DYNAMIC-CATENAL PHYTOSOCIOLOGICAL MAPPING OF CORSICA: INDUCTIVE METHODOLOGICAL APPROACH

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Abstract: Since the 1970's, the works of Tüxen, Géhu and Rivas-Martínez on the dynamic-catenal phytosociology, allowed a better integration of vegetation dynamics, by describing more precisely the dynamic trajectories of vegetation series. Since 1973, the context of sigmatist phytosociology extends the conceptual and methodological approach to conservatory management applications of natural and semi-natural vegetations.

Since the end of the XXth century, methodologies for the study of vegetation dynamics have been developed according to various typological and cartographical scalar approaches. Logistic and IT tools have contributed significantly to the research work by integrating a spatial dimension into vegetation dynamics.

The national program for the mapping of natural and semi-natural vegetation in France (CarHAB) was launched in 2010 at the initiative of the Ministry of Ecology, Sustainable Development and Energy (MEDDE). Its aim is to establish an Information System on natural and semi-natural vegetations in France, with a view to developing tools for spatial planning, national policies for nature conservation (strategy for the creation of protected areas...) and European obligations (assessment of the state of conservation of habitats of community interest...). This program is focused on the dynamical and landscape phytosociological method or dynamic-catenal phytosociology. This methodology provides a systematic and integrated analysis of all the biotic and abiotic components and the complexity of the ecological systems of the plant landscape.

This paper explains the methodology of mapping vegetation series and geoseries on various synphytosociological map approaches in Europe, whose aim is:

- to develop a precise and pragmatic methodological approach for mapping the series and geosystems of Corsican vegetation at 1: 25000;
- consider the scientific aspects of the design of maps (work scales, typology, map underlayers ...), techniques and semiology of its realization (colours saturation and tone, forms of expression...).

Keywords: landscape mapping, vegetation series and geoseries, vegetation landscape, CarHAB program, bioclimatic regions and belts, zonal and azonal units, GIS.

Introduction

Several vegetation and habitats maps have been published since the XXth century [122, 111]. The vegetation mapping of France carried out in 1945 by Gaussen *et al.* and Ozenda *et al.* in the Alps [87, 93, 90, 91], the maps of plant communities [44, 45], and more recently [5, 38, 43, 72, 95] demonstrate the interest of vegetation mapping for monitoring and conservation of vegetation, land use and nature conservation issues.

The map of vegetation/vegetation series of France realized at 1: 200,000 under the direction of Henri Gaussen [41, 42], represented a pioneer work in dynamic mapping of vegetation. Focused on physiognomy and phytogeographical approach, this map uses the main forest species as discriminating criteria of the dynamic stages of vegetation series [91]. For four decades, the mapping work of vegetation has moved towards a phytosociological dynamic-catenal approach, in order to model and spatially represent the structural patterns of vegetation landscape, based on the serial and geoserial units [65]. Mapping of vegetation series and geoseries developed strongly all over Europe [126, 124, 30, 109, 118, 29, 71, 8, 2, 23, 24, 78, 47], but it remains punctual in France [64, 52, 53].

The aim of this article is to expose the methodology for mapping vegetation series and geoseries according to a inductive methodological approach. Considering different synphytosociological mapping approaches of neighbouring countries [124, 2, 24, 113, 78], it is aimed to:

- identify a methodological approach for mapping vegetation series and geoseries of Corsica at 1:25000;
- consider the scientific aspects of the map design (working scales, typologies, ecological cartographic underlayer...), the technical and semiologic aspects of its realization (census, landscape diagnosis ...) [121].

The vegetation series of Corsica, were firstly described according to the principles and concepts of dynamic series of Gaussen (1954) and Ozenda (1964, 1982). Such methods and techniques were used by different authors until the 1980's [39, 52, 4, 53, 92].

In Corsica, the first map of vegetation concerning terrestrial plant communities of Capi Corsu was realized by Molinier (1959, 1962). Mapping experiences have developed strongly in the 1980's, in order to provide complementary spatial information at synsystematic and phyto-ecological studies. Corsica has been subject of many mapping work that can be divided into three categories:

- vegetation mapping [54, 74, 107, 94, 99, 79, 100, 101, 102, 115, 96, 116, 80, 17, 103, 81, 106, 117, 105, 119, 104, 120, 18, 19, 20, 97, 98, 95];
- habitat mapping: [86, 21, 34, 33, 35, 137, 135];
- vegetation series mapping (physiognomically *sensu* Gaussen): Gamisans & Grüber (1979) on «Vallée du Niolu», and Gamisans *et al.* (1981b) on «Massif du Haut-Vénacais».

Materials and Methods

Geographic information system

An important part of our research project is to develop a database to gather the data collected on the field. The definition of a dynamic model is necessary to:

- manage phytosociological, synphytosociological and geosynphytosociological data;
- manage referential typology (phytosociological, synphytosociological and geosynphytosociological levels);
- manage all ecological mapping data (geology, bioclimatology, geomorphology, soil...), vegetation maps (plant community map, habitat map...) and land use (CORINE Land Cover, fires map...).

This database should allow to enter and process the information collected during the

proceedings of mapping inventories at different levels of integration of the landscape.

Pesaresi *et al.* (2007) developed a database for Italy, from phytosociological to geoserial levels, based on dynamic relationships between various GIS information tables:

- phytosociological data (phytosociological relevés and phytosociological typology);
- synphytosociological data (synphytosociological relevés and serial typology);
- geosynphytosociological data (geosynphytosociological relevés and geoserial typology).

The database of vegetation series is based on that of Pesaresi *et al.* (2007) while adapting to the aim of our research project. The main layer of information, on which relations are carried out, is made up of objects "vegetation series" and not "plant communities" objects.

The mapping work was carried out under the ArcGIS 10® software. For the realization of GIS, Geodatabase has been established from a database of type "dynamic relationships".

The database is established from two matrices:

- a non-spatial matrix corresponding to synrelevés;
- a spatial matrix on GIS (ArcGIS 10®) which corresponds to polygons of vegetation series.

These two matrix are linked in GIS by the synrelevé number (Fig. 1). This number corresponds to a plant associations number (relationship "1" to "-∞"). This essential relationship allows to obtain the data inside the polygons where a synrelevé is realized.

Figure 1 shows the information flows of the computer system established in the geodatabase for mapping vegetation series and geoseries. The lines represent the relationships between tables: every relationship is a fundamental component to establish a connection between the attributes of the mapped objects. If a vegetation series can characterize a multitude of polygons, a polygon can contain only one set of vegetation (one to many "1 - ∞"). Tables 1, 2 and 3 are generated in the first step under Excel® and are, then, imported to ArcGIS software.

Projection system

The projection system used in mapping to represent on a plan all elements that are located on a sphere, corresponds to the projection coordinate system "RGF93_Lambert_93".

Characteristics of spatial data

Our aim is to represent spatially sigmetal units that are the expression of ecological and anthropogenic phenomena of vegetation landscape. Their components can be expressed in various forms [31]:

- punctual: object size "0" indicates the location by its coordinates;
- linear: described by a succession of points and a series of coordinate pairs [XY];
- superficial: described by two dimensions that are the area and perimeter, the object is defined by a succession of coordinate pairs [XY], the first and last pairs being identical.

In our study, we chose to represent the vegetation series and geoseries only by polygons.

Choice of scale

It makes sense to remember that map object is the corresponding of serial entity observable on field. This fact implies that even if the object and the entity are similar, they may

not be completely identical, in so far as it is impossible to maintain a physical size and be in a 1:1 ratio. The choice of a scale depends on the phenomenon to represent and on the size of the smallest object to make it visible on the map [70, 3, 73].

The scale of a map expresses the ratio of the length measured on this map to the corresponding length field measured horizontally [32, 66]. There are two types of scale [1, 32, 66]:

- "large scale" means that the fraction has a small denominator, for example 1: 5 000 (1 cm= 50 m). It is often used to represent phytosociological objects (plant associations).
- "small scale" means that the fraction has a large denominator, 1: 50,000 (1 cm = 500 m).

This level of scale is used for mapping synphytosociological or geosynphytosociological units.

Within the CarHAB program, the scale of restitution is 1: 25,000 (1 cm=250 m). We retain the 1: 4000 for field scale. The scale of capture has, for certain parts of valleys, being greater (1: 2,500 - 1: 3,000). If this scale is greater than the ground scale, it is above all to refine the contours of the sigmetal objects and not to detour new sigmetal objects. The choice of these two scales was made to obtain a:

- sufficient precision for the spatial representation of sigmetal units;
- complete vision of potential vegetation;
- scale adapted to spatial planning and management.

Inductive methodological approach

Figure 2 shows the three steps for mapping vegetation series.

Definition of environmental compartments (Tessella)

The analysis of the ecological descriptors was carried out with the available map data (Tab. 1).

Table 1 highlights the scaling problems of various ecological descriptors. The restitution scale allows the visualization of vegetation sequence from the sea to the inland. In our project, ecological spatial data at the scales closest to the 1: 25,000 scale of restitution were selected.

Fig. 2: Scheme of inductive methodological approach

Table 1: Spatial ecological data available.

Ecological descriptor	Authors	Shape	Scale	Territory
Geology	Rossi & Rouire (1980)	GIS Raster	1 : 250 000	Corsica
	BRGM (2000)	GIS Vector	1 : 50 000	
Soil	Demartini & Favreau (2011b)	Paper	1 : 25 000	Agricultural sectors of alluvial plains
Bioclimate	ISTHME (2015)	SIG Raster	1 : 25 000	Corsica

Study areas (geographical entities)

The study areas were selected according to their geographical, ecological and plant originality (Tab. 2, Fig. 3).

Table 2: Features of mapped sites.

	Sites	Lithology	Altitude (min-max)	Area mapped (ha)
1	Coastal sites (33)	-	Sea level - 100 m	1246.8
2	Asco valley	Hercynian corsica	230 - 2 700 m	16513.9
3	Niolu valley	Hercynian corsica	345 - 2 700 m	22556
4	Massif of Haut-Vénacais	Hercynian corsica	559 - 2 622 m	7801
5	Cap Corse	Alpine corsica	Sea level - 1 350 m	32842.1
6	Castagniccia (east part of the San Pedrone Massif)	Alpine corsica	Sea level -1 767 m	8267.5
7	Bonifacio limestone plateau	Alpine corsica	Sea level - 95 m	3485.4
8	Plateau of Cuscione (Massif de l'Incudine)	Hercynian corsica	1 105 - 2 129 m	6142.9
Total				98855.6

Typology of geographical entities

34 vegetation series, 14 minoriseries and 30 geopermaseries have been identified [36]. Three typological units have been added for:

- mountain lakes;
- screes/rocks without vegetation;

Delimitation methods

Tools such as ecological white underlayer and the physiognomic underlayer [46, 82] developed within CarHAB could not be directly used in order to identify large ecological landscape units. The mapping of vegetation series was therefore based on bioclimatic, geomorphological and phytogeographical mapping data.

Mapping of vegetation series is mainly based on field observations and completed by photo-interpretation extrapolations for inaccessible sectors. The delimitation of vegetation series was divided into three steps (Fig. 4):

- photo-interpretation;
- field observation and verification;
- digitization.

Fig. 3: Study areas. 1 - Asco valley; 2 - Capi Corsu; 3 - Niolu valley; 4 - “Massif du Haut-Vénacais” valley; 5 - “étang de Biguglia» pond; 6 - Bonifacio limestone plateau; 7 - Castagniccia (east part of the «Massif du San Pedrone»; 8 - «Massif de l’Incudine»; * - 30 coastal sites.

Fig. 4: Method to delimit ecological entities (tessella)

Minimal map area

Within the CarHAB program, the area of the smallest mappable object is 0,5 ha for a rendering mapping at 1: 25 000. This minimal area can be discussed because it depends on how the object appears in the landscape: if a 0,5 ha object appears in a linear way, it is not very perceptible on the map; on the other hand, a polygon-like object is apparent on the map at 1: 25 000. For this research project, the mapped minimum area retained is 0,25 ha [36].

Special case of coastal vegetation

The coastal area constitutes an important part of Corsica [67]. It corresponds to the "land-sea" interface and is subject to ecological processes which induce a rapid change in the succession of vegetation, from the sea to the inland. The analysis of specific dynamic processes of coastal areas requires a high-resolution, spatio-temporal mapping approach [72].

The survey scale should be sufficiently precise to establish a boundary between geopermaseries and minoriseries. Individualization of geopermaserial and minoriserial envelopes is based on orthophotographs, topography (BD Alti) and the major physiognomic types of vegetation (thicket and grassland vegetation). The scale of field surveys used for coastal vegetation is 1: 4000. The mapping restitution scale depends on the diversity of mapped objects and their spatial extension (length and width). The choice of the restitution scale for coastal units is 1: 10 000.

Map interpretation of ecological descriptors

Map of ecological descriptors (geology, soil, bioclimatology, topography) allows a first segmentation of homogeneous ecological entities (or tessellar envelopes). This first division distinguishes three main types of objects:

- coastal azonal units: distinguished by their geomorphological configuration (sandy beaches, pebble beaches, sandy-gravel terraces, salty vases and rocky coasts).
- riparian units: from low-altitude to high-altitude floodplains.
- urbanized areas: constituted by specific polygons.

This division was automatically re-evaluated and re-adjusted in the field due to the scalar disparities of ecological descriptors and sometimes unperceivable orographic effects on orthophotographs (geomorphological and topographical micro-variations).

Field Step

The field step allows to redefining the delimitation of azonal units, making differences between the serial units types. For climatophilous and edaphoxerophilous series, observations and changes in vegetation made it possible to set a limit between two vegetation series.

Input and scanning procedure

Mapping of vegetation series implies that only the current potential vegetation is delimited. The map of the series represents only the potentiality of the vegetation and not the dynamic stages which compose them, despite the obvious linkage between the map of vegetation series and the explanatory note. The dynamic stages composing the series are not represented. The delimitation of serial units can be established based on two approaches (Fig. 5):

- the approach following the delimitation of all components of the vegetation series (Fig 5a);

- the approach following the delimitation of tessellar envelopes (Fig 5b).

Fig. 5: Example of delimitation of serial objects in Capi Corsu region. a - Delimitation of all components of vegetation series. b - Delimitation of the tessellar envelopes.

Synrelevés were carried out on components of vegetation series and not on tessellas: this choice allows to keep this delimitation only for polygons including synrelevés. Elsewhere, the segmentation of tessellar envelopes was retained. Once the delimitation mode is selected, information collected in the field are imported into an attribute table in GIS that comprises several fields (Tab. 3).

Table 3: Identification of polygons and information on vegetation series: structure of the attribute table.

Field	Notice	Type of field	Example
OBJECTID	Automatic order number generated by GIS	Integer (automatic number)	147
REGION	Information about the area in which the polygon lies (text).	text	CORSICA
CODE_DPTMT	Each French department is identified by a unique number followed by the geographical code of France: 2A (Corse-du-Sud), 2B Haute-Corse.	text	2B
NAME_DPTMT	Name of department	text	Haute-Corse
CODE_INSEE	INSEE code from the website: http://insee.fr/fr/methodes/nomenclatures/cog/	text	20276
NAME_COMM	Optional field indicating the name of the municipality	text	Asco

NAME_OBS	Name of the observer	text	Pauline Delbosc
ORGANISM	UBO and CBNC	text	UBO-CBNC
YEAR		text	2012
ALTITUDE	Average altitude in meters	Double real	1705
SLOPE	Average slope in degrees	Double real	14
EXPOSITION	North; South ; East ; West ; South East ; South West ; North East ; North West	text	South-East
AREA	The area is indicated in hectares	Double real	10.07
GEOLOGY	According to the typology of geological map of Corsica (Rossi & Rouire 1980).	text	Alkaline rhyolites: sills and domes
GEOMORPHO	According to the topographical and geomorphological typology used for the approach of vegetation series in Corsica (Delbosc 2015)	text	Slope habitat
SOIL	According to the typology of soils of Corsica (Synthesis after Favreau 2002 and Favreau & Demartini 2011).	text	Cryosols
BIOCLIMATE	According to the typology of bioclimate of Rias-Martínez (2004)	text	Hyper-humid
VEG_BELT	Riparian azonal unit; coastal azonal unit; thermomediterranean; lower mesomediterranean; upper mesomediterranean; supramediterranean; oromediterranean; cryo-oromediterranean; subalpine; alpine.	text	Oromediterranean
CODE_SERIES		text	51
NAME_SERIES	Name of series	text	Climatophilous Corsican series, of humid- hyperhumid oromediterranean level with <i>Luzula</i> <i>pedemontana</i> and <i>Pinus nigra</i> subsp. <i>laricio</i> on crystalline substrate
HEAD_SERIES	Corresponds to the head of series	text	<i>Galio rotundifolii</i> - <i>Pinetum laricionis</i> <i>luzuletosum</i> <i>pedemontanae</i>
SIGMETUM	Name of sigmetum	text	<i>Galio rotundifolii</i> - <i>Pineto laricionis</i> sigmetum variant with <i>Luzula</i> <i>pedemontana</i>

TYPE_SERIES	Type of landscape unit: Climatophilous, edaphoxerophilous, edaphohygrophilous...	text	Climatophilous
NUM_RELEVÉ	Enter the relevé number Specify "VOID" if no relevé	text	PADE241
POT_VEG	Potential natural vegetation	text	-
ANTHR_FACT	The field "anthropogenic factors" takes into account the mode of exploitation of areas: urbanization (degree of urbanization); grazing; mowing; agriculture (crops); fire	text	grazing and fire

Analysis of mapping data

The interpretation of vegetation landscape can be performed based on two coefficients, reviewed by Foltête & Tolle *in* [28]:

- the abundance-dominance coefficient concerns the extension of each component in the landscape and is expressed in relative frequencies.
- the spatial configuration coefficient that describes the shape of mapped objects.

From a phytosociological dynamic-catenal point of view, it is necessary to describe the shape of each series and its catenal positioning in the landscape.

Synthetic mapping step

The map must include essential informative elements (title reflecting the information contained in the map, information about the data and layers used, scale bar, legend, north arrow).

Legend

The organization of the legend follows a principle of coherence in order to standardize the structuring of all the typological posts. The legend of vegetation series has been analyzed from several works [124, 77, 24, 78, 111]. Two main groups of organizations emerge from Italian and Spanish schools.

The construction of the legend corresponds to a structured set of typological posts that:

- take into account large typological units (coastal azonal units, vegetation stages, azonal units...);
- integrate ecological systems of landscape: these systems are essentially valid for coastal units that differ according to their geomorphology (sandy beaches, sandy gravel terraces, pebble beaches, salted vases and rocky coasts);
- highlight different serial units (geopermaseries, minoriseries and series);
- integrate ecology of serial units (climatophilous, edaphoxerophilous, edaphohygrophilous).

Graphic semiology

Color is widely used as a visual variable in cartography because it improves document description and contributes to its aesthetic content. In vegetation mapping, the principles of graphic semiology are based on the works of Gaussen [55, 56, 57, 58, 59, 60], Emberger (1961) and Dupias *et al.* (1965).

Each color represents an ecological expression of the studied vegetation [59]: warm colors (red and orange) are attributed to dry vegetations of mediterranean types, submediterranean vegetations are represented in yellow and green, and montane in cold colors (blue, purple). This semiologic principles was taken up by Dupias *et al.* (1965) whose aim was to visualize the arrangement of vegetation according to an altitudinal gradient (vegetation belts). These semiologic principles have been preserved for mapping of vegetation series and geosystems in many European countries: Italy [108, 24, 15, 12, 112, 110, 26, 2, 24, 25, 111]; Spain [134, 124, 76, 136, 78]; Germany [128]; Switzerland [129, 6, 7, 8] and France [40, 52, 53, 20].

The idea of assigning and representing a specific color to a vegetation series corresponds to our objective of dynamic classification where the dynamic stages of series correspond to ecological conditions that determine the head of series [59, 40]. Beyond this approach, no conventional representation or national semiological code has been truly established. It seems important to propose semiological nomenclatural principles to represent landscape units according to vegetation belts and singularities of studied environments:

- Vegetation belts. One color was associated per vegetation belt: warm colors for low-altitude belts (red and orange respectively representing thermomediterranean and mesomediterranean belts); (green for supramediterranean, purple for montane-oromediterranean, green-blue for cryo-oromediterranean, pink for subalpine and blue-black for alpine belt). The color of each belt is declined into a gradient to differentiate the serial units. A numeric code has been assigned for each serial unit.
- Specificity of coastal units. From a typological point of view, the coastline has been apprehended according to ecological systems (sandy beaches, pebble beaches, rocky coasts ...). This approach has also been used in definition of semiological code: one specific color has been assigned for each ecological system [2, 24, 78].
- Riparian units were distinguished from marshy units by two types of blue: green-blue for marshy units and blue for riparian units.

White has not been used because it does correspond to the absence of vegetation [60]. Heterogeneous textures could have been used for distinguishing mapping objects but this choice limits the reading of map and introduces a quantitative character: textures have not been retained. One of mapping principles stated by Gaussen (1961b) is not to mix color and texture.

Results

The Asco valley (16513.9 ha) is characterized by 26 serial and geoserial units: 12 series, 4 minoriseries, 8 geopermaseries and two non-vegetable units (urbanized areas (villages, hamlets) and screes/rocks) (Table 6).

This valley is characterized by three major units (Fig. 7):

- (51) *Galio rotundifolii*-*Pineto laricionis* sigmetum variant with *Luzula pedemontana*: 3339.3 ha (20.2% of mapping area);
- (25) *Galio scabri*-*Querceto ilicis* sigmetum variant with *Lathyrus venetus*: 2530.5 ha, i.e. 15.3% of mapping area);
- *Junipero oxycedri*-*Querceto ilicis* sigmetum extends over 2456.9 ha (14.9% of mapping area).

Fig. 6: Principles of organization of the legend.

Table 4: Typology, area and proportion of different vegetation series and geoseries in the “Asco Valley”.

Code of series	Name of series	Sigmatum	Vegetation belt	Area (ha)	Area percent (%)
25	Oak climatophilous series on crystalline substrates (<i>Lathyrus venetus</i> variant)	<i>Galio scabri-Querceto ilicis</i> sigmetum (<i>Lathyrus venetus</i> variant)	Upper mesomediterranean	2530.5	15.3
28	Boxwood and oak edaphoxerophilous series of acidophilous alluvial systems	<i>Buxo sempervirentis-Querceto ilicis</i> sigmetum	Lower mesomediterranean	611.4	3.7
31	Juniper scrub edaphoxerophilous minoriseries on crystalline substrates	<i>Stachydo glutinosae-Genisteto corsicae</i> minorisigmatum (<i>Juniperus oxycedrus</i> variant)	Upper mesomediterranean	383.2	2.3
32	Juniper scrub edaphoxerophilous minoriseries on crystalline substrates	<i>Stachydo glutinosae-Genisteto corsicae</i> minorisigmatum	Lower mesomediterranean	11.8	0.1
33	Chasmophytic and chomophytic vegetation geopermaseries on crystalline rocky cliffs in mesomediterranean belt	<i>Saxifrago tridactylitis-Sedeto stellati</i> geopermasigmatum	Upper mesomediterranean	23.7	0.1
38	Juniper and oak climatophilous series on crystalline substrates	<i>Junipero oxycedri-Querceto ilicis</i> sigmetum	Supramediterranean	2456.9	14.9
39	Laricio pine edaphoxerophilous series on crystalline substrates	<i>Galio rotundifolii-Pineto laricionis</i> sigmetum (<i>Erica arborea</i> variant)	Supramediterranean	1318.6	8.0
42	Maple edaphohygroclinous series on crystalline substrates	<i>Fraxino orni-Acereto monspessulani</i> sigmetum	Supramediterranean	401.2	2.4
44	Maple and oak edaphoanthropophilous series on crystalline substrates	<i>Acero monspessulani-Querceto ilicis</i> sigmetum	Supramediterranean	38.4	0.2
45	Juniper scrub edaphoxerophilous minoriseries on crystalline substrates	<i>Helichryso italici-Genisteto salzmännii</i> minorisigmatum	Supramediterranean	5.8	0.04
47	Chasmophytic and chomophytic vegetation geopermaseries on crystalline rocky cliffs in the supramediterranean belt	<i>Sedo brevifolii-Diantheto godroniani</i> geopermasigmatum	Supramediterranean	263.4	1.6
51	Laricio pine climatophilous series on crystalline substrates	<i>Galio rotundifolii-Pineto laricionis</i> sigmetum (<i>Luzula pedemontana</i> variant)	Oromediterranean	3339.3	20.2

54	Chasmophytic and chomophytic vegetation geopermaseries on the crystalline cliffs in the montane belt	<i>Doronic corsici-Narthecieto reverchonii</i> geopermasigmetum	Oromediterranean	1013.4	6.1
56	Juniper scrub climatophilous minoriseries on the crystalline substrates	<i>Paronychio polygonifoliae-Armerio multicepitis</i> minorisigmetum	Cryo-oromediterranean	634.5	3.8
57	Maple edaphohygroclinous series on crystalline substrates	<i>Sorbo aucupariae-Acereto pseudoplatani</i> sigmetum	Subalpine	1446.9	8.8
58	Geopermaseries on the crystalline rocks in the subalpine belt	<i>Geo montani-Phleeto brachystachydis</i> geopermasigmetum	Subalpine	809.5	4.9
59	Geopermaseries on the crystalline screes in the subalpine belt	<i>Valeriano rotundifoliae-Adenostyleto briquetii</i> geopermasigmetum	Subalpine	488.2	3.0
60	Geopermaseries on the crystalline rock massifs in the alpine belt	<i>Acino corsici-Tanaceteto tomentosii</i> geopermasigmetum	Alpine	467.5	2.8
61	Geopermaseries on the crystalline screes in the alpine belt	<i>Doronic grandiflori-Oxyrieto digynae</i> geopermasigmetum	Alpine	8.0	0.05
62	Alder edaphohygrophilous acidophilous Corsican series on peat substrates	<i>Dryopteridi carthusianae-Alneto glutinosae</i> sigmetum	Peat azonal unit	33.7	0.2
67	Alder edaphohygrophilous riparian series on low altitude, alluvial substrates	<i>Eupatorio corsici-Alneto glutinosae</i> sigmetum	Riparian azonal unit	62.4	0.4
70	Cyclamen and Phillyrea latifolia edaphohygrophilous minoriserie	<i>Cyclamino repandi-Phillyreeto latifoliae</i> minorisigmetum	Riparian azonal unit	34.7	0.2
71	Alder riparian series on high altitude, acidic, alluvial substrates	<i>Athyrio filix-feminae-Gentianeto asclepiadeae</i> sigmetum	Riparian azonal unit	78.4	0.5
74	Temporal hygrophilous geopermaseries on alluvial substrates	<i>Dittricho viscosae-Saliceto purpureae</i> geopermasigmetum	Riparian azonal unit	1.1	0.01
80	Screes, rocks	-	Riparian azonal unit	0.4	0.003
81	Urban areas	-	-	50.7	0.3
Total				16513.9	100

Four other units mark the vegetation landscape of the Asco valley: *Sorbo aucupariae-Acereto pseudoplatani* sigmetum (1446,9 ha, 8,8%), *Galio rotundifolii-Pineto laricionis* sigmetum variant with *Erica arborea* (1318.6 ha, 8%), *Doronico corsici-Nartheccio reverchonii* geopermasigmetum (1013.4 ha, 6.1%) and *Geo montani-Phleeto brachystachydis* geopermasigmetum (809.5 ha, 4.9%).

This valley includes a very peculiar series, endemic of the bottom of the Asco valley: *Dryopteridi carthusianae-Alneto glutinosae* sigmetum (33.7 ha).

In a regional context, the Asco valley presents a great diversity of serial units, with 24 serial units (excluding the no-vegetation units), which represent 32% of the sigmetum richness of Corsica. Mapping of vegetation series can be easily transposed into mapping of vegetation belts.

Discussion

Mapping of vegetation series highlights the complexity of the main structural patterns of Corsica. It helps to a better understanding of sigmacoenotic diversity according to a pluri-structural approach, from plant association to vegetation series [9, 10].

The simultaneous representation of sigmetum and geosigmetum on the same map involves considering two hierarchical levels of vegetation landscape: the serial and the geoserial levels [124, 2, 24, 78]. It allows the spatial representation of vegetation complexes with an objective point of view.

Mapping of vegetation series integrates a significant number of landscape properties while being synthetic. For a given polygon, the information available in the descriptive note consist in the name of vegetation series and its different dynamic stages. It should however be noted that this map remains little interactive: the information is available only for the polygons that have been synthesized.

As vegetation series mapping represents only the potential natural vegetation, it is a limitation. Even if a GIS technique has been set up to link synrelevés to polygons (join of the main attribute table with the table of synrelevés), it remains limited in so far as this data are only accessible under GIS. The VegFrance national platform aims to organize and structure the typology of French vegetation. This platform constitutes a database related to the mapping of national territory within the framework of CarHAB program [27, 127].

Roux *et al.* (2015) proposed a specific module of VegFrance called "SYNPHYTO", in order to integrate serial and geoserial data, and link with map data. This project will facilitate the reading of maps by means of dynamic links between the database of synrelevés and geosynrelevés with the maps.

In Corsica, delimitation of vegetation series remains fairly easy as the vegetation zonation is rather well marked from the coastal zone to the alpine belt:

- for coasts, orthophotographs analysis reveals a clear change in physiognomy of vegetation: in general, the anemomorphic vegetations are readable on photographs; the internal limit of coastal vegetation corresponds to anemomorphosed thickets.
- zonal series follow the altitudinal gradient. The main difficulties arise when ruderal or very disturbed vegetation is spread over two vegetation beltss, as it is the case for *Pruno spinosae-Rubion ulmifolii*.

Fig. 7: Distribution of vegetation series and geoseries in the Asco Valley (see the herein folded map and the legend on the next page).

Vegetation series and geoseries of Corsica

Crystalline mountains

ASCO VALLEY

Rendering Scale: 1 : 80 000

Scale of field surveys: 1 : 4 000

Size of area: 16 526 ha

Inventories: Delbosc P., Bioret F. & Panaïotis C.

Typology of vegetation series: Delbosc P., Bioret F. & Panaïotis C.

Entering and digitization of data: Delbosc P.

Average annual rainfall (mm)

Average annual temperatures (° C)

Ombrothermic types

Slopes

Vegetation belts

Site

MEDITERRANEAN BIOCLIMATIC REGION	ALPINE BIOCLIMATIC REGION
<p>Mesomediterranean</p> <p>25 <i>Galio scabri-Querceto ilicis</i> sigmetum variant with <i>Lathyrus venetus</i></p> <p>28 <i>Buxo sempervirentis-Querceto ilicis</i> sigmetum</p> <p>31 <i>Stachydo glutinosae-Genisteto corsicae minoris</i>sigmetum variant with <i>Junciperus oxycedrus</i> subsp. <i>oxycedrus</i></p> <p>32 <i>Stachydo glutinosae-Genisteto corsicae minoris</i>sigmetum</p> <p>33 <i>Saxifrago tridactylites-Sedeto stellati</i> geopermasigmetum</p> <p>Supramediterranean</p> <p>38 <i>Junipero oxycedri-Querceto ilicis</i> sigmetum</p> <p>39 <i>Galio rotundifolii-Pineto laricionis</i> sigmetum variant with <i>Erica arborea</i></p> <p>42 <i>Fraxino orni-Acereto monspessulani</i> sigmetum</p> <p>44 <i>Acero monspessulani-Querceto ilicis</i> sigmetum</p> <p>45 <i>Helichryso italici-Genisteto salzmannii minoris</i>sigmetum</p> <p>47 <i>Sedo brevifolii-Diantheto godroniani</i> geopermasigmetum</p> <p>Montane-Oromediterranean</p> <p>51 <i>Galio rotundifolii-Pineto laricionis</i> sigmetum variant with <i>Luzula pedemontana</i></p> <p>54 <i>Doronico corsici-Narthecieto reverchonii</i> geopermasigmetum</p> <p>Cryo-Oromediterranean</p> <p>56 <i>Paronychio polygonifoliae-Armerieto multicepitiis minoris</i>sigmetum</p>	<p>Subalpine</p> <p>57 <i>Sorbo aucupariae-Acereto pseudoplatani</i> sigmetum</p> <p>58 <i>Geo montani-Phleeto brachystachyi</i> geopermasigmetum</p> <p>59 <i>Valeriano rotundifoliae-Adenostylecto briquetii</i> geopermasigmetum</p> <p>Alpine</p> <p>60 <i>Acino corsici-Tanaceteto tomentosi</i> geopermasigmetum</p> <p>61 <i>Doronico grandiflori-Oxyrieto digynae</i> geopermasigmetum</p> <p>HYGROPHILOUS AZONAL UNITS</p> <p>Azonal units of peat bogs</p> <p>62 <i>Dryopterido carthusianae-Alneto glutinosae</i> sigmetum</p> <p>Riparian azonal units</p> <p>67 <i>Eupatorio corsici-Alneto glutinosa</i> sigmetum</p> <p>70 <i>Cyclamino repandi-Phillyreeto latifoliae</i> sigmetum</p> <p>71 <i>Athyrio filix-feminae-Gentianeto asclepiadeae</i> sigmetum</p> <p>74 <i>Dittricho viscosae-Saliceto purpureae</i> geopermasigmetum</p> <p>NON-VEGETATION COVERED UNITS</p> <p>79 <i>Lakes</i></p> <p>81 <i>Urban areas</i></p>

- for riparian azonal units, the main difficulty arises with altitude, due to narrow streams. They are represented by polygons and not by lines, in order to keep an homogeneous treatment of objects and to facilitate the analyzes.
During mapping work, several difficulties were raised:
- locating and interpreting the vegetation series of wooded slopes with limited access (Asco valley, Niolu valley, Capi Corsu and Castagniccia...). Since landmarks are rare in forests, the location, interpretation and delimitation of landscape features are often difficult, which is a source of potential error;
- mapping of series developed on rock faces. The horizontal projection of series colonizing vertical surfaces makes their individualization random. This is the case for rocky cliffs geopermaseries.

In these cases, it was chosen to photo-interpret them by taking into account the adjacent vegetation. The GPS integrated digital tablet (integrating Scan 25 and orthophotographs) was useful to overcome these difficulties.

As mapping vegetation series is an interpretation of landscape made by an observer, the limits and perception of vegetation units may vary. The map represents a synthetic tool where all the information observed cannot be transcribed. This is the case for permaseries of screes and rock outcrops, which are expressed within a vegetation series and whose small area make them not visible on the map.

A solution would have been to georeference these punctual units by GPS and to create a separate layer of information, before overlapping them on the map of objects. This option was not chosen for two reasons:

- homogenization: unlike coastal, thermomediterranean and mesomediterranean belts where the sectors are accessible, the problem arises with altitude. The distribution of these data would have been heterogeneous on mapped areas;
- readability of the map: for sectors comprising a large number of point units, the readability of map would have been limited due to the overload of information;
- homogeneity of grain of information.

Some sigmetal units that are expressed in a linear or a punctual way have been represented on the map. This is the case of the riparian azonal units of high altitude characterized by narrow rivers, which may appear to be over-represented in terms of proportional area. This technical mapping problem can be avoided depending on the scale of approach and the choices made regarding the area of the smallest mapped object. The tests carried out showed that the area of the smallest mapping object was 0,25 ha. Such amount has the advantage of being able to represent serial units of small area, especially in environments under strong ecological constraints (shorelines and rock massifs at high altitude).

If vegetation maps remain actual for a period of about five years, vegetation series maps are timeless. The definition of tessellar envelopes, or individuals of vegetation series, constitutes a stable ecological envelope in time and space [63, 64, 69]. From such maps, it is possible to obtain thematic maps, such as mapping of vegetation belts [52, 53].

The 1: 25,000 scale is a fine and precise map scale. Giacomini (1961) pointed out that the preferable scale for mapping an entire country was 1: 200,000, since the 1: 100,000 would slow down its realization and would be very time consuming. In the case of the highly overlapping series (especially, climatophilous series), the 1:25,000 scale makes it possible to clearly visualize

their cartographic distribution, but this is not the case for coastal zones. The coastal azonal units develop linearly and are not easily visible at 1: 25,000. Our choice was therefore a mapping rendering between 1: 10,000 and 1: 13,000.

The delimitation of vegetation series and geoseries is realized by a manual segmentation. The first versions of the «white» underlayer or ecological underlayer for Corsica are only available since the end of 2013, and the improvement tests were only carried out in 2014. The ecological white underlayer has therefore not been used, but constitutes a research perspective.

Each valley and massif have its own bioclimatic, geomorphological and geomorphological identity, providing an ecological singularity. Causal and dynamic comparative analysis of vegetation series between sectors will make it possible to compare vegetation systems according to major entities. That is matching the concept of a functional landscape cell. These entities represent current landscape elements, characterized by a main economic function, which is sufficiently durable and has contributed to shaping its physiognomy and biological value.

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CARTAREA FITOSOCIOLOGICĂ DINAMICO-CATENALĂ A CORSICĂI: O ABORDARE METODOLOGICĂ INDUCTIVĂ

(Rezumat)

Programul național de cartare a vegetației naturale și seminaturale a Franței (CarHAB) a fost lansat în 2010 la inițiativa Ministerului Ecologiei, Dezvoltării Durabile și Energiei. Scopul acestui program este să implementeze un sistem informatic despre vegetația naturală și seminaturală din Franța, în vederea dezvoltării de instrumente pentru planificare teritorială, politici naționale de conservare a naturii (strategia instituirii de arii protejate ...) și angajamente europene (evaluarea stării de conservare a habitatelor de interes comunitar ...). Acest program se bazează pe metoda fitosociologiei peisagere și dinamice, denumită și fitosociologie dinamico-catenală. Această metodologie permite o analiză sistematică și integrată a tuturor componentelor biotice și abiotice, precum și a complexității sistemelor ecologice ce compun peisajul vegetal.

Lucrarea de față prezintă metodologia cartării seriilor de vegetație și geoseriilor, aplicată sub diverse forme de hărți sinfitosociologice din Europa. Obiectivele prezentului studiu au fost:

- să propună o abordare metodologică pragmatică și precisă pentru cartarea seriilor și geoseriilor de vegetație din Corsica la scara 1:25000;
- să ia în considerare aspectele științifice (scara de lucru, tipologia, straturile suprapuse, ...), tehnice și semiologice (tonul și saturația culorilor, formele de expresie, ...) legate de design-ul și realizarea hărților.

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