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Analysis of potential ecological distributional factors of fauna and flora in Belgium

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Résumé

Les premiers résultats d'une analyse des facteurs de distribution écologiques potentiels sont présentés. Ils montrent que ceux-ci sont très bien corrélés à l'altitude, qu'il existe des régions homogènes en Belgique, et qu'en général, les frontières entre ces régions homogènes sont réellement des frontières biogéographiques potentielles.
Mots-clefs : Biogéographie, analyses multivariées, facteurs de distribution.

Summary

The first results of an analysis of the potential ecological distributional factors are summarily presented. They show that potential ecological distributional factors are highly correlated with altitude, homogeneous areas exist in Belgium and in general, borders between these homogeneous areas are really potential biogeographical ones.
Key-words : Biogeography, Multivariate analysis, Distributional factors.

Introduction

When species distribution maps are analysed, one tries to interpret them in terms of ecological factors or of homogeneous biogeographical areas. In some obvious cases, this interpretation does not raise problems. When the distribution is more fuzzy or when the sampling is incomplete, we need a tool to quantify the relation between species distribution and potential ecological factors.
Before studying this kind of relation, we must analyse the study area to get an idea of the relations among the potential ecological factors. Our purpose here is to present this analysis. First, we will examine how the ecological factors interact. Afterwards, we will define areas where these interactions among factors are homogeneous in Belgium. Finally we will check to see if boundaries of homogeneous biogeographical areas square with real potential biogeographical ones.

Description of the Data Set

The area of investigation comprises 380 U.T.M. squares. These squares are the Operational Geographical Units (sensu CROVELLO, 1981, in short the OGUs. For each OGU, we have scored the dominance of the different states of eleven characters from the first or second edition of the "Atlas of Belgium" according the available maps. The stored characters are the number of days with and without frost, the first and last day of frost, the average temperature, the average pluviosity, the number of rainy days, lithology, geology, pedology and altitude. The state of each character was also recorded on a present of absence basis. Only these presence/absence data will be analysed here. Finally, we obtain 109 character states describing the 380 OGUs.

Ordination of the OGUs

We employ a correspondence analysis to search for geographical trends and for interactions between characters states. The results give an extraordinary GUTTMAN or horseshoe effect on every axis. The first Figure shows that the character states follow closely an altitudinal gradient. A nonlinear regression analysis points out character states which are either widely distributed in Belgium (between the arms of the horseshoe on axis one and two) or independent of altitudinal gradient (character state related to Southern Belgium).

Classification of the OGUs

We have chosen the JACCARD's coefficient as a resemblance measure. This coefficient is a very natural one, measuring the ratio of number of species in common to the total number of species of the two OGUs that are compared. This coefficient does not take the number of joint absences into account for similarity. Any weighting of the different character states is used.
First, we use an agglomerative method (intermediate linkage) with and without geographical constraints. The analyses were made with MAPPING (R package LEGENDRE & VAUDOR, 1988) . These methods give satisfactory OGUs classifications. But this clustering method is hierarchical. Upper groups are dependent on the classification history. There are no boundary readjustments during the size increase of-the groups.

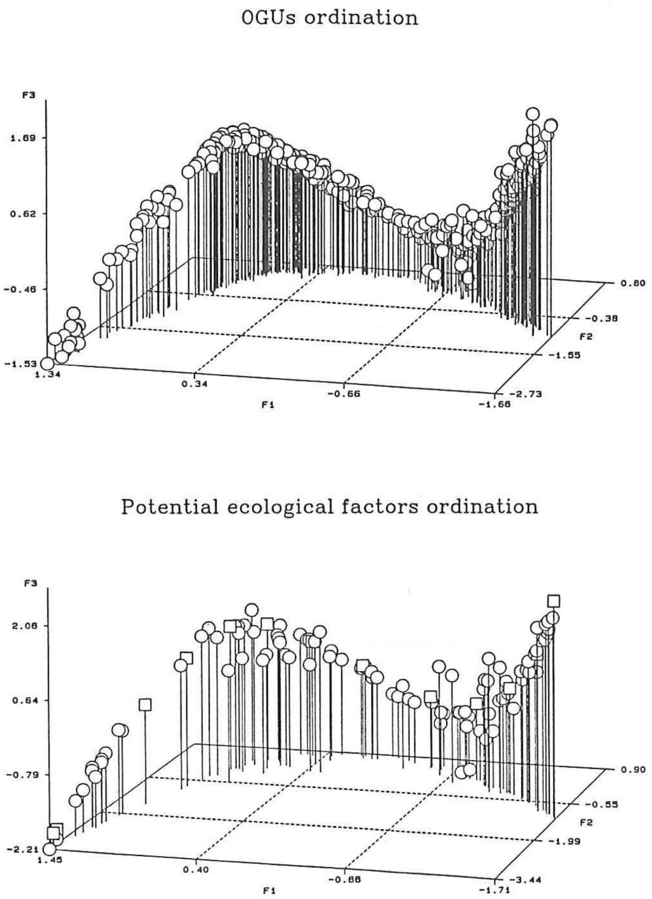

Figure 1 . Tridimensionnal plots of the correspondence analysis axes for the OGUs (upper) and the character states (bottom). The altitudinal classes are represented by squares.

But, we know that the OGUs closely follow an altitudinal gradient and, as a consequence, the persistence of biogeographical boundaries fixed by agglomerative methods could be an artifact.

We use k-means clustering (see SPÄTH, 1980) to optimize the groups structure at a given level. It produces partitions of the objects with minimum within-group variance. The overall sum of squares, i. e. the sum of within-group sums of squares, is used to decide which partition is most acceptable. As the method gives local, rather than global, optima, we decide to begin with clusters produced by MAPPING and hundred random classification as initial configurations. The program KMEANS was also developped by P. LEGENDRE and A. VAUDOR.

The results are displayed for each value of k (number of groups). It's surprising to obtain very homogeneous groups with a method without geographical constraints (Figure 2). This indicates relevant regional trends. The general structure is shaped by strips more or less oblique which follow the altitudinal gradient. From 13 groups of OGUs, there is no great difference between the sum of square values for the differents local minimums. The new groups are more difficult to interpret. We think that 12 groups constitute a good representation of biogeographical areas in Belgium. The other groups give an idea of possible later divisions. It's interesting to compare the maps with those published by other authors like phytogeographers (DE LANGHE *et al.,* 1978). We can see that in the outline, we obtain same results. However, if we compare the phytogeographers' map with the k-means maps for k=7 or 8, there is a major difference. We have a supplementary region centered on the Meuse and Sambre valley.

This area is certainly an important transition because the first scission in Belgium is precisely on the Meuse and Sambre valley. K-means method also point out resemblance between areas. Even if we do not use an hierarchical method, it's obvious that an hierarchical structure exists. Some OGUs exchanges exist between the groups.

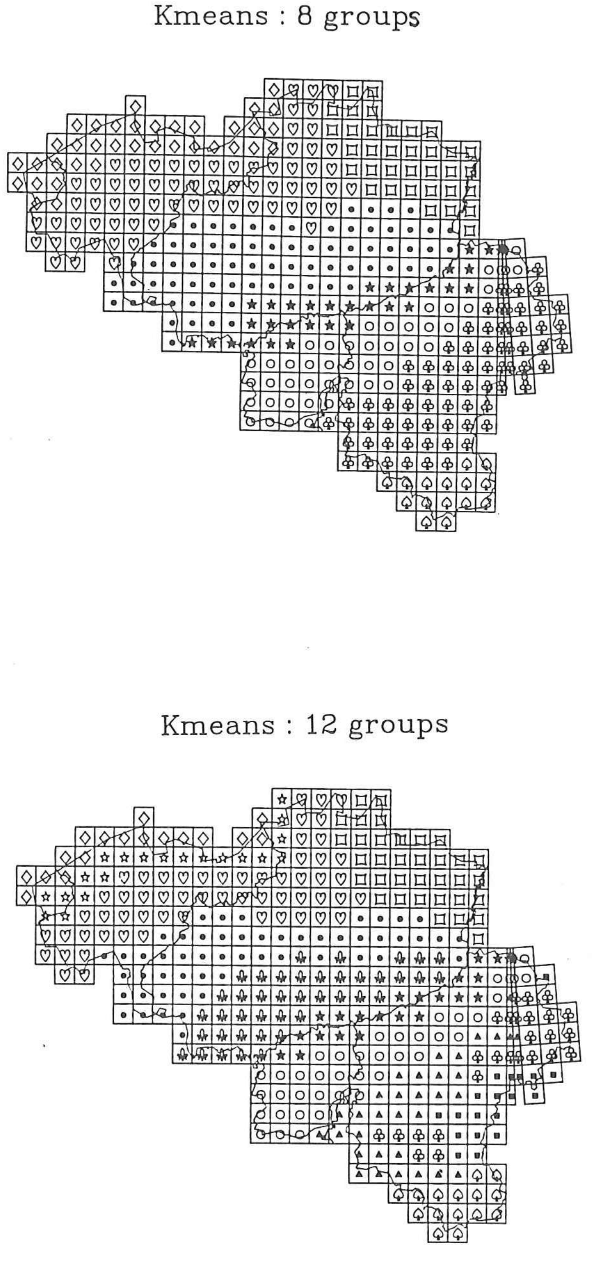

Figure 2. Maps of the kmeans groups for k=8 (upper) and k=12 (bottom).

Figure 3. Mapping of the distance between the OGUs and representation of the borders (in white) for k=12 (see text).

Searching for real potential biogeographical boundaries.

It's seems that the k-means method gives us a good representation of the biogeographical structure of Belgium. As homogeneous areas are isolated by boundaries, we can ask ourself about their relevance. Are these borders real biogeographical ones or are they only limits on one or some gradient trends ?

We choose to use a distance measure between adjacent OGUs. These distance measures (Euclidian distance) are calculated on the binary data. For each value of distance, we compute its difference with regard to the mean of all other values in term of standard deviation. Six classes have been constructed : three positive and three negative with limits 0-1, 1-2 and more than 2 standard deviations.

The results are displayed on a map (Figure 3). Each square represents the distance between two adjacent OGUs. For example, the distance between the two southern OGUs in Belgium (UTM31UFQ78 and UTM31UFQ88) are represented by only one square. Its color is clear : these two OGUs are very similar.

Campine is the most homogeneous area. It is followed by Oesling (east) and Flanders regions. Contrarily, Condroz and Ardenne are very heterogeneous areas.

If we compare this map with those produced by k-means, we can see that some of the boundaries are really biogeographical ones, principally near the coast and in Southern Belgium. For k=12, the proportion of squares crossed by a border increases regularly with the distance value.

In the outline, k-means boundaries are potential biogeographical ones. However, this kind of map points out too that the border effect is more or less variable along some boundaries.

Conclusions and perspectives

Although the results are summarily presented, this work shows that potential ecological distributional factors are highly correlated with altitude, homogeneous areas exist in Belgium and in general, borders between these homogeneous areas are really potential biogeographical ones.

This work was very stimulating in that it represents the first time that potential ecological factors and biogeographical areas have been compared for Belgium. We have begun to better understand how the Belgium's

Class of distance value	Number of squares by class	Number of crossed squares	Proportion
Class 1	18	0	0.0 %
Class 2	84	3	3.8 %
Class 3	288	50	17.4 %
Class 4	213	82	38.5 %
Class 5	78	49	62.8 %
Class 6	21	15	71.4 %

different biogeographical areas are connected and what the relevant boundaries of these areas are.

We hope that these data will be a good tool for distributional maps interpretation, and that they could answer at many questions asked in biogeography as :

- Are these potential ecological distributional factors also suitable factors for each or groups of species ?
- Are other ecological factors such as distribution of habitat types necessary ?
- Is it possible to define potential distribution areas ?
- What is the similarity or the differences between potential distribution areas and the actual ones ?
- Are the faunal distribution area types related to the biogeographical ones ?

To answer these questions involves having a good faunal data set. This is one of the purposes of the project "Ecology, Cartography and Faunistic of Carabid Beetles in Belgium and Northern France".

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