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# The vegetation map of France going numerical: a new harmonised national geographical database

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## Keywords

Numerical mapping; Geographical Information System; digitalisation; harmonisation; scan; vegetation series; vector; potential vegetation.

## Abbreviations

BDGveg\_FR = *Base de Données Géographique de la VÉGétation de la France* (geographical database of the vegetation of France)

CNRS = *Centre National de la Recherche Scientifique* (French national centre for scientific research)

VMU = Vegetation Mapping Units

## Abstract

In this paper we present the digitalisation of the map of the vegetation of France edited in 64 sheets by the CNRS between 1947 and 1991. The geographical covers and the databases built during this work are gathered in a geographical database called “*Base de Données Géographique de la VÉGétation de la France*” (BDGveg\_FR). The main covers show respectively the vegetation succession stages, as a georeferenced scan, at 1/200,000, and the harmonised map of the potential vegetation, in a vector format, at 1/1,000,000. The harmonised map of the potential vegetation is linked with a national 6-level typology synthesised from the keys of the 64 sheets. The BDGveg\_FR is unique because of its period of time, its local and national scales, its exhaustive cover, and its information on the plant associations. Thus, it is actually complementary to the other databases on the French vegetation presently available. It is particularly well appropriate to assess the impact of global changes (*e.g.* climate, atmospheric pollution) on ecosystem behaviour.

## Introduction

Between 1947 and 1990, the “*Centre National de la Recherche Scientifique*” (CNRS) published 64 paper sheets which form a vegetation map of the metropolitan French territory. This vegetation map draws two kinds of information: the succession stages at the date of the survey and the natural potential vegetation, *i.e.* the vegetation that should develop considering the partly irreversible environmental changes (see Ozenda, 1986; Härdtle, 1995). This paper map is a unique source of information for the French territory with its detailed scale, the period of time it concerns, its exhaustive cover, and the vegetation data it provides (Rey, 2009). In this note we present the digitalisation of the vegetation map of the CNRS, the geographical covers, and the databases produced. A detailed description of the mapping process, the maps produced as well as several applications is available in Leguédais *et al.* (2011).

## Mapping sources

Each sheet of the vegetation map of the CNRS includes:

- the map *sensu stricto* at 1/200,000 which gives the succession stages at the time of the survey;
- a series of seven insets at 1/1,250,000 characterising the agricultural and ecological conditions of the mapped territory and, among them, the botanical inset which represents the natural potential vegetation;
- a detailed key specific to the sheet.

The global coherence of the vegetation map of the CNRS has been ensured (Gauquelin *et al.*, 2005) by: (i) a relatively short surveying period (80 % of the 64 sheets were edited between 1963 et 1985), (ii) the small number of main authors (19 authors are responsible for 94 % of the sheets), (iii) the centralised management (the “*Service de la Carte de Végétation*” created in 1945 in Toulouse) and, (iv) a common mapping method even though the mapping rationales have been adapted with the authors and the periods. The cornerstone of this classification is the succession which actually reflects the different stages leading to the climax vegetation. However some mapped vegetation series represent only one single stage of the succession like pine forests or some oak forests in lowland. Moreover, depending on the authors, the mapped natural potential vegetation can reflect either the site natural conditions only, or the site natural conditions plus the durable man-made changes (*i.e.* pollution, soil erosion, drainage, species naturalisation like Maritime Pine in the Landes). Despite these mapping inconsistencies inherent to each classification system, the data provided by the vegetation map of the CNRS is a unique, reliable, detailed, rare, and exhaustive source of information for the considered period.

## Digitalisation and harmonisation

A set of digitalisation and harmonisation procedures have been followed to produce the different items constituting the BDGveg\_FR.

The map *sensu stricto* as well as the insets (except the relief inset) of the 64 sheets have been scanned at high resolution (600 dpi) and then patched as well as georeferenced to produce seven continuous raster covers for the whole metropolitan French territory. The georeferenced scan at 1/200,000 issued from the map *sensu stricto*, is the succession stage cover which reproduces the original paper map. The six others georeferenced scans are secondary covers which represent the 1/1,250,000 insets of the paper map: botanical data, soil conditions, soil use, agriculture, climate, and agricultural restrictions.

The harmonised vector cover of the natural potential vegetation at 1/1,000,000 is based on the 1/1,250,000 botanical insets of each of the 64 sheets of the paper map of the CNRS. Because of the inconsistencies of classification between the different sheets (see previous section) a harmonisation work was needed. This harmonisation has been done in two steps: firstly the synthesis of a national typology based on the legends of the 64 maps at 1/200,000 and, secondly, the digitalisation of the botanical insets. The general idea of the synthesis of the typology was to homogenise, as efficiently as possible at a national level, the information of the 64 sheets while trying to stay closer to the original legends. It resulted in a national nested 6-level typology of the vegetation of France. The digitalisation of the natural potential vegetation cover results from the vectorisation, the patching, and the georeferencing of the 64 botanical insets. The precision of the georeferencing (from 100 to 800 m depending on the considered region) agrees with a use at 1/1,000,000. Each polygon of the natural potential vegetation cover has been assigned to one type of vegetation as classified in the 5<sup>th</sup> level of the typology. The chosen type of vegetation and the mapping limits have been checked against the original paper maps of the CNRS and others vegetation maps at the local scale (more particularly Ozenda et Wagner, 1975; Ozenda et Lucas, 1987).

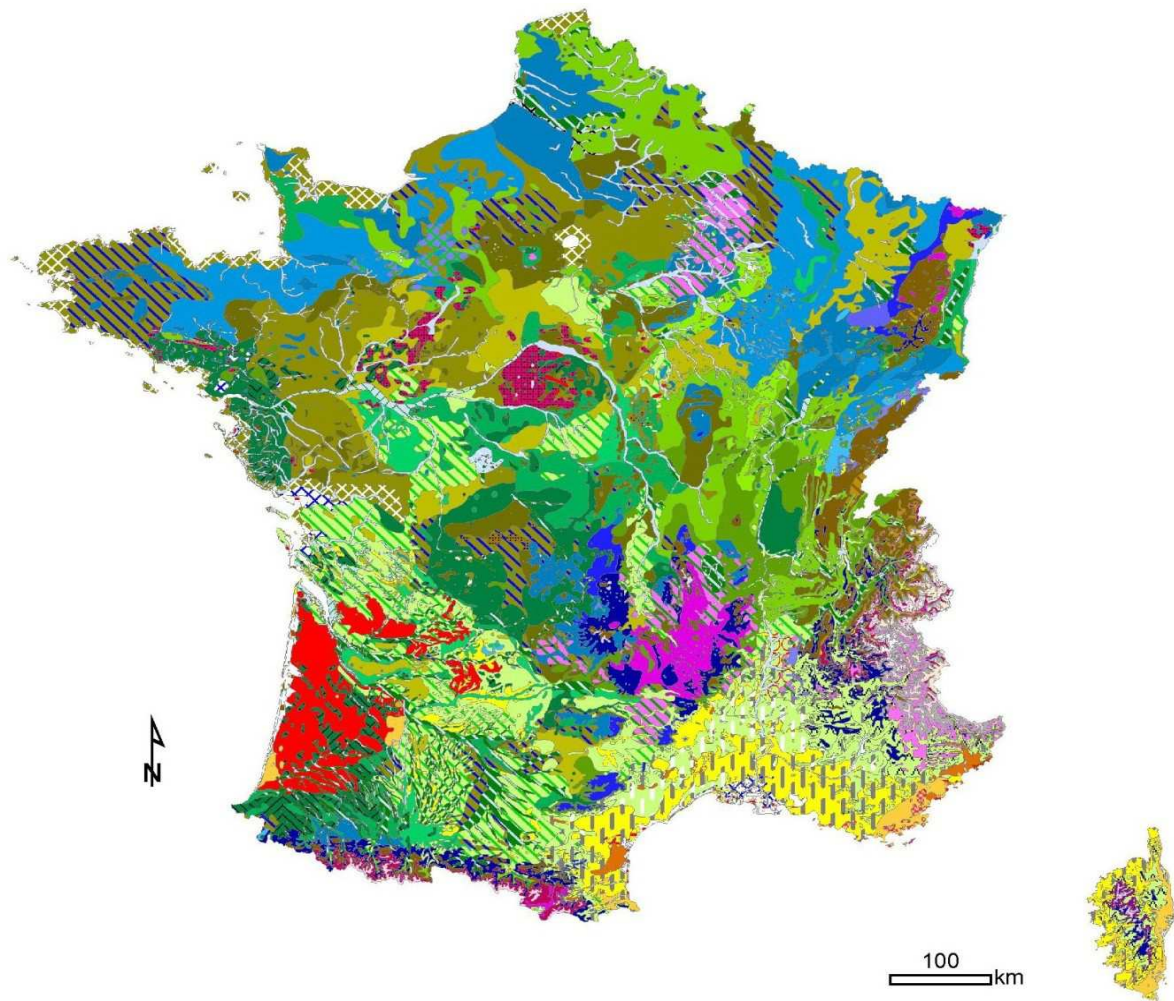
## Results and discussion

All the digital information produced during this work has been gathered in a geographical database, called “*Base de Données de la VÉGétation de la France*” (BDGveg\_FR). The BDGveg\_FR contains:

- a 1/200,000 georeferenced scan of the succession stages which is a testimony of the vegetation of the years 1940–1990;
- a harmonised 1/1,000,000 vector cover of the potential vegetation (Fig. 1) with descriptive data for each mapping unit; this cover has been checked and verified by comparison with other maps (see previous section) and the floristic heterogeneity of each mapping unit has been quantified;
- a database of the 6-level typology (Fig. 2) of the French vegetation which can be joined to the harmonised potential vegetation cover at the 5<sup>th</sup> level (Vegetation Mapping Units or VMU);
- six secondary covers as georeferenced scans which correspond to the insets of the paper map (soil, land cover, agriculture, climate, local potential vegetation) as well as 10 vector covers which regroup data extracted from the botanical inset (main secondary tree species, distribution area of some Mediterranean species, and drainage level);

- a database with the main metadata for each paper sheet (authors, collaborators, publication date, number, name, extent).

The vegetation information of the BDGveg\_FR is more synthetic than the distribution data of species gathered in floristic geographical databases (Brisse *et al.*, 1995; Drapier et Cluzeau, 2001; Gégout *et al.*, 2005).



**Fig. 1:** Harmonised map of the French natural potential vegetation (Leguédoin *et al.*, 2011). The detailed legend is shown in Fig. 2.

## Conclusion and perspectives

The BDGveg\_FR is a novel geographical database on the French vegetation which fills a gap in the available databases by the period of time its covers (1940–1990), its local and national scales (1/200,000 and 1/1,000,000), its exhaustive cover, and the information it provides on the plant associations. The BDGveg\_FR could be used to analyse long-term and large-scale impacts of global changes like climate, atmospheric pollution or tree species substitution as well to design sampling schemes. An equivalence between the EUNIS European classification and the VMUs has already been established. It enables assessment of the impacts of long range atmospheric pollution at the European level (Probst *et al.*, 2012). On an applied point of view, this database could be used to characterise the biogeographical and ecological situation of naturalist studies or environmental impact assessments as well as to help vegetation mapping by remote sensing. For example, current stages of vegetation could be obtained by combining the harmonised map of potential vegetation with the Corine Land Cover database<sup>1</sup>. It is also an attractive teaching material.

<sup>1</sup> <http://www.statistiques.developpement-durable.gouv.fr/donnees-ligne/li/1825/1097/occupation-sols-corine-land-cover.html> [In French, checked 07/07/2014].

## 1. Planar belt

111. Marine and coastal areas
- 1111. Marine vegetation
    - 11111: Marine vegetation
  - 1112. Coastal grasslands
    - 11121: Coastal marshes and salt meadows
    - 11122: Coastal heathlands and grasslands
  - 1113. Coastal vegetation on mineral soils
    - 11131: Cliffs, sands and pebbles
    - 11132: Dunes
  - 1114. Coastal scrublands
    - 11141: Groves and scrubs
  - 112. Non-forested inland wetlands
    - 1121. Non-forested inland wetlands
      - 11211: Halophytic vegetation
      - 11212: Aquatic and helophytic vegetation, dry grasslands on alluvial sands
      - 11213: Oligotrophic and acidic bogs
      - 11214: Eutrophic and alkaline fens
  - 113. Riparian woodlands
    - 1131. Black alder forest
      - 11311: Bog-alder forest
      - 11312: Black alder forest
    - 1132. Grey alder forest
      - 11321: Grey alder forest
    - 1133. Alder-willow-poplar forest
      - 11331: Alder-willow / alder-poplar forest
    - 1134. Alder-ash-elm forest
      - 11341: Alder forest with ash or elm
    - 1135. Alder-birch forest
      - 11351: Alder forest with birch
    - 1136. White willow forest
      - 11361: White willow forest
    - 1137. Riparian pedunculate oak forest
      - 11381: Riparian pedunculate oak forest on calcareous substrate

## 2. Colline belt

21. Lower to middle colline belt
- 211. Pedunculate oak-dominated woodlands
    - 2111. Acid pedunculate oak forest
      - 21111: Pedunculate oak forest and acid heathlands
    - 2112. Neutrocalcicolous to eutrophic pedunculate oak forest
      - 21121: Mesotrophic to eutrophic pedunculate oak forest
      - 21122: Calcicolous pedunculate oak forest
    - 2113. Mixed forest with pedunculate oak (and hoary oak)
      - 21131: Acid pedunculate oak forest with hoary oak
  - 212. Sessile oak-dominated woodlands
    - 2121. Acid sessile oak forest
      - 21211: Acid sessile oak forest
    - 2122. Meso-neutrophile to calcicolous sessile oak forest
      - 21221: Sessile oak forest and meso-neutrophile heathlands
      - 21222: Calcicolous sessile oak forest
  - 213. Mixed-oak woodlands
    - 2131. Acid mixed-oak forest
      - 21311: Mixed forest with sessile and pedunculate oaks, hornbeam and beech, acid heathlands
    - 2132. Calcicolous mixed forest
      - 21321: Calcicolous mixed forest with sessile and pedunculate oaks
    - 2133. Meso-neutrophile mixed-oak forest
      - 21331: Meso- to eutrophic mixed forest with sessile and pedunculate oaks, scrublands and grasslands
      - 21332: Sessile and pedunculate oaks, hornbeam and beech
      - 21333: Borage of pedunculate oak, elm, hornbeam and beech, with meadows and grasslands
  - 22. Middle to higher (and submontane) belt
    - 221. Beech-oak woodlands
      - 2211. Acid beech-oak forest
        - 22111: Acidiphilous beech-sessile oak forest, scrublands and grasslands
      - 2212. Meso-neutrophile beech-oak forest
        - 22121: Neutrophile beech-sessile oak forest, scrublands and grasslands
      - 2213. Calcicolous beech-oak forest
        - 22131: Calcicolous beech-sessile oak forest, scrublands and grasslands
    - 222. Pubescent oak woodlands
      - 2221. Pubescent oak forest
        - 22211: Pubescent oak forest
      - 22213: Mixed pubescent oak forest with various broad-leaved trees, scrublands and grasslands
      - 2222. Patched evergreen oak forest
        - 22221: Evergreen oak forest
    - 223. Scots pine woodlands (and pubescent oak)
      - 2231. Scots pine forest
        - 22311: Scots pine
        - 22312: Scots pine and oaks (mainly pedunculate)
      - 2232. Planted conifers
        - 22321: Planted spruce, Douglas-fir, fir and larch
        - 22322: Planted Scots, maritime, black and Mediterranean pines
  - 23. Thermo- and middle Mediterranean belt
    - 231. Pubescent oak woodlands
      - 2311. Pubescent oak forest
        - 23111: Pubescent oak forest, associated scrublands and grasslands
        - 23112: Pubescent oak forest, mulberry type, associated scrublands and grasslands
        - 23113: Pubescent oak forest, hop hornbeam type, associated scrublands and grasslands
      - 2312. Mixed-oak forest with pubescent and evergreen oaks
        - 23114: Mixed-oak forest with pubescent and evergreen oaks
        - 23115: Mixed-oak forest with pubescent and evergreen oaks, mulberry type

- 232. Evergreen oak woodlands
  - 2321. Evergreen oak forest
    - 23211: Evergreen oak forest and xeric calcicolous garrigue
    - 23212: Evergreen oak forest and xeric calcicolous garrigue, Phoenician juniper type
    - 23213: Evergreen oak forest and xeric calcicolous garrigue, lentisk pistache type
    - 23214: Evergreen oak forest and xeric calcicolous garrigue, myrtle type
    - 23215: Evergreen oak forest and xeric calcicolous garrigue, olive-lentisk type
- 233. Cork-oak woodlands
  - 2331. Cork-oak forest
    - 23311: Well-drained cork-oak forest
    - 23312: Well-drained cork-oak forest, oleander type
    - 23313: Well-drained cork-oak forest, myrtle type
    - 23314: Well-drained cork-oak forest, olive-lentisk type
- 234. Mediterranean pines woodlands
  - 2341. Mediterranean pines forest (Aleppo, Salzmänn's, umbrella)
  - 2342: Calcareous Mediterranean pines forest (Aleppo, Salzmänn's, umbrella), carob tree type
- 235. Maritime pine woodlands
  - 2351. Maritime pine forest
    - 23511: Siliceous pine forest

## 3. Montane belt

31. Submontane belt
- 311. Beech woodlands
    - 3111. Acid beech forest
      - 31111: Acid beech forest
    - 3112. Calcicolous and neutrophile beech forest
      - 31121: Meso-neutrophile to acidocline beech forest
      - 31123: Calcicolous beech forests
      - 31124: Cold calcicolous beech forest
      - 31125: Thermo-calcicolous beech forest
    - 3113. Lime-maple forest
      - 31131: Hygrosciaphile beech forest with lime and maple (fir in the western regions)
  - 32. Low to middle montane belt
    - 321. Fir and beech-fir woodlands
      - 3211. Beech-fir and fir forest
        - 32111: Beech-fir and fir forest
    - 322. High altitude beech woodlands
      - 3221: High altitude beech forest, heathlands and grasslands
    - 323. Scots pine woodlands
      - 3231. Scots pine forest
        - 32311: Acid Scots pine forest
        - 32313: Calcicline Scots pine forest
  - 33. High and oro-Mediterranean belt
    - 331. Pubescent oak woodlands
      - 3311. Pubescent oak forest
        - 33111: Pubescent oak forest, scrublands and grasslands
    - 332. Evergreen oak woodlands
      - 3321. Evergreen oak forest
        - 33211: Maquis of the evergreen oak forest from Corsica
    - 333. Oro-Mediterranean pine woodlands
      - 3331. Open forest with Corsican pine
        - 33311: Bois clairs de la Pinède à Pin Laricio de Corse

## 4. Subalpine (and high-Mediterranean, from Corsica) belt

- 411. Spruce woodlands (humid variant)
  - 4111. Spruce and fir-spruce forest
    - 41111: Spruce forest with beech and fir (including peatlands), heathlands and grasslands
  - 4112. Mesophilous spruce forest
    - 41121: Spruce forest (including peatlands), heathlands and grasslands
- 412. Spruce woodlands (dry variant)
  - 4121. Meso-xerophile spruce forest
    - 41211: Dry spruce forest, heathlands and grasslands
- 413. Spruce and fir woodlands
  - 4131. Fir and spruce forest
    - 41311: Fir forest with spruce (including peatlands), heathlands and grasslands
- 414. Subalpine pine woodlands
  - 4141. Pine forest with mountain and Swiss stone pines
    - 41411: Mountain pine forest (including peatlands)
- 415. Larch woodlands
  - 4151. Larch forest
    - 41511: Open larch woodland
- 416. Subalpine heathlands and grasslands
  - 4161. Rhododendron-juniper heathlands
    - 41611: Heathlands and grasslands, scrublands

## 5. Alpine belt

- 511. Alpine (or pseudo-alpine) heathlands and grasslands
  - 5111. Calcicolous heathlands and grasslands
    - 51111: Alpine grasslands on limestone
  - 5112. Siliceous heathlands and grasslands
    - 51121: Alpine siliceous grasslands
- 512. Nival belt
  - 5121. Rocks, snow and ice
    - 51211: Rocks, snow and ice (lichens and algae)

□ Non mapped

Fig. 2: Detailed legend of the harmonised map of potential vegetation of France (Leguédou et al., 2011).

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