Journal of Biogeography (J. Biogeogr.) (2010) 37, 2209–2215

CORRESPONDENCE

Understanding properly the 'potential natural vegetation' concept

ABSTRACT

This is a response to critical comments concerning the inappropriate use of the potential natural vegetation (PNV) concept made in a recent contribution to the Commentary section of this journal. We consider that the PNV concept has been misinterpreted. PNV has been used extensively in several European countries since the mid-1950s and was never intended to be used to make a prediction of what vegetation would dominate in an area if human influence were removed. PNV maps express hypothetical assumptions of what corresponds to dominant or natural vegetation in each area. Remnants of the vegetation of the past provided by palaeopalynology and other disciplines provide valuable information for interpreting modern vegetation, but natural changes and anthropogenic influences operating over the last millennia have to be taken into account. Annex I of the Habitats Directive provides a balanced list of habitat types for implementing conservation policies within the European Union.

Keywords Habitats Directive, human impact, phytosociology, potential natural vegetation, primitive vegetation, Spain, succession, vegetation dynamics, vegetation mapping, vegetation series.

A recent article in the Commentary section of this journal, entitled 'The survival of the "natural potential vegetation concept" (or the power of tradition)' (Carrión & Fernández, 2009), revives an old debate in plant ecology. The debate is so old and has so completely run its course that, in our opinion, it no longer holds any interest for an international audience. Rather, it is a local echo of the old Gleasonian–Clementsian controversy long since resolved, regarding which most plant ecologists adopted an intermediate position some time ago (Gurevitch *et al.*, 2002).

After examining the article, it seems clear that it is based on an inexact interpretation of the potential natural vegetation (PNV) concept. This concept was one of Tüxen's notable contributions to vegetation science and it dates from the middle of the last century (Tüxen, 1956). Since then, many other authors in various countries have added to and used it, frequently in association with vegetation mapping projects. It is important to point out that PNV units are always constructed on the basis of the modern vegetation present in the area, and, as reasonable as that may be, they represent a projection to the future (not to the past). The potentiality of one particular vegetation type has been formulated more in terms of a hypothesis than a prediction; it has never been intended to be a prophecy of what vegetation would be certain to establish in the absence or removal of human impact (Härdtle, 1995). After the survey of a territory, a vegetation scientist decides which type of vegetation found in the area can be designated as PNV; ordinarily, the largest, most structured and competitive remnant type is chosen. This has meant that many *Quercus* and *Fagus* forests have been used as PNV types, as they are among the most competitive trees of the modern native dendroflora. Forest types dominated by other tree species, such as, for example, native pines, have however been used to a lesser extent. This is because many of the modern pine formations are secondary forests associated with disturbance (fire, management, etc.) and cannot be considered to be the most competitive type in many areas. In other cases, these forests are associated with steep slopes and shallow soils, and their primary stations correspond to permanent vegetation in rough stony terrains. Nevertheless, the PNV area attributed to pine forests in the Iberian Peninsula has increased in recent times with respect to that in previous approaches for this region (Rivas-Martínez, 1987, 2007).

Another important point is that, from the very beginning, the PNV concept was established as different from that of primitive vegetation, and it has always been accepted that the potential vegetation cannot correspond exactly to what was there before human disturbance began (Braun-Blanquet, 1964). This is true for many reasons: changes in topography, soil and climate have taken place across large areas of the world in the period since human impact began; in addition, many taxa have become extinct or have migrated. If human pressure were to be removed now, it would take a long time for a potential natural forest to grow; indeed, it would take so long that the climate would probably change again in that time. Thus, PNV is more a theoretical concept than a true prediction of the future.

For that reason, in some cases the term vegetation series (VS), or *Sigmetum*, has been used, as it is more neutral, less predictive, and suggests that units are being constructed from vegetation complexes that live under homogeneous environmental conditions. In practical terms, the cartography of such VS becomes equivalent to the mapping of ecologically homogeneous units, each of them populated by a particular complex of vegetation types that have a particular system of dynamic relationships. Among these vegetation types the one selected as PNV is interesting because it represents an assessment of the biotic possibilities of the habitat (Braun-Blanquet, 1964).

Unlike the future, which can only be guessed at, the past can be known, at least to a certain extent, and is studied in several scientific disciplines, for example palaeopalynology and anthracology, that identify evidence of the flora of the past. All findings are extremely valuable for determining what vegetation was present at various times in the past, as well as its evolution towards the current situation. However, a direct reconstruction of the vegetation following the relative abundances of the various pollen types appearing in the spectrum is not possible, as each plant species produces different amounts of pollen, which in turn spreads very different distances. It also has to be taken into account that some pollen types can originate from trees that were quite distant from the surveyed site; that is, there is no linear equivalence between pollen abundance and the abundance of mother plants (Rodrigues Tarroso, 2007). Thus, the pollen spectrum of each site has to be interpreted carefully, and the reconstruction of the surrounding vegetation is approximate. Even so, vegetation scientists tend to read findings published from this field of research with interest, as they help in the interpretation of present vegetation. Extant reality must, however, be used to construct PNV units – the past is essential for interpreting the present but should not condition the formulation and definition of modern vegetation units.

The map included in the paper by Carrión & Fernández (2009) shows differences between the data from the past and the situation today in several sites, but the remnants of the past cannot be interpreted as representatives of a modern or future PNV, as conditions have changed considerably during the last millennia. It is also generally accepted by the scientific community that anthropogenic influence has been the dominant shaping factor of the vegetation of modern vegetal landscapes in terms of plant taxa and vegetation distribution and abundance (Loidi, 2007). These human-induced transformations occurred while the vegetation was probably still reacting to previous climatic changes: we must assume that there is a lag between environmental changes and the adaptation of the vegetation to new conditions, particularly among long-living trees and their forests. In many areas, however, it is probable that human influence has catalyzed some changes in vegetation distribution. In fact, predictive distribution models of forest tree species based on current climate (Benito *et al.*, 2006, 2007) do not differ from PNV patterns as markedly as the Carrión & Fernández map seems to imply, and the same is true of remote sensing mapping derived from the normalized difference vegetation index (NDVI) (Lobo *et al.*, 1997), although in both cases discrepancies may be detected in some territories.

Phytosociologists in Spain have recently made notable contributions to the inventories of habitat types, particularly after the implementation of the Habitats Directive of the European Union in this country, and feel proud of having been instrumental in this task, which consisted mostly in the realization of a 1:50,000 vegetation map of the entire country (Loidi, 1999). This inventory, rigorously drawn up, substantially increased the knowledge of the distribution of all vegetation types across the territory, with strong implications for conservation and land planning in favour of the biodiversity and functioning of terrestrial ecosystems in order to ensure their sustainability and services (Rivas-Martínez *et al.*, 2003). It is hardly reasonable to accuse this Directive of a bias against conifer forests or in favour of certain PNV types, when its Annex I includes all natural and semi-natural Mediterranean pine forests (except recent plantations) among the habitat types of European conservation interest, as well as a vast number of semi-natural habitats related to different disturbance regimes, and contains a substantial proportion of the Mediterranean endemic flora, while some beech, oak and birch forests have been excluded.

Potential natural vegetation or VS cartography, widely used in Europe (Härdtle, 1995; Bohn *et al.*, 2000), represents a valuable tool for land management as it provides a reference for ecological restoration in terrestrial ecosystems (Moravec, 1998). It does not produce a map of recommendations exclusively oriented to favouring or restoring the PNV vegetation types because decisions are made by local managers and interests vary according to area. If natural forests are desired, targets for the most appropriate ones are provided, whereas if other seral vegetation types are to be maintained in complex systems, some guidance for management should also be given. Such a map is useful for conservationists and for ecological land management and planning; however, it does not represent a hard and fast rule of what must be done in each place.

The PNV is a scientific concept that requires a detailed knowledge of the flora, the vegetation and the mesological conditions of the territory, of course within the European geobotanical tradition. It has nothing to do with authority.

Javier Loidi[1]*, Marcelino del Arco[2], Pedro Luis Pérez de Paz[2], Alfredo Asensi[3], Blanca Díez Garretas[3], Manuel Costa[4], Tomás Díaz González[5], Federico Fernández-González[6], Jesús Izco[7], Ángel Penas[8], Salvador Rivas-Martínez[9] and Daniel Sánchez-Mata[10]

[1]Department of Plant Biology and Ecology, University of the Basque Country, Ap. 644, 48080 Bilbao, Spain,
[2]Department of Plant Biology, Faculty of Pharmacy, University of La Laguna, Campus de Anchieta, 38071 La Laguna, Spain,
[3]Department of Plant Biology, Faculty of Sciences, Campus de Teatinos, University of Málaga, 29071 Malaga, Spain,
[4]Botanical Garden of the University of Valencia, Carrer Quart, 80, 46008 Valencia, Spain,
[5]Department of Organism and Systems Biology, University of Oviedo, Catedrático Rodrigo Uría s/n, 33071 Oviedo, Spain,
[6]Department of Environmental Sciences, Faculty of Environmental Sciences, University of Castilla-La Mancha, 45071 Toledo, Spain,
[7]Department of Botany, Faculty of Pharmacy, University of Santiago de Compostela, 15782 Santiago de Compostela, Spain,
[8]Department of Biodiversity and Environmental Management, Faculty of Biological and Environmental Sciences, University of León, 24071 Leon, Spain,
[9]Phytosociological Research Center CIF, José María Usandizaga, 46, 28409 Los Negrales, Madrid, Spain,
[10]Department of Plant Biology II, Faculty of Pharmacy, Complutense University, 28040 Madrid, Spain
**E-mail: javier.loidi@ehu.es*

REFERENCES

Benito, M., Blazek, R., Neteler, M., Sánchez, R., Sáiz, H. & Furanello, C. (2006) Predicting habitat suitability with machine learning models: the potential area of *Pinus sylvestris* L. in the Iberian Peninsula. *Ecological Modelling*, **197**, 383–393.

Benito, M., Sánchez, R. & Sáiz, H. (2007) Predictive modelling of tree species distribution in the Iberian Peninsula during the Last Glacial Maximum and Mid-Holocene. *Ecography*, **30**, 120–134.

Bohn, U., Gollub, G. & Hettwer, C. (2000) *Map of the natural vegetation of Europe. Scale 1:2500000*. Bumdesamt für Naturschutz, Bonn-Bad Godesberg.

Braun-Blanquet, J. (1964) *Pflanzensoziologie.* Grundzüge der Vegetationskunde. Springer Verlag, Vienna.

Carrión, J.S. & Fernández, S. (2009) The survival of the 'natural potential vegetation' concept (or the power of tradition). *Journal of Biogeography*, **36**, 2202–2203.

Gurevitch, J., Scheiner, S.M. & Fox, G.A. (2002) *The ecology of plants*. Sinauer Associates, Sunderland, MA.

Härdtle, W. (1995) On the theoretical concept of Potential Natural Vegetation and proposals for an up-to-date modification. *Folia Geobotanica et Phytotaxonomica*, **30**, 263–276.

Lobo, A., Ibáñez, J.J. & Carrera, C. (1997) Regional scale hierarchical classification of temporal series of AVHRR vegetation index. *International Journal of Remote Sensing*, **18**, 3167–3193.

Loidi, J. (1999) Preserving biodiversity in the European Union: the Habitats Directive and its application in Spain. *Plant Biosystems*, **133**, 99–106.

Loidi, J. (2007) La evolución del paisaje vegetal del centro-norte de la Península Ibérica a lo largo de la historia. *Boletín de la RSBAP*, **11**, 11–51.

Moravec, J. (1998) Reconstructed natural versus potential natural vegetation in vegetation mapping. *Applied Vegetation Science*, **1**, 173–176.

Rivas-Martínez, S. (1987) *Mapa de series de vegetación de España*. ICONA Serie Técnica, Madrid.

Rivas-Martínez, S. (2007) Mapa de series, geoseries y geopermaseries de vegetación de España. Parte I. *Itinera Geobotánica*, **17**, 5–435.

Rivas-Martínez, S., Penas, A., Asensi, A., Costa, M., Llorens, L., Pérez de Paz, P.L., Loidi, J., Díaz, T.E., Izco, J., Ladero, M., Fernández-González, F., Masalles, R. & Sánchez-Mata, D. (2003) *Atlas y manual de los hábitat de España*. Dirección General de la Conservación de la Naturaleza, Ministerio de Medio Ambiente, Madrid.

Rodrigues Tarroso, J.P. (2007) *Late-Quaternary landscape dynamics in the Iberian Peninsula and Balearic Islands*. Universidade do Porto, Porto.

Tüxen, R. (1956) Die heutige potentielle natürliche Vegetation als Gegenstand der Vegetationskartierung. *Angewandte Pflanzensoziologie*, **13**, 5–55.

Editor: John Lambshead

doi:10.1111/j.1365-2699.2010.02302.x

The power of potential natural vegetation (and of spatial-temporal scale): a response to Carrión & Fernández (2009)

ABSTRACT

A commentary by Carrión & Fernández (*Journal of Biogeography*, 2009, **36**, 2202–2203) compared Holocene pollen records with models of potential natural vegetation (PNV) proposed in the phytosociological literature and concluded that the predicted PNV resulted from anthropogenic disturbance. However, the authors misinterpreted PNV, leading to two serious flaws in their assumptions: (1) PNV is not defined as a pre-anthropic or climax plant community; and (2) PNV is not a concept restricted to the phytosociological method. Therefore we criticize the conclusions expressed in the commentary, and we stress the need for an interdisciplinary approach based on multi-temporal and multi-spatial scales to achieve a modern framework for the study of plant communities.

Keywords Climax concept, ecological restoration, Holocene vegetation, landscape dynamics, phytosociology, potential natural vegetation, secondary succession, vegetation classification, vegetation science.

In a commentary regarding Holocene pollen deposits from the Canary Islands, Carrión & Fernández (2009) argued that the discovery of *Quercus* and *Carpinus* pollen is noteworthy because 'the prevailing concepts of natural potential vegetation in the study region imply that the pre-anthropic (mature phase or climax) vegetation' would be an evergreen forest dominated by species of Lauraceae. Inferences of pre-anthropic vegetation made by palynologists were also compared with the potential natural vegetation (PNV; incorrectly quoted in the commentary as 'natural potential vegetation') proposed in the phytosociological literature at a number of sites in the Iberian Peninsula. The results of the two models indicated that, in many instances, the dominant species differed. Therefore they concluded that the PNV types determined in previous studies were the result of anthropogenic disturbance. Consequently, the authors polemically argued that there is a bias 'in the conceptualization of the vegetational dynamics' by 'traditional vegetation science', and resistance to abandon this bias 'has little to do with scientific evidence', in front of 'a growing body of work questioning the floristic-phytosociological approach'. Unfortunately, this line of reasoning is based on two serious misunderstandings regarding the PNV concept.

First and foremost, PNV is *not* defined by vegetation scientists as 'pre-anthropic (mature phase or climax) vegetation'. On the contrary, PNV is defined as the plant community that 'would become established if all successional sequences were completed without interference by man *under the present climatic and edaphic conditions (including those created by man)*' (Mueller-Dombois & Ellenberg, 1974, p. 422; our emphasis; see also: Westhoff & van der Maarel, 1973; Ellenberg, 1988; Ricotta *et al.*, 2002). European landscapes exhibit present soil conditions that are often dramatically different from their original state, due to recent or ancient but irreversible human disturbance (cf. Dupouey *et al.*, 2002). Consequently, it is an essential part of the PNV theory that the potential vegetation of a site can be very different from the pre-anthropic vegetation at the same site (e.g. Mueller-Dombois & Ellenberg, 1974; Chytrý, 1998; Moravec, 1998; Zerbe, 1998; Gamisans, 1999). The PNV concept was introduced (Tüxen, 1956) to express the *present* ('heutige') potential of a region or site as a useful reference to define a target for restoration ecology and ecological engineering projects, or for landscape management purposes (e.g. to forecast and manage landscape evolution on a time-scale of a few decades) (Rodwell & Patterson, 1994; Härdtle, 1995; Miyawaki, 1998; Zerbe, 1998; Verheyen *et al.*, 2006; Dostalek *et al.*, 2007).

It is quite surprising that Carrión & Fernández (2009) completely ignored the large body of works addressing and defining PNV theory. Furthermore, it is perplexing they assumed that 'climax vegetation' and PNV are considered synonyms in vegetation science. On the contrary, it is well known that the idea of PNV arose as an outcome of (and reaction to) the long-lasting debate on the 'climax' concept (Zerbe, 1998; Ricotta *et al.*, 2002). European vegetation scientists have questioned the concept of climax for decades (Mueller-Dombois & Ellenberg, 1974; Chytrý, 1998; Schulze *et al.*, 2005), and we now acknowledge that vegetation is not returning to an alleged, past equilibrium, but is adapting continuously to a changing abiotic environment and biotic interactions. In addition, the inferred climax phase requires a long period of succession, which introduces not only the effects of long-term climatic changes, but also those of vegetation-induced soil modifications. Finally, the climax concept was developed to study the phytogeography of North America, a continent featuring abiotic homogeneity over large areas, a condition rarely verified in Europe.