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Mountain ash (*Sorbus aucuparia*) forests of the Central and Southern Alps (Grisons and Ticino, Switzerland – Prov. Verbano-Cusio-Ossola, N-Italy): Plant ecological and phytosociological aspects

Vogelbeeren (*Sorbus aucuparia*)-Wälder der Zentral- und Südalpen (Graubünden und Tessin, Schweiz – Prov. Verbano-Cusio-Ossola, N-Italien): Pflanzenökologische und pflanzensoziologische Aspekte

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Abstract

Mountain ash (*Sorbus aucuparia*) is widespread in Europe from sea level to the timberline and reaches its most northern range in N-Norway at 71 °N. *Sorbus aucuparia* occurs on acid, dry to moist and mesotrophic to oligotrophic soils. The species often grows in secondary forests together with *Alnus viridis*, *Sambucus racemosa*, *Betula pendula*, *Frangula alnus* and some *Salix* spp. In most climax forests mountain ash grows only in the shrub layer. In the subalpine belt, the tree is present in green alder scrub and European larch-Swiss stone pine forests. On some N-exposed mountain slopes of the S-Alps, small mountain ash forests with green alder build the upper forest limit above 1500 m. In this study, ecological and phytosociological aspects of this particular forest community along a N-S-transect from the Swiss Central Alps (Grisons) to the South Alps (Ticino/ N-Italy) were investigated. We consider site conditions, local spread, rejuvenation, tree age structure, infestation and phytosociological aspects of *S. aucuparia*. The occurrence of *A. viridis* in the N-S-transect and the role of *S. aucuparia* in the secondary and climax forests have been investigated. While in the green alder scrub (*Alnetum viridis*) of the North single mountain ash trees are present, alder-mountain ash forests have been found at the S-Alpine sites with *S. aucuparia* covers 25–80%. Here, the *Alnetum viridis* is absent, and *A. viridis* is element of the mountain ash forests. In the montane and lower subalpine zone, *S. aucuparia* will often be replaced later by beech or other climax trees. Above the upper beech limit, we consider the green alder-mountain ash forests as climax forests. At the driest forest sites, grass species are predominant – mainly *Calamagrostis* spp. and *Avenella flexuosa*. Based on the earlier provisional phytosociological name of S-Alpine green alder-mountain ash forests, we suggest the name *Alno viridi-Sorbetum aucupariae* Hari, Leisinger et Zysset 1993 – according to the first description by HARI et al. (1993). Based on our vegetation records of green alder-mountain ash forests, we propose a new subassociation *Alno viridi-Sorbetum aucupariae calamagrostietosum* subass. nov.

Keywords: *Alnetum viridis*, biology of rejuvenation, Central Western Alps, phytosociology, secondary succession, *Sorbus aucuparia* forests, Southwestern Alps, tree age structure

Erweiterte deutsche Zusammenfassung am Ende des Artikels

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1. Introduction and problem issue

Mountain ash is an attractive slender deciduous tree 10–20 m in height with silvery-brown bark, creamy-white flowers in spring and brilliant orange berries in autumn. It provides berries as a valuable crop in early winter for consumption by birds. The trees reach a maximum of 27 m in height in sheltered places, but much less in exposed sites. On almost bare mountain rocks, they grow as bushes. Mountain ash is a light-demanding pioneer tree having a fast but ephemeral early growth, reaching maximum ages of 80 to 100 years (ELLENBERG 1996). Young mountain ash trees are shadow tolerant. In general, mountain ash grows on wet or dry acid soils having moderate nutrient content (MAIER 1997, LANDOLT 2010, ROLOFF et. al. 2010). On steep slopes the trees often show one-sided growth due to snow creep and soil sliding. Therefore, mountain ash is perfectly adapted for various sites and climatic conditions. Mountain ash occurs in a wide European range covering Spain, South Italy, North Greece, North Turkey, Black Sea to the Caucasus. The Eastern European distribution boundary is not well known – it fits approximately with the course of Volga and the Ural Mountains. Eastwards, mountain ash has also been recorded in Siberia and China. Mountain ash reaches its northernmost European occurrence in N-Norway at 71° N (HEGI 1995, ROLOFF et. al. 2010, STEIGER 2010). The Swiss range of *Sorbus aucuparia* is shown on two maps published by BRÄNDLI (1996). On calcareous soils mountain ash is often replaced by whitebeam (*Sorbus aria*). Mountain ash grows as a single tree or as small stand in all Central European altitudinal vegetation belts. It often occurs as a pioneer tree in secondary forests together with green alder (*Alnus viridis*), several willow species (*Salix* spp.), red-berried elder (*Sambucus racemosa*), silver birch (*Betula pendula*), and alder buckthorn (*Frangula alnus*). In some phases of reforestation, mountain ash occurs as a dominant tree (e.g. *Piceo-Sorbetum aucupariae* Aichinger ex Oberd. 1973, *Sambuco-Salicion capreae* Tx. et Neumann ex Oberd. 1957, MUCINA et al. 2016). In the subalpine belt, a typical mountain ash occurrence can be found in green alder bush and mountain pine scrub or in larch and larch-Swiss stone pine forests. In the colline belt, mountain ash is present in acid mixed beech forests, but also in calcareous mixed oak forests and riparian forests as well as on forest edges and hedges together with other shrub species. In Swiss broadleaved woodland and coniferous forests, *S. aucuparia* occurs in general as single trees or small groups with a cover of 25–55%, but in most forest communities only within the shrub layer (ELLENBERG & KLÖTZLI 1972). In contrast to that, at some S-Alpine mountains of Ticino and N-Italy mountain ash forests occur at the upper forest limit. For this reason of mountain ash occurrence led us to the present study. For this purpose, we investigated a N-S transect from the Swiss Central Alps (Grisons) to the South Alps (Ticino, N-Italy, BÜHRER 2007). As *A. viridis* is regularly associated with *S. aucuparia* in the subalpine green alder bush with tall perennial herbs (*Alnetum viridis* Br.-Bl. 1918, BRAUN-BLANQUET 1918) of the Swiss Alps, the investigation transect starts in Tschamut (Upper Rhine valley) in the subalpine belt. Here, on NE-exposed mountain slopes, vital green alder bush occurs. The N-S transect continues to the Southern Alps of Ticino and N-Italy, i.e. along a line of the sites Mte Lema-Mte Morissolo-I Balmit (Mte Zeda)-Mottarone. The last site lies close to the Po Plain.

In the following section, more details are given of mountain ash occurrence in the S-Alps. In the Canton of Ticino (Switzerland) and the Province of Verbano-Cusio-Ossola (Lago Maggiore, N-Italy) mountain ash occurs on N-exposed slopes at the forest limit, partly as local pure stand growth. On Mte Gradiccioli (1780 m, Ticino) it reaches one of the highest points. These pure stands of mountain ash often form ramets of up to 20 trunks. It seems that clusters of mountain ash are more resistant at these extreme sites than single one-stemmed individual trees. Moreover, some authors suppose that pure stands of mountain ash are supported due to the lack of browsing by game (HARI et al. 1993). The first study of small green alder-mountain ash forests on the forest limit of the region Mte Lema – Mte Gradiccioli – Mte Tamaro (Ticino) was done by HARI et. al. (1993). The present study is an enlarged and more detailed investigation along the above-mentioned transect from the Swiss Central Alps to the Southern border of the N-Italian Alps.

The following issues have been addressed: (1) Under which site conditions do dominant stands of mountain ash exist, and where do they occur along the investigated N-S transect? (2) What are the characteristics of regeneration of mountain ash (growth and age-structure)? (3) What is the role of green alder along the studied N-S transect? (4) Are green alder-mountain ash forests only a successional stage of regeneration of former cleared beech or other forests or a climax forest community, today occurring close by the upper potential beech forest limit? (5) Phytosociological aspects to S-Alpine green alder-mountain ash forests at the upper forest limit.

2. Short description of the study sites

2.1 Location, geology, soils and dominant vegetation

The study area on the Southern slope of the Central Alps of the region Grisons-Ticino (Switzerland) Province of Verbano-Cusio-Ossola (N-Italy) is shown in Figure 1. The transect starts in the subalpine zone of Tschamut (1667 m, Canton of Grisons) near the Oberalp pass. This site lies within sedimentary gneiss rocks (muscovite gneiss) of the Tavetscher intermediate massif, which is located between the Aare and Gotthard massif at the SE border of the Helveticum (GNÄGI & LABHART 2015). The investigated vegetation plots of dense green alder bush having their characteristic tall perennial herbs (*Alnetum viridis*) on acid brown soils (silicate moraine) are located on the Northern slope of Piz Cavradi above Tschamut. Mountain ash grows only as single trees within the *Alnetum viridis* (BRAUN-BLANQUET 1918).

The next four sites are located in the S-Alps within the Alpine Insubric crystalline zone or in the Ivrea zone having gneiss and crystalline schist (mainly two-mica granite). The site of Mte Lema (1607 m) lies in the Ticino Alps NW of Lugano. This study site having acid brown soil (silicate scree) near the top was formerly used as a ski slope. The vegetation consists of a mosaic of mat-grass pasture (*Nardion strictae* Br.-Bl. 1926 [BRAUN-BLANQUET & JENNY 1926]) and ericaceous scrub (mainly *Vaccinium myrtillus* and *Rhododendron ferrugineum*) with single mountain ash seedlings. Nearby a small mountain ash forest grows above the upper limit of beech forest (Fig. 2). The next two study sites Mte Morissolo (1277 m) and I Balmit (1605 m) are located in the region of Province of Verbano-Cusio-Ossola (N-Italy) W of Ticino Alps. The site Mte Morissolo above Cannero/Lago Maggiore was treeless during World War I (for strategic purposes); later it was used as meadow and pasture. Nowadays, on these acid brown soils beech and mountain ash mixed forests having dense undergrowth of small-reed (*Calamagrostis arundinacea* and *C. villosa*) and Alpine rose (*Rhododendron ferrugineum*) grow (Fig. 3).

At the site I Balmit, a mountain ridge of Monte Zeda (2156 m, Parco Nazionale della Val Grande) N of Intra, is the largest mountain ash forest of this study area (c. 100 ha). Mountain ash grows on acid brown soils and reaches nearly the top at 1605 m, which is above the upper beech limit of 1500 m. I Balmit shows the following well-developed vertical

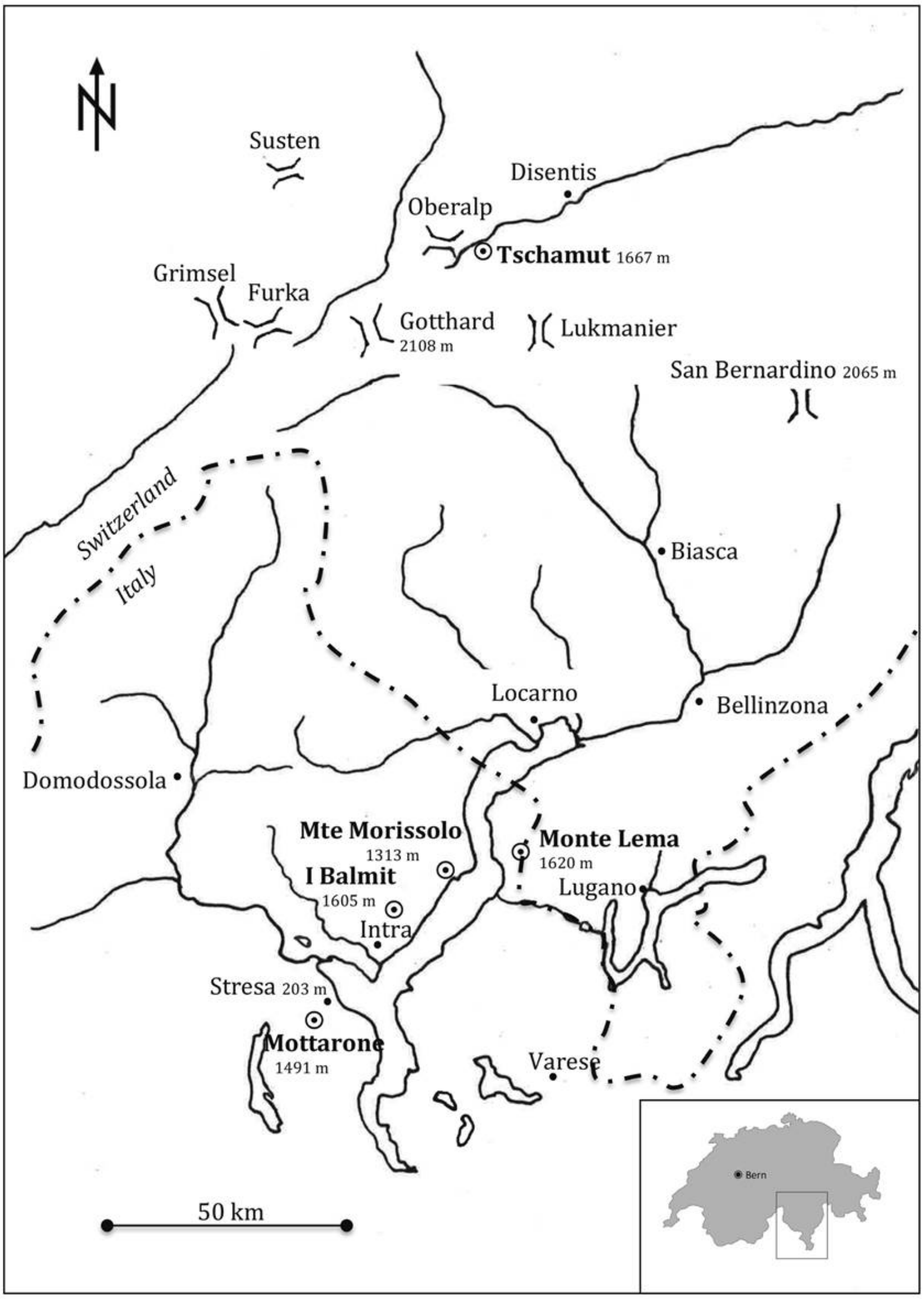

Fig. 1. Map of study sites Grisons – Ticino (Switzerland) and Province Verbano-Cusio-Ossola (N-Italy).

Fig. 1. Karte zu den Untersuchungsstellen Graubünden – Tessin (Schweiz) und Provinz Verbano-Cusio-Ossola (N-Italien).

Fig. 2. Mte Lema (1620 m). At the top a small green alder-mountain ash forest grows above the actual upper limit of beech forest. Within the herb layer dominates *Calamagrostis villosa* (Photo: S. Bührer, 2007).

Fig. 2. Mte Lema (1620 m). Auf dem Gipfel stockt ein kleiner Grünerlen-Vogelbeerenwald über der aktuellen Buchenwald-Obergrenze. In der Krautschicht dominiert *Calamagrostis villosa* (Foto: S. Bührer, 2007).

Fig. 3. Mte Morissolo (1277 m) above Cannero/ Lago Maggiore. Regeneration after World War I with beech and mountain ash forest having a dense undergrowth of bush grass (*Calamagrostis villosa* and *C. arundinacea*) and Alpine rose (*Rhododendron ferrugineum*) (Photo: S. Bührer, 2007).

Fig. 3. Mte Morissolo (1277 m) oberhalb Cannero/ Lago Maggiore. Wiederbewaldung nach dem I. Weltkrieg mit Buche und Vogelbeere, mit dichtem Reitgras-Unterwuchs (*Calamagrostis villosa* und *C. arundinacea*) und Alpenrose (*Rhododendron ferrugineum*) (Foto: S. Bührer 2007).

Fig. 4. Mottarone (1491 m) above Stresa. On a former skiing ground, a dense mountain ash forest settled on acid brown soil (Photo: S. Bührer, 2007).

Fig. 4. Mottarone (1491 m) oberhalb Stresa. Eine frühere Skipiste mit saurer Braunerde wird nun von einem dichten Vogelbeerenwald bestockt (Foto: S. Bührer, 2007).

vegetation zonation: Montane beech forest up to c. 1500 m, followed by mountain ash forest, then small green alder bush and Alpine rose scrub and at the top is mat-grass pasture (*Nardion strictae*).

The most southwest site of this study is Mottarone (1491 m) above Stresa, one of the last Southern foothills close by the Po Plain. During the 1920s, the forest limit was lowered to 800–850 m with a tree limit at c. 1000 m due to ski tourism. Afterwards it was reforested with birch and Norway spruce (KELLER 1931). On the former skiing grounds, a dense mountain ash forest settled on acid brown soil (Fig. 4). In addition, green alder (*Alnus viridis* and *A. viridis* var. *brembana*), sycamore maple (*Acer pseudoplatanus*) and Alpine laburnum (*Laburnum alpinum*) grow there: only a few Alpine rose individuals occur there. The vegetation of this site is different to the other described mountain ash sites. In Val Strona, Southwest of the Parco Nazionale della Val Grande and Northwest of Lago d'Orta, also small mountain ash forests occur. For this site, no vegetation or plant sociological research of *Sorbus aucuparia* forests has been published so far (LEHRINGER et al. 2008). ANTONIETTI (2002, 2005) established a checklist of the flora in the investigated sites of the Prov. Verbano-Cusio-Ossola (N-Italy). The vegetation profile covering the Eastern Swiss and N-Italian Alps from NE to SW (Säntis – Mottarone) (Fig. 5) shows the subalpine occurrence of green alder-mountain ash forests and green alder scrub on N-exposed slopes at the upper forest limit of the S-Alps.

2.2 Climate aspects

The N-S-transect of our study starts in the N with the Tschamut site. This small village lies in the Swiss Central Alps and has a continental climate (low annual precipitations, large temperature fluctuations, strong solar radiation). At this site, wind from N and NW bring

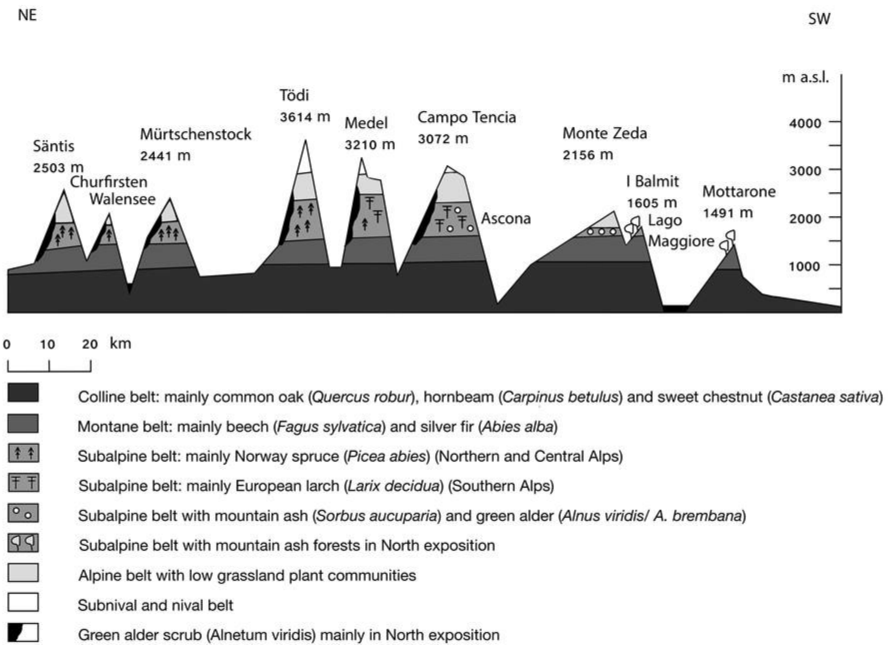

Fig. 5. Vegetation profile through the Eastern Swiss and N-Italian Alps from NE to SW (Säntis – Mottarone) with the subalpine occurrence of green alder bush and green alder-mountain ash forests in the S-Alps.

Fig. 5. Vegetationsprofil durch die östlichen Schweizer und den norditalienischen Alpen von NO nach SW (Säntis-Mottarone) mit der subalpinen Verbreitung von Grünerlen-Busch und Grünerlen-Vogelbeeren-Wäldern der S-Alpen.

the main yearly precipitations of c. 1500 mm (thunderstorms during 15–20 days per year). The average yearly temperature is c. 1 °C (yearly sunshine hours 1600–1700, KIRCHHOFER 1982, 1984). The other sites of Ticino and N-Italy are located in the S-Alpine or Insubric climate region, which have high yearly precipitations and strong radiation; lower areas enjoy mild winters. Yearly precipitations vary between 1800 and 2200 mm. It rains mainly during summer (May – August), and there occur thunderstorms on 50–55 days per year. The summer is hot (c. 16–22 °C), whereas winter has a mild temperature (c. 0–4 °C). This S-Alpine region enjoys 2100–2300 yearly sunshine hours (the Swiss maximum), but during winter there is more fog from the Po Plain (URFER et al. 1979, KIRCHHOFER 1991). The yearly mean temperature (°C) and yearly precipitations (mm) for the S-Alpine sites are as follows: Mte Lema (c. 4.9/c. 1500), Mte Morissolo (c. 6.5/c. 1800), I Balmit (c. 4.3/c. 2000) and Mottarone (c. 5.0/c. 2400, KIRCHHOFER 1982, 1984).

3. Methods

On a N-S transect from the Swiss Central Alps (Upper Rhine valley) to the S-Alps of Ticino and N-Italy, we selected mountain sites having small mountain ash forests and/or mixed beech-mountain ash forests at the upper forest limit. The sites of these forest types (see section 2) have been investigated according to the following methods: (1) Vegetation records according to BRAUN-BLANQUET (1964, p. 39). There were flowering plants and ferns (no mosses and lichens) recorded on plots of c. 100 m^2

(DIERSCHKE 1994). Nomenclature of plant names according LAUBER et al. (2012). The degree of coverage 2 (10–25%) has been modified as follows: 2.1 (10 to < 15%), 2.2 (15 to < 20%) and 2.3 (20 to < 25%). In order to get a good statistical base to estimate the degree of plant-coverage, each vegetation record has been carried out by two different persons. The total of the vegetation records are as follows: Tschamut 29, Mte Lema 27, Mte Morissolo 23, I Balmit 30 and Mottarone 29. (2) Wood growth of mountain ash: Counting of annual rings (number and ring width) of mountain ash stems by using wood-cores drilled at a height of 1.3 m above surface-level. A source of error could occur in several instances due to polyphyletic growth, browsing by game or light deficiency. Only trees reaching the forest canopy having the thickest stems were chosen. The width of annual rings has been classified in three groups: a) large rings, b) medium width and c) small rings. Errors due to wood compression and wood tension should be taken into account. This investigation should be taken to give only some information about the trend of mountain ash growth at the investigated sites. (3) Tree propagation: Count of young mountain ash trees. At the site Mte Morissolo, the generative rejuvenation of mountain ash trees of less than 20 cm height has been studied on different plots of 4 m^2 situated within the mountain ash forest, at the forest edge and at the adjacent meadow. The most frequently recorded young mountain ash individuals are ramets of more than 10 stems. This rejuvenation strategy of mountain ash seems to be better adapted at extreme sites and allows a longer longevity than monophyletic individuals. (4) Identification of insect-damage by beetles on the sites of Mte Morissolo and I Balmit.

4. Results

4.1 Vegetation aspects to sites having green alder-mountain ash forests

Within the study area, mountain ash grows on N-exposed sites free of snow avalanches at 1200–1650 m. It is important to distinguish mountain ash sites below and above the upper beech limit, because here beech forms the main competition tree for mountain ash. The investigations show that mountain ash forests below the upper beech limit at c. 1500 m will be driven out. So, small secondary mountain ash forests at Mte Morissolo in 1200–1300 m grow on a former site of beech forest, which has been cleared for cultivation (mainly by gain of charcoal at the end of 19th century) and for strategic purposes during World War I. At Mottarone in c. 1400 m a former afforestation after the 1920s with birch and Norway spruce was cleared for skiing grounds and pasture. The present mountain ash forest started after the abandonment of these grounds in 1943; it represents a pioneer stage of secondary reforestation after human activities ceased. Nowadays, at Mte Morissolo most of the mountain ash trees are dead and will gradually be replaced by beech. The development of the open mountain ash forest of Mottarone is much younger (the reason; see above): so there is a richer herb layer compared to the oldest mountain ash forest site of Mte Lema (47 and 32 flowering plant species respectively, see detailed vegetation records of all sites in the Supplements E1–E5). At the onset of the 19th century, vast subalpine areas of the S-Alps were deforested to establish meadows and pastures. After the decline of agriculture in this area, a marked secondary spread of small green alder-mountain ash forests has been recorded within and above the beech forest range (CESCHI 2006, Fig. 6). Green alder-mountain ash forests of Mte Lema and I Balmit lie above the natural upper beech limit. Nowadays, they represent probably a local climax forest community. The site I Balmit was formerly partly used as pasture. When agricultural use was given up, mountain ash could spread more intensively.

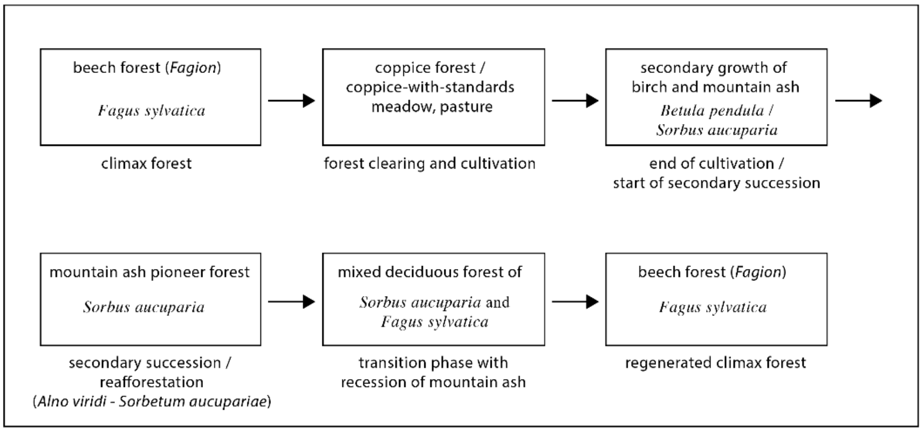

Fig. 6. Succession model within the S-Alpine beech belt: beech forest clearing, coppice forest, cultivation, secondary mountain ash-forest and regeneration to new climax beech forest (BÜHRER 2007).

Fig. 6. Sukzessions-Modell innerhalb des südalpinen Buchengürtels: Buchenwald-Rodung, Niederwald, Nutzung, Sekundär-Vogelbeerenwald und Regeneration zu neuem Buchen-Klimax-Wald (BÜHRER 2007).

4.2 Natural regeneration, growth form, infestation and age structure of mountain ash

At the investigated sites, we recognised a weak or missing generative mountain ash reproduction. On all sites, there were only few seedlings in the mountain ash forests, even in the old forest of Mte Lema. At Mte Morissolo, three vegetation plots – i.e. the neighbour pasture, the edge of mountain ash forest and the forest itself – were checked regarding mountain ash seedlings (smaller than 20 cm). The majority of them were recorded in the pasture, at the forest edge, a few were recorded and there were no seedlings found inside the forest; this weak occurrence or absence of mountain ash seedlings inside the forest is not easy to explain. The following hypotheses can be considered as possible reasons. Dense grass cover, mainly of small-reed species (*Calamagrostis villosa* and *C. arundinacea*), recorded on different sites, could inhibit the growth of seedlings. On the other hand, it is known that at higher altitudes the occurrence of mountain ash trees and their successful survival is declining – and the dry weight of their seeds is also decreasing (BARCLAY & CRAWFORD 1984). In addition, mountain ash does not every year produce ripe fruits at the tree limit. During winter, the fruits of the last year produce germination inhibitors such as parascorbic acid, abiscin acid and isopropyl-acetic acid. Therefore, the seeds would germinate only one year later after fruit ripening (MAIER 1997). A marked insect damage has been recognised mainly at Mte Morissolo and I Balmit. Different authors also reported related damages, e.g. SCHMIDT (1989), LEMME (1995) and ERLBECK (1998). Other damages such as browsing by game, mycosis and viral diseases have been reported on mountain ash trees, but not all these impacts are considered as lethal. Therefore, we suggest that a dense grass cover of small-reed (*Calamagrostis villosa* and *C. arundinacea*) and/or a combination of other different reasons causes this reduced natural mountain ash regeneration. At Mte Morissolo, four plots each of 100 m^2 have been checked concerning vegetative mountain ash propagation, i.e. the amount of clonal single young mountain ash trees. The plots revealed single trees with 1 to a max. of 27 stems. Moreover, only 21 mountain ash trees out of 125 showed shoots from the stump. Most of them are very thin stems having little chance of survival. The main reason for that is due to browsing by game and beetle infestation (e.g. *Gonioctena* spec., ERLBECK 1997). Nevertheless, HARI et. al. (1993) described mountain ash forests without seed production (e.g. at the timber limit), but which produce vegetative propagation such as root bulbils, suckers and shoots from the stump as important survival strategies. At Mte Morissolo it is not clear whether the mountain ash forest will rejuvenate or develop in the future. Overall, this could eventually explain the small size and rare occurrence of mountain ash forests in the S-Alps. In contrast to that, at Tschamut (Central Alps) where only single mountain ash trees occur within the green alder bush (*Alnetum viridis*), the mountain ash trees show a lot of shoots from the stump and generally a higher vitality.

Along the N-S-transect Tschamut-Mottarone, the counting of annual rings of 25–50 mountain ash trees (see Chapter 3) revealed average tree ages of 40–55 years (BÜHRER 2007). The different frequencies of age classes of the single sites are conspicuous (Table 1). The site Tschamut shows the lowest average tree age of 28.3 years. Here, the majority of the trees are only 20–30 years old. The reason for that is probably a high frequency of snow avalanches, which affect a higher vitality by lowering the production of new shoots from the stump. At Mte Lema the oldest trees grow, having an average age of 50.5 years. Among them, the oldest mountain ash was 77 years old. At this site, there was a wide range of age class distribution, i.e. a good mixture of young and old trees (Fig. 7). So, the mountain ash forest of Mte Lema represents a stable population having a good regeneration capacity. At Mte Morissolo and I Balmit the average tree ages of 49.6 years and 49.0 years respectively were similar to Mte Lema, but the age class distribution is different. The high standard deviation of 12 at Mte Morissolo can be explained as by its being an open area or one lacking deciduous forest, which was opened for strategic purpose during World War I and used afterwards as pasture. Old maps show the presence of an open forest there during that time. At present, the green alder-mountain ash forest shows only a weak regeneration. At I Balmit there is a wide range of age class distribution representing a stable mountain ash population. As this site is located within the Parco Nazionale della Val Grande, a weaker human impact is to be expected. The site Mottarone revealed an average tree age of 42.8 years having a standard deviation of only 5.3. As mentioned above, the top zone of Mottarone was cleared for skiing grounds during the 1920s. After abandonment of these grounds, the present natural mountain ash afforestation started in 1943. The actual oldest trees still belong to the first generation.

Measurements of the annual ring width of mountain ash trunks at the different sites revealed the following results: after c. 10 years of growth, the tree rings became narrower, this probably being due to a stronger tree competition (BÜHRER 2007). At the site I Balmit, the trees of similar ages do not show an optimal vitality, and they form a weak mixed

Table 1. Age-structure of mountain ash trees. Count of annual rings (BÜHRER 2007).

Tabelle 1. Altersstruktur der Vogelbeeren-Bäume. Jahrringzählungen (BÜHRER 2007).

site (metres a.s.l.)	total trees	average age (y)	max. age (y)	SD
Tschamut (1667)	47	28.3	50	8.4
Mte Lema (1607)	40	50.5	76	8.2
Mte Morissolo (1277)	25	49.6	71	12
I Balmit (1605)	25	49	70	9.1
Mottarone (1491)	50	42.8	55	5.3

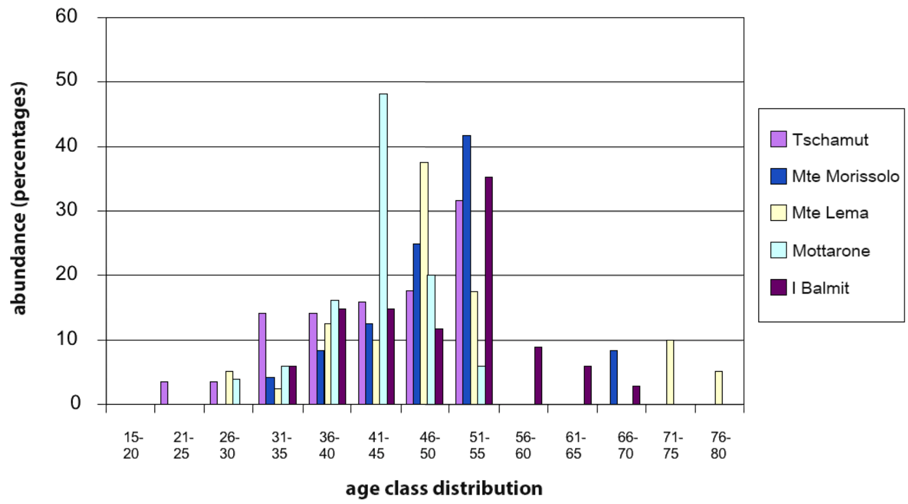

Fig. 7. Age structure of mountain ash forests. For details see Table 1 (BÜHRER 2007).

Fig. 7. Altersstruktur von Vogelbeerenwäldern. Für Details siehe Tabelle 1 (BÜHRER 2007).

population age-structure. The mountain ash forests of Mte Lema are much older because they represent the natural-potential forest community. Compared with I Balmit and Mte Morissolo, the age-structure of the trees of Mte Lema is more diverse.

4.3 The role of green alder (*Alnus viridis*) from North to South

Green alder bush with its characteristic tall perennial herbs occurs as *Alnetum viridis* (an association of *Adenostylion alliariae* Br.-Bl. 1926) mainly in the Swiss North and Central Alps (e.g. site Tschamut). As usual, single trees of mountain ash are present within the green alder bush. Slopes in N-exposition have a high frequency of avalanches, and sites where Norway spruce growth is inhibited mainly are covered with green alder bush. The S-Alpine climate, which has dry phases during summer is thus less favourable for green alder bush and the associated tall perennial herbs because they demand a regular water supply over the whole year (RICHARD 1968a, RUBLI 1976, ELLENBERG 1996, OBERDORFER 2001, WETTSTEIN 2001). Therefore, N-exposed steep slopes above the upper beech limit (c. 1500 m) of the S-Alps are favoured sites of mountain ash (up to c. 1800 m or even higher). Here, at the most humid sites, single green alder bushes are associated with the mountain ash crops. Besides the *Alnus viridis* there, *A. viridis* var. *brembana* is also present, distinguished from *A. viridis* by its lower growth, smaller leaves and fruit cones – a floristic element of the Insubric beech forest belt (LANDOLT 1993).

Regarding our N-S transect from Tschamut to Mottarone, only at the Tschamut site a good developed *Alnetum viridis* is present, having associated single mountain ash trees (coverage 10–50%, Table 2). Here, we recorded the index species *A. viridis* (coverage 50–80%), *Achillea macrophylla* (1–10%) and *Stellaria nemorum* s.l. (10–15%) with the typical alliance species *Adenostyles alliariae* (10–25%), *Cicerbita alpina* (10–25%), *Peucedanum ostruthium* (10–15%), *Veratrum album* subsp. *lobelianum* (10–15%), *Saxifraga rotundifolia* (0.5–5%), order species *Rumex alpestris* (10–15%), *Chaerophyllum hirsutum* agg. (0.5–5%) and accessory species *Viola biflora*, *Oxalis acetosella*, *Poa nemoralis*,

Table 2. Vegetation surveys of green alder bush and green alder-mountain ash forests of the investigated sites. Range of coverage in % (mean values) of association, index and alliance species.

Tabelle 2. Vegetationsaufnahmen zu Grünerlen-Busch und Grünerlen-Vogelbeeren-Wäldern der untersuchten Standorte. Schwankungsbreite des Deckungsgrades in % (Mittelwerte) von Assoziations-, Charakter- und Verbands-Arten.

Investigation sites	Tschamut	Mte Lema	Morissolo	I Balmit	Mottarone
number of surveys	29	27	23	30	29
Index species: Flowering plants and ferns (without accessory species of weak coverage)	.				
Cicerbita alpina	10–25	.	.	.	.
Adenostyles alliariae	10–25	.	.	.	.
Peucedanum ostruthium	10–15	.	.	.	.
Achillea macrophylla	1–10	.	.	.	0.1–0.5
Viola biflora	10–15	.	.	.	.
Rumex alpestris	10–15	.	.	.	.
Saxifraga rotundifolia	0.5–5	.	.	.	.
Ranunculus platanifolius	1–15	.	.	.	.
Poa nemoralis	0.5–5	.	10–25		.
Stellaria nemorum s.l.	10–15	.	.	0.1–0.2	.
Veratrum album ssp. *lobelianum*	10–15	0.2–0.5	0.2–0.5	.	0.2–5
Homogyne alpina	0.5–1	0.1–0.2	.	0.1–0.5	.
Chaerophyllum hirsutum agg.	0.5–5	.	.	.	.
Vaccinium myrtillus	10–15	10–20	10–15	0.5–5	0.5–10
Rhododendron ferrugineum	0.5–5	10–50	10–50	5–10	2–10
Athyrium distentifolium	25–75	5–10	10–15	0.5–5	.
Athyrium filix–femina	10–15	.	0.2–5	0.2–0.5	0.2–5
Dryopteris dilatata	10–15	5–15	0.1–0.5	0.1–0.2	.
Alnus viridis, incl. *Alnus viridis* var. *brembana*	50–80	10–25	10–15	5–20	1–10
Sorbus aucuparia	10–50	25–80	25–75	25–75	50–80
Calamagrostis arundinacea	.	5–10	10–15	25–75	1–10
Calamagrostis villosa	.	20–75	10–15	1–10	0.1–0.2
Avenella flexuosa	.	1–10	0.5–5	0.1–0.5	0.2–10
Maianthemum bifolium	.	1–15	0.1–0.2	0.1–0.8	0.1–0.2
Phegopteris connectilis	.	0.5–5	5–10	0.1–0.8	0.1–0.2
Luzula nivea	.	0.5–10	0.5–5	0.1–0.5	0.1–0.2
Oxalis acetosella	.	0.5–10	0.2–0.5	0.1–0.5	0.1–0.2
Deschampsia cespitosa	.	0.5–10	.	0.1–0.8	0.1–0.2
Luzula sylvatica agg.	.	0.2–0.5	0.1–0.2	0.1–0.2	0.1–0.2
Luzula pilosa	.	0.5–5	.	.	.
Polygonatum verticillatum	.	0.2–0.5	.	0.1–0.5	0.1–0.2
Gentiana asclepiadea	.	.	.	.	0.1–0.2
Senecio ovatus	.	.	.	.	0.2–5
Solidago virgaurea s.l.	.	.	.	0.1–0.5	
Vaccinium vitis–idaea	.	.	.	.	0.2–5
Acer pseudoplatanus	.	1–10	1–5	.	0.5–1
Fagus sylvatica	.	.	5–10	1–10	.
Betula pendula	.	.	1–5	.	.

Solidago virgaurea s.l., *Homogyne alpina*, *Deschampsia cespitosa*, *Sorbus aucuparia*, *Vaccinium myrtillus*, *Rhododendron ferrugineum*, *Dryopteris dilatata*, *Athyrium distentifolium*, *A. filix-femina* and other species (Table 2 and vegetation survey Tschamut in the Supplements E–E5). At this Tschamut site, J. Braun-Blanquet did a vegetation record (site no. 21, see BRAUN-BLANQUET 1973). At the next southern sites, green alder is present, but only with a mean cover of 5–12%. The alliance and accessory species of *Alnetum viridis* are more or less absent. So, *Alnetum viridis* is any more represented to the South. Now, *A. viridis* is associated with *S. aucuparia*, forming S-Alpine green alder-mountain ash forests. Mountain ash reaches a 25–80% level of cover (Table 2) in the vegetation records of Mte Lema, Mte Morissolo, I Balmit and Mottarone.

5. Discussion

5.1 Further development of green alder-mountain ash forests

As mentioned above, the actual subalpine green alder-mountain ash forests at our Mte Morissolo and Mottarone sites represent a secondary forest community that occurs after forest clearing and a cultivation phase. After the end of the cultivation, these secondary forests will probably be replaced without human impact by a climax deciduous forest. At Mte Morissolo, for instance, by beech forest (*Fagion*, e.g. *Luzulo niveae-Fagetum typicum*), see succession model (Fig. 6). At the Mottarone site, the actual green alder-mountain ash secondary forest will later probably be replaced by a beech-silver fir forest or possibly by a birch-common oak forest, according to the survey to the potential natural vegetation of the S-Alps by SCHRÖTER & SCHMID (1956). According to our vegetation surveys of Mte Lema and I Balmit, the green alder-mountain ash forest represents a stable community at sites which are unfavourable for beech or other deciduous trees and coniferous species (e.g. silver fir). In this case, the green alder-mountain ash forest takes the position of an established community or a climax forest community.

5.2 Phytosociological aspects

Many mountain ash forest communities of Switzerland, Germany, Austria and France have been investigated and documented so far: e.g. MOOR 1947, 1952; RICHARD 1968b, PASSARGE 1987, LEIBUNDGUT 1991, HARI et. al. 1993, POTT 1995, BRÄNDLI 1996, MAIER 1997, OBERDORFER 2001, CARRARO 2010, STEIGER 2010, MUCINA et. al. 2016 and others. Mountain ash occurs in 55 out of a total of 71 Swiss forest communities, but only in shrub layers having a degree of cover of 25–76% (ELLENBERG & KLÖTZLI 1972, KELLER et. al. 1998). In the Swiss South Alps, mountain ash was recorded in the following forest communities: *Luzulo niveae-Fagetum typicum* Ellenberg et Klötzli 1972, *Luzulo niveae-Fagetum dryopteridetosum* Ellenberg et Klötzli 1972, *Streptopo-Fagetum* Ellenberg et Klötzli 1972, *Calamagrostio villosae-Abietetum* Ellenberg et Klötzli 1972 and *Arunco-Fraxinetum castanosum* Rehder, Ellenberg et Klötzli 1972, (ELLENBERG & KLÖTZLI 1972, KELLER et. al. 1998). HARI et. al. (1993, p. 24) provisionally named in their forest vegetation investigations of Mte Lema-Mte Gradiccioli-Mte Tamaro (Malcantone, Ticino) the green alder-mountain ash forest community "*Alnetum viridis-Sorbetum aucupariae*". CARRARO (2010) and STEIGER (2010) for the same forest community use the name "*Alno viridi-Sorbetum aucupariae* prov.". In Steiger's book about the Swiss forests he mentioned the following localities with green alder-mountain ash forests: In Ticino Mte Tamaro, Val Colla, Sopraceneri, and in the Misox valley (Grisons) Cima delle Cicogne (2015 m a.s.l.) above Roveredo. CARRARO (2010) in his manual about the forest communities of the Canton Ticino says green alder-mountain ash forests are present at different localities in 1500–1800 m, exposed from NW to NE. While *Larix decidua* dominates in the tree layer, the shrub layer consists of mountain ash, green alder and Alpine rose. The herb layer is identical to our vegetation records from Mte Lema to Mottarone. According to CARRARO (2010), the "*Alno viridi-Sorbetum aucupariae* prov." represents a pioneer forest community, mainly on slopes having green alder, which are affected by avalanches. In Carraro's opinion, climax coniferous forests of *Larix decidua*, *Abies alba*, *Picea abies* and eventually *Pinus cembra* will later replace the green alder-mountain ash forests of Sopraceneri (N-Ticino). Based on the above-cited publications to the phytosociological name of S-Alpine green alder-mountain ash forests and according to the first description by HARI et. al. (1993) in the Swiss S-Alps we propose to establish this forest community as *Alno viridi-Sorbetum aucupariae* Hari, Leisinger et Zysset 1993.

In Table 3 the degree of constancy of association, index and alliance species of green alder-mountain ash forests are shown for the Mte Lema, Mte Morissolo and I Balmit sites. The herbaceous undergrowth at these sites consists of two dominant small-reed species (*Calamagrostis villosa* and *C. arundinacea*) having a mean cover range of 5–50% (Table 2). At all three sites, *C. villosa* is present having consistently high degrees of presence; 27% (Mte Lema), 21% (Mte Morissolo) and 30% (I Balmit); the values for *C. arundinacea* are 20%, 21% and 30% respectively (Table 3). We therefore propose a new sub-association of

Table 3. Degree of constancy of association, index and alliance species of green adler-mountaim ash forests (sites Mte Lema, Mte Morissolo and I Balmit; in brackets number of vegetation surveys).

Tabelle 3. Stetigkeiten von Assoziations-, Charakter- und Verbands-Arten der Grünerlen-Vogelbeeren-Wälder (Standorte Mte Lema, Mte Morissolo und I Balmit; in Klammern Zahl der Vegetationsaufnahmen).

Association, index and alliance species	Mte Lema (27)	Mte Morissolo (23)	I Balmit (30)
Sorbus aucuparia	27	23	30
Alnus viridis	24	15	30
Vaccinium myrtillus	26	22	28
Rhododendron ferrugineum	22	20	15
Calamagrostis villosa	27	21	30
Calamagrostis arundinacea	20	21	30
Avenella flexuosa	27	23	28
Maianthemum bifolium	24	22	29
Luzula nivea	12	21	29
Luzula sylvatica agg.	5	8	4
Oxalis acetosella	27	22	15
Anemone nemorosa	15	4	4
Homogyne alpina	3	0	16
Phegopteris connectilis	26	22	29
Athyrium distentifolium	23	22	25
Athyrium filix-femina	0	19	26
Dryopteris dilatata	26	7	17

Alno viridi-Sorbetum aucupariae having dense herbaceous undergrowth of *C. villosa* and *C. arundinacea* as index species, which will be called *Alno viridi-Sorbetum aucupariae calamagrostietosum*. Further phytosociological research having more case studies is needed in the S-Alps of Ticino and N-Italy to better establish the *Alno viridi-Sorbetum aucupariae* as an established plant community (secondary or climax forest community) and to determine definitively the proposed new green alder-mountain ash forest sub-association.

Erweiterte deutsche Zusammenfassung

Einleitung – Die Vogelbeere (*Sorbus aucuparia*) ist nahezu in ganz Europa vom Meeresspiegel bis zur Waldgrenze von Spanien, gegen Osten bis zum Kaukasus und darüber hinaus bis Sibirien und China verbreitet. Die europäische N-Grenze wird in N-Norwegen bei 71° N erreicht. Allgemein kommt die Vogelbeere auf sauren, trocken bis feuchten, mässig nährstoffeichen Böden vor. Auf kalkreichen Böden wird die Vogelbeere durch *S. aria* ersetzt. Die Vogelbeere bildet oft Sekundärwälder zusammen mit Grün-Erle, Rotem Holunder, Hänge-Birke, Faulbaum und einigen Weidenarten. Bisweilen kann die Vogelbeere in Sekundärwäldern in der Baumschicht vorkommen; meistens ist der Baum in Klimaxwäldern lediglich in der Strauchschicht vertreten. In der subalpinen Stufe der Alpen tritt der Baum regelmässig im Grünerlenbusch und im Lärchen-Arvenwald auf. In den S-Alpen (Tessin und N-Italien) kann *S. aucuparia* an der oberen Waldgrenze in N-Exposition jedoch in über 1500 m Reinbestände mit Grün-Erlen bilden.

Material und Methoden – In dieser Studie wurden in einem N-S-Transekt von den Schweizer Zentralalpen (Graubünden) zu den S-Alpen (Tessin und N-Italien, Prov. Verbano-Cusio-Ossola) pflanzenökologische und -soziologische Aspekte dieser Grünerlen-Vogelbeerenwaldgesellschaft untersucht. Folgende Aspekte zur Vogelbeerenverbreitung in den S-Alpen wurden berücksichtigt: Standortbedingungen, lokale Verbreitung, Naturverjüngung, Altersstruktur der Bestände, Schädlingsbefall, Grünerlen-Vorkommen im N-S-Transekt, die Rolle der Vogelbeere im Sekundär- und Klimaxwald sowie pflanzensoziologische Aspekte. Der N-S-Transekt umfasst die Standorte Tschamut (Graubünden), Mte Lema (Tessin), ferner in N-Italien Mte Morissolo, I Balmit/Mte Zeda und Mottarone (oberhalb Stresa). Der Standort Tschamut weist kühl-kontinentales Klima auf, die übrigen Standorte befinden sich im insubrischen Klimabereich. Während in Tschamut Grünerlenbusch mit einzelnen Vogelbeeren dominiert, wachsen an den südalpinen Standorten Sekundär- oder Klimax-Grünerlen-Vogelbeerenwälder.

Ergebnisse – Die Untersuchungsresultate zeigen, dass *Sorbus aucuparia* unterhalb der natürlichen Buchenobergrenze in ca. 1500 m nicht konkurrenzkräftig ist, wie dies im Sekundärwald Mte Morissolo festgestellt wurde. An diesem potenziellen Buchenwald-Standort wird die Vogelbeere im Verlauf der Sekundärsukzession durch die Buche als Klimax-Baumart abgelöst werden. Die Grünerlen-Vogelbeerenwälder von Mte Lema und I Balmit liegen über der natürlichen Buchenobergrenze und können als Klimaxwälder betrachtet werden. An allen Standorten konnte eine schwache oder fehlende generative Fortpflanzung der Vogelbeere festgestellt werden. Eine Erklärung hierfür könnte in der dichten Reitgras-Rasenschicht (*Calamagrostis villosa* und *C. arundinacea*) liegen, die einen Aufwuchs von Vogelbeeren-Sämlingen weitgehend hemmen dürfte. Als weitere Ursachen kommen u.a. verspätete Samenkeimung, Wildverbiss, Insektenfrass und Pilzbefall in Frage. Die Ausbreitung durch Stockausschläge ist eine wichtige vegetative Überlebensstrategie, denn an einigen Standorten wurde eine grosse Anzahl (125 Stämme) von mehrstämmigen Bäumchen beobachtet, insbes. auf N-exponierten Bergflanken. 25 bis 50 auf Jahrringe untersuchte Vogelbeerbäume pro Standort wiesen ein mittleres Alter zwischen 40 und 55 Jahren auf. Am Mte Lema wurde die breiteste Baumalter-Verteilung mit den ältesten Bäumen aller Standorte festgestellt. Am Mte Morissolo und I Balmit wurden ähnliche Baum-Durchschnittsalter von ca. 50 Jahren gemessen, während auf Mottarone die Bäume deutlich jünger sind. Die Grün-Erle und Vogelbeere kommen zusammen sowohl im *Alnetum viridis* als auch in Grünerlen-Vogelbeerenwäldern vor. Während die Vogelbeere im Grünerlenbusch nur als Einzelbaum auftritt, kann die Grün-Erle in beiden Pflanzengesellschaften höhere Deckungsgrade erreichen. Jedoch an den südlichsten Standorten ist die Grün-Erle im Mittel mit nur 5–12 % Deckung vertreten, dies wohl bedingt durch trockenere Standort- und/oder lokale Klimabedingungen. Infolge unregelmässiger Niederschlagsverteilung und dadurch trockenerem Bestandesklima fehlen dort weitgehend die Hochstaudenarten des Grünerlenbuschs. So ist das *Alnetum viridis* an unseren S-Alpen-Standorten nicht realisiert, und die Grün-Erle ist Teil der südalpinen Grünerlen-Vogelbeerenwälder, wo *Sorbus aucuparia* 25–80 % Deckung erreicht.

Diskussion – Gemäss früherer provisorischer Vorschläge zur pflanzensoziologischen Benennung der südalpinen Grünerlen-Vogelbeerenwälder schlagen wir auf Grund der ersten Beschreibung aus den S-Alpen (HARI et al. 1993) den Gesellschaftsnamen *Alno viridi-Sorbetum aucupariae* Hari, Leisinger et Zysset 1993 vor. Auf den trockensten Standorten wird die Krautschicht von Gräsern dominiert, v. a. Reitgras-Arten (*Calamagrostis* spec.) und Draht-Schmiele (*Avenella flexuosa*). Gemäss unseren Vegetationsaufnahmen wird eine neue Subassoziation *Alno viridi-Sorbetum aucupariae calamagrostietosum* subass. nov. vorgeschlagen.

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Author contribution statement

Conradin A. Burga started the research project, did the experimental design, supervised the fieldwork, did the plant ecological analyses, created the manuscript and did the revision. Stefan Bührer did the experimental design, carried out the relevés on the field, identified vascular plant species, did investigations to mountain ash rejuvenation, tree age structure and created some figures and did all photos. Frank Klötzli contributed with his many years of experience and expertise in Swiss forest ecology and plant sociology.

Supplements

Additional supporting information may be found in the online version of this article.

Zusätzliche unterstützende Information ist in der Online-Version dieses Artikels zu finden.

Supplement E1. Vegetation surveys Tschamut (Grisons, Switzerland) July 2005.

Anhang E1. Vegetationsaufnahmen Tschamut (Graubünden, Schweiz) Juli 2005.

Supplement E2. Vegetation surveys Monte Lema (Ticino, Switzerland) July 2005.

Anhang E2. V Monte Lema (Ticino, Schweiz) Juli 2005.

Supplement E3. Vegetation surveys Monte Morissolo (above Cannero/Lago Maggiore) August 2005.

Anhang E3. Vegetationsaufnahmen Monte Morissolo (oberhalb Cannero/Lago Maggiore) August 2005.

Supplement E4. Vegetation surveys I Balmit, Monte Zeda (N Intra, Val Grande, Italy) July 2005.

Anhang E4. Vegetationsaufnahmen I Balmit, Monte Zeda (N Intra, Val Grande, Italien) Juli 2005.

Supplement E5. Vegetation surveys Mottarone (above Stresa, Italy) August 2005.

Anhang E5. Vegetationsaufnahmen Mottarone (oberhalb Stresa, Italien) August 2005.

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Supplement E1. Vegetation surveys Tschamut (Grisons, Switzerland) July 2005.

Anhang E1. Vegetationsaufnahmen Tschamut (Graubünden, Schweiz), Juli 2005.

Vegetation survey no.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29
Altitude (m a.s.l.)	1894	1905	1921	1927	1929	1934	1946	1943	1932	1927	1923	1907	1902	1893	1901	1895	1883	1879	1887	1892	1896	1904	1900	1893	1893	1889	1881	1572	1879
Exposition	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
Tree layer																													
Sorbus aucuparia	23	3	.	.	4	3	.	.	1	.	.	21	.	.	.	1	.	.	3	.	.	23	.	.	.	3	.	22	.
Shrub layer																													
Alnus viridis	3	3	5	5	3	4	5	5	5	5	5	5	3	4	5	4	4	5	1	5	5	4	5	3	4	3	4	3	5
Tall perennial herbs																													
Adenostyles alliariae	1	+	1	1	23	21	21	23	.	1	21	21	23	3	22	22	22	21	1	1	1	22	21	21	1	r	1	21	1
Cicerbita alpina	21	1	1	1	1	1	1	23	1	21	22	21	23	22	1	21	21	21	21	21	21	1	23	1	1	r	r	21	1
Pseucedanum ostruthium	.	.	.	1	1	21	1	21	.	+	1	1	21	1	1	1	21	21	r	1	1	1	+	+	21	21	21	1	21
Chaerophyllum hirsutum agg.	.	.	.	+	.	.	.	.	.	.	.	.	21	1	1	1	r	1	.	.	.	.	.	.	.	.	1	+	.
Anthriscus sylvestris	.	.	+	.	.	.	+	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Acontium vulparia agg.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	1	.	r	1	.
Acontium napellus agg.	.	.	.	.	r	.	.	.	.	.	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Geranium sylvaticum	.	.	r	r	.	.	+	.	.	.	.	+	.	1	r	.	.	.	.	.	.	.	.	.	1	+	+	1	+
Gentiana punctata	.	.	.	.	.	.	.	.	.	+	1	.	.	.	.	.	.	.	.	.	.	1	+	.	.	.	.	+	.
Veratrum album subsp. *lobelianum*	21	1	21	21	+	1	22	21	1	21	22	1	+	1	1	21	1	1	1	+	1	1	1	.	21	21	21	1	21
Herbaceous layer																													
Achillea macrophylla	1	.	+	+	+	1	1	+	r	1	1	1	1	.	.	1	+	1	1	1	+	1	1	1	1	1	2	+	r
Stellaria nemorum s.l.	1	+	1	1	+	.	.	.	.	.	.	.	1	21	21	1	1	1	1	1	.	.	1	1	1	1	21	21	+
Saxifraga rotundifolia	.	+	r	1	+	.	.	+	.	+	.	1	1	+	1	1	+	+	+	.	.	.	.	.	1	.	+	1	1
Saxifraga aizoides	.	+	+	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Saxifraga stellaris	.	.	.	.	.	.	.	.	r	r	r	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Alchemilla xanthochlora agg.	.	.	.	+	.	.	.	+	.	.	.	.	1	1	.	1	+	1	.	.	.	1	.	.	+	.	1	.	1
Viola biflora	+	+	.	1	+	1	23	23	.	1	22	1	1	+	+	1	21	1	1	1	+	21	1	+	1	+	1	1	21
Rumex alpestris	21	22	1	.	1	1	.	+	21	21	1	21	.	+	1	21	1	21	1	1	1	r	1	1	1	21	1	.	+
Oxalis acetosella	+	+	+	.	1	1	.	.	+	r	1	.	.	+	.	+	1	1	1	1	+	1	.	.	.	+	+	1	+
Sorbus aucuparia seedlings	+	.	.	.	1	1	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	1	.	.	.	1	.	+	.
Avenella flexuosa	+	.	.	.	+	.	.	.	.	+	.	.	.	.	.	.	.	r	.	.	.	.	.	.	1	.	.	.	.
Poa nemoralis	+	+	1	1	+	.	1	.	+	1	1	1	1	1	+	+	1	1	+	.	.	1	+	.	.	1	+	.	.
Deschampsia cespitosa	.	1	1	1	.	.	.	.	r	r	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Luzula alpinopilosa	.	r	r	.	.	.	.	.	.	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Carex frigida	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Carex flava agg.	.	.	.	r	.	.	.	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Anthoxanthum alpinum	.	.	.	.	.	.	.	.	.	.	r	.	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Homogyne alpina	.	r	.	.	.	1	.	.	.	1	+	.	.	.	.	.	1	1	.	.	+	.	+	.	.	.	+	.	+
Polygonatum verticillatum	.	.	.	+	.	.	.	.	.	.	.	.	r	r	.	.	r	.	.	.	.	.	.	.	.	.	.	.	.
Caltha palustris	.	.	.	+	.	.	.	+	.	.	.	.	r	+	.	.	r	.	.	.	.	+	.	.	.	.	.	.	r
Dactylorhiza fuchsii	.	.	.	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Carum carvi	.	.	.	.	.	+	1	1	.	1	1	.	.	+	.	.	1	r	.	r	+	1	1	+	.	.	.	.	.
Ranunculus platanifolius	.	.	.	.	.	.	1	21	.	1	.	.	21	1	+	+	1	.	.	.	.	1	.	.	.	.	.	.	.
Trollius europaeus	.	.	.	.	.	.	r	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.
Ranunculus acris s.l.	.	.	r	.	.	.	.	r	.	.	.	.	.	.	.	.	.	r	.	.	.	.	.	.	.	.	r	.	.
Silene dioica	.	.	.	r	r	r	.	.	.	.	.	.	.	.	r	.	.	.	+	+	.	.	.	.	.	.	.	.	.
Pedicularis recutita	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	r	.	.	.
Bellidiastrum michelii	.	.	.	.	.	.	.	.	.	r	.	.	.	.	.	+	.	+	.	.	.	.	.	.	.	.	.	.	.
Solidago virgaurea s.l.	.	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	r	r	.	.
Allium schoenoprasum	.	.	r	.	.	.	.	r	r	.	.	.	.	.	.	.	.	.	r	r	.	r	.	.	.	.	.	.	.
Potentilla aurea	.	r	.	.	.	.	.	r	.	.	.	.	.	.	.	.	.	.	r	.	.	.	r	.	.	.	.	.	.
Petasites albus	.	.	r	.	.	.	.	.	.	.	.	.	.	.	.	.	+	r	.	.	.	.	.	.	.	.	.	.	r
Dwarf shrubs																													
Vaccinium myrtillus	1	1	.	1	22	21	+	1	1	.	1	21	.	+	.	.	.	1	1	1	+	21	+	.	1	1	+	1	+
Rhododendron ferrugineum	.	.	.	.	.	23	.	.	.	+	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	1	1	1	.
Ferns																													
Athyrium distentifolium	4	4	5	4	3	.	3	23	4	4	3	22	23	3	4	.	21	4	5	3	5	3	4	5	4	4	.	.	4
Athyrium filix-femina	.	21	1	21	.	.	.	21	1	1	.	.	1	.	1	3	21	.	.	21	.	.	21	1	3	1	.	.	1
Dryopteris dilatata	.	1	1	1	.	.	.	1	.	1	.	.	.	.	1	.	21	21	.	1	1	.	.	1	1	.	.	.	.

Supplement E2. Vegetation surveys Monte Lema (Ticino, Switzerland) July 2005.

Anhang E2. Vegetationsaufnahmen Monte Lema (Ticino, Schweiz) Juli 2005.

Vegetation survey no.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27
Altitude (m a.s.l.)	1546	1550	1553	1549	1555	1555	1554	1541	1540	1542	1545	1548	1540	1535	1535	1535	1535	1532	1532	1532	1532	1531	1531	1571	1572	1578	1581
Exposition	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
Tree layer																											
Acer pseudoplatanus	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	23	.	1	1	.
Picea abies	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1
Sorbus aria	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.
Sorbus aucuparia	4	4	4	3	4	3	4	4	4	4	5	4	5	4	4	3	3	3	3	4	5	3	4	5	5	3	5
Shrub layer																											
Acer pseudoplatanus	.	.	.	.	.	.	.	21	.	.	1	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.
Alnus viridis	21	23	22	21	21	21	21	1	.	.	22	22	21	1	22	21	r	1	22	22	21	23	21	23	22	.	3
Herbaceous layer																											
Acer pseudoplatanus seedlings	.	.	.	.	.	.	.	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.
Alnus viridis seedlings	.	.	r	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Anemone nemorosa	1	+	+	r	.	+	.	.	.	.	.	r	+	r	.	.	r	.	.	+	r	r	1	+	.	.	+
Avenella flexuosa	+	1	1	+	1	+	1	+	+	r	1	1	+	1	1	1	+	+	1	+	1	1	1	1	1	1	1
Calamagrostis arundinacea	21	.	.	1	21	.	+	+	.	+	.	+	1	+	1	+	+	22	.	1	+	+	.	+	+	+	+
Calamagrostis villosa	21	3	3	1	5	4	3	23	23	23	4	4	21	21	21	1	1	4	21	3	23	1	22	3	23	1	1
Deschampsia cespitosa	1	1	+	+	22	1	1	+	+	3	1	1	+	+	1	21	21	+	+	1	1	1	+	+	22	23	3
Homogyne alpina	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	+	.
Luzula nivea	r	+	.	.	.	1	r	.	.	.	.	.	+	.	21	1	.	+	+	.	.	1	.	.	r	21	.
Luzula pilosa	1	1	1	+	+	+	1	+	r	+	1	r	21	1	1	.	1	1	+	1	21	1	1	+	r	.	+
Luzula silvatica agg.	r	r	.	.	.	.	.	.	.	.	r	.	.	.	.	.	.	r	.	.	.	.	.	r	.	.	.
Majanthemum bifolium	1	1	.	.	+	1	r	r	+	r	1	1	+	+	+	+	+	r	+	r	.	r	1	1	21	21	1
Oxalis acetosella	1	+	1	1	+	+	1	1	1	1	+	1	1	1	+	+	1	1	+	+	1	21	1	1	21	1	21
Paris quadrifolia	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	r	.	.	.	.
Polygonatum verticillatum	+	.	+	+	+	.	.	1	.	+	.	r	.	.	r	.	.	+	+	+	+	.	.	+	.	.	r
Ranunculus platanifolius	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	r	.	.	.	.	.	.	.
Rosa gallica	.	.	.	.	.	.	.	.	.	.	.	.	.	1	r	.	.	.	.	.	.	.	.	.	.	.	.
Rubus idaeus	.	+	.	.	.	+	.	r	r	r	.	.	1	.	.	+	.	.	.	.	.	+	1	.	.	.	r
Senecio ovatus	.	.	.	.	.	.	.	.	.	.	.	.	r	.	.	.	.	.	.	.	.	.	1	.	.	.	.
Sorbus aucuparia	.	.	r	.	.	.	.	.	.	.	r	.	.	r	.	r	.	.	.	.	r	.	.	.	.	.	r
Urtica dioica	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	r	.	.
Veratrum album subsp. *lobelianum*	+	.	.	.	.	r	.	r	.	.	r	.	+	.	.	.	.	r	.	r	.	.	.	.	.	.	.
Dwarf shrubs																											
Rhododendron ferrugineum	21	21	21	4	21	.	21	3	3	23	+	.	+	+	3	5	5	23	5	3	.	4	3	+	.	21	.
Vaccinium myrtillus	3	21	22	21	21	+	+	+	+	1	+	r	21	22	21	22	+	21	21	21	.	21	+	1	22	23	22
Ferns																											
Asplenium adiantum-nigrum	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.
Athyrium distentifolium	21	1	+	+	.	21	+	1	+	+	.	1	1	+	+	+	+	+	.	22	21	+	+	.	+	+	1
Dryopteris carthusiana	.	.	r	.	.	.	.	.	+	.	.	.	.	r	.	.	.	.	.	.	.	.	.	.	.	.	.
Dryopteris dilatata	21	22	1	+	.	21	21	1	21	22	21	21	1	1	1	+	r	+	+	+	+	1	+	1	1	1	1
Gymnocarpium dryopteris	.	.	r	r	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Phegopteris connectilis	1	+	1	+	.	1	1	r	1	1	+	+	1	+	1	+	r	+	+	+	1	1	21	1	1	21	1

Supplement E3. Vegetation surveys Monte Morissolo (above Cannero/Lago Maggiore) August 2005.

Anhang E3. Vegetationsaufnahmen Monte Morissolo (oberhalb ve Cannero/Lago Maggiore) August 2005.

Vegetation survey no.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
Altitude (m a.s.l.)	1272	1274	1291	1299	1310	1310	1310	1290	1270	1272	1291	1295	1295	1281	1283	1275	1284	1286	1289	1289	1319	1319	1320
Exposition	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
Tree layer																							
Sorbus aucuparia	4	4	4	4	4	22	3	4	3	22	4	3	4	3	5	4	4	21	3	21	3	4	5
Acer pseudoplatanus	.	.	.	1	1	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	1	.
Fagus sylvatica	.	.	.	.	.	.	.	.	21	22	.	.	.	.	1	.	.	.	.	.	.	.	.
Sorbus aria	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.
Betula pendula	.	.	1	1	.	.	21	.	.	.	.	.	.	1	.	.	.	1	.	.	.	.	.
Shrub layer																							
Alnus viridis	1	1	.	1	.	1	1	1	1	1	1	1	.	.	.	1	1	1	.	r	.	21	.
Fagus sylvatica young growth	1	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Tall perennial herbs																							
Veratrum album subsp. *lobelianum*	.	.	.	.	.	.	.	r	.	.	.	.	1	1	.	+	1	.	.	.	.	.	.
Herbaceous layer																							
Calamagrostis arundinacea	5	1	21	+	21	1	1	+	3	1	21	.	21	21	1	3	1	1	21	21	1	.	1
Calamagrostis villosa	1	5	4	4	.	23	21	3	1	23	23	.	21	21	4	1	1	3	22	4	21	22	+
Deschampsia cespitosa	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Avenella flexuosa	1	1	+	+	+	1	1	1	1	1	1	1	1	1	+	1	1	1	+	1	1	1	1
Poa nemoralis	1	23	1	3	21	1	21	21	2	21	1	1	21	22	21	23	4	1	21	1	3	22	21
Majanthemum bifolium	r	r	+	+	+	+	+	1	+	+	+	+	+	+	+	.	+	+	r	+	+	1	+
Rubus idaeus	.	+	1	.	+	.	.	.	+	+	+	+	r	+	1	1	+	+	r	+	.	+	r
Rubus fruticosus agg.	.	.	.	.	r	.	.	.	r	.	r	.	.	.	.	.	.	.	r	.	.	r	r
Luzula nivea	1	1	1	1	1	+	+	+	+	+	+	r	+	1	+	1	+	+	r	+	.	1	.
Luzula sylvatica agg.	+	+	r	.	.	r	.	.	.	r	+	.	.	.	.	.	.	.	.	+	.	+	.
Oxalis acetosella	.	r	r	+	+	r	+	+	r	r	+	r	r	+	+	+	+	+	r	r	+	+	+
Polygonatum verticillatum	.	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Anemone nemorosa	.	.	r	.	.	.	r	r	.	.	.	.	.	r	.	.	.	.	.	.	.	.	.
Sorbus aucuparia seedlings	.	.	.	.	.	.	.	.	.	r	.	.	.	.	.	.	.	.	.	.	.	.	.
Acer pseudoplatanus seedlings	.	r	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Stellaria nemorum s.l.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	r	r
Viola biflora	.	+	.	.	.	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Homogyne alpina	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	r	.	.	.	.
Fagus sylvatica seedlings	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Dwarf shrubs																							
Vaccinium myrtillus	21	1	1	21	1	+	1	1	1	1	+	1	1	21	1	.	+	21	+	1	1	1	1
Rhododendron ferrugineum	1	1	21	.	21	4	4	23	3	.	.	4	21	21	21	21	21	3	4	23	4	23	5
Ferns																							
Athyrium distentifolium	1	1	1	1	+	1	.	1	21	1	21	+	1	1	1	1	+	1	1	+	+	+	1
Athyrium filix-femina	1	1	+	1	+	r	.	1	+	1	1	.	+	+	1	+	r	+	r	.	.	r	+
Dryopteris dilatata	1	.	+	.	r	.	.	.	.	+	r	.	.	.	.	.	.	.	.	.	r	+	.
Phegopteris connectilis	21	21	1	21	1	r	.	1	1	r	1	1	21	1	1	1	1	1	1	1	1	1	1
Cystopteris fragilis	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	r	.

Supplement E4. Vegetation surveys I Balmit, Monte Zeda (N Intra, Val Grande, Italy) July 2005.

Anhang E4. Vegetationsaufnahmen I Balmit, Monte Zeda (N Intra, Val Grande, Italien) Juli 2005.

Vegetation survey no.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
Altitude (m a.s.l.)	1490	1490	1490	1490	1490	1490	1495	1500	1505	1510	1515	1520	1525	1530	1535	1540	1545	1550	1555	1560	1559	1558	1556	1550	1547	1545	1540	1535	1528	1518
Exposition	NE	NE	NE	NE	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	NE	NE	NE	NE	NE	NE	NE
Tree layer																														
Sorbus aucuparia	4	3	4	3	4	1	4	3	4	23	3	3	3	3	21	4	4	3	4	23	4	4	4	22	4	4	4	3	3	4
Acer pseudoplatanus young growth	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Fagus sylvatica	.	.	.	.	1	4	.	1	.	.	23	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Shrub layer																														
Alnus viridis	1	+	+	1	21	+	1	2	r	2	+	23	21	21	21	1	+	1	+	1	21	21	23	3	21	1	+	1	1	r
Acer pseudoplatanus young growth	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Tall perennial herbs																														
Senecio ovatus	.	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	r	.	.	.
Gentiana purpurea	.	.	.	.	.	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Veratrum album subsp. *lobelianum*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	r	1	.	.	.	.	.	.	.	.	.	.
Herbaceous layer																														
Calamagrostis arundinacea	4	4	3	3	3	3	23	3	5	3	4	3	3	3	3	3	3	3	5	4	4	4	3	23	4	4	5	4	5	4
Calamagrostis villosa	1	1	1	1	+	+	+	+	1	1	1	+	1	+	+	1	1	1	1	1	1	1	1	+	1	1	+	+	1	1
Deschampsia cespitosa	.	.	.	+	+	r	+	+	+	+	+	+	+	+	+	+	1	.	+	+	21	+	+	+	+	+	r	+	+	+
Avenella flexuosa	+	+	.	r	+	+	+	+	+	+	+	r	+	.	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
Majanthemum bifolium	r	+	+	+	+	r	+	+	+	+	+	+	+	+	.	+	+	+	+	+	+	+	+	+	.	1	+	+	+	+
Rubus idaeus	+	1	.	+	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	r	.
Rubus fruticosus agg.	.	.	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Luzula nivea	+	+	+	+	r	r	+	+	+	.	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
Luzula sylvatica agg.	.	.	.	.	.	.	.	.	.	.	.	.	r	+	.	+	.	.	.	.	.	.	.	.	.	.	.	.	+	.
Oxalis acetosella	r	+	r	+	.	.	r	.	+	.	.	r	+	+	+	.	.	.	.	.	r	.	.	.	.	+	+	+	.	r
Polygonatum verticillatum	r	.	+	+	+	r	.	r	.	.	.	.	.	r	r	+	+	+	+	+	+	r	.	+	+	.	+	+	+	+
Anemone nemorosa	r	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	r	.	.	.	.	.	.	r	.	.	.
Sorbus aucuparia seedlings	.	.	.	.	.	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Homogyne alpina	.	r	.	.	+	r	+	+	+	+	.	.	.	.	.	r	.	.	r	+	+	.	.	r	r	.	.	.	.	+
Solidago virgaurea s.l.	1	.	.	r	r	.	+	r	r	+	.	.	1	1	.	1	1	1	.	+	+	.	r	r	.	.	r	.	.	r
Stellaria nemorum subsp. *montana*	.	+	+	.	.	.	.	.	.	r	r	.	.	r	.	.	.	+	+	.	.	.	.	.	r	r	r	.	r	.
Convallaria majalis	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.
Phyteuma hemisphaericum	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	r	.	.
Dwarf shrubs																														
Vaccinium myrtillus	+	.	1	+	+	1	+	+	+	+	+	r	1	r	+	+	+	1	.	1	+	+	+	+	+	+	+	+	+	+
Rhododendron ferrugineum	.	.	r	+	1	+	21	21	.	+	.	.	.	.	1	22	22	23	.	+	.	.	.	22	+	.	.	1	.	.
Ferns																														
Athyrium distentifolium	.	+	+	23	+	1	+	+	r	+	+	+	1	23	23	.	.	+	.	+	+	+	.	+	+	+	+	+	r	+
Athyrium filix-femina	+	+	+	+	+	+	+	r	+	1	1	+	+	+	+	.	+	.	.	r	+	r	.	+	+	+	r	r	+	+
Dryopteris dilatata	.	.	.	.	.	+	+	.	r	+	+	1	+	+	+	+	.	.	.	+	r	r	.	+	r	.	.	.	r	+
Phegopteris connectilis	+	+	+	+	+	+	+	+	+	1	+	+	+	+	+	+	+	+	+	+	+	+	.	+	+	+	+	+	+	+

Supplement E5. Vegetation surveys Mottarone (above Stresa, Italy) August 2005.

Anhang E2. Vegetationsaufnahmen Mottarone (oberhalb Stresa, Italy) August 2005.

Vegetation survey no.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29
Altitude (m a.s.l.)	1440	1438	1437	1436	1436	1437	1438	1438	1439	1439	1440	1441	1442	1443	1434	1435	1437	1438	1439	1430	1431	1432	1432	1433	1434	1433	1433	1434	1435
Exposition	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
Tree layer																													
Sorbus aucuparia	5	5	5	5	4	5	4	4	5	5	5	5	5	5	5	5	5	4	5	5	5	5	5	5	4	5	5	5	5
Acer pseudoplatanus	.	.	.	.	21	.	1	.	.	.	.	.	.	+	1	1	.	.	.	.	.	.	.	+	.	.	.	1	.
Laburnum alpinum	.	.	.	.	.	.	.	1	.	1	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.
Fraxinus excelsior	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.
Picea abies	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	+	.	.
Shrub layer																													
Alnus viridis (incl. *A. brembana)*	1	+	+	22	r	.	r	.	1	+	+	+	1	1	21	+	1	1	1	1	1	21	1	1	21	1	+	21	21
Laburnum alpinum young growth	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Fraxinus excelsior young growth	.	.	.	.	.	.	.	.	1	.	.	.	.	+	r	r	.	.	.	.	.	.	.	+	.	.	.	.	.
Tall perennial herbs																													
Senecio ovatus	+	+	+	+	+	1	+	r	1	+	1	+	+	+	+	1	1	1	+	+	+	+	+	+	+	1	+	r	+
Gentiana purpurea	.	.	.	.	.	.	.	.	.	.	.	r	r	.	.	+	.	.	r	r	.	.	.	+	.	.	r	.	.
Veratrum album subsp. *lobelianum*	+	+	+	1	1	r	1	+	+	+	r	+	r	+	+	1	+	+	+	+	+	+	+	+	+	1	1	+	+
Herbaceous layer																													
Acer pseudoplatanus seedlings	r	.	.	.	.	.	.	.	+	.	.	r	r	.	.	r	r	.	.	.	.	.	.	.	.	.	r	.	.
Achillea macrophylla	.	+	.	.	+	r	+	r	+	+	+	r	.	.	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Anemone nemorosa	.	.	.	r	+	r	r	.	r	r	.	.	.	r	r	r	.	.	.	.	r	.	.	r	.	.	.	.	r
Anthoxanthum odoratum agg.	r	r	r	r	.	.	.	.	.	.	.	.	.	.	.	.	.	+	+	.	.	.	.	.	.	.	.	.	.
Astrantia minor	.	.	.	.	.	.	.	.	.	.	.	r	r	r	+	+	r	r	r	r	.	.	.	.	.	.	.	.	.
Avenella flexuosa	+	+	+	+	.	+	+	r	+	+	+	.	1	+	+	+	1	21	21	23	22	21	21	1	+	+	+	+	21
Calamagrostis arundinacea	.	+	+	+	21	1	+	3	3	1	21	1	+	.	+	+	.	.	+	.	+	.	.	.	1	+	+	3	22
Calamagrostis villosa	.	.	.	.	.	.	.	.	.	.	.	+	+	+	.	.	r	r	r	.	.	1	+	+	.	.	.	.	r
Chaerophyllum villarsii	.	.	.	.	+	.	.	.	.	.	.	r	r	+	+	+	.	.	.	.	.	.	.	.	.	.	.	.	.
Convallaria majalis	+	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	+	+	r	+	.	+
Crocus albiflorus	.	+	.	+	.	+	+	.	.	.	.	+	.	.	.	+	+	.	.	.	.	.	.	.	.	+	.	.	.
Dactylorhiza fuchsii	.	.	.	.	.	.	.	.	.	.	.	.	.	.	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Deschampsia cespitosa	+	+	+	+	.	+	r	.	r	.	.	.	.	1	+	1	1	1	+	+	.	+	.	+	.	.	.	.	+
Fagus sylvatica seedlings	r	.	.	.	.	.	r	.	.	.	r	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Fragaria vesca	.	.	.	.	.	.	.	.	.	.	.	.	.	.	23	1	.	.	.	.	.	.	.	.	.	.	.	.	.
Gentiana asclepiadea	+	.	.	.	.	.	.	.	.	+	+	1	1	+	.	.	r	r	r	+	+	+	.	1	+	+	+	+	+
Homogyne alpina	.	r	.	r	.	.	.	.	.	.	.	.	r	r	.	.	.	.	.	.	+	+	.	+	.	.	+	.	.
Laburnum alpinum	.	.	.	.	.	.	.	+	+	.	.	.	.	.	.	.	.	.	.	.	r	.	.	.	.	.	.	r	.
Luzula nivea	+	+	+	+	+	+	r	r	.	+	.	.	.	r	1	+	+	+	r	.	+	+	r	+	+	+	+	.	r
Luzula sylvatica agg.	+	+	+	+	.	.	.	.	r	+	r	r	+	r	+	+	+	+	+	r	+	+	+	+	+	+	+	r	+
Majanthemum bifolium	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
Melica nutans	.	r	.	.	.	.	.	.	.	.	.	.	r	.	.	.	.	.	.	.	.	r	r	.	.	.	.	r	.
Oxalis acetosella	.	.	+	+	1	+	+	+	+	+	r	+	r	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Petasites albus	.	+	+	+	.	.	.	.	.	.	.	.	+	.	.	+	+	.	.	.	.	.	+	.	.	.	.	.	.
Polygonatum verticillatum	+	r	+	+	+	r	+	.	r	.	r	.	.	.	r	.	+	r	r	+	.	+	.	.	.	.	+	r	.
Polygonum persicaria	+	+	1	+	+	r	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	.	.	+	+	+	+	+
Prenanthes purpurea	+	.	.	+	+	r	r	r	+	.	+	.	.	r	.	r	.	.	.	+	.	.	+	.	.	.	.	.	.
Rubus fruticosus agg.	.	r	.	.	r	.	.	+	+	.	.	.	.	r	.	r	.	.	r	+	.	.	+	+	.	+	+	+	.
Rubus idaeus	.	r	.	.	.	.	.	.	+	.	+	+	+	+	r	+	+	+	+	+	.	.	+	.	.	.	.	.	.
Solidago virgaurea s.l.	+	.	r	.	.	r	r	.	.	+	+	+	.	.	.	.	.	r	r	r	.	+	.	.	+	+	+	.	r
Sorbus aucuparia seedlings	.	.	.	r	.	.	.	.	.	.	.	.	.	.	.	.	.	r	.	.	.	.	r	.	.	.	.	.	.
Tussilago farfara	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Dwarf shrubs																													
Vaccinium myrtillus	23	+	+	+	+	+	+	+	+	1	+	1	1	+	.	+	1	21	21	1	21	21	21	1	+	+	+	+	+
Vaccinium vitis-idaea	.	1	1	1	1	.	+	1	1	1	.	+	.	.	1	1	1	.	+	1	.	.	+	1	+	.	.	.	+
Rhododendron ferrugineum	1	r	+	22	.	.	.	r	r	+	1	.	.	.	.	.	.	.	21	1	23	21	22	4	3	1	21	21	22
Ferns																													
Athyrium distentifolium	.	+	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	r	.	.	.	.	.	r	.	.	.
Athyrium filix-femina	+	+	+	+	1	1	1	1	+	21	+	r	.	+	1	+	.	.	r	1	+	.	1	.	+	1	+	+	+
Dryopteris dilatata	.	.	.	.	.	.	.	+	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	r	.	.	.
Phegopteris connectilis	+	+	+	+	+	+	+	+	1	+	1	+	+	+	.	.	+	+	+	+	+	.	.	+	+	+	+	+	+