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Vegetation outlines of a debris-covered glacier descending below the treeline

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Abstract
Debris-covered glaciers are glaciers with the ablation zone covered by a debris layer, which are able to persist below the treeline and to support plant life. These landforms are increasing on many mountain regions of the world as consequence of climate change, providing new habitat for plant colonization, but their vegetation features are still little known. Our aim was to describe the vegetation of an alpine debris-covered glacier descending below the treeline (Belvedere: Western Italian Alps) and compare it with those of the adjacent iceless moraine and stable slope. Our hypothesis was that plant community of the supraglacial debris differs from those of the surrounding landforms for the presence of cold-adapted species. Data were collected by phytosociological method performing 45 relevés of 25 m^2. Plant communities were compared by a cluster analysis based on the presence/absence species matrix; species relative frequencies for each landform were calculated. The cluster analysis clearly separated three plant assemblages, each corresponding with one of the investigated landforms. Unlike the iceless moraine, debris-covered glacier stands out for the presence of cold-adapted species typically widespread in the alpine and nival belts (e.g. *Poa laxa* and *Cerastium pedunculatum*), allowing them to survive below their normal altitudinal distribution, where the stable slopes host subalpine woodlands and shrublands.

Key words: alpine flora, alpine vegetation, Belvedere glacier, climate change, moraine, refugia.

Introduction

Vegetation studies on glacial landforms date back to the beginning of 20th century (Lüdi, 1921; Braun-Blanquet & Jenny 1926; Negri, 1934, 1935, 1942; Valbusa, 1937; Friedel, 1938) and several reviews on the matter were performed by now (e.g. Lüdi, 1955, 1958; Matthews, 1992; Caccianiga & Andreis, 2004). However, most of the knowledge concerns plant colonization of glacier forelands and recent moraines within alpine and nival belts, while little is known about the vegetation of glacial landforms located below the treeline (Burga, 1999, Burga *et al*., 2010; Friedel, 1938; Richard, 1973, 1987). Among the latter, debris-covered glaciers can locally play an important role at landscape level because of their peculiar glaciological features. Debris-covered glaciers are glaciers with the ablation zone covered by a debris layer. They should not be confused with rock glaciers, periglacial landforms with different geomorphic and climatic significance (Humlum, 1998, 2000), in spite of some ecological affinities hailed from the coexistence of debris and ice (Tampucci *et al*., 2015). Debris-covered glaciers are relatively decoupled from atmosphere temperature, since a debris layer thicker than 1-2 cm acts as thermal insulator and protects the underlying ice from ablation (Mattson *et al*., 1993; Nakawo & Rana, 1999). Such glaciers thus differ from debris-free ones for less negative mass balance, smaller amplitude of frontal fluctuations and tongue descending to lower elevations (Kirkbride, 2000; Diolaiuti *et al*., 2003; Deline, 2005), sometimes overstepping the treeline and durably persisting in the forest context.

In spite of the harsh ecological conditions, debris-covered glaciers can provide suitable habitat for plant life, as showed by old observations (e.g. Negri, 1934, 1935, 1942; Valbusa, 1937; Birks, 1980) and more recent works focused on the matter (Fickert *et al*., 2007; Caccianiga *et al*., 2011; Pelfini *et al*., 2012). Supraglacial debris is colonized by pioneer herbaceous and woody species generally coherent with the altitudinal context, but can also allow cold-adapted plants to grow below their normal altitudinal distribution, probably as consequence of the thermal effect of underlying ice (Fickert *et al*. 2007; Caccianiga *et al*. 2011). Studies performed on Miage glacier (Western Italian Alps) showed that plant cover and species assemblages are affected by ground stability as a function of ice flow velocity (from 0.3 to 16.1 m/y) and by ground temperature as a function of debris thickness (from 10 to 56 cm) (Caccianga *et al*., 2011). The ecological features of debris-covered glaciers brought to different hypotheses about their contingent biogeographical role towards the glacial-interglacial periods. Fickert *et al*. (2007) proposed such landforms as refugia and dispersal pathways during the ice ages besides the unglaciated areas, complementing the hypotheses of *nunatakker* and *tabula-rasa* and calling into question the ice ages themselves as periods of biogeographical isolation. Other authors interpreted debris-covered glaciers

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as potential warm-stage refugia for cold-adapted plant (Caccianiga *et al*. 2011) and arthropod species (Gobbi *et al*., 2011), as consequence of the microclimate features due to the ice presence and the thermal inertia due to the debris cover.

The amount of supraglacial debris is currently increasing on many mountain systems of the world as response to climate change, because of the progressive exposure of endoglacial debris with ice melting and the increasing rock-falls from the slopes freed by glacier thinning (Kirkbride & Warren, 1999; Mattson, 2000; Diolaiuti *et al*., 2003; Stokes *et al*., 2007). Such landforms are thus taking on more and more relevance in mountain landscapes as expanding habitat for plant colonization. Further investigation are needed to clarify the syntaxonomical position of their plant communities, their spatial arrangement with respect to the vegetation belts and their ecological and biogeographical significance in the climate change context.

Aim of this paper is to describe the vegetation of an alpine debris-covered glacier descending below the treeline (Belvedere: Western Italian Alps) and to compare it with those of the neighboring iceless moraine and stable slope as reference sites. Our hypothesis is that plant community of the supraglacial debris differs from those of the surrounding landforms for the presence of cold-adapted species.

Study area

Belvedere glacier (Western Italian Alps; N45 57.685 E7 54.925) (fig. 1) is one of the most well-known debris-covered glaciers of the Alps (Monterin, 1923). Its fame is partially due to its interesting as hazardous dynamics, like the several outburst floods recorded from 1868 to 1979 and the surge-type movement performed between the summers of 2001 and 2002 (Haeberli *et al*., 2002; Mortara & Tamburini, 2009). The glacier takes origin from the confluence of four tongues descending from the ice cap of Monte Rosa (4633 m a.s.l.) and lies in the uppermost part of Valle Anzasca (I/B-9.III in Marazzi, 2005). It is c. 3400 m long and 700 m wide, covering a total surface of c. 7.5 km^2. The terminus splits into two divergent lobes which descend down to 1820 and 1785 m a.s.l. respectively, a minimum elevation second only to that of Miage glacier (1730 m a.s.l.) in the Italian Alps (Mortara & Tamburini, 2009). The glacier surface is almost completely covered by a debris layer thick from c. 5 cm in the upper tongue to 20-30 cm in the frontal lobes, with peaks level of c. 80 cm in the depressions (Diolaiuti *et al*. 2003). Two moraine systems delimit the glacier mass: an external one deposed in the Little Ice Age (at present consolidated and fully vegetated) and an internal more recent one (still unconsolidated and less vegetated). The substrate is composed by gneiss and schists (Mattirolo *et al*., 1951). Temperatures and precipitations of the area within the period 2000-2014 were analyzed using the records provided by ARPA Piemonte (station of Pecetto, 1360 m a.s.l.) (fig. 2). Calculating the Rivas-Martinez Index for thermal continentality (Rivas-Martínez & Rivas-Saenz, 1996-2009) and the Gams Index for hygric continentality (Ozenda, 1985), the area results to be characterized by a sub-oceanic climate regime (25,15 and 41,80° respectively).

Methods

Data were collected in July and August 2014. Forty-five vegetation relevés were performed by phytosociological method with the Braun-Blanquet scale as modified by Pignatti (1952) on three adjacent landforms corresponding to three different ecological conditions: stable slope (sites without ice, supposed to have the potentiality for climax vegetation), iceless moraine (unconsolidated debris substrate without underlying ice) and supraglacial debris (unconsolidated debris substrate with underlying ice) (fig. 3). All the relevés were performed on 25 m^2 surfaces, a value which allows a homogeneous and representative sampling of the main object of our research (glareicolous vegeta-

Fig. 1 - Belvedere glacier (photo by Lindsey Nicholson).

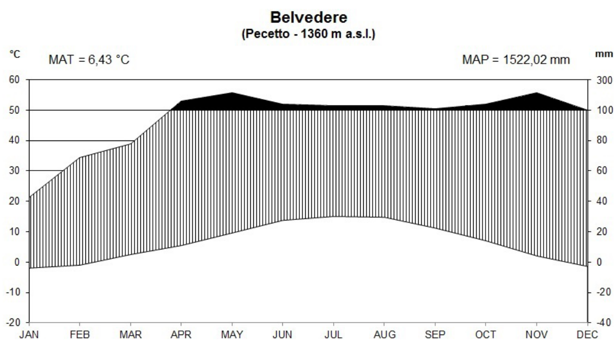

Fig. 2 - Climogram of Pecetto meteorological station.

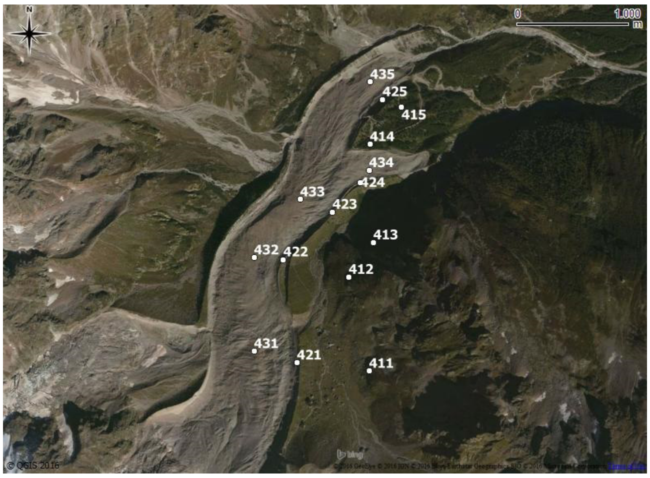

Fig. 3 - Sampling design with relevés position. Three relevés (A, B, C) c. 10 m far from each other were performed for each position.

tion of the iceless moraine and the supraglacial debris). Relevés were compared by a cluster analysis based on the presence/absence species matrix, using the UPGMA method with Jaccard dissimilarity index. Species relative frequencies for each landform were calculated and gathered in five frequency classes with resolution of 20%. The nomenclature follows Aeschimann *et al*. (2004) for species and Biondi *et al*. (2014) and Biondi & Blasi (2015) for syntaxa to the alliance level. The phytosociological interpretation generally agrees with Grabherr & Mucina (1993) and Oberdorfer (1977).

Results

We identified 117 vascular plant species. The cluster analysis (fig. 4) separated first of all the vegetation of the stable slope from those of the debris-featured landforms. Within the latter group, a further distinction between the iceless moraine and the supraglacial debris was clearly recognizable. It was thus possible to distinguish three main clusters that correspond to the analyzed landforms. Data were reported in the analytic table (tab. 1, in attachment on the inside back cover) and the synoptic table (tab. 2).

Cluster 1: stable slope

The stable slope embraced a wide range of vegetation structures: woodlands dominated by *Larix decidua* and *Salix appendiculata* (relevés 414, 415) (fig. 5), shrublands of *Alnus viridis* (relevés 413) or *Rhododendron ferrugineum* (relevés 411, 412) and all the seamless transitions between each other. However, a relatively homogeneous species assemblage was recognizable. The shrub layer was always dominated by *Rhododendron ferrugineum* and *Vaccinium myrtillus*, while the herbaceous one included *Calamagrostis villosa*, *Agrostis stolonifera*, *Avenella flexuosa* and *Dryopteris dilatata*. The presence of species like *Sorbus aucuparia*, *Melampyrum sylvaticum*, *Pyrola minor* and the sporadic but highly faithful *Corallorhiza trifida*, allowed a clear attribution of the woodlands to the class *Vaccinio myrtilli-Piceetea abietis* Br.-Bl. in

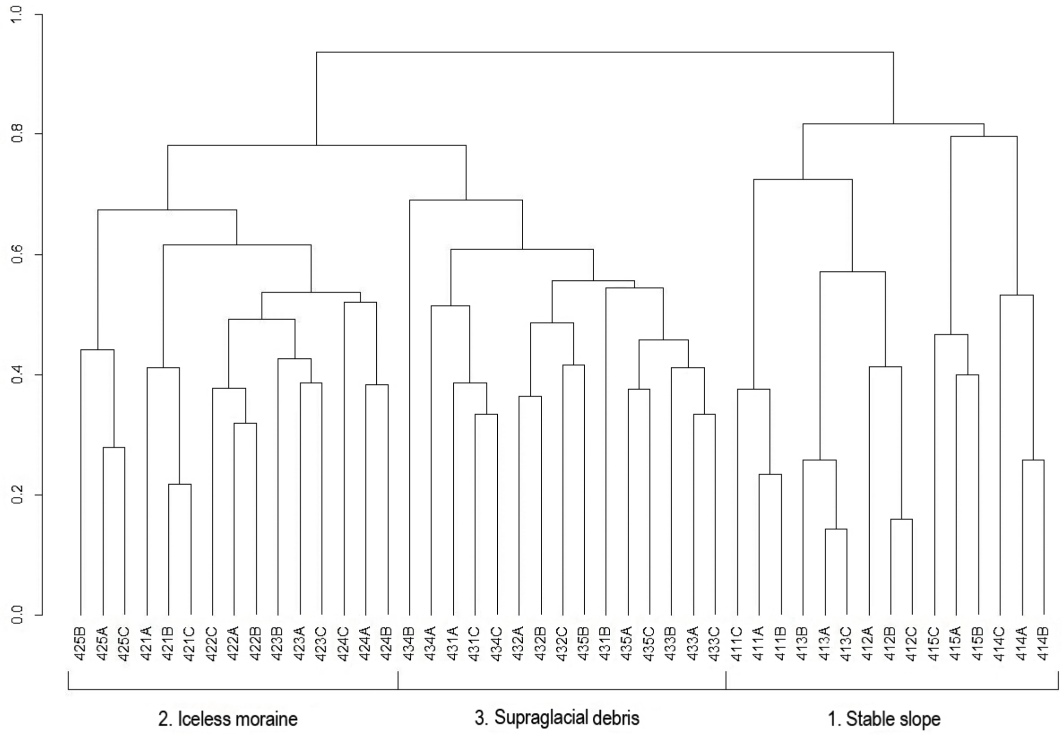

Fig. 4 - Dendrogram resulting from the cluster analysis of relevés.

Tab. 2 - Synoptic table of mean relevés values and species frequency classes for each landform (I = 1-20%, II = 21-40%, III = 41-60%, IV = 61-80%, V = 81-100%).

Species	1. Stable slope	2. Iceless moraine	3. Supraglacial debris
Arboreous cover (%)	20	0	0
High-shrubs cover (%)	25	0	0
Low-shrubs cover (%)	56	11	1
Herbaceous cover (%)	60	22	7
Bryophytes and lichens cover (%)	8	4	3
Outcrops cover (%)	0	0	0
Debris cover (%)	8	63	89
Soil cover (%)	7	0	0
Species richness	23	19	11
Avenella flexuosa	V		
Vaccinium myrtillus	V		
Dryopteris dilatata	IV		
Astrantia minor	III		
Gentiana purpurea	III		
Homogyne alpina	III		
Veratrum album subsp. lobelianum	III		
Arnica montana	II		
Campanula barbata	II		
Dryopteris filix-mas	II		
Helictotrichon versicolor	II		
Juniperus communis subsp. alpina	II		
Leontodon helveticus	II		
Ligusticum mutellina	II		
Luzula sieberi	II		
Melampyrum sylvaticum	II		
Nardus stricta	II		
Rumex alpestris	II		
Soldanella alpina	II		
Sorbus aucuparia	II		
Vaccinium gaultherioides	II		
Achillea macrophylla	I		
Adenostyles alliariae	I		
Alchemilla gr. alpina	I		
Alchemilla gr. vulgaris	I		
Carex curvula subsp. curvula	I		
Carex sempervirens	I		
Centaurea nervosa subsp. nervosa	I		
Chaerophyllum hirsutum	I		
Cicerbita alpina	I		
Corallorhiza trifida	I		
Dactylorhiza maculata	I		
Festuca arundinacea subsp. arundinacea	I		
Festuca nigrescens	I		
Geranium sylvaticum	I		
Geum montanum	I		
Hieracium pilosum	I		
Hieracium murorum	I		
Huperzia selago	I		
Maianthemum bifolium	I		
Milium effusum	I		
Oxalis acetosella	I		
Phyteuma hemisphaericum	I		
Poa nemoralis	I		
Polypodium vulgare	I		
Polystichum lonchitis	I		
Potentilla aurea	I		
Prenanthes purpurea	I		
Primula hirsuta	I		
Pseudorchis albida	I		
Pyrola minor	I		
Ranunculus gr. montanus	I		
Rubus idaeus	I		

Sedum alpestre	I		
Stellaria nemorum subsp. nemorum	I		
Streptopus amplexifolius	I		
Thesium alpinum	I		
Trifolium alpinum	I		
Viola biflora	I		
Myosotis alpestris	I	I	
Cerastium arvense subsp. strictum	I	II	
Alnus viridis	I	III	
Trifolium pratense subsp. nivale	I	III	
Sempervivum montanum subsp. montanum	II	III	
Anthoxanthum alpinum	III	III	
Silene vulgaris subsp. vulgaris	III	II	
Calamagrostis villosa	III	I	
Athyrium distentifolium	II	I	
Campanula scheuchzeri	II	I	
Cystopteris fragilis	II	I	
Peucedanum ostruthium	II	I	
Phleum alpinum	II	I	
Phyteuma betonicifolium	II	I	
Solidago virgaurea subsp. virgaurea	II	I	
Trifolium pallescens		V	
Achillea erba-rotta subsp. moschata		IV	
Epilobium fleischeri		III	
Festuca halleri		III	
Bartsia alpina		II	
Arabis alpina subsp. alpina		I	
Epilobium nutans		I	
Galium anisophyllon		I	
Hieracium staticifolium		I	
Pedicularis tuberosa		I	
Rhinanthus alpinus		I	
Saxifraga oppositifolia subsp. oppositifolia		I	
Silene rupestris		V	IV
Rumex scutatus		V	III
Cardamine resedifolia		IV	III
Luzula lutea		IV	II
Linaria alpina subsp. alpina		III	III
Saxifraga aspera		III	I
Sagina saginoides		II	II
Silene exscapa		II	I
Saxifraga bryoides		I	I
Cerastium pedunculatum		I	V
Poa laxa		I	V
Leucanthemopsis alpina		I	III
Luzula alpinopilosa subsp. alpinopilosa		I	III
Campanula excisa			II
Saxifraga stellaris			II
Betula pendula			I
Epilobium alsinifolium			I
Gnaphalium supinum			I
Oxyria digyna			I
Ranunculus glacialis			I
Agrostis rupestris	I	II	IV
Agrostis stolonifera	IV	V	V
Euphrasia minima	I	II	I
Festuca gr. varia	III	IV	I
Juncus trifidus	II	IV	I
Larix decidua	II	IV	II
Lotus alpinus	I	II	I
Poa alpina	I	III	I
Rhododendron ferrugineum	V	I	I
Salix appendiculata	I	V	V
Salix helvetica	II	III	I
Total species richness	85	51	31

Fig. 5 - *Larix decidua* subalpine woodlands on the stable slope (cluster 1).

Fig. 6 - Glareicolous vegetation of the iceless moraine, with *Trifolium pallescens*, *Achillea erba-rotta* subsp. *moschata* and *Agrostis stolonifera* (cluster 2).

Br.-Bl., Sissingh & Vlieger 1939. They likely belong to the association *Astrantio minoris-Laricetum deciduae* Andreis, Armiraglio, Caccianiga & Cerabolini 2009, which includes the sub-oceanic larch-dominated woodlands, as indicated by the presence of *Astrantia minor*, *Gentiana purpurea* and *Prenanthes purpurea*. By the other hand, differential species as *Rhododendron ferrugineum*, *Vaccinium myrtillus* and *Dryopteris dilatata* suggest that the shrublands may belong to the association *Rhododendro ferruginei-Alnetum viridis* Boscutti, Poldini & Buccheri 2014 (class *Betulo carpaticae-Alnetea viridis* Rejmánek in Huml, Lepš, Prach & Rejmánek 1979). Remarkable was also the massive occurrence of species belonging to the class *Mulgedio alpini-Aconitetea variegate* Hadac & Klika in Klika & Hadac 1944, like *Peucedanum ostruthium*, *Adenostyles alliariae*, *Achillea macrophylla*, *Cicerbita alpina* and *Geranium sylvaticum*.

Cluster 2: iceless moraine

The iceless moraine was colonized both by woody and herbaceous species (fig. 6). The shrub layer consisted of young individuals of *Salix appendiculata* and *S. helvetica*, locally accompanied by *Larix decidua* and *Alnus viridis*. Among the herbaceous elements, *Achillea erba-rotta* subsp. *moschata* and *Trifolium pallescens* were the most constant ones, followed by *Epilobium fleischeri*, *Euphrasia minima*, *Festuca halleri*, *Poa alpina*, *Trifolium pratense* subsp. *nivale* and *Saxifraga aspera*. As much frequent, but shared with the adjacent landforms, were *Agrostis stolonifera*, *Anthoxanthum alpinum*, *Cardamine resedifolia*, *Festuca varia*, *Juncus trifidus*, *Linaria alpina*, *Luzula lutea*, *Sempervivum montanum*, *Silene rupestris* and *Rumex scutatus*. The vegetation structure varied along the moraine ridge: the uppermost communities resemble those of the glacier surface (cluster 3), with *Poa laxa*, *Cerastium pedunculatum* and a scarce shrub layer (relevés 421); proceeding downstream, subalpine woody species as *Alnus viridis* and *Larix decidua* acquire more relevance (relevés 423, 424, 425). The community was clearly attributable to the alliance *Androsacion alpinae* Br.-Bl. in Br.-Bl. & Jenny 1926. It resembled the association *Agrostio rupestris-Trifolietum pallescentis* Caccianiga & Andreis 2004, except for the lacking of some *Caricetea curvulae* Br.-Bl. 1948 elements (e.g. *Agrostis rupestris* and *Minuartia recurva*) and the relatively high frequency of *Thlaspietea rotundifolii* Br.-Bl. 1948 ones (e.g. *Cardamine resedifolia*, *Linaria alpina* and *Rumex scutatus*).

Cluster 3: supraglacial debris

The community of supraglacial debris (fig. 7) stands out for the presence of high alpine species as *Poa laxa* and *Cerastium pedunculatum*, followed in frequency by *Luzula alpinopilosa*, *Leucanthemopsis alpina*, *Saxifraga stellaris* and *Agrostis rupestris*. Other abundant but not exclusive species were *Agrostis stolonifera*, *Silene rupestris*, *Rumex scutatus*, *Cardamine resedifolia* and *Linaria alpina*. Noteworthy was the presence of *Campanula excisa*, a Western Alps endemic species; even though in our study case it resulted exclusive of the supraglacial debris, it was frequently observed by the Authors in other not investigated environments (e.g. rocky pastures, eroded terrains and path edges). Unlike the moraine ridge, the supraglacial debris was homogeneously colonized, without evident discontinuities or gradients in terms of vegetation structure. The same plant assemblage can thus be found from the upper zones of the glacier to the minimum elevation of 1895 m a.s.l., even including sporadic individuals of the high-alpine *Ranunculus glacialis*. The shrub layer was absent, except for few young individuals of *Salix appendiculata* and to a lesser extent *Larix decidua*. As

Fig. 7 - Glareicolous vegetation of the supraglacial debris, with *Poa laxa* and *Cerastium pedunculatum* (cluster 3).

well as for the adjacent moraine, such plant assemblage was ascribable to the alliance *Androsacion alpinae* Br.-Bl. in Br.-Bl. & Jenny 1926, but its placement at the association level is uncertain.

Discussion

All the investigated landforms differ each other for distinct plant communities. Particularly interesting is the comparison between the iceless moraine and the supraglacial debris, environments similar to each other except for the occurrence of underlying ice. While the community of the iceless moraine is characterized by pioneer species generally widespread on a wide altitudinal range, that of supraglacial debris stands out for cold-adapted species typical of alpine and nival belts (Aeschimann *et al*., 2004; Landolt *et al*., 2010). Such phenomenon can be likely attributed to the thermal effect of underlying ice, according to Fickert *et al*. (2007) and Caccianiga *et al*. (2011). The supraglacial debris allows thus cold-adapted species to grow below their normal altitudinal distribution, where the stable slopes have the potentiality for subalpine woodlands (Andreis *et al*., 2009) and shrublands (Boscutti *et al*., 2014). Coherently with the geographical context and the results of our climate analyses, the woodlands belongs to the *Astrantio minoris-Laricetum deciduae*, a western-alpine association linked to the sub-oceanic climate regime, sometime able to include typical elements of montane broad-leaved forests (Andreis *et al*., 2009). This peculiar feature furtherly accentuates the contrast between supraglacial and potential vegetation, achieving the coexistence of nival species (e.g. *Ranunculus glacialis*) few meters aside from montane ones (e.g. *Prenanthes purpurea*).

Iceless moraine and supraglacial debris are also differently subjected to the colonization by subalpine woody species. On the moraine ridge, *Alnus viridis*, *Larix decidua* and *Salix* spp. built up a well-structured shrub layer up to one meter high, while the vegetation of supraglacial debris is mainly herbaceous and contingent individuals of *Salix appendiculata* and *Larix decidua* seems unable to grow above few decimeters. Summarizing, the community of the iceless moraine is interpretable as an ephemeral stage over the subalpine primary succession, where herbaceous early-successional species coherent with the altitudinal context are supposed to be rapidly replaced by woody late-successional ones. By contrast, the supraglacial debris appears more selective, promoting the persistence of pioneer cold-adapted species in an adverse altitudinal context and preventing the subalpine succession development. Unlike that of the iceless moraine, the vegetation of supraglacial debris should be thus considered as extrazonal at landscape level. Geomorphological and microclimatic heterogeneity enhances species turnover (Körner, 2003) and provides refugia opportunities for stenotherm species in spite of climate variations at large scale (Ashcroft *et al*., 2012; Birks & Willis, 2008; Dobrowski 2011; Gentili *et al*., 2015; Stewart *et al*., 2010). Our results suggest that Belvedere debris-covered glacier have the ecological requirements to act as refugia for plant species, especially for cold-adapted ones during warm-climatic stages, according to Caccianiga *et al*. (2011).

Concerning the phytosociological viewpoint, the iceless moraine and the supraglacial debris were colonized each one by a distinct aspect of the alliance *Androsacion alpinae*, but their placement at the association level is debatable. The association *Agrostio rupestris-Trifolietum pallescentis* was formerly referred to the terrain ice-free since the Little Ice Age on the glacier forelands located above the treeline (Caccianiga & Andreis, 2004). Our relevés on the iceless moraine of Belvedere glacier suggest that a subalpine variant of the same association may be proposed for the moraines younger than Little Ice Age located below the treeline, implying thus higher colonization speed at lower elevation. Less can be said about the vegetation of supraglacial debris because of species scarcity. More defined is the case of the not too far Miage glacier, mainly colonized by *Epilobium fleischeri*, *Saxifraga aizoides*, *Linaria alpina*, *Ranunculus glacialis*, *Geum reptans* and *Oxyria digyna* (Caccianiga *et al*., 2011). This plant assemblage can be attributed to the *Sieversio-Oxyrietum digynae* Friedel 1956 em. Englisch *et al*. 1993 (probably to the *Saxifraga aizoides* and *Epilobium fleischeri* subtype described in Caccianiga & Andreis, 2004), an association normally widespread on the scree slopes of alpine and nival belts (Grabherr & Mucina, 1993; Oberdorfer, 1977). Even if the plant assemblage found on Belvedere glacier cannot be certainly attributed to *Sieversio-Oxyrietum digynae* because of the lack of characteristic elements (*Geum reptans* and *Oxyria digyna*), all the identified differential species are typically constant or dominant of this association (Grabherr & Mucina, 1993). We thus hypothesize that *Sieversio-Oxyrietum digynae* is nevertheless the most plausible representative association of silicate supraglacial debris of the Alps in general. Anyway, more data should be collected from other areas to perform a comprehensive syntaxonomic overview of both the iceless moraines and supraglacial debris vegetation located below the treeline.

Syntaxonomic scheme

VACCINIO MYRTILLI-PICEETEA ABIETIS Br.-Bl. in Br.-Bl., Sissingh & Vlieger 1939
PICEETALIA EXCELSAE Pawłowski in Pawłowski, Sokołowski & Wallisch 1928
Piceion excelsae Pawlowski in Pawlowski, Sokolowski & Wallisch 1928
Astrantio minoris-Laricetum deciduae Andreis, Armiraglio, Caccianiga & Cerabolini 2009

BETULO CARPATICAE-ALNETEA VIRIDIS Rejmánek in Huml, Lepš, Prach & Rejmánek 1979
ALNETALIA VIRIDIS Rübel 1933
Alnion viridis A. Schnyd. 1930
Rhododendro ferruginei-Alnetum viridis Boscutti, Poldini & Buccheri 2014

MULGEDIO ALPINI-ACONITETEA VARIEGATI Hadac & Klika in Klika & Hadac 1944
ADENOSTYLETALIA ALLIARIAE Br.-Bl. 1931

THLASPIETEA ROTUNDIFOLII Br.-Bl. 1948
ANDROSACETALIA ALPINAE Br.-Bl. in Br.-Bl. & Jenny 1926
Androsacion alpinae Br.-Bl. in Br.-Bl. & Jenny 1926
Agrostio rupestris-Trifolietum pallescentis Caccianiga & Andreis 2004
Sieversio-Oxyrietum digynae Friedel 1956 em. Englisch, Valachovič, Mucina, Grabherr & Ellmauer in Grabherr & Mucina 1993

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Appendix: Sporadic species

Tab. 1 – Rel 411B: Centaurea nervosa subsp. nervosa +, Sedum alpestre +, Trifolium alpinum +; Rel 412A: Festuca nigrescens 1, Alchemilla gr. Vulgaris +, Carex curvula subsp. curvula +, Hieracium pilosum +; Rel 412C: Viola biflora +; Rel 415C: Maianthemum bifolium +; Rel 415B: Rubus idaeus 1, Streptopus amplexifolius +; Rel 414C: Thesium alpinum +; Rel 414A: Chaerophyllum hirsutum +, Corallorhiza trifida +; Rel 414B: Dactylorhiza maculata +, Polypodium vulgare +, Polystichum lonchitis +; Rel 425B: Rhinanthus alpinus +; Rel 425C: Epilobium nutans +; Rel 423C: Saxifraga oppositifolia subsp. oppositifolia +; Rel 424C: Galium anisophyllon +, Hieracium staticifolium +; Rel 434B: Epilobium alsinifolium +; Rel 435A: Ranunculus glacialis +; Rel 435C: Betula pendula +; Rel 433C: Gnaphalium supinum +.

Tab. 1 - Analytic table of relevés.

Cluster	1. Stable slope														
Code	411C	411A	411B	413B	413A	413C	412A	412B	412C	415C	415A	415B	414C	414A	414B
Date	27.07.2014	27.07.2014	27.07.2014	27.07.2014	27.07.2014	27.07.2014	27.07.2014	27.07.2014	27.07.2014	27.07.2014	27.07.2014	27.07.2014	27.07.2014	27.07.2014	27.07.2014
Coordinates	N45 57.106 E7 55.262	N45 57.096 E7 55.266	N45 57.097 E7 55.263	N45 57.538 E7 55.285	N45 57.536 E7 55.281	N45 57.542 E7 55.288	N45 57.414 E7 55.157	N45 57.420 E7 55.164	N45 57.424 E7 55.170	N45 58.006 E7 55.435	N45 57.996 E7 55.417	N45 58.000 E7 55.421	N45 57.881 E7 55.271	N45 57.864 E7 55.272	N45 57.871 E7 55.256
Landform	Stable slope	Stable slope	Stable slope	Stable slope	Stable slope	Stable slope	Stable slope	Stable slope	Stable slope	Stable slope	Stable slope	Stable slope	Stable slope	Stable slope	Stable slope
Elevation (m a.s.l.)	2135	2135	2135	2055	2055	2055	2075	2075	2075	1875	1885	1880	1930	1930	1935
Aspect (°)	260	260	260	300	305	320	300	315	315	350	350	340	5	10	20
Slope (°)	40	30	35	20	30	25	25	20	20	25	20	20	35	30	30
Arboreous cover (%)	0	0	0	0	0	0	0	0	0	30	40	60	50	60	60
High-shrubs cover (%)	0	0	0	60	70	80	0	0	0	5	5	0	30	60	60
Low-shrubs cover (%)	50	65	60	20	25	40	70	70	75	30	80	80	90	50	30
Herbaceous cover (%)	75	80	60	75	75	65	50	60	50	80	30	50	25	70	50
Bryophytes and lichens cover (%)	0	5	10	10	15	5	10	5	10	5	10	5	0	20	15
Outcrops cover (%)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Debris cover (%)	0	5	10	0	0	0	20	10	25	0	0	0	5	25	20
Soil cover (%)	5	0	5	0	0	0	10	0	5	15	15	10	5	20	10
Number of species	23	26	30	14	14	12	27	21	26	20	19	23	24	33	33
Diff. stable slope															
Rhododendron ferrugineum	2	1	2	1	1	2	3	3	3	1	4	3	4	2	2
Vaccinium myrtillus	1	1	1	1	1	1	2	1	2	.	1	1	1	1	1
Dryopteris dilatata	.	.	.	1	1	1	1	+	1	2	1	+	1	1	+
Astrantio minoris-Laricetum deciduae															
Astrantia minor	1	1	1	.	.	.	1	+	1	.	.	.	+	+	+
Gentiana purpurea	+	+	.	+	1	1	1	+	+	.	.	.	1	.	.
Prenanthes purpurea	.	.	.	.	.	.	.	.	.	1	1	+	.	.	.
Vaccinio myrtilli-Piceetea abietis, *Piceetalia excelsae* and *Piceion excelsae*															
Avenella flexuosa	1	2	1	1	1	1	1	1	1	1	1	1	.	1	1
Homogyne alpina	1	1	+	+	1	+	1	+	1	.	.	.	.	.	.
Calamagrostis villosa	2	.	.	4	4	3	1	.	.	4	1	1	.	.	.
Sorbus aucuparia	.	.	.	.	.	.	.	.	.	1	+	+	+	+	+
Melampyrum sylvaticum	.	.	.	.	.	.	.	.	.	+	.	.	1	2	1
Pyrola minor	.	.	.	.	.	.	.	.	.	.	.	.	+	1	+
Mulgedio alpini-Aconitetea variegati and *Adenostyletalia alliariae*															
Veratrum album subsp. lobelianum	.	.	.	1	1	1	1	+	1	1	+	.	.	.	.
Athyrium distentifolium	.	.	.	.	1	1	.	+	1	.	1	1	.	.	.
Rumex alpestris	.	.	.	1	1	1	+	+	1	.	.	.	.	.	.
Luzula sieberi	.	.	.	+	.	.	1	1	1	.	.	.	.	1	.
Peucedanum ostruthium	.	.	.	.	.	.	.	.	.	1	1	.	.	1	1
Achillea macrophylla	.	.	.	.	.	.	.	.	.	1	+	1	.	.	.
Adenostyles alliariae	.	.	.	.	.	.	.	.	.	1	+	1	.	.	.
Geranium sylvaticum	.	.	.	.	.	.	.	.	.	1	.	+	+	.	.
Stellaria nemorum subsp. nemorum	.	.	.	.	1	.	.	.	.	.	+	+	.	.	.
Cicerbita alpina	.	.	.	.	.	.	.	.	.	.	1	+	.	.	.
Milium effusum	.	.	.	.	.	.	.	.	.	1	.	1	.	.	.
Diff. iceless moraine															
Epilobium fleischeri	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Poa alpina	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+
Trifolium pratense subsp. nivale	.	.	.	.	.	.	.	.	.	.	.	.	.	+	+
Saxifraga aspera	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Agrostio rupestris-Trifolietum pallescentis															
Trifolium pallescens	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Achillea erba-rotta subsp. moschata	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Festuca halleri	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Euphrasia minima	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.
Agrostis rupestris	.	1	1	.	.	.	.	.	.	.	.	.	.	.	.
Diff. supraglacial debris															
Poa laxa	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Cerastium pedunculatum	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Leucanthemopsis alpina	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Luzula alpinopilosa subsp. alpinopilosa	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Campanula excisa	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Saxifraga stellaris	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Androsacetalia alpinae and *Androsacion alpinae*															
Silene rupestris	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Cardamine resedifolia	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Sagina saginoides	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Saxifraga bryoides	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Oxyria digyna	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Thlaspietea rotundifolii															
Rumex scutatus	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Linaria alpina subsp. alpina	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Arabis alpina subsp. alpina	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Subalpine woody species															
Salix appendiculata	.	.	.	.	.	.	.	.	.	.	.	.	2	3	3
Larix decidua	.	.	.	.	.	.	.	.	.	2	2	3	3	3	3
Salix helvetica	1	1	1	.	.	.	.	.	.	.	.	.	2	.	.
Alnus viridis	.	.	.	3	4	4	.	.	.	.	.	.	.	.	.
Vaccinium gaultherioides	1	2	2	.	.	.	2	1	3	.	.	.	.	.	.
Juniperus communis subsp. alpina	1	1	+	.	.	.	.	.	.	1	.	.	+	.	.
Companion species															
Agrostis stolonifera	1	1	+	+	1	1	1	1	1	.	.	.	1	1	1
Festuca gr. varia	.	1	1	.	.	.	1	.	.	.	.	+	1	1	+
Juncus trifidus	1	+	1	.	.	.	.	+	1	.	.	.	.	.	.
Anthoxanthum alpinum	1	1	2	+	.	.	1	2	2	.	.	.	.	1	1
Luzula lutea	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Sempervivum montanum subsp. montanum	.	+	+	.	.	.	.	.	.	.	.	.	+	+	+
Silene vulgaris subsp. vulgaris	+	.	.	1	1	.	1	.	+	+	+	.	.	.	.
Silene exscapa	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Cerastium arvense subsp. strictum	.	.	.	.	.	.	.	.	.	.	.	.	.	+	+
Lotus alpinus	.	.	.	.	.	.	.	.	.	.	.	.	+	+	+
Phyteuma betonicifolium	1	1	+	.	.	.	.	.	.	.	.	.	.	1	+
Cystopteris fragilis	.	.	.	.	.	.	.	.	.	+	+	+	.	+	.
Leontodon helveticus	+	1	+	.	.	.	1	+	1	.	.	.	.	.	.
Campanula scheuchzeri	.	+	+	.	.	.	.	.	.	.	+	.	.	+	.
Solidago virgaurea subsp. virgaurea	1	1	+	.	.	.	.	.	.	.	.	.	1	.	+
Campanula barbata	+	.	+	.	.	.	.	.	.	.	.	+	.	1	+
Ligusticum mutellina	.	.	.	.	.	.	+	+	1	.	.	.	+	.	+
Phleum alpinum	.	.	.	.	.	.	.	+	1	.	.	.	.	1	+
Dryopteris filix-mas	.	.	.	.	.	.	.	.	.	.	.	+	1	1	+
Arnica montana	1	1	1	.	.	.	.	.	.	.	.	.	+	.	.
Bartsia alpina	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Helictotrichon versicolor	+	1	1	.	.	.	+	.	.	.	.	.	.	.	.
Myosotis alpestris	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+
Nardus stricta	1	+	1	.	.	.	1	.	.	.	.	.	.	.	.
Soldanella alpina	.	+	.	.	.	.	.	.	.	.	.	+	.	1	+
Hieracium murorum	1	.	.	.	.	.	.	.	.	1	.	.	.	1	.
Poa nemoralis	.	.	.	.	.	.	.	.	.	.	.	.	1	1	+
Alchemilla gr. alpina	.	.	.	.	.	.	1	+	1	.	.	.	.	.	.
Carex sempervirens	1	1	1	.	.	.	.	.	.	.	.	.	.	.	.
Festuca arundinacea subsp. arundinacea	.	.	.	.	.	.	.	.	.	.	.	.	1	1	1
Geum montanum	.	.	1	.	.	.	.	+	+	.	.	.	.	.	.
Oxalis acetosella	.	.	.	.	.	.	.	.	.	1	1	+	.	.	.
Phyteuma hemisphaericum	.	+	+	.	.	.	.	.	+	.	.	.	.	.	.
Primula hirsuta	.	.	+	.	.	.	+	.	+	.	.	.	.	.	.
Huperzia selago	.	.	.	.	.	.	+	.	.	.	.	.	.	+	.
Pedicularis tuberosa	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Potentilla aurea	.	+	.	.	.	.	.	.	+	.	.	.	.	.	.
Pseudorchis albida	.	.	.	.	.	.	.	+	+	.	.	.	.	.	.
Ranunculus gr. montanus	.	.	.	.	.	.	.	.	.	.	.	.	.	+	+
Sporadic species	0	0	3	0	0	0	4	0	1	1	0	2	1	2	3

Cluster	2. Iceless moraine														
Code	425B	425A	425C	421A	421B	421C	422C	422A	422B	423B	423A	423C	424C	424A	424B
Date	21.07.2014	21.07.2014	21.07.2014	02.07.2014	02.07.2014	02.07.2014	21.07.2014	21.07.2014	21.07.2014	21.07.2014	21.07.2014	21.07.2014	21.07.2014	21.07.2014	21.07.2014
Coordinates	N45 58.027 E7 55.329	N45 58.026 E7 55.324	N45 58.029 E7 55.339	N45 57.135 E7 54.911	N45 57.126 E7 54.911	N45 57.122 E7 54.907	N45 57.484 E7 54.849	N45 57.475 E7 54.840	N45 57.480 E7 54.842	N45 57.642 E7 55.083	N45 57.649 E7 55.089	N45 57.638 E7 55.079	N45 57.743 E7 55.229	N45 57.743 E7 55.214	N45 57.745 E7 55.218
Landform	Iceless moraine	Iceless moraine	Iceless moraine	Iceless moraine	Iceless moraine	Iceless moraine	Iceless moraine	Iceless moraine	Iceless moraine	Iceless moraine	Iceless moraine	Iceless moraine	Iceless moraine	Iceless moraine	Iceless moraine
Elevation (m a.s.l.)	1895	1895	1895	2125	2125	2125	2055	2065	2060	2005	2005	2005	1955	1960	1960
Aspect (°)	330	325	320	270	260	280	120	45	80	300	305	305	150	150	155
Slope (°)	35	35	30	35	15	15	30	25	25	15	0	0	30	25	35
Arboreous cover (%)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
High-shrubs cover (%)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Low-shrubs cover (%)	15	10	10	0	0	0	0	5	5	15	35	25	10	25	15
Herbaceous cover (%)	55	50	50	20	20	20	20	10	20	10	10	10	15	10	5
Bryophytes and lichens cover (%)	5	10	5	5	5	5	10	5	5	0	0	0	0	0	0
Outcrops cover (%)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Debris cover (%)	25	30	35	75	75	75	70	80	70	75	55	65	75	65	80
Soil cover (%)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Number of species	12	16	16	16	19	22	18	18	19	23	23	28	18	22	20
Diff. stable slope															
Rhododendron ferrugineum	.	+	+	.	.	.	.	.	.	.	.	.	.	.	.
Vaccinium myrtillus	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Dryopteris dilatata	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Astrantio minoris-Laricetum deciduae															
Astrantia minor	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Gentiana purpurea	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Prenanthes purpurea	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Vaccinio myrtilli-Piceetea abietis, *Piceetalia excelsae* and *Piceion excelsae*															
Avenella flexuosa	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Homogyne alpina	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Calamagrostis villosa	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.
Sorbus aucuparia	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Melampyrum sylvaticum	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Pyrola minor	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Mulgedio alpini-Aconitetea variegati and *Adenostyletalia alliariae*															
Veratrum album subsp. lobelianum	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Athyrium distentifolium	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.
Rumex alpestris	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Luzula sieberi	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Peucedanum ostruthium	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.
Achillea macrophylla	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Adenostyles alliariae	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Geranium sylvaticum	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Stellaria nemorum subsp. nemorum	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Cicerbita alpina	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Milium effusum	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Diff. iceless moraine															
Epilobium fleischeri	.	.	.	.	.	.	+	+	+	+	+	+	+	+	+
Poa alpina	.	.	.	+	+	1	.	+	+	+	+	+	.	.	.
Trifolium pratense subsp. nivale	.	+	.	.	.	+	+	.	+	+	+	+	.	.	.
Saxifraga aspera	.	.	.	+	.	.	.	.	.	+	+	+	+	+	+
Agrostio rupestris-Trifolietum pallescentis															
Trifolium pallescens	+	+	+	.	+	+	1	+	1	+	+	+	+	+	+
Achillea erba-rotta subsp. moschata	.	.	+	+	+	+	+	+	+	.	+	+	+	.	.
Festuca halleri	.	.	.	+	+	+	+	+	.	.	.	+	.	+	+
Euphrasia minima	+	+	+	.	.	.	.	.	.	.	.	+	.	+	.
Agrostis rupestris	.	+	+	.	.	.	.	.	.	+	+	.	.	.	.
Diff. supraglacial debris															
Poa laxa	.	.	.	+	+	+	.	.	.	.	.	.	.	.	.
Cerastium pedunculatum	.	.	.	+	.	+	.	.	.	.	.	.	.	.	.
Leucanthemopsis alpina	.	.	.	+	.	.	+	.	.	+	.	.	.	.	.
Luzula alpinopilosa subsp. alpinopilosa	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.
Campanula excisa	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Saxifraga stellaris	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Androsacetalia alpinae and *Androsacion alpinae*															
Silene rupestris	+	+	1	.	+	+	1	+	+	+	+	+	+	+	+
Cardamine resedifolia	.	+	+	+	+	+	+	+	+	+	+	.	.	+	+
Sagina saginoides	.	.	.	+	+	+	.	.	.	+	.	+	.	.	.
Saxifraga bryoides	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.
Oxyria digyna	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Thlaspietea rotundifolii															
Rumex scutatus	+	1	+	+	+	+	+	+	+	+	+	+	1	+	+
Linaria alpina subsp. alpina	.	.	.	+	+	+	+	.	+	.	+	+	.	.	.
Arabis alpina subsp. alpina	.	.	.	.	+	+	.	.	.	.	.	.	.	.	.
Subalpine woody species															
Salix appendiculata	+	+	1	+	+	+	+	+	+	1	+	+	1	1	1
Larix decidua	1	1	1	.	.	.	.	+	+	+	+	+	+	1	.
Salix helvetica	.	.	.	.	.	+	+	+	+	+	.	1	.	+	+
Alnus viridis	1	1	.	.	.	.	.	.	.	1	2	1	+	1	1
Vaccinium gaultherioides	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Juniperus communis subsp. alpina	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Companion species															
Agrostis stolonifera	2	2	2	1	1	1	1	1	1	+	+	1	1	1	1
Festuca gr. varia	1	1	+	.	.	.	+	.	.	+	1	+	+	+	+
Juncus trifidus	.	.	.	+	+	+	+	+	+	+	.	+	+	+	+
Anthoxanthum alpinum	.	.	.	1	1	1	.	+	.	.	+	+	+	.	.
Luzula lutea	.	+	+	+	+	+	+	+	+	+	+	+	.	+	.
Sempervivum montanum subsp. montanum	.	.	.	.	.	.	+	+	+	+	.	+	+	+	+
Silene vulgaris subsp. vulgaris	.	.	.	.	.	.	.	.	.	+	+	+	.	.	+
Silene exscapa	.	.	.	.	+	.	+	+	.	+	.	.	.	+	+
Cerastium arvense subsp. strictum	.	+	.	.	.	+	.	+	+	+	.	+	.	.	.
Lotus alpinus	1	1	1	.	.	.	.	.	.	.	+	.	.	.	.
Phyteuma betonicifolium	.	.	.	.	.	.	.	.	.	.	+	+	.	.	+
Cystopteris fragilis	.	.	+	.	.	.	.	.	.	.	.	.	+	+	.
Leontodon helveticus	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Campanula scheuchzeri	.	.	.	.	.	.	.	.	.	.	.	.	.	+	+
Solidago virgaurea subsp. virgaurea	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+
Campanula barbata	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Ligusticum mutellina	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Phleum alpinum	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Dryopteris filix-mas	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Arnica montana	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Bartsia alpina	.	.	.	.	+	+	.	.	.	.	+	+	.	.	.
Helictotrichon versicolor	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Myosotis alpestris	.	.	.	.	+	+	.	.	.	.	.	.	.	.	+
Nardus stricta	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Soldanella alpina	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Hieracium murorum	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Poa nemoralis	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Alchemilla gr. alpina	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Carex sempervirens	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Festuca arundinacea subsp. arundinacea	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Geum montanum	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Oxalis acetosella	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Phyteuma hemisphaericum	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Primula hirsuta	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Huperzia selago	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Pedicularis tuberosa	.	.	.	.	.	.	.	.	.	.	.	+	+	.	.
Potentilla aurea	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Pseudorchis albida	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Ranunculus gr. montanus	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Sporadic species	1	0	1	0	0	0	0	0	0	0	0	1	2	0	0

Cluster	3. Supraglacial debris														
Code	434B	434A	431A	431C	434C	432A	432B	432C	435B	431B	435A	435C	433B	433A	433C
Date	19.07.2014	19.07.2014	03.07.2014	03.07.2014	19.07.2014	19.07.2014	19.07.2014	19.07.2014	19.07.2014	03.07.2014	19.07.2014	19.07.2014	19.07.2014	19.07.2014	19.07.2014
Coordinates	N45 57.785 E7 55.264	N45 57.789 E7 55.259	N45 57.167 E7 54.694	N45 57.164 E7 54.709	N45 57.779 E7 55.266	N45 57.486 E7 54.708	N45 57.486 E7 54.698	N45 57.487 E7 54.688	N45 58.086 E7 55.269	N45 57.165 E7 54.699	N45 58.080 E7 55.274	N45 58.091 E7 55.264	N45 57.685 E7 54.925	N45 57.693 E7 54.921	N45 57.680 E7 54.924
Landform	Supraglacial debris	Supraglacial debris	Supraglacial debris	Supraglacial debris	Supraglacial debris	Supraglacial debris	Supraglacial debris	Supraglacial debris	Supraglacial debris	Supraglacial debris	Supraglacial debris	Supraglacial debris	Supraglacial debris	Supraglacial debris	Supraglacial debris
Elevation (m a.s.l.)	1920	1920	2115	2120	1915	2055	2055	2055	1890	2120	1890	1890	2015	2015	2010
Aspect (°)	70	55	10	180	80	45	50	45	70	15	60	45	95	30	130
Slope (°)	20	15	10	25	15	5	10	10	10	5	10	10	15	5	10
Arboreous cover (%)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
High-shrubs cover (%)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Low-shrubs cover (%)	0	0	0	0	0	0	0	0	0	0	0	5	5	0	5
Herbaceous cover (%)	5	0	5	5	5	10	5	10	5	5	10	10	10	10	10
Bryophytes and lichens cover (%)	0	0	0	0	0	5	5	5	0	5	0	5	5	5	5
Outcrops cover (%)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Debris cover (%)	95	100	95	95	95	85	90	85	95	90	90	80	80	85	80
Soil cover (%)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Number of species	11	10	7	6	9	8	10	9	10	12	12	16	12	14	17
Diff. stable slope															
Rhododendron ferrugineum	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.
Vaccinium myrtillus	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Dryopteris dilatata	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Astrantio minoris-Laricetum deciduae															
Astrantia minor	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Gentiana purpurea	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Prenanthes purpurea	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Vaccinio myrtilli-Piceetea abietis, *Piceetalia excelsae* and *Piceion excelsae*															
Avenella flexuosa	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Homogyne alpina	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Calamagrostis villosa	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Sorbus aucuparia	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Melampyrum sylvaticum	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Pyrola minor	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Mulgedio alpini-Aconitetea variegati and *Adenostyletalia alliariae*															
Veratrum album subsp. lobelianum	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Athyrium distentifolium	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Rumex alpestris	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Luzula sieberi	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Peucedanum ostruthium	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Achillea macrophylla	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Adenostyles alliariae	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Geranium sylvaticum	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Stellaria nemorum subsp. nemorum	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Cicerbita alpina	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Milium effusum	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Diff. iceless moraine															
Epilobium fleischeri	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Poa alpina	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.
Trifolium pratense subsp. nivale	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Saxifraga aspera	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Agrostio rupestris-Trifolietum pallescentis															
Trifolium pallescens	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Achillea erba-rotta subsp. moschata	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Festuca halleri	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Euphrasia minima	.	+	.	.	.	.	.	.	.	.	.	.	.	+	+
Agrostis rupestris	.	.	+	+	+	+	+	+	.	+	.	+	+	+	+
Diff. supraglacial debris															
Poa laxa	1	+	+	+	+	1	+	1	+	+	+	+	1	1	1
Cerastium pedunculatum	+	+	+	+	+	+	+	+	+	+	+	.	+	+	+
Leucanthemopsis alpina	.	+	.	.	.	.	.	+	+	.	+	+	+	+	+
Luzula alpinopilosa subsp. alpinopilosa	.	.	.	.	.	+	.	+	.	+	+	+	+	+	+
Campanula excisa	.	.	.	.	.	.	.	.	.	+	+	+	+	.	+
Saxifraga stellaris	.	.	.	.	.	.	+	+	+	.	.	+	.	.	+
Androsacetalia alpinae and *Androsacion alpinae*															
Silene rupestris	.	+	.	.	+	.	+	+	+	.	+	+	+	+	+
Cardamine resedifolia	.	.	.	.	.	+	+	+	+	+	+	+	.	.	+
Sagina saginoides	+	.	.	.	+	.	.	.	.	.	+	+	.	.	.
Saxifraga bryoides	.	+	.	.	.	.	+	.	.	.	.	.	.	.	.
Oxyria digyna	.	.	+	.	.	.	.	.	.	+	.	.	.	.	.
Thlaspietea rotundifolii															
Rumex scutatus	.	+	+	.	+	.	.	.	.	.	+	+	.	+	+
Linaria alpina subsp. alpina	+	+	+	+	+	.	.	.	+	+	.	.	.	+	.
Arabis alpina subsp. alpina	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Subalpine woody species															
Salix appendiculata	+	+	.	+	+	+	+	+	+	+	+	1	+	+	+
Larix decidua	+	.	.	.	.	.	.	.	.	.	.	+	+	+	+
Salix helvetica	.	.	.	.	.	.	.	.	.	+	.	.	+	.	+
Alnus viridis	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Vaccinium gaultherioides	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Juniperus communis subsp. alpina	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Companion species															
Agrostis stolonifera	+	+	+	+	+	+	+	.	+	+	1	1	+	1	+
Festuca gr. varia	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Juncus trifidus	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Anthoxanthum alpinum	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Luzula lutea	.	.	.	.	.	+	+	.	.	.	.	.	.	+	+
Sempervivum montanum subsp. montanum	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Silene vulgaris subsp. vulgaris	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Silene exscapa	.	.	.	.	.	.	.	.	.	+	.	+	.	+	.
Cerastium arvense subsp. strictum	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Lotus alpinus	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.
Phyteuma betonicifolium	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Cystopteris fragilis	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Leontodon helveticus	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Campanula scheuchzeri	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Solidago virgaurea subsp. virgaurea	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Campanula barbata	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Ligusticum mutellina	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Phleum alpinum	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Dryopteris filix-mas	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Arnica montana	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Bartsia alpina	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Helictotrichon versicolor	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Myosotis alpestris	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Nardus stricta	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Soldanella alpina	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Hieracium murorum	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Poa nemoralis	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Alchemilla gr. alpina	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Carex sempervirens	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Festuca arundinacea subsp. arundinacea	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Geum montanum	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Oxalis acetosella	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Phyteuma hemisphaericum	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Primula hirsuta	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Huperzia selago	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Pedicularis tuberosa	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Potentilla aurea	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Pseudorchis albida	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Ranunculus gr. montanus	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Sporadic species	1	0	0	0	0	0	0	0	0	0	1	1	0	0	1