

The "Carta della Natura" project: the case study of Molise region

Dora Ceralli ^{a, *}, Chiara D'Angeli ^a, Lucilla Laureti ^a

^a ISPRA - Istituto Superiore per la Protezione e la Ricerca Ambientale

dora.ceralli@isprambiente.it, chiara.dangeli@isprambiente.it, lucilla.laureti@isprambiente.it

* Corresponding author

Abstract: This document shows the conceptual and operational framework adopted to realise the "Carta della Natura" of Molise region at 1:25, 000 scale. In particular, the methodology used to create the Map of habitats is briefly described and the habitats mapped and identified on the scale of analysis are listed.

The next phase of the Carta della Natura project is also described: the assessment phase that using a set of indicators and indexes, assigns specific marks to the territorial units included that are representative of their natural value and risk of degradation. The mapping and the evaluation of the Molise regions' habitats represent a valid landmark for bodies and agencies responsible for the safeguard, control, planning and management of the territory.

Keywords: Carta della Natura, Habitat mapping, Ecological Value, Environmental Fragility, Molise

1. Introduction

In this article is presented the realization of "Carta della Natura" in the Molise region.

The term "Carta della Natura" identifies a national project of cartography and assessment of terrestrial ecological systems. The project was institutionally established with the Law on protected areas (L.n.349/91) that at article 3, identifies as its goal the production of an instrument to "*understand the state of natural environment in Italy with a particular focus on natural values and territorial vulnerability profiles*".

Tasks and results of the project are linked to two main stages of analytical work: a cartographic and an assessment stage.

The cartographic one allows to understand and represent at different scales the typologies and the distribution of Italian terrestrial ecosystems:

- Map of the Italian Landscape Units at a scale of 1:250, 000;
- Map of Habitats at regional scale of 1:25,000/1:50,000;
- Map of Habitats at local scale of 1:10,000.

The assessment phase, using a set of indicators and indexes, assigns specific marks to the territorial units included that are representative of their natural value and risk of degradation.

Final indexes used to represent the state of ecosystems are:

- Ecological Value;
- Ecological Sensitivity;
- Anthropogenic Pressure;
- Environmental Fragility.

The cartographic products and the associated data banks are part of a territorial informative system.

The Italian "Istituto Superiore per la Protezione e la Ricerca Ambientale" (ISPRA) coordinates all the activities involved in the project and their realization with the possible collaboration of other institutions (Regions, Regional Agencies for the Environment, Park institutions and Universities).

2. The realization of "Carta della Natura" in Molise region

Molise is a region of central-southern Italy. It extends for 443,758 Ha with altitudes ranging from sea level (the region is bordered by the Adriatic Sea to the east) to 2,050 m a.s.l. of Monte Miletto, on the Apennine chain of Matese. It is located between 41° 22' and 42° 41' north latitude and 14° 29' and 15° 42' east longitude from the Greenwich meridian. It is a predominantly mountainous region: it includes 136 municipalities, of which 111 are mountainous and 12 partially, for a total of 349,149 Ha of mountainous territory equivalent to 78.68% of the surface of the entire region. The molisan territory was the subject of the "Carta della Natura"'s works since the experimental phases of the project. A first cartography of the habitats was produced on a vast area and in the following time, between 2005 and 2008, through a collaboration between Ispra and Arpa Molise, was extended to the remaining territory of the region with the issuing of the Map of Habitats at scale 1:50,000.

Following important methodological updates and with new basic data available, in 2021, Ispra proceeded in autonomy, sustained by the competence of its technicians and researchers, to completely update the project products improving the cartographic detail. Therefore were realized the Map of Habitats at scale of 1:25,000 and the following assessment process of the habitats.

2.1 The habitat mapping

The cartographic technique used for the realization of the Map of Habitats at scale of 1:25.000 of the Molise region (Figure 1) follows the methodological pattern described by the guidelines of "Carta della Natura" (Angelini et al., 2009) and illustrated in the technical report ISPRA **"Carta della Natura della regione Molise: cartografia e valutazione degli habitat alla scala 1:25.000"** (Ceralli et al., 2021). It consists of a complex procedure that requires the interpretation of aerial photographs and the using of both bibliographical data and of data produced by research on the field. The data available on the territory that was taken into exam allowed to avoid using remote sensing in favor of a manual polygon study from aerial photographs that results geometrically more precise, and of an interpretation of the habitats through fieldwork and different data sources.

2.1.1 Cartographic data used

Different typologies of cartographic data were used:

- Ortofoto Agea 2006 and 2018 IR ed RGB;
- Land use map IV Level Corine Land Cover at scale of 1:25,000;
- "Carta della Natura" of Molise previous versions;
- map of habitats Natura 2000;
- map of forest types;
- geological map at scale of 1:100,000;
- topographic maps at different scale.

2.1.2 Cartographic basis

The Corine Land Cover map of the Molise Region 1:25,000 of 2012 (Molise Region, 2012) was used as a cartographic basis. The different Corine Land Cover classes have been transformed into Habitat codes.

This conversion was complex as the two maps represent different aspects of the territory. During the transformation of the codes from Corine Land Cover (CLC) to the "Carta della Natura" (HCN) habitat codes, 4 types of conversion ratio were created:

- 1: 1 ratio: a CLC code has been interpreted as an HCN ie the two legends interpret that territorial aspect in the same way. This happened only on rare occasions.
- M-1 ratio: many CLC codes have been converted to a single HCN code. This has happened above all for the areas related to anthropogenic activities, which are very detailed in the use of the land while in the HCN they are sold grouped into macro-categories crops, industrial sites).
- 1-M ratio: one CLC code has been transformed into many HCN codes; this happened for all the natural emergencies (woods, rivers, meadows, bushes) which in the legend of the habitat map are much more detailed as the main object of study.
- 1-X ratio: it was not possible to find a correspondence between the CLC code and

those of the HCN; polygons must be assigned on a case-by-case basis.

Once the conversion was completed, an intermediate map was produced in which only a small number of polygons were assigned a habitat code in a defined manner.

Most of the polygons had to be attributed, interpreted and divided into several sub-polygons corresponding to the habitats present.

2.1.3 Photointerpretations

Starting from the intermediate map produced, a long phase of photointerpretation began based on the "Terraitaly" digital color orthophotos of flight IT2018.

Every single polygon of the map has been checked and, where necessary, the polygon and the attribution of the habitat code of "Carta della Natura" has been corrected.

2.1.4 Research on the field

The field activity was carried out with several missions in the years 2013, 2014, 2018, 2019, 2020 and 2021. They were preparatory for the choice of habitats present and useful for testing the maps produced. The field survey was conducted to collect direct observation data to support the photointerpretation activity.

2.1.5 Legend

Each particular type of habitat and therefore each polygon of the map (defined as "biotopo"), are identified by a specific code, derived from the Palaearctic european classification of habitats, and put in relation with EUNIS codes and, whereas possible, with NATURA 2000 codes sed for habitats of european communitarian interests as per habitat directive 92/43/EEC (Biondi et al. 2009, 2012). For the identification of habitats and the choice of codes, the reference is the **National legend for habitat mapping of Carta della Natura**, a key valid for the entire national territory, purposely structured for the cartographic representation at scale 1:25:000 of Italian terrestrial habitats.

2.1.6 The mapped habitats: the environmental mosaic

There are 103 different types of habitat identified and mapped.

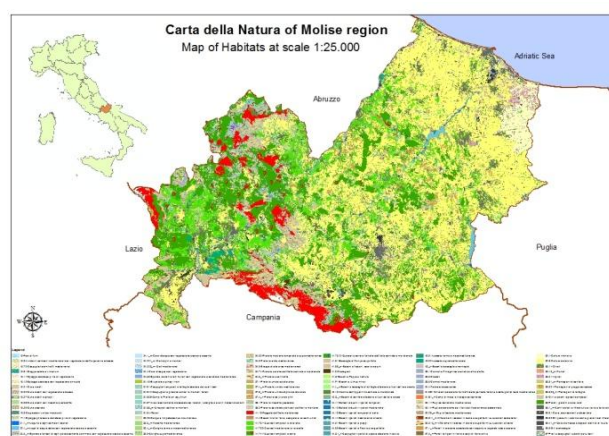


Figure 1. The map of habitats for Molise region (ISPRA, Serie Rapporti 348/2021)

A sheet is associated with each identified habitat (Figure 2). Each sheet indicates the denomination and coding of the habitat, the possible relationship with other classification systems, the territorial distribution and a brief description of the habitat.

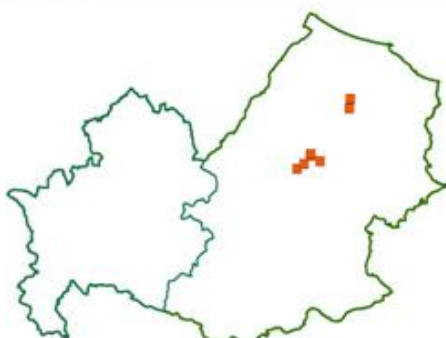

62.11 Mediterranean carbonate cliffs
Relations with other classification systems
EUNIS H3.21 Tynheno-Adriatic eumediterranean calcicolous chasmophyte communities Natura 2000 Code 8210 Calcareous rocky slopes with chasmophytic vegetation
Distribution

Description
<p>Rocky limestone and dolomitic environments of central-southern Italy. They develop in correspondence with the more thermophilic slopes of the reliefs of the Mediterranean coastal strip. These cliffs have a typical basophilic and sparse chasmophytic vegetation that colonizes the cracks and discontinuities present in the rock. In addition to the chasmophytic species, which are always present, shrub species can also be found.</p>
 Carbonate cliffs near the village of Pescopennataro

Figure 2: example of identification sheet (ISPRA, Serie Rapporti 348/2021)

Table 1 illustrates, for each habitat, the number of cartographed polygons, the extension in hectares and the percentage of coverage in respect to the entire region.

Habitat "Carta della Natura"	Surface (Ha)	Regional area in%	Number of biotopes
13-Tidal rivers and estuaries	13	0	3
15.5-Mediterranean salt meadows	5	0	4
15.72-Mediterranean halo-nitrophilous scrubs	70	0.02	22
15.81- Salty steppes in <i>Limonium</i>	1	0	1
16.11-Unvegetated sand beaches	145	0.03	8
16.12-Sand beach annual communities	7	0	4
16.21-Shifting dunes	28	0.01	8
16.22-Grey dunes	39	0.01	7
16.27-Dune juniper thickets and woods	34	0.01	2
16.28-Dune sclerophyllous scrubs	42	0.01	10
16.29-Wooded dunes	127	0.03	7
16.3-Humid dune-slacks	34	0.01	5
17.1-Unvegetated shingle beaches	2	0	2
21.1_m- Sea-connected lagoons	1	0	1
22.1_m-Fresh waters	1329	0.3	64
22.2_m-Amphibious communities	33	0.01	15
22.4-Freshwater lakes and ponds with vegetation	19	0	5
24.1_m-River course	201	0.05	54
24.221_m-Boreo-alpine stream gravel communities	140	0.03	38
24.225_m-Mediterranean gravel beds	534	0.12	120
24.4-Rivers with vegetation	4	0	2
24.53-Banks, banks and river beds with Mediterranean vegetation	21	0	6
31.43-Dwarf juniper scrub	148	0.03	7
31.81-Middle-European rich-soil thickets	9076	2.05	1549
31.844-Italian hilly and mountain gorse bushes	1308	0.29	115
31.863- <i>Pteridium aquilinum</i> fields	54	0.01	21
31.87-Areas recently cleared by fires, avalanches or extreme weather events	182	0.04	13
31.88_m-Hill and mountain junipers	1459	0.33	107
31.8A- Brambles	367	0.08	113
32.23-Garrigues of <i>Ampelodesmos mauritanicus</i>	281	0.06	13
32.3_m-Mediterranean maquis	707	0.16	121
32.4_m-Thermo and Mesomediterranean garrigues	16	0	7
32.6-Supra-mediterranean garrigues	40	0.01	9
32.A- <i>Spartium junceum</i> fields	8241	1.86	1772
34.32-Mesic temperate and supramediterranean grassland	5572	1.26	1028

34.5-Mediterranean xeric grasslands	474	0.11	137	54.4-Acidic fens	257	0.06	1
34.6-Steppe di alte erbe mediterranee	8	0	4	61.3B1-Macrothermal carbonate screes of the Italian peninsula and the Tyrrhenian islands	266	0.06	28
34.74-Mediterranean tall-grass steppes	9748	2.2	626	61.B1_n- Carbonatic boulder fields	9	0	2
34.8_m-Subnitrophilous grasslands	2195	0.49	515	62.11- Mediterranean carbonate cliffs	8	0	5
36.436-Apennine stripped grassland	784	0.18	15	62.14- Western mediterraneo-montane cliffs	909	0.2	268
37.1-Lowland tall herb communities	30	0.01	7	62.28_m-Mediterranean silicate cliffs	63	0.01	36
37.4_m-Wet Mediterranean grasslands	1	0	1	62.311_m - Rocky outcrops in slabs and domes on carbonate substrates	14	0	8
37.8_m-Wet alpine high grass grassland	6	0	3	62.312_m - Rocky outcrops in slabs and domes on silicate substrates	22	0.01	10
37.A_n- <i>Arundo plinii</i> grassland	779	0.18	160	67.1_n- Slopes in accelerated erosion with sparse or no vegetation cover	5788	1.3	653
38.1-Mesophile pastures	4221	0.95	391	67.2_n- Landslide terrigenous slopes and active landslide bodies	484	0.11	185
38.2-Lowland hay meadows	4471	1.01	525	81-Anthropic meadows	110	0.02	18
41.18-Southern Italian beech forests	16557	3.73	156	82.1- Intensive crops	7953	1.79	18
41.4- Mixed ravine and slope forests	11	0	2	82.3- Extensive crops	166989	37.64	3453
41.731 - Temperate oak woods with <i>Quercus pubescens</i>	20605	4.64	642	83.11-Olive groves	21677	4.89	3067
41.732-Mediterranean oak woods with <i>Quercus pubescens</i>	21683	4.89	1750	83.15_m-Orchards	789	0.18	210
41.741-Temperate oak forests with Turkey oak	49094	11.07	845	83.21- Vineyards	3010	0.68	368
41.7511-Mediterranean oak forests with Turkey oak	20120	4.53	770	83.31_m-Conifer plantations	36	0.01	13
41.7512-Southern Italian <i>Quercus frainetto</i> woods	1194	0.27	18	83.321-Populus plantations	226	0.05	36
41.81-Hop-hornbeam woods	5271	1.19	171	83.325_m- Broadleaved deciduous plantations	1808	0.41	446
41.88_m-Woods of ash, maple and hornbeam	2598	0.59	135	84-Vegetable gardens and complex agricultural systems	5668	1.28	1121
41.9- Chesnut woods	396	0.09	45	85- gardens and green areas	896	0.2	313
41.D-Aspen woods	57	0.01	17	86.1_m- Urban centers and road and railway infrastructures	9118	2.06	1519
41.F1-Woods and scrubs with <i>Ulmus minor</i>	607	0.14	106	86.31-Quarries, excavations and landfills	590	0.13	108
41.L_n-Woods and thickets of allochthonous broad-leaved trees or outside their range	1129	0.25	237	86.32-Production and commercial sites and large infrastructural nodes	2604	0.59	542
42.15-Southern apennine silver fir forests	397	0.09	21	86.41_m-Disused quarries and quarry backfill	169	0.04	24
42.G_n-Forests of conifers allochthonous or outside their range	5097	1.15	498	86.6-Archaeological sites and ruins	26	0.01	6
44.11-Temperate riparian willow brush	172	0.04	24	87-Peri-urban ruderal meadows and bushes	714	0.16	110
44.12-Mediterranean riparian willow brush	289	0.07	51	89.2- Freshwater canals and reservoirs	63	0.01	22
44.13-Temperate riparian willow forests	285	0.06	59				
44.14-Mediterranean riparian willow forests	298	0.07	56				
44.61-Riparian poplar forests	8215	1.85	941				
44.63-Riparian forests with <i>Fraxinus angustifolia</i>	15	0	2				
44.D1_n-Riparian bushes of invasive alien species	45	0.01	9				
44.D2_n-Riparian woods and scrubs of invasive alien species	160	0.04	38				
45.31-Thermo and mesomediterranean holm oak forests	327	0.07	20				
45.32-Supra-Mediterranean holm-oak forests	1509	0.34	37				
4D_n-Synanthropic woods and scrubs	3456	0.78	631				
53.1- Reed beds with <i>Phragmites australis</i> and other helophytes	479	0.11	70				
53.3-Cladieti	2	0	1				
53.6-Mediterranean riparian cane formations	328	0.07	72				

Table 1. For each type of habitat sensu "Carta della Natura, the extension, the percentage in respect to the regional territory, the number of biotopes mapped and their average surface are reported

From the examination of the data shown in the table and from the analysis of the distribution of habitats divided into macro-categories (Figure 3), the prevalence of agricultural mosaics is evident, bearing witness to the agricultural vocation of the region.

The agricultural areas cover about 47% of the territory with a prevalence of extensive crops and olive groves. The forest cover is also noteworthy: the woods occupy, in fact, 33.83% of the regional surface.

It is also important to pay attention to river, lake and marshy environments, which, although they have a

predominantly linear and sometimes fragmentary extension, occupy almost 3% of the regional surface. Of the remaining surface, meadows and pastures occupy 4.26% and shrub environments 7.05%.

The rocky and detrital environments occupy about 1.7% of the total regional surface.

The coastal environments deserve particular attention which, although not very extensive (546 hectares corresponding to 0.13% of the regional surface), contain important habitats from a conservation point of view.

Within this group, rare habitats with a very low number of polygons can be observed as the salt steppes in *Limonium* (1 polygon), the dunes with junipers (2 polygons), the brackish environments with herbaceous halophilic vegetation (4 polygons), the tree-lined dunes (7 polygons).

With a single biotope of limited extension, in addition to the salt steppes in *Limonium*, the following habitats are noted: lagoons and coastal brackish lakes (21.1_m); humid Mediterranean grasslands (37.4_m), Cladieti (53.3).

They are all important habitats from the conservation point of view; all, except habitat 37.4_m, are a priority according to the Habitat Directive 92/43/EEC (European Commission, 1992).

The environments entirely built by man cover an area of 14,292 hectares and represent 3.22% of the entire region.

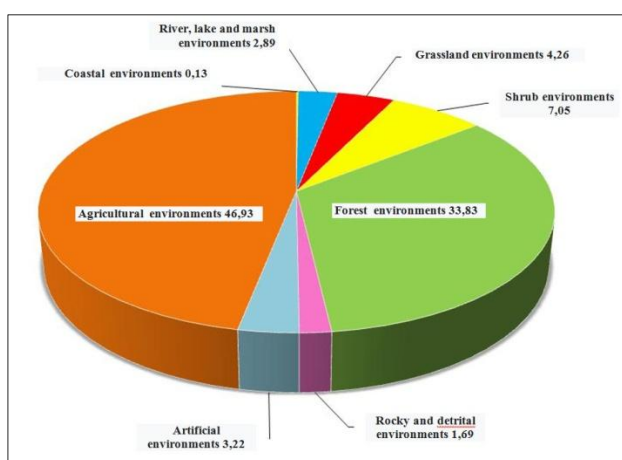


Figure 3. Percentage distribution of habitats in macro-categories: coastal environments; fluvial, lake and marsh environments; grassy environments; shrubby environments; forest environments; rocky and detrital environments; agricultural environments and artificial Margin settings for A4 size paper (ISPRA, Serie Rapporti 348/2021)

2.2 The assessment process: habitat evaluation habitat mapping

The assessment process consists of a series of operations aimed at evidencing what the institutive Law of the project (L.394/91) defined as "natural values and profiles of territorial vulnerabilities".

The habitat map represents the basis of the process of evaluation that is applied to each and every mapped polygon (biotope) but not to every type of habitat.

All the polygons relative to areas occupied by buildings and infrastructure are excluded from the process.

In Molise a total of 25.330 biotopes were evaluated meanwhile 27.661 were mapped.

The assessment process allowed to calculate for each biotope some synthetic indexes named as:

Ecological Value, Ecological Sensitivity, Anthropogenic Pressure and Environmental Fragility (Figure 4).

These indexes are calculated using available basic data that must be homogenous on a national level, derived from official sources or directly elaborated by ISPRA.

The indicators considered refer to three different categories:

- indicators that incorporate values (areas and habitat types) already recognized based on the Habitat Directive (Dir.92/43/EEC) and Ramsar Areas;
- biodiversity indicators which refer to the potential presence of flora and fauna species based on criteria of ecological suitability of species / habitat and based on their respective areas of presence and distribution;
- indicators that refer to ecological parameters indirect expression of a good state of conservation directly derived from the Habitat Charter such as shape, size and rarity.

The standard process is carried out through a procedure developed by ISPRA in order to guarantee uniformity in calculations and in the treatment of basic data (Angelini et al.,2009).

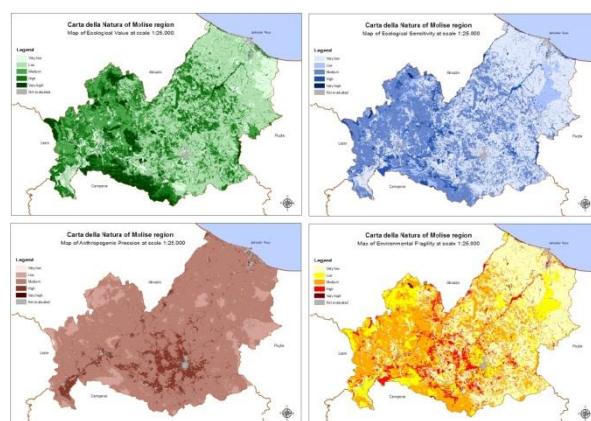


Figure 4. The maps of Ecological Value, Ecological Sensitivity, Anthropogenic Pressure and Environmental Fragility (ISPRA, Serie Rapporti 348/2021)

As an example of application of the assessment data produced, the study relating to the criticality and protection of natural areas is reported.

As a function of better regional management in terms of planning and environmental protection, the analysis that allows us to highlight the types of habitats and their

surface characterized by high values of Ecological Value and at the same time of Environmental Fragility appears very significant.

It was, therefore, considered useful to highlight the biotopes of the "High" and "Very high" Ecological Value classes that fall into the Environmental Fragility classes from "High" to "Very high" at the same time.

This analysis brings out some habitats on which it is necessary to pay attention as they have a high natural value, but also a high risk of degradation due to both natural and anthropogenic factors.

Therefore, they statistically represent the biotopes most threatened, i.e. the most at risk of losing the natural heritage they preserve.

Table 2 shows the habitats that present more than 75% of their surface at the same time falling into the classes indicated above.

It also indicates whether the habitat is present in Annex I of Dir. 92/43/EEC, whether it is a priority and how many biotopes have relevant values of the two Indices on the number of total biotopes belonging to that habitat.

These are 26 habitats of great ecological value and national importance.

The structural characteristics and the biodiversity components that distinguish them represent a heritage to be preserved but the level of fragility resulting from the estimates of the "Carta della Natura" classifies them at risk of degradation and in a threatened state of conservation.

Figure 5 cartographically shows the criticalities obtained from the analysis: the importance of some environmental systems is evident, such as hydrographic and coastal systems.

In addition, there are isolated criticalities such as those observed in areas characterized by very rare woods in the region such as gorge and fir woods or ecologically important woods such as holm oaks.

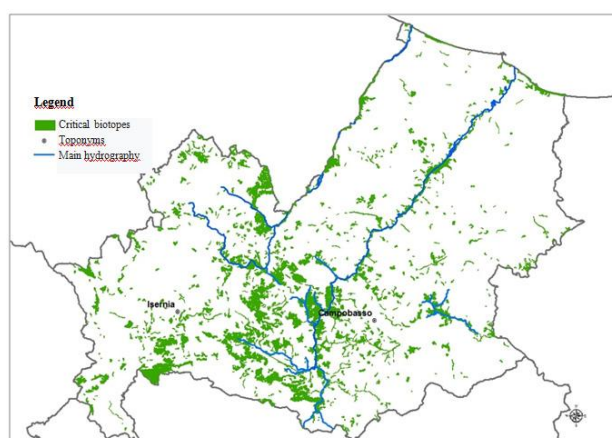


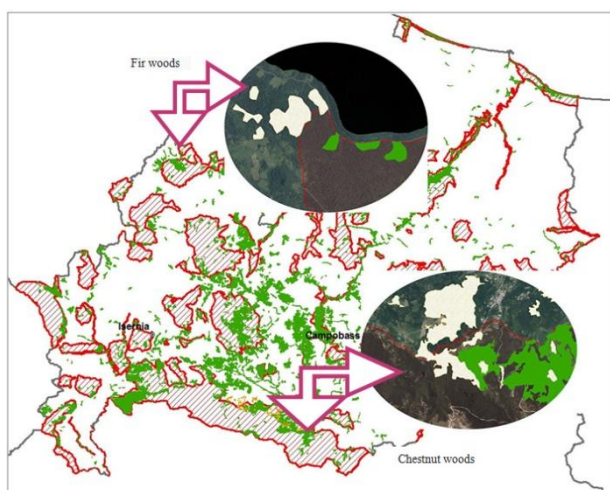
Figure 5. Biotopes that fall into the highest Fragility and Ecological Value classes (ISPRA, Serie Rapporti 348/2021)

If we then associate this data with the distribution of the areas subject to forms of protection (Natura 2000 areas and EUAP areas), it is possible to identify where those biotopes are located that still lack any forms of protection or conservation management

It can be observed that most of the critical habitats fall within protected areas with important exceptions (Figure 6) such as some strips of fir forest that fall outside the "Bosco di Vallazzuna" or some chestnut woods observed outside the Sic "La Gallinola, Monte Miletto, Monti del Matese".

Habitat Carta della Natura	Natura 2000	Priority	Number of Biotopes	% Ha
15.81 - <i>Limonium</i> salt steppes	X	X	1/1	100
16.21 - Shifting dunes	X		7/8	94.35
16.22-Grey dunes	X	X	5/7	88.14
16.27-Dune juniper thickets and woods	X	X	2/2	100
16.28-Dune sclerophyllous scrubs	X		10/10	100
16.29-Wooded dunes	X	X	7/7	100
21.1_m- Sea-connected lagoons	X	X	1/1	100
22.4-Freshwater lakes and ponds with vegetation	X		4/5	81.04
32.23-Garrigues of <i>Ampelodesmos mauritanicus</i>	X		12/13	99.32
34.5-Mediterranean xeric grasslands	X	X	89/137	79.89
34.6-Steppe di alte erbe mediterranee	X	X	3/4	84.57
37.1-Lowland tall herb communities	X		6/7	82.08
37.4_m-Wet Mediterranean grasslands	X		1/1	100
37.8_m-Wet alpine high grass grassland	X		3/3	100
41.4- Mixed ravine and slope forests	X	X	2/2	100
41.7512-Southern Italian <i>Quercus frainetto</i> woods	X		16/18	98.67
41.9- Chestnut woods	X		42/45	97.48
42.15-Southern apennine Xlver fir forests	X	X	21/21	100
44.11-Temperate riparian willow brush	X		22/24	91.45
44.12-Mediterranean riparian willow brush	X		44/51	94.76
44.13-Temperate riparian willow forests	X		51/59	87.67
44.14-Mediterranean riparian willow forests	X		45/56	79.79
44.63-Riparian forests with <i>Fraxinus angustifolia</i>	X		2/2	100
45.31-Thermo and mesomediterranean holm oak forests	X		20/20	100
45.32-Supra-Mediterranean holm-oak forests	X		34/37	99.06
53.3 - Cladieti	X	X	1/1	100

Table 2. Habitats that fall into the high and very high classes of Ecological Value and Environmental Fragility



Ceralli D., Laureti L., 2021. *Carta della Natura della regione Molise: cartografia e valutazione degli habitat alla scala 1: 25.000*. ISPRA, Serie Rapporti 348/2021.

Figure 6. Example of habitats with high Ecological Value and High Fragility outside protected areas (ISPRA, Serie Rapporti 348/2021)

3. Conclusion

The habitat map, in a vectorial format, allows to obtain distributive, qualitative and quantitative data on the region's habitats, giving a picture of the environmental mosaic of the entire territory, both inside and outside of protected areas.

Evaluational indexes mark the natural areas of major interest and the ones more at risk of degradation from an ecological-environmental point of view.

The comparison between these territorial analyses and the system of regional protected areas can help to identify areas of special conservational interest and new areas to protect.

The mapping and the evaluation of the Molise region's habitats represent a valid landmark for bodies and agencies responsible for the safeguard, control, planning and management of the territory.

ISPRA permits an easy usability of the data in support of such activities: all the data can be viewed in detail on the ISPRA geoportal and can be requested using the online form available on the institutional website.

4. References

- Angelini P., Augello R., Bagnaia R., Bianco P., Capogrossi R., Cardillo A., Ercole S., Francescato C., Giacanelli V., Laureti L., Luger F., Luger N., Novellino E., Oriolo G., Papallo O., Serra B., 2009. *Il progetto Carta della Natura alla scala 1:50.000 – Linee guida per la cartografia e la valutazione degli habitat*. ISPRA, Manuali e linee guida 48/2009. Roma.
- Biondi E., Blacchi C., Burrascano S., Casavecchia S., Copiz R., Del Vico E., Galdenzi D., Gigante D., Lasen C., Spampinato G., Venanzoni R., Zivkovic L., 2009. *Manuale italiano di interpretazione degli habitat della Direttiva 92/43/CEE*. <http://vnr.unipg.it/habitat/index.jsp>.