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

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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 Appennine 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 because 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 Photointerpretation

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 "biotope"), are identified by a specific code, derived from the Palaeartic 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.

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 Limonium                  | 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-slags                            | 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-Pteridium aquilinum 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 Ampelodesmus mauritanicus      | 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                  |
| 32.8-A-Spartium junceum fields                    | 8241         | 1.86              | 1772               |
| 34.32-Mesic temperate and supramediterranean grassland | 5972 | 1.26 | 1028 |

Figure 2: example of identification sheet (ISPRA, Serie Rapporti 348/2021)
34.5-Mediterranean xeric grasslands 474 0.11 137
34.6-Steppe di alte erbe mediterrane 8 0 4
34.74-Mediterranean tall-grass steppes 9748 2.2 626
34.8_m-Subnitrophilous grasslands 2195 0.49 515
36.436-Apennine stripped grassland 784 0.18 15
37.1-Lowland tall herb communities 30 0.01 7
37.4_m-Wet Mediterranean grasslands 1 0 1
37.8_m-Wet alpine high grass 6 0 3
37.2_A-arundo plana grassland 779 0.18 160
38.1-Mesophile pastures 4221 0.95 391
38.2-Lowland hay meadows 4471 1.01 525
41.18-Southern Italian beech forests 16557 3.73 156
41.4- Mixed ravine and slope forests 11 0 2
41.731 -Temperate oak woods with Quercus pubescent 20605 4.64 642
41.732-Mediterranean oak woods with Quercus pubescent 23183 4.89 1750
41.741-Temperate oak forests with Turkey oak 49094 11.07 845
41.7511-Mediterranean oak forests with Turkey oak 20120 4.53 770
41.7512-Southern Italian Quercus frainetto woods 1194 0.27 18
41.81-Hop-hornbeam woods 5271 1.19 171
41.88_m-Woods of ash, maple and hornbeam 2598 0.59 135
41.9- Chestnut woods 396 0.09 45
41.D- Aspen woods 57 0.01 17
41.F1-Woods and scrubs with Ulmus minor 607 0.14 106
41.L_n-Woods and thickets of allochthonous broad-leaved trees or outside their range 1129 0.25 237
42.15-Southern ampine silver fir forests 397 0.09 21
42.G_n-Forests of conifers allochthonous or outside their range 5097 1.15 498
44.11-Temperate riparian willow brush 172 0.04 24
44.12-Mediterranean riparian willow brush 289 0.07 51
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 Fraxinus angustifolia 15 0 2
44.D1_m-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 meso-mediterranean holm oak forests 327 0.07 20
45.32-Supa-Mediterranean holm-oak forests 1569 0.34 37
4D_n-Synanthropic woods and scrubs 3456 0.78 631
53.1- Reed beds with Phragmites australis and other helophytes 479 0.11 70
53.3-Ciadieti 2 0 1
53.6-Mediterranean riparian cane formations 328 0.07 72

54.4-Acidic fens 257 0.06 1
61.3B1-Macrothermal carbonate screes of the Italian peninsula and the Tyrrenian islands 266 0.06 28
61.3B1_n- Carbonatic boulder fields 9 0 2
62.11-Mediterranean carbonate cliffs 8 0 5
62.14- Western mediterranean-montane cliffs 909 0.2 268
62.28_m-Mediterranean silicate cliffs 63 0.01 36
62.311_m - Rocky outcrops in slabs and domes on carbonate substrates 14 0 8
62.312_m - Rocky outcrops in slabs and domes on silicate substrates 22 0.01 10
67.L_n-Slopes in accelerated erosion with sparse or no vegetation cover 5788 1.3 653
67.2_n- Landslide terrigenous slopes and active landslide bodies 484 0.11 185
81.- Anthropic meadows 110 0.02 18
82.1- Intensive crops 7953 1.79 18
82.3- Extensive crops 106989 37.64 3455
83.11-Olive groves 21677 4.89 3067
83.15_m-Orchards 789 0.18 210
83.21- Vineyards 3010 0.68 368
83.31_m-Conifer plantations 36 0.01 13
83.321-Populans plantations 226 0.05 36
83.325_m- Broadleaved deciduous plantations 1808 0.41 446
84-Vegetable gardens and complex agricultural systems 5668 1.28 1121
85- gardens and green areas 896 0.2 313
86.1_m- Urban centers and road and railway infrastructures 9118 2.06 1519
86.31-Quarries, excavations and landfills 590 0.13 108
86.32-Production and commercial sites and large infrastructural nodes 2604 0.59 542
86.41_m-Disused quarries and quarry backfill 169 0.04 24
86.6-Archaeological sites and ruins 26 0.01 6
87.-Peri-urban ruderal meadows and bushes 714 0.16 110
89.2- Freshwater canals and reservoirs 63 0.01 22

Table 1. For each type of habitat senso “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 m²); humid Mediterranean grasslands (37.4 m²), Cladieti (53.3).

They are all important habitats from the conservation point of view; all, except habitat 37.4 m², 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.

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
- Environmental Fragility

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 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)

**Figure 4.** The maps of Ecological Value, Ecological Sensitivity, Anthropogenic Pressure and Environmental Fragility (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 constitutive Law of the project (L..394/91) defined as“ natural values and profiles of territorial vulnerabilities”.

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.

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 - Limonium salt steps 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 Ampeledesmus mauritanicus X | | 12/13 | 99.32 |
| 34.5-Mediterranean xeric grasslands X | X | 89/137 | 79.89 |
| 34.6-Steppe di alte erbe mediterranea 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 grassland X | X | 3/3 | 100 |
| 41.4-Mixed ravine and slope forests X | X | 2/2 | 100 |
| 41.7512-Southern Italian Quercus frainetto woods X | | 16/18 | 98.67 |
| 41.9-Chesnut woods X | | 42/45 | 97.48 |
| 42.15-Southern apennine 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 Fraxinus angustifolia 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. Habits that fall into the high and very high classes of Ecological Value and Environmental Fragility
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.

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