

UPDATE AND DEVELOPMENT OF A METHODOLOGY FOR THE IDENTIFICATION OF HIGH NATURAL VALUE FARMLAND (HNVF) AND THE ELABORATION OF CARTOGRAPHY IN GIS

Overall report of the activities



Dr. Giuseppe Colangelo
Dr. Remo Bertani
Dr. Simone Luppi
Dr. Maurizio Potzulu

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1. Report on knowledge of HNVF

The naturalistic value of environmental resources plays a pivotal role in evaluations in support of rural development policies. The theme has been extensively analysed over the last decades to offer adequate and multi-criteria tools that can facilitate a detailed analysis of resources and provide a set of indicators disconnected from the critical issues that have emerged over time.

We can identify two main research domains related to crop intensity and biodiversity level. Crop intensity implies a reduction in naturalness and refers to land use and land cover classes indexes. Biodiversity and species richness lead to the opportunity to use criteria related to the presence of species or strategies for the conservation of their habitats.

A first stage of knowledge is based on a bibliographic analysis work set on the selection and extraction of abstracts from the Scopus database which is a tool created in 2004 by the publishing house Elsevier through which it is possible to outline the main characteristics of scientific production.

The result of the analysis gives us some representations of the phenomenon of scientific production on the subject. All BibTeX files derived from the identified and downloaded literature were processed using VOSviewer 2.6.5 (van Eck and Waltman, 2009) to display bibliometric networks among the keywords reported in the publications (Fig.1)

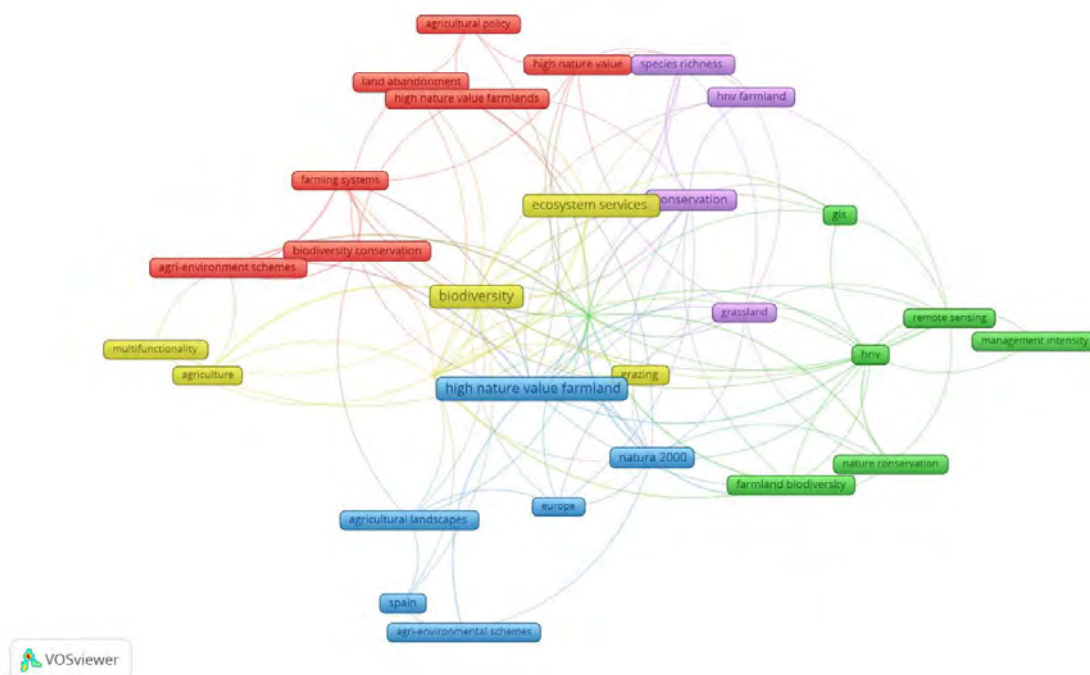


Figure 1. Bibliometric network of keywords.

The analysis of the keywords also allows to define the spatial distribution of the research work (Fig.2). In the bibliometric network represented by nations, the node size indicates the number of publications produced by affiliated authors in a given country; while the edge size indicates the number of documents shared between authors from two different countries (nations with less than 50 manuscripts were excluded).

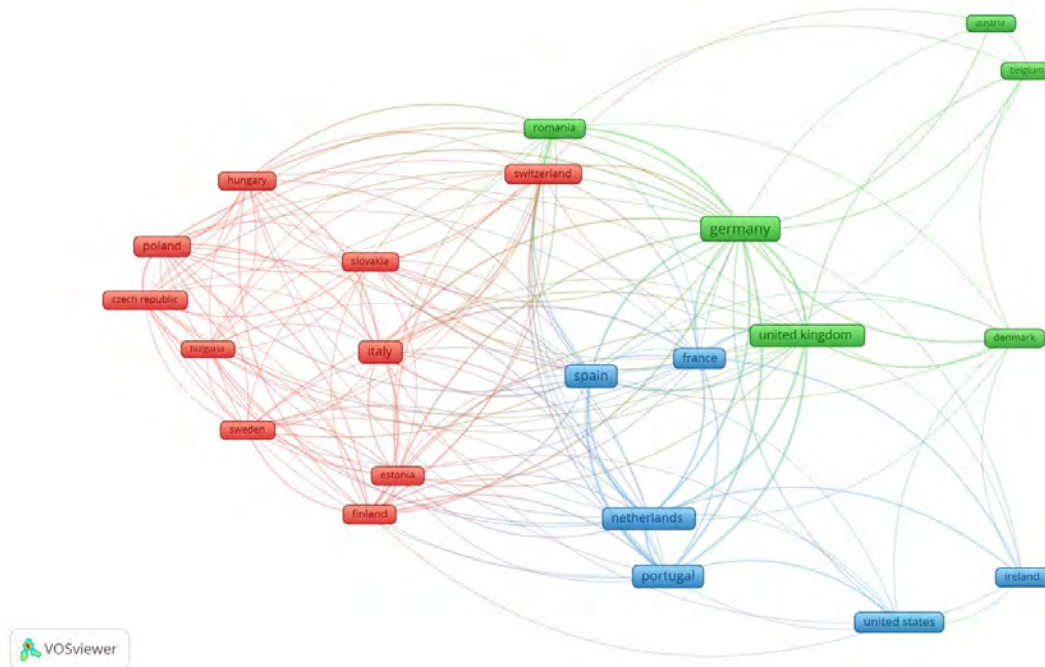


Figure 2. Bibliometric map expressed in nodes and edges between countries. The size of the node depends on the number of documents produced by the authors of a given country. The size of the edges indicates the number of documents shared between authors of different nationalities, while the colour of the nodes indicates the cluster to which each country belongs.

A further aspect of interest in bibliographic research is represented by the evolution that scientific production has had over time. The number of publications per year shows how the HNMF theme refers to some key publications already mentioned above on the basis of which there has been a significant increase, especially in the last decade (Fig. 3).

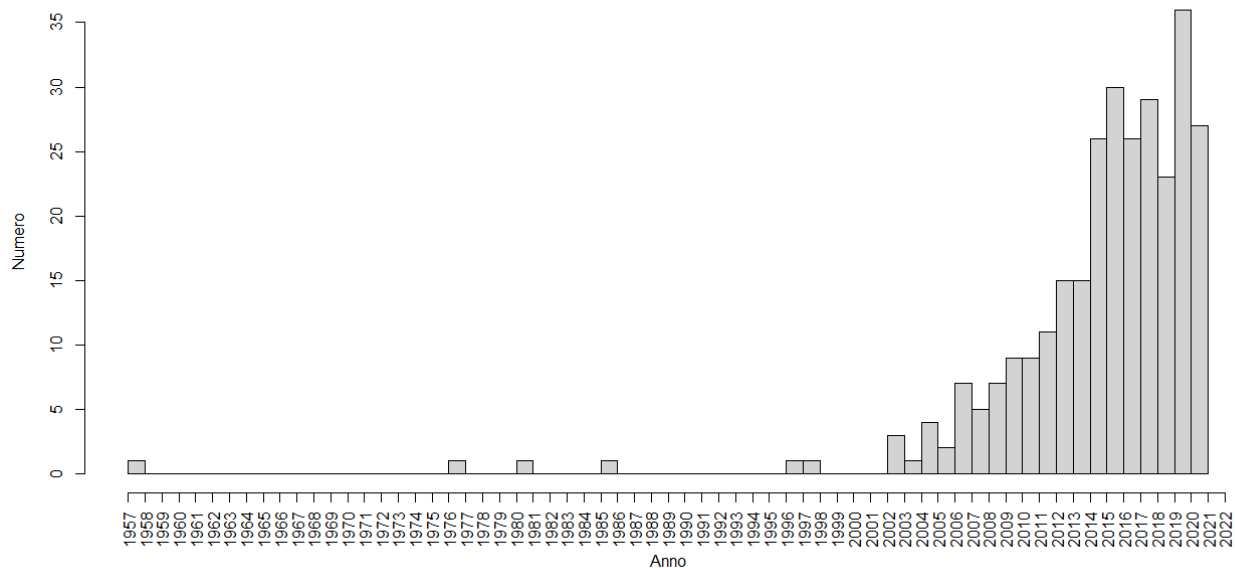


Figure 3. Distribution of the number of scientific publications over time.

The data becomes relevant if we also consider the evolution in the use of keywords

2. Verification and updating of HNPF identification methodologies

The verification was carried out by identifying a logical process based on the availability of the databases and on the updating of the analysis methods. A logical-procedural framework (otherwise called a “Logical Framework”) has been defined to synthesize and schematize the analytical phases of the project.

According to the Logical Framework, the following elements of analysis have been defined:

- *Indexes that return the types and methods of aggregation between indicators.* These indicators are shown in figure 1, elaborated in the Final Project Report.
- *Indicators that measure the phenomenon defined by the index and meet the chosen criteria.* Below is the table showing the indicators and their data. Within the draft revision of the methodology, the starting point is this list increased by some additional indicators. We also proceed to the evaluation of the quality of some indicators considered obsolete or not completely adequate in terms of spatial and temporal resolution.
- *Criteria and indicators outlining the phases of the project, the source data and methods for the verification.*

The QL is a strategic planning tool, which allows the association of the traditional approach to design defining the objectives through the *bottom-up* orientation, which applies participatory processes to the drafting of projects and plans. The obtained QL can be read both from the bottom up, that is, defining the aims that can

be achieved on the basis of the means available, and from the top down, that is, defining the activities necessary to achieve the predetermined objectives.

The purpose of the application of the QL is to seek maximum expository and conceptual clarity, focusing on the objectives. These characteristics facilitate the management, monitoring and evaluation of the projects, facilitating the transparency of decision-making mechanisms.

The QL is presented as a matrix (Table 1), where the boxes in the first column express the logic of the intervention, and the boxes in the first horizontal row provide the information (indicators) that allow you to measure the implementation and results of the project, the methods of verification of the same indicators and the hypotheses, meant as external factors that could affect the project implementation process.

A preliminary formulation of the QL concerning the proposed project is presented in Table 1.

Table 1. Example of Logical Framework

	Intervention rationale	Indicators (objectively verifiable)	Verification sources
General objectives	Conservation of biodiversity	Increase in HNVF classified area	HNVF charter
Specific purpose of the project	Conservation of biodiversity in agriculture	low crop intensity crops	Land Use Charter; National Census of Agriculture
Specific purpose of the project	Development of a specific methodology for the Apulian territory	Standardized working protocol	Manual for the identification and mapping of HNVFs
Results	Mapping of the HNVFs to manage the territory through the RDP (Rural Development Programme)	Tools	HNVF charter
Actions	Identification of HNVF areas at regional level	Area of crops (arable crops, vineyards, olive groves, tree crops) with low input use; Incidence of permanent woods and meadows-grasses on the unit of surface. Incidence of protected areas (Natura 2000. Areas)	Sentinel Image Processing Theme Cards
	Assessment of interactions between HNVF and landscape transformations	Density of linear and punctual elements of the agricultural landscape landscape ecology indicators	TOF (Trees Outside Forest) inventory using Sentinel image processing
	Diachronic analysis (2017-2020) of HNVF surface changes	Surface differences of HNVFs	GIS Processing
	Formulation of scenarios for the protection of HNVF and future developments	Simulation of different alternative scenarios	GIS Processing

Tools and methods.

The identification methodology for HN VF in Puglia. The application following the DGR n.623/2017.

As mentioned in paragraph 1, the purpose of the methodological comparison between past and current experience is to reorganise prior knowledge from a methodological point of view. Inevitably referring to a reading of the document in its entirety (complete both with the results obtained and the methodological and technical notes), a critical presentation of the methodology developed in the context of the research project is proposed here. The scientific-technical report accompanying the final phase of the project "HN VF in Puglia - Identification of Agricultural Areas with High Naturalistic Value" (DISAAT – Department of Agro-Environmental and Territorial Sciences, 2017) provides a summary description of the methodological approach. It can in fact be summarized in the following steps aimed at "quantifying, locating and monitoring over time the HN VF areas on a regional scale", based on what is theorized by Andersen et al. 2004)¹.

During this design experience, a process was developed according to the following steps, reported here as defined in the afore mentioned report and in the related publication²

- *Identification of the most appropriate single or multiple criteria to break down the three types.* The following diagram shows the summary, extracted from the final report:

¹Andersen, E., Baldock, D., Brouwer, F. M., Elbersen, B. S., Godeschalk, F. E., Nieuwenhuizen, W., & Hennekens, S. M. (2004). Developing a high nature value farming area indicator: Final report. EEA, Copenhagen, Denmark.

² 1. Bozzo F, Fucilli V, Petrontino A, Girone S. Identification of High Nature Value Farmland: a methodological proposal. Italian Review of Agricultural Economics. December 28, 2019;29-41 Pages.

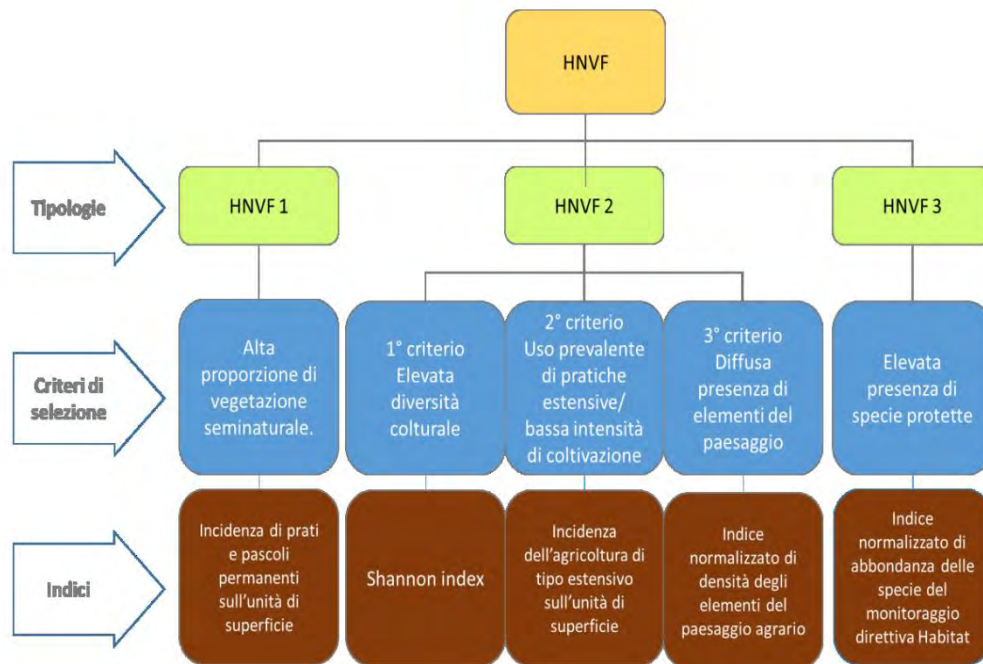


Figure 5 - Types of HNVF - (Processing by DISAAT 2017)

- The identification phase reported the selection of 3 types:

1. Areas with a high proportion of natural vegetation;
2. Areas characterized by high cultural diversity, prevalence of extensive practices, high incidence of landscape elements;
3. High presence of protected species

- *Indexes that return the types and methods of aggregation between indicators.* These indicators are shown in figure 1, elaborated in the Final Project Report.
- *Indicators that measure the phenomenon defined by the index and meet the chosen criteria.* Below is the table showing the indicators and their data. Within the draft revision of the methodology, the starting point will be this list increased by some additional indicators. We will also proceed to the evaluation of the quality of some indicators considered obsolete or not completely adequate in terms of spatial and temporal resolution.

Indices and indicators allow you to identify the input data, essential for the drafting of the areas and to test the data analysis procedures.

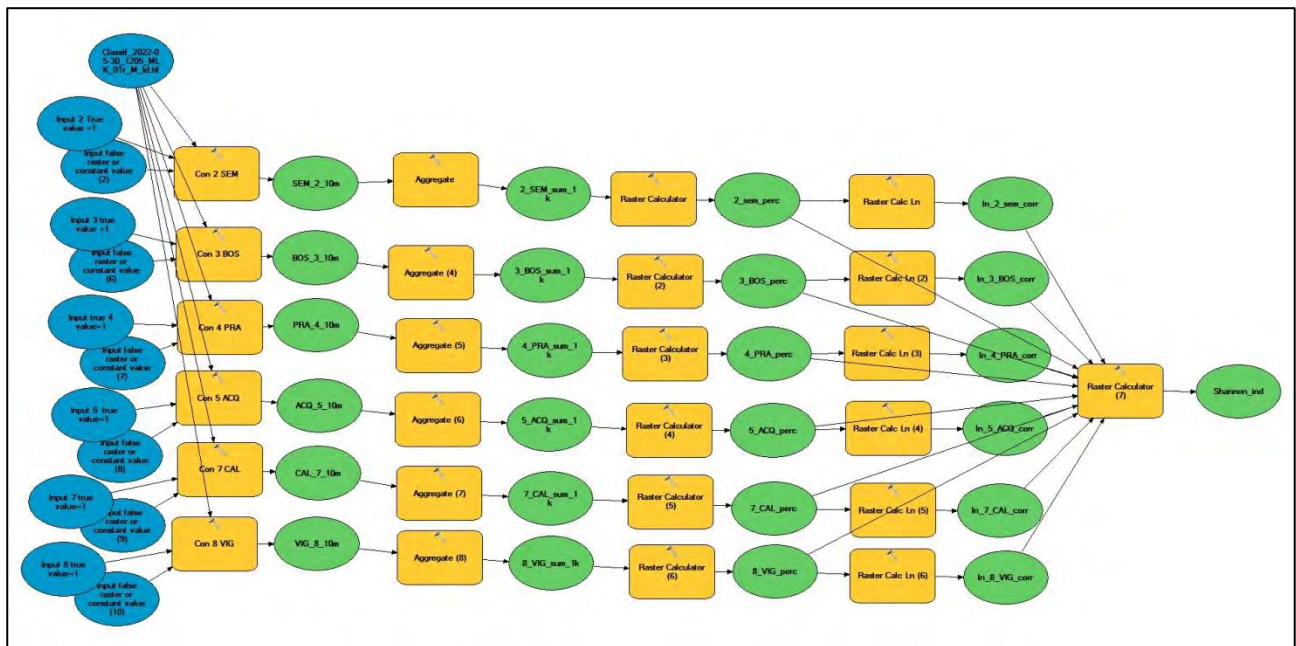
Table 2. Indicators used in the definition of HNVF (in yellow those inserted ex-novo)

Contents	Indicator	Source	Spatial detail	Dynamism	Updating
Incidence of permanent grassland and pastures on the unit area	Incidence of permanent grassland and pasture on the unit area	Sentinel 2	Raster with 10m cell	Yes	5 days
Shannon index	Incidence of arable land on the unit area	Sentinel 2	Raster with 10m cell	Yes	5 days
	Incidence of Forests on the surface unit				
	Impact of Tree Crops on Area Unit				
	Impact of Vineyards on Area Unit				
	Incidence of permanent grassland and pasture on the unit area				
	Inland water impact on unit area				
	Area occupied by arable land with low use of agricultural inputs				
	Area occupied by vineyards with low use of agricultural inputs				
	Area occupied by tree crops with low use of agricultural inputs				
	Incidence of Forests on the surface unit				
Impact of extensive agriculture on unit area (aggregated index)	Incidence of permanent grassland and pasture on the unit area	Sentinel 2	Raster with 10m cell	Yes	5 days
	Agricultural patch composition [APC], ratio between patches of tree and herbaceous cover, expresses the balance between tree and herbaceous component in the most disturbed agricultural environment	Sentinel 2	Raster with 10m cell	Yes	5 days
	Incidence of forests on the unit of area (area elements of the agricultural landscape)	Sentinel 2	Raster with 10m cell	Yes	5 days
Indices of Landscape	Hill's Diversity Number	Sentinel 2	Raster with 10m cell	Yes	5 days

Contents	Indicator	Source	Spatial detail	Dynamism	Updating
Ecology, (as proposed by ReteRurale)	Sharpe index	Sentinel 2	Raster with 10m cell	Yes	5 days
	Edge Density	Sentinel 2	Raster with 10m cell	Yes	5 days
	Landscape Shape Index	Sentinel 2	Raster with 10m cell	Yes	5 days
Standardised index of species abundance under the monitoring of the Habitats Directive	Number of species monitored by the Habitats Directive on the unit area	Monitoring the Habitats Directive	Yes (very large and indicative distribution areas: 10 km)	Yes	6 years

3. Evaluation of methodologies for HN VF identification

Data analysis was articulated in a process of subsequent approximation through which an adaptive workflow procedure was experimented. Starting from a small number of initial data, the verification of the outputs was repeated through visual comparison on a map and the estimation of the degree of accuracy of the classification in GIS environment. The analysis procedure is described in the form of a workflow as in the example below.



Satellite data is the main source of information for updating the methodology and for verifying HN VF areas. Through them, a map of land use is obtained; from the elaboration of the latter, numerous indices necessary for the detection of HN VF are produced.

Therefore, we defined the periods of Sentinel image acquisition (Sentinel 2) using 4 steps between April and September, but also reanalysing the phenological phases of vegetation and agricultural crop development in the entire territory of the Apulia region.

Table 3. Sentinel2 images selected.

		Early Spring	Late Spring	Summer	Late summer-early autumn
		April 1-30	May 15 – Jun 15	July 1-30	Sep 1-30
Area	Sentinel Scene	Detected Sentinel Images			
North west	33TWG-33TWF-33TVG	Mar 28, 2021	May 2nd, 2021	Jul 6, 2021	Sep 24, 2021
	33TWG-33TWF-33TVG	March 3rd, 2021 (*)	Jun 11, 2021	Jul 21, 2021	Oct 4, 2021
Center	33TXF-33TXE	Mar 30, 2021	May 9, 2021	Jul 8, 2021	Sep 26, 2021
	33TXF-33TXE				Sep 21, 2021 (*)
South East	33TYF-33TYE	Mar 30, 2021	May 9, 2021	Jul 8, 2021	Sep 26, 2021
	33TYF-33TYE				21 Sep 2021 (*)

(*) images chosen to replace areas with cloud cover

The classification of the images is of *Supervised* type. It presupposes the instruction of the *Maximum Likelihood* (MLK) classifier, through the acquisition of the spectral signatures of each class delimiting the ROI (*Region of Interest*) or "Training area".

The analysis work was carried out in two phases. In the first, some test areas distributed throughout the regional territory were used to verify the accuracy of the analysis method and the quality of the results. Subsequently, the method used in the test areas was replicated throughout the regional territory.

307 ROIs distributed in the various images were identified for the classification of the images. Some of these ROIs consist of 2 or more polygons.

The result of the classification of the 4 sets of mosaic images, was in turn mosaicked to obtain the final map of the land use of the regional territory.

This map of land use, the fundamental basis for all the following elaborations, obtained through a classifier, was verified on the 2019 orthophotos.

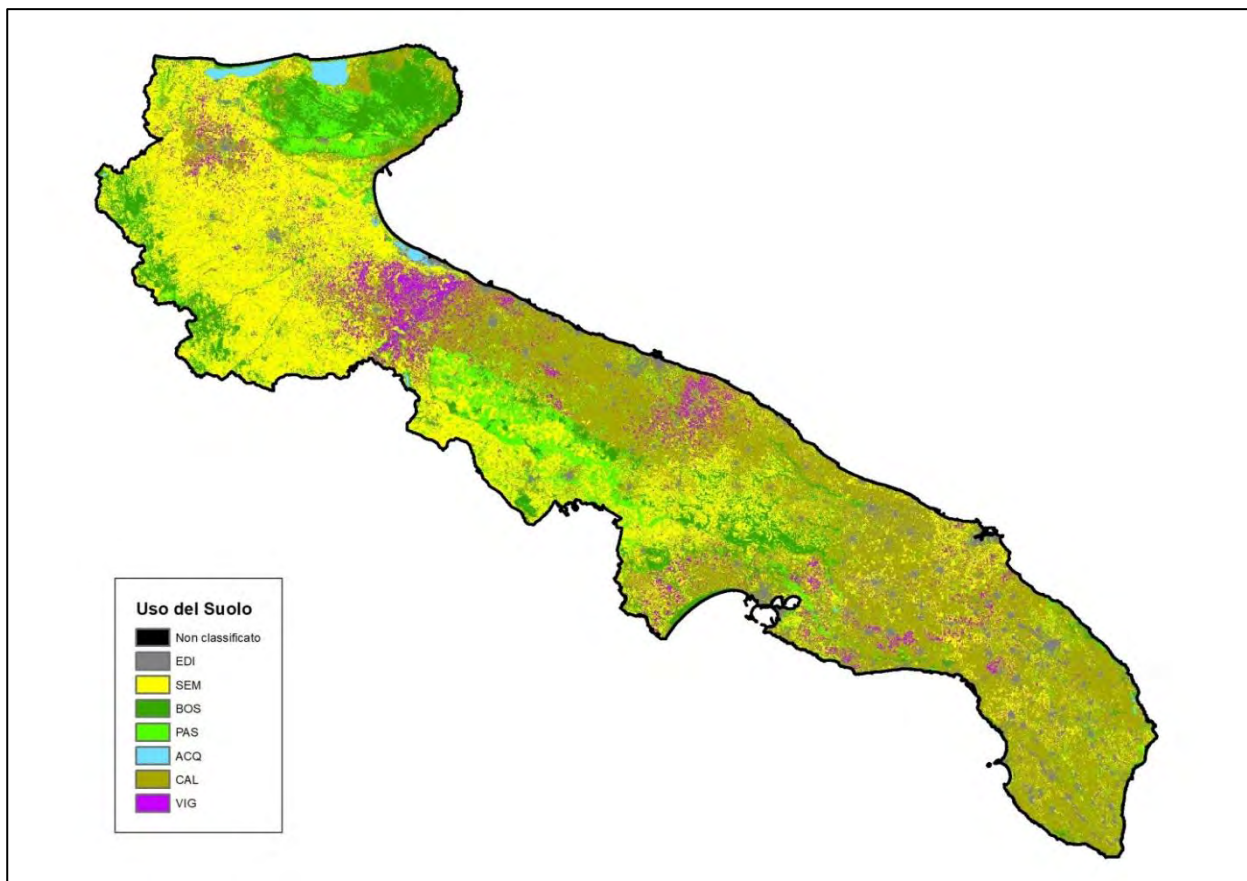


Figure 4. Land use map obtained through Sentinel 2 image classification

Table 4. Diffusion and incidence of land use at regional level (excluding islands)

Code	Class	Surf [Ha]	Surf [%]
1	Artificial surfaces	141900.16	7.34%
2	Arable land	633272.54	32.77%
3	Wooded territories and semi-natural environments	227176.67	11.76%
4	Grasslands and Prairies	177053.38	9.16%
5	Water Bodies	15011.38	0.78%
7	Tree crops	646527.96	33.46%
8	Vineyards	91335.57	4.73%

4. Main Results

Type 1 HNVF detection

Based on the relative prevalence of meadows and pastures.

The 1x1 km cells for a predominant "agricultural-natural" soil use were selected, and only within these cells the prevalence (>50%) of grasslands and pastures has been verified on the total of the other "agricultural-natural" land uses.

In order to identify the cells belonging to this Type, an automated procedure has been implemented.

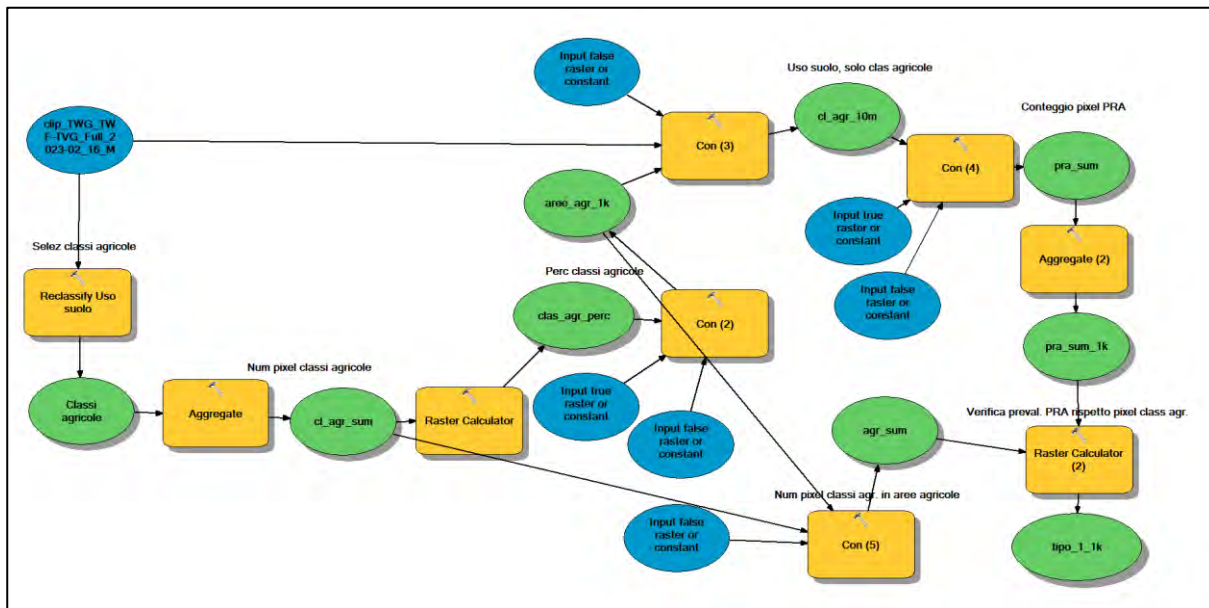


Figure 5. Detection Algorithm of HNVF 1

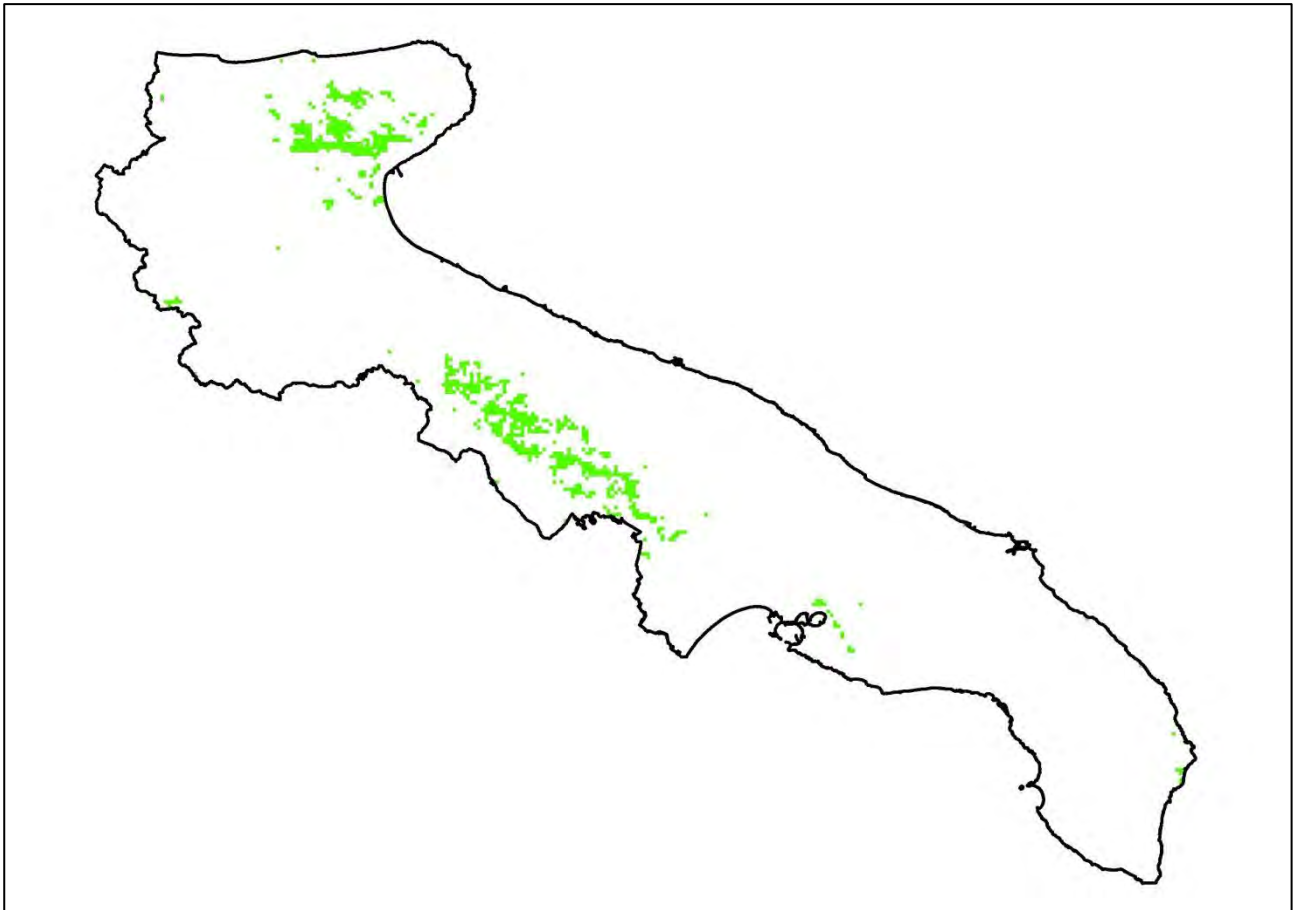


Figure 6. Type 1 HNVF. These areas are particularly widespread on the Gargano promontory and in the Alta Murgia plateau.

Identification of type 2 HNMF

The second type of high nature value farmland is identified by the presence of two criteria attributable to a non-intensive agricultural activity that therefore supports the biodiversity of the territory:

- Crop diversity indicates a lack of specialization of crops and a higher complexity of the agricultural landscape that therefore favours the spread of wild species.
- It is assumed that the presence of extensive practices leads to a limited use of external inputs in agriculture that are at odds with biodiversity.

The two criteria taken into account, if included in a defined territorial unit, can constitute a highly representative index of the ability of agriculture to conserve animal and plant biodiversity. The aggregation of the two criteria was therefore non-compensatory, which means that only the areas where they are present at the same time were selected.

Type 2 HNMF Detection - 1st Criterion (Crop Diversity)

The Shannon Diversity Index has been calculated. The index takes into account Wealth (presence of different land uses) and Equality (similar extension of the various land uses).

$$H' = -C \sum_{j=1}^S p_j \ln p_j$$

Where:

C = 1.

p_j = incidence of each land use with respect to the total

j = land use class

S = number of classes present.

All the (6) classes are taken into account in the calculation except for Built Surfaces (EDI). The calculation then involves the classes of land use including arable crops, pastures, forests, tree crops, vineyards and water.

To have full control of the algorithm, the calculation was implemented as an automated procedure.

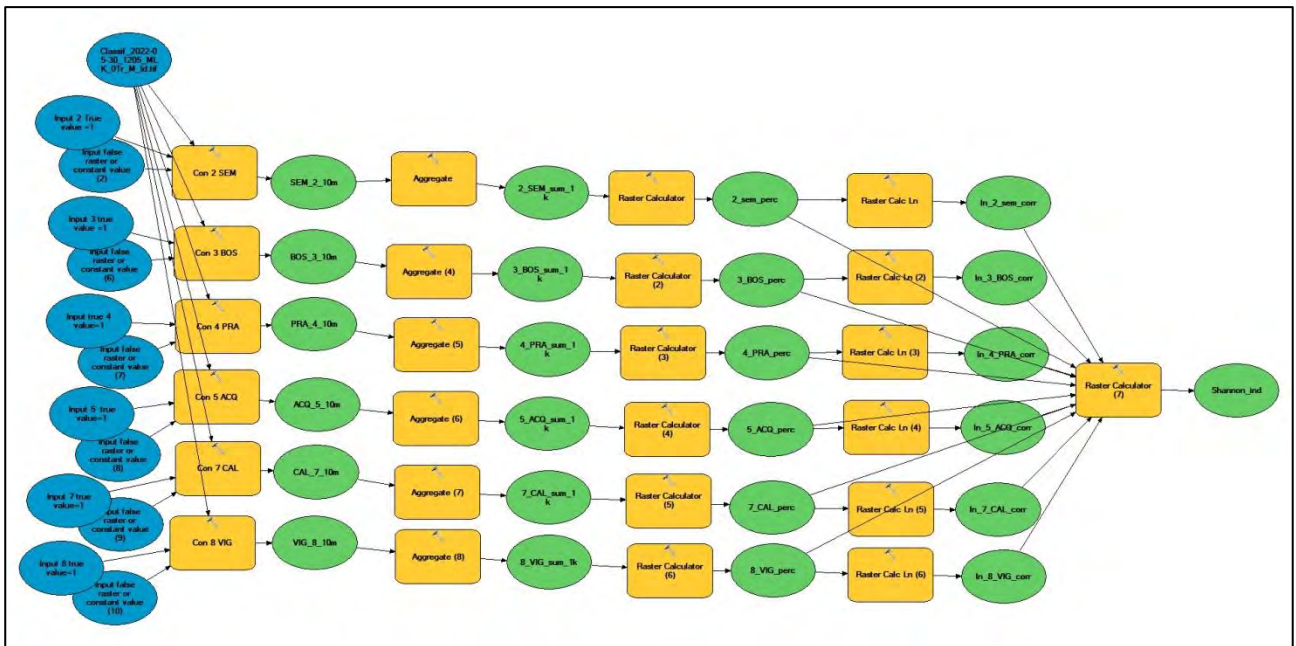


Figure 7. Implemented algorithm calculating the incidence of the Forest and Prairies in each cell

This index expresses the cultural diversity that methodologically assumes the function of indicator of the 1st criterion of Type 2 HNPF.

The resulting values of this index in the Apulia region range from 0 to 1.667. In order to compare the various indicators, it is necessary to normalize the linear index, which then shows the values between 0 and 1. They were therefore considered as agricultural areas with an appreciable complexity of the agricultural landscape when the value exceeds 0.44 normalized, equal to an absolute value of 0.71.

Identification of Type 2 HNVF - 2nd Criterion (Intensity of agricultural activity)

This criterion concerns the type of agriculture practiced (farming system); for one of its components, instead of the FADN economic-accounting data, after having tested many of them, an index developed and applied in the field of Landscape Ecology was used: the Edge Density (ED).

$$ED = \frac{p_j}{a_j}$$

Where: p_j = overall perimeter of class j in meters

a_j = total area of class j in hectares

For each 1x1Km cell, the Edge Density (which expresses its fragmentation) of the "Arable" class was calculated; this index is adopted as a proxy indicator, which participates with others in the identification of areas with a prevalence of extensive agriculture.

The ED in the regional territory was between 0 and 0.028. The cells 1x1km in which the value is greater than 0.016 (equal to a normalized value of 0.56) were therefore considered non-intensive for agriculture.

In addition to the cells identified through the Edge density, the classes (by their nature extensive) of the Woods and Prairies-grassland were considered, and the incidence (the percentage presence) of each of them in each cell was calculated. The cells in which their sum exceeds 50% were then selected.

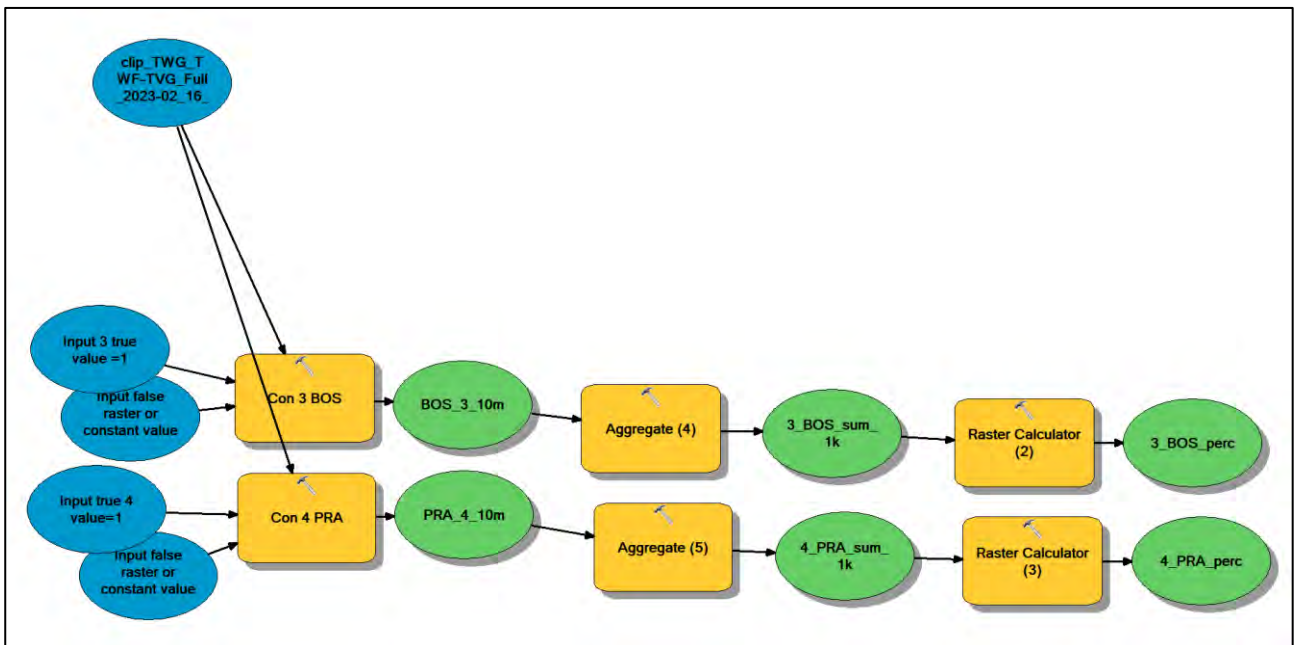


Figure 8. Implemented algorithm calculating the incidence of the Forest and Prairies in each cell

The second criterion is obtained by adding the extracted cells with the two previous processing: with a specific command through which the two rasters are superimposed and crossed: Edge Density > 0.016 and Incidence Woods and Prairies-Grassland >50%. The output grid raster cells contain the attributes of the two original layers. They are then selected on the table and then in the cells where at least one of the two indexes is present. For the second criterion, in fact, it is sufficient that one of the two indicators is met.

Identification of Type 2 HNPF - Aggregation of the 1st and 2nd Criterion

To identify the Type 2, it is necessary to aggregate the two criteria. In practice, always with a specific command through which the two rasters synthesizing them are superimposed and crossed. The output grid raster cells contain the attributes of the two original layers. In this case, however, both criteria must be met. Then the cells meeting the two criteria were selected and the others were discarded.

The result was further filtered by eliminating 1x1km cells not having a prevalent “agricultural-natural” land use.

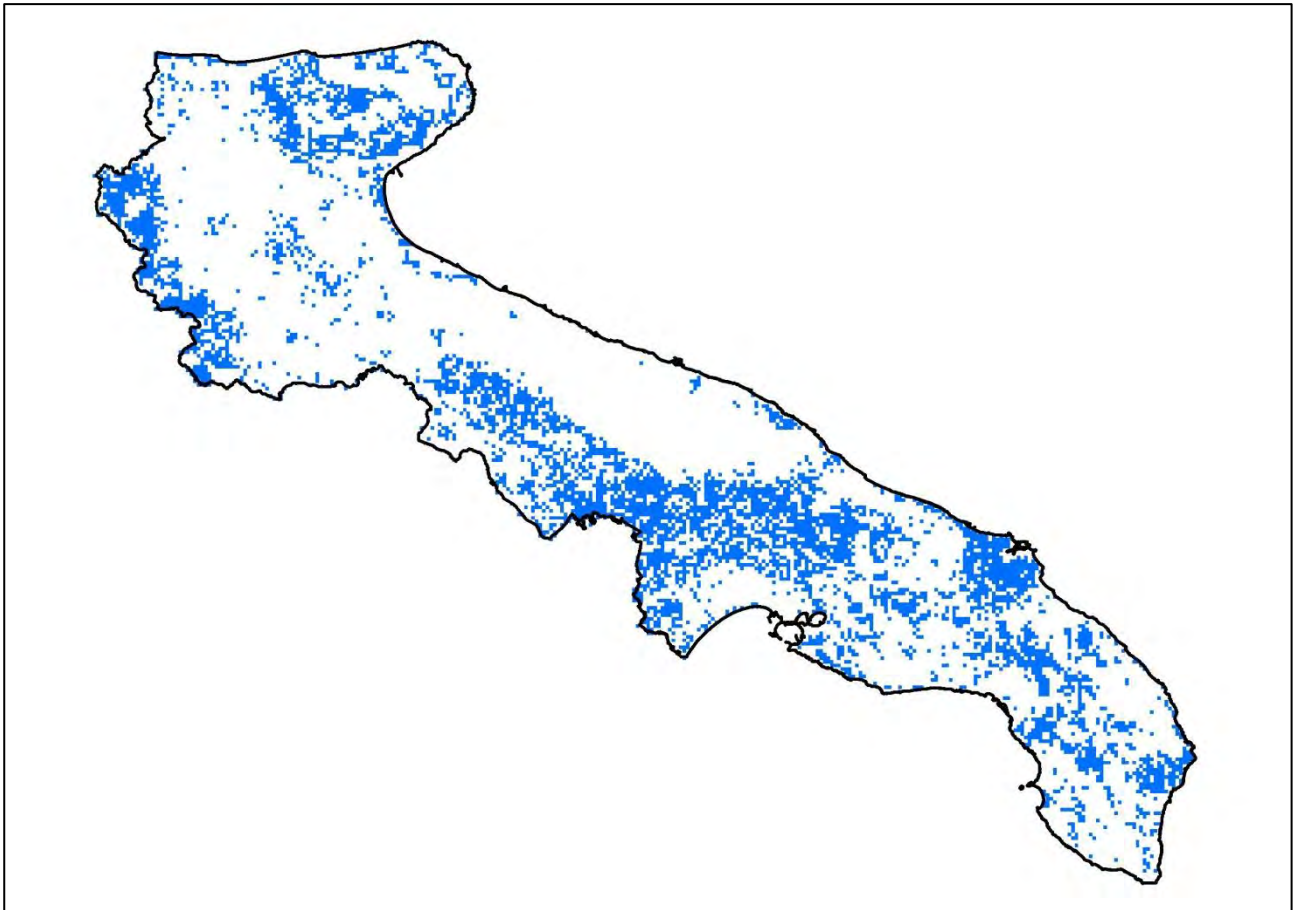


Figure 9. Type 2 HNVF

Type 3 HNVF detection

This type is based on the processing of data on the number of species surveyed for the purposes of the Habitats Directive available on regional web portals. Since there is no single archive of the species present in each cell, it was necessary to:

- Extract the alphanumeric data of each species and calculate the centroids of the reference cells.
- Create a grid with 10x10Km cells (800 polygons).
- Count the number of species in each cell

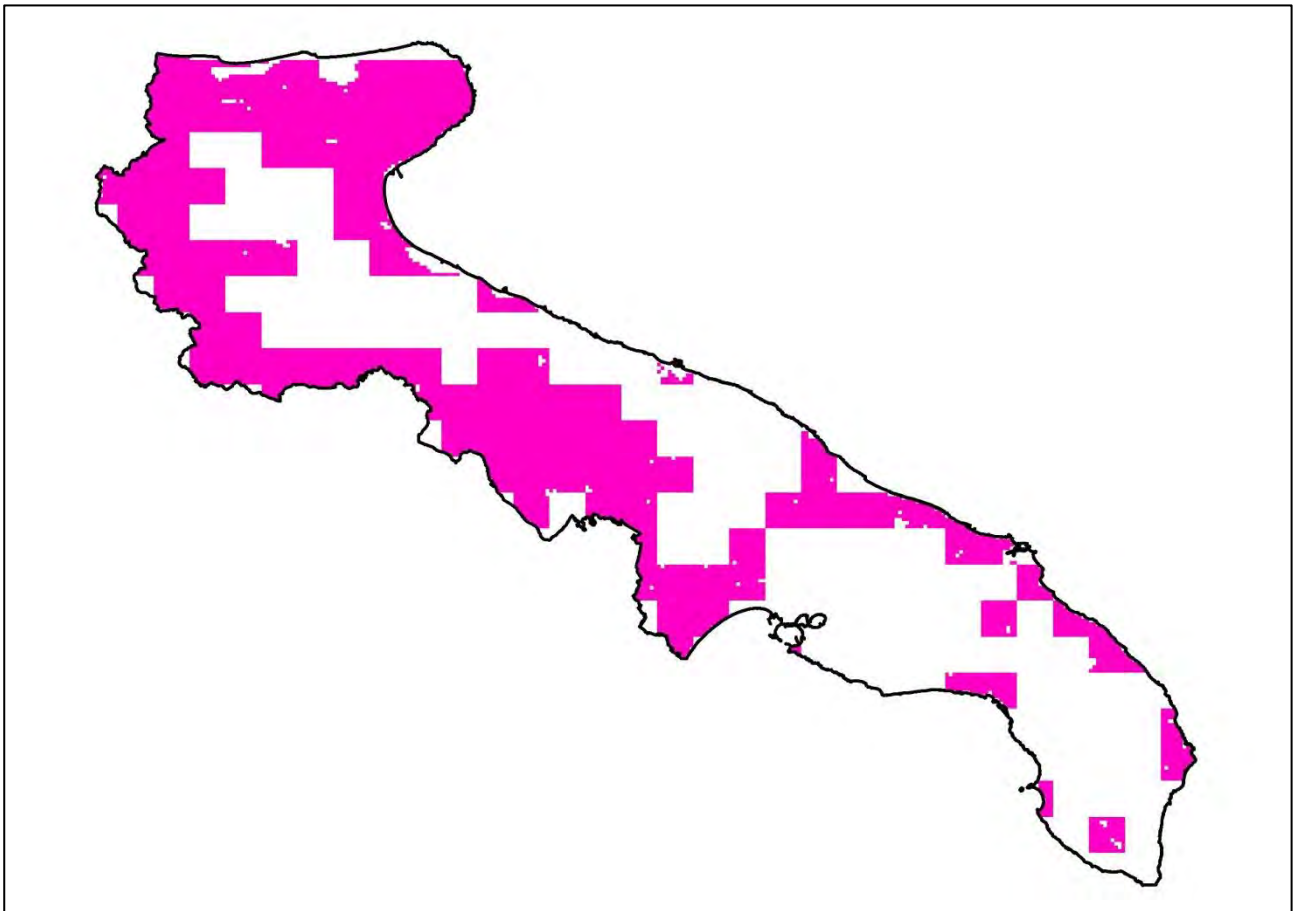
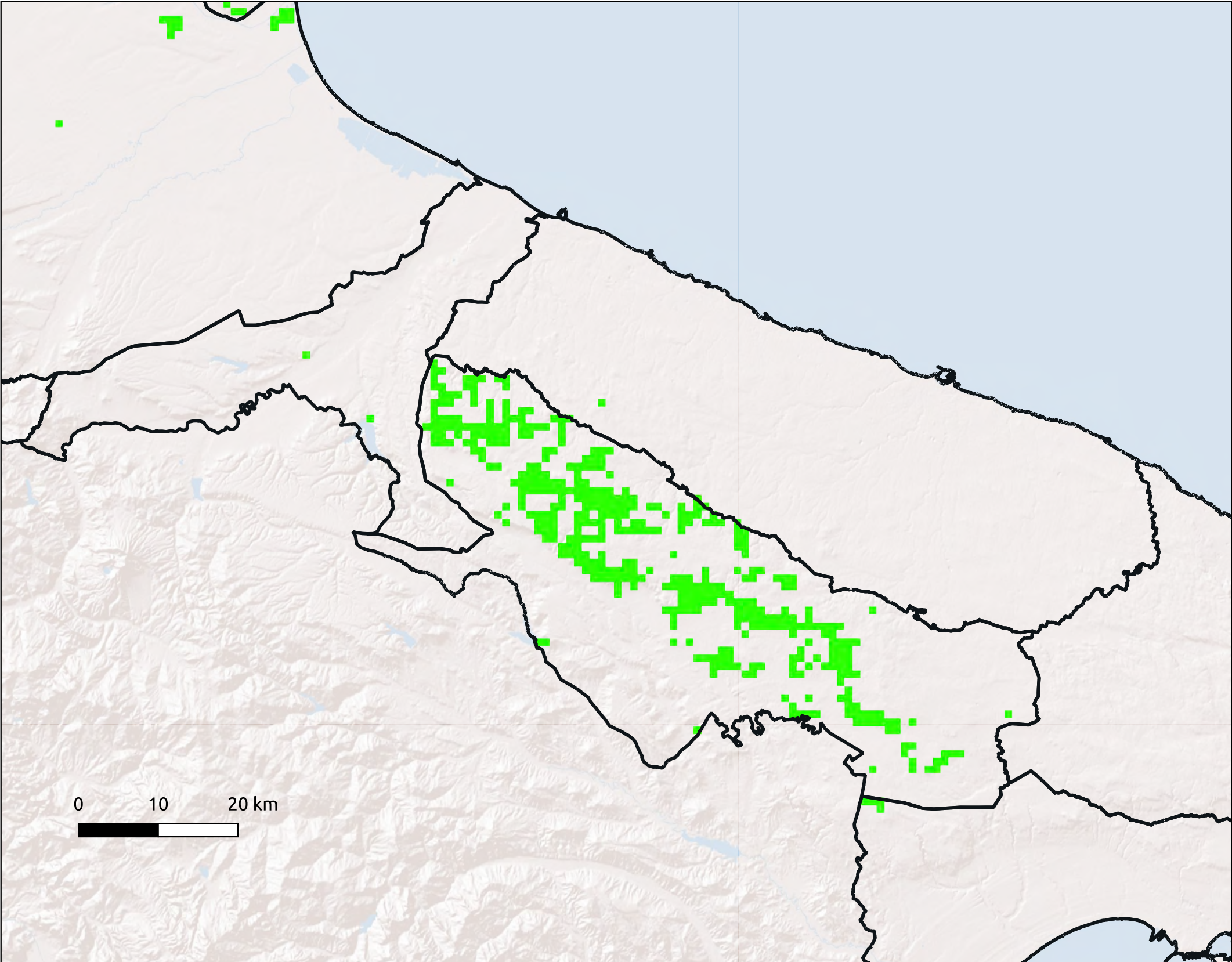


Figure 10. Type3 HNVF

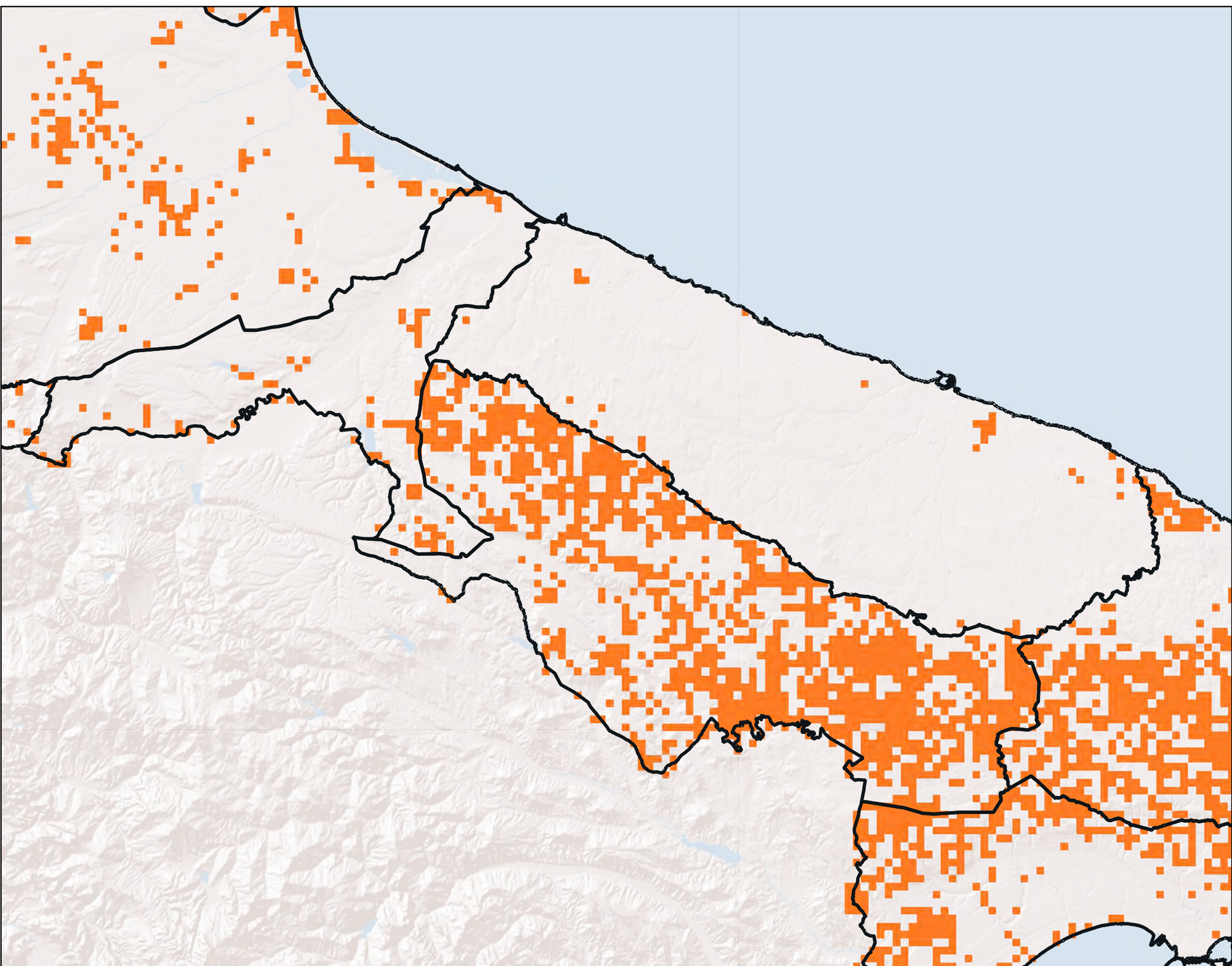
1.

HN VF - tipo 1



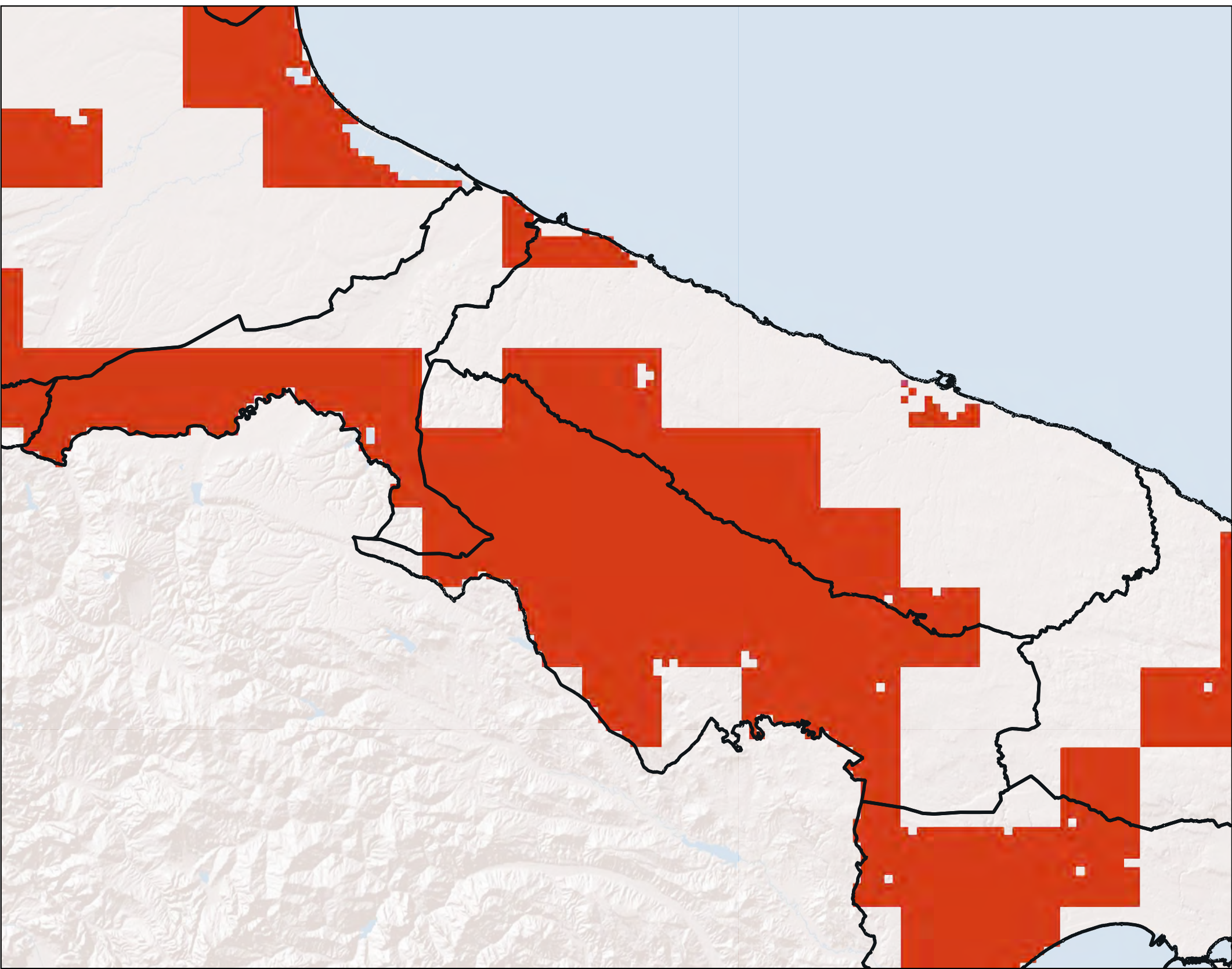
2.

HN VF - tipo 2



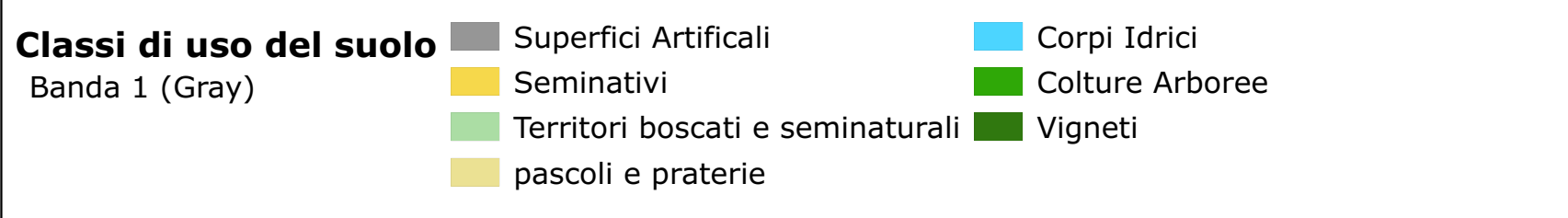
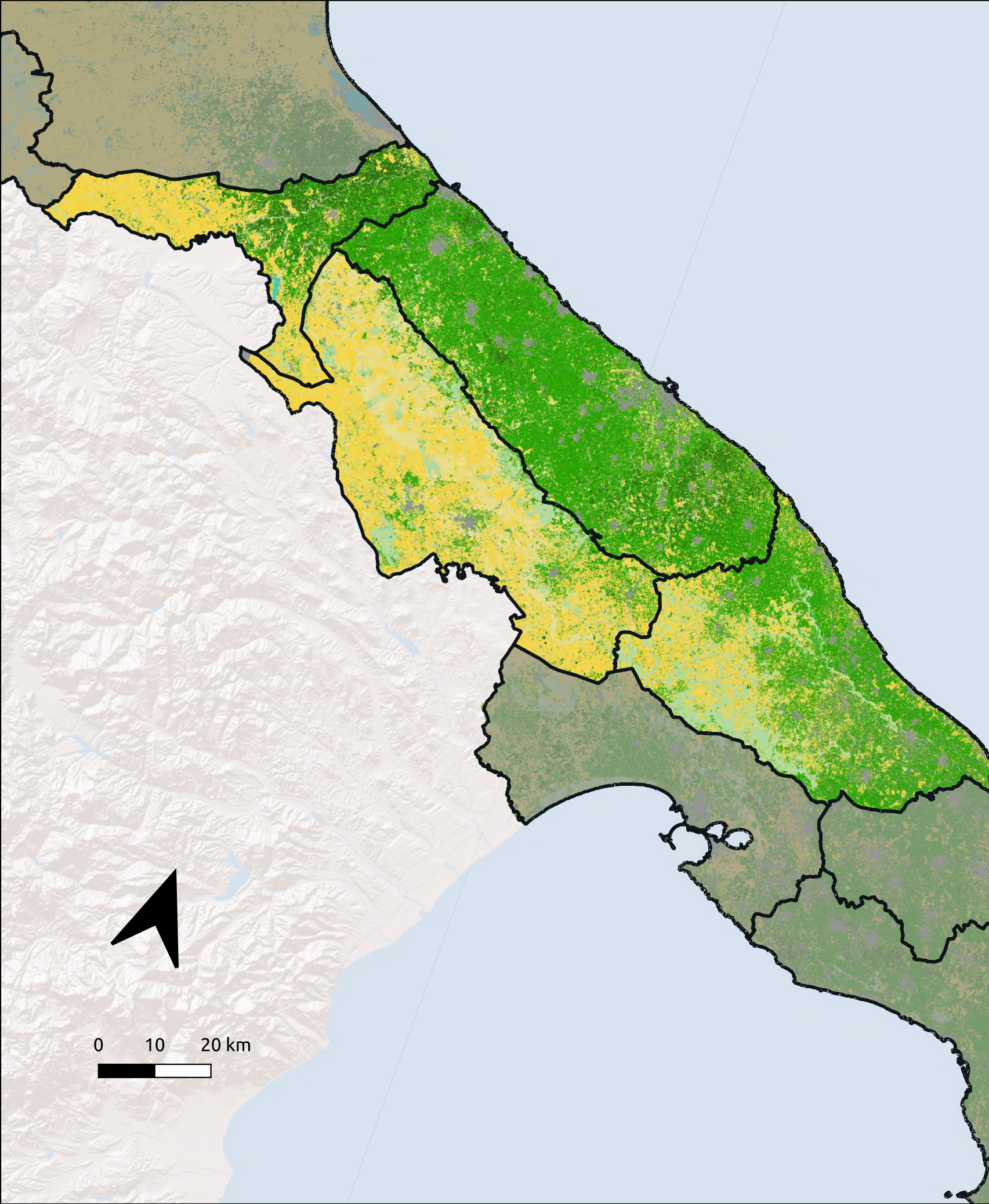
3.

HN VF - tipo 3



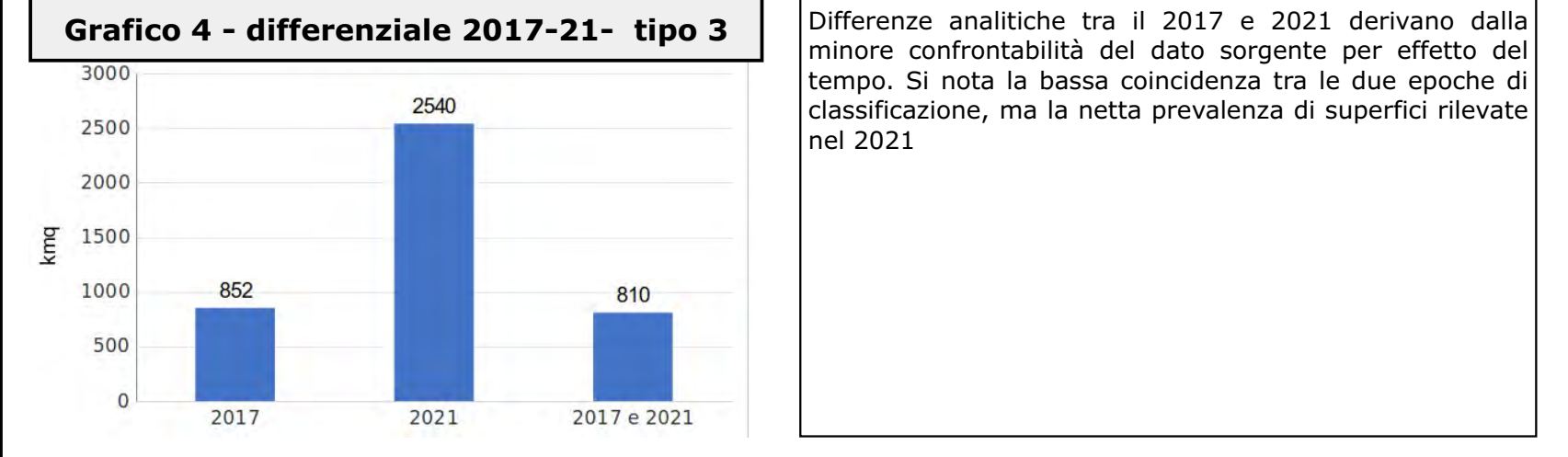
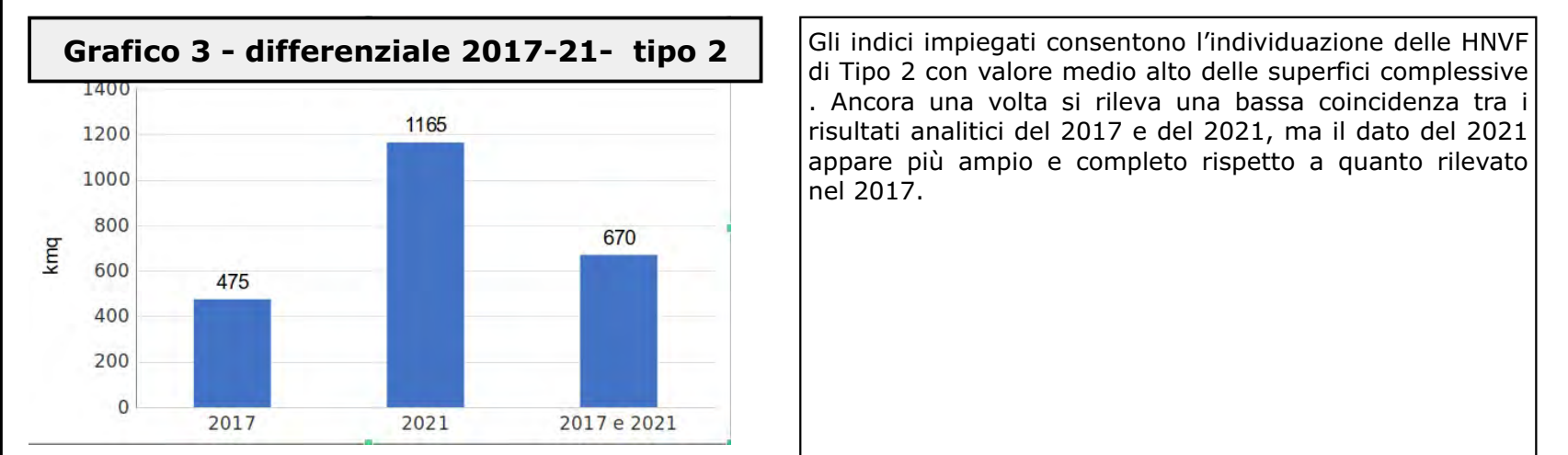
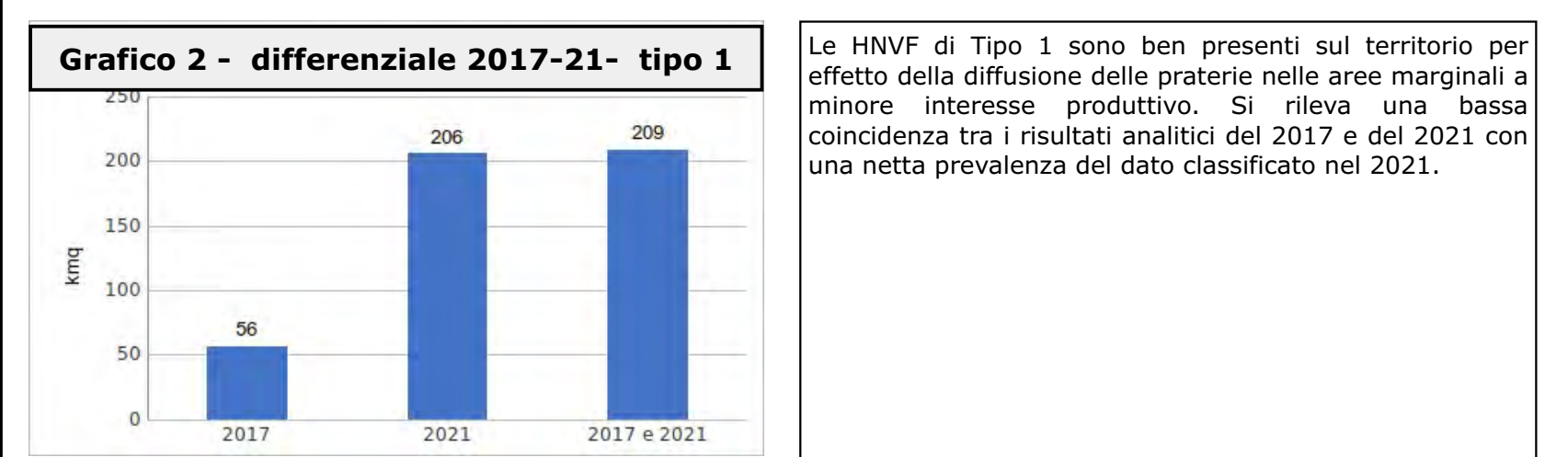
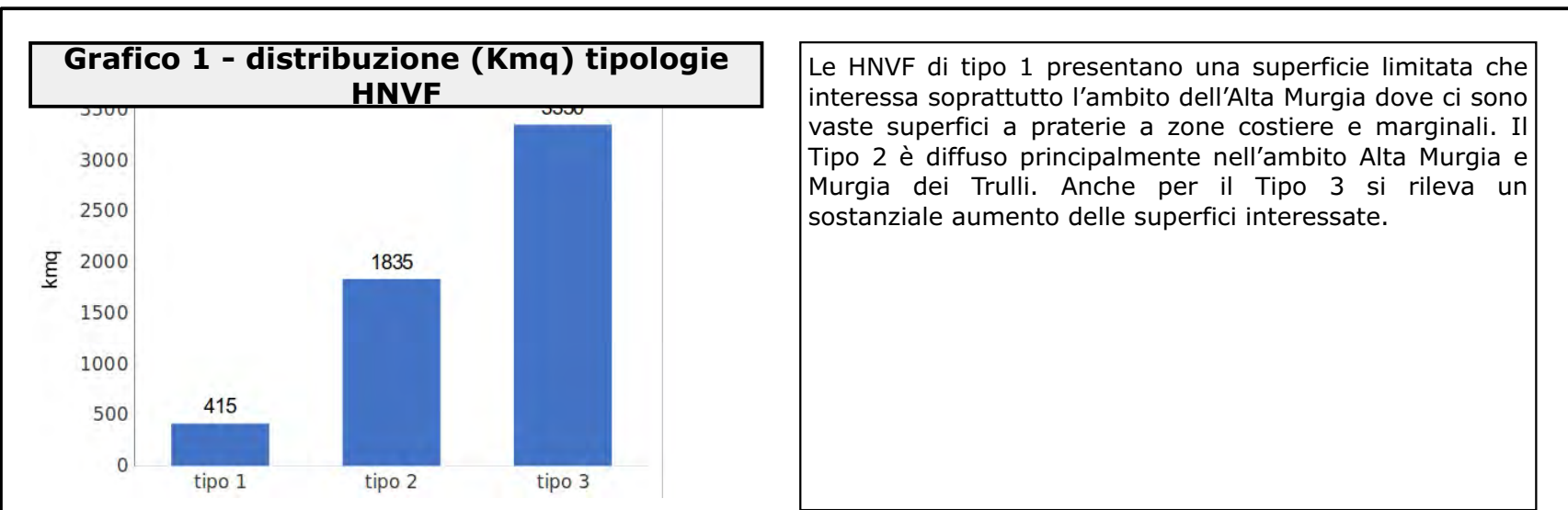
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Uso del Suolo (2021)



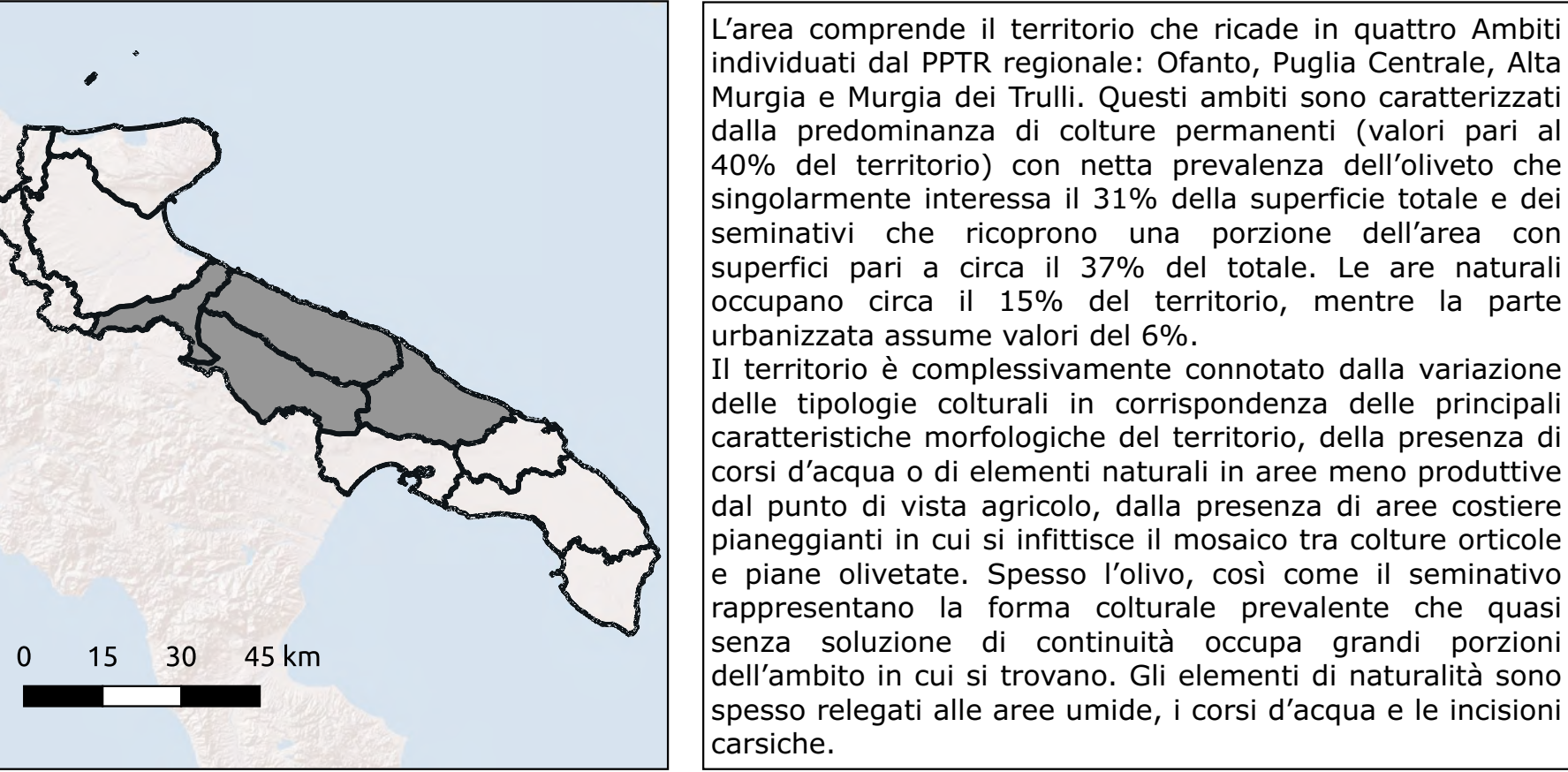
La creazione della carta di uso del suolo è stata portata avanti su immagini da satellite (Sentinel2), per le quali sono stati definiti i periodi di acquisizione di interesse per il presente studio. Per far questo ci si è basati considerando l'esperienza della precedente edizione (2017) nella quale sono stati usati 4 passaggi acquisiti tra aprile e settembre, ma anche rianalizzando le fasi fenologiche della vegetazione e di sviluppo delle colture agrarie nell'intero territorio della regione Puglia. Le immagini scaricate sono Level-2A (già corrette per attenuare il disturbo dell'atmosfera).

La classificazione delle immagini utilizzata è stata di tipo Supervised, con classificatore di tipo Maximum Likelihood (MLK). A questo scopo sono state acquisizione le firme spettrali delimitando 94 ROI (Region Of Interest) o "Training area" appartenenti a varie tipologie di uso del suolo.



a

Inquadramento territoriale



L'area comprende il territorio che ricade in quattro Ambiti individuati dal PPTR regionale: Ofanto, Puglia Centrale, Alta Murgia e Murgia dei Trulli. Questi ambiti sono caratterizzati dalla predominanza di colture permanenti (valori pari al 40% del territorio) con netta prevalenza dell'oliveto che singolarmente interessa il 31% della superficie totale e dei seminativi che ricoprono una porzione dell'area con superfici pari a circa il 37% del totale. Le aree naturali occupano circa il 15% del territorio, mentre la parte urbanizzata assume valori del 6%.

Il territorio è complessivamente connotato dalla variazione delle tipologie colturali in corrispondenza delle principali caratteristiche morfologiche del territorio, della presenza di corsi d'acqua o di elementi naturali in aree meno produttive dal punto di vista agricolo, dalla presenza di aree costiere pianeggianti in cui si infittisce il mosaico tra colture orticole e pianie olivetate. Spesso l'olivo, così come il seminativo rappresentano la forma colturale prevalente che quasi senza soluzione di continuità occupa grandi porzioni dell'ambito in cui si trovano. Gli elementi di naturalità sono spesso relegati alle aree umide, i corsi d'acqua e le incisioni carsiche.

5

Analisi Diacronica 2017-2021

