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Notions on dynamic-catenal phytosociology as a basis of landscape science

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Abstract
Short essential notions of dynamic-catenal phytosociology are defined as the basis of landscape vegetation science. The most important units – vegetation series, geoseries, permaseries and geopermaseries (sigmetum, geosigmetum, permasigmetum and permageosigmetum) – are discussed and synthesized in several figures.

Key words: *Geobotany, landscape science, plant sociology, vegetation dynamics.*

Introduction

Geobotany is an ecological science that deals with the relationship between plant life and the terrestrial environment in the geobiosphere and in the hydrobiosphere. The terms phytogeography and plant ecology have also been used with a similar meaning. At present, the basic sciences of geobotany are: phytosociology, plant taxonomy, bioclimatology, biogeography, edaphology, and geomorphology. Today, there is a tendency to give geobotany the following general objectives: (i) to study all phytocenotic biodiversity and habitat types on Earth, with the scope of attaining sustainable use, management and conservation; (ii) to create vegetational, bioclimatic, biogeographical and functional macromodels and micromodels, which allow prediction, provide considerable information and are easy to use and practical; (iii) to attempt to harmonize the underlying theories and paradigms of various schools that study vegetation, to stimulate scientific debate and make further progress in epistemological knowledge, in order to achieve a greater universality in its employment and teaching.

Although the old debate on the Gleasonian and Clementsian succession theories is not yet over – over the fact that individual species have individual responses to environmental factors, which represents an individualist concept (Gleason), or on the contrary, that communities are discrete because the individual components respond similarly to the most limiting environmental factors (Clements) – the controversy has become speculative and of little importance. Firstly, because it is widely accepted that through vegetation relevés carried out by experts in a particular homogeneous area, logical, statistical and hierarchical models that we call plant communities can be created out of juxtaposition, which provide important data and show great biological homogeneity and great predictive ability in terms of geographical distribution and physical and chemical properties. Secondly, the already discredited discussion on ‘continuum’ continues to be interesting only at a philosophical level because, paraphrasing Kant and the renowned controversy on the reality of species, we can say that: as far as we cannot be absolutely sure of the real existence of plant communities, we need their models and taxonomy to create a plant science that is both objective and rigorous (Clements, 1916, 1936, 1949; Gleason, 1926; Goodall, 1954; Whittaker, 1965, 1967, 1972, 1975; Westhoff & van der Maarel, 1978; Austin, 1985; Austin & Smith, 1989; Mucina & van der Maarel, 1989; Feoli, 1988; Yu & Orlócci, 1990; Anand & Orlócci, 1997; Anand, 2000; Anand & Kadmon, 2000; Loidi, 2004; Biondi et al., 2004).

Phytosociology, also known as plant sociology, phytocenology, and plant synecology, is a branch of

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geobotany that studies plant communities and their relationship with the environment. It is the science of syntaxa, in which *association* is the basic unit of the taxonomic system, which deals with bioceonosis from a botanical point of view (phytocoenosis or phytosyntaxa). It is concerned with plant communities, their relationships with the environment and the temporary processes that modify them. With all this information, by means of an inductive and statistic method based on the phytosociological relevè, it attempts to create a universal hierarchic typology with the association as the basic unit of the syntaxonomical system. Nowadays, besides classic or Braun-Blanquet's phytosociology (association level), there are also dynamic-catenal, integrated or landscape phytosociology (the science of sigmataxa and geosigmataxa), whose units are *series* or sigmetum in dynamic or successional phytosociology; *permaseries* or permasigmetum (sigmataxa) and *geoseries* or geosigmetum in catenal phytosociology (geosigmataxa).

Theoretically, phytosociology is simply a holistic discipline of ecology. At present, *association* is defined as a plant community, represented through its own nomenclature code and vegetation relevé, which has certain ecological characteristics, a precise biogeographical jurisdiction, as well as an original combination of characteristic and differential species. These are statically consistent with the ecological features of a real habitat, which corresponds to a structurally stable vegetational stage in the process of succession, in a precise territory. The association may be determined from the comparative study of relevés, in which the floristic composition is recorded and quantified, as the rest of the ecological and geographic information of a specific homogeneous plant community. Associations with similar floristic composition, dynamic stage, structure, habitat or biogeography may be grouped together in types or units of higher rank denominated alliances, orders or classes (Braun-Blanquet, 1921, 1928, 1948, 1964; Braun-Blanquet & Pavillard, 1928; Braun-Blanquet et al., 1947, 1952; Bertrand, 1968, 1972; Géhu & Rivas-Martínez, 1981; Rivas-Martínez, 1985, 1987; Mateo, 1983; Folch, 1986; Ferreras, 1987; Pignatti, 1994; Loidi, 1994, 2004; Dierschke, 1994; Dierßen, 1996; Izco, 1998; Alexiu, 1998; Capelo, 2003; Cantó, 2004; Fuertes, 2004; Costa, 2004).

Dynamic-catenal phytosociology

Dynamic-catenal phytosociology and dynamic-permacatenal phytosociology developed over the last decade. They deal with biodiversity and the structure and dynamics of vegetational landscape within natural, seminatural and rural terrestrial ecosystems, using geobotanical and environmental sciences.

Their basic units are: sigmetum (series), geosigmetum (geoseries), permasigmetum (permaseries) and geopermasigmetum (geopermaseries), with their respective subunits or facies. The corresponding units of higher rank are principally: sigmion, sigmetalia, sigmetea (macroseries, megaseries, hyperseries); geosigmion, geosigmetalia, geosigmetea (macrogeoseries, megageoseries, hypergeoseries); permasigmion, permasigmetalia, permasigmetea (macropermaseries, megapermaseries, hyperpermaseries); geopermasigmion, geopermasigmetalia and geopermasigmetea (macrogeopermaseries, megageopermaseries, hypergeopermaseries) (Tables I and II).

To study, describe and map vegetation in dynamic-catenal terms, the climatophilous and edaphoxerophilous forest or shrub vegetation with its seral stages is analysed and summarized on the basis of vegetation series (sigmeta). Woods and shrubs of the fluvial beds and lake areas, with their associated replacement stages and permanent aquatic communities, are mainly described through their geoseries (geosigmeta), that is through the catenas of riparian or lake vegetation series, in which the hygrophilous and adjacent climatophilous vegetation are mentioned as reference. Finally, the perennial mono-layered vegetation of high-altitude mountain areas and of polar regions, as well as the perennial mono-layered potential vegetation of coastlines, salt steppes, peat bogs, springs and waterfalls, are studied on the basis of their geopermaseries (geopermasigmeta).

All these vegetational groupings should integrate and adapt themeselves to the orography and geology of the surrounding areas, according to the universal geomorphological model crest-slope-piedmont-valley. In turn, these landscape phytosociological macromodels should relate themselves to the known hierarchical biogeographical types or units (districts, sectors or provinces).

Vegetation series or sigmetum

Vegetation series or sigmetum is the basic typological unit of dynamic phytosociology. This geobotanical notion attempts to express all the plant communities, or collection of stages that can be found in similar teselar places as a result of their succession processes. Therefore, it includes not only the representative vegetation type of the mature stage, or head series, but also the initial or subserial communities replacing it. The vegetation series is the fundamental unit of dynamic phytosociology (science of vegetation series and of sigmataxa that it encompasses).

It is necessary to make the distinction between climatophilous, edaphoxerophilous and edaphohygrophilous series. The climatophilous series are found on mature soils in accordance with the mesoclimate and receive only rain water. The

Unit	Unit type	Main higher ranking units
Syntaxa	Association	Alliances, orders, classes (division, not in the CPN – Code of Phytosociological Numenclature)
Sigmataxa	Sigmetum Vegetation series	Sigmion, sigmetalia, sigmetea Macroseries, megaseries, hyperseries
Geosigmataxa	Geosigmetum Geoseries	Geosigmion, geosigmetalia, geosigmetea Macrogeoseries, megageoseries, hypergeoseries
Permasigmataxa	Permasigmetum Permaseries	Permasigmion, permasigmetalia, permasigmetea Macropermaseries, megapermaseries, hyperpermaseries
Geopermasigmataxa	Geopermasigmetum Geopermaseries	Geopermasigmion, geopermasigmetalia, geopermasigmetea Macrogeopermaseries, megageopermaseries, hypergeopermaseries

Figure 1. Typological units of classic, dynamic-catenal and permacatenal phytosociology.

edaphoxerophilous series are found on xerophytic soils (leptosols, arenosols, gypsisols, serpentine soils or soils containing heavy metal), on dunes, lithosols, rocky slopes, crests, coastal slopes, etc. Finally, the edaphohygrophilous series occupy particularly wet soils such as fluvisols, halosols, histosols, etc, and are usually found in fluvial beds, along the banks of lakes and ponds, marshland, salt steppes, peat bogs, etc., (Figure 3).

To define a vegetation series one should consider the most important ecological and geographical qualities (biogeography, bioclimatic plane, edaphic factor, etc.), as well as the representative vegetation type of the mature stage, or head series association. It is also useful to indicate the structure of the potential vegetation and to use the common names of the plants. Subseries (subassociations) and vegetation facies can be used as units of lower rank. The units of higher rank are superseries, macroseries, megaseries and hyposeries (sigmenion, sigmion, sigmetalia, sigmetea), which correspond to the sub-alliances, alliances, orders and classes to which the head series associations can be assigned. For the Latinized name of these sigmataxa, the phytosociological name is used, changing the word-ending of the rank (-etosum, -etum, -enion, -ion, -etalia, -etea) with the linking vowel (-o, -i) depending on the declension, followed by the epithets: sigmetosum, sigmetum, sigmion, sigmetalia, sigmetea.

Geoseries or geosigmetum

Geoseries or geosigmetum is the basic unit of dynamic-catenal phytosociology or landscape phytosociology (the science of geosigmataxa or geosigmeta). It corresponds to a group of contiguous climatophilous, edaphoxerophilous, and edaphohygrophilous vegetation series, which replace each other along edaphic gradients in a bioclimatic belt and in a given biogeographical territory. Structurally, the geosigmetum is built up with the contiguous sigmeta or vegetation series, distributed according to the geomorphological and soil conditions.

The number of geoseries or geosimeta identified at a given hierarchical biogeographical level depends on the height, lithology, soil, bioclimate, paleoclimate and geographical situation. However, all these elements can be reduced ideally to the general model of crest – slope – piedmont – valley. This simple topographical frame of reference allows us to distinguish the three most important geomorphological aspects of any complete catena. The most xeric areas coincide with the crests or rocky outcrops, the wettest or most hygrophilous areas are always found in valleys, depressions or springs, while the mesophytic and subxerophytic areas that are situated halfway correspond to the gently-inclined slopes, piedmonts or plain areas. Due to gravitation, rain water tends to run towards the valleys both in terms of flow and percolation, creating a gradient of increasing soil humidity. At the same time, rainfall erosion facilitates the disgregation and transport of particles and solutes downwards, thus increasing the thickness and trophic levels of the soils of the piedmonts and valleys.

This simple outline – which can greatly change depending on terrain roughness and on the lithology and composition of the soils – indicates where the

Units	Basic and higher ranking units	Nomenclature reference
Sigmataxa or Sigmeta	Vegetation series: macroseries, megaseries, hyperseries Sigmetum: sigmion, sigmetalia, sigmetea	Association representative of the climax stage (head series) of vegetation series, and of the associations that compose it.
Geosigmataxa or Geosigmeta	Geoseries: macrogeoseries, megageoseries, hypergeoseries Geosigmetum: geosigmion, geosigmetalia, geosigmetea	Association representative of the climax stage (head series) of preponderant vegetation series in fluvial catenas, and of the associations that compose it.
Geopermasimataxa or Geopermasigmeta	Geopermaseries: macrogeopermaseries, megageopermaseries, hypergeopermaseries Geopermasigmetum: geopermasigmion, geopermasigmetalia, geopermasigmetea	High-montane association of unsnowy areas or association of the coastal zone, representative of the vegetation permaseries and of the associations that compose it.

Figure 2. Units of vegetation and syntaxa used for nomenclature.

plant communities are positioned harmoniously and where they produce successional and catenal phenomena that tend to balance out the biosystem. The distribution of vegetation in the general model crest – slope – piedmont – valley goes from the most resistant to xericity: from the ones that occupy the crests and driest soils (edaphoxerophilous series), to the ones that need the most humidity found in valleys and depressions adjacent to rivers and superficial aquifers, which usually flood the soils in given periods (edaphohygrophilous series). The in-between areas depend strictly on rainfall throughout the year or on a moderate seasonal increase of water in the soil during the wet season (climatophilous series: submesophytic, mesophytic and temporhygrophilous). If the gravitational contribution or water flow in the soil is significant, and the lack of edaphic aeration is long-lasting, then the hypertemporhygrophilous vegetation already belongs to an edaphohygrophilous series.

From a theoretical viewpoint, it is necessary to distinguish two types of geoseries or geosimeta,the topographic and the cliseral. Topographic or geomorphologic sigmetum expresses the crest – slope – piedmont – valley model; if it were complete (explegeosigmetum), it would include all the edaphohygrophilous, climatophilous and edaphoxerophilous series in contiguity, that correspond to the topographic catena occurring within a biogeographical area. The geosigmetum can also express a part or a portion of the geoseries that is called fractogeosigmetum: xero-, climaciedafo-, hydro- (Figure 2). Cliseral geosigmetum (orogeosigmetum), groups all the climatophilous series in altitudinal contiguity of a mountain region with considerable differences in level that is with at least two adjacent thermoclimatic belts. It is also necessary to distinguish between homogeneous cliseral geosigmeta (iso-oreogeosigmetum) and the heterogeneous ones (etero-oreogeosigmetum), on the basis of their position on mountains, whose altitudinal catenas are found on the same or different substrate, owing to the chemical composition and nutrients (Figure 3). The same affixes are used with or without the hyphen for geoseries.

Vegetation series (sigmetum)	Edaphoxerophilous series (edaphoxerophilous sigmetum) [Leptosols: lithosols, crests, steep slopes, spurs, crests, etc., dunal and psammophilous s., silicibasicole and magnesicole s.: serpentine, peridotitas, heavy metals, dolomite, etc.]
	Climatophilous series (sigmetum climatofilo) [Acidophilous s., neutrophilous s., basophilous s., temporigrofile s., etc.]
	Edaphohygrophilous series (edaphohygrophilous sigmetum) [S. fluvial: rivers, streams, torrents, etc., halophilous s., lagoonal, s. marine (mangroves), etc.]

Figure 3. Summary of climatophilous, edaphoxerophilous and edaphohygrophilous vegetation series (sigmetum).

In fluvial edaphohygrophilous geosigmeta, depending on the quantity and intermittence of circulating water, a distinction can be made between the fluvial geosigmeta of rivers, the geosigmeta of streams and torrents and those of temporary riverbeds. In fluvial beds, the vegetation series to be taken into consideration include those that develop in the deepest part of the riverbed, as well as those on the river anks and adjacent flood plains.

Topographic geoseries (fractogeoseries) Topographic geosigmetum (fractogeosigmetum)	Geoseries edaphoxerophilous or xerofractogeoseries Geosigmetum edaphoxerophilous or xero-fractogeosigmetum: hyperxerophile and xerophile [Spur and coastal areas g., crests, coastal dune g., etc.]
	Climatophile series in contiguity or climaciedafo-fractogeoserie Climatophilous sigmetum in contiguity or climaciedafo-fractogeosigmetum: submesophytic, mesophytic and temporigrofili. [Acidophilous s., neutrophilous s., basophilous s., etc.]
	Edaphohygrophilous geoseries or igrofractoserie Edaphohygrophilous or hygro-fractogeosigmetum geosigmetum: hipertemporigrofili, hygrophilous and acquatic. [Fluvial G.: river beds and river banks, lacustrine g., salt steppes g., marine g. (mangroves), etc.]

Figure 4. Summary of topographic geoseries or the general model: crest (edaphoxerophilous position), slope and piedmont (climatophilous position), valley (edaphohygrophilous position).

Cliseral Geoseries (orogeoseries) Cliseral geosigmetum (orogeosigmetum)	Homogeneous cliseral geoseries or iso-orogeoseries Homogeneous cliseral geosigmetum or iso-oreogeosigmetum [Geosigmeta or climatophile cliseral geoserie estabilshed on subtrates with homogeneous trophic levels]
	Heterogeneous cliseral geoseries or hetero-oreogeoseries Heterogeneous cliseral geosigmetum or hetero-oreogeosigmetum [Geosigmeta or cliseral climatophile geoseries established on substrates with diverse trophic levels]

Figure 5. Summary of cliseral geoseries or cliseral geosigmetum.

To define geosimeta or geoseries it is firstly necessary to separate cliseral geoseries from topographic ones, as well as fluvial edaphohygrophilous geoseries from coastal edaphoxerophilous ones. In all cases, the edaphic, biogeographic, and bioclimatic references should be mentioned, as well as the series and plants that are representative of the head series. Independently from the type of geosigmetum, due to the particular floristic, vegetational, biogeographic and bioclimatic characteristics, geofacies are considered the formal units of lower rank, while the units of higher rank are: macrogeoseries (geosigmion), megageoseries (geosigmetalia) and hypergeoseries (geosigmetea). Their nomenclatural communities are the syntaxa of principal rank to which the head series of the specific geosigmetum belongs.

As regards to the Latinized names of fluvial geosigmeta, the word-ending should be that of the most important sigmetum that corresponds to the deepest part of the riverbed, which is the most observable, as the geoseries of the external part of the river, the banks or flood plain are usually subjected to great variations, or replaced by cultivated land. However, if the riparian wood, which corresponds to the external part (banks) of the river, is partly or completely recognizable, it is possible that the ending and the name be that of the riparian geosigmetum of that head series association. When riparial series of riverbeds and dry riverbeds constitute the prevalent vegetation in streams and torrents, they can be regarded as fractogeosigmetum irrespective of the complete geosigmetum that encompasses them. In some cases, for problems of scale, coastal, dunal and rupestrian edaphoxerophilous sigmetum and geosigmetum can be considered together with the adjacent geopermasigmetum, and treated as particular geofacies.

One might think that all types of vegetation located in these habitats, differing only in terms of greater or lesser hydric nature of the soil, have a synchronic origin in the territory, and that their stability or resistance to the Holocenic climatic changes is similar. The idea of global stability of geosigmeta is very far from reality, because this unit reacts and modifies itself in several ways depending on the climatic variations and trends in each age.

Each geosigmetum hosts vegetation types that are not only antithetical in their hydric requirements, but also with very different phytocoenoses as for the chronology of their appearance and establishment in the territory. Generally speaking, one can say that edaphoxerophilous communities correspond to periods of drier climate, while edaphohygrophilous communities belong to periods of more humid climate.

These facts allow us to make numerous disquisitions and interpretations, and also explain two essential facts of dynamic-catenal phytosociology. The first is that any well-preserved steep area presents particular geosimeta and geopermasigmeta, and has sufficient phytocenotic resources to face possible climatic changes in humidity, on the basis of the release and flow of hygrophilous or xeric vegetation types and species that are more suited to the new climatic situation.

Obviously, the same restoration capacity, with similar mechanisms, will occur with thermoclimatic changes, though in this case it will be the species and the communities of the climatophilous series of contiguous homogeneous cliseral geoseries that will move themselves in an altitudinal direction.

Another aspect to consider is the closeness of the sigmeta in the catenas, that is what type of edaphoxerophilous or edaphohygrophilous vegetation is found in the corresponding structural levels. Today, we know that the vegetation change due to climatic changes is universal, and that the living elements that are interchanged are species with a precise geographic and bioclimatic jurisdiction. As a consequence, in comparative studies of catenal sequences of large regions, paleoclimates and their former boundaries can be inferred with a high degree of fidelity. This information can help to improve the units that are employed in bioclimatology and biogeography, and to formulate the theoretical vegetation models on the basis of forecasts of climatic changes (Del Río, doctoral thesis, León).

To give a name and define a geoseries, apart from the common abbreviated name, it is necessary to indicate the most important geographical and ecological features: biogeography, bioclimatic belt, topographic and edaphic characteristics, etc., as well as the dominant species or the species that gives the name to the reference association. For the Latinized names of these units, the name of the reference association and that of the syntaxa that it encompasses are used, changing the word-ending of the phytosociological rank with the epithets: geosigmion, geosigmetalia and geosigmetea.

Permaseries or permasigmetum

Permaseries or permasigmetum are perennial, stable communities that populate microtesela or microtesela complexes that are very similar to each other, of particular areas such as: polar regions, crests of high mountains, coastal zones, mobile dunes, cliffs, coastal reefs washed by seawater, etc. The steady mature stage, or climax, corresponds to a perennial vascular community that is generally poorly stratified and poor in perennial seral stages. This means that apart from the annual ephemeral species and communities that can establish themselves temporarily in open or degraded zones, only the perennial plants of the mature communities can flourish and thus reorganize the same permanent plant community.

To define permaseries, as in the case of sigmeta or vegetation series, it is necessary to refer to a diagnostic sentence that indicates the biogeographical distribution, the bioclimatic and edaphic requirements and the most characteristic species of the community (if possible, this should be the species having the word-ending of the association's name). Subpermaseries (subassociations) and permafacies can be used as lower ranking units. The following terms can be used for higher ranking units: superpermaseries, macropermaseries, megapermaseries and hyperpermaseries (permasigmenion, permasigmion, permasigmetalia, permasigmetea), which correspond to the sub-alliances, orders and classes in which the associations corresponding to permaseries are included. The name of the phytosociological syntaxon is used to latinize the name of these units, changing the word-ending of the rank (-etosum, -etum, -enion, -ion, -etalia, -etea) for the linking vowel (-o, -i) followed by the epithets:

permasigmetium, permasigmetum, permasigmion, permasigmetalia, permasigmetea.

Geopermaseries or geopermasigmetum

Geopermaseries or geopermasigmetum is the catenal expression used to describe a group of contiguous permasigmeta, delimited by different topographic or edaphic situations. It is influenced by variable climatic, microtopographic and edaphic situations, which give rise to many adjacent ecological situations, populated by permanent perennial communities (contiguous permaseries) at the equilibrium. In these cases, reference to the mature stages of regional theoretical sigmeta (head series and substitution stages) is ambiguous or unfeasible. The most favourable areas for geopermasigmeta, more than those corresponding to potential vegetation types of extreme bioclimates of high mountain areas and polar regions, are the lithosols of crests and coastal zones, cliffs, rock crevices, rocky shores washed by sea water, peat bogs, glaciers, mobile dunes, the shores of lakes and ponds, springs, etc.

The study of these adjacent communities should be carried out only in one bioclimatic belt, within a precise geomorphological range, and attention should be paid to the gradient of the ecological factor determining the catena. First of all, it is necessary to use climatophilous permasigmetum for the designation of geopermaseries. In high montane areas and polar regions, if this lacks or is ambiguous, the permasigmetum of unsnowy areas should be used. In the azonal catena the nomenclature should refer to the prevalent community that best represents the ecological factor balancing and determining the ecological environment. In some cases, the biogeographical position, the bioclimatic data, the contacts with adjacent sigmetum and the possible geographical vicariants should be described (Tüxen, 1956, 1977, 1979; Rivas Goday 1958, 1961; O. Bolòs, 1962, 1963, 1979, 1984, 1989; Géhu, 1974, 1991; Müller-Dombois & Ellenberg, 1964; Béguin, 1974; Rivas-Martínez, 1976, 1983, 1987, 1988; 1994, 1996, 2004; Rivas-Martínez & Géhu, 1979; Sotchava, 1979; Pignatti, 1979; Béguin et al. 1979; O. Bolòs & Molinier, 1984; Valle, 1985; Ansseau & Grandtner, 1990; Loidi, 1991; Theurillat, 1992; Géhu & Biondi, 1994; Rodwell et al. 1995; Biondi, 1994, 1996; Alcaraz, 1996; Asensi, 1996; Gillet & Gallandat, 1996; Capelo, 1996, 2003; Bueno, 1997; Vigo, 1998; Díaz, 2004; Pedrotti, 2004).

In the "2005 Potential Natural Vegetation Map of Spain", the cryorotemperate and the cryoromediterranean bioclimatic belts (the latter mentioned only on the crests of Sierra Nevada) were mapped through their geopermaseries named after the permaseries of unsnowy areas. In the case of the submediterranean peaks of the cordilleras of the Iberian Peninsula, in the upper orotemperate level the geopermaseries include the climatophilous shrub vegetation of the adjacent vegetation series or mosaics. Likewise, the azonal geopermaseries of the dune systems and of coastal or inland halophytic habitats, described by the prevalent perennial association or by the permaseries, which mostly represent the main ecological factor, include the shrub vegetation of the adjacent edaphoxerophilous series A description of the geopermaseries should include the abbreviated common name and the most important geographical and ecological factors: the biogeography, the bioclimatic belt, the topographical and edaphic characteristics, etc., as well as the dominant species or those that have the name of the reference association. Independently from the type of geopermasigmetum, due to its floristic, vegetational, biogeographical and bioclimatic peculiarities, geopermafacies can be regarded as formal units of lower rank, while the units of higher rank are: macrogeopermaseries (geopermasigmion), megageopermaseries (geopermasigmetalia) and hypergeopermaseries (geopermasigmetea), whose nomenclatural communities are the upper ranking syntaxa to which the reference associations of geopermasigmetum belong to: climatophilous, unsnowy areas, prevalent, etc. (Figure 6).

Vegetation facies

Vegetation facies are lower ranking units of series, permaseries, geoseries or geopermaseries (sigmetum, permasigmetum, geosigmetum e geopermasigmetum), that are particularly useful in mapping potential vegetation and in bioclimatic definitions. They can describe potential plant communities or groups of potential communities that are different from the main descriptive types of sigmetum, permasigmetum, geosigmetum or geopermasigme-

Facies	Geofacies	Geopermafacies
Sigmetum Series	Geosigmetum Geoseries	Geopermasigmetum Geopermaseries
Sigmenion Superseries	Geosigmenion Supergeoseries	Geopermasigmenion Supergeopermaseries
Sigmion Macroseries	Geosigmion Macrogeoseries	Geopermasigmion Macrogeopermaseries
Sigmetalia Megaseries	Geosigmetalia Megageoseries	Geopermasigmetalia Megageopermaseries
Sigmetea Hyperseries	Geosigmetea Hypergeoseries	Geopermasigmetea Hypergeopermaseries

Figure 6. Summary of the typological units of dynamic-catenal and permacatenale phytosociology

Fluvial geofacies: natural and seminatural	Fluvial (rivers)
	Rivulari (streams and torrents)
	Resurgent (springs)
Fluvial geofacies: heavily anthropized	Agricultural (cultivations)
	Pastoral (grassland)
	Forestry (reafforestation)
	Hydraulic (basins)
	Industrial (constructions, areas without vegetation)

Figure 7. Classification of fluvial geofacies based on naturalness, geomorphology and exploitation by man.

tum: facies, geofacies and geopermafacies. They have vegetational features that are in some way connected to each other, though this is not enough to create independent higher ranking units. These facies usually correspond to structural variations of particular floristic and dynamic features, as a consequence of clear edaphic, biogeographic, or bioclimatic differences, compared to the descriptive type.

Even geofacies can be used to describe vegetational and landscape variations that derive from man's exploitation. The most frequent cases are: agricultural, pastoral, forestry, industrial or hydraulic use of areas corresponding to fluvial geosigmetum.

Fluvial geofacies have been separated into natural, seminatural and heavily exploited. In the first case, a distinction can be made between fluvial geofacies of rivers, geofacies of streams and torrents and geofacies of sources and springs, according to the quantity and irregularity of water flow. In the most exploited areas, like the fluvial geoseries of wide riverbeds with adjacent floodplains, which are frequently enlarged and terraced for irrigation and building purposes, a distinction can be made between agricultural, pastoral, forestry, hydraulic and industrial geofacies (Figure 7).

To name facies, geofacies and geopermafacies by the name of the series, permaseries, geoseries or geopermaseries, the most important floristic, geographic, ecologic or anthropic epithets should be used to easily identify them.

References

Alcaraz F. 1996. Fitosociología integrada, paisaje y Biogeografía. In: Loidi J, editor. Avances en Fitosociología. Universidad del País Vasco. pp. 59–94.

Alexiu VF. 1998. Practicum de Fitosociologie. Cultura. Piteşti.

Anand M, Orlóci I. 1997. Chaotic dynamics in a multispecies community. Environ Ecolog Stat 4:337–44.

Anand M. 2000. The fundamentals of vegetation change: complexity rules. Acta Biotheoretica 48:1–14.

Anand M, Kadmon R. 2000. Community-level analysis of spatiotemporal plant dynamics. Ecoscience 7:101–10.

Ansseau C, Grandtner MM. 1990. Symphytosociologie du paysage végétale. Phytocoenologia 19(1):109–22.

Asensi A. 1996. Fitosociología y paisaje (Una aproximación histórica). In: Loidi J, editor. Avances en Fitosociología. Universidad País Vasco. pp. 43–58.

Austin MP. 1985. Continuum concept, ordination methods, and niche theory. Ann Rev Ecol Syst 16:39–61.

Austin MP, Smith TM. 1989. A new model for the continuum concept. Vegetatio 83:35–47.

Béguin C. 1974. Contribution a l'étude phytosociologique et écologique du Haut Jura. Beitr Geobot Landesaufn Schweiz 54:1–190.

Béguin C, Géhu JM, Hegg O. 1979. La symphytosociologie: une approche nouvelle des paysages végétaux. Doc Phytosoc NS 4:49–68.

Bertrand G. 1968. Paysage & géographie physique globale. Esquisse méthodologique. Rev Géogr Pyrénées et du Sud-Ouest 39(3):249–72.

Bertrand G. 1972. La science du paysage, une science diagonale. Rev Géogr Pyrénées et du Sud-Ouest 43(2):127–33.

Biondi E. 1994. The phytosociological approach to landscape study. Ann Bot Roma 52:135–41.

Biondi E. 1996. L'analisi fitosociologica nelle studio integrato del paesaggio. In: Loidi J, editor. Avances en Fitosociología: 13–22. Universidad del Pais Vasco.

Biondi E, Feoli E, Zuccarello V. 2004. Modelling Environmental responses of plant associations: a review of some critical concepts in vegetation study. Crit Rev Plant Sci 23(2):149–56.

Bolòs O de. 1962. El paisaje vegetal barcelonés. Fac Filosofía Letras Cátedra Ciudad de Barcelona. Barcelona.

Bolòs O de. 1963. Botánica y geografía. Mem Real Acad Ci Barcelona 34:443–80.

Bolòs O de. 1984. Plant landscape (phytogeographie). In: Kuhbier H., Alcover JA, Guerau d'Arellano C, editors. Biogeography and ecology of the pityusic islands. Barcelona: Junk. pp.185–221.

Bolòs O de. 1989. Bioclimatologia i geografia botànica. Mem Real Acad Ci Barcelona 48:423–44.

Bolòs O de, Molinier R. 1984. Vegetation of the Pityusic Islands. In: Kuhbier H, Alcover JA, Arellano G, editors. Biogeography and ecology of the Pityusic Islands. Dr. W. Junk. Den Haag. pp. 185–221

Braun-Blanquet J. 1921. Prinzipien einer systematik der pflanzengesellschaften auf floristischer grundlage. Jahrb St Gallischen Naturwiss Ges 57(2):346.

Braun-Blanquet J. 1928. Pflanzensoziologie. Grundzüge der vegetationskunde. Berlin: Springer.

Braun-Blanquet J. 1948. La végétation alpine des Pyrénées orientales. Monografía de la Estación Estudios pirenaicos, Botanica 1, N. general 9. Barcelona.

Braun-Blanquet J. 1964. Pflanzensoziologie. Grundzüge der vegetationskunde. 3rd ed. Wien: Springer Verlag.

Braun-Blanquet J, Pavillard J. 1928. Vocabulaire de sociologie végétale. 3rd ed. Montpellier.

Braun-Blanquet J, Emberger L, Molinier R. 1947. Instructions pour l'établissement de la carte des groupements végétaux. Montpellier: Gausse Graille Castelnau.

Braun-Blanquet J, Roussine N, Nègre R. 1952. Les groupements végétaux de la France Méditerranéenne. Montpellier: Centre National de la Recherche Scientifique.

Bueno A. 1997. Flora y vegetación de los estuarios asturianos. Cuadernos de Medio Ambiente, Naturaleza. Oviedo 3:1 – 334.

Cantó P. 2004. Estudio fitosociológico y biogeográfico de la Sierra de San Vicente y tramo inferior del valle del Alberche (Toledo, España). Lazaroa 25:187 – 249.

Capelo JH. 1996. Esboço da paisagem vegetal da Bacia Portuguesa do Río Guadiana. Silva Lusit N° especial: 13 – 64.

Capelo JH. 2003. Conceitos e métodos da fitossociologia. Formulação contemporânea e métodos numéricos de análise da vegeação, Estacão Florestal Nacional/Sociedade Portuguesa de Ciências Florestais. Oeiras.

Clements FE. 1904. The development and structure of vegetation. Bot Surv Nebraska 7:1 – 175.

Clements FE. 1916. Plant succession. An analysis of development of vegetation. Washington, DC: Carnegie Institute.

Clements FE. 1936. Nature and structure of the climax. J Ecol 24.

Clements FE. 1949. Dynamics of vegetation. New York:

Costa JC. 2004. A investigaçao de fitossociologia em Portugal. Lazaroa 25:63 – 71.

Dierschke H. 1994. Pflanzensoziologie. Grundlagen un Methoden. Stuttgart: Verlag Eugen Ulmer.

Dierßen K. 1996. Vegetation nordeuropas. Stuttgart: Verlag Eugen Ulmer.

Feoli E. 1988. Exploring multidimensional space in vegetation science. In: Kazmierczak E, Nienartowicz A, Piernik A, Wilkon-Michalska J, editors. Computer methods in investigation of the structure and functionning the vegetation cover. Torun: Wydaw Univ. Mikolaja Kopernica. pp 143 – 56.

Ferreras C. 1987. La phytosociologie comme moyen de diagnostic de l'état du paysage végétal. Coll Phytosociol 15:747 – 52.

Folch R. 1986. La vegetació dels Països Catalans. 2nd ed. Ketres: Barcelona.

Fuertes E. 2004. Desarrollo histórico de la Briosociología en España. Lazaroa 25:23 – 33.

Géhu JM. 1974. Sur l'emploi de la méthode phytosociologique sigmatiste dans l'analyse, la définition et la cartographie des paysages. Compt Rend Acad Sci Paris 279:1167 – 70.

Géhu JM. 1979. Pour une approche nouvelle des paysages végétaux: la symphytosociologie. Bull Soc Bot France Lettres Bot 126(2):213 – 23.

Géhu JM. 1991. L'analyse phytosociologique et géosymphytosociologique de l'espace. Théorie et méthodologie. Coll Phytosoc 17:11 – 46.

Géhu JM, Rivas-Martínez S. 1981. Notions fondamentales de phytosociologie. In: Dierschke H, editor. Syntaxonomie. Ber Intern Symposium IV-V: 5 – 53. Cramer, Vaduz.

Géhu JM, Biondi E 1994. Végétation du littoral de la Corse: Essai de synthèse phytosociologique. Braun-Blanquetia, 13:1 – ??.

Gillet F, Gallandat JD. 1996. Integrated synusial phytosociology: some notes on a new, multiscalar approach to vegetation analysis. J Vegetat Sci 7:13 – 8.

Gleason HA. 1926. The individualistic concept of plant association. Bull Torrey Bot. Club 53:7 – 26.

Goodall DW. 1954. Vegetational classification and vegetational continua. Angew Pflanzensoz 1:169 – 82.

Izco J. 1998. Diversidad fitosociológica. Riqueza de cabezas de series sucesionales en relación con la altitud. Acta Bot Barc 45:525 – 34.

Loidi J. 1991. Vegetation series: its use for small scale geobotanical mapping. Phytocoenosis 3:119 – 22.

Loidi J. 1994. Phytosociology applied to nature conservation and land management in Spain. In: Song Y, Dierschke H, Wang X, editors. Applied vegetation ecology. Proceedings of the 35th Symposium of I.A.V.S. Shangai: East China Normal University Press. pp 17 – 30.

Loidi J. 2004. Phytosociology and Biodiversity: an undissociable relationship. Fitosociologia 41(1 Suppl. 1):3 – 13.

Mateo G. 1983. Estudio sobre la flora y vegetación de las sierras de Mira y Talayuelas. Publ Ministerio de Agricultura, Ser Monogr 31:1 – 290.

Mucina L, van der Maarel E. 1989. Twenty years of numerical syntaxonomy. Vegetatio 81:1 – 15.

Müller-Dombois D, Ellenberg H. 1964. Aims and methods of vegetation ecology. New York: Wiley.

Pedrotti F. 2004. Cartografia geobotánica. Bologna: Pitagora.

Pignatti S. 1994. Ecologia del paesaggio. Torino: UTET.

Rivas Goday S. 1958. Bases ecológicas y estadísticas de la Fitosociología. Anales Real Acad Farm 24(3):191 – 210.

Rivas Goday S. 1961. Los complejos climáticos de la cartografía de la vegetación (necesidad de precisar la etapa de sustitución y establecer los dominios para su cartografía). Bol Soc Esp Hist Nat 59:65 – 72.

Rivas-Martínez S. 1976. Sinfitosociología, una nueva metodología para el estudio del paisaje vegetal. Anales Inst Bot Cavanilles 33:179 – 88.

Rivas-Martínez S. 1983. Series de vegetación de la región eurosiberiana de la Península Ibérica. Lazaroa 4:155 – 66.

Rivas-Martínez S. 1985. Biogeografía y vegetación. Discurso de ingreso como Académico de Número. Madrid: Real Academia de Ciencias Exactas, Físicas y Naturales.

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

Rivas-Martínez S. 1987. Nociones sobre Fitosociología, Biogeografía y Bioclimatología. In: Peinado M, Rivas-Martínez S, editors. La vegetación de España. Madrid: Serv. Publ. Universidad Alcalá de Henares. pp. 19 – 45.

Rivas-Martínez S. 1988. Bioclimatología, biogeografia y series de vegetacion de Andalucía occidental. Lagascalia 15: 91 – 119.

Rivas-Martínez S. 1994. Dynamic-zonal phytosociology as landscape science. Phytocoenologia 24:23 – 5.

Rivas-Martínez S. 1996. Geobotánica y climatología. Discurso investidura Dr. 'Honoris causa' Universidad de Granada. Serv. Publ. Granada: Universidad de Granada.

Rivas-Martínez S. 2004. Globalbioclimatics. Available at: http://www.ucm.es/info/cif. Accessed May 2005.

Rodwell JS, Pignatti S, Mucina L, Schaminée JHJ. 1995. European vegetation survey: update on progress. J Veg Sci 6:759 – 62.

Theurillat JP. 1992. Etude et cartographie du paysage végétal (symphytocoenologie) dans la région d'Aletsch (Valais, Suisse). Développement historique et conceptuel de la symphytocoenologie, niveaux de perception, méthodologie, applications. Beitr Geobot Landesaufn. Schweiz 68:1 – 384.

Theurillat JP. 1992. L'analyse du paysage végétal en symphytocoenologie: ses niveaux et leurs domaines spatiaux. Bull Ecol 23(1 – 2):83 – 92.

Tüxen R. 1956. Die heutige potentielle natürliche Vegetation als genenstand der vegetationskartierung. Angew Pflanzensoz Stolzenau 13:5 – 42.

Tüxen R. 1977. Zur homogenität von sigmassoziationen, ihner syntaxonomischen ordnung und ihrer verwendung in der vegetationskartierung. Doc Phytosoc NS 1:321 – 8.

Tüxen R. 1979. Sigmeten und geosigmeten, ihre ordnung und ihre bedeutug für wissenschaft, naturschutz und planung. Biogeographie 16:79 – 92.

Valle F. 1985. Mapa de las series de vegetación de Sierra Nevada. Ecol Medit 11:184 – 99.

Vigo J. 1998. Some reflections on geobotany and vegetation mapping. Acta Bot Barcinon 45:535 – 56.

Westhoff V, van der Maarel E. 1978. The Braun-Blanquet approach. In: Whittaker RH. editor. Classification of plant communities, 2nd ed. The Hague: Dr.W.Junk. pp. 287 – 399.

Whittaker RH. 1965. Dominance and diversity in land plant communities. Science 147:250 – 60.

Whittaker RH. 1967. Gradient analysis of vegetation. Biol Rev London 42:207–64.
Whittaker RH. 1975. Communities and ecosystems. New York: Macmillan.
Yu S, Orlöci L. 1990. On niche overlap and its measurement. Coenoses 5:159–65.