habitats (UE Directive 92/43, European Commission, 2007) refers to Biondi et al. [26]. Due to the higher level of resolution of phytosociological plant communities classification at the association level, the Habitats Map was derived from the Map of Vegetation.

To assess the ecological and conservation value of the riparian plant communities we calculated at plot level several indicators: species richness, evenness, number of species of conservation concern, number of alien species, distance from potential natural vegetation (PNV) [27]. The use of these indicators complies the approach used for the ecological and environmental evaluation of habitat quality in the framework of Natura 2000 network, e.g. [28,29].

At landscape level, these indicators were used to calculate a synthetic index of quality (naturalness) for each detected plant community.

To assess the landscape conservation status, we grouped vegetation map categories into seven environmental quality categories defined according to a decreasing human impact to vegetation structure and composition. The seven categories are ordered on a scale ranging from 1 to 7, where 1 corresponds to the lowest environmental quality and 7 to the highest. We summarized the information on quality using the index of landscape conservation (ILC) [30,31]. The index varies between 0 (high level of human impact) and 1 (high level of naturalness).

Figure 3: Example of buffer area (300 m width) along the Alento river, with releves location, for vegetation mapping

3.3 Results

We collected 273 relevès (Fig. 4) and detected 748 taxa of vascular plants (approx. 1/3 of the regional flora) with several new findings for the Cilento and Campania Region and a not negligible amount of these are alien species (e.g. *Tradescantia fluminensis, Ipomoea indica, Araujia sericifera, Abutilon teophrasti*) showing an invasive behaviour in riparian habitats [32].

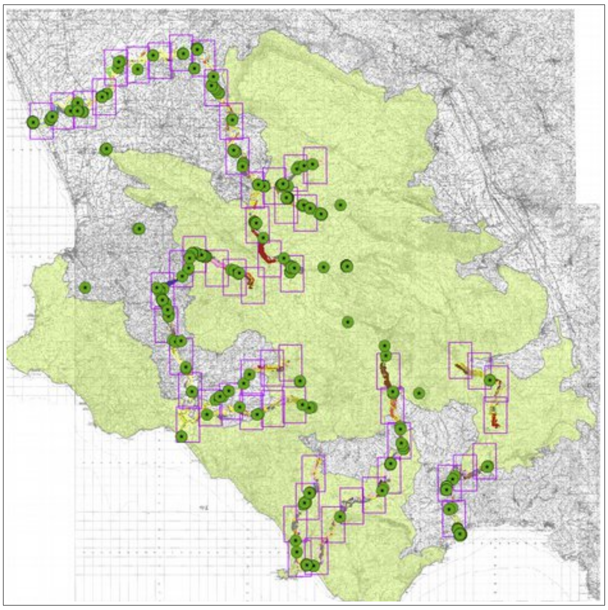

Figure 4: location of the 273 phytosociological relevès (green circle) collected in this project along the river basins of the Cilento (National Park area in light green).

We mapped at 1:5,000 scale, nine water bodies (Calore, Fasanella, Ripiti, Alento, Badolato, Palistro, Lambro, Mingardo and Bussento river) amounting to 13,835 ha. Map legend has a hierarchical framework and is composed of 70 items, integrated up to the fifth level, within the CORINE Land cover framework, that has defined the first three levels. Vegetation mapping was supported by interpretation of digital orthoimages and about 1,500 ground control points, each one georeferenced with GPS.
Main riparian forest types were identified as belonging to *Roso sempervirenti-Populetum nigrae*, *Populetum albae, Hyperico hircini-Alnetum glutinosae* and *Rubo ulmifolii-Salicetum albae*. Land use is dominated by agriculture, with arable land, olive orchards and complex agricultural areas that amount about to 34%. (Fig. 6)

27 habitats *sensu* Natura2000 were identified accounting to 45% of the mapped area; the most widespread riparian habitats are represented by 92A0 *Salix alba* and *Populus alba* galleries, 3270 Rivers with muddy banks with *Chenopodion rubri* p.p. and *Bidention* p.p. Vegetation; 3250 Constantly flowing Mediterranean rivers with Glaucium flavum types. A large amount of river bank are occupied by degraded aspects of habitat 92A0, in particular along the river, where the floodplain agricultural areas prevail (Table 1).

The indices of naturalness of riparian woodlands showed that *Salix alba*/*Populus spp* stands have the lower number of characteristic species of riparian forests, the higher number of aliens, nitrophilous and ruderal species and the lower mean values of richness and evenness. The highest ecological conservation values was detected within the montane *Alnus glutinosa* community (cfr. *Euphorbio corallioides-Alnetum glutinosae*).

At landscape level, the most widespread quality classes (Fig. 6) were 6 (high) and 4 (medium) with only 4.6 percent of the study area that showed the lower value (1-2) of quality (Table 2). However, there are huge variations between the analyzed rivers and between river segments within or outside the National Park boundaries (Fig. 7). For example, in the Calore basin we calculated that the Index of Landscape Conservation (ILC), for the river segments within the National Park, is about double than the value outside the Protected area.

Table 2: percentage of quality class extension

QUALITY CLASS		%
1	very low	3.16
2	low	1.53
3	medium-low	19.63
4	medium	23.67
5	medium-high	6.06
6	high	28.58
7	very high	17.37

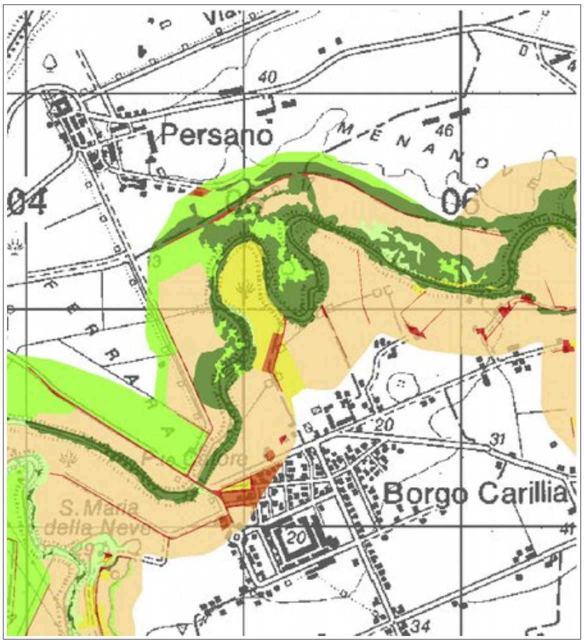

Figure 5: Example of Land quality map of Calore river. Quality legend: red=very low; orange=low; light orange=medium low; yellow=medium; light green= medium high; green=high.

4 Conclusion

The riverine vegetation plays an essential role for the hydraulic and geomorphological features of a river as well as for biodiversity conservation. It also contribute to purifying water courses from pollutions and reduce river banks erosion. In fact, they can be considered as good ecological indicators, because plant communities structure and species assemblages well respond to bioclimate parameters, geomorphological features and anthropogenic factors of a river course.

The project results contribute to assess the reference conditions of Southern Italian Peninsula water bodies, a necessary data to answer to the European Water Framework Directive (WFD 2000/60 CE).

In particular, the vegetation plots of a Potential Natural Vegetation type (e.g. *Hyperico hircini-Alnetum glutinosae*) with the highest value of the index of naturalness should be considered as the “reference” for this specific riverine environment. Furthermore, the data collected in this study represents a first step to monitoring species and plant riparian communities in the Cilento National Park. This action is considered indispensable to address conservation efforts and to evaluate the results of management and restoration policies as explicitly requested by art. 11 of Habitats Directive.

In particular, should be defined specific programs of ecological restoration, aimed at the restoration of riparian plant communities in those sectors with lower environmental quality index (e.g. in the river sectors outside the protected areas). In this way it is also possible to increase the role of ecological corridor of river courses in the landscape.

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Table 1: percentage of overall habitats extension within the study area.

HABITAT N2000	**%**
Riverine habitats	
92A0: Salix alba and Populus alba galleries	4.9
3270: Rivers with muddy banks with Chenopodion rubri p.p. and Bidention p.p. vegetation	1.7
92A0: Salix alba and Populus alba galleries (fragments)	1.6
3250: Constantly flowing Mediterranean rivers with Glaucium flavum	1.5
91E0: Alluvial forests with Alnus glutinosa and Fraxinus excelsior (Alno-Padion, Alnion incanae, Salicion albae)	1.4
6430: Mediterranean tall humid herb grasslands of the Molinio-Holoschoenion (fragments)	0.6
92C0: Platanus orientalis and Liquidambar orientalis woods (Platanion orientalis)	0.3
3280: Constantly flowing Mediterranean rivers with Paspalo-Agrostidion species and hanging curtains of Salix and Populus alba	0.2
91F0: Riparian mixed forests of Quercus robur, Ulmus laevis and Ulmus minor, Fraxinus excelsior or Fraxinus angustifolia, along the great rivers (Ulmenion minoris)	0.1
Not riverine habitats	
5330: Thermo-Mediterranean and pre-desert scrub	8.6
91M0: Pannonian-Balkanic turkey oak-sessile oak forests	7.9
9340: Quercus ilex and Quercus rotundifolia forests	6.6
6220: Pseudo-steppe with grasses and annuals of the Thero-Brachypodietea	4.5
9260: Castanea sativa woods	1.5
9330: Quercus suber forests	0.5
9540: Mediterranean pine forests with endemic Mesogean pines	0.1
1210: Annual vegetation of drift lines	0.1
8210: Calcareous rocky slopes with chasmophytic vegetation	0.1
Others habitats and mosaics	3.8
Not habitat for N2000 network	54.2

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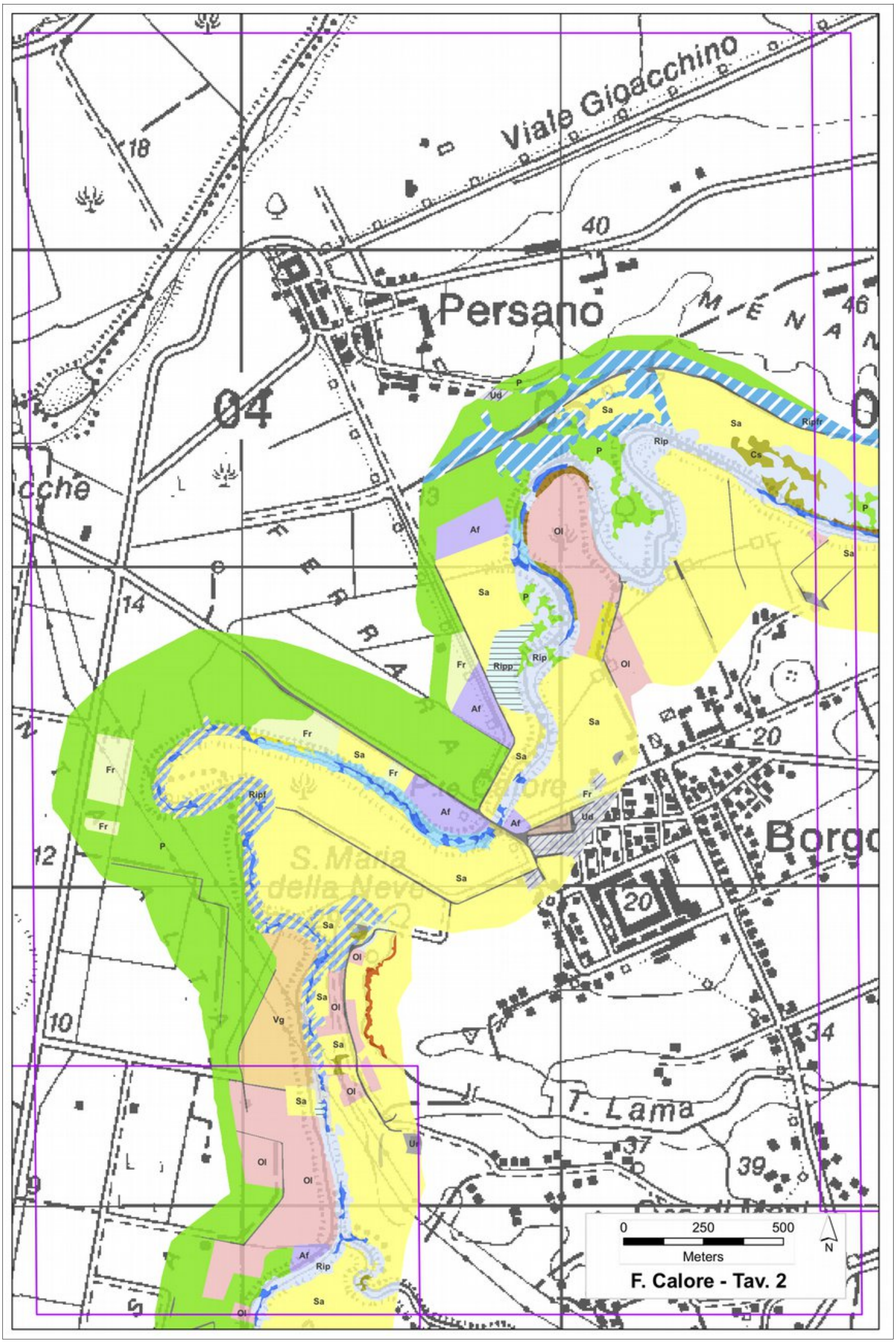
Figure 6: Example of land cover and vegetation map of lower course of the Calore river. Af=non fruit arboriculture, Cs=shrubs (Pruno-Rubion), Fr=orchards, Ol=olive orchards, P=pastures (Artemisietea;Molinio-Arrhenateretea), Rip=riparian woodlands with Salix alba and Populus spp. (Salicion albae), Ripf= fragments of riparian Salix alba stands, Sa=arable land, Ud= urban settlement;, Vg=vineyard.



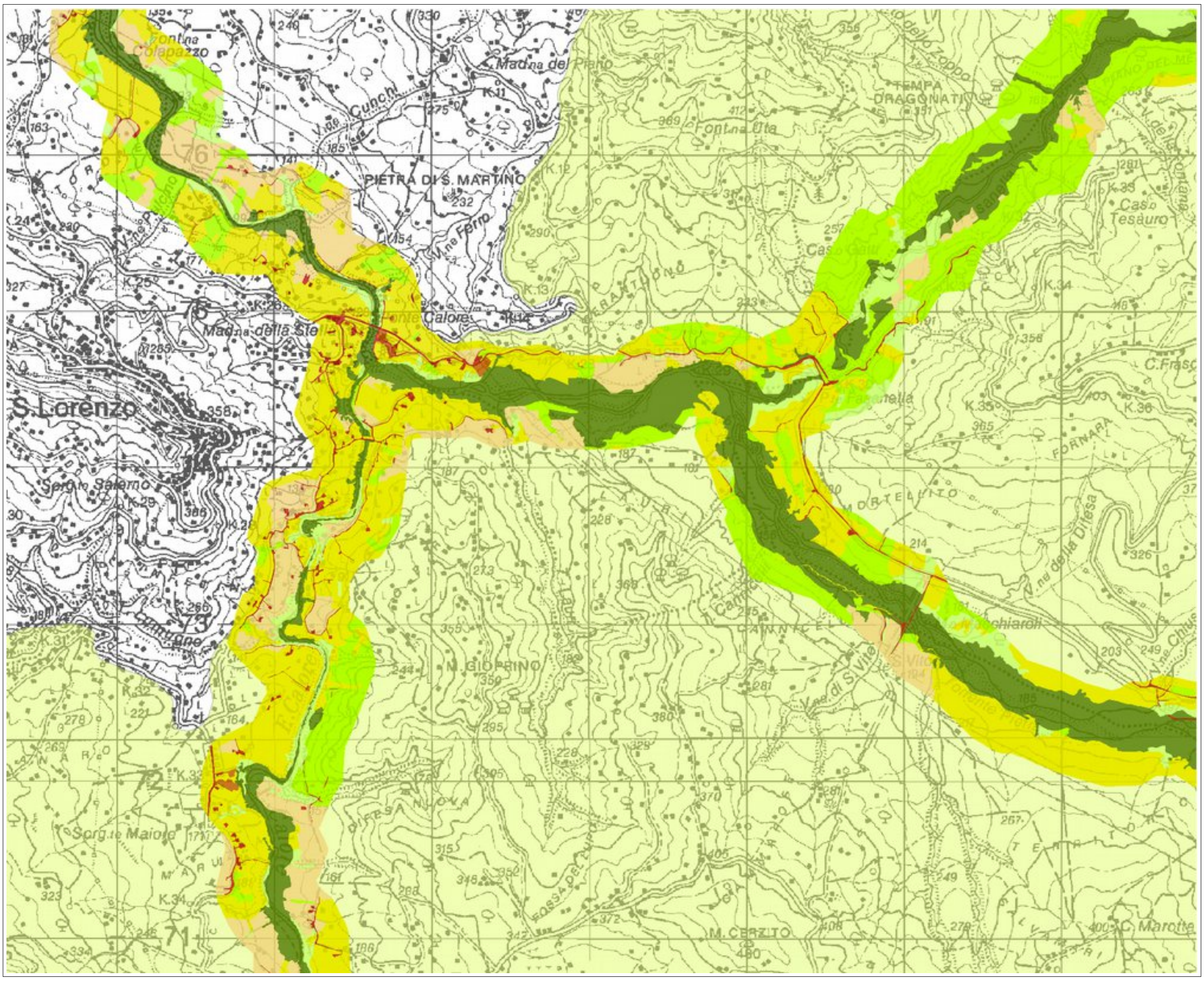


Figure 7: Land quality map of the Calore river and its tributaries (Fasanella and Ripiti): the map evidences a huge decreasing of quality values, shifting from the National Park areas (pale green) towards the buffer zones (white). Quality legend: red=very low; orange=low; light orange=medium low; yellow=medium; light green= medium high; green=high. Grid=1x1 km