Contribuţii Botanice – 2019, LIV: 55-75 DOI: 10.24193/Contrib.Bot.54.4
Grădina Botanică "Alexandru Borza"
Cluj-Napoca

GEOSERIES INTERPRETATION AND MAPPING

Franco PEDROTTI
University of Camerino, Via Pontoni 5, **I-62032 Camerino, Italy**
e-mail: franco.pedrotti@unicam.it

Abstract: A geoseries (or geosigmetum) is a catenal unit of vegetation series on an ecologically homogeneous phytotopographical unit of a given chorological sector. It includes the complete altitudinal sequence of zonal, extrazonal and intrazonal vegetation series. A geoseries can be divided into smaller sectors known as "geoseries individuals" on the basis of orography, hypsometry and aspect. Theoretically speaking, the geoseries individuals should be composed of the same number and type of series; however, in practice the number of sigmeta may vary for orographic, hypsometric and geological reasons. A geoseries is complete when it extends from sea level to an altitude of at least 3000 m (in the European mountains) and reduced if truncated at the top when the altitude range is less (lower massifs). Each geoseries is characterised by at least one vegetation series. A geoseries is bordered by geological, geomorphological and geographic limits (watershed line, watercourses, etc.). A geoseries can be mapped in three ways: 1) a single map unit including all the series and indicated with a single colour; 2) a map unit subdivided into series indicated with different colours; 3) a map unit divided into series indicated with different tones of the same colour. This method was used to produce a map (1:150,000) of the geoseries in the Val d'Adige (Central Alps) consisting of 6 climatophilous series and 3 edaphophilous series.

Keywords: chorological sector; morphotype; geobotanical significance; geoseries individuals; geoseries mapping; Val d'Adige; Central Alps.

Introduction

A geoseries (or geosigmetum) is the reference unit of geo-synphytosociology, the science of plant landscapes based on the concepts and methods of sigmatist phytosociology. The term geoseries was introduced into botanical literature quite recently [9, 12, 10, 26, 27, 11, 14] and is used to describe a vegetation series, or series of proximate permanent communities, occurring sequentially along any ecological gradient within the same chorological sector. The purpose of this contribution is to examine problems related to geoseries interpretation and mapping, with particular reference to mountain ranges.

The geoseries

A geoseries (or geosigmetum) is a catenal unit of contiguous vegetation series on a phytotopographic unit of a given chorological sector. Each phytotopographic unit consists of a single type of lithological substrate and a single morphotype (slope, plain, orographic terrace, fluvial terrace, plateau, alluvial cone, etc.), and is therefore relatively homogeneous from an ecological point of view. It includes the complete altitudinal (massifs) and latitudinal-longitudinal (plains) sequence of the climatophilous (zonal, extrazonal and intrazonal) and edaphophilous (azonal) vegetation series.

Theoretically speaking, the patches of a given geoseries should be composed of the same number and type of vegetation series (Figure 1); however, in practice one or more series (sigmeta) may be missing for orographic, hypsometric and geological reasons. Each geoseries is characterised by at least one vegetation series.

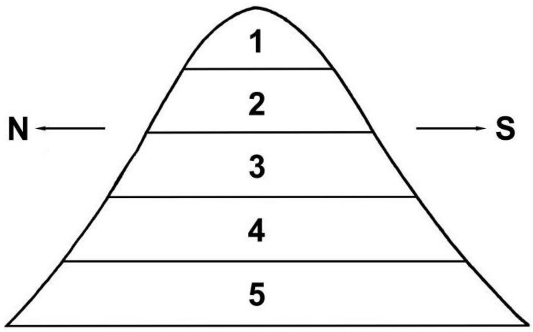

Fig. 1: Geoseries model composed of five vegetation series (1 to 5); depending on slope aspect (North or South) the vegetation series can be different.

A geoseries may be *complete* [5] or *reduced* due to the orography (altitude). In the first instance, it extends from sea level to an altitude of 3000 m (the limit for European mountains); in the second, it is truncated at the top when the altitude range is less, as with lower massifs. It can also be reduced for geological reasons when different types of substrates replace each other altitudinally (Figure 2). Finally, it may be *interrupted* if formed of separate (non-contiguous) parts as a result of alternating geological strata (Figure 3) or morphotypes.

Topography and aspect are also important factors, as different vegetation series may be present on the North and South slopes of the same mountain range or of the same valley (Figure 1). For example, *Abies alba* series occupy exclusively North-facing slopes, while *Quercus ilex* series are found only on South-facing slopes.

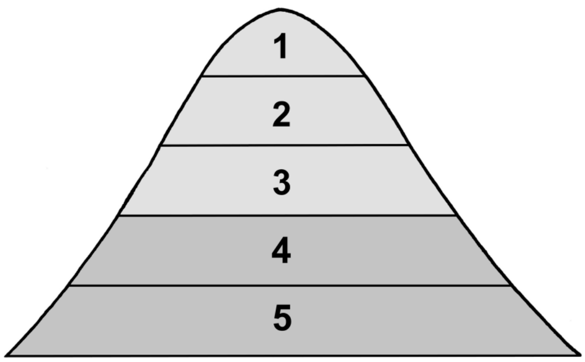

Fig. 2: Model of two geoseries (indicated by different shades of grey) that are distinguished according to geology (1-3 and 4-5 are the component sigmeta on calcareous and siliceous substrata, respectively).

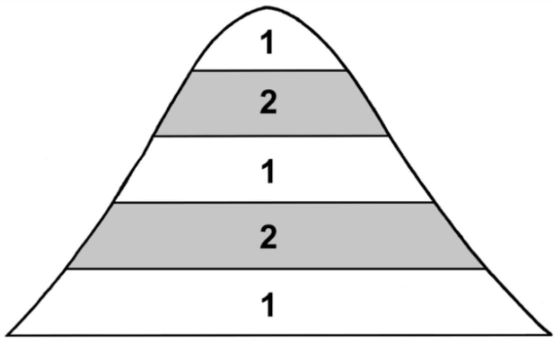

Fig. 3: Model of two geoseries (in white and grey) that are distributed in strips due to the alternation of different geological strata (1 - calcareous; 2 - basaltic).

Delimiting the geoseries

On massifs, the limits defining a geoseries are based on hypsometry (altitude), topography (aspect) and geology, and consequently on pedology, geomorphology (morphotypes) and geography (such as the watershed line and watercourses). On plains, on the other hand, the limits are exclusively geomorphological (morphotypes), pedological and geographical.

Figure 4 shows the map of the geoseries in the municipality of Montemonaco in the Central Apennines (Italy). It displays three geoseries: one on calcareous slopes (geoseries of *Seslerieto apenninae* sigmetum / *Scutellario-Ostryeto* sigmetum) and two on marly sandstone slopes, facing North (geoseries of *Solidagini-fageto* sigmetum / *Hieracio murorum-Ostryeto* sigmetum) and facing South (geoseries of *Erico arboreae-Querceto pubescentis* sigmetum / *Cyclamino hederifolii-Castaneto* sigmetum). The geoseries are delimited as follows: number 1 is a geographical limit (watershed line on the calcareous massifs), number 2 is a geological limit corresponding to a fault line, number 3 is a geographical limit (watershed line on the marly sandstone massifs), number 4 is a geographical limit (watercourse) and number 5 is not a limit of the geoseries, but the mid-slope administrative boundary of the municipality of Montemonaco.

Figure 5 shows the morphotypes of the North side of the Brenta Dolomites group (Central Alps) from the valley bottom (700 m) to 2043 m of altitude. Each morphotype corresponds to a phytotopographic unit and contains specific geoseries as follows: 1 – calcareous slopes (geoseries of *Seslerio-Cariceto sempervirentis* sigmetum / *Fraxino orni-ostryeto carpinifoliae* sigmetum); 2 – morainic deposits (geoseries of *Empetro-Vaccinieto* sigmetum / *Luzulo nemorosae-Piceeto* sigmetum p.p.); 3 – fluvio-glacial terraces (geoseries of *Salvio glutinosae-Fraxineto excelsioris* sigmetum / *Caltho-Alneto glutinosae* sigmetum); 4 – alluvial fans (geoseries of *Chamaecytiso-Pineto sylvestris* sigmetum, belonging to the geoseries defined in number 1); 5 – recent fluvial deposits (geoseries of *Alneto incanae* sigmetum / *Saliceto incano-purpureae* sigmetum).

Figure 6 shows an example of a map of plain geoseries, the Bialowieza area in Poland. This is a plain formed of periglacial morainic deposits with depressions occupied by peatlands and marshes crossed by a valley with recent fluvial terraces.

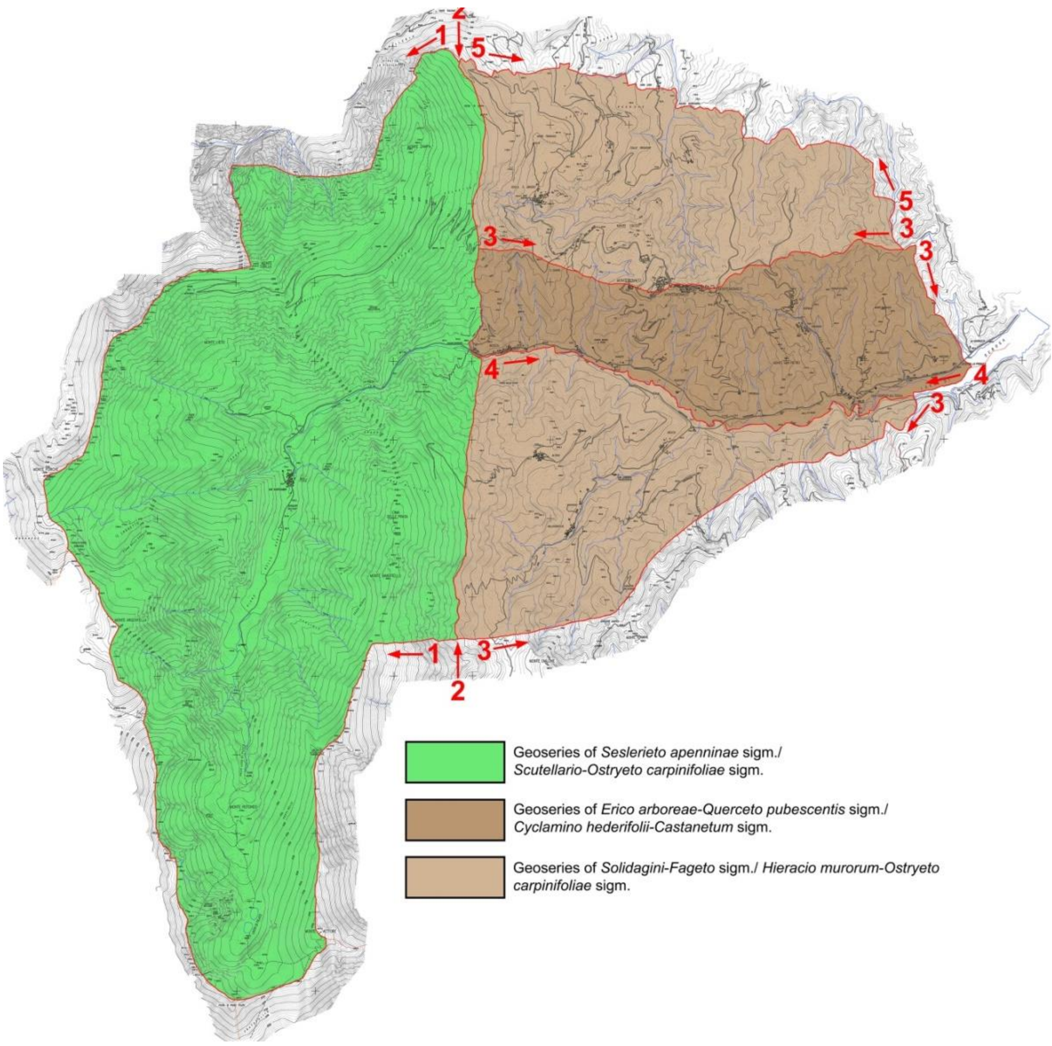

Fig. 4: The geoseries of the municipality of Montemonaco, central Apennines (Italy);
1 - geographical limit (watershed line) on calcareous massifs; 2 - geological limit (fault line); 3 - geographical limit (line of watersheds) on marly-arenaceous solid masses; 4 - geographical limit (water course); 5 - administrative limit of the municipality of Montemonaco, which runs halfway up the slope.

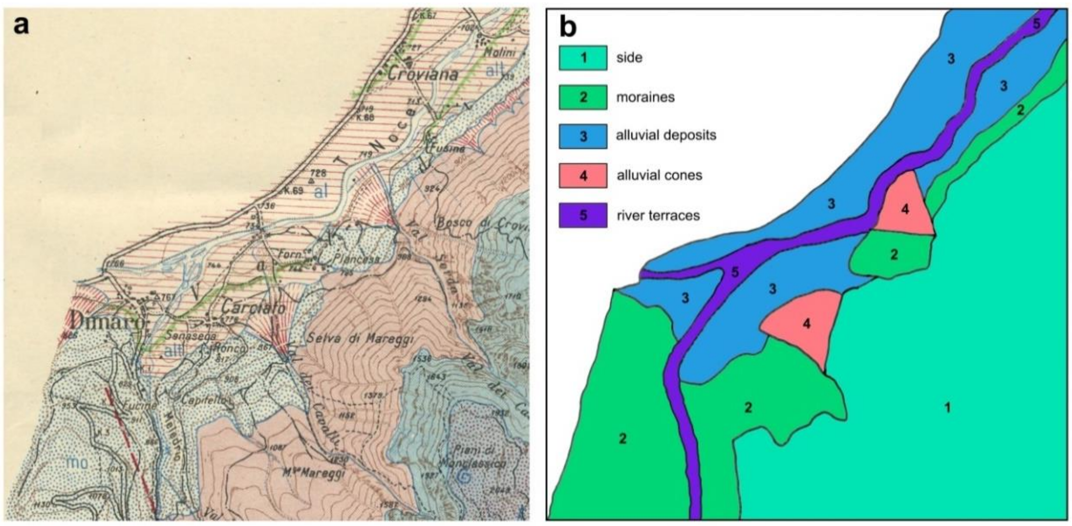

Fig. 5: Geological map of the northern slope of the Brenta Dolomites (central Alps) formed of carbonatic rocks, moraines, alluvial deposits and river terraces (a); morphotype map (b).

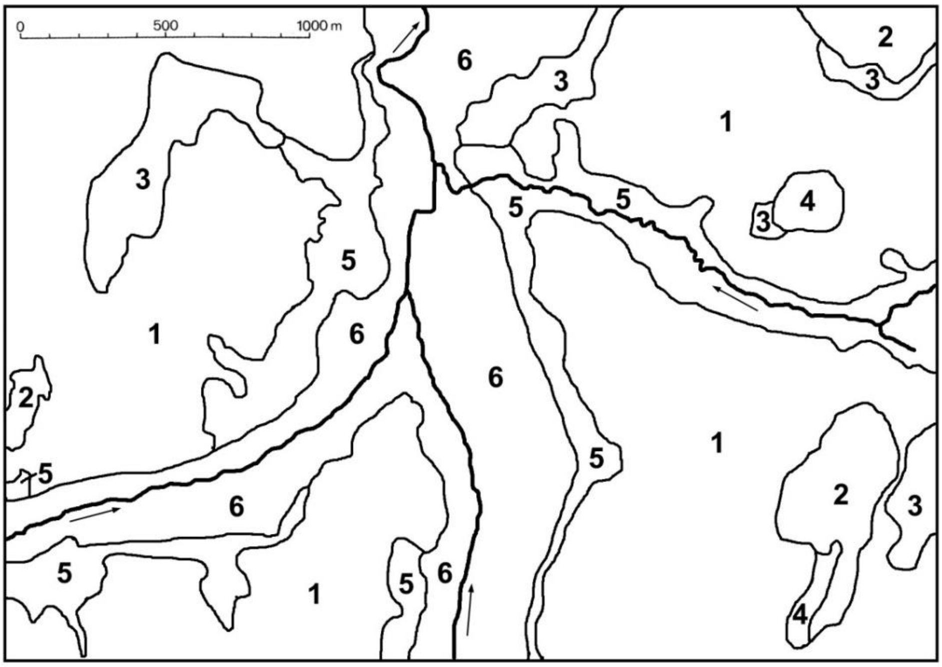

Fig. 6: Geoseries map of the Bialowieza forest (Poland) (from Pedrotti and Venanzoni, 1994, modified).

The geoseries can be divided into smaller sectors known as “geoseries individuals” and delimited on the basis of orography, hypsometry and aspect as seen on the map in Figure 7. Their use makes it possible to examine geoseries in more depth at local level, particularly if these are very large, such as the geoseries of *Seslerio-Cariceto sempervirentis* sigmetum / *Fraxino orni-Ostryeto carpinifoliae* sigmetum which has been divided into 23 geoseries individuals. For each of these, a list of the series is given in Table 1.

Geobotanical significance of the geoseries

The geoseries has a dual, vegetational and phytogeographical significance as the geo-synphytosociological map represents a link between the vegetation map and the phytogeographical map [20, 3]. The vegetational significance derives from the vegetation series, while the phytogeographical significance derives from the synthesis obtained by means of geoseries, which can be considered as the first level of a phytogeographical division. This is evident in maps constructed on the basis of geoseries and higher units such as chorological complexes [30], mega-geoseries [21] and geopermasigmeta [26]. In the past, the phytogeographical subdivisions were defined on the basis of general floristic, geobotanical and botanical-geographic criteria [13]. Today, geo-synphytosociology makes it possible to recognise and define phytogeographical subdivisions on the basis of vegetation series and geoseries; this is done no longer through vegetation mapping, but phytogeographical mapping [20].

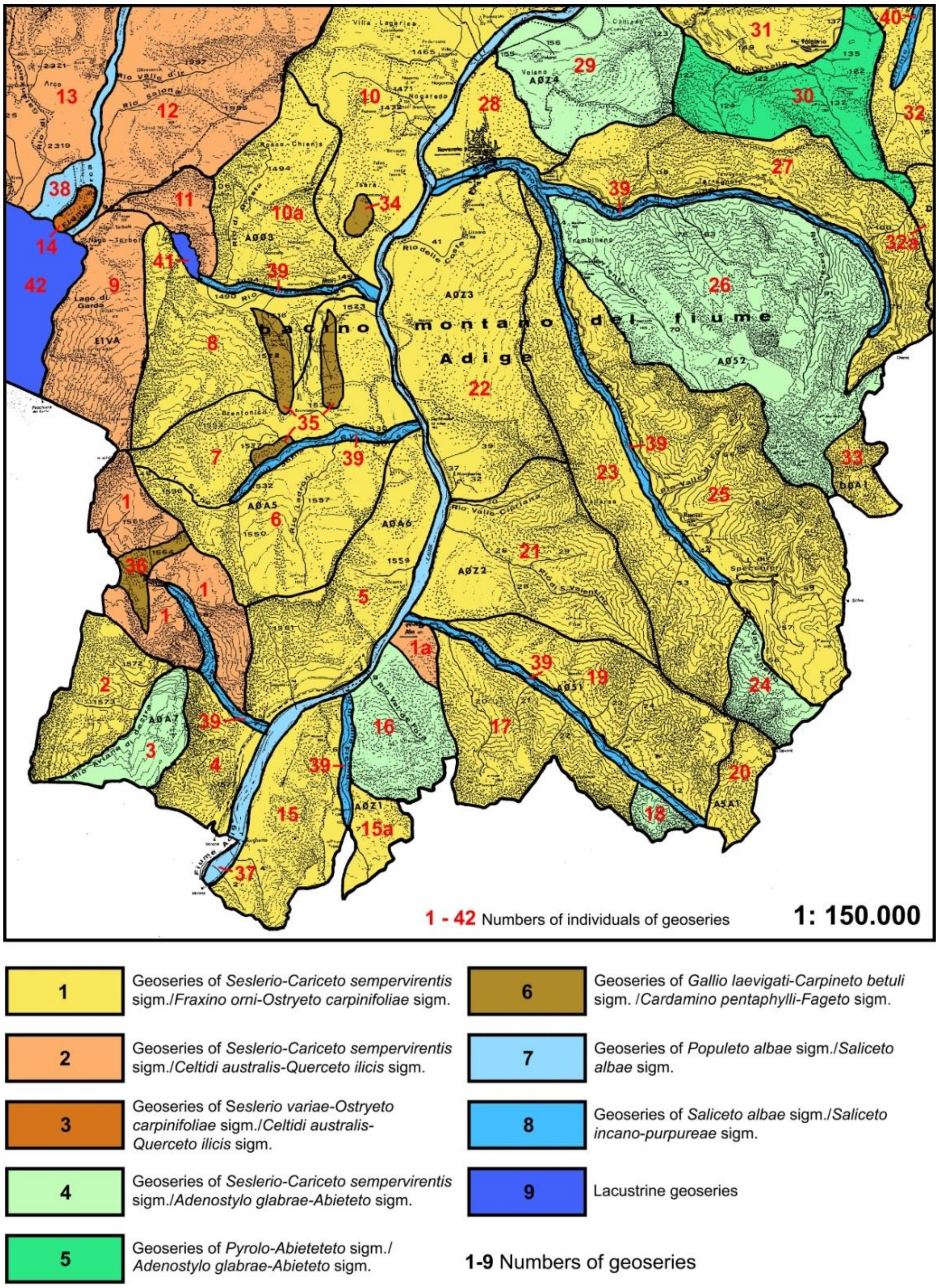

Fig. 7: Map of geoseries and geoseries individuals (indicated with in red by numbers from 1 to 42) of the Adige valley (central Alps). Localities of the geoseries individuals:

1 - Geoseries of *Seslerio-Cariceto sempervirentis* sigm./*Fraxino orni-Ostryeto carpinifoliae* sigm.; 2 – Cima delle Pozzette, East; 4 – Peak (without name) 1388 m, East; 5 – Cima della Paura, South-East; 6 – Cima della Paura, North; 7 – M. Altissimo, South-East; 8 – M. Altissimo, North; 10 – M. Stivo, East-South-East; 10a – Gresta valley, South; 15 and 15a – Slopes of Borghetto; 17 Ala valley, North-North-East; 19 – Ala valley, South; 20 – M. Carega, East; 21 – Valli Rio San Valentino and Cipriana; 22 – Adige valley, West, between S. Margherita and Rovereto; 23 – Vallarsa, East-North-East; 25 – Vallarsa, South-West; 27 – Terragnolo valley, South; 28 – Rovereto, South-West; 31 – Folgaria valley, South; 32 – Astico valley (slopes); 32a – Small area next to the previous one, Veneto side; 33 – Cima Palon, East. [see Table 1]

2 - Geoseries of *Seslerio-Cariceto sempervirentis* sigm./*Celtidi australis-Querceto ilicis* sigm.; 1 – Aviana valley, South-East; 1a – Ala; 9 – M. Altissimo, West; 11 – Gresta valley; 12 – M. Stivo, West-North-West; 13 – Sarca valley, East. [see Table 2]

3 - Geoseries of *Seslerio variae-Ostryeto carpinifoliae* sigm./*Celtidi australis-Querceto ilicis* sigm.; 14 – M. Brione. [see Table 3]

4 - Geoseries of *Seslerio-Cariceto sempervirentis* sigm./A*denostylo glabrae-Abieteto* sigm.; 3 – M. Cerbiolo, West-North-West; 16 – M. Castelberto, slopes between Vò Sinistro and Ala; 18 – Ala valley, North-East; 24 – Vallarsa, North-East; 29 – Folgaria valley, North; 26 – Col Santo, North-East. [see Table 4]
5 - Geoseries of *Pyrolo-Abietetето* sigm.; 30 – Folgaria-Serrada plateau. [see Table 5]
6 - Geoseries of *Gallio laevigati-Carpineto betuli* sigm./*Cardamino pentaphylli-Fageto* sigm.; 34 – Isera, South-South-East; 35 – Brentonico, East: 36 - Aviana valley, East. [see Table 6]
7 - Geoseries of *Populeto albae* sigm./*Saliceto albae* sigm.; 37 – Adige valley; 38 – Sarca valley. [see Table 7]
8 - Geoseries of *Saliceto albae* sigm./*Saliceto incano-purpureae* sigm.; 39 – Side valleys of the Adige valley: 40 – Astico valley. [see Table 8]
9 - Lacustrine geoseries 41 – Loppio lake; 42 – Garda lake. [see Table 9]

Geoseries mapping

The geoseries may be mapped in three different ways, according to the models in Figure 8: **a)** using a single map unit including all the series represented by a given colour; examples of this method include maps of the Rome area [2], the Côtes d'Armor (Brittany) [1], the Asturias [5], the Asco Valley in Corsica [4], Spain [27, 28, 29] and the Val di Sole in Italy [16]; this type of mapping emphasises the phytogeographical significance of the geoseries; **b)** using a map unit divided into subunits corresponding to single series, each represented with a different colour; this type of mapping highlights the vegetational significance of the geoseries; **c)** using a map unit divided into units corresponding to individual series, each represented by a single colour with different tones; this type of mapping emphasises both the vegetational and phytogeographical significance of the geoseries.

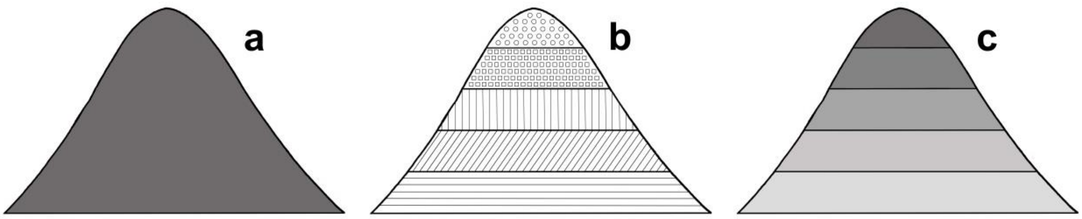

Fig. 8: Cartographic representation models of geoseries; *model a*, with a single unit indicated by a single color; *model b*, with a single unit divided into sub-units corresponding to the individual vegetation series, indicated through different colours or patterns; *model c*, with a single unit divided into sub-units corresponding to the individual vegetation series, indicated by shades of grey.

The three methods were applied during the geoseries survey of the Val di Sole, Central Alps (Italy). The map in Figure 9 refers to the climatophilous geoseries of *Empetro-Vaccinieto* sigmetum / *Luzulo niveae-Querceto petraeae* sigmetum (a geoseries individual), including a number of valleys with surface waters that determine the occurrence of one edaphophilous geoseries, the *Alneto incanae* sigmetum, of which four geoseries individuals are present. Each geoseries is represented by a single colour (*model a*).

The map in Figure 10 shows the same geoseries individual as the previous figure, but in this case, the series are indicated with different colours, as in phytosociological type maps (*model b*).

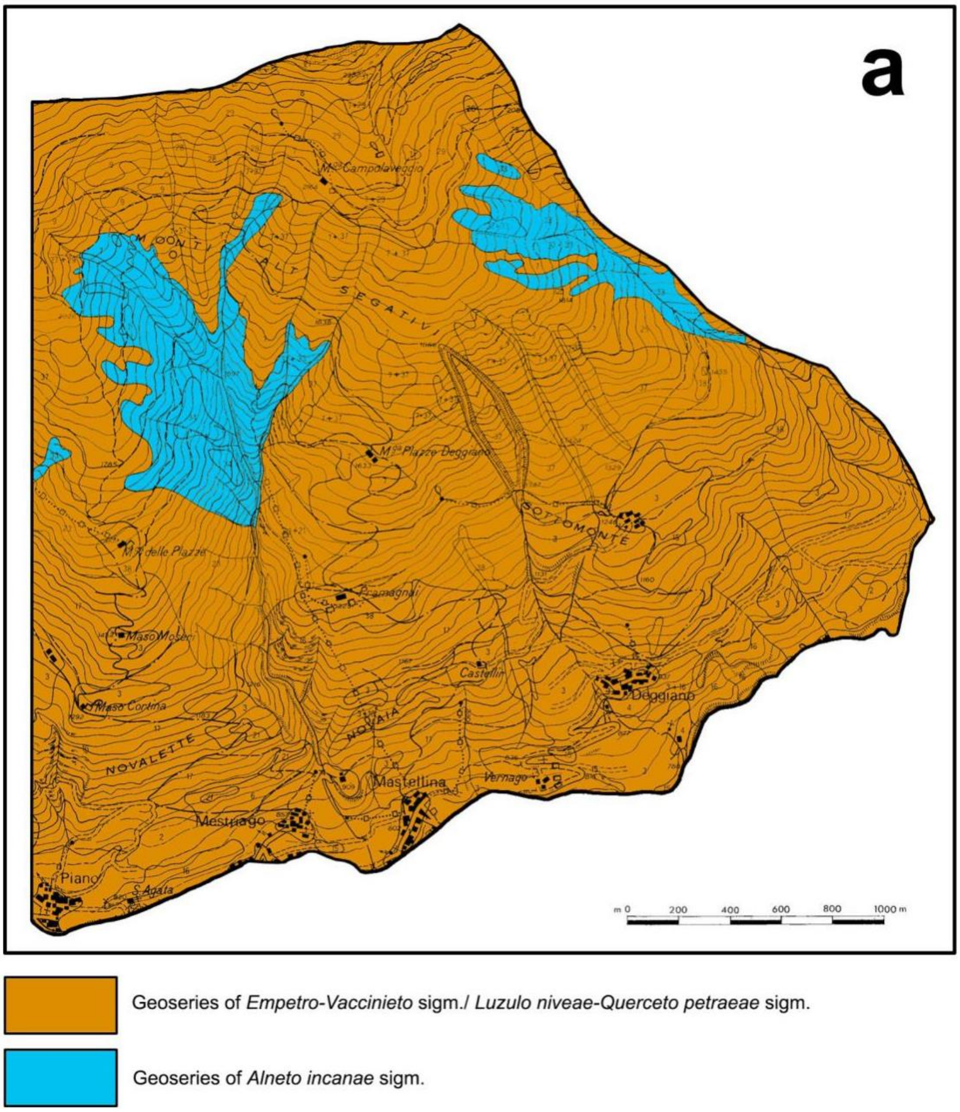

Fig. 9: Geoseries map on the southern slope of Sole valley according to the *model a*; two geoseries are represented, the *Empetro-Vaccinieto* sigmetum / *Luzulo niveae-Querceto petraeae* sigmetum (climatophilous series) and the *Alneto incanae* sigmetum (edaphophilous series).

The map in Figure 11 refers again to the same geoseries individual, but in this case the series are indicated with different tones of the same colour (*model c*).

The greatest amount of information on both series and geoseries can be obtained from the map based on *model c*, as the use of just one colour with the relative tones makes both the geoseries and the constituent series immediately comprehensible.

The map produced on the basis of *model b* also contains information on the individual geoseries, but their comprehension is less immediate; this map corresponds to an integrated phytosociological map and, as mentioned above, has a predominantly vegetational significance,

Finally, the map based on *model a* provides information on the geoseries in their entirety only; it therefore has a synthesis function and corresponds to a phytogeographical map.

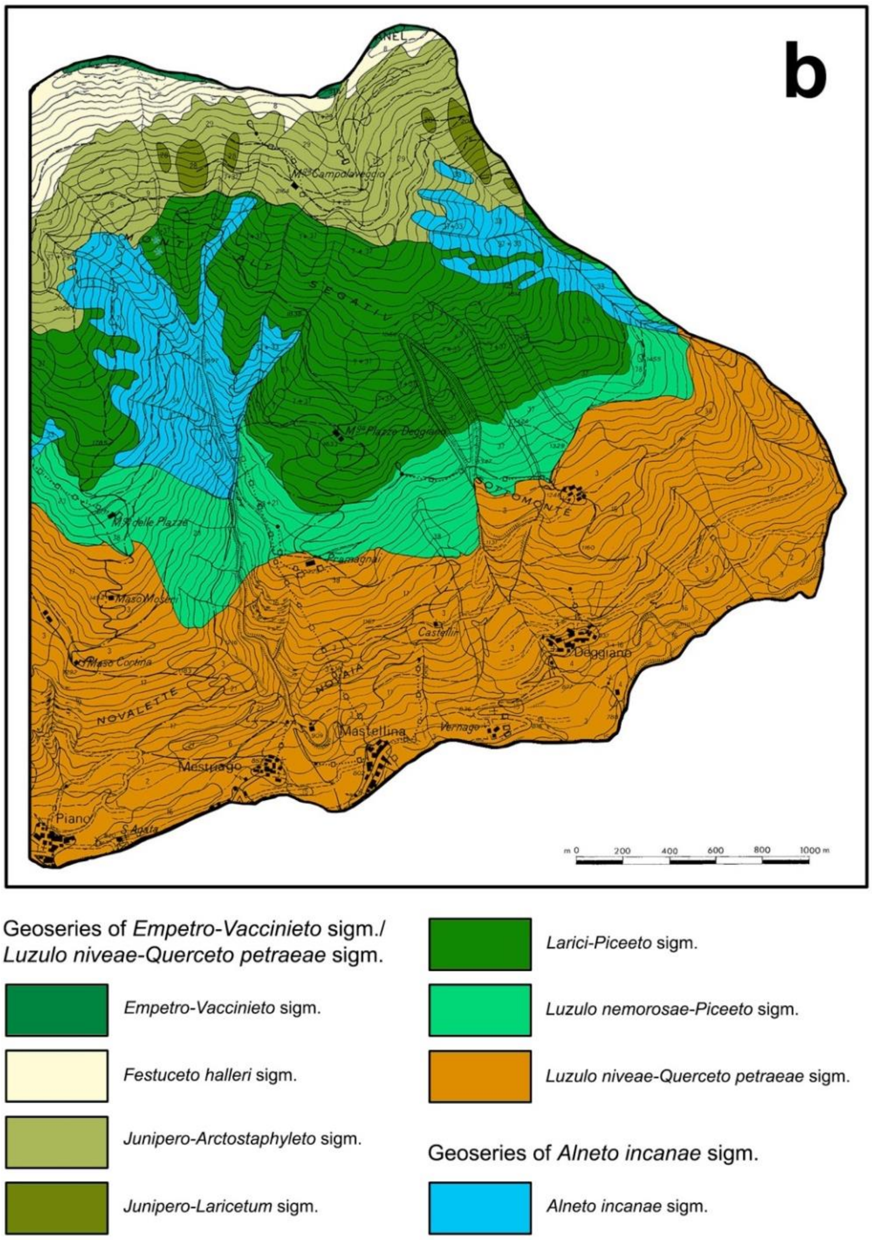

Fig. 10: Map of the same geoseries represented according to the *model b*.

Example of geoseries interpretation and mapping

The study area is situated in Trentino Province (Central Alps) and corresponds to the basin of the Adige River between Nomi and Borghetto (Valle Lagarina), together with the lower part of the Sarca river basin and Lake Garda and the upper part of the Val d'Astico.

It is a mountainous area crossed by two main valleys, the Val d'Adige (known here as the Valle Lagarina) and the Valle del Sarca, both with a wide alluvial valley bottom. The numerous tributaries, on the other hand, flow through deep, typically "V" shaped-valleys without flat alluvial zones. The lowest altitude corresponds to Lake Garda (62 m), while the highest massifs reach an altitude of 2000 m or just above along the watershed on both the right and left slopes.

These massifs are formed of predominantly Triassic and Jurassic calcareous rocks, with the exception of limited outcrops of basaltic lava and tuff on the orographic right side of the valley and alluvial deposits on the valley bottom.

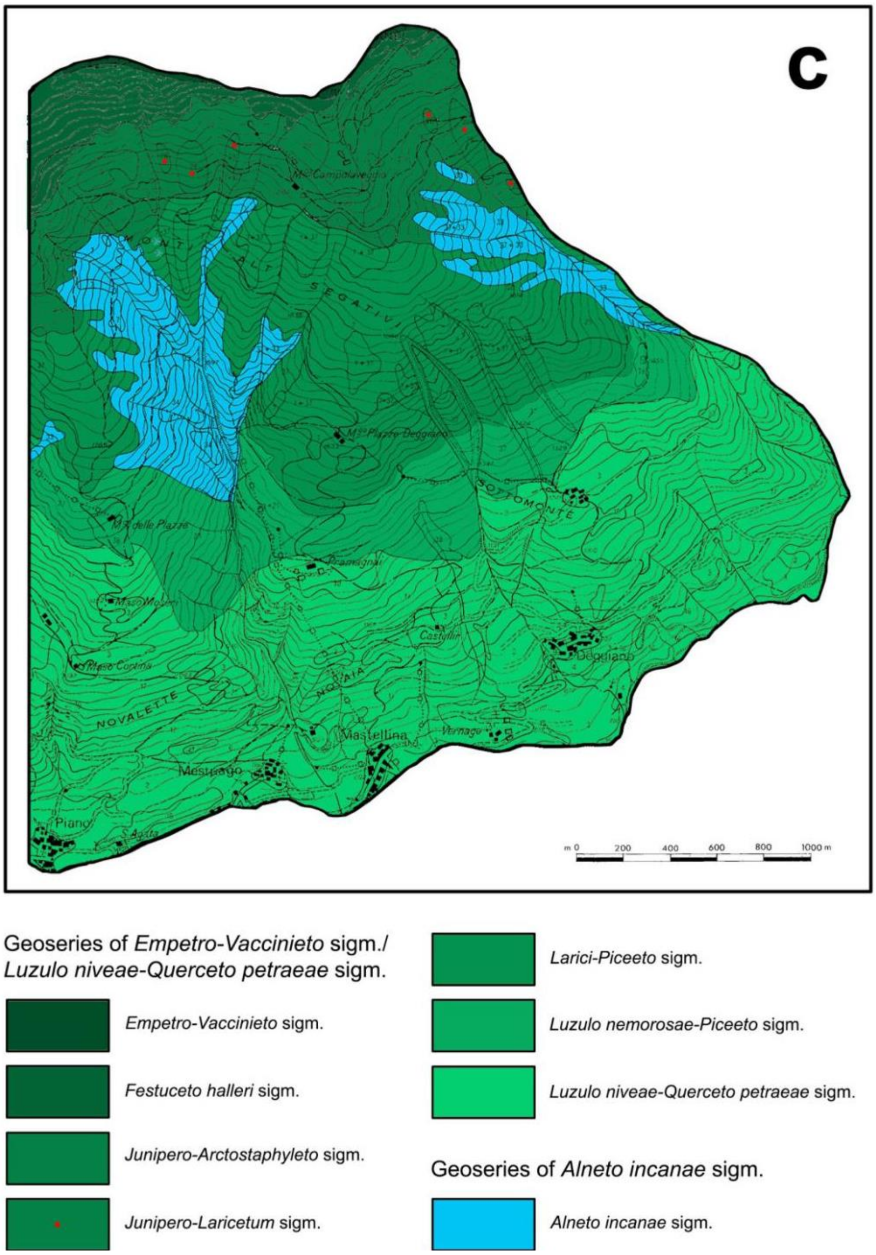

Fig. 11: Map of the same geoseries represented according to the *model c*.

The Trentino-Alto Adige region has a temperate macrobioclimate [25] and can be subdivided into three bioclimatic sectors according to pluvial continentality: pre-alpine, alpine and endo-alpine. The study area lies entirely within the pre-alpine sector. The phytoclimate of the two major valleys is suboceanic pre-alpine subhumid lower meso-temperate (Valle del Sarca) and subcontinental pre-alpine subhumid lower meso-temperate (Valle dell'Adige); in the massifs, on the other hand, the phytoclimate is pre-alpine humid upper meso-temperate, pre-alpine, humid, lower supra-temperate, pre-alpine humid upper supra-temperate and pre-alpine humid oro-temperate [7].

The climatophilous vegetation belongs to the colline (*Fraxino Orni-Ostryetum carpinifoliae*, *Buglossoido purpurocaeruleae-Ostryetum carpinifoliae, Celtidi australis-Quercetum ilicis* and *Galio laevigati-Carpinetum betuli*), montane (*Carici albae-Fagetum*, *Cardamino pentaphylli-Fagetum, Adenostylo glabrae-Abietetum, Pyrolo-Abietetum*), sub-alpine

(*Rhododendro hirsuti-Pinetum prostratae, Mugo-Ericetum*) and alpine (*Seslerio variae-Caricetum sempervirentis*) altitudinal belts, while the edaphophilous vegetation belongs to the *Salicetum incano-purpureae*, *Salicetum albae*, *Populetum albae* s.l. and *Salicetum cinereae* associations and lacustrine series. The vegetation in the study area was surveyed and mapped in two phytosociological maps at 1:1,000,000 and 1:500,000 scale [15, 19].

The map in Figure 7 was produced with reference to the cliserial geosigmetum, which includes all the contiguous climatophilous series in a mountainous area with a wide altitude range, defined by Géhu (2006) as *orogeosigmetum* (Figure 7). The map also shows the edaphophilous series of the valley bottom.

Nine geoseries were identified and, as described above, subdivided into geoseries individuals, indicated by numbers that are also given on the vegetation map. Each geoseries individual was surveyed and listed in the table. The survey involved drawing up a list of the vegetation series forming the geoseries and it is therefore a qualitative survey.

The list of geoseries and geoseries individuals is given below with the relative locations.

1 - Geoseries of *Seslerio variae-Cariceto sempervirentis* sigmetum / *Fraxino orni-Ostryeto carpinifoliae* sigmetum.

This geoseries extends from the colline belt (Riva del Garda, 62 m) to the alpine belt (2000-2259 m); in the complete form, it consists of 5 vegetation series which drop to 4, 3, 2 and 1 as the altitude decreases (Table 1). In some cases, such as Monte Altissimo, there are also a number of groups of *Alnetum viridis.* This is the most widespread geoseries in the study area, found with a high degree of homogeneity on the slopes of the calcareous massifs.

In the study area, there is also an association related to the *Fraxino orni-Ostryetum carpinifoliae*, the *Buglossoido purpurocaeruleae-Ostryetum carpinifoliae* association; whether or not this association forms an independent geoseries requires further investigations.

The above described geoseries is often interrupted by rocky outcrops with *Seslerio variae-Ostryetum carpinifoliae*, but as this association is influenced by the rocky substrate, it is not part of the geoseries. The islands of *Seslerio variae-Ostryetum carpinifoliae* on the rocky outcrops, in fact, represent a separate edaphophilous geoseries, the *Seslerio variae-Ostryeto carpinifoliae* sigmetum, within the belt occupied by the climatophilous series of *Seslerio variae-Cariceto sempervirentis* sigmetum / *Fraxino orni-Ostryeto carpinifoliae* sigmetum. This geoseries was not considered on the map in Figure 7.

2 - Geoseries of *Seslerio variae-Cariceto sempervirentis* sigmetum / *Celtidi australis-Querceto ilicis* sigmetum.

This one differs from the previous geoseries through the presence of *Celtidi australis-Querceto ilicis* sigmetum in the colline belt, an extrazonal series of microclimatic South-facing slopes distributed throughout the Sarca River basin, together with two isolated stations in the Val d'Adige, one on the orographic right side (Valle Aviana) and one on the orographic left side (Ala). This geoseries is made up of 6 vegetation series (Table 2).

Table 1: Geoseries of *Seslerio variae-Cariceto sempervirentis* sigmetum / *Fraxino orni-Ostryeto carpinifoliae* sigmetum (to be continued on the next page)

Number of geoseries individuals (according to the map in Fig. 7)	2	6	7	8	10	19	25	27	10a	23	20
Altitude (m a.s.l.)	900-2128	300-2078	160-2078	160-2078	170-2059	160-2300	270-2239	260-1873	190-2059	250-2300	1500-2259
Aspect	E-SE	N-NE	SE	E	SE	SW	SW	SW	S	NE	SE
Geomorphology	slope	slope	slope	slope	slope	slope	slope	slope	slope	slope	slope
Lithology	calcareous	calcareous	calcareous	calcareous	calcareous	calcareous	calcareous	calcareous	calcareous	calcareous	calcareous
Bioclimatology	pre-alpine	pre-alpine	pre-alpine	pre-alpine	pre-alpine	pre-alpine	pre-alpine	pre-alpine	pre-alpine	pre-alpine	pre-alpine
Seslerio-Cariceto sempervirentis sigm.	+	+	+	+	+	+	+	+	+	+	+
Pinion mugo sigmion	+	+	+	+	+	+	+	+	+	+	+
Cardamino pentahylli-Fageto sigm.	+	+	+	+	+	+	+	+	+	+	+
Carici albae-Fageto sigmetum	+	+	+	+	+	+	+	+	+	+	+
Fraxino orni-Ostryeto carpinifoliae sigm.	+	+	+	+	+	+	+	+	+	+	.
Number of series (sigmeta)	5	5	5	5	5	5	5	5	5	5	4
Type of geoseries	complete	complete	complete	complete	complete	complete	complete	complete	complete	complete	reduced

Table 1:- Geoseries of *Seslerio variae-Cariceto sempervirentis* sigmetum / *Fraxino orni-Ostryeto carpinifoliae* sigmetum (continuated from the previous page).

Number of geoseries individuals (according to the map in Fig. 7)	17	21	33	4	5	15	22	32	28	31	15a	32a
Altitude (m a.s.l.)	170-1600	170-2000	1800-2230	120-1559	150-1500	120-1500	160-1854	850-1700	180-700	400-1300	1200-1500	1600-1873
Aspect	N	SW	E	E-SE	S-SE	N-NW	W	E, N, W	SW	S	SW	S
Geomorphology	slope	slope	slope	slope	slope	slope	slope	slope	slope	slope	slope	slope
Lithology	calcareous	calcareous	calcareous	calcareous	calcareous	calcareous	calcareous	calcareous	calcareous	calcareous	calcareous	calcareous
Bioclimatology	pre-alpine	pre-alpine	pre-alpine	pre-alpine	pre-alpine	pre-alpine	pre-alpine	pre-alpine	pre-alpine	pre-alpine	pre-alpine	pre-alpine
Seslerio-Cariceto sempervirentis sigm.	.	.	+	.	.	.	.	.	.	.	.	.
Pinion mugo sigmion	+	+	+	.	.	.	.	.	.	.	.	.
Cardamino pentahylli-Fageto sigm.	+	+	+	+	+	+	+	+	.	.	+	+
Carici albae-Fageto sigmetum	+	+	.	+	+	+	+	+	+	+	+	.
Fraxino orni-Ostryeto carpinifoliae sigm.	+	+	.	+	+	+	+	+	+	+	.	.
Number of series (sigmeta)	4	4	3	3	3	3	3	3	2	2	2	1
Type of geoseries	reduced	reduced	reduced	reduced	reduced	reduced	reduced	reduced	reduced	reduced	reduced	reduced

Table 2: Geoseries of *Seslerio variae-Cariceto sempervirentis* sigm. / *Celtidi australis-Querceto ilicis* sigm.

Number of geoseries individuals (according to the map in Fig. 7)	1	9	12	13	11	1a
Altitude (m a.s.l.)	100-2078	75-2078	75-2059	75-1033	224-850	180-400
Aspect	SE	W	W	E	S	W-SW
Lithology	calcareous	calcareous	calcareous	calcareous	calcareous	calcareous
Geomorphology	slope	slope	slope	slope	slope	slope
Bioclimatology	pre-alpine	pre-alpine	pre-alpine	pre-alpine	pre-alpine	pre-alpine
Seslerio-Cariceto sempervirentis sigm.	+	+	+	.	.	.
Pinion mugo sigmion	+	+	+	.	.	.
Cardamino pentaphylli-Fageto sigmetum	+	+	+	.	.	.
Carici albae-Fageto sigmetum	+	+	+	+	+	.
Celtidi australis-Querceto ilicis sigmetum	+	+	+	+	+	+
Fraxino orni-Ostryeto carpinifoliae sigm.	+	+	+	+	+	+
Number of series (sigmeta)	6	6	6	3	3	2
Type of geoseries	complete	complete	complete	reduced	reduced	reduced

3 - Geoseries of *Celtidi australis-Querceto ilicis* sigmetum.

Given the low altitude of Monte Brione (m 360), this geoseries is formed of just one vegetation series, the *Celtidi australis-Querceto ilicis* sigmetum, on a marly calcareous substrate. It is present in a reduced form and the higher altitude series are not known (Table 3). The *Seslerio variae-Ostryetum carpinifoliae* can also be found on Monte Brione and the above observations also apply in this case. For the vegetation of Monte Brione, see Prosser and Sarzo (2003).

Table 3: Geoseries of C*eltidi australis-Querceto ilicis* sigm.

Number of geoseries individuals (according to the map in Fig. 7)	14
Altitude (m a.s.l.)	75-374
Aspect	E-W
Lithology	marls-limestones
Geomorphology	slope
Bioclimatology	pre-alpine
Celtidi australis-Querceto ilicis sigmetum	+
Number of series (sigmeta)	1
Type of geoseries	reduced

4 - Geoseries of *Seslerio variae-Cariceto sempervirentis* sigmetum / *Adenostylo glabrae-Abieteto* sigmetum.

This geoseries differs from the geoseries of *Seslerio variae-Cariceto sempervirentis* sigmetum / *Fraxino orni-Ostryeto carpinifoliae* sigmetum through the presence of the *Adenostylo glabrae-Abieteto* sigmetum in the montane belt (Table 4), an intrazonal series established on the North-facing slopes, as can also be seen from the Map of Fir Woods in the Trentino (*Carta delle abetine del Trentino*) by Gafta (1994).

Table 4: Geoseries of *Seslerio variae-Cariceto sempervirentis* sigm. / A*denostylo glabrae-Abieteto* sigm.

Number of geoseries individuals (according to the map in Fig. 7)	24	26	29	18	3	16
Altitude (m a.s.l.)	1000-2080	200-2112	180-1600	1000-1600	1000-1559	180-1751
Aspect	SW	NE	N-NW	N	N-NW	NW
Lithology	calcareous	calcareous	calcareous	calcareous	calcareous	calcareous
Geomorphology	slope	slope	slope	slope	slope	slope
Bioclimatology	pre-alpine	pre-alpine	pre-alpine	pre-alpine	pre-alpine	pre-alpine
Seslerio-Cariceto sempervirentis sigm.	+	+	+	+	.	.
Pinion mugo sigmion	+	+	+	+	.	.
Adenostylo glabrae-Abieteto sigm.	+	+	+	+	+	+
Cardamino pentaphylli-Fageto sigm.	+	+	+	+	+	+
Carici albae-Fageto sigmetum	+	+	+	.	+	+
Fraxino orni-Ostryeto carpinifoliae sigm.	+	+	+	.	+	+
Number of series (sigmeta)	6	6	6	4	4	4
Type of geoseries	complete	complete	complete	reduced	reduced	reduced

5 - Geoseries of *Pyrolo-Abieteteto* sigmetum / *Adenostylo glabrae-Abieteto* sigmetum.

This geoseries is found on calcareous substrates underlying slightly acidic soil, as in flat upland areas such as the Folgaria-Serrada plateau (Table 5).

Table 5: Geoseries of *Pyrolo-Abieteteto* sigm. / *Adenostylo glabrae-Abieteto* sigm.

Number of geoseries individuals (according to the map in Fig. 7)	30
Altitude (m a.s.l.)	1200-1500
Aspect	N
Lithology	calcarous
Geomorphology	plateau
Bioclimatology	pre-alpine
Adenostylo glabrae - Abieteto sigmetum	+
Pyrolo - Abieteto sigmetum	+
Carici albae - Fageto sigmetum	+
Number of series (sigmeta)	3
Type of geoseries	complete

6 - Geoseries of *Galio laevigati-Carpineto betuli* sigmetum / *Cardamino pentaphylli-Fageto* sigmetum.

This geoseries found in the colline and montane belts is interrupted and reduced. It occupies, in fact, tuff outcrops in four isolated locations in the colline belt and one in the montane belt on the right side of the Valle Lagarina between Isera and Monte Baldo (Table 6).

Table 6: Geoseries of *Galio laevigati-Carpineto betuli* sigm. / *Cardamino pentaphylli-Fageto* sigm.

Number of geoseries individuals (according to the map in Fig. 7)	34	35	36
Altitude (m a.s.l.)	400-700	200-800	1360-1600
Aspect	SE	E	SE
Geomorphology	slope	slope	slope
Lithology	basaltic	basaltic	basaltic
Bioclimatology	pre-alpine	pre-alpine	pre-alpine
Galio laevigati - Carpineto betuli sigmetum	+	+	.
Cardamino pentaphylli - Fageto sigmetum	.	.	+
Number of series (sigmeta)	1	1	1
Type of geoseries	reduced	reduced	reduced

The forest vegetation in the colline and montane belt is represented by *Galio laevigati-Carpinetum betuli* and, respectively, *Cardamino-pentaphylli-Fagetum*. The *Galio laevigati-Carpinetum betuli* is today practically non-existent in the area; it is almost completely cultivated. Tuff outcrops similar to those on the orographic right side of the Val d'Adige also emerge at a location not far from the San Giovanni Ilarione area (Verona Pre-Alps), where *Carpinus betulus* is still frequent.

7 - Geoseries of *Populeto albae* sigmetum / *Saliceto incano-purpureae* sigmetum.

This geoseries occupies the flat valley bottom of the Adige and Sarca valleys. On the basis of the few remnants still surviving today, this geoseries consists probably of four vegetation series: *Saliceto incano-purpureae* sigmetum, *Saliceto albae* sigmetum, *Populeto albae* sigmetum and *Querceto roboris* sigmetum (Table 7). A single remnant patch of the latter series is present in the entire Val d'Adige from Merano to Borghetto, but it is located outside the study area, further to the North at La Rupe (Mezzolombardo). In these valleys with their wide flat bottom, there were probably also forests of *Quercus robur* that no longer exist today, although remnants of this oak community (*Quercetum roboris* s.l.) have been found in the Valsugana, in the alluvial plain above Lake Levico.

Table 7: Geoseries of *Populeto albae* sigm. / *Saliceto albae* sigm.

Number of geoseries individuals (according to the map in Fig. 7)	37	38
Altitude (m a.s.l.)	120-180	68-123
Aspect	-	-
Geomorphology	valley bottom	valley bottom
Lithology	alluvial	alluvial
Bioclimatology	pre-alpine	pre-alpine
Querceto roboris sigmetum (s.l.)	+	+
Populeto albae sigmetum (s.l.)	+	+
Saliceto albae sigmetum	+	+
Saliceto incano-purpureae sigmetum	+	+
Number of series (sigmeta)	4	4
Type of geoseries	complete	complete

Finally, *Alnus glutinosa stands* are absent today from the part of the Adige valley represented on the map in Figure 7. There were probably also water-filled depressions known as "*lanche*" with floating (*Nymphaeion albae*) and emergent (*Phragmition*) vegetation. These have been drained in the study area, but are present in the Adige Valley further North [17].

8 - Geoseries of *Saliceto albae* sigmetum / *Saliceto incano-purpureae* sigmetum.

This geoseries occupies the fluvial terraces along the lateral valleys of the Val d'Adige and the upper part of the Val d'Astico. Here the riparian communities (*Salicetum albae* and *Salicetum incano-purpureae*) occupy a relatively narrow band, due to the morphology of the valley slopes, almost always quite steep (Table 8).

Table 8: Geoseries of *Saliceto albae sigm.* / *Saliceto incano-purpureae* sigm.

Number of geoseries individuals (according to the map in Fig. 7)	39	40
Altitude (m a.s.l.)	130-1400	850-1500
Aspect	-	-
Geomorphology	valley bottom	valley bottom
Lithology	alluvial	alluvial
Bioclimatology	pre-alpine	pre-alpine
Saliceto albae sigmetum	+	+
Saliceto incano-purpureae sigmetum	+	+
Number of series (sigmeta)	2	2
Type of geoseries	complete	complete

9 - Lacustrine geoseries.

The study area includes two lakes, Lake Loppio and Lake Garda (Table 9). The banks of the Lake Loppio consist partly of peat and partly of lacustrine silt; the peat is occupied by the *Saliceto cinereae* sigmetum, and the silt by the *Phragmition* sigmion. Following the artificial drainage of the lake, the entire bottom of the lacustrine basin has been colonised by *Salix alba* forming the *Salicetum albae* association [18]. These riparian woods have occupied much of the bottom of Lake Loppio, but as it is not part of the original lacustrine vegetation, the *Saliceto albae* sigmetum was not considered as one of the lacustrine sigmeta. Before being drained, the *Nymphaeion albae* sigmion was also present in the Lake Loppio. In Lake Garda, given its steep banks, there is little lacustrine vegetation, which is represented by few fragments of *Phragmition* sigmion. In the past, the *Littorellion* sigmion was probably also present.

The nine geoseries were subdivided into 46 geoseries individuals and the composition of each of these was surveyed (see Tables 1-9). The data given show the variability within the single geoseries. The climatophilous geoseries are all complete, with the exception of two, geoseries 3 and 6, which are reduced for geomorphological and geological reasons. One geoseries (number 6) is interrupted. The edaphophilous geoseries are all complete. The composition of the lacustrine geoseries is highly variable depending on limnology and seasonal conditions.

Table 9: Lacustrine geoseries

Number of geoseries individuals (according to the map in Fig. 7)	41	42
Altitude (m a.s.l.)	225	62
Aspect	-	-
Geomorphology	lake basin	lake basin
Lithology	alluvial	alluvial
Bioclimatology	pre-alpine	pre-alpine
Phragmition sigmion	+	+
Nymphaeion albae sigmion	+	.
Saliceto cinereae sigmetum	+	.
Number of series (sigmeta)	3	1
Type of geoseries	complete	reduced

The most widespread geoseries is the *Seslerio-Cariceto sempervirentis* sigmetum / *Fraxino orni-Ostryeto carpinifoliae* sigmetum, but two variants can be further distinguished on contrasting slope aspects: geoseries of *Seslerio variae-Ostryeto carpinifoliae* sigmetum / *Celtidi australis-Querceto ilicis* sigmetum on South-facing slopes and, geoseries of *Seslerio variae-Cariceto sempervirentis* sigmetum / *Adenostylo glabrae-Abieteto* sigmetum on North-facing slopes.

Table 10: Sigmeta composition of the geoseries mapped in Figure 7.

Sigmetum (vegetation series)	Geoseries (codes from 1 to 9 as in Fig. 7)								
	1	2	3	4	5	6	7	8	9
Seslerio variae - Cariceto sempervirentis sigm.	+	+	.	+	.	.	.	.	.
Pinion mugo sigmion	+	+	.	+	.	.	.	.	.
Adenostylo glabrae - Abieteto sigmetum	.	.	.	+	+	.	.	.	.
Pyrolo - Abieteto sigmetum	.	.	.	.	+	.	.	.	.
Cardamino pentaphylli - Fageto sigmetum	+	+	.	+	+	+	.	.	.
Carici albae - Fageto sigmetum	+	+	.	+	.	.	.	.	.
Celtidi australis - Querceto ilicis sigmetum	.	+	+	.	.	.	.	.	.
Fraxino orni - Ostryeto carpinifoliae sigmetum	+	+	.	+	.	.	.	.	.
Gallio laevigati - Carpineto betuli sigmetum	.	.	.	.	.	+	.	.	.
Querceto roboris sigmetum (s.l.)	.	.	.	.	.	.	+	.	.
Populeto albae sigmetum (s.l.)	.	.	.	.	.	.	+	.	.
Saliceto albae sigmetum	.	.	.	.	.	.	+	+	.
Saliceto incano - purpureae sigmetum	.	.	.	.	.	.	+	+	.
Saliceto cinereae sigmetum	.	.	.	.	.	.	.	.	+
Phragmition sigmion	.	.	.	.	.	.	.	.	+
Nymphaeion albae sigmion	.	.	.	.	.	.	.	.	+
Number of vegetation series (sigmeta)	5	6	1	6	3	2	4	2	3

Concluding remarks

The map in Figure 7 is a map of the geoseries, namely a geo-synphytosociological map. It should be read together with tables 1-9 listing the component vegetation series of each geoseries individual.

Table 10 gives the composition of all geoseries, facilitating comparison and comprehension of the differences and similarities between them; six are climatophilous and three are edaphophilous. The climatophilous series (1 to 5) lie all on the slopes, with the exception of one being linked to plateaus (number 6); all edaphophilous series (7, 8 and 9) occur in valley bottoms. The geoseries 1, 2 and 4 are very similar, with five repeating vegetation series (characterised by *Sesleria varia*, *Pinus mugo*, *Fagus sylvatica* - two series, *Fraxinus ornus* - *Ostrya carpinifolia*), and two "differential" series, the South-facing slope series characterised by *Quercus ilex* and the North-facing slope characterised by *Abies alba*.

In conclusion, a geoseries map can be regarded as a map of synthesis representing catenal vegetation. Such a map enables the phytogeographic subdivision of an area based on component vegetation series.

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INTERPRETAREA ȘI CARTOGRAFIEREA GEOSERIILOR

(Rezumat)

O geoserie (sau geosigmetum) este o unitate catenală a seriilor de vegetație dintr-o unitate fitotopografică omogenă din punct de vedere ecologic, a unui sector corologic dat. Ea include secvența altitudinală completă a seriilor de vegetație zonale, extrazonale și intrazonale. O geoserie poate fi împărțită în sectoare mai mici, cunoscute sub denumirea de "geoserii individuale", pe baza orografiei, hipsometriei și expoziției. Din punct de vedere teoretic, o geoserie este alcătuită din același număr și tip de serii; în practică însă, geoseriile individuale pot să varieze din motive orografice, hipsometrice și geologice. O geoserie este completă atunci când se întinde de la nivelul mării până la altitudinea de 3000 m (munții europeni) și redusă dacă este trunchiată la vârf, în cazuri de altitudini mai joase (masive joase). Fiecare geoserie este caracterizată de cel puțin o serie de vegetație. O geoserie are limite

geologice, geomorfologice și geografice (cumpăna apelor, cursuri de apă etc.). O geoserie poate fi cartografiată în trei moduri: 1) ca o singură unitate cartografică incluzând toate seriile și marcată cu o singură culoare; 2) ca o unitate cartografică subdivizată în serii marcate cu culori diferite; 3) ca o unitate cartografică divizată în serii marcate cu diferite nuanțe ale aceleiași culori. Această metodă a fost utilizată pentru a realiza o hartă (1:150.000) a geoseriilor din Val d'Adige (Alpii Centrali) constând din 6 serii climatofile și 3 serii edafofile.