Plant diversity along altitudinal gradients in the Southern and Central Alps of South Tyrol and Trentino (Italy)

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Abstract

Plant diversity in the Southern Alps (Dolomites, South Tyrol and Trentino, Italy) and in the Central Alps (Nature Park Texelgruppe, South Tyrol, Italy) was studied along altitudinal gradients using a standardized method according to the GLORIA-Europe project. Four more or less pristine summits were selected in each mountain region from the treeline ecotone to the subnival/nival zone. The main aim was to assess actual diversity on different scales and to establish a net of permanent plots for long term observations in order to control climate-induced risks of diversity changes. Migration tendencies of montane species to higher altitudes should be shown. The following sampling was used: (1) number and cover of species of the summit areas from the highest summit point down to the 10 m contour line; (2) floristic composition and frequency of the species in 1 m² permanent plots in each compass direction at the 5 m contour line; (3) number of species per 1 dm² in the permanent plots.

A higher richness in vascular plant species was found for the summits of the Southern Alps (198 species) compared to those of the Central Alps (137 species). The two mountain regions shared 21 % of the species, the lowest summits showing the highest similarity. Regarding species numbers within the permanent 1 m² plots, no significant differences were found. However, on the smallest scale (1 dm²) species numbers were significantly higher at the alpine and subnival summits of the Central Alps.

A pronounced species turnover was observed from the treeline ecotone to the alpine zone. At the lowest summits, 40 % (Central Alps) and 32 % (Southern Alps) of the species, respectively, had a montane and/or timberline distribution range. At the higher summits only few elements of lower altitudes were recorded. The vegetation of the higher summits of both of areas was regarded to be rather conservative preventing probably invasions of montane/timberline species for longer periods.

Key words: alpine, climate change, endemism, GLORIA, migration, similarity, species richness, treeline ecotone.

1. Introduction

According to the climate change scenarios (i.e. temperature increase of 1.5 to 5.6 K till 2100, IPCC 2001), considerable diversity changes are assumed worldwide (Sala et al. 2000, Bakkenes et al. 2002). Also in Europe vegetation zones are expected to shift (Ozenda & Borel 1995, Körner & Walther 2001). The zones above the treeline are regarded as more sensitive to climate change than lower altitudes (Körner 1992, 1999). And in fact, changes of species richness were already proved by Braun-Blanquet (1957) within the uppermost 30 elevation metres of Piz Linard for the period 1835 to 1947. Meanwhile, migrations of alpine species during the last 50 -100 years were observed on several summits of

the Central Alps (Gottfried et al. 1994, 1999, Grabherr et al. 1994, 2001, Pauli et al. 1996). The knowledge of species diversity along altitudinal gradients becomes highly important for observing the hypothesized widening of species distribution boundaries.
In the Alps, altitudinal transects were described mainly for the Valaisian Alps in Switzerland (Geissler & Velluti 1997, Theurillat & Schlüssel 1997, Theurillat et al. 2003). This paper aims to demonstrate two alpine gradients comparing calcareous and siliceous conditions. In general, numerous anthropo-zoogenic impacts, land use changes, natural disasters, and tourism influence alpine diversity, and these effects cannot easily be separated from climate change impacts. However, even within the over-exploited Alps more or less undisturbed summits can be found where impacts by climate change are hardly masked by land use or tourism effects. Such summits were selected for the GLORIA-Europe project (**Gl**obal **O**bservation **R**esearch **I**nitiative in **A**lpine Environments) in order to compare actual high mountain diversity in Europe and to install a permanent observation network for climate change impacts from the treeline ecotone to the nival zone.

The present paper compares vascular plant diversity of the Southern (carbonate rocks) and the Central Alps (silicate rocks) in South Tyrol and Trentino (Italy)[1] from the treeline ecotone to the nival zone. According to Gigon (1987) the species composition above treeline depends more strictly on the chemism of the substrate than at lower altitudes. Significant differences in species composition between the two mountain regions were therefore assumed for the alpine and nival zones. The treeline areas of both regions were expected to be similar due to a more advanced soil development and a subsequent disconnection between substrate and species occurrence.
The main questions of the study were: (1) What species diversity exists from the treeline ecotone to the alpine-subnival-nival zones of the Central Alps compared to the Southern Alps? (2) Are there similar diversity gradients along the altitudinal gradient in siliceous and calcareous mountains? (3) Are there signs of migrating montane species to the alpine/subnival/nival zones of both mountain regions?

2. Study sites

In 2001 the Southern Alps[1] (Dolomites, South Tyrol and Trentino, Italy) were selected as one of the 18 GLORIA-Europe target regions (http://www.gloria.ac.at). The following summits were selected in the Latemar group (N 46°19’- N 46°23’, E 11°33’ - 11°37’): ‘Grasmugl’ (GRM 2199 m a.s.l.) at the treeline ecotone, i.e. about 100 m above the actual tree line; Do Peniola at the lower alpine zone (PNL 2463 m); ‘Ragnaroek’ at the upper alpine zone (RNK 2757 m) and ‘Monte Schutto’ in the Sella group (N 46°31’, E 11°49’) representing the ecotone between the alpine and the nival zone, i.e. the subnival zone (MTS 2893 m). The summits were selected according to the guidelines of the multi-summit-approach (Pauli et al. 2004), considering a moderate geomorphology (a summit should

[1] in this paper, the terms ‘Southern Alps’ and ‘Central Alps’ are applied according to the common use among East Alpine authors, i.e. designing the respective geological zones within the eastern half of the European Alps.

be cone-shaped and accessible on all directions), avoiding remarkable tourism and grazing impacts. Most summit names were invented. Geologically, the summits consist of calcareous or dolomitic rocks (LEONARDI 1967, BOSELLINI 1998, ERSCHBAMER 2004). Close to the lowest summit (GRM) channels with porphyritic material and tuffs are characteristic (VARDABASSO 1930), thus this summit resembles a contact zone between calcareous and volcanic rocks.

In 2003, a second set of summits was selected in Central Alps (Nature Park Texelgruppe, South Tyrol, Italy, N 46°43' – 46°46', E 10°53' – 11°10'). On this study area crystalline rocks prevail, i.e. the so-called Oetztal-Stubai complex (FRANK et al. 1987, HOINKES & THÖNI 1993) with quartzo-feldspatic rocks and metapelites mixed with orthogneisses and more rarely with amphibolites. The chosen summits are characterized by siliceous bedrocks. They were called 'Faglmugl' (FAG 2180 m a.s.l.) at the treeline ecotone, i.e. about 100 m above the actual tree line; 'Schafberg' at the alpine zone (SBG 2619 m); 'Da Wöllane' at the subnival zone (DWO 3074 m), and Kasererwartl at the nival zone (KAS 3287 m).

3. Methods

The sampling design propagated by the GLORIA-Europe project (PAULI et al. 2004, GLORIA-manual see also http://www.gloria.ac.at) was used in both study sites on each summit. The whole monitoring procedure will be repeated every 5-10 years. 3 m x 3 m square clusters were marked in all four main compass directions at the 5 m contour line below the highest summit point. The four corner plots (1 m x 1 m permanent plots) of each square cluster were sampled using a frequency frame divided into 100 subplots (=16 plots of 1 m² and 1600 subplots of 1 dm² per summit). The presence of species was monitored in each subplot. The vegetation cover and the occurrence of solid rocks, scree and bare ground were recorded in percentage in each 1 m² permanent plot.
In the summit areas (= area from the highest summit point to the 10 m contour line) vascular plant species were recorded using an abundance estimation scale (PAULI et al. 2001). Summits of the same altitudinal zone and all summits of both mountain regions were compared using the similarity index by JACCARD (programme SPSS 11.0). Statistics were performed using the programmes STATISTICA 6.0 (regressions) and SPSS 11.0 (oneway ANOVA for means).
Altitudinal ranges of the species were described according to ADLER et al. (1994). Three ranges were distinguished: alpine (= species restricted to the alpine zone), montane-timberline-alpine (mo-tl-al = species with a very wide altitudinal range), montane-timberline (mo-tl = species concentrated at lower altitudes and/or at the timberline).
Ordinations of the 1 m² plot data were performed with the programme CANOCO 4 for WINDOWS (TERBRAAK & ŠMILAUER 1998).
Nomenclature of taxa follows Flora Europaea (Royal Botanic Garden Edinburgh, http://193.62.154.38/FE/fe.html), nomenclature of syntaxa: GRABHERR & MUCINA (1993).

4. Results

4.1 Diversity of the 10 m summit areas

The overall diversity was higher in the Southern Alps (198 vascular plant species) compared to the Central Alps (137 vascular plant species), resulting in a higher species number at the treeline ecotone and in the alpine zone (Fig. 1, Appendix). In the Southern Alps, the number of species at the summits of the lower and the upper alpine zone was rather similar (PNL 76 vs. RNK 74 species, Fig. 1). In the subnival zone of the Central Alps 41 species were recorded compared to 32 in the Southern Alps. A steep decline in species number was detected from the subnival to nival zone in the Central Alps (Fig. 1).
Only 21 % of the total amount of species occurred in both mountain regions; 51 % were confined to the Southern Alps and 28 % to the Central Alps. In the Southern Alps 7 southern alpine endemic species were found (*Achillea oxyloba, Draba dolomitica, Gentiana terglouensis, Phyteuma sieberi, Saxifraga facchinii, Saxifraga squarrosa, Sesleria sphaerocephala*), 6 on RNK, 5 on PNL, 4 on MTS and 3 on GRM. In the Central Alps only one endemic species (*Primula glutinosa*) was present, at SBG and DWO.

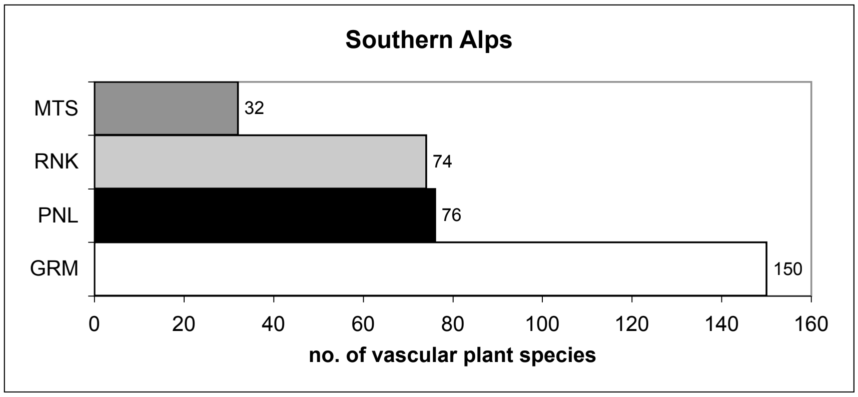
At FAG 40 % of the species were typical for the montane / timberline zone (mo-tl, Fig. 2), among them dwarf shrubs (Ericaceae species) and young individuals of *Larix decidua.* At GRM about 32 % of the species had a montane / timberline distribution range, for instance *Sorbus chamaemespilus, Rosa pendulina, Rubus saxatilis* and young individuals of *Pinus cembra* and *Picea abies*. At PNL only 6 % montane / timberline species were found, at SBG ca. 5 %, at DWO 2.4 %, at RNK 1.4 % (Fig. 2). No lower altitudinal species was recorded at the highest summits of both areas (MTS, KAS).

Similarity of the species pool was generally low between the summits and between the two mountain regions. The highest similarity index was detected between the lower alpine and the higher alpine summit in the Southern Alps (0.490, Table 1) and between the alpine and the subnival summit in the Central Alps (0.411, Table 1). The similarity between the lowest summits of the two regions was 0.230. The similarities between the lowest and the highest summits were rather low. None of the species occurred on each of the 8 summits; three (*Agrostis alpina, Kobresia myosuroides, Poa alpina*) were shared by 6 summits.

Table 1 Similarity index (Jaccard) between the species composition of the summits (bold numbers = high similarities); Central Alps = FAG, SBG, DWO, KAS; Southern Alps = GRM, PNL, RNK, MTS.

	FAG	SBG	DWO	KAS	GRM	PNL	RNK
SBG	**0.294**						
DWO	0.101	**0.411**					
KAS	0.009	0.109	0.190				
GRM	**0.230**	0.146	0.061	0.006			
PNL	0.060	0.070	0.064	0.024	**0.314**		
RNK	0.048	0.063	0.075	0.038	**0.232**	**0.490**	
MTS	0.015	0.068	0.058	0.051	0.052	0.161	**0.280**

Fig. 1
Number of vascular plant species per summit, from the highest summit point to the 10 m contour line, in the Southern Alps (Dolomites) and in the Central Alps (Nature Park Texelgruppe), Italy.



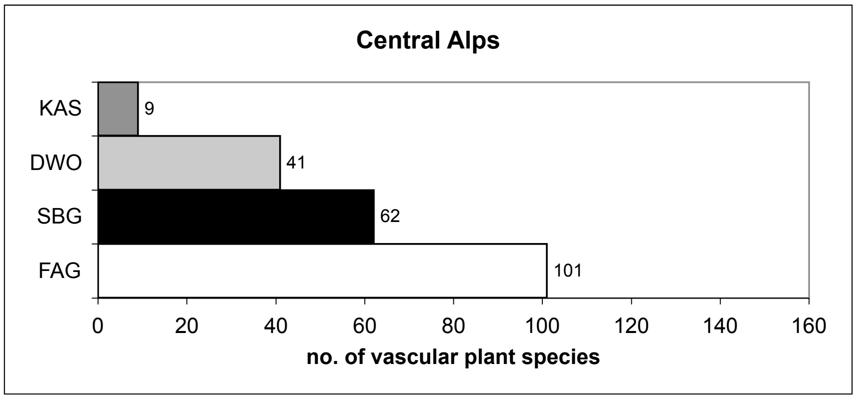
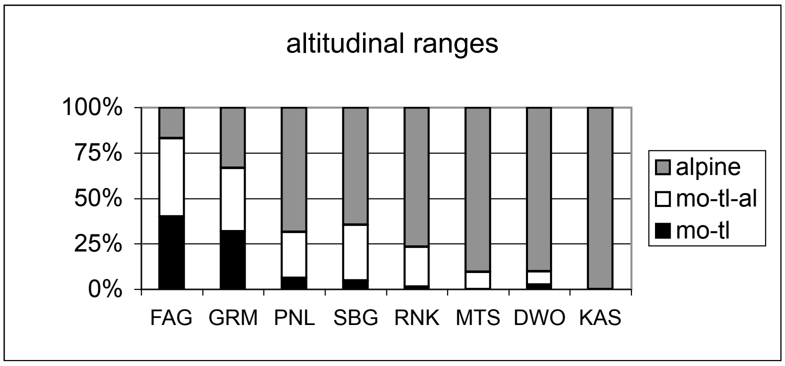


Fig. 2
Altitudinal ranges of the vascular plant species per summit in the Southern Alps (Dolomites: GRM, PNL, RNK, MTS) and in the Central Alps (Nature Park Texelgruppe: FAG, SBG, DWO, KAS); mo = montane, tl = timberline, al = alpine.



4.2 Diversity in the permanent plots

The ordination of the 1 m² permanent plots exhibits a clear separation of the two mountain systems by the substrate along the second DCA-axis (4.422 SD, Eigenvalue 0.646), however, the two lowest summits resulted to be more similar than each of it compared to the respective alpine summit. The first DCA-axis shows distinct altitudinal gradients (6.611 SD, Eigenvalue 0.719, Fig. 3).

At GRM four communities were distinguished depending on the exposition (Erschbamer et al. 2003): a Gentianello-Festucetum variae on the south-facing slope, a Seslerio-Caricetum sempervirentis on the west-facing slope, a Caricetum firmae on the north - and a dwarf shrub with *Juniperus communis* ssp. *alpina* on the east-facing slope. At PNL an initial grassland (Caricetum firmae with *Potentilla nitida*) was found. RNK was determined by scree and rock crevices vegetation patches dominated by *Sesleria sphaerocephala* and *Poa alpina.* Also at MTS species of scree and rock crevices predominated (*Cerastium uniflorum*, *Pritzelago alpina*, *Saxifraga sedoides* ssp. *sedoides*).

At FAG a Sieversio-Nardetum strictae with dwarf shrub patches (*Rhododendron ferrugineum*, *Vaccinium* spec.) was detected (Mallaun & Unterluggauer, unpubl.). At SBG a typical grassland of siliceous bedrocks (Caricetum curvulae) was found. At DWO a scree vegetation (Androsacetum alpinae) prevailed on each exposition. In the nival zone (KAS) highly scattered patches of scree species were present, belonging to the same community as in the subnival zone (Mallaun & Unterluggauer, unpubl.).

Comparing the means of species numbers in the 1 m² permanent plots, higher values result for the Southern Alps at the lowest summit (Table 2), though not significantly different from that of the Central Alps (Table 3). The alpine and the subnival summits of the two mountain regions showed neither significant differences (Table 3). However, species numbers per 1 dm² were significantly higher at the alpine and subnival summits of the Central Alps (Table 2, $p < 0.0001$).

In both mountain regions a positive linear relationship was found between species numbers in the 1 m² permanent plots and cover: the higher the cover of vascular plants, the higher the species number. In the Southern Alps the relationship was highly significant (Fig. 4, $R^2 = 0.707$, adjusted $R^2 = 0.702$), in the Central Alps only a weak correlation was found ($R^2 = 0.489$, adjusted $R^2 = 0.477$). Regarding the presence of scree material and bare ground significantly higher values were found in the plots of the Southern Alps ($p = 0.005$ and $p = 0.002$, respectively).

Table 2
Mean species numbers per 1 m² and per 1 dm², respectively, and standard deviations (st. dev.). Southern Alps: GRM, PNL, RNK, MTS. Central Alps: FAG, SBG, DWO, KAS.

		GRM	PNL	RNK	MTS	FAG	SBG	DWO	KAS
1m²	**means**	28.75	16.2	13.3	7.2	20.9	13.1	14.5	1.9
	st.dev.	6.3	2.3	5.0	2.6	4.5	2.9	3.1	1.6
1dm²	**means**	6.78	2.54	1.73	1.50	6.41	4.86	3.01	0.27
	st.dev.	3.0	1.7	1.7	1.6	2.8	2.2	1.9	0.6

Table 3
P-values of the comparisons of species numbers in the 1 m² plots. Central Alps = FAG, SBG, DWO, KAS; Southern Alps = GRM, PNL, RNK, MTS. Significant differences: < 0.05 (bold numbers).

	GRM	PNL	RNK	MTS	FAG	SBG	DWO
GRM							
PNL	**0.008**						
RNK	**0.000**	0.386					
MTS	**0.000**	0.072	0.978				
FAG	0.462	0.487	**0.006**	**0.001**			
SBG	**0.001**	0.993	0.833	0.297	0.144		
DWO	**0.001**	0.976	0.911	0.395	0.099	1.000	
KAS	**0.000**	**0.001**	0.137	0.579	**0.000**	**0.006**	**0.009**

Fig. 3
DCA of the relevées (axis 1 and 2) of the 1 m² permanent plots at the summits in the Southern Alps (Dolomites: GRM, PNL, RNK, MTS) and in the Central Alps (Nature Park Texelgruppe: FAG, SBG, DWO, KAS).

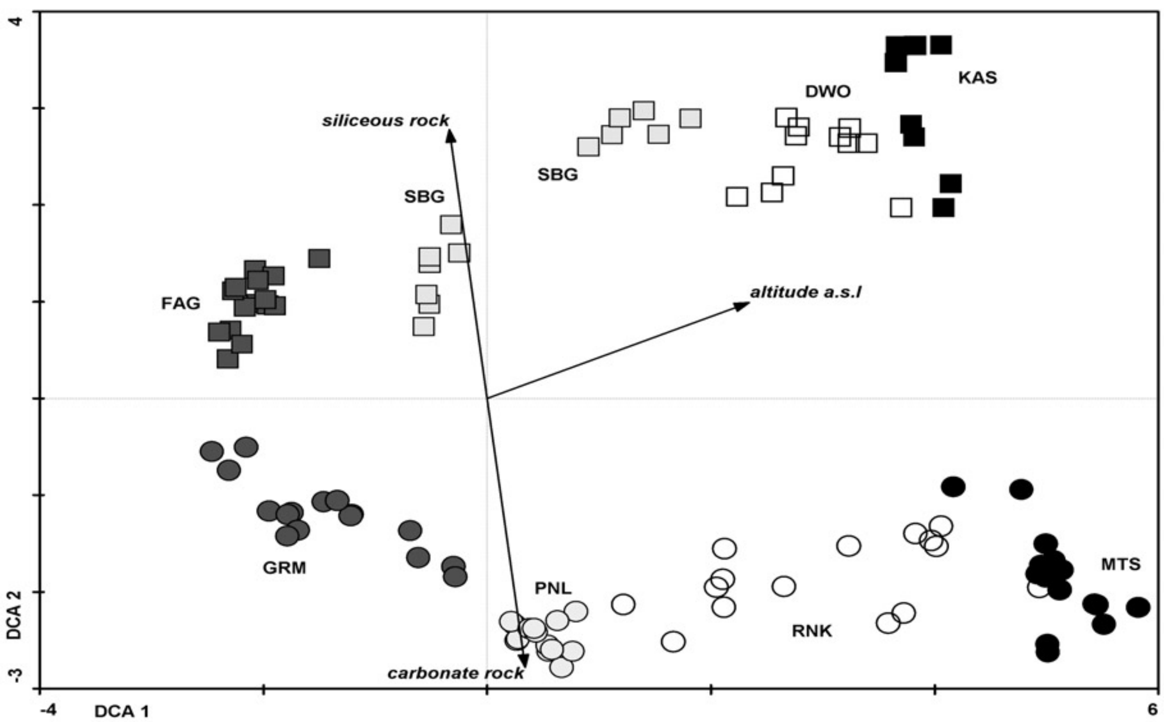
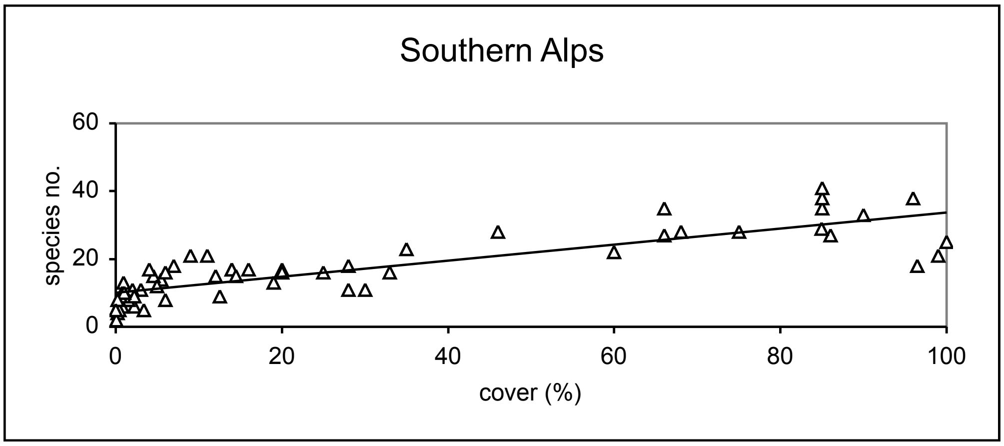


Fig. 4
Relationship between species number and cover (%) of the 1 m² permanent plots in the Southern Alps (Dolomites).



5. Discussion

Area, isolation and habitat heterogeneity are often regarded as essential factors of species richness (review in Bruun 2000). It is generally known that larger regions have more species than smaller ones (Rosenzweig 1995). However, for European mountains Virtanen et al. (2002, 2003) found that "there was a poor fit between species richness and the size of a mountain area". In this study the area of the summits was not measured, therefore it is not possible to contribute to this hypothesis.

Isolation and habitat heterogeneity may be important determinants for the higher overall species diversity of the Southern Alps. The steep and rough summits of the Dolomites offer an array of microhabitats for grassland mosaics on the warmest slopes and abundant rock and scree habitats for endemic species. Several authors pointed out that calcareous substrates are species richer than siliceous areas (review in Virtanen et al. 2003), and also recent studies supported this finding (Wohlgemuth 1998, Virtanen et al. 2003). The explanations reach from the higher species pool hypothesis on calcareous substrate (Zobel 1997) to the evolutionary hypothesis of an older origin of calcareous species (Conti et al. 1999) to the competitive exclusion hypothesis on silicate (Gigon 1987). During the GLORIA-Europe project (see folder: www.gloria.ac.at) the highest species numbers were recorded in the Southern Alps (198 vascular plant species, see present paper), followed by the North-Eastern Calcareous Alps (174) and the North Apennines (169, Pauli et al. unpubl.). In contrast, siliceous mountains showed a lower diversity (Texelgruppe-Central Alps 137 species – see present paper; Entremont-W Alps 137; Mercantour-South-Western Alps 79; Pauli et al. unpubl.).

The differences in total species numbers between Southern and Central Alps may have historical causes. More calcareous species may have survived at the margins of the Southern Alps than did species of siliceous substrate in the Central Alps (Wohlgemuth 2002). This hypothesis will be supported by the number of endemic species: only one was found in the Central Alps compared to the 7 southern alpine endemics in the Dolomites. Although the Dolomites were glaciated, glacial refugia were present close to the investigated area (Merxmüller 1952, 1953, 1954, Schönswetter et al. 2002, Tribsch et al. 2002). The high plant diversity of the Dolomites fits to the theory of diversity hot spots in nunatak areas of the Alps (Stehlik 2000).

Significant differences were found regarding small scale diversity (1 dm²), the species number being higher on the siliceous substrate of the Central Alps compared to the calcareous Southern Alps. This was rather surprising because the clonal growth form of the dominant species, *Carex curvula*, was generally thought to suppress diversity. It was regarded as space-filling dominant (Grabherr 1987) and competitive stress tolerant species (Mair 1986). Tilman (1982) suggested that species coexistence should be enhanced by soil heterogeneity and this effect should be generally stronger in nutrient-poor habitats. The alpine summits in the Dolomites exhibit a significantly higher occurrence of rock/scree material in the 1 m² plots. At the smallest scale (1 dm²) niches were obviously more restricted compared to the summits of the siliceous Alps where vegetation cover was significantly higher. The study confirms the importance of scale when studying species diversity (Whittaker 1972).

A matter of scale may be also the relationship of species richness and cover (Pastor et al. 1996, Weiher 1999, Grytnes & Birks 2003). In the present study, a positive linear relationship was shown. In contrast, Grytnes & Birks (2003) found a unimodal or humped-back relationship at small sampling sizes and a monotonic positive relationship at larger sampling sizes. It seems that the pattern of relationship depends on the vegetation type (Grytnes 2000).

The number of species decreases stepwise with increasing altitude (Ozenda 1988, Grabherr et al. 1995, 2000, Odland & Birks 1999, Holten 2003, Theurillat et al. 2003, Stanisci et al. 2005) exhibiting 'true floristic discontinuities' (Grabherr et al. 1995) and reflecting the zonation of the alpine belt (Körner 1999). This was shown also by the present study. Decreasing temperatures from the lowest to the highest summit (Erschbamer et al. 2003) are in line with decreasing species richness along altitudinal gradients (Rahbek 1995, Theurillat et al. 2003). A striking change of species composition was observable in both regions from the treeline ecotone to the alpine zone. This discontinuity could (1) be due to a high degree of habitat heterogeneity on the lowest summits or (2) reflect a strong influence from the montane-timberline species pool. Both explanations are correct for the investigated mountain regions. At the lowest summits a relatively high percentage of montane-timberline species was recorded. At GRM the main compass directions showed also different communities. Single young trees and shrubs were already present at the lowest summits suggesting upwards migration tendencies of the treeline. The species rich grassland patches observed by this first monitoring could be replaced by dwarf shrubs and young trees in both mountain regions in the near future. The north-exposed site on GRM with the calcareous pioneer grassland seems to be more resistant against invaders of lower altitudes probably due to a weak soil development and colder temperatures (see results of temperature measurements in Erschbamer et al. 2003). The same conclusion was pointed out by Stanisci et al. (2005) for the northern slopes of three summits in the central Apennines.

Considering migration scenarios for the alpine/nival zones, different hypotheses may be put forward: (1) diversity increases may be expected in the alpine zone for the near future due to the invasion by species of lower altitudes. Alpine species may be outcompeted by species of lower altitudes and a subsequent diversity loss will take place; (2) diversity may remain more or less stable in the alpine zone because climax grasslands, scree and rock vegetation patches of this altitude are "conservative" and they do not allow invasions. It was hypothesized that high degrees of instability and erosion will interrupt the upwards movement of species (Pauli et al. 1996). This may be the case on the steep north- and west-exposed alpine/subnival summit sides of the Southern Alps where mobile scree or solid rocks prevail.
Increased species richness and migration was already shown by Grabherr et al. (1994) at siliceous and calcareous mountain peaks of the Central Alps, moving rates being between zero and four metres per decade for common alpine species. Theurillat & Guisan (2001) assumed severe changes of the alpine vegetation if temperature increases amount to 3 K whereas lower increases should be tolerated. Endemic species on the low mountains of the Eastern Alps were assumed to be highly threatened as they are not able to adjust their geographic distribution (Grabherr et al. 1994, 1995, Gottfried et al. 1994, Grabherr et al. 2000, Dirnböck et al. 2003). Endemics with wide distribution ranges were expected to be less endangered compared to those with a disjunct distribution pattern (Theurillat 1995). Most southern alpine endemics found in this study have a relatively wide distribution and they are specialized to extreme habitats (scree, rock crevices) where montane invaders may have severe problems. The highest risk may be hypothesized for the lowest summits where alpine grasslands are likely to be invaded by montane/timberline species within the next decades. A similar scenario was drawn for the North-Eastern Alps by Dirnböck et al. (2003).
The species of lower altitudes have generally higher edaphic demands than those of the alpine environments. It takes time for alpine soils to develop before invaders are able to establish, and thus a considerable time-lag of the invasion processes was suggested (Holten & Carey 1992 in Sætersdal et al. 1998).
In the Central Alps one timberline species (*Rhododendron ferrugineum*) has already reached the subnival zone (3074 m a.s.l.). The microrelief and the microclimate enable species of lower altitudes to occupy niches far beyond their normal ranges. However, such outposts were rather rare at the investigated summits. Population studies of the competitive ability of the high altitude species in contrast to the lower altitudinal invaders should be carried out in order to evaluate the potential risks.

Zusammenfassung

Im Rahmen des GLORIA-Europe-Projektes (www.gloria.ac.at) wurden in den Südalpen (Dolomiten, Südtirol-Trentino, Italien) und in den Zentralalpen (Naturpark Texelgruppe, Südtirol, Italien) Dauerflächen eingerichtet, um die Folgen einer Klimaänderung über längere Zeiträume hinweg zu beobachten. Zunächst sollte eine aktuelle Übersicht über die Artenvielfalt der beiden Hochgebirgsregionen gewonnen werden und ein etwaiges Höherwandern der montanen Arten aufgespürt werden. In den beiden Gebirgsregionen wurden jeweils vier mehr oder weniger unberührte Gipfel vom Waldgrenzökoton bis hinauf zur subnivalen/nivalen Stufe ausgewählt. Die Untersuchungen umfassten die Artenvielfalt in unterschiedlichen Flächengrößen: 1.) die Anzahl und Deckung der Arten im gesamten oberen Gipfelbereich, d.h. vom höchsten Punkt bis 10 Höhenmeter unterhalb jeden Gipfels, 2.) die floristische Zusammensetzung und Frequenz der Arten in 1 m² großen Dauerflächen in allen vier Himmelsrichtungen 5 Höhenmeter unterhalb jeden Gipfels, 3.) die Anzahl der Arten pro 1 dm² in diesen Dauerflächen.
In den Dolomiten wurde eine höhere Vielfalt an Gefäßpflanzen vorgefunden (198 Arten) im Vergleich zu den Zentralalpen (137 Arten). 21 % der Arten kommen in beiden Gebirgsregionen gemeinsam vor. Die niedrigsten Gipfel wiesen dabei die höchste Ähnlichkeit auf. Betrachtet man die Artenanzahl in den 1 m² Dauerflächen, so konnten keine signifikanten Unterschiede zwischen den beiden Untersuchungsgebieten festgestellt werden. Signifikant höhere Artenzahlen ergaben sich jedoch für die 1 dm² Flächen der alpinen und subnivalen Gipfel in den Zentralalpen.
Interessante Ergebnisse zeitigte die Auswertung der Verbreitungsmuster der Arten. Auf den niedrigsten Gipfeln wiesen 40 % (Zentralalpen) bzw. 32 % (Dolomiten) einen montanen bzw. subalpinen Verbreitungsschwerpunkt auf. Auf den höheren Gipfeln konnten nur sehr wenige Elemente dieser Höhenstufen beobachtet werden. Dies erlaubt die Schlussfolgerung, dass die Flora der höheren Gipfel vermutlich über lange Zeiträume hinweg sehr stabil verbleibt und ein Höherwandern von montanen/subalpinen Arten nur vereinzelt und sehr zögerlich voranschreitet.

Riassunto

La diversità in specie vegetali è stata analizzata nelle Alpi del Sud e nelle Alpi Centrali usando il metodo standardizzato del progetto GLORIA-Europe. Quattro cime più o meno senza influsso antropogenico sono state scelte in ognuna delle regioni considerate seguendo un gradiente altitudinale che parte dal limite degli alberi fino alla zona subnivale/nivale. Gli scopi principali del progetto sono stati i seguenti: studiare la diversità attuale, installare aree permanenti per monitorare gli effetti dei cambiamenti climatici per lungo tempo, osservare l'eventuale migrazione di specie lungo il gradiente altitudinale, valutare il rischio di perdita in diversità floristica. Il progetto si è concentrato su tre tipi di monitoraggio: 1) il numero e la copertura delle specie dalla cima più elevata fino a 10 altimetri al di sotto lungo i punti cardinali, 2) la composizione floristica e la frequenza delle specie per m² nelle aree permanenti a 5 metri sotto la sommità di ogni cima, 3) il numero di specie per dm² in ogni area permanente.
Nelle Alpi del Sud la diversità floristica rilevata è stata molto più alta (198 specie) confrontata con quella delle Alpi Centrali (137 specie). Le due regioni hanno in comune solo il 21 % delle specie, le cime a quote più basse hanno mostrato una somiglianza in specie maggiore rispetto a quelle a quote più elevate. Se si considera il numero di specie nelle aree permanenti la differenza non è significativa. Nonostante, su scala minore (1 dm²), la diversità in numero di specie è risultata significativamente più alta sulle cime della zona alpina e subnivale delle Alpi Centrali.

Un considerevole cambiamento in specie si è notato tra le cime a quote minori (sopra il limite degli alberi) e quelle della zona alpina; sulle prime il 40% (Alpi Centrali) e il 32% (Alpi del Sud) delle specie sono risultate tipiche della zona montana o del confine degli alberi, sulle seconde pocchissime specie di bassa quota sono state rilevate. La vegetazione delle cime più elevate puó essere considerata stabile e questo potrebbe impedire l'invasione di specie di basse quote per lungo tempo.

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Appendix
Occurrence of the species at the four summits from the highest summit point to the 10 m contour line in the Southern Alps and in the Central Alps. Species abundance estimation scale: d = dominant, c = common, s = scattered, r = rare, r! = very rare; l = locally (Pauli et al. 2001).

GLORIA regions	Southern Alps				Central Alps			
	Dolomites				Texelgruppe			
Summits	**MTS**	**RNK**	**PNL**	**GRM**	**FAG**	**SBG**	**DWO**	**KAS**
m above sea level	2893	2757	2436	2199	2180	2619	3074	3278
Saxifraga facchinii	s, lc	.	.	.	.	.	.	.
Draba dolomitica	r,ls	r	.	.	.	.	.	.
Draba cf. *hoppeana*	r,lc	.	.	.	.	.	.	.
Saxifraga androsacea	s, lc	.	.	.	.	.	.	.
Arabis caerulea	ls	.	.	.	.	.	.	.
Sesleria ovata	r	.	.	.	.	.	.	.
Salix cf. *alpina*	r	.	.	.	.	.	.	.
Valeriana elongata	r!	.	.	.	.	.	.	.
Saxifraga sedoides subsp. *sedoides*	c	s	.	.	.	.	.	.
Draba tomentosa	s, lc	s	.	.	.	.	.	.
Carex parviflora	ls	r	.	.	.	.	.	.
Thlaspi rotundifolium subsp. rotundifolium	r, lc	r, ls	.	.	.	.	.	.
Papaver alpinum subsp. *rhaeticum*	r, lc	r, ls	.	.	.	.	.	.
Taraxacum apenninum agg.	r	r, lc	.	r	.	.	.	.
Artemisia genipi	.	c	.	.	.	.	.	.
Sagina saginoides subsp. *saginoides*	.	lc	.	.	.	.	.	.
Saxifraga exarata subsp. *moschata*	.	ls	.	.	.	.	.	.
Ligusticum mutellinoides	.	r, lc	.	.	.	.	.	.
Veronica fruticans	.	r, ls	.	.	r	.	.	.
Carex curvula subsp. *rosae*	.	ls	.	.	.	.	.	.
Geum reptans	.	r, ls	.	.	.	.	.	.
Arabis alpina subsp. *alpina*	.	r, ls	.	.	.	.	.	.
Gentianella tenella	.	r, ls	.	.	.	.	.	.
Acinos alpinus subsp. *alpinus*	.	r	.	.	.	.	.	.
Carex ornithopoda subsp. *ornithopodioides*	.	r	.	.	.	.	.	.
Festuca alpina	.	s	s, lc	.	.	.	.	.
Achillea oxyloba subsp. *oxyloba*	.	r	r, ls	.	.	.	.	.
Sedum atratum	.	r	r, ls	.	.	.	.	.
Achillea clavennae	.	.	s, lc	.	.	.	.	.
Campanula cochlearifolia	.	.	lc	.	.	.	.	.
Androsace helvetica	.	.	s	.	.	.	.	.
Pedicularis rosea subsp. *rosea*	.	.	s	.	.	.	.	.
Ranunculus seguieri subsp. *seguieri*	.	.	ls	.	.	.	.	.
Poa cenisia subsp. *cenisia*	.	.	ls	.	.	.	.	.
Paederota bonarota	.	.	ls	.	.	.	.	.
Athamanta cretensis	.	.	r, ls	.	.	.	.	.

GLORIA regions	Southern Alps				Central Alps			
	Dolomites				Texelgruppe			
Summits	**MTS**	**RNK**	**PNL**	**GRM**	**FAG**	**SBG**	**DWO**	**KAS**
m above sea level	2893	2757	2436	2199	2180	2619	3074	3278
Oxytropis campestris subsp. *campestris*	.	.	r!	.	.	.	.	.
Pritzelago alpina	c	c	r	.	.	.	.	.
Saxifraga oppositifolia subsp. *oppositifolia*	c	s, lc	r, ls	.	.	.	.	ls
Minuartia verna subsp. *verna*	c	r, ls	s., lc	.	.	.	.	.
Minuartia cherlerioides subsp. *cherlerioides*	lc	s	s	.	.	.	.	.
Potentilla nitida	r!	r, ls	s, lc	.	.	.	.	.
Gentiana terglouensis subsp. *terglouensis*	ls	s	s	.	.	.	.	.
Festuca intercedens	r!	s, lc	ls	.	.	.	.	.
Veronica aphylla	.	r, lc	r, ls	.	.	.	.	.
Arabis pumila	r	s	s	r	.	.	.	.
Salix retusa	r	s, lc	r	r	.	.	.	.
Galium anisophyllon	.	lc	lc	c	.	.	.	.
Sesleria albicans	.	r, lc	r, lc	c	.	.	.	.
Potentilla crantzii	.	r, lc	r	c	.	.	.	.
Dryas octopetala	.	r!	s, lc	c, ld	.	.	.	.
Salix serpillifolia	.	s, lc	.	s, lc	.	.	.	.
Pedicularis verticillata	.	lc	r	c	.	.	.	.
Anthyllis vulneraria subsp. *alpestris*	.	r	s, lc	s, lc	.	.	.	.
Helianthemum oelandicum subsp. *alpestre*	.	lc	c	s, lc	.	.	.	.
Phyteuma sieberi	.	s, lc	c	s, lc	.	.	.	.
Festuca quadriflora	.	s, lc	c	c	.	.	.	.
Ranunculus montanus	.	r	r, lc	c	.	.	.	.
Bartsia alpina	.	r	r, lc	c	.	.	.	.
Carex capillaris	.	r	.	lc	.	.	.	.
Oxytropis jacquinii	.	r, ls	s, lc	s, lc	.	.	.	.
Crepis jacquinii subsp. *kerneri*	.	r	s, lc	lc	.	.	.	.
Arenaria ciliata subsp. *ciliata*	.	s, lc	c	r, ls	.	.	.	.
Saxifraga caesia	.	ls	c	s, lc	.	.	.	.
Saxifraga squarrosa	.	r, ls	c	r!	.	.	.	.
Gentiana verna subsp. *verna*	.	ls	r, ls	s, lc	.	.	.	.
Euphrasia salisburgensis	.	r, lc	s	ls	.	.	.	.
Botrychium lunaria	.	r, ls	r	s, lc	.	.	.	.
Salix cf. *hastata*	.	r!	r!	s, lc	.	.	.	.
Saxifraga paniculata	.	r	r, ls	r, ls	.	.	.	.
Linaria alpina	.	ls	.	r	.	.	ls	.
Carduus defloratus	.	r	.	r, ls	.	.	.	.
Carex firma	.	.	c	r, ls	.	.	.	.
Carex mucronata	.	.	r, ls	r	.	.	.	.
Carex ornithopoda subsp. *ornithopoda*	.	.	ls	c	.	.	.	.
Hedysarum hedysaroides	.	.	s, lc	c	.	.	.	.
Aster alpinus	.	.	r	lc	.	.	.	.
Biscutella laevigata subsp. *laevigata*	.	.	r	s, lc	.	.	.	.

GLORIA regions	Southern Alps				Central Alps			
	Dolomites				Texelgruppe			
Summits	**MTS**	**RNK**	**PNL**	**GRM**	**FAG**	**SBG**	**DWO**	**KAS**
m above sea level	2893	2757	2436	2199	2180	2619	3074	3278
Leontopodium alpinum subsp. *alpinum*	.	.	r, ls	r, ls	.	.	.	.
Anemone baldensis	.	.	r	s, lc	.	.	.	.
Saxifraga aizoides	.	.	r, ls	r, ls	.	.	.	.
Gypsophila repens	.	.	r	r, ls	.	.	.	.
Astragalus australis	.	.	r	r	.	.	.	.
Aster bellidiastrum	.	.	r	r	.	.	.	.
Gymnadenia conopsea	.	.	r	r	.	.	.	.
Hieracium pilosum	.	.	r!	s, lc	.	.	.	.
Festuca norica	.	.	.	c	.	.	.	.
Helianthemum nummularium subsp. *grandiflorum*	.	.	.	c	.	.	.	.
Trollius europaeus	.	.	.	lc	.	.	.	.
Knautia longifolia	.	.	.	lc	.	.	.	.
Hippocrepis comosa	.	.	.	lc	.	.	.	.
Cotoneaster integerrimus	.	.	.	lc	.	.	.	.
Arctostaphylos alpinus	.	.	.	lc	.	.	.	.
Polygonatum verticillatum	.	.	.	lc	.	.	.	.
Calamagrostis varia	.	.	.	s, lc	.	.	.	.
Salix reticulata	.	.	.	s, lc	.	.	.	.
Daphne striata	.	.	.	s, lc	.	.	.	.
Erica herbacea	.	.	.	s, lc	.	.	.	.
Luzula lutea	.	.	.	s, lc	.	.	.	.
Polygala chamaebuxus	.	.	.	s, lc	.	.	.	.
Soldanella alpina	.	.	.	s, lc	.	.	.	.
Scabiosa lucida	.	.	.	s, lc	.	.	.	.
Rhododendron x *intermedium*	.	.	.	s, lc	.	.	.	.
Rubus saxatilis	.	.	.	s, lc	.	.	.	.
Senecio abrotanifolius subsp. *abrotanifolius*	.	.	.	s, lc	.	.	.	.
Festuca varia	.	.	.	s, lc	.	.	.	.
Polygala alpestris	.	.	.	s, lc	.	.	.	.
Carlina acaulis	.	.	.	s, lc	.	.	.	.
Chamorchis alpina	.	.	.	s, lc	.	.	.	.
Valeriana tripteris	.	.	.	s, lc	.	.	.	.
Valeriana saxatilis subsp. *saxatilis*	.	.	.	s, lc	.	.	.	.
Pinguicula alpina	.	.	.	s, lc	.	.	.	.
Nigritella nigra subsp. *nigra*	.	.	.	s	.	.	.	.
Clematis alpina subsp. *alpina*	.	.	.	r, lc	.	.	.	.
Carex montana subsp. *montana*	.	.	.	r, lc	.	.	.	.
Arctostaphylos uva-ursi	.	.	.	r, lc	.	.	.	.
Centaurea triumfetti	.	.	.	r, lc	.	.	.	.
Pulmonaria angustifolia	.	.	.	ls	.	.	.	.
Carex atrata subsp. *atrata*	.	.	.	ls	.	.	.	.
Potentilla grandiflora	.	.	.	ls	.	.	.	.

GLORIA regions	Southern Alps				Central Alps			
	Dolomites				Texelgruppe			
Summits	**MTS**	**RNK**	**PNL**	**GRM**	**FAG**	**SBG**	**DWO**	**KAS**
m above sea level	2893	2757	2436	2199	2180	2619	3074	3278
Valeriana montana	.	.	.	ls	.	.	.	.
Rhamnus pumilus	.	.	.	ls	.	.	.	.
Luzula sylvatica	.	.	.	ls	.	.	.	.
Parnassia palustris	.	.	.	r, ls	.	.	.	.
Carex ericetorum	.	.	.	r, ls	.	.	.	.
Scorzonera aristata	.	.	.	r, ls	.	.	.	.
Lilium martagon	.	.	.	r, ls	.	.	.	.
Trifolium pratense subsp. *nivale*	.	.	.	r, ls	.	.	.	.
Picea abies subsp. *abies*	.	.	.	r	.	.	.	.
Dianthus superbus	.	.	.	r	.	.	.	.
Alchemilla vulgaris agg.	.	.	.	r	.	.	.	.
Juncus trifidus subsp. *monanthos*	.	.	.	r	.	.	.	.
Hieracium lactucella	.	.	.	r	.	.	.	.
Pinus cembra	.	.	.	r	.	.	.	.
Veratrum album	.	.	.	r	.	.	.	.
Sorbus chamaemespilus	.	.	.	r	.	.	.	.
Poa minor	.	.	.	r	.	.	.	.
Cystopteris fragilis	.	.	.	r!	.	.	.	.
Aconitum lycoctonum subsp. *neapolitanum*	.	.	.	r!	.	.	.	.
Carex rupestris	s, lc	s, lc	c	lc	.	.	.	.
Silene acaulis subsp. *acaulis*	s, lc	s, lc	c	lc	.	.	.	.
Sesleria sphaerocephala	r, ls	c	c	s, lc	.	.	.	.
Nardus stricta	.	.	.	.	c, ld	.	.	.
Festuca nigrescens subsp. *nigrescens*	.	.	.	.	s, ld	.	.	.
Phleum alpinum subsp. *rhaeticum*	.	.	.	.	lc	.	.	.
Calamagrostis villosa	.	.	.	.	lc	.	.	.
Trifolium alpinum	.	.	.	.	s, lc	.	.	.
Potentilla erecta	.	.	.	.	s, lc	.	.	.
Luzula multiflora	.	.	.	.	s, lc	.	.	.
Rhinanthus aristatus	.	.	.	.	s, lc	.	.	.
Sempervivum montanum	.	.	.	.	s, lc	.	.	.
Silene rupestris	.	.	.	.	s, lc	.	.	.
Empetrum nigrum subsp. *hermaphroditum*	.	.	.	.	s	.	.	.
Dryopteris dilatata	.	.	.	.	s	.	.	.
Euphrasia rostkoviana	.	.	.	.	s	.	.	.
Ajuga pyramidalis	.	.	.	.	ls	.	.	.
Laserpitium halleri subsp. *halleri*	.	.	.	.	ls	.	.	.
Hieracium glaciale	.	.	.	.	ls	.	.	.
Antennaria dioica	.	.	.	.	ls	.	.	.
Achillea millefolium	.	.	.	.	ls	.	.	.
Agrostis capillaris	.	.	.	.	ls	.	.	.
Molinia caerulea subsp. *caerulea*	.	.	.	.	ls	.	.	.

GLORIA regions	Southern Alps				Central Alps			
	Dolomites				Texelgruppe			
Summits	**MTS**	**RNK**	**PNL**	**GRM**	**FAG**	**SBG**	**DWO**	**KAS**
m above sea level	2893	2757	2436	2199	2180	2619	3074	3278
Diphasiastrum alpinum	.	.	.	.	ls	.	.	.
Urtica dioica	.	.	.	.	ls	.	.	.
Gymnocarpium sp.	.	.	.	.	r, ls	.	.	.
Cirsium spinosissimum subsp. *spinosissimum*	.	.	.	.	r, ls	.	.	.
Phegopteris connectilis	.	.	.	.	r, lc	.	.	.
Veronica chamaedrys subsp. *chamaedrys*	.	.	.	.	r, ls	.	.	.
Calluna vulgaris	.	.	.	.	r, ls	.	.	.
Veronica officinalis	.	.	.	.	r, lc	.	.	.
Lycopodium clavatum	.	.	.	.	r, ls	.	.	.
Pinguicula vulgaris	.	.	.	.	r	.	.	.
Phyteuma betonicifolium	.	.	.	.	r	.	.	.
Hieracium intybaceum	.	.	.	.	r	.	.	.
Alchemilla alpina	.	.	.	.	r	.	.	.
Bellardiochloa violacea	.	.	.	.	r	.	.	.
Cryptogramma crispa	.	.	.	.	r	.	.	.
Hieracium pilosella	.	.	.	.	r!	.	.	.
Gentiana punctata	.	.	.	.	r!	.	.	.
Saxifraga aspera	.	.	.	.	r!	.	.	.
Larix decidua	.	.	.	.	r!	.	.	.
Soldanella pusilla	.	.	.	.	c	lc	.	.
Agrostis agrostiflora	.	.	.	.	lc	lc	.	.
Ligusticum mutellina	.	.	.	.	s, lc	lc	.	.
Deschampsia cespitosa subsp. *cespitosa*	.	.	.	.	s, lc	s, lc	.	.
Luzula alpinopilosa	.	.	.	.	s, lc	s, lc	.	.
Veronica bellidioides subsp. *bellidioides*	.	.	.	.	r, ls	lc	.	.
Hieracium alpinum	.	.	.	.	s	r!	.	.
Pedicularis kerneri	.	.	.	.	.	c	.	.
Sibbaldia procumbens	.	.	.	.	.	lc	.	.
Arenaria biflora	.	.	.	.	.	lc	.	.
Achillea erba-rotta subsp. *moschata*	.	.	.	.	.	ls	.	.
Cerastium cerastoides	.	.	.	.	.	r	.	.
Sorbus aucuparia	.	.	.	.	.	r!	.	.
Silene acaulis subsp. *bryoides*	.	.	.	.	.	c	c	.
Primula glutinosa	.	.	.	.	.	c	lc	.
Salix herbacea	r!	.	.	.	.	c	s, lc	.
Minuartia recurva	.	.	.	.	.	r	c	.
Gentiana bavarica	.	.	.	.	.	r	s, lc	.
Veronica alpina	.	.	.	.	.	lc	ls	.
Omalotheca supina	.	.	.	.	.	lc	ls	.
Senecio incanus subsp. *carniolicus*	.	.	.	.	.	ls	ls	.
Lloydia serotina	.	.	.	.	.	.	lc	.

GLORIA regions	Southern Alps				Central Alps			
	Dolomites				Texelgruppe			
Summits	**MTS**	**RNK**	**PNL**	**GRM**	**FAG**	**SBG**	**DWO**	**KAS**
m above sea level	2893	2757	2436	2199	2180	2619	3074	3278
Androsace alpina	.	.	.	.	.	.	s, lc	.
Potentilla frigida	.	.	.	.	.	.	s, lc	.
Cardamine bellidifolia subsp. *alpina*	.	.	.	.	.	.	ls	.
Arenaria serpyllifolia subsp. *marschlinsii*	.	.	.	.	.	.	ls	.
Koeleria hirsuta	.	.	.	.	.	.	r!	.
Carex curvula subsp. *curvula*	.	.	.	.	lc	c, ld	s, lc	.
Primula hirsuta	.	.	.	.	c, ld	ls	r	.
Agrostis rupestris	.	.	.	.	c, ls	c	s, lc	.
Oreochloa disticha	.	.	.	.	r	c	s, lc	.
Cardamine resedifolia	.	.	.	.	ls	s, lc	s, lc	.
Sedum alpestre	.	.	.	.	r	ls	lc	.
Poa laxa	.	.	.	.	.	c	c	lc
Saxifraga bryoides	.	.	.	.	.	c	c	r, lc
Ranunculus glacialis	.	.	.	.	.	ls	c	c
Luzula spicata	.	.	.	.	.	r, ls	c	lc
Saxifraga exarata subsp. *exarata*	.	.	.	.	.	r!	c	ls
Leucanthemopsis alpina	.	.	.	.	ls	c	c	r
Gentianella anisodonta	.	r, ls	r, ls	s, lc	r, ls	.	.	.
Thymus praecox subsp. *polytrichus*	.	r, lc	ls	lc	s, lc	.	.	.
Myosotis alpestris	.	ls	ls	s, lc	r, ls	.	.	.
Lotus corniculatus	.	ls	.	lc	ls	.	.	.
Juniperus communis subsp. *alpina*	.	.	r	s, ld	r	.	.	.
Hieracium murorum agg.	.	.	r	r, ls	r, ls	.	.	.
Vaccinium vitis-idaea subsp. *vitis-idaea*	.	.	.	s, lc	c	.	.	.
Vaccinium myrtillus	.	.	.	s, lc	c	.	.	.
Deschampsia flexuosa	.	.	.	r, ls	c	.	.	.
Leontodon hispidus	.	.	.	c	s, lc	.	.	.
Selaginella selaginoides	.	.	.	lc	s, lc	.	.	.
Luzula luzuloides	.	.	.	s, lc	s, lc	.	.	.
Hypochoeris uniflora	.	.	.	r, lc	s, lc	.	.	.
Arnica montana	.	.	.	r, lc	s, lc	.	.	.
Geranium sylvaticum	.	.	.	s, lc	r, ls	.	.	.
Silene vulgaris subsp. *vulgaris*	.	.	.	s, lc	s, lc	.	.	.
Pedicularis tuberosa	.	.	.	s	ls	.	.	.
Pulsatilla alpina subsp. *apiifolia*	.	.	.	ls	s	.	.	.
Campanula barbata	.	.	.	r, ls	ls	.	.	.
Thesium alpinum	.	.	.	r, ls	ls	.	.	.
Crocus vernus subsp. *albiflorus*	.	.	.	r, ls	ls	.	.	.
Coeloglossum viride	.	.	.	s, lc	r	.	.	.
Rosa pendulina	.	.	.	s, lc	r	.	.	.
Vaccinium uliginosum subsp. *microphyllum*	.	.	.	c	c	ls	.	.

GLORIA regions	Southern Alps				Central Alps			
	Dolomites				Texelgruppe			
Summits	**MTS**	**RNK**	**PNL**	**GRM**	**FAG**	**SBG**	**DWO**	**KAS**
m above sea level	2893	2757	2436	2199	2180	2619	3074	3278
Carex sempervirens	.	.	r	c	c, ld	s. lc	.	.
Leontodon pyrenaicus subsp. *helveticus*	r!	.	.	c	c	c	.	.
Juncus trifidus subsp. *trifidus*	.	.	.	lc	c	lc	.	.
Avenula versicolor	.	.	.	s, lc	c	c	.	.
Potentilla aurea subsp. *aurea*	.	.	.	s	c	lc	.	.
Homogyne alpina	.	.	.	s, lc	c	s, lc	.	.
Geum montanum	.	.	.	s, lc	s, lc	s, lc	.	.
Gentiana acaulis	.	.	.	s, lc	s	r, ls	.	.
Anthoxanthum odoratum subsp. *alpinum*	.	.	.	s, lc	c	s, lc	.	.
Loiseleuria procumbens	.	.	.	s, lc	s, lc	r, ls	.	.
Pulsatilla vernalis	.	.	.	s	r, ls	r!	.	.
Antennaria carpatica	.	.	.	s, lc	r	r, ls	.	.
Rhododendron ferrugineum	.	.	.	r, ls	s, lc	.	r!	.
Solidago virgaurea subsp. *minuta*	.	.	.	r	c	r!	.	.
Viola biflora	.	.	.	lc	s, lc	r!	.	.
Cerastium fontanum subsp. *fontanum*	.	.	.	r, ls	ls	s, lc	.	.
Huperzia selago subsp. *selago*	.	.	.	r, ls	s, lc	r	r!	.
Festuca halleri subsp. *halleri*	.	.	.	s, lc	r	ls	c	.
Phyteuma hemisphaericum	.	.	.	s, lc	c	c	s, lc	.
Doronicum clusii	.	.	.	lc	.	r!	r!	.
Poa alpina	s, lc	c	s, lc	s, lc	r	s, ld	.	.
Kobresia myosuroides	r!	r, lc	r	s	.	lc	ls	.
Agrostis alpina	.	lc	r, lc	c	s, lc	s, lc	lc	.
Polygonum viviparum	.	lc	c	c	.	c	.	.
Draba dubia	.	r	s	ls	.	.	r, ls	r!
Campanula scheuchzeri	.	r, lc	r, lc	c	c	s, lc	.	.
Euphrasia minima subsp. *minima*	.	.	c	lc	c	s, lc	c	.
Cerastium uniflorum	c	c	.	.	.	ls	c	s, lc
Minuartia sedoides	s, lc	s	s, lc	.	.	c	c	.
Gentiana brachyphylla	.	ls	s, lc	.	.	.	s, lc	.
Erigeron uniflorus	.	c	r, ls	r	.	ls	c	.