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Vegetation geoseries of the Ortles-Cevedale massif (central Alps, Italy) and their phytogeographic significance

Abstract

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The description of the vegetation geoseries (pemaseries, curtaseries oloseries) of the Ortles-Cevedale massif, central Alps is reported; the study area is between 3,905 m (top of the Ortles) and 700-800 m (bottom of the valleys). For each geoseries the composition (i.e. the component series), the altitudinal belt and the phytoclimatic sectors are reported (21 geoseries). The map of the vegetation geoseries was also detected, on which each series is divided into their individuals of geoseries.

Key words: Central Alps, Ortles-Cevedale massif, geoseries, individuals of geoseries, map of geoseries.

Introduction

The purpose of this work is to describe the vegetation geoseries of the southern slope of the Ortles-Cevedale massif (central Alps, Italy) and to highlight their phytogeographic significance.

A geoseries (or geosigmetum) is a catenal unit of contiguous vegetation series in a mountainous area with a wide altitude range, 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 sequence of the climatophilous (zonal, extrazonal and intrazonal) and edaphophilus (azonal) vegetation series.

In particular, reference is made here to the cliserial geosigmetum or orogeosigmetum, according to the definition given by Géhu (2006). Previously, the cliserial geosigmeta of another sector in Trentino were identified and mapped, corresponding to the Lagarina Valley, Lake Garda and the Sarca Valley (Pedrotti 2019).

Methodology

The geoseries were surveyed according to the methodology reported in Pedrotti (2019), which - in turn - refers to the previous contributions of Rivas Martìnez (2005, 2007), Géhu (2006), Lazare (2009), Díaz González (2014) and Bioret & al. (2019). On massifs (as in the Ortles-Cevedale), 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). A geoseries may be *complete* or *reduced* due to the orography (altitude). In the first instance, it extends from sea level to an altitude of 3,000 m (the limit of European mountains); in second, it is truncated at the top when the altitude range in less, as with lower massifs. The vegetation series (sigmeta) are named according to the indications of Cristea & al. (2015), the geoseries (geosigmeta) according to Géhu & Géhu-Franck (1989).

Environmental features

The Ortles-Cevedale massif is located in the central Alps and is bordered to the north by Val Venosta and to the south by Val di Sole (Trentino-Alto Adige region). The main peaks of the massif are Ortles (3,905 m), Gran Zebrù (3,851) and Monte Cevedale (3,769), from which several ridge lines and deeply carved valleys branch off. The southern slope of the group is crossed by the two valleys of Peio and Rabbi, which are lateral valleys of the Val di Sole.

The Trentino-Alto Adige Region has a temperate macrobioclimate (Rivas Martìnez 1996) and can be subdivided into three phytoclimatic sectors according to pluvial continentality (Gafta & Pedrotti 1997): pre-alpine, alpine and endo-alpine. The study area belongs in part to the pre-alpine sector (Val di Rabbi) and in part to the alpine sector (Val di Peio) (Fig. 1). The endo-alpine sector is present in Val Venosta, north of the Ortles-Cevedale Group, but outside the area under study. In addition, there are two ombrotypes, subhumid and humid.

The tree species present in this territory are five: *Fraxinus excelsior, Abies alba*, *Picea abies*, *Larix decidua* and *Pinus cembra*; three are distributed both in the pre-alpine sector and in the alpine sector (*Fraxinus excelsior*, *Picea abies*, *Larix decidua*), one is exclusive to the alpine sector (*Pinus cembra*) and one of the pre-alpine sector (*Abies alba*).

The southern slope of the Ortles-Cevedale massif is between 1,000 m (the village of Cogolo) and 3,768 m (Monte Vioz). The altitudinal belts are as follows: alpine (cryo-orotemperate), subalpine (cryo-orotemperate), mountain (orotemperate) (upper and lower) and hilly (mesotemperate) (upper and lower).

The alpine belt (cryo-orotemperate) is developed between 2,100 m and the highest peaks (3,768 m) with the following associations: *Primulo-Caricetum curvulae*, *Festucetum halleri* and *Festucetum scabriculmis*.

The subalpine belt (cryo-orotemperate) is developed between 2,000 and 2,100 m with the associations: *Empetro-Vaccinietum gaultherioidis*, *Rhododendretum ferruginei*, *Junipero nanae-Arctostaphyletum uvae-ursi*, *Junipero nanae-Laricetum deciduae* and

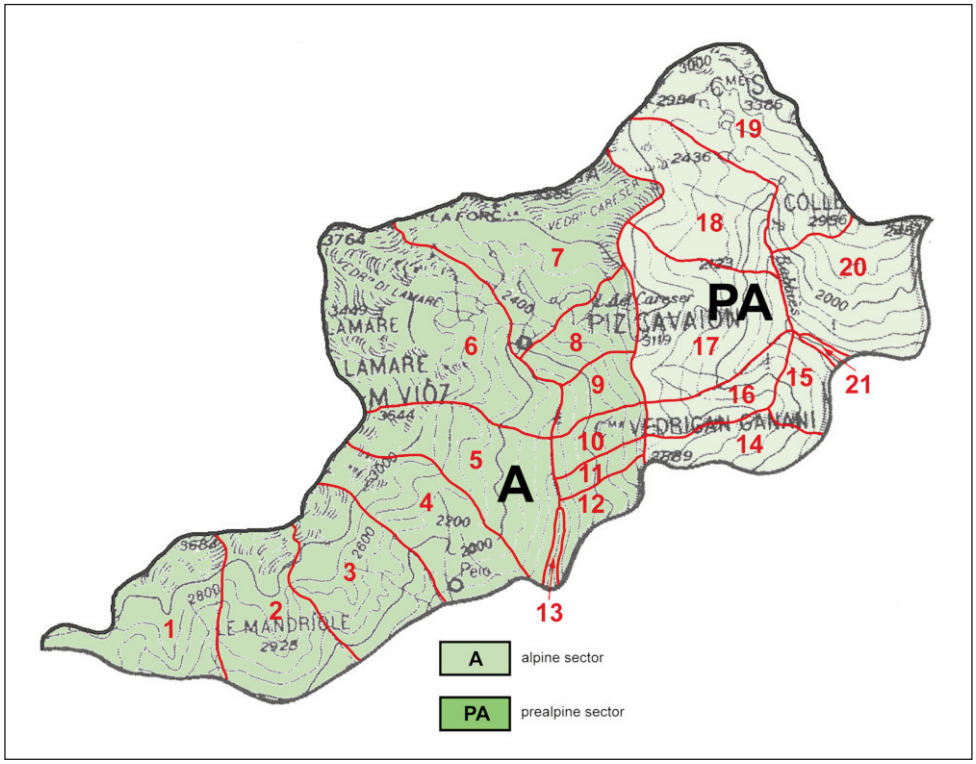

Fig. 1. Phytoclimatic sectors; A alpine sector; B pre-alpine sector; numbers 1-21 indicate the type of geoseries, according to the list shown in Fig. 2.

Larici-Pinetum cembrae; *Alnetum viridis* is also present in this belt, especially on the north-facing north slopes; this association can frequently descend along the gullies at lower altitudes, in the upper mountain belt.

The mountain belt (orotemperate) is developed between 700-800 (1,100) and 2,000-2,050 m with the following associations: *Calamagrosio villosae-Abietetum albae*, *Luzulo luzuloidis-Piceetum*, *Asplenio viridis-Piceetum*, *Homogyno alpinae-Piceetum*.

The hilly (mesotemperate) belt is developed between 700-800 m and 1,000 - 1,100 m with the association *Salvio glutinosae-Fraxinetum excelsiori*s.

Previous botanical knowledge

The previous botanical knowledge on the vegetation of the Ortles-Cevedale massif is summarized in the 1 : 50,000 scale map of vegetation, a classic phytosociological map on which plant associations and some physiognomic formations are represented (Pedrotti & al. 1974). The vegetation series of the whole Trentino-Alto Adige Region are listed in Pedrotti (2006, 2010b) and Pedrotti & Gafta (2003).

By referring to the vegetation map and carrying out surveys on the ground, it was possible to recognize the vegetation series (or sigmeta) and the vegetation geoseries (or geosigmeta).

Plant associations

Adonido-Delphinietum consolidae Braun-Blanquet 1970, weed vegetation in spring crops (wheat, rye and oat fields), currently in sharp decline due to the abandonment cereal crops;

Alnetum incanae Lüdi 1921, riparian forest of *Alnus incana*, hilly and mountain belts, pre-alpine and alpine sectors (Pedrotti & Cortini Pedrotti 2005);

Alnetum viridis Braun-Blanquet 1918, shrub of *Alnus viridis*, north-facing slopes and gullies, subalpine belt, pre-alpine and alpine sectors;

Asplenio viridis-Piceetum Kuoch 1954, *Asplenium viride* and *Picea abies* forest, mountain belt, pre-Alpine sector; small areas on very steep slopes, with scree and debris, large boulders; this association is intrazonal in the *Luzulo luzuloidis-Piceetum;*

Berberido-Rosetum Braun-Blanquet 1961, shrub of *Berberis vulgaris* and *Rosa* sp. pl., south-facing slopes between Peio and Cogolo; this association is typical of the endo-alpine sector, Val Venosta, which is not included in the study area; therefore appears in the alpine sector, in Val di Peio;

Calamagrostio villosae-Abietetum albae Ellenberg et Klötzli 1972, *Calamagrostis villosa* and *Abies alba* forest, lower mountain belt, pre-Alpine sector; present in only one station, in Val di Rabbi (Gafta 1994);

Caricetum nigrae Braun-Blanquet 1915 nom. mut. propos., vegetation of the peat bogs of the glacial cirque basins and of the slopes with spring waters; each peaty basin, even of a small size, corresponds to a geosigmetum; the alpine lakes also correspond to geosigmeta (Lagostel, Lago Covel, Lago delle Marmotte, Lago Lungo, Lago Corvo, Laghi Sternai, Laghetto Dorigoni, etc.); these geosigmeta have not been taken into account for the evaluation of geoseries;

Caricetum paniculatae Wangerin 1916, in a swamp in Val del Monte;

Caricetum rostratae Rübel 1911 ex Osvald 1923 em Dierssen 1982, peat bogs;

Cicerbitetum alpinae Bolleter 1921 vegetation of tall herbs (megaphorbs), subalpine belt, pre-alpine and alpine sectors (Pedrotti 1983);

Cotoneastro integerrimae-Pinetum cembrae Béguin et Theurillat 1982 [*Junipero-Arctostaphyletum cembretosum* Pedrotti 1965 n. n.], *Cotoneaster integerrima* and *Pinus cembra* forest, south-facing slopes, subalpine belt, alpine sector;

Empetro-Vaccinietum gaultherioidis Braun-Blanquet in Braun-Blanquet & Jenny 1926 corr. Grabherr 1993, subalpine heath, subalpine belt, pre-alpine and alpine sectors;

Eriophoretum scheuchzeri Rübel 1911, vegetation of the shores of alpine lakes, alpine and subalpine belts, alpine and pre-alpine sectors, Laghi Sternai (Val di Rabbi);

Euphorbio-Galinsogetum ciliatae Passarge 1981, Weed vegetation in summer crops (potato and buckwheat fields); associazione di nuova comparsa in Val di Sole, ove tende a sostituire il *Galinsogo-portulacetum oleraceae* (Pedrotti 2010a);

Festucetum halleri Braun-Blanquet in Braun-Blanquet et Jenny 1926, primary grassland of *Festuca halleri*, alpine belt, pre-alpine and alpine sectors;

Festucetum scabriculmis Rübel 1911 corr. Theurillat 1989„primary grassland of *Festuca scabriculmis*, alpine belt, pre-alpine and alpine sectors;

Galinsogo-Portulacetum Braun-Blanquet 1949 ex Pedrotti 1959, Weed vegetation in summer crops (potato and buckwheat fields), currently in sharp decline due to the abandonment of potato and buckwheat crops (Pedrotti 1959, 2005a, 2005b, 2013);

Homogyno alpinae-Piceetum Zukrigl 1973 [*Larici-Piceetum* Ellenberg et Klötzli], *Homogyne alpina* and *Picea abies* forest, upper mountain belt, pre-Alpine and alpine sectors;

Junipero nanae-Arctostaphyletum uvae ursi Braun-Blanquet ex Haffter in Braun-Blanquet & al. 1939, *Juniperus nana* and *Arctostaphylos uva-ursi* shrub, south-facing slopes, subalpine belt;

Junipero nanae-Laricetum deciduae Kuoch et Amiet 1970, *Juniperus nana* and *Larix decidua* forest, south-facing slopes, subalpine belt;

Larici-Pinetum cembrae Ellenberg 1963, *Pinus cembra* forest, north-facing, slopes subalpine belt, alpine sector;

Lolietum perennis Gams 1927, vegetation of the trampled places, mountain and hilly belt, pre-alpine and alpine sectors;

Luzuletum alpinopilosae Br.-Bl in Br.-Bl. et Jenny 1926, pioneer vegetation of *Luzula alpinopilosa* of silicate scree, alpine belt, pre-alpine and alpine sectors;

Luzulo luzuloidis-Piceetum Grabherr (*Luzulo nemorosae-Piceetum* Braun-Blanquet e Sissingh in Braun-Blanquet, Sissingh et Vlieger 1939), *Luzula luzuloides* and *Picea abies* forest, lower mountain belt, pre-Alpine and alpine sectors;

Melandrio-Arrhenatheretum Oberdorfer 1964, stable meadow lower mountain belt, pre-Alpine and alpine sectors. This association is not part of any series of vegetation, because it was obtained in environments deeply modified by man and is maintained over time thanks to the intervention of man through irrigation, fertilization and mowing (Pedrotti 1963);

Oxyrietum digynae (Lüdi 1921) Braun-Blanquet 1926, pioneer vegetation of *Oxyria digyna* of silicate scree, alpine belt, pre-alpine and alpine sectors;

Peucedano ostruthii-Cirsietum spinosissimi G. & J. Braun-Blanquet 1931, vegetation of *Peucedanum ostruthium* and *Cirsium spinosissimum*, alpine belt, pre-alpine and alpine sectors (Pedrotti 1983); this association is distributed in the belt of the Alpine grasslands of *Festucetum halleri*;

Polytrichetum sexangularis Rübel ex Frey 1922, vegetation of the snow beds, alpine belt, pre-alpine and alpine sectors; this association is distributed in the belt of the Alpine grasslands of *Primulo-Caricetum curvulae*;

Populo-Coryletum Braun-Blanquet 1950 [*Corylo-Populetum tremulae* Braun-Blanquet (1919) 1938], secondary shrub of *Corylus avellana* and *Populus tremula*, hilly and lower mountain belts, pre-alpine and alpine sectors (Pedrotti 2005b);

Primulo-Caricetum curvulae Oberdorfer, primary grassland, alpine belt, pre-alpine and alpine sectors;

Rhododendretum ferruginei Rübel 1911, *Rhododendron ferrugineum* shrub, north-facing slopes, subalpine belt, pre-alpine and alpine sectors;

Rhododendro ferruginei-Laricetum deciduae Hegg, Béguin & Zoller 1993, *Rhododendron ferrugineum* and *Larix decidua* forest, north-facing slopes, subalpine belt, pre-alpine and alpine sectors;

Rhododendro ferruginei-Pinetum prostratae Zöttl 1951 nom. inv., *Rhododendron ferrugineum* and *Pinus mugo* shrub, subalpine belt, alpine sector; only on the slopes above Malga Mare (Val di Peio), developed in a limited area, very small;

Rubetum idaei Gams 1927, secondary vegetation of *Rubus idaeus* of forest clearings, mountain and subalpine belts, pre-alpine and alpine sectors;

Rumicetum alpini Beger 1922, nitrophilous vegetation prevalently of *Rumex alpinus,* near mountain farmhouses; alpine, subalpine and mountain belts, pre-alpine and alpine sectors;

Sagino procumbentis-Bryetum argentei Diemont et al. 1940, vegetation of the trampled places, streets paved with stones; mountain and hilly belt, pre-alpine and alpine sectors;

Salicetum capreae Schreier 1955, secondary shrub of *Salix caprea* of the forest clearings, mountain belt, pre-alpine and alpine sectors;

Salicetum herbaceae Rübel 1911, vegetation of the snow beds alpine belt, pre-alpine and alpine sectors; this association is distributed in the belt of the Alpine grasslands of *Primulo-Caricetum curvulae*;

Salvio glutinosae - Fraxinetum excelsioris Oberdorfer 1964, *Salvia glutinosa* and *Fraxinus excelsior* forest, hilly belt, pre-alpine and alpine sectors;

Scirpetum sylvatici Ralski 1931, wet grasslands of *Scirpus sylvaticus*;

Sclerantho-Sempervivetum arachnoidei Br.-Bl. (1949) 1955, association developed on rocky outcrops and on large stone boulders, a few centimeters deep soil, slopes facing south in the Peio area, mountain belt, alpine sector;

Senecionetum fuchsii Kaiser 1926, Vegetation of *Senecio fuchsii* of forest clearings, shady and humid environments, mountain belt, pre-Alpine and alpine sectors;

Senecioni-Epilobietum angustifolii Hueck 1931, secondary vegetation of forest clearings, mountain and subalpine belts, pre-alpine and alpine sectors;

Senecioni fuchsii-Sambucetum racemosae Noirfalise ex Oberdorfer 1957, shrub of Sambucus racemosa, mountain belt, pre-alpine and alpine sectors; fragmentary;

Sieversio-Nardetum strictae Lüdi 1948, secondary grasslands, subalpine and mountain belts, pre-alpine and alpine sectors;

Trichophoretum cespitosi Rübel 1911 nom. mut. PRopos., vegetation of the peat bogs, common in the locality of Saent, in Val di Rabbi;

Trisetetum flavescentis Rübel 1911, stable meadow, upper mountain belt, pre-alpine and alpine sectors; also the *Trisetetum flavescentis* does not belong to any series of vegetation, for the same reasons exposed for the *Melandrio-Arrhenatheretum*;

Tunico-Koelerietum gracilis Braun-Blanquet 1961, arid and steppe grassland, hilly and lower mountain belts, alpine sectors; south-facing slopes, Peio valley; there are two small areas of this association, one of them just above Cogolo, 1250 m, the second above Peio-Paese, 1600 m; the *Tunico-Koelerietum gracilis* belongs to the series of *Quercus petraea* [*Luzulo-Querceto petraeae* sigmetum], however this series is not present in the study area, but in the lower Val di Sole (Pedrotti, 2015);

Urtico urentis-Chenopodietum boni-henrici Tüxen 1937, nitrophilous vegetation prevalently of *Chenopodium bonus-henricus,* near farmhouses; mountain belt, pre-alpine and alpine sectors.

Vegetation series (sigmeta)

The vegetation series are defined with a diagnostic phrase that refers to: type of series (permaseries, curtaseries, oloseries), altitude belt (cryo-orotemperate, orotemperate, mesotemperate), phytoclimatic sector (alpine or pre-alpine (in the area covered by study the ombrotype is always humid), denomination of the series and sigmetum.

1) Permaseries of *Primula daonensis* and *Carex curvula* alpine grassland [*Primulo-Cariceto curvulae* sigmetum] of the Ortles-Cevedale massif (central Alps), cryo-orotemperate, alpine, humid, acidophilous, climatophilous

Grassland, *Primulo-Caricetum curvulae*
Pioneer vegetation, *Oxyrietum digynae, Luzuletum alpinopilosae*

2) Permaseries of *Festuca halleri* alpine grassland [*Festuceto halleri* sigmetum] of Central Alps, cryo-orotemperate, alpine, humid, acidophilous, climatophilous

Grassland, *Festucetum halleri*
Pioneer vegetation, *Oxyrietum digynae, Luzuletum alpinopilosae*

3) Permaseries of *Festuca scabriculmis* alpine grassland [*Festuceto scabriculmis* sigmetum] of central Alps, cryo-orotemperate, alpine, humid, acidophilous, climatophilous, south-facing slopes,

Prateria, *Festucetum scabriculmis*

4) Curtaseries of *Vaccinium gaultherioides* subalpine heath [*Empetro-Vaccinieto gaultherioidis* sigmetum] of central Alps, cryo-orotemperate, alpine, humid, acidophilous, climatophilous

Heath, *Empetro-Vaccinietum gaultherioidis*

5) Curtaseries of *Rhododendron ferrugineum* shrub [*Rhododendreto ferruginei* sigmetum] of central Alps, cryo-orotemperate, alpine, humid, acidophilous, climatophilous, north-facing slopes

Shrub, *Rhododendretum ferruginei*
Grassland, *Sieversio-Nardetum strictae*

6) Oloseries of *Rhododendron ferrugineum and Pinus mugo* (*P. prostrata*) shrub [*Rhododendro ferruginei-Pineto prostratae* sigmetum] of central Alps, cryo-orotemperate, alpine, humid, acidophilous, climatophilous, north-facing slopes;

Shrub, *Rhododendro ferruginei-Pinetum prostratae*
Grassland, *Sieversio-Nardetum strictae*

7) Oloseries of *Rhododendron ferrugineum* and *Larix decidua* forest [*Rhododendro-Lariceto deciduae* sigmetum] of central Alps, cryo-orotemperate, alpine, humid, acidophilous, climatophilous, north-facing slopes

Forest, *Rhododendro-Laricetum deciduae*
Grassland, *Sieversio-Nardetum strictae*

8) Oloserie of *Pinus cembra* forest [*Larici-Pineto cembrae* sigmetum] of central Alps, cryo-orotemperate, alpine, humid, acidophilous, climatophilous, north- facing slopes,

Forest, *Larici-Pinetum cembrae*
Grassland, *Sieversio-Nardetum strictae*

9) Curtaseries of *Juniperus nana* and *Arctostaphylos uva-ursi* shrub [*Junipero nanae-Arctostaphyleto* sigmetum] of central Alps, cryo-orotemperate, alpine, humid, acidophilous, climatophilous, south-facing slopes

Shrub, *Junipero nanae-Arctostaphyletum uvae-ursi*
Grassland, *Sieversio-Nardetum strictae*

10) Oloseries of *Juniperus nana* and *Larix decidua* forest [*Junipero nanae-Lariceto deciduae* sigmetum] of central Alps, cryo-orotemperate, alpine, humid, acidophilous, climatophilous, south-facing slopes

Forest, *Junipero nanae- Laricetum deciduae*
Grassland, *Sieversio-Nardetum strictae*

11) Oloseries of *Cotoneaster integerrima* and *Pinus cembra* forest [*Cotoneastro integerrimae-Pineto cembrae* sigmetum] of central Alps, cryo-orotemperate, alpine, humid, acidophilous, climatophilous, south-facing slopes

Forest, *Cotoneastro integerrimae-Pinetum cembrae*
Grassland, *Sieversio-Nardetum strictae*

12) Curtaseries of *Alnus viridis* shrub [*Alneto viridis* sigmetum] of Alps, orotemperate. alpine, humid, subalpine belt

Shrub, *Alnetum viridis*
Vegetation of megaphorbs, *Cicerbitetum alpinae*
Grassland, *Sieversio-Nardetum strictae*

13) Oloseries of *Homogyne alpina* and *Picea abies* forest [*Homogyno alpinae-Piceeto* sigmetum] of central Alps, orotemperate, alpine, humid, acidophilous, climatophilous

Forest, *Homogyno alpinae-Piceetum*
Shrub, *Salicetum capreae*
Forest clearings vegetation of *Rubus idaeus*, *Rubetum idaei*
Forest clearings vegetation of *Senecio sylvaticus* and *Epilobium angustifolium*, *Senecioni sylvatici-Epilobietum angustifolii*
Forest clearings vegetation (shady and humid environment) of *Senecio fuchsii*, *Senecionetum fuchsiii*
Grassland, *Sieversio-Nardetum strictae*
Weed vegetation in spring crops, *Adonido-Delphinietum consolidae*
Weed vegetation in summer crops, *Galinsogo-Portulacetum* and *Euphorbio-Galinsogetum ciliatae*

14) Oloseries of *Calamagrostis villosa* and *Abies alba* forest [*Calamagrostio villosae-Abieteto albae* sigmetum] of Alps, orotemperate, pre-alpine, humid, acidophilous. climatophilous

Forest*, Calamagrostio villosae-Abietetum albae*
Shrub, *Salicetum capreae*
Forest clearings vegetation of *Rubus idaeus*, *Rubetum idaei*
Forest clearings vegetation of *Senecio sylvaticus* and *Epilobium angustifolium*, *Senecioni sylvatici-Epilobietum angustifolii*
Forest clearings vegetation (shady and humid environment) of *Senecio fuchsii*, *Senecionetum fuchsii*
Grassland, *Sieversio-Nardetum strictae*

15) Oloseries of *Luzula luzuloides* and *Picea abies* forest [*Luzulo luzuloidis-Piceeto* sigmetum] of central Alps, orotemperate, alpine, acidophilous, climatophilous

Forest, *Luzulo luzuloidis-Piceetum*
Shrub, *Populo-Coryletum*
Shrub, *Salicetum capreae*
Forest clearings vegetation of *Rubus idaeus*, *Rubetum idaei*
Forest clearings vegetation of *Senecio sylvaticus* and *Epilobium angustifolium*, *Senecioni sylvatici-Epilobietum angustifolii*
Forest clearings vegetation (shady and humid environment) of *Senecio fuchsii*,

Senecionetum fuchsii
Grassland, *Sieversio-Nardetum strictae*
Weed vegetation in spring crops, *Adonido-Delphinietum consolidae*
Weed vegetation in summer crops, *Galinsogo-Portulacetum* and *Euphorbio-Galinsogetum ciliatae*

16) Oloseries of *Asplenium viride* and *Picea abies* forest [*Asplenio viridis-Piceeto* sigmetum] of central Alps, orotemperate, pre-alpine, acidophilous, *very small areas*

Forest, *Asplenio viridis-Piceetum*
Shrub, *Senecioni fuchsii-Sambucetum racemosae Noirfalise ex Oberdorfer 1957*

17) Oloseries of *Salvia glutinosa* and *Fraxinus excelsior* forest [*Salvio glutinosae-Fraxineto excelsioris* sigmetum] of central Alps, mesotemperate, alpine, acidophilous, climatophilous

Forest, *Salvio glutinosae-Fraxinetum excelsioris*
Shrub, *Populo-Coryletum*
Shrub, *Berberido-Rosetum*
Weed vegetation in spring crops, *Adonido-Delphinietum consolidae*
Weed vegetation in summer crops, *Galinsogo-Portulacetum* and *Euphorbio-Galinsogetum ciliatae*

18) Oloseries of *Alnus incana* forest [*Alneto incanae* sigmetum] of Alps, edaphophilous

Forest, *Alnetum incanae*
Prairie humide, *Scirpetum sylvatici*

Vegetation geoseries (geosigmeta)

The vegetation geoseries (geosigmeta) have also been identified in the study area, the composition of which is shown in Table 1. 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. Seven geoseries were identified and, as described above, subdivided into geoseries individuals (Table 2 & Table 3), indicated by numbers that are also given on the geoseries map (Fig. 2).

The name of the geoseries (geosigmeta) is built with the names of the sigmetum which is located at the highest and lowest altitude; in some cases it is necessary to resort to a third sigmetum, with reference to different exposures and different phytogeographic sectors.

I - Geoseries of the Ortles-Cevedale massifs (central Alps), climatophilous, acidophilous, alpine sector, mountainous slopes exposed to the south, silicate rocks, formed of alpine grassland, subalpine heaths, coniferous forests and deciduous forests (*Primulo-Cariceto curvulae*

sigmetum / *Junipero-Lariceto deciduae* sigmetum / *Salvio-Fraxineto excelsioris* sigmetum);

II - Geoseries of the central Alps, climatophilous, acidophilous, of the alpine sector, mountainous slopes exposed to the south, silicate rocks, formed of alpine grassland, subalpine heaths, coniferous forests and deciduous forests (*Primulo-Cariceto curvulae* sigmetum / *Cotoneastro integerrimae-Pineto cembrae* sigmetum / *Salvio-Fraxineto excelsioris* sigmetum); this geoserie differs from the previous one for *Pinus cembra*, which forms the *Cotoneastro integerrimae-Pineto cembrae* sigmetum);

III - Geoseries of the central Alps, climatophilous, acidophilous, of the alpine and pre-alpine sectors, mountainous slopes exposed to the north, silicate rocks, formed of alpine grassland, subalpine heaths, coniferous forests and deciduous forests (*Primulo-Cariceto curvulae* sigmetum / *Rhododendro-Lariceto deciduae* sigmetum / *Salvio-Fraxineto excelsioris* sigmetum);

IV - Geoseries of the central Alps, climatophilous, acidophilous, of the alpine sector, mountainous slopes exposed to the north, silicate rocks, formed of alpine grassland, subalpine heaths, coniferous forests and deciduous forests (*Primulo-Cariceto curvulae sigmetum* / *Larici-Pineto cembrae* sigmetum / *Salvio-Fraxineto excelsioris* sigmetum);

V - Geoseries of the central Alps, climatophilous, acidophilous, alpine and pre-alpine sectors, mountainous slopes exposed to the south, silicate rocks, formed of alpine meadows, subalpine heaths, coniferous forests and deciduous forests (*Primulo-Cariceto curvulae* sigmetum / *Junipero-Lariceto deciduae* sigmetum / *Salvio-Fraxineto excelsioris* sigmetum); this geoseries is similar to geoseries number 1, but differs from it in the absence of *Festuceto scabriculmis* sigmetum;

VI - Geoseries of the central Alps, climatophilous, acidophilous, of the pre-alpine sector, mountainous slopes exposed to the West, silicate rocks, formed of subalpine heaths, coniferous forests and deciduous forests (*Empetro-Vaccinieto gaultherioidi*s sigmetum / *Calamagrostio villosae-Abieteto* sigmetum / *Salvio-Fraxineto excelsioris* sigmetum); this geoserie is well distinct from *Abies alba*, with the *Calamagrostio villosae-Abietetum albae* forest;

VII - Geoseries of the Alps, edaphophilous, azonal, alpine and pre-alpine sectors, alluvial valley floors, formed of riparian forests (*Alneto incanae sigmetum*).

Map of phytoclimatic sectiors and map of geoseries

The map of the phtoclimatic sectors (scale 1: 50,000) was reproduced by Gafta and Pedrotti (1997). As already mentioned, the study area includes two valleys, one of which (Val di Rabbi) belongs to the pre-alpine sector, the second (Val di Peio) to the alpine one (Fig. 1). The phytogeographic difference between the two valleys is that the *Pinus cembra* is missing in the pre-alpine sector, which is instead widespread in the Alpine sector.

The map of the vegetation geoseries (scale 1: 50,000) was performed with the same methodology used for the map of another study area in Trentino (Pedrotti 2019); first of all, it shows the geoseries, mapped with different colors (Fig. 2). The geoseries were then divided into “individuals of geoseries”, each of which has its own numbering. (see also Tables 1, 2 & 3). As can be seen from Table 3, the individuals of geoseries may differ from each other due to the lack of any of the component series.

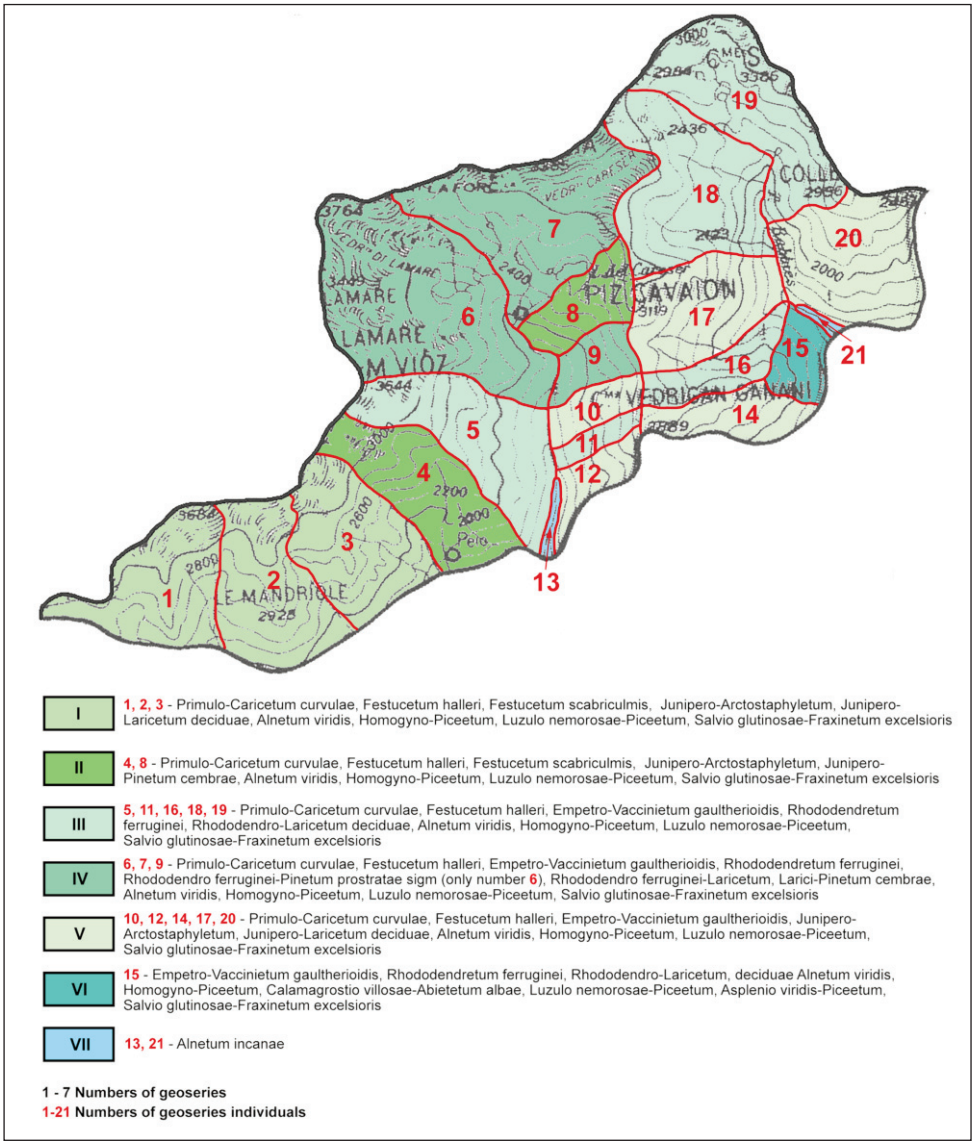

Fig. 2. Map of geoseries and geoseries individuals.

This map therefore has two meanings of a general nature: the first is that relating to the vegetation cover expressed through geoseries, the second is that of phytocenotic biodiversity assessed within the geoseries, making use of individuals of geoseries.

Table 1 – Geosigmeta (geoseries) composition of the geoseries mapped in Fig. 1.

Number of geoseries	I	V	II	III	IV	VI	VII
Aspect	S	S	S	N	N	N	-
Phytoclimatic sector	A	A-PA	A	A-PA	A	PA	A-PA
Primulo-Cariceto curvulae sigmetum	+	+	+	+	+	+	.
Festuceto halleri sigm.	+	+	+	+	+	+	.
Festuceto scabriculmis sigm.	+	.	+	.	.	.	.
Empetro-Vaccinieto gaultherioidis sigm.	.	.	.	+	+	+	.
Junipero-Arctostaphyleto sigm.	+	+	+	.	.	.	.
Junipero-Lariceto deciduae sigm.	+	+	.	.	.	.	.
Cotoneastro int.-Pineto cembrae sigm.	.	.	+	.	.	.	.
Rhododendreto ferruginei sigm.	.	.	.	+	+	+	.
Rhododendro-Pineto prostratae sigm	.	.	.	.	+	.	.
Rhododendro ferruginei-Lariceto deciduae sigm.	.	.	.	+	.	+	.
Larici-Pineto cembrae sigm.	.	.	.	.	+	.	.
Alneto viridis sigm.	+	+	+	+	+	+	.
Homogyno alpinae-Piceeto sigm.	+	+	+	+	+	+	.
Calamagrostio villosae-Abieteto albae sigm.	.	.	.	.	.	+	.
Luzulo nemorosae-Piceeto sigm.	+	+	+	+	+	+	.
Asplenio viridis-Piceeto sigm	.	.	.	+	.	+	.
Salvio glutinosae-Fraxineto excels. sigm.	+	+	+	+	+	+	.
Alneto incanae sigm.	.	.	.	.	.	.	+

Geobotanical significance of the geoseries (geosigmeta)

The geoseries has a dual, vegetational and phytogeographical significance as the geosynphytosociological map represents a link between the vegetation map and the phytogeographical map. 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. The geosynphytosociology makes it possible to recognise and define phytogeographical subdivisions on the basis of vegetation series and geoseries (Rivas Martìnez 2005, 2007).

Table 2 – Geoseries (geosigmeta) of Alpine sector (A)

Number of geoseries	I	I	I	V	V	II	II	III	III	IV	IV	IV	VII
Number of geoseries individuals	1	2	3	10	12	4	8	5	11	6	7	9	13
(according to the map in Fig. 2)													
Altitude	2230-3678	1900-3678	1450-3524	1400-2936	1400-2795	1500-3645	1900-3162	1500-3645	1400-2892	1400-3769	1900-3386	1400-2936	1160-1790
Geomorphology	slope	slope	slope	slope	slope	slope	slope	slope	slope	slope	slope	slope	river bed
Aspect	S	S	S	W	W	S-E	W	E	W	E	W	W	-
Lithology	S	S	S	S	S	S	S	S	S	S	S	S	S
Phytoclimatic sector	A	A	A	A	A	A	A	A	A	A	A	A	A
Primulo-Cariceto curvulae sigmetum	+	+	+	+	+	+	+	+	+	+	+	+	.
Festuceto halleri sigm.	+	+	+	+	+	+	+	+	+	+	+	+	.
Festuceto scabriculmis sigm.	+	+	+	.	.	+	.	.	.	.	.	.	.
Empetro-Vaccinieto gaultherioidis sigm.	.	.		.	.	.	.	.	.	+	.	.	.
Junipero-Arctostaphyleto sigm.	+	+	+	+	+	+	+	.	.	.	.	.	.
Junipero-Lariceto deciduae sigm.	.	+	+	+	+	.	.	.	.	.	.	.	.
Junipero-Pineto cembrae sigm.	.	.	.	.	.	+	+	.	.	.	.		.
Rhododendreto ferruginei sigm.	.	.	.	.	.	.	.	+	+	+	+	+	.
Rhododendro-Pineto prostratae sigm	.	.	.	.	.	.	.	.	.	+	.	.	.
Rhododendro-Lariceto deciduae sigm.	.	.	.	.	.	.	.	+	+	.	.	.	.
Larici-Pineto cembrae sigm.	.	.	.	.	.	.	.	.	.	+	+	+	.
Alneto viridis sigm.	+	+	+	+	+	+	+	+	+	+	+	+	.
Homogyno-Piceeto sigm.	.	+	+	+	+	+	+	+	+	+	+	+	.
Luzulo nemorosae-Piceeto sigm.	.	.	.	+	+	+	.	+	+	+	+	+	.
Salvio glutinosae-Fraxineto excels. sigm.	.	.	.	.	+	+	.	+	.	.	.	.	.
Alneto incanae sigm.	.	.	.	.	.	.	.	.	.	.	.	.	+
Tipe of geoseries	reduced	reduced	reduced	reduced	complete	complete	reduced	complete	reduced	reduced	reduced	reduced	complete

Table 3 – Geoseries of Pre-Alpine sector (P-A)

Number of geoseries	V	V	V	III	III	III	VI	VII
Number of geoseries individuals (according to the map in Fig. 2)	14	17	20	18	16	19	15	21
Altitude	1554-2735	1380-3120	1300-3385	1550-3347	1380-2935	1780-3380	1400-2350	1315-1500
Geomorphology	slope	slope	slope	slope	slope	slope	slope	river bed
Aspect	S-W	E	S	E	N	S-W	E	-
Lithology	S	S	S	S	S	S	S	S
Phytoclimatic sector	PA	PA	PA	PA	PA	PA	PA	PA
Primulo-Cariceto curvulae sigmetum	+	+	+	+	+	+	.	.
Festuceto halleri sigm.	+	+	+	+	+	+	.	.
Empetro-Vaccinieto gaultherioidis sigm.	+	+	.	+	+	.	+	.
Junipero-Arctostaphyleto sigm.	+	+	+	.	.	.	.	.
Junipero-Lariceto deciduae sigm.	+	+	+	.	.	.	.	.
Rhododendreto ferruginei sigm.	.	.	.	+	+	+	+	.
Rhododendro-Lariceto deciduae sigm.	.	.	.	+	+	+	+	.
Alneto viridis sigm.	+	+	+	+	+	+	+	.
Homogyno-Piceeto sigm.	+	+	+	.	+	+	+	.
Luzulo nemorosae-Piceeto sigm.	+	+	+	.	+	.	+	.
Asplenio viridis-Piceeto sigm.	.	.	.	.	+	.	+	.
Calamagrostio villosae-Abieteto albae sigm.	.	.	.	.	.		+	.
Salvio glutinosae-Fraxineto excels. sigm.	.	.	+	.	.	.	.	.
Alneto incanae sigm.	.	.	.	.	.	.	.	+
Type of geoseries	reduced	reduced	complete	reduced	reduced	reduced	reduced	complete

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