The Environmental Classification of Europe, a new tool for European landscape ecologists

De Environmental Classification of Europe, een nieuw gereedschap voor Europese landschapsecologen

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Summary

In the European Union (EU) member states, environmental policy and habitat and species protection is regulated by EU policy. But although millions of Euros are spent to underpin these policies and protection measures, it remains difficult to represent, compare and monitor Europe's diverse environments and landscapes and habitats. Stratification in relatively homogenous regions is a tried and tested method to achieve these objectives. Such a classification forms an essential basis for strategic sampling of ecological variables and consistent modelling exercises. Within a given class, changes or effects can be analysed within a consistent environment, which then enables variation to be partitioned. Such a process is imperative to produce statistically robust results, which require data to be representative from a defined population. For example, when examining a single class to determine the influence of causal factors of change on species abundance, statistical procedures can ensure that the observed effects are indeed caused by that change and not by inherently different environments. Until recently no adequately detailed stratification of the European environment was available. However, the eighty-four class Environmental Classification of Europe (EnC), developed recently in a collaboration between Wageningen University and Alterra, meets these requirements. It was constructed by Principal Component Analysis and statistical clustering of climatic and topographic variables, thus minimising personal bias. The EnC is appropriate for strategic random sampling for resource assessment, measurement of change, and modelling. The Environmental Classification is available for non-commercial use by applying to the corresponding author.

Introduction

When analysing environmental processes, statistical classification is the first step because areas and situations must be comparable in a reproducible way. On a continental scale of spatial research, e.g. biodiversity monitoring, data comparisons, and scenario building for the European Union (EU), a stratification of land into more or less homogeneous regions would provide a valuable framework since statistical inference requires data to be representative of a defined population. Within each stratum or class, changes or effects can then be analysed separately from environmental heterogeneity employing the classical statistical procedure of partitioning the sums of squares between classes.

For example, when comparing the influence of different land-use changes on species abundance within an environmental class, one can be sure that differences in species abundance are indeed the result of those changes and not the product of inherently different environments. Furthermore, an environmental classification would provide a basis for stratified random sampling and would enable samples to be placed consistently within the context of the entire continent. It is, however, essential that the environmental classification has a sufficiently fine resolution and that it is unbiased and derived statistically so that the classes are unambiguously determined by given variables. The classification would then be reproducible and independent of personal bias. This is of particular importance where large-scale continuous gradients are involved over thousands of kilometres, e.g. from Britain to Denmark, Sweden and Finland. No obvious boundaries are present in such cases, and statistical rules are needed to make robust divisions.

Most existing classifications are qualitative, with classes having ambiguous definitions. They depend on the experience and judgement of the originators and rely upon the intuition of the observer in interpreting observed patterns on the basis of personal experience. Quantitative classifications have been applied in some national studies, most notably in the United Kingdom Countryside Survey (Firbank *et al.*, 2003). An earlier continental classification lacked the detail necessary for ecological monitoring as it was at a 0.5° x 0.5° resolution (Bunce *et al.*, 1996). In this paper we present a new Environmental Classification of Europe (EnC) in eighty-four classes with a 1 km^2 resolution.

The classification is based on statistical clustering, so that personal biases are minimised and the classes can be seen in the context of Europe as a whole. By demonstrating this new classification approach, and by making the EnC public, we are providing a new tool for European ecologists to use, e.g. for site selection for representative studies across the continent or to provide strata for modelling exercises and reporting.

Methods

The selection of relevant variables

Due to software restrictions, a maximum of 20 variables could be selected. The selected variables (see Table 1) are comparable to those used in the ITE classification (Bunce *et al.*, 1996), although the original statistical selection procedure was not followed. As Bunce *et al.* (2002) have shown, the core patterns are stable regardless of the details pertaining to the variables and algorithms.

Running the classification

Principal Component Analysis (PCA) allows redundant data to be compacted into fewer layers that are non-correlated and independent and are often more interpretable than the source data.

The first three principal components, used for the subsequent clustering, explain 88% of the variation in the input variables. The Iterative Self-Organising Data Analysis Technique (ISODATA), a frequently used technique in remote sensing, was used to cluster the principal components into environmental classes.

Table 1. Comparison of selected parameters in the EnC and the ITE classification.

EnC	ITE European Land classification
Altitude	Maximum altitude
	Mean altitude
	Minimum altitude
Slope	
Northing (latitude)	Northing (latitude)
Oceanicity	Oceanicity
Minimum temperature January	
Minimum temperature April	
Minimum temperature July	Frost days in July
Minimum temperature October	Frost days in November
Maximum temperature January	
Maximum temperature April	
Maximum temperature July	Maximum temperature in September
Maximum temperature October	Maximum temperature in October
Precipitation January	Rain days in December
Precipitation April	
Precipitation July	Precipitation in June
Precipitation October	Precipitation in October
	Precipitation in November
	Rain days in November
Sunshine January	
Sunshine April	Sun hours in May
Sunshine July	Sun hours in June
Sunshine October	
	Wind speed in April

Aggregating and naming

An aggregation of the classes into a limited number of Environmental Zones (EnZs) was created to facilitate communication (see figure 1). By subdividing main biogeographic regions based on the first principal component score of the classes, and aggregating the eighty-four classes, 13 EnZs were created. Each EnC class was given a systematic name based on a three letter abbreviation of the EnZ to which the class belongs, and an ordered number based on the mean first principal component score.

Validation

In order to validate whether the EnC is an ecologically appropriate stratification the correlations between existing European datasets and the EnC were assessed. Different soil, vegetation, land use and species datasets all showed statistically signification correlations, justifying its wider application.

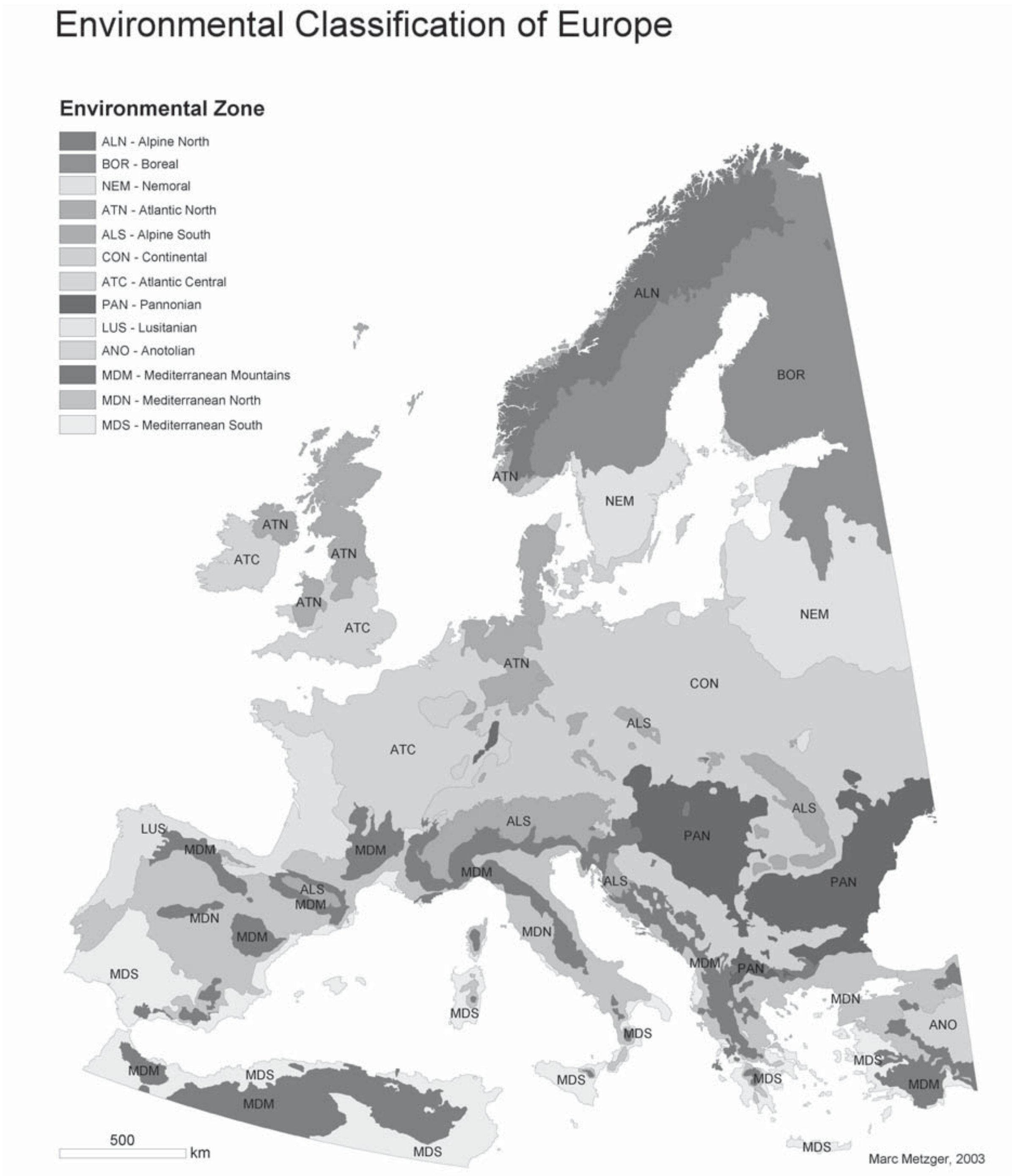

Figure 1. The Environmental Classification of Europe aggregated to 13 Environmental Zones. The borders of the underlying eighty-four classes are mapped. Because certain classes do not necessarily fit traditional experience, in this classification strict statistical rules have been maintained, recognising these apparent inconsistencies, e.g. the Pannonian class in the Vosges and Schwartzwald and the Continental class southern Norway.

Applications and conclusion

The EnC (figure 1) is especially suited for strategic random sampling across Europe and facilitates the construction of a European-wide monitoring framework for biodiversity and habitats. Recent work shows that, when needed, EnC classes can readily be subdivided in regional environmental classes (REnCs), i.e. based on soil characteristics. The Portuguese case study demonstrated that only a few samples give a good estimate of 11 main land use types. Standard errors decrease when more samples are taken, but mean estimates hardly change, emphasising that the quality of the stratification. Besides forming a sampling framework, the EnC proves a useful tool for site selection, the identification of gaps in data, the integration of habitat information, and for summarising impacts at the EnZ level (Jongman *et al.*, submitted). Furthermore, in the EU 5th framework project ATEAM, the EnC classes are fitted to climate change scenarios. The shifting classes form the basis for a vulnerability assessment of European ecosystem services under global change (Metzger & Schroeter, in prep.). In conclusion, we are confident that the Environmental Classification of Europe will prove a useful tool for European environmental scientists. The EnC is available for non-commercial use by application to the corresponding author.

Literatuur

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