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# BRAUN-BLANQUETIA

RECUEIL DE TRAVAUX DE GEOBOTANIQUE / REVIEW OF GEOBOTANICAL MONOGRAPHS

14

## IMPACT OF TOURISM ON FLORA AND VEGETATION IN THE GRAN PARADISO NATIONAL PARK (NW ALPS, ITALY)

Consolata Siniscalco

CAMERINO
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PUBLICATION DU DEPARTEMENT DE BOTANIQUE ET ÉCOLOGIE DE L'UNIVERSITÉ DE CAMERINO ET DE LA STATION INTERNATIONALE DE PHYTOSOCIOLOGIE DE BAILLEUL SOUS L'ÉGIDE DE L'ASSOCIATION AMICALE DE PHYTOSOCIOLOGIE ET DE L'ASSOCIATION INTERNATIONALE POUR L'ÉTUDE DE LA VÉGÉTATION



## BRAUN-BLANQUETIA

Un héritage est enrichissant et ouvre de nouvelles possibilités créatrices. Mais il en découle en contre partie l'obligation de ne pas gaspiller le patrimoine reçu. Ceux qui, aujourd'hui étudient la végétation grâce à la phytosociologie peuvent utiliser des méthodologies bien au point et tirer profit d'un ensemble cohérent de connaisances.
C'est le résultat du travail méthodique de nombreux chercheurs de qualité pendant plusieurs décennies. Aujourd'hui, nous nous trouvons face à des problèmes qui ne sont sans doute pas tout à fait nouveaux mais qui paraissent infiniment plus graves que dans le passé: primauté de la technique, spécialisation, pénurie de matières premières, d'énergie et d'espace, crise de l'environnement...
Il se développe ainsi des problèmes spécifiques divers pour lesquels il est nécessaire de trouver des réponses nouvelles. Les chercheurs sont placés devant un véritable défi et il dépend de leur savoir et de leur imagination de montrer si la Science de la végétation est capable d'apporter une contribution appréciable à la solution de ces problèmes. La tradition phytosociologique dans ce contexte constitue une base essentielle. La conception typologique de la végétation et la clarté du système qui en découle, l'habitude des chercheurs de vivre en contact étroit avec la végétation, les recherches basées sur l'observation condition antithétique de l'expérimentation, sont les traits caractéristiques de la phytosociologie.
Les lignes directrices qui nous ont été transmises par les maîtres de la Science de la végétation, Josias Braun-Blanquet et Reinhold Tüxen avant tout, constituent actuellement une part importante de notre patrimoine d'idées. Notre but est de valoriser cet héritage et d'honorer la mémoire du premier de ces maîtres et fondateur de la phytosociologie moderne par une nouvelle série de publications.
Pourront y trouver place des monographies étudiant concrètement la végétation selon les enseignements de J. Braun-Blanquet et R. Tüxen qui, à travers la créativité des auteurs, produiront de nouveaux fruits. Disciples nous-mêmes de J. Braun-Blanquet et ayant collaboré à son activité, nous pensons qu'à travers cette série de publications son héritage restera vivant dans l'esprit originel et avec de nouvelles idées.

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J. BRAUN-BLANQUET, 1954
*Drawn form a photograph by Françoise M. Dansereau*

## INTRODUCTION

The present appearance of the Alps reflects more than two thousand years of human activity that has deeply altered both the environment as a whole and the vegetation in particular.

Forestry and pasture were and are rarely destructive in themselves, since they produce very slow changes and respect the morphology of the surroundings. They have been responsible for the typical physiognomy of an Alpine valley: mown meadows and crops on the floor, woods in less accessible areas or on slopes with a poor exposure, terraces, meadows and pastures in the more favoured zones. Today, however, human activity has both receded, to the extent that much of the land has been abandoned, and expanded in the form of a host of changes that have been introduced (mainly to promote tourism) very quickly, thanks to efficient modern equipment, with little respect for the natural limitations of the environment, and have nearly always resulted in destruction.

The main purpose of this study is to show the effects of human impact in the form of tourism on the flora and vegetation in Gran Paradiso National Park, an area whose environment and signs of past and present human activity well reflect the situation in many parts of the Western Alps. The data presented are taken from my doctoral thesis and from subsequent researches. The reason for this study is the greater use that will probably be made of protected areas for tourism and, at the same time, a growing interest in the collection of objective data for the evaluation of human impact on "natural areas". A recent report by the International Union for the Conservation of Nature and Natural Resources, in fact, points to tourism as one of the main causes of change in the Alps, along with variations in the climate, the abandonment of agricultural land, and forest degradation (BRIAND *et alii*, 1989).

One of the principal problems raised by the study was the need to get to the exact causes of changes in the flora and vegetation through isolation of the variations, in both the environment as a whole and its vegetation, due to other factors. It was thus judged desirable to establish a clear picture of the past and present use of the area and of the vegetation in comparison sites of the Park, not exposed to the influence of tourism.

## 1. HUMAN IMPACT AND VEGETATION

Until recent times, the effects of anthropization have been more evident on vegetation than on other components of the environment, so much so that human activities have been regarded as an important, and in some cases decisive factor in interpretation of the findings of phytogeographical studies. The way in which this factor is brought out, of course, greatly depends on how the relationship between man and nature is viewed. Previous attitudes throughout the centuries and in differing cultures have treated man as nature's antagonist to a greater or lesser degree, whereas the biologists of today see him as a particular, yet by no means separate component of the natural world (VAN DER MAAREL, 1980; WESTHOFF, 1983). This approach subtends most historical and social studies in which human impact is considered as one of several environmental factors. A similar line is adopted in the studies collected under the heading "Documents de la cartographie écologique", where great importance is attached to population densities, tourism, motor traffic and social and economic activities in general (GENSAC, 1972 and many subsequent papers).

The methods employed are open to immediate application, and easy-to-use data for land use management have been provided in the form of vegetation degradation scales (BARBERO *et alii*, 1973; GENSAC, 1974, 1985) and naturality scales (GIACOMINI, 1973; LAUSI *et alii*, 1978; UBALDI, 1978; VAN DER PLOEG, VAN DER VLJM, 1978; PIROLA *et alii*, 1980).

Several attempts have been made over the last forty years to formalise and define the relationship between anthropization and vegetation (THOMAS, 1956; TÜXEN, 1966; SUKOPP, 1969; DUFFEY, WATT, 1971; FUKAREK, 1979; GOUDIE, 1981; HOLZNER *et alii*, 1983; FERRARI, 1989). The concepts formulated so far are of two kinds (KOWARIK, 1990):

1) a general concept proposed by WESTHOFF (1949, 1951) and ELLENBERG (1963), and adopted by a host of later Authors, whereby the degree of anthropization of a plant community is measured in terms of its distance from a primitive state known as "Nature I", i.e. the prior vegetation not yet exposed to human influences;

2) the "hemeroby" system of JALAS (1955), as extended by SUKOPP (1972, 1976) and KOWARIK (1988), TÜXEN's "Ersatzgesellschaft" concept (1956) adopted by MIYAWAKI, FUJIWARA (1975), and LONG's "artificialisation" (1974). These Authors view the present level of human impact in relation to a future state of "self-regulation", or Nature II. For Tüxen, this state is represented by the potential vegetation, which cannot always be predicted with a good degree of certainty, whereas the "hemeroby" system sees it as the final stage of a succession, whatever this stage may be. Nature II, in fact, can even be attained in irreversibly altered sites, such as those in urban areas, where the succession leads to a final stage that has no link with the initial vegetation. Hemeroby is thus a very useful concept when examining human impact in irremediably impaired environments. In situations where the primitive vegetation is readily identifiable, on the other hand, and the post-disturbance succession is heading towards a potential vegetation, it is possible to determine the distance between the current vegetation and Nature I, and hence apply the general concept just described. In this case, of course, the same results would be given by reference to either Nature I or Nature II. When dealing with types of vegetation such as that found in the Alps, however, and with the forms of human impact described in this paper, evaluation of this distance is both possible and a more linear approach, since much is known about the local vegetation dynamics.

Several definitions and interpretations have been advanced with regard to human impact as the distance from Nature I. FALINSKI (1972 a, b, c; 1974, 1976 and 1986) uses the term "synanthropization" for the sum of the changes in the plant cover caused directly or indirectly by human activities. The nature of this directional process involves the replacement of specific (e.g. endemic) components by non-specific (cosmopolitan) ones, native (autochthonous) by newcomers (allochthonous) elements, and stenotopic by eurytopic elements.

These modifications lead to the replacement of primary systems with high homeostasis, and conditioned by the interaction of both endogenous and exogenous factors, by secondary systems with low homeostasis, and mainly influenced by the action of exogenous factors (FALINSKI, 1975).

According to KORNAS (1983), human actions alter the plant cover, i.e.

both the flora and the vegetation. A general definition of the floristic changes states that they involve:
1. extension of plants positively affected by man (hemerophilous);
2. decline of plants negatively affected by man (hemerophobous).

The vegetational changes involve:
4. expansion of hemerophilous communities;
5. decline of hemerophobous communities;
6. formation of new, anthropogenous communities.

The main floristic variations concern the diffusion of some species at the expense of others owing to their better resistance to the various kinds of disturbance. From the vegetational standpoint, the variations displayed by a secondary vis-à-vis a primary community may be qualitative and quantitative, i.e. linked to its specific diversity.

The concepts of anthropization referred to above will now be applied in the following sub-sections to examine the relations between human impact and floristic variations (1.1), the autoecological features of the species present in disturbed and undisturbed areas (1.2), species diversity (1.3) and plant community stability (1.4).

## 1.1 FLORISTIC VARIATIONS

Expansion of species that benefit from human activities (hemerophilous, according to LINKOLA, 1919) is a process which underlies many vegetational changes. There are both native hemerophiles (called "apophytes" by RIKLI, 1903) that move from natural to anthropized communities and are apophytized (KOPECKY, 1985), and exotic species (anthropophytes) that are introduced by human beings and undergo anthropophytization.

The first of these two processes is undoubtedly more frequent in the Alps, though unfortunately it is the less understood, whereas at the lower altitudes the second is very common and fairly well known. Some writers maintain that the degree of artificiality of an area is closely related to its number of exotic species (FALINSKI, 1968; JÄGER, 1988).

The list of exotics in Italy, first compiled by FIORI in 1908, and then by SACCARDO (1909), BÉGUINOT, MAZZA (1916), VIEGI *et alii* (1974) and HRUSKA (1987) is currently composed of 949 items, that for Piedmont of 282 (ABBÀ, 1980).

There are countless works on the distribution of exotic species in Europe. Those for Poland (KORNAS, 1968; KORNAS, MEDWEKA-KORNAS, 1968), Central Europe (SUKOPP, 1962, 1966) and Britain (PERRING, 1970) are among the most complete.

KORNAS (1966) and BAKER (1972) suggest that the immigration of exotics is reached via four stages, each more difficult than the one before:
- introduction of propagules;
- permanent establishment on very disturbed sites;
- colonization of slightly disturbed sites;
- colonization of undisturbed sites.

An exotic species, in fact, must overcome two selective barriers before it can establish itself and invade a community (CRAWLEY, 1987): that imposed by the climate, which is active everywhere and eliminates most hemerophiles, and that imposed by the biotic factors, especially competition. As we shall see, consideration of naturalization in terms of the "overcoming of barriers" enables it to be interpreted with reference to different altitudes.

Apophytization is of particular importance at high altitudes. At present, however, it has only been assessed in terms of quality (HRUSKA, 1987). Reduction of species negatively affected by human impact, on the other hand, is, at high altitudes, a relatively minor process.

## 1.2 AUTOECOLOGICAL FEATURES OF THE SPECIES IN DISTURBED AND UNDISTURBED AREAS

Most studies have looked at the autoecological features of genera closely associated with disturbance, such as *Poa* (LAW, 1981) and *Plantago* (NOË, BLOM, 1981). The most significant characteristics for the survival and diffusion of species in disturbed sites are related to germination and growth rate (BLOM *et alii*, 1979).

Investigations on the resistance to trampling of *Carex curvula* in the Austrian Alps (GRABHERR, 1982; GRABHERR *et alii*, 1978, 1980) has been directed to its primary production, its ability to reproduce and multiply (the latter proving far more important), and its growth rate, as expressed by the efficiency of the production of its epigeal part. Every tuft of this species, in fact, grows at a rate of about 1 mm in diameter per year, and is thus unable to occupy areas in which vegetation has been destroyed due to human impact, such as ski runs.

Investigation of species autoecology has led to the formulation by GRIME (1974, 1977, 1979) of a model that is particularly useful in interpretation of human impact on high-altitude flora. It posits two external factors that limit the amount of plant material: stress, i.e. the sum of the environmental factors that limit photosynthetic production (light, water, temperature, soil mineral nutrients), and disturbance associated with partial or total destruction of the plant biomass on the part of herbivores and pathogens, and principally as the result of human activities. The adaptive "strategies" evolved in response to these factors are defined as "groupings of similar or analogous genetic characteristics which recur widely among species or populations and cause them to exhibit similarities in ecology".

Three types of strategy have evolved in accordance with the relative intensity of the two factors:

| Intensity of disurbance | Intensity of stress: Low | High |
|---|---|---|
| Low | Competitive | Stress-tolerant |
| High | Ruderal | No viable strategy |

Ruderal species are characterised by:
- a high potential growth rate during the seedling phase;
- early flowering, often associated with self-pollination, and rapid seed ripening and release;
- allocation of most of the plant's resources to reproduction, and hence relatively limited root development in favour of the part above ground.

Competitors possess many features that enable them to monopolise nutrient capture in relatively productive, undisturbed environments:
- a relatively high growth rate;
- considerable size and a tendency to form long lateral roots and shoots;
- a high degree of variability of root and leaf shape;
- delayed seed production.

Stress-tolerators live in low-productivity habitats with scanty resources, i.e. in conditions in which some environmental factors are limiting.

They are therefore characterised by:
- long-lasting structures morphologically and physiologically appropriate to the difficult environment;
- low above and below-ground growth rates;
- low resource allocation to reproduction, and frequent dominance of vegetative multiplication.

The fourth permutation (high stress-high disturbance) does not permit plant survival, since the effect of intensive disturbance in a very stressed environment is to prevent recolonisation.

Some species can be be substantially assigned to one of these specialisation extremes. Others live in intermediate habitats and are thus in intermediate situations, as illustrated in the triangular model.

Examination of the ecological characteristics of a species in relation to the type of soil in which it lives, the temperature, humidity and type of disturbance to which it is exposed enables it to be classified in terms of strategy. Most common British species have already been studied (GRIME *et alii*, 1988), and the dominant strategies and general features of a plant community can be established. A dichotomic key can be used to identify the strategies of species that have not been studied.

## 1.3 SPECIES DIVERSITY

Disturbance alters the species diversity of a plant community. Growing awareness of the fragility of ecosystems in recent years has promoted extensive investigation of relation between diversity and stability (PEET, 1974; PIELOU, 1975; MAY, 1981; PIMM, 1984; PEET *et alii*, 1985; GRIME, 1987; PIGNATTI, 1993). Species diversity is composed of the number of species per unit area (floristic richness), and of their relative abundance (equitability). Reference may be made to a recent paper by GANIS (1991) and to the results of the present study (6.2) for an account of various indices proposed.

Graphic representation of the relations between the number of species and their relative abundance in the form of dominance-diversity curves is of significant assistance in determination of the variations provoked by human impact, since it permits simultaneous analysis of both parameters, and for this reason it has been regarded as the fullest and clearest mathematical description of the data (MAY, 1981).

WHITTAKER (1965) suggests that the curves plotted on dominance-diversity diagrams can be related to the four types of community behaviour illustrated in fig. 1, which he explains by reference to the niche concept. A niche is "a species' specialization in the community - its particular way of relating to other species and to intercommunity conditions of environment". Variations in the environmental factors and the space and time in which species live form the axes of a "niche space" or hypervolume. This space is thus an "arena", in which species compete for the environmental resources. The result of such competition is evident in the numerical ratios between species, for which the four theoretical models - geometric, broken stick, lognormal and logarithmic - are proposed.

Grime's model predicts that moderate stress and/or disturbance increase both species richness and total species diversity by reducing the vigour of the dominants and allowing the development of other species, whereas more intense stress (or disturbance) decreases density by creating conditions in which only a small number of species manage to survive.

This application of the model is in line with ODUM's assertion (1963) that the greatest species diversity is found in medium or moderate conditions of a physical gradient. The model implies, in fact, that a moderate level of stress or disturbance is needed to prevent competitive exclusion (HUSTON, 1979), as demonstrated by the fact that modest grazing increases diversity (NAVEH, WHITTAKER, 1980; ACUTIS *et alii*, 1989). WHITTAKER, NIERING (1975) showed that the maximum diversity occurs in communities located at middle altitudes. This is presumably related to more intense disturbance at low elevations. Several authors, in fact, maintain that in the absence of disturbance diversity increases from high to low altitudes, and also increases if the limiting factors diminish (KREBS, 1975; HUSTON, 1979; WILSON *et alii*, 1990; FEDERICI, PIGNATTI, 1992). It can readily be shown, indeed, that mature, low-altitude communities marked by considerable diversity are more stable than equally mature, but less diverse high altitude communities. Wherever possible, therefore, comparison must be made between similar environmental conditions, or with due reference to "basic" variations.

Of the two components of species diversity, it will be found that floristic

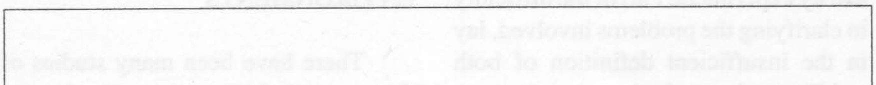


*Fig. 1* — Dominance-diversity curves (from WHITTAKER, 1965). The curves illustrate the broken-stick (a), lognormal (b), logarithmic (c) and geometric (d) distributions.

richness is extremely variable, whereas equitability is more simply interpretable in relation to the "maturity" of a community, i.e. there is a more uniform distribution of species in mature as opposed to young ruderal and pioneer communities. During a succession starting from abandoned land, both the number of species and the uniformity of their distribution within a community grow as time passes (BAZZAZ, 1975).

### 1.4 PLANT COMMUNITY STABILITY

One of the last important aspects that need to be examined in the evaluation of human impact is the relationship between the species diversity, complexity and stability of a community.

The stability of a community expresses its sensitivity to disturbance and must thus be defined to enable an estimate to be made of the effects of disturbance in the light of the experimental data.

The traditional wisdom of the Fifties and Sixties (ELTON, 1958) held that diminution of the complexity of an ecosystem entailed a reduction of its stability, but was belied both in theory and by experiment. Part of the difficulty in clarifying the problems involved, lay in the insufficient definition of both stability and complexity.

The current definition of stability is that advanced by HOLLING (1973), namely the tendency of a system to remain in a particular state or maintain a steady range of fluctuations. Three factors contribute to the stability of a community: its resistance, its resilience and its persistence (ALLEN, STARR, 1982; PIMM, 1984). Resistance is the ability of a species or community to adapt to a disturbance without change, resilience is a measure of its rate of return to its initial equilibrium after a disturbance, and persistence is its ability to continue without alteration in time.

The stability of a community is obviously dependent on its environment and the characteristics of its component species. Communities whose stability lies within narrow or wide environmental limits are referred to as dynamically fragile or robust respectively. The complexity of a community is mainly indicated as a function of its floristic richness, number of species interactions (known as "connectance") and their strength, and equitability. MAY determined (1981) that the percentage of stable communities decreases in function of increasing complexity, and this was understandable considering that more complex plant communities are less resilient. Stable communities are generally very complex, yet fragile, whereas more variable communities are both simpler and more robust, while the intrinsic features of their component species enable them to mount a quicker response to disturbance. The formations of stable environments, in fact, are characterised by K-selection species (PIANKA, 1970) that are very resistant, but poorly resilient, whereas r-selection species with poor resistance and high resilience form the communities of unstable environments.

Grime's three types of species can also be distinguished in this way (GRIME, 1987): competitors have medium resistance and good resilience, ruderals have no resistance, but good recolonisation ability, and stress-tolerants have good resistance and persistence, but no ability to recolonise disturbed habitats.

### 1.5 HUMAN IMPACT IN MOUNTAIN AND ALPINE ENVIRONMENTS

There have been many studies of the outcome of the most common human activities in the Alps, namely the effects of grazing, deforestation for the production of timber, and lowering of the tree line due to the extension of pasturelands (MONTACCHINI, 1972; STERN, 1983), and of vegetational variations in areas where nitrates have been heavily employed as fertilisers (BRAUN-BLANQUET, 1972). *Urtica dioica* dominated communities (HADAC, 1984; KOPECKY, 1984) and ruderal formations (HUSÁKOVÁ, 1988) have also been analysed.

It is not always easy to determine the impact of man's age-old rural activities, nor the results of their abandonment, and even such effects as can be identified cannot always be related to distinct anthropic operations. As GIACOMINI (1958) put it: "many plant habitats would be incomprehensible were one to interpret them solely in the light of their present state with no reference to the vicissitudes of history in the near and distant past". This concept underlies a number of extensive studies of the vegetation of the Alps, such as that of GENSAC (1972) on the Vanoise National Park and that of MONTACCHINI *et alii* (1982) on the Susa Valley.

In recent years, tourism has exerted an increasing impact on the Alps, and its influence is also being felt in the Himalayas and the Andes, and the mountains of Africa and North America. Some features of this impact, of course, are common to human influence at lower altitudes. There are also several major differences, however, mainly due to:

- a harsher climate resulting in shorter vegetative periods;
- the particular features of highland flora and vegetation;
- geological and morphological settings in which the soils are usually less evolved than at lower elevations.

## 2. INVESTIGATION METHODS

### 2.1 DATA COLLECTION

The sampling sites for the general vegetational analysis were sited so as to cover the most common physiognomic types (woods, meadows and pastures), as uniformly as possible in the five valleys, and also to embrace a broad spectrum of differences in substrate, exposure and elevation that would be representative of the main types observed in earlier preliminary studies of the area.

The need to draw a precise picture of the prior and current anthropic causes of vegetational changes was met by seeking the cooperation of the wardens in charge of the 35 supervision areas into which the Gran Paradiso Park is divided, each of whom filled in a questionnaire on tourism, past and present use of woods, meadows and pastures, and the presence of terraces.

The areas directly affected by tourism were the subject of phytosociological relevés conducted at increasing distances from the source of impact, namely:

- the edges of roads and then outwards;
- the middle and edges of ski-runs, and then outwards;
- the edges of paths and tracks, and then outwards;
- the centre of camping and parking areas and shelters, and then outwards.

The phytosociological method and Raunkiaer's method were compared for the vegetation relevé. The former proved to be more efficient, quicker and sufficiently informative, and was therefore used on all occasions, though the decision was also taken to determine the percentage coverage and abundance-dominance index of each species, in order to have precise distribution data.

The study areas were ten-square-meter quadrats. Diversity was evaluated with several indices from the percentage cover of each species as referred in 6.2.

All plant species were recorded for the three physiognomic types of vegetation (woods, meadows and pastures), and the areas most subject to human impact. A list of flora is presented for the species present in anthropized areas only, with an indication of the areas of study with heavy human impact in which each species was recorded.

To examine some of the reasons for the diffusion or survival of some species in the face of particularly heavy human impact, the soil bulk density was determined in relation to the frequent presence of an over-abundant skeleton in the soil. Measurements were taken with hollow cylinders of known volume. Soil was drawn from the first 10 cm in depth and weighed after oven-drying. The soil pH at 5 cm depth was also determined on each occasion with a Hellige comparative pH meter.

## 2. 2 DATA EVALUATION

Cluster analysis of "species x samples" multivariate matrixes was run with the SPSS program package, using the Euclidean distance and Ward's method (Anderberg, 1973) to analyse the vegetation data. Heuristic procedures (Aldenderfer, Blashfield, 1987) were employed to choose the groups within the dendrograms.

The nomenclatures follow "Flora Europaea" (Tutin *et alii*, 1964-80) and "The moss flora of Britain and Ireland" (Smith, 1978). Lichens were determined according to Poelt, Vezda (1981); their nomenclature follows Clauzade, Roux (1985).

## 3. THE STUDY AREA

## 3. 1 GEOGRAPHICAL FEATURES

The Gran Paradiso massif lies in the Graian Alps. It forms the watershed between the Aosta Valley and Piedmont (fig. 2), and is a prominent feature of the national park that bears its name.

Its shape is that of a rectangle bounded to the South by the Orco Valley, to the North-West by the Rhêmes Valley, to the North by the Cogne Valley, and to the South-East by the Soana Valley, and with a maximum length of 35 km (Rosa dei Banchi to Col du Nivolet) and width of 25 km (River Grand'Eyvia to the Orco). The mean elevation of its peaks is 3000 metres and the highest peak is the Gran Paradiso itself (4061 m).

The flanks of the massif are steep on the southern (Piedmontese) side, and gentler on the Aosta side to the North, where broad glens are separated from each other by long North-South ridges, especially that which divides Valsavarenche from the Cogne Valley, and runs from the Grivola (3969 m) to the North.

The several glaciers between the Piedmontese and the Aosta Valley sectors have retreated a long way in recent years.

The Park itself covers much of the massif. Its approximately 70,000 hectares straddle the main range and comprise an area bounded by the western side of the Orco Valley, from Locana at its head, the eastern side of the Rhêmes Valley, Valsavarenche (the only main valley wholly contained within the Park), the southern side of the Cogne Valley, and the head and western side of Soana Valley. The difference in elevation ranges from Albrella (850 m) (Locana) to the Gran Paradiso (4061 m). All the typical Alpine environments are represented in terms of exposure, valley orientations, and geomorphological patterns.

## 3. 2 GEOLOGICAL FEATURES

The geology of the Gran Paradiso massif is relatively simple despite its differences in form. The central part is formed of Augen gneisses (fig. 3), whose resistance to erosion has resulted in a very severe general morphology. Its formations consist of rocks that were crystallised during the last stages of the Hercynian orogeny, and then transformed during the Alpine orogeny (Compagnoni *et alii*, 1972). The most common crystalline types are granular quartz, plagioclase, biotitic mica, and K-feldspar in more or less intact individuals forming the "eyes".

The fine-grained gneiss inserted in this complex represents the primary metamorphic cover. This, too, was transformed during the Alpine orogeny, and now consists of fine-grain lithologies that outcrop in the upper portion of Valnontey and Valeille, on the Aosta side, and in the Ciamousseretto, Roc and Soana Valleys on the Piedmontese side.

The central part of the Massif is enfolded by what remains of the Mesozoic sedimentary cover which, subjected to tectonic overthrust, both surrounds and isolates the large outcrops of magmatic rocks. It is composed of arenaceous marine deposits and more recent calcareous-clayey lacustrine sediments. This cover is now formed by metamorphic calcschists formed during the Alpine orogeny that only crop out in the Park from Col Lauson to the North side of the Mount Grivola along the ridge separating Valsavarenche from Cogne Valley.

The Valsavarenche massif is the geological opposite of the Gran Paradiso. It is composed of granodiorites and diorites, gneisses, albitic mica-schists and prasinite, all of which acquired a mainly schistose fabric as a result of the Alpine metamorphism.

The terranes generated by this set of gneisses and diorites are usually surficial owing to the steep upward slopes and slow alteration of the rock matrix. Acid and poorly evolved soils prevail, therefore, even at relatively low altitudes.

## 3. 3 CLIMATE

The rainfall distribution (absolute spring maximum and relative autumn maximum), minimum winter temperature, temperature and pluviosity variations with altitude in the Park's valleys are those typical of the continental Piedmontese alpine climate. Generally speaking, however, the rainfall is much less in the Aostan as opposed to the Piedmontese valleys, since they are protected against the moist winds coming up from the Po valley by the Levanne and Gran Paradiso massifs, and by both the Piedmontese and the French mountains from those arriving from the Atlantic (fig. 4).

The Aosta Valley is a typical inner Alpine valley. In the central areas, the precipitations drop to 500-600 mm per year, rising to 700-900 mm at higher elevations. The ranges for the Park's three Aostan valleys are 633-842 mm and 60-79 days of rain per year, compared with 1100-1400 mm and 91-120 days in the two Piedmontese valleys (Mercalli, 1992).

Of the three Aostan valleys, Val di

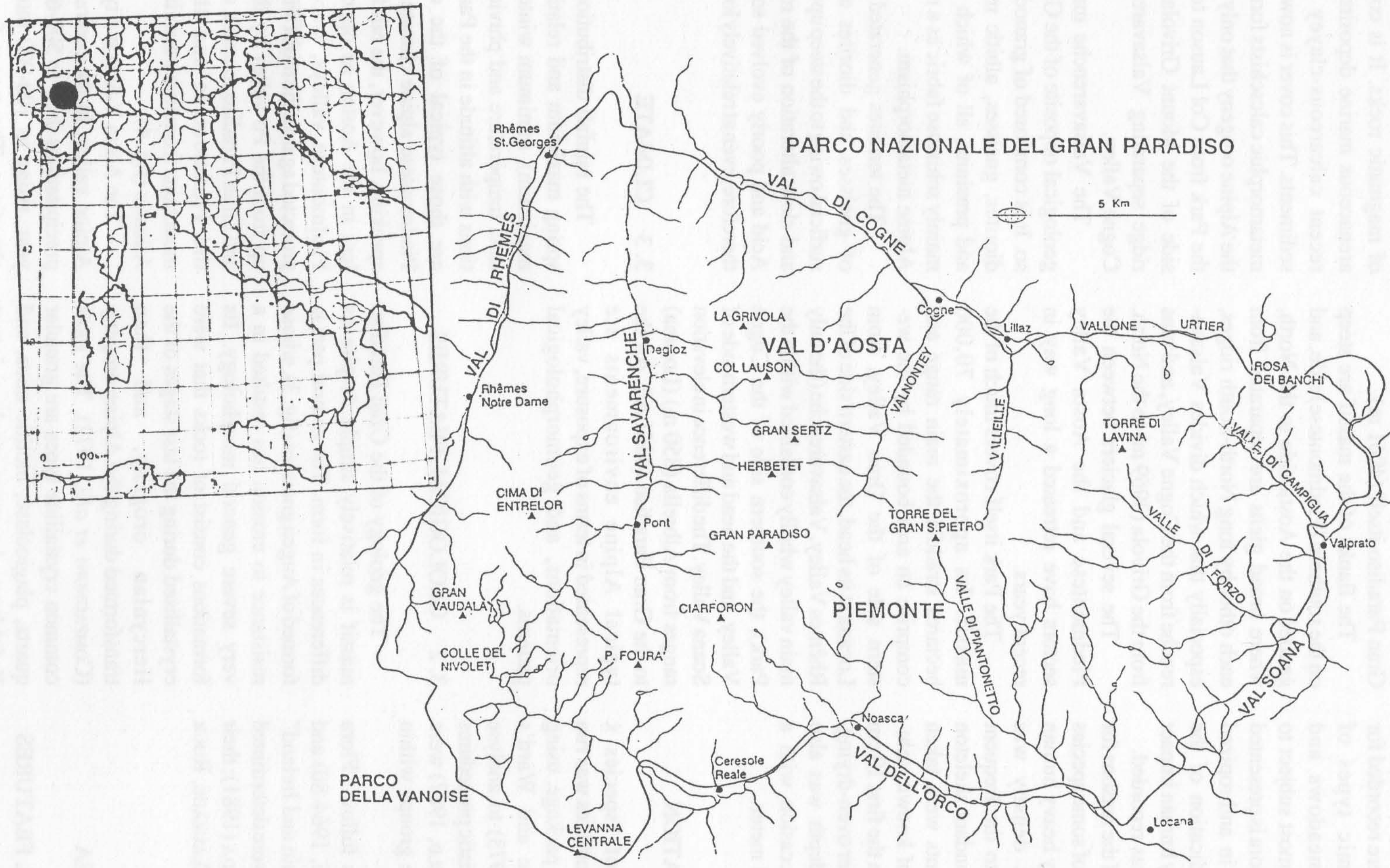


*Fig. 2* — The Gran Paradiso National Park and its location in Italy.

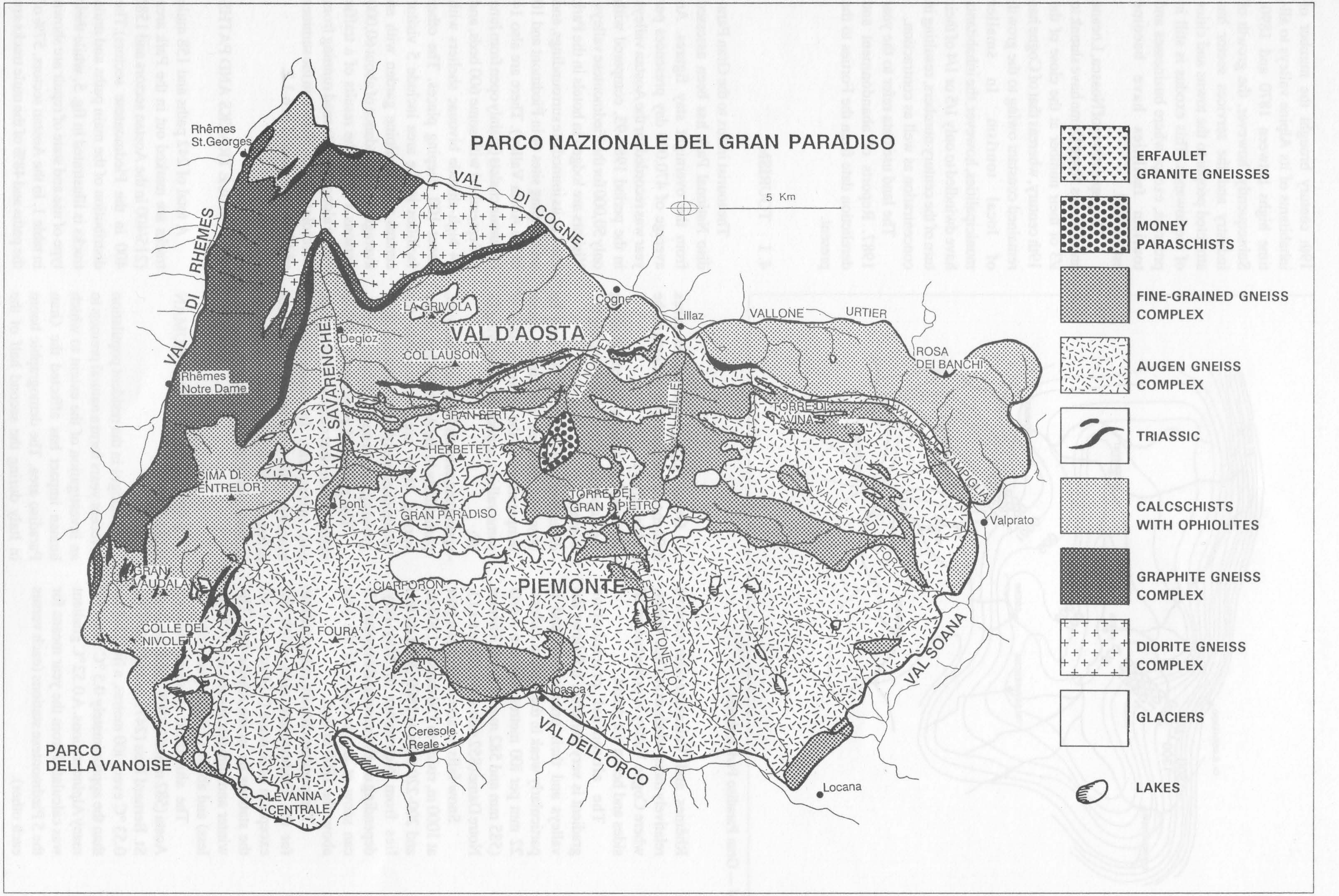


*Fig. 3* — Geological map of the Gran Paradiso Massif (redrawn from COMPAGNONI *et alii*, 1972).

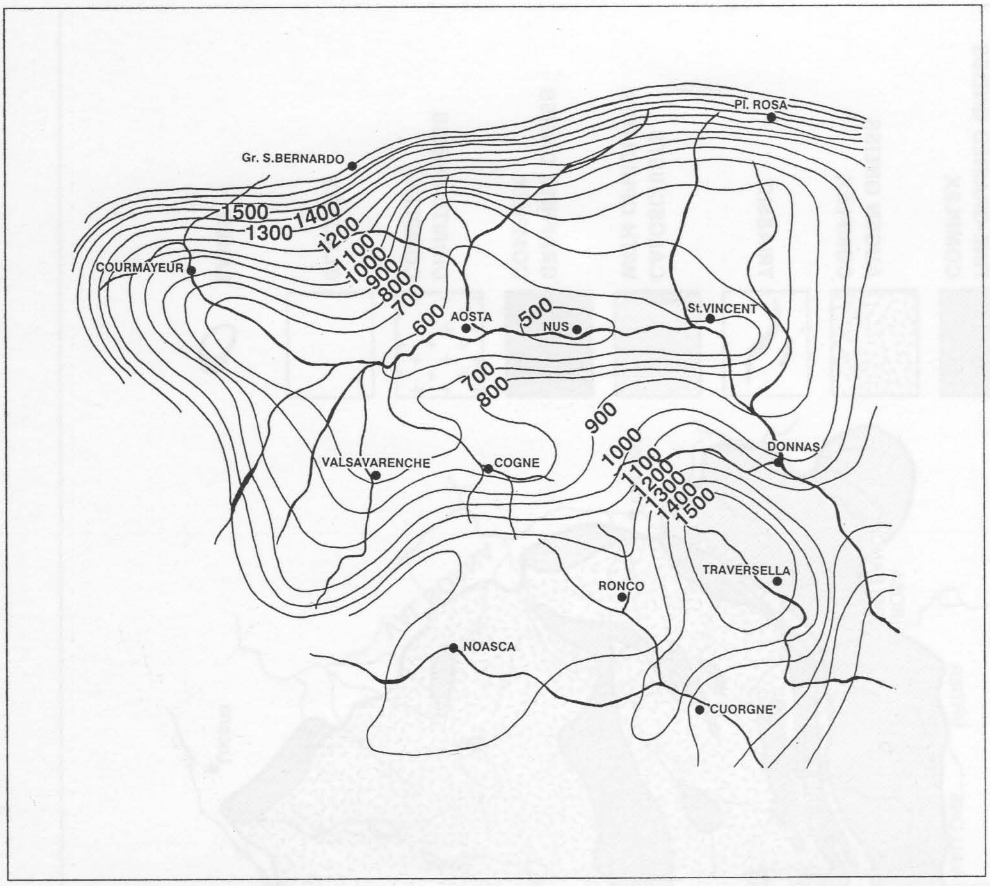


*Fig. 4* — Gran Paradiso Park isohyets.

Rhêmes and Valsavarenche receive relatively moist winds from Orco Valley, where Cogne Valley is protected on all sides and hence the driest.

The altitudinal precipitation gradient is very variable. It follows the valleys and their orientations, and is particularly weak in the Aostan valleys: 22 mm per 100 metres between Aosta (585 mm and 582 m a.s.l.) and Rhêmes Notre Dame (852 mm and 1723 m a.s.l.).

Snow falls on about 80 days a year at 1000 m, rising to 150 days at 1300 m, and 200-220 days at 1800-2000 m, and lies from November to May-July, depending on elevation and exposure. It can snow at any moment of the year above the 1800 m line.

Temperature data are only available for the Piedmontese side. With the exception of Rosone (714 m a.s.l.), all the stations lie in the Alpine belt. The winter and summer means are 0 °C (or less) and about 12 °C respectively.

The altitudinal gradient between Aosta (582 m and 11.9 °C) and the Great St. Bernard Pass (2473 m and 1.8 °C) is 0.53 °C every 100 metres, a little higher than the approximately 0.5 °C mean for many Alpine stations. A 0.52 °C gradient was calculated from the year means for the 5 Piedmontese stations (each versus each other).

Other topographical features influence the temperature patterns of the Park's valleys:

- very marked thermal inversion along the slopes in narrow valleys during the winter;
- differences of 0.2 to 2 °C may be observed between the annual mean temperatures of the opposite sides of some valleys, especially those lying E-W;
- spring and autumn foehns are common, particularly in the Aosta Valley. In the spring, they are responsible for avalanches, early snow-thaw and plant growing season onset on bare patches.

The protected position of all five valleys means that other winds are weak and infrequent. In some valleys, however, valley or mountain breezes offset the effect of insolation and result in more uniform temperatures.

## 4 PAST AND RECENT HUMAN IMPACT

Changes in the resident population in recent years form a natural premiss to an investigation of the extent to which human impact has affected the Gran Paradiso area. The demographic boom in Italy during the second half of the 19th century brought the number of inhabitants of its Alpine valleys to all-time highs between 1870 and 1890. Subsequently, however, the growth of industry and the services sector has attracted people to the towns and cities of the lowands. This exodus is still in progress, except where businesses and tourism facilities have become established.

The populations of Noasca, Locana and Rhêmes Notre Dame have shrunk to 1/3 of their number at the close of the 19th century, whereas that of Cogne has remained constant owing to the growth of local tourism. In smaller municipalities, however, the inhabitants have dwindled to only 1/5 or 1/4 of their turn of the century numbers, resulting in concentration as well as contraction.

The land use data refer to the year 1987. Reports of abandonment and dereliction date from the Forties to the present.

### 4. 1 TOURISM

The tourist influx to the Gran Paradiso National Park has been assessed from the overnight stay figures. An average of 470,000 day presences per year was recorded for the Aostan valleys in the period 1989-93, compared with only 50,000 for the Piedmontese valleys. Visitors are lodged in hotels in the Park itself or its immediate surroundings, and on camping sites (4 in Piedmont and 10 in the Aosta Valley). There are also 14 mountain chalets (mainly open from June to September) with some 600 beds, and 14 high-altitude bivouac shelters with about 100 sleeping places. The other facilities in the area include 5 visitor centres and an alpine garden with an average total attendance of about 60,000 persons a year. The results of a traffic relevé along the state road running from Ceresole to Col du Nivolet in the summer of 1993 are included in 6.1.2.

### 4. 2 MULE TRACKS AND PATHS

A total of 242 paths and 158 mule tracks are marked out in the Park area (215/400 in the Aostan sectors and 158/400 in the Piedmontese sectors).The distribution of the main paths and mule tracks is illustrated in fig. 5, while their type of use and state of repair are shown in table 1. In the Aostan sectors, 57% of the paths and 48% of the mule tracks are

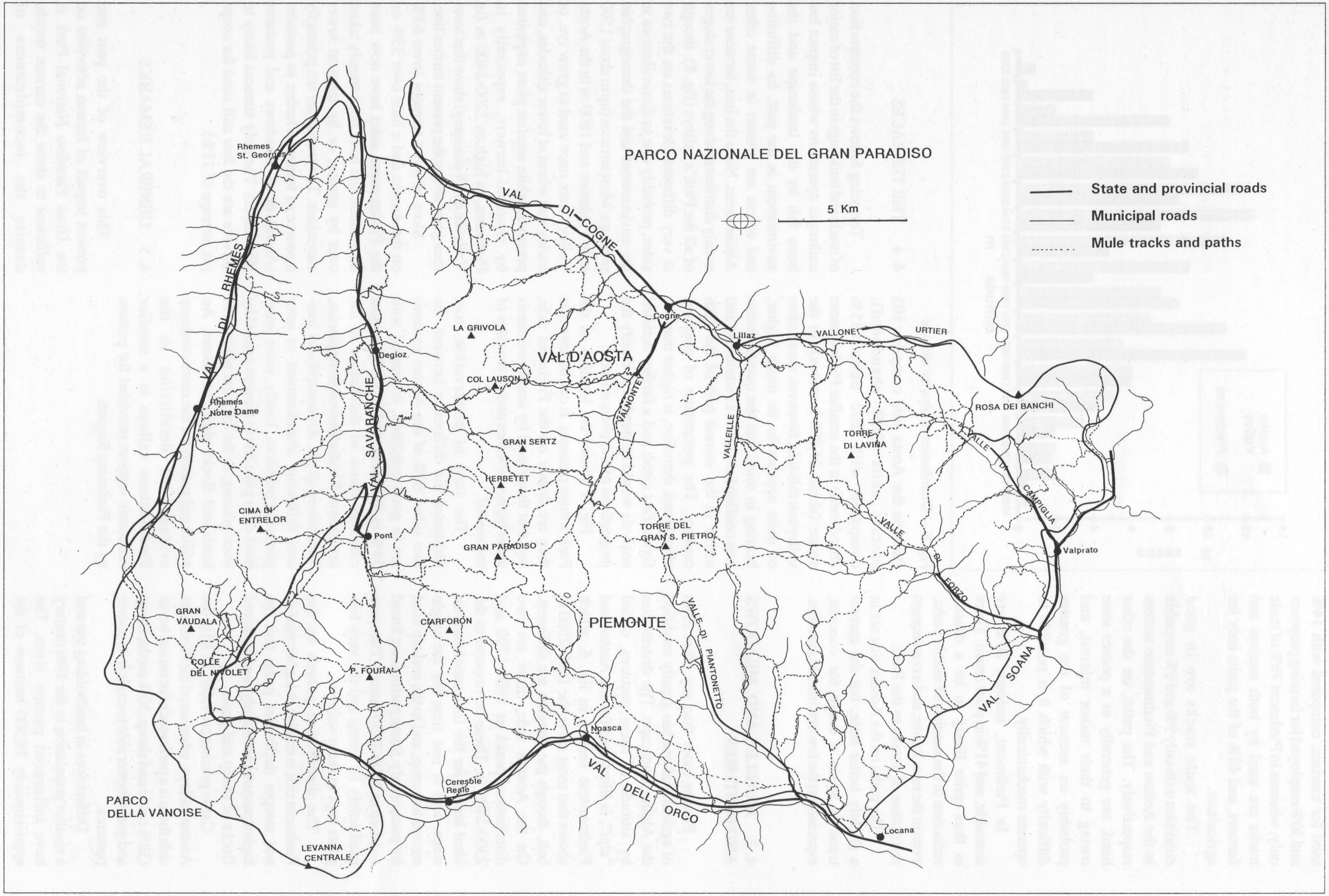


*Fig. 5* — The Park's main paths, mule tracks and access roads (State, provincial and municipal).

used for tourism, compared with 14% and 30% employed for farming purposes only, whereas in Piedmont 76% of mule tracks are used by both tourists and farmers, and 48% of the paths only for agriculture.

The mule tracks are in good condition with only 9% and 6% unusable in the Aostan and Piedmontese sectors respectively. The paths, on the other hand, are generally in a poorer state owing to their minor interest, and probably on account of the greater difficulty with which it is possible to operate mechanically.

In Piedmont, indeed, 20% are unusable, and 41% in poor repair. There is thus quite likely to be a drastic reduction in the number of usable paths, even in the near future, and a consequent restriction of access to the Park.

The paths on the Aostan side are in a slightly better state, but the current trend is again a cause for concern, especially at the low and middle altitudes.

## 4. 3 ARABLE LAND, MEADOWS AND PASTURES

Pasture more than any other form of agricultural use has greatly modified the Alpine landscape. The distribution by altitude of these pastures, called "alpi", is illustrated for the Aostan and Piedmontese sectors in fig. 6, which shows that most are in the 1500-2500 m belt, though the patterns are different. On the Aostan side, there are two distribution peaks at 1600-1700 and 2300-2400 m. These correspond to the ideal height for the first transhumance stage, and at one time for the single annual hay crop, and to the real alp used for pasture only. Some pastures are found as far up as 2600-2750 metres. These are used solely by sheep and the very few goats kept in these valleys.

The distribution pattern on the Piedmont side is similar. A higher rainfall and steeper declivities mean that the higher pastures are mainly used by mixed flocks of sheep and goats.

Cattle grazing prevails (72%) in the Aostan valleys, whereas on the Piedmont side there is a preference for mixed herds (38% cattle and sheep, 30% cattle, sheep and goats) better able to exploit its poorer pastures.

Differences in landholding use and a smaller population in the 19th century have influenced pasture sizes. The approximately 38,500 hectares of the

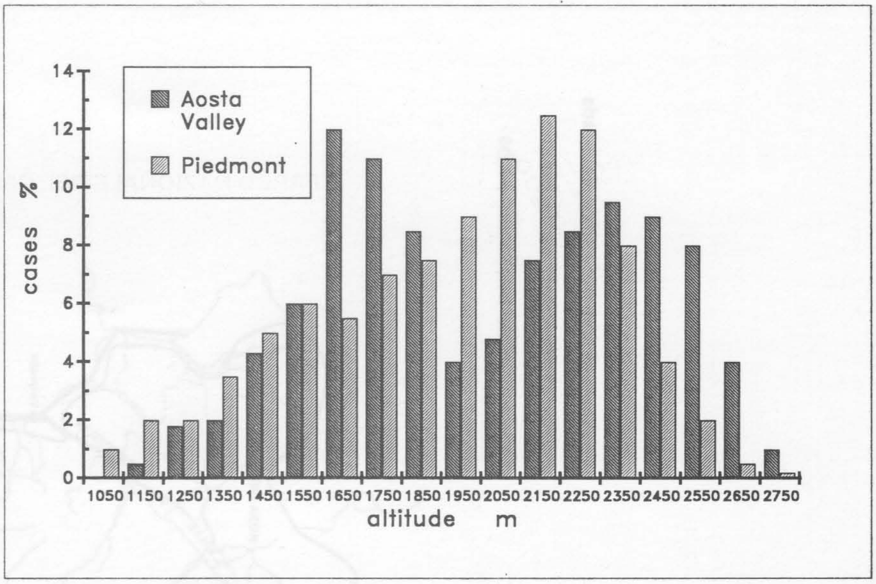


*Fig. 6* — Distribution of alps by altitude

Park on the Aosta side comprise 103 pasture units (30% abandoned), compared with 202 units (35% abandoned) in the smaller Piedmontese sector (about 31,500 hectares). In the valleys on this side, however, the number of units appears to be much higher, bearing in mind that the questionnaire was confined to alps of a certain size and active in the second part of the 20th century. The percentage of pastures abandoned, therefore, is higher than the figure first cited, and a further detailed analysis would be needed to clarify the proportions of the phenomenon.

Fig. 7 shows the location of the Park's main pastures. It can be seen that they are denser on the Piedmont side, and that those used by small ruminants are at higher altitudes and on the edge of the massif.

The state of preservation, too, illustrates the difference between the two sides: 62% of the Aostan pastures are in good condition, compared with 34% in Piedmont (table 1). The most common cause of dereliction is the invasion of *Rhododendron ferrugineum*, *Vaccinium* sp.pl., *Arctostaphylos uva-ursi* following abandonment or poor pasturing practices. Lastly, some areas have clear gaps due to erosion caused by over-grazing, or the frequent passage of herds and flocks along set routes. An additional reason for the more common evidence of dereliction in the Piedmontese valleys is a smaller economic support provided for pasture by the Piedmont Region.

## 4. 4 THE TERRACES

Terracing follows the construction of roads and buildings in the list of major anthropic operations whose impact has been felt by the landscape and the environment in the past. Its diffusion and extent are greater in some other Alpine areas. None the less, terraces are evenly distributed along the lower slopes of all the Park's valleys (fig. 8), though at very different elevations on the two sides, probably due to dissimilarities in the environment and the demographic pressure. Most terraces (up to about 1500 m in Piedmont and 1800 m in the Aosta Valley) were once used to grow rye, or barley and wheat at lower altitudes, and potatoes, while smaller plots exploited by charcoal-burners, especially in Piedmont, as high as 2200-2400 m (in Valleille and Valnontey) show that trees then grew above the present timber line.

Most of these terraces (over 63% on the Aostan and a little over 35% on the Piedmontese side) have now been abandoned and have been mostly taken over by shrubs, or by trees at lower elevations. The remainder are primarily a source of forage, whether as pastures (Aosta) or as meadows and pastures (Piedmont). The only terraces likely to survive are the few still used for crops (an average of 11%).

## 4. 5 GENERAL REMARKS

This overview of the past and present impact of human activities on the Gran Paradiso National Park is sufficient to show the current trends, despite the incompleteness of

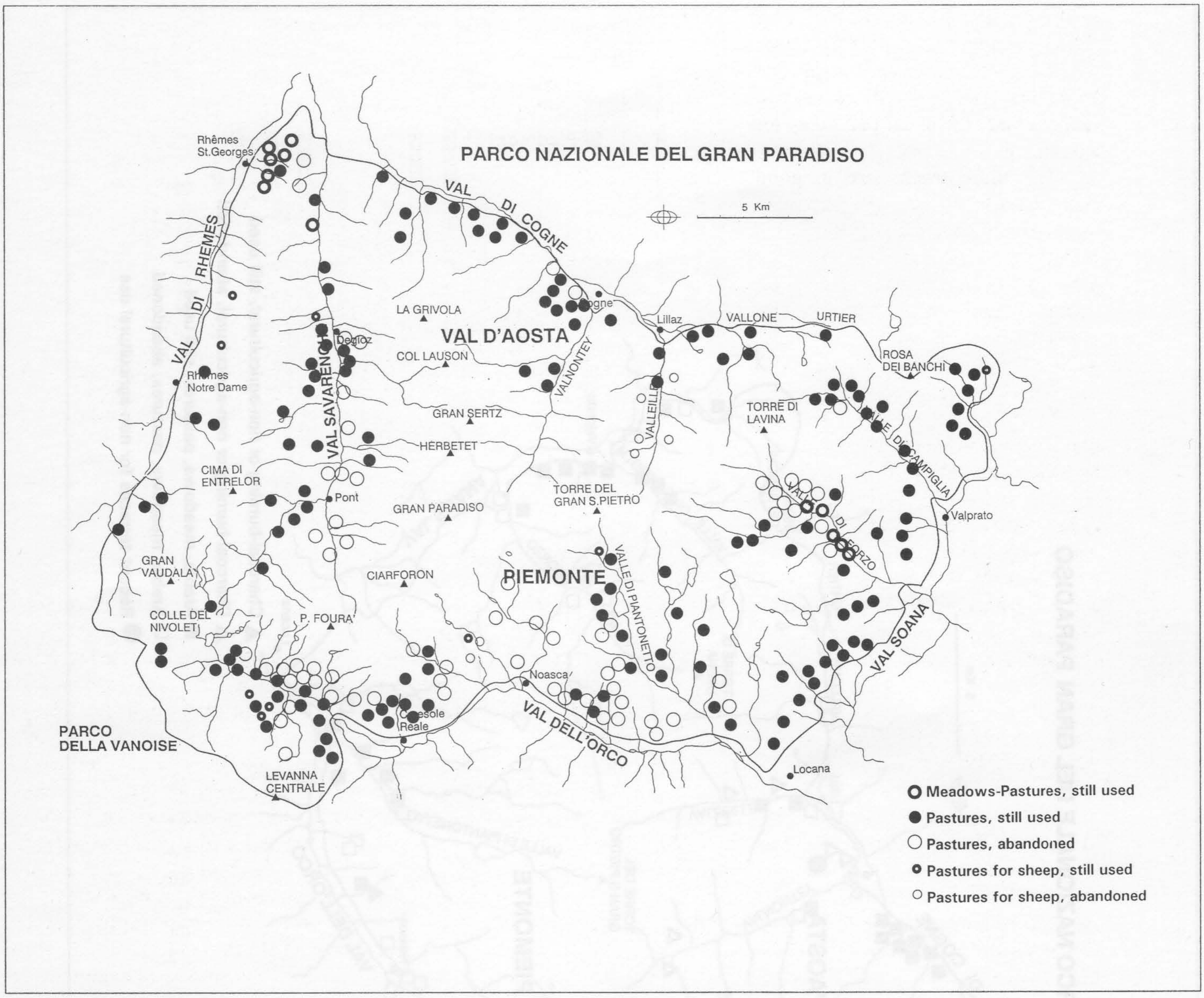


*Fig. 7* — Distribution of the Park's main alps.

quantitative data. The number of paths has decreased, and those that remain are less frequented because farming operations have diminished, and fewer people are still living in isolated hamlets far from a road, while tourists tend to use established routes in the highlands or the tracks leading to huts and shelters, and ignore the byways of the uplands and lower levels.

Very little of the land is now farmed intensively. Haymaking, for example, is confined to the valley floor and certain favourable slopes, and always close to roads suitable for wheeled traffic.

Diminished pasturage, too, has reduced the pressure on the herbaceous vegetation, since grazing by domestic animals is much heavier than that of wild ungulates with their smaller needs and lower density.

The survey has provided evidence of a transformation that has been in

*Table 1* — State of preservation of mule tracks, paths and alps.

| conservation | side | pasture non eroded % | pasture eroded % | mule tracks % | paths % |
|---|---|---|---|---|---|
| good | Piedmont | 34 | 0 | 73 | 40 |
| | Aosta Valley | 62 | 0 | 65 | 59 |
| fair | Piedmont | 17 | 23 | 21 | 40 |
| | Aosta Valley | 4 | 12 | 25 | 27 |
| poor | Piedmont | 24 | 2 | 6 | 20 |
| | Aosta Valley | 15 | 7 | 9 | 14 |

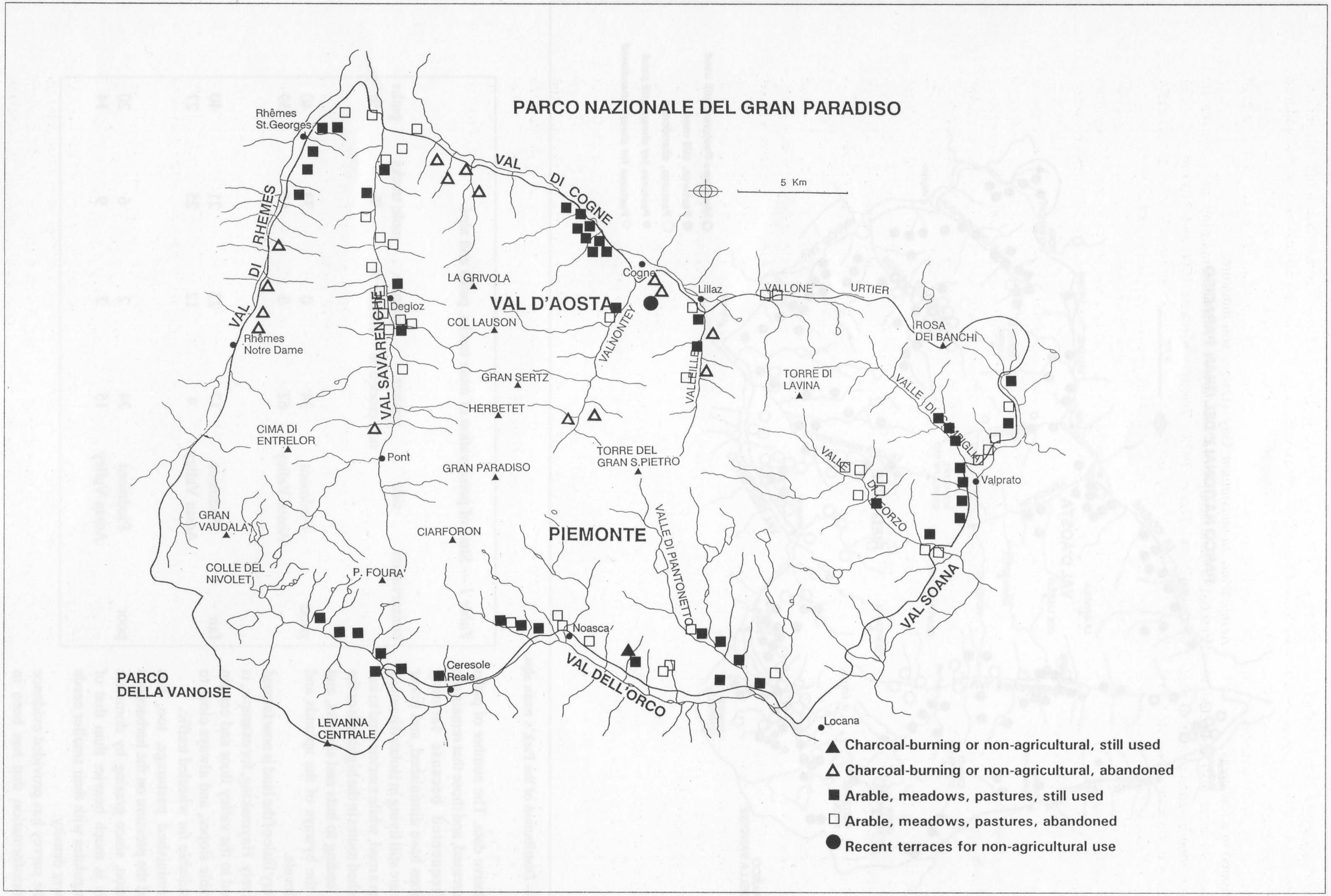


*Fig. 8* — Distribution of the Park's terraces.

progress for some time, namely reduction of widespread human impact of an agricultural type in favour of a predominantly touristic land use concentrated in a few areas.

The data were also collected to provide a zone-by-zone picture of past and present farming, forestry and foraging activities, so as to prevent any risk of confusion between the effects of tourism on the flora and vegetation on one hand and those due to other operations dating back to the distant past, on the other hand.

## 5. TYPES OF VEGETATION

The uniformity of the geological substrate in most of the Gran Paradiso National Park is reflected in greater uniformity of its flora and vegetation compared with other parts of the Western Alps. In addition, its siliceous rocks are more resistant to erosion than calcareous rocks, and hence give rise to fewer micro-environments.

This section of the paper provides a general overview of the present vegetation of the Park. Phytosociological relevés were made of the physiognomic types shown on a map (fig. 9) prepared, and still unpublished, to illustrate the results of a previous series of investigations.

### 5. 1 PUBLISHED STUDIES ON THE PARK'S FLORA AND VEGETATION

No comprehensive examination has yet been made of the Park's flora and vegetation. The former has indubitably attracted greater attention. Vaccari published data on Soana Valley in 1909, while his Catalogue raisonné of the Aosta Valley's vascular plants (1904-11) included many species found also in the Park's valleys. Additions have since been made to this catalogue in the light of unpublished data of the Vaccari Herbarium present in the Florence (FI) and Turin (TO) Herbarium collections (PEYRONEL *et alii*, 1988).

MATTIROLO's studies (1925; 1928 a, b; 1932 a, b) of the Park's flora were confined to a botanical bibliography and data collected in some particular areas. Another early study is that of LANZA on the Valprato Valley (1921).

Coming closer to our own times, there are general studies (PEYRONEL, 1955), and data on particular species, such as *Potentilla pennsylvanica* L. (PEYRONEL, 1962), *Astragalus alopecuroides* L. (PEYRONEL, 1964, 1967) and *Aethionema thomasianum* Gay (DAL VESCO, 1967) and the algae of a Valontey peatbog (BAIER, TOSCO, 1978). TOSCO (1973 to 1991) has long been engaged on the preparation of a complete catalogue of the flora of the Park. A rather limited number of families, however, have been covered so far.

Vegetation studies were made in the calcareous moraines in the Rhêmes Valley (PEYRONEL, 1968), derelict fields in Cogne Valley (PEYRONEL, DAL VESCO, 1973), the lichens of the alpine and subalpine belts on the Piedmontese side of the Park (MONTACCHINI, PIERVITTORI, 1978-79), and some woods on the Aosta Valley side (CRISTOFOLINI, 1979-80; HOFFMANN, 1978; LYABEL, 1973).

### 5. 2 MEADOWS

Attention was focused to herbaceous formations currently mown at least twice a year nearly all of which are always manured and irrigated, at least in the Aosta Valley. Table 3 (out of text) was structured on the basis of multivariate analysis of the 31 analysed sites (table 2).

The first group of relevés (nos. 20 to 1 on the top left of the table) are marked by dominance of species of the *Arrhenatherion* alliance (such as *Dactylis glomerata* and *Heracleum sphondylium*), the *Polygono-Trisetion*, and many *Arrhenatheretea* species (*Achillea millefolium, Ranunculus acris, Trifolium pratense, Trifolium repens, Leontondon hispidus, Taraxacum officinale*) abundant in all the sites. These fifteen meadows are all at low elevations (900 - 1650 m) and are supported by flat, or nearly flat, deep, nutrient-rich soils.

The second group (nos. 28 to 26) are at a slightly higher altitude. They again display species characteristic of the *Polygono-Trisetion*, such as *Polygonum bistorta, Trisetum flavescens* and *Geranium sylvaticum*, and bring together the typical communities of mown meadows in the lower mountain belt. They also comprise species characteristic of the *Poion alpinae* (e.g. *Poa alpina, Trifolium pratense* ssp. *frigidum*) that groups transition communities between mown meadows and alpine pastures representing an anthropic paraclimax, as was said, to the classic combination of irrigation, manuring and mowing. The abundance of species such as *Polygonum bistorta* and *Trollius europaeus* is due to high soil moisture.

The remaining nine relevés lie between 1700 and 2100 m and differ sharply from the other two groups in the absence or only sporadic presence of the *Arrhenatherion* species, a greater abundance of the *Poion alpinae* ones (*Phleum alpinum, Festuca violacea, Crepis aurea*), and the presence of typical highland pastures species, such as *Potentilla grandiflora, Centaurea uniflora* ssp. *nervosa, Cerastium arvense* ssp. *strictum* of the *Caricetea curvulae*. These species indicate a tendency of such formations towards those of alpine pastures, a tendency currently limited by ongoing cultivation practices.

The most evident aspect in the study of the mown meadows of these valleys is the ascent of species typical of lowlands hills, such as all those characteristic of the *Arrhenatheretalia* and the *Arrhenatheretea*, to elevations of 1500-1800 or even more than 2000 m above sea level. This is due to their greater resistance to mowing compared with high altitude species, coupled with greater competition ability owing to their faster tissue turnover and their ability to use soil nutrients.

High altitude herbaceous formations (up to at least 1800-2000 m) subjected to periodic cutting and manuring tend to gradually increase the number of species typical of lower elevations, and maintain this floristic composition as long as mowing continues.

### 5. 3 WOODS

Woods have taken over all the areas facing north, the steeper and less accessible slopes, and the former abandoned pastures. They are almost all composed of conifers, with a predominance of *Picea abies, Larix decidua* and *Pinus cembra*, whereas *Abies alba* and *Pinus sylvestris* are confined to certain damper and drier areas respectively.

Woods along watercourses are limited to certain areas and are not considered in this paper.

Woods composed of broad-leaved trees are only present in a few areas on the Piedmontese side. The diffusion of conifers even as high as 1000-1500 m

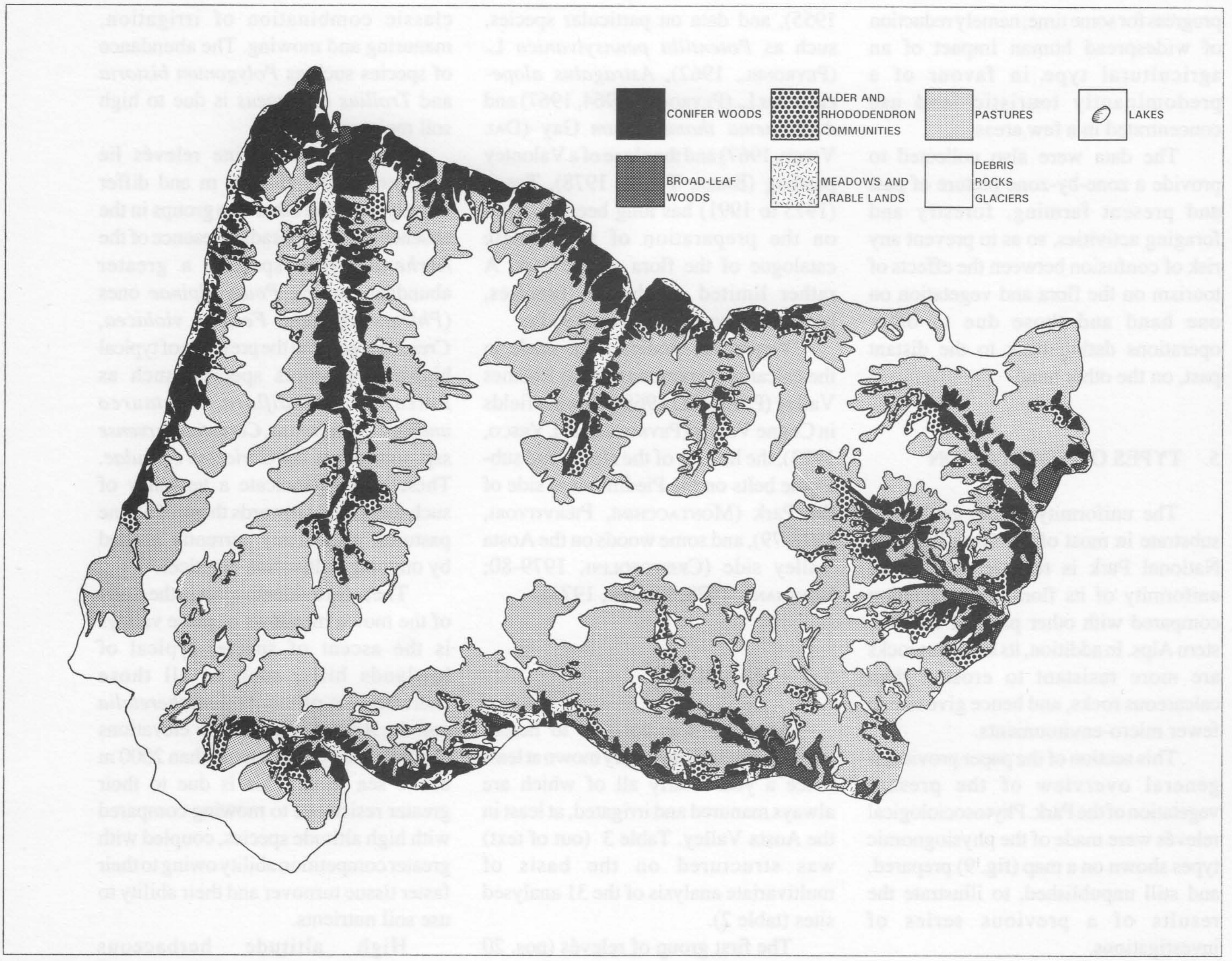


*Fig. 9* — Physiognomic map of the Park's vegetation.

*Table 2* — List of the 31 relevé points for the mown meadows.

| Relevé no. | Site | |
|---|---|---|
| 1, 2, 7, 10, 11 | Soana Valley | S. Besso |
| 6, 19, 39 | Soana Valley | Vallone di Forzo, Alpe Muanda |
| 8 | Soana Valley | Above S. Besso |
| 15, 36, 38 | Soana Valley | Vallone di Forzo Casotto Giavin |
| 19 | Soana Valley | Vallone di Forzo. Lago della Valletta |
| 3, 9, 14, 16, 20, 27, 30-35, 37, 40 | Orco Valley | Casotto Bastalon |
| 4, 5 | Orco Valley | Vallone di Piantonetto, Pontese Shelter |
| 12, 13 | Orco Valley | Chiapili di sopra. |
| 17 | Orco Valley | Casotto Bastalon, up to Colle della Terra. |
| 24 | Orco Valley | Casotto Bastalon, Lago Gias di Ben |
| 18, 21, 22, 25, 26, 28, 29 | Orco Valley | Valsoera |
| 41, 42 | Cogne Valley | Vittorio Sella Shelter |
| 47, 61 | Cogne Valley | Casolari Money |
| 60 | Cogne Valley | Up to Col Pousset |
| 62 | Cogne Valley | Vallone di Valeille, Casotto Arolla |
| 43 | Rhêmes Valley | Grange Chassettaz |
| 44 | Rhêmes Valley | Montagne di Entrelor |
| 45 | Rhêmes Valley | Above Montagne di Entrelor |
| 46 | Rhêmes Valley | Pian delle Feje |
| 47, 48, 49 | Rhêmes Valley | Vallone della Gran Vaudala |
| 51 | Rhêmes Valley | Mont Blanc |
| 53, 54 | Valsavarenche | Ripiano di Leviona |
| 55, 56 | Valsavarenche | Alpe di Lavassey |
| 57 | Valsavarenche | Casotto di Orvieille |
| 58 | Valsavarenche | Piano del Nivolet |

and the almost total absence of broad-leaved species can be partly ascribed to the typically inner alpine climate of the Aosta Valley (ELLENBERG, 1963). Another possible cause is human replacement of the existing broad-leaved species with more valuable conifers in the distant past. *Fagus sylvatica* cannot withstand the over-dry climate of the Park's Aostan valleys (TURBIGLIO *et alii*, 1987), and hence the most common trees are *Acer platanoides*, *A. pseudoplatanus*, *Fraxinus excelsior*, *Betula pendula*, *Sorbus aucuparia* and *S. aria*. *Castanea sativa*, *Quercus pubescens* and *Q. petraea* are present in the central valley, but are unable to penetrate its higher branches.

The results of multivariate analysis of the 40 relevés in the five valleys (table 4) are set out in the respective tables in the order obtained with the dendrogram. The only example of a *Fagus sylvatica* wood was found in the Forno Valley (Soana Valley), at about 1050 m (table 5). The tree cover is 90%, with dominant *Fagus sylvatica* and subordinate *Abies alba*. The understory was greatly impoverished floristically, as in many such woods in the Western Alps. Renewal of the beech is not present and the herbaceous cover is confined to 10% of the area. In view of their extreme floristic poverty, these woods display atypical paraclimax features and are difficult to classify in phytosociological terms. Their communities resemble those of other parts of the Western Alps where the *Veronico urticifoliae-Fagetum* has been described (MONTACCHINI, 1972). This is referable to the *Luzulo-Fagion* as typical of impoverished and degraded soils such as these.

Planted chestnut woods are established in an acidophilic paraclimax on some parts of the S-SW-facing side of Orco Valley. The herbaceous cover of the underbrush is rather scanty (table 6), with character species of the *Querco-Fagetea*, *Vaccinio-Piceetea* and *Arrhenatheretea* indicative of former use of the woods for pasture. The phytosociological classification of these communities is difficult. Account must be taken of the fact that the dynamics of the vegetation is often rapid, with the invasion of other tree or shrub species, such as *Betula pendula*, *Corylus avellana* or *Larix decidua*. Species from the *Calluno-Ulicetea*, such as *Calluna vulgaris*, *Potentilla erecta*, *Genista tinctoria* and *Carex montana*, have invaded some of the unreleveéd areas.

*Table 4* — List of the 40 relevé points for the woods.

| Relevé no. | Site | |
|---|---|---|
| 1, 2, 3 | Cogne Valley | Near ski runs |
| 28 | Cogne Valley | On the way up to Col Pousset |
| 5 | Rhêmes Valley | On the way up to Colle d'Entrelor |
| 6, 13, 14 | Rhêmes Valley | Chassettaz |
| 7, 8, 9 | Rhêmes Valley | Path to Chassettaz |
| 10, 11 | Rhêmes Valley | Sort shelter |
| 12 | Rhêmes Valley | To Colle d'Entrelor |
| 15 | Rhêmes Valley | Creton |
| 16, 17 | Rhêmes Valley | Rhêmes St. Georges |
| 18 | Rhêmes Valley | Rhêmes Notre Dame |
| 19, 20 | Rhêmes Valley | Mont Blanc |
| 21 | Valsavarenche | Tignet |
| 22 | Valsavarenche | To Lavassey |
| 23, 24, 25 | Valsavarenche | Path to Orvieille |
| 26 | Valsavarenche | Path to Nivolet |
| 27 | Valsavarenche | Near Bocconiere |
| 29 | Soana Valley | Forzo near Grange Lavinetta |
| 30 | Soana Valley | Forzo, above Boschiettiera |
| 32 | Soana Valley | Forzo, between Bosco and Bettassa |
| 33 | Soana Valley | Ronco |
| 4, 37, 38 | Soana Valley | Azaria |
| 40 | Soana Valley | Grange Balmaion |
| 34 | Orco Valley | Fè |
| 35 | Orco Valley | Ceresole Reale |
| 36 | Orco Valley | Chiapili |
| 39 | Orco Valley | Ceresole Reale, path to Colle Sià |
| 31 | Orco Valley | Chantel de la Regina |

*Table 5* — Phytosociological relevé in a beech wood.

| | |
|---|---|
| Relevé no. | 32 |
| Altitude (m) | 1050 |
| Exposure | NE |
| Slope (°) | 15 |
| Tree cover (%) | 90 |
| Herbaceous cover (%) | 10 |
| **cl. Querco-Fagetea** | |
| *Fagus sylvatica* | 5 |
| *Abies alba* | 2 |
| *Prenanthes purpurea* | 2 |
| *Athyrium filix-femina* | 1 |
| *Luzula nivea* | 1 |
| *Veronica urticifolia* | + |
| *Lilium martagon* | + |
| *Lonicera nigra* | + |
| *Epilobium montanum* | + |
| *Viola hirta* | + |
| **cl. Vaccinio-Piceetea** | |
| *Deschampsia flexuosa* | 2 |
| *Luzula sylvatica* | 1 |

*Table 6* — Phytosociological relevé in a chestnut wood.

| | |
|---|---|
| Relevé no. | 34 |
| Altitude (m) | 1000 |
| Exposure | SW |
| Slope (°) | 10 |
| Tree cover (%) | 85 |
| Shrub cover (%) | 1 |
| Herbaceous cover (%) | 35 |
| **cl. Querco-Fagetea** | |
| *Castanea sativa* (tree) | 5 |
| *Castanea sativa* (shrub) | + |
| *Poa nemoralis* | 1 |
| *Salvia glutinosa* | 1 |
| *Geranium nodosum* | + |
| *Mycelis muralis* | + |
| *Luzula nivea* | 3 |
| **cl. Vaccinio-Piceetea** | |
| *Juniperus communis* | 1 |
| *Deschampsia flexuosa* | 2 |
| *Epipactis atrorubens* | + |
| **cl. Arrhenetheretea** | |
| *Anthoxanthum odoratum* | + |
| *Agrostis capillaris* | + |
| *Phyteuma betonicifolium* | + |
| *Hieracium sabaudum* | + |
| *Veronica officinalis* | + |
| *Viola canina* | + |

The Park's most common trees are *Picea abies* and *Larix decidua*. These occupy the areas where the *Abies alba* and *Fagus sylvatica* are excluded, even starting from elevations of 900-1000 m.

Pure larch woods are occasionally found, though mixed communities whose composition is determined by the microclimate associated with the exposure and slope, by the extent to which the rock substrate crops out, and by past or present human impact. The red spruce predominates on cooler sites and relatively deep substrates, and where human impact (if any) took place in the distant past.

*Larix decidua*, on the other hand, prevails on warmer sites and on even very surficial substrates, as well as where there has been more recent grazing or deforestation. Both species are widespread from 1000-1200 m to the timberline (2000-2500 m), though the larch is more abundant at higher altitudes owing to the microclimatic factors mentioned earlier, and its pronounced heliophily and pioneer character. There are thus mountain and sub-alpine woods of red spruce and/or larch, phytosociologically classified in relation to their understory species rather than the trees themselves.

The stations where *Picea abies* is predominant and the communities are mature and stable with a 40-80% tree cover (nos. 31 to 24) are shown in table 7.

The other abundant species included *Vaccinium myrtillus*, *Melampyrum sylvaticum* and *Hieracium murorum* (*Vaccinio-Piceetea*), *Luzula nivea*, *Geranium sylvaticum* and *Hepatica nobilis* (*Querco-Fagetea*). Heavy overshadowing of the undergrowth has always prevented the establishment of *Rhododendron ferrugineum*.

The mountain red spruce woods are referable to the *Luzulo nemorosae-Piceetum* and are typically spread over siliceous rocks, and hence very acidic soils.

Low-elevation relevés 31 and 33 (Orco Valley) differed from the others on account of the presence of mesophilous species such as *Geranium nodosum*, *Salvia glutinosa*, *Prenanthes purpurea* and *Maianthemum bifolium* (*Querco-Fagetea* ), and can be referred to the *Veronico urticifoliae-Piceetum*.

At higher elevations (nos.19, 10, 25, 12), the *Picea abies* woods take on a sub-alpine character, and the red spruce mixes with the larch. The floristic composition remains much the same, but there is always a considerable *Rhododendron ferrugineum* cover. These communities can be ascribed to the *Larici-Piceetum* with *Deschampsia flexuosa*, *Vaccinium myrtillus*, *Vaccinium vitis-idaea* and *Homogyne alpina*. Species characteristic of the *Querco-Fagetea* are less numerous than in the previous relevés.

The larch is dominant on pasturelands abandoned over the last decades (table 8, relevés 26, 27, 4 and 39), with an undergrowth consisting of species characteristic of mown meadows and areas used for both haymaking and pasture, such as *Galium mollugo*, *Phyteuma betonicifolium* and *Veronica chamaedrys*. These conditions result in the typical appearance of woods used for pasture, known as park-woodlands, which are common at altitudes between 1500 and 2000 m in areas with a slight or average slope. These communities are referable to the *Rhododendretum ferruginei laricetosum*. Abandonment lasting more than 30-50 years leads to their further development with the appearance of *Picea abies* in the shrub layer, *Rhododendron ferrugineum* and *Rubus idaeus*, coupled with the disappearance of species typical of pastures and meadows. The herbaceous cover is mostly composed of *Festuca flavescens*, a Western Alps endemic, accompanied by *Deschampsia flexuosa* and *Oxalis acetosella*.

Woods with an abundance of *Pinus cembra* can be readily distinguished from those just described: on the orographic right-hand side of the Rhêmes Valley, which is exposed N-NW, there is a particular association (table 9) consisting of *Pinus cembra*, *Calamagrostis villosa*, *Lonicera caerulea*, *Luzula sylvatica*, *Hieracium prenanthoides* and *Festuca flavescens*. The floristic stock common to all the relevés is formed of *Deschampsia flexuosa*, *Rhododendron ferrugineum*, *Vaccinium myrtillus*, *V. vitis-idaea*, *Melampyrum sylvaticum* and other distinctly mesophilous species, such as *Oxalis acetosella*, *Maianthemum bifolium*, *Saxifraga cuneifolia* and *Geranium sylvaticum*. This association was described by FILIPELLO *et alii* (1976, 1980) as the *Calamagrostio villosae-Pinetum cembrae festucetosum flavescentis*, on the basis, inter alia, of relevés carried out in the area. The community differs from the *Pinus cembra* wood typical of the Eastern Alps from the floristic standpoint on account of its appreciable ecological diversity. The subassociation is also found at the foot of the Mount Grivola and on the eastern slopes of the Urtier Valley, whereas the association in the true sense, of which the described samples are occidental vicariants, is widespread to the east of the areas referred to. In some places, especially Cogne Valley, the subassociation is also joined by the rare and localised species *Linnaea borealis*.

The interesting feature of this diffusion of the *Pinus cembra* lies in the fact that it is not abundant in the Aosta Valley and the Western Alps generally, and never forms true, characteristic communities as in this case. Most Authors have attributed it to constant and selective felling for timber.

## 5. 4 ALPINE PASTURES

The 62 phytosociological relevés carried out in the Park's five valleys (table 10) have been set out in individual tables in accordance with the results of the multivariate analysis.

Since rock substrates have a very strong influence on high-altitude vegetation, alpine pastures in the Park are very homogeneous owing to the uniformity of the siliceous bedrock. Some basophilous species are found in the few areas with basic rocks, though always within acidophilous communities whose presence is referable to acidification of the soil due to leaching.

The *Caricetum curvulae* (table 11), is the most widespread climax association on deep, acidic terrains and occurs between 2200 and 2600 m with *Carex curvula* as the dominant component. The character species are *Gentiana punctata* and *Hieracium glanduliferum*, whereas *Silene acaulis* ssp. *exscapa*, *Festuca halleri*, *Senecio halleri*, *Minuartia sedoides* and *Hieracium glaciale* are characteristic of the *Festucetum halleri*. The most frequent representatives of the *Caricetalia curvulae* and the class are *Hieracium piliferum*, *Potentilla aurea* and *Veronica bellidioides*. They are occasionally accompanied in soil discontinuities by species characteristic of the *Thlaspietea rotundifolii*, such as *Cardamine resedifolia*, *Androsace alpina* and *Achillea erba-rotta*. The communities belonging to this association are an indication of considerable evolution of both the soil and the vegetation. They are extremely

*Table 7* — Phytosociological relevés in the spruce woods.

| Relevé no. | 31 | 33 | 16 | 17 | 20 | 28 | 24 | 19 | 23 | 10 | 18 | 25 | 12 | 36 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Altitude (m) | 1659 | 1170 | 1390 | 1850 | 1810 | 1850 | 1990 | 2115 | 1800 | 2050 | 1890 | 2050 | 2160 | 1810 |
| Exposure | N | SW | NW | SE | W | NE | N | W | NE | NW | NW | NE | NE | N |
| Slope (°) | 45 | 20 | 30 | 30 | 30 | 15 | 10 | 45 | 20 | 15 | 15 | 35 | 40 | 30 |
| Tree cover (%) | 80 | 80 | 75 | 60 | 40 | 65 | 40 | 35 | 60 | 20 | 35 | 20 | 50 | 40 |
| Shrub cover (%) | 10 | 1 | 40 | 0 | 0 | 15 | 5 | 30 | 25 | 90 | 85 | 85 | 90 | 80 |
| Herbaceous cover (%) | 40 | 15 | 50 | 15 | 70 | 60 | 50 | 80 | 90 | 5 | 10 | 10 | 10 | 40 |
| **cl. Vaccinio-Piceetea** | | | | | | | | | | | | | | |
| *Larix decidua* (tree) | . | . | . | 2 | 2 | + | . | 3 | 3 | 2 | 2 | 2 | 3 | 3 |
| *Larix decidua* (shrub) | . | . | . | . | . | . | . | + | . | . | + | + | . | 1 |
| *Pinus cembra* (tree) | . | . | . | . | . | . | . | . | . | . | 1 | . | + | . |
| *Pinus cembra* (shrub) | . | . | . | . | . | . | . | . | . | . | + | . | . | . |
| *Picea abies* (tree) | 5 | 5 | 4 | 3 | 3 | 4 | 3 | | 2 | . | 2 | 2 | | . |
| *Picea abies* (shrub) | . | . | 3 | . | . | 2 | 1 | + | 1 | . | . | + | . | . |
| *Festuca flavescens* | . | . | . | + | . | + | 2 | 2 | 3 | . | 1 | . | . | 3 |
| *Rhododendron ferrugineum* | . | . | . | . | . | . | . | 3 | 2 | 4 | 4 | 3 | 4 | 5 |
| *Vaccinium myrtillus* | + | 1 | + | . | 2 | 1 | + | 3 | 3 | 3 | 2 | 2 | 2 | 2 |
| *Vaccinium uliginosum* | . | . | . | . | . | . | . | . | . | . | . | 3 | 2 | . |
| *Vaccinium vitis-idaea* | . | . | + | + | . | 1 | . | 1 | . | 1 | 1 | . | . | . |
| *Juniperus communis* | . | . | . | . | . | . | . | . | + | . | . | 1 | . | + |
| *Lonicera caerulea* | + | + | . | . | . | . | . | . | . | + | + | . | + | . |
| *Deschampsia flexuosa* | 2 | . | . | 2 | . | . | . | . | . | + | . | . | 2 | . |
| *Homogyne alpina* | . | . | . | . | . | + | 2 | + | . | . | + | 1 | . | . |
| *Luzula sylvatica* | + | . | . | . | + | 1 | . | + | . | 1 | 1 | . | . | + |
| *Melampyrum sylvaticum* | . | . | 3 | + | 2 | 2 | + | + | 2 | 1 | 1 | + | . | + |
| *Rubus saxatilis* | . | . | + | . | . | . | . | . | . | . | . | . | . | . |
| *Oxalis acetosella* | . | . | + | . | + | . | 2 | . | . | . | . | . | . | 1 |
| *Sorbus aucuparia* | + | + | . | . | . | . | . | . | . | . | . | . | . | 1 |
| *Hieracium prenanthoides* | . | . | . | . | . | . | . | . | . | . | + | . | . | . |
| *Calamagrostis villosa* | . | . | . | . | . | . | . | . | . | 1 | . | . | . | . |
| **cl. Querco-Fagetea** | | | | | | | | | | | | | | |
| *Luzula nivea* | 1 | + | 1 | 1 | + | + | + | . | . | . | . | . | . | . |
| *Geranium sylvaticum* | . | . | + | + | 1 | . | 1 | 3 | 1 | + | + | . | . | . |
| *Hepatica nobilis* | . | + | + | . | 1 | + | . | . | . | . | . | . | . | . |
| *Athyrium filix-femina* | 3 | 1 | . | . | . | . | . | . | . | . | . | . | . | . |
| *Poa nemoralis* | . | . | . | + | 1 | . | 2 | . | . | . | . | 1 | . | . |
| *Gymnocarpium dryopteris* | . | . | . | . | 1 | . | . | . | . | . | . | . | . | 2 |
| *Saxifraga cuneifolia* | . | . | . | . | . | + | + | + | + | . | . | . | . | + |
| *Viola reichenbachiana* | . | . | . | . | + | + | . | . | + | . | . | . | . | . |
| *Abies alba* | . | . | 2 | . | . | . | . | . | . | . | . | . | . | . |
| *Lilium martagon* | . | . | . | . | . | . | . | + | . | . | . | . | . | . |
| *Geranium robertianum* | + | + | . | . | . | . | . | . | . | . | . | . | . | . |
| *Geranium nodosum* | + | + | . | . | . | . | . | . | . | . | . | . | . | . |
| *Salvia glutinosa* | + | + | . | . | . | . | . | . | . | . | . | . | . | . |
| *Prenanthes purpurea* | + | 1 | . | . | . | . | . | . | . | . | . | . | . | . |
| *Polygonatum odoratum* | + | + | . | . | . | . | . | . | . | . | . | . | . | . |
| *Maianthemum bifolium* | + | + | . | . | 2 | . | . | . | . | . | . | . | . | . |
| *Viola biflora* | . | . | . | . | . | . | + | . | . | . | . | . | . | . |
| *Chaerophyllum hirsutum* | . | . | + | . | . | . | . | . | . | . | . | . | . | . |
| **cl. Arrhenetheretea** | | | | | | | | | | | | | | |
| *Festuca rubra* | . | . | . | . | . | . | . | . | . | . | . | 1 | . | . |
| *Ranunculus acris* | . | . | . | . | + | + | . | 1 | . | . | . | . | . | . |
| *Anthoxanthum odoratum* | . | . | . | + | 1 | . | . | + | . | . | . | 1 | . | + |
| *Campanula scheuchzeri* | . | . | . | . | . | + | . | . | + | + | . | . | . | . |
| *Phyteuma betonicifolium* | . | . | . | . | . | . | . | . | . | . | . | + | . | . |
| *Poa alpina* | . | . | . | . | . | . | . | . | . | + | . | . | 1 | . |
| **companion species** | | | | | | | | | | | | | | |
| *Pulsatilla alpina* | . | . | . | . | . | . | . | + | . | . | . | . | . | . |
| *Gentiana punctata* | . | . | . | . | . | . | . | . | . | . | + | . | . | . |
| *Laserpitium halleri* | . | . | . | . | . | . | . | . | . | + | + | . | . | . |
| *Lotus corniculatus* | . | . | . | . | + | . | . | + | . | . | . | 1 | . | . |
| *Thymus pulegioides* | . | . | . | . | . | . | . | + | . | . | . | . | . | . |
| *Brachypodium sylvaticum* | . | . | . | . | . | 3 | . | . | . | . | . | . | . | . |
| *Poa chaixi* | . | . | . | . | . | . | . | . | . | + | . | . | . | . |
| *Solidago virgaurea* | . | . | . | . | . | + | . | + | . | . | . | + | + | . |
| *Fragaria vesca* | . | . | + | . | . | + | + | . | . | . | . | . | . | . |
| *Empetrum nigrum* | . | . | . | . | . | . | . | . | . | . | . | . | + | . |
| *Gentiana lutea* | . | . | . | . | . | . | . | . | . | + | . | . | . | . |

*Table 8* — Phytosociological relevés in the larch woods.

| Relevé no. | 26 | 27 | 4 | 39 | 5 | 6 | 2 | 11 | 35 | 37 | 40 | 38 | 29 | 30 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Altitude (m) | 2070 | 1880 | 1650 | 1680 | 1950 | 1870 | 2112 | 1950 | 1880 | 1600 | 1670 | 1600 | 1500 | 1690 |
| Exposure | NE | W | W | S | W | W | NE | NW | SE | N | N | N | SE | SE |
| Slope (°) | 3 | 25 | 30 | 25 | 30 | 15 | 10 | 10 | 25 | 35 | 50 | 45 | 25 | 20 |
| Tree cover (%) | 70 | 40 | 50 | 40 | 30 | 30 | 10 | 25 | 40 | 30 | 20 | 50 | 40 | 35 |
| Shrub cover (%) | 10 | 5 | 10 | 1 | 1 | 20 | 35 | 90 | 3 | 60 | 60 | 85 | 80 | 15 |
| Herbaceous cover (%) | 75 | 40 | 50 | 80 | 60 | 75 | 80 | 5 | 95 | 35 | 70 | 50 | 80 | 70 |
| **cl. Vaccinio-Piceetea** | | | | | | | | | | | | | | |
| *Larix decidua* (tree) | 4 | 3 | 3 | 3 | 3 | 3 | 2 | 2 | 3 | 3 | 2 | 3 | 3 | 3 |
| *Picea abies* (tree) | . | . | . | . | . | . | . | . | . | . | . | | 2 | + |
| *Picea abies* (shrub) | . | . | . | . | . | . | . | . | . | 2 | 2 | 1 | | |
| *Pinus cembra* | . | . | . | . | 1 | . | 1 | 2 | | . | . | . | | |
| *Festuca flavescens* | 2 | 2 | . | . | + | . | + | . | | 2 | 4 | 3 | 3 | 2 |
| *Rhododendron ferrugineum* | 1 | . | . | . | . | . | 2 | 2 | + | 3 | 3 | 2 | | 3 |
| *Rubus idaeus* | . | 1 | 1 | . | . | . | . | . | . | 2 | 2 | 4 | 3 | |
| *Oxalis acetosella* | + | . | . | . | . | . | . | . | . | 1 | . | 1 | + | |
| *Vaccinium myrtillus* | + | . | . | . | 2 | 2 | 3 | 4 | 4 | 2 | 2 | 2 | . | 3 |
| *Vaccinium uliginosum* | . | . | . | . | + | 2 | 1 | . | . | . | . | . | . | . |
| *Vaccinium vitis-idaea* | . | . | . | . | 2 | . | + | 1 | . | . | . | . | . | + |
| *Deschampsia flexuosa* | . | . | . | . | 1 | . | 2 | 1 | . | . | + | 2 | . | 2 |
| *Hieracium murorum* gr. | . | 1 | 1 | . | 2 | + | . | + | . | . | . | . | + | + |
| *Homogyne alpina* | . | . | . | . | + | . | + | + | . | . | . | . | . | . |
| *Juniperus communis* | 1 | . | 2 | + | . | . | . | . | + | . | + | | | |
| *Juniperus communis* ssp. *nana* | . | . | . | . | + | 2 | . | 1 | . | . | . | . | . | + |
| *Lonicera caerulea* | . | . | . | . | . | . | . | + | . | . | . | . | . | . |
| *Luzula sylvatica* | . | . | . | . | . | + | . | 1 | . | . | . | . | . | . |
| *Melampyrum sylvaticum* | . | . | . | . | 2 | 2 | . | 1 | + | . | . | . | . | . |
| **cl. Querco-Fagetea** | | | | | | | | | | | | | | |
| *Luzula nivea* | . | . | . | . | . | . | . | . | 2 | + | + | + | 2 | + |
| *Viola biflora* | . | . | . | . | . | . | . | . | . | . | . | 1 | 2 | |
| *Viola reichenbachiana* | 1 | . | . | + | . | . | . | . | . | . | . | . | | |
| *Daphne mezereum* | 1 | . | 1 | . | . | . | . | . | . | . | . | . | | |
| *Poa nemoralis* | . | 1 | + | . | + | . | . | . | . | . | . | . | | |
| *Viola reichenbachiana* | . | . | . | . | . | . | . | . | 1 | . | . | . | . | |
| *Geranium sylvaticum* | . | . | . | . | 2 | 1 | . | . | 1 | . | . | . | 2 | . |
| **cl. Arrhenaterethea** | | | | | | | | | | | | | | |
| *Phyteuma betonicifolium* | . | + | + | + | + | . | . | . | . | . | . | . | . | . |
| *Brachypodium sylvaticum* | 3 | 2 | 1 | . | . | . | . | . | . | 2 | . | 2 | . | . |
| *Campanula scheuchzeri* | + | + | . | . | + | + | . | . | . | . | . | . | . | . |
| *Galium mollugo* | + | 1 | 1 | 1 | . | . | . | . | . | . | . | . | . | . |
| *Veronica chamaedrys* | . | + | + | . | . | . | . | . | . | . | . | . | . | . |
| *Silene vulgaris* | 2 | . | . | . | . | . | . | . | . | . | . | . | . | . |
| *Chaerophyllum hirsutum* | . | . | . | . | 2 | 2 | . | . | + | + | . | 1 | + | 1 |
| *Ranunculus acris* | . | . | . | . | + | + | . | . | + | . | . | . | . | . |
| **companion species** | | | | | | | | | | | | | | |
| *Festuca varia* | . | . | . | 4 | . | . | . | . | . | . | . | . | . | . |
| *Alnus viridis* | . | . | . | . | . | . | . | . | . | + | . | 1 | + | . |
| *Peucedanum ostrutium* | 1 | . | . | . | . | . | . | . | . | . | . | . | . | . |
| *Hieracium pilosella* | . | . | . | 1 | . | . | . | . | . | . | . | . | . | . |
| *Fragaria vesca* | . | . | 1 | . | . | . | . | . | . | . | . | . | + | . |
| *Sambucus racemosa* | . | . | . | . | . | . | . | . | . | + | . | . | 2 | . |
| *Sedum album* | . | 1 | . | . | . | . | . | . | . | . | . | . | . | . |
| *Festuca ovina* | . | + | 2 | . | . | . | . | . | . | . | . | . | . | . |
| *Anthoxanthum odoratum* | . | . | + | 1 | + | 1 | + | + | + | . | . | . | . | 1 |
| *Pulsatilla alpina* | . | . | . | . | 2 | + | . | . | + | . | . | . | . | . |
| *Avenula versicolor* | . | . | . | . | . | . | + | + | . | . | . | . | . | . |
| *Laserpitium halleri* | . | . | . | . | + | . | . | . | + | . | . | . | . | + |
| *Lotus corniculatus* | . | . | . | . | + | + | . | . | + | . | . | . | . | . |
| *Poa chaixi* | . | . | . | . | + | 2 | . | + | . | . | . | . | . | + |
| *Empetrum nigrum* | . | . | . | . | . | . | 2 | + | . | . | . | . | . | . |

*Table 9* — Phytosociological relevés in the *Pinus cembra* woods.

| Relevé no. | 9 | 13 | 7 | 14 | 15 | 1 | 8 | 3 | 21 | 22 |
|---|---|---|---|---|---|---|---|---|---|---|
| Altitude (m) | 2100 | 1870 | 1865 | 1925 | 1732 | 2220 | 2000 | 1900 | 2090 | 2090 |
| Exposure | NW | NW | W | W | W | E | NW | NE | NO | W |
| Slope (°) | 20 | 40 | 20 | 25 | 45 | 5 | 15 | 10 | 15 | 25 |
| Tree cover (%) | 35 | 30 | 25 | 50 | 35 | 3 | 20 | 40 | 50 | 60 |
| Shrub cover (%) | 70 | 40 | 1 | 35 | 45 | 30 | 2 | 15 | 2 | 40 |
| Herbaceous cover (%) | 30 | 100 | 90 | 60 | 60 | 10 | 90 | 60 | 70 | 30 |
| *Larix decidua* (tree) | 2 | 3 | 2 | 1 | 3 | 1 | 2 | 3 | 2 | 2 |
| *Larix decidua* (shrub) | . | + | + | . | + | . | . | . | . | |
| *Picea abies* | . | + | . | 3 | 2 | . | 1 | 2 | 2 | 1 |
| *Pinus cembra* | 2 | + | . | 1 | . | 1 | 2 | 1 | 2 | 3 |
| *Sorbus aucuparia* | . | + | . | . | 2 | . | . | . | . | |
| **ass. Calamagrostio villosae-Pinetum cembrae** | | | | | | | | | | |
| *Calamagrostis villosa* | 3 | 4 | 5 | + | 2 | . | . | | . | . |
| *Lonicera caerulea* | + | 1 | + | 1 | 2 | . | . | | . | |
| *Luzula sylvatica* | + | . | 1 | | . | . | 1 | . | . | . |
| *Hieracium prenanthoides* | + | . | . | + | | . | 1 | . | . | . |
| *Festuca flavescens* | . | . | . | | 3 | . | . | 1 | 2 | . |
| **cl. Vaccinio-Piceetea** | | | | | | | | | | |
| *Rhododendron ferrugineum* | 3 | 3 | 1 | 2 | 2 | . | + | . | + | 3 |
| *Deschampsia flexuosa* | 1 | 2 | + | 1 | 2 | 1 | + | 2 | . | . |
| *Vaccinium myrtillus* | 3 | 2 | + | + | + | 2 | 1 | 2 | 2 | 1 |
| *Vaccinium vitis-idaea* | 1 | + | + | | | 1 | + | 3 | 2 | + |
| *Homogyne alpina* | + | + | + | | | . | + | . | 1 | . |
| *Hieracium murorum* gr. | + | . | 1 | | | . | + | . | . | |
| *Melampyrum sylvaticum* | + | + | + | 2 | + | . | + | | 2 | |
| *Clematis alpina* | . | . | . | . | + | . | . | . | . | . |
| *Cotoneaster integerrimus* | . | + | . | . | . | . | . | . | . | . |
| *Rubus saxatilis* | . | . | + | . | . | . | + | . | . | . |
| *Rosa pendulina* | . | . | . | . | + | . | . | . | . | . |
| *Oxalis acetosella* | . | . | . | + | . | . | . | . | 1 | . |
| *Sorbus chamaemespilus* | + | . | . | . | . | . | . | . | . | . |
| *Rubus idaeus* | . | . | . | . | + | . | . | . | . | . |
| *Juniperus communis* | . | 2 | . | . | . | . | . | . | . | . |
| *Juniperus communis* ssp. *nana* | + | . | . | . | . | 2 | 1 | 2 | . | . |
| **cl. Querco-Fagetea** | | | | | | | | | | |
| *Geranium sylvaticum* | . | 1 | + | 2 | 1 | . | + | . | + | . |
| *Viola reichenbachiana* | . | . | . | 1 | + | . | . | . | . | . |
| *Luzula nivea* | . | . | . | + | + | . | . | . | . | . |
| *Thalictrum aquilegifolium* | . | . | . | . | + | . | . | . | . | . |
| *Lilium martagon* | . | + | . | . | . | . | . | . | + | . |
| *Prenanthes purpurea* | . | . | . | + | . | . | . | . | . | . |
| *Maianthemum bifolium* | . | . | . | . | + | . | . | . | . | . |
| *Daphne mezereum* | . | . | + | . | . | . | . | . | . | . |
| *Populus tremula* (seedlings) | . | . | . | . | + | . | . | . | . | . |
| *Saxifraga cuneifolia* | . | . | . | + | . | . | . | . | . | . |
| *Poa nemoralis* | . | . | . | + | . | . | . | . | . | . |
| *Salix caprea* | . | . | . | . | 2 | . | . | . | . | . |
| **companion species** | | | | | | | | | | |
| *Campanula barbata* | . | + | . | + | . | . | . | . | . | . |
| *Chaerophyllum hirsutum* | . | 1 | . | + | . | . | + | . | . | . |
| *Anthoxanthum odoratum* | . | + | . | + | . | . | + | . | + | . |
| *Campanula scheuchzeri* | . | + | . | + | . | . | + | . | . | . |
| *Phyteuma betonicifolium* | . | . | . | + | + | . | . | . | . | . |
| *Alnus viridis* | . | . | . | 2 | + | . | . | . | . | . |
| *Peucedanum ostrutium* | . | . | . | 3 | 1 | . | . | . | . | . |
| *Solidago virgaurea* | . | + | . | . | 1 | . | . | . | . | . |
| *Epilobium angustifolium* | . | . | . | 2 | 1 | . | . | . | . | . |
| *Fragaria vesca* | . | + | . | + | . | . | . | . | . | . |
| *Gentiana lutea* | 1 | . | . | . | . | + | . | . | . | . |
| *Leucanthemum adustum* | . | + | . | . | + | + | 1 | . | . | . |
| *Poa chaixi* | + | + | . | + | + | . | . | . | . | . |
| *Ranunculus montanus* | . | + | . | + | . | . | . | . | . | . |

*Table 10* — List of the 62 relevé points for alpine pastures.

| Relevè no. | Site | |
|---|---|---|
| 1, 2, 7, 10, 11 | Soana Valley | S. Besso |
| 6, 19, 39 | Soana Valley | Vallone di Forzo, Alpe Muanda |
| 8 | Soana Valley | Above S. Besso |
| 15, 36, 38 | Soana Valley | Vallone di Forzo Casotto Giavin |
| 19 | Soana Valley | Vallone di Forzo. Lago della Valletta |
| 3, 9, 14, 16, 20, 27, 30-35, 37, 40 | Orco Valley | Casotto Bastalon |
| 4, 5 | Orco Valley | Vallone di Piantonetto, Pontese Shelter |
| 12,13 | Orco Valley | Chiapili di sopra |
| 17 | Orco Valley | Casotto Bastalon, up to Colle della Terra |
| 24 | Orco Valley | Casotto Bastalon, Lago Gias di Ben |
| 18, 21, 22, 25, 26, 28, 29 | Orco Valley | Valsoera |
| 41, 42 | Cogne Valley | Vittorio Sella Shelter |
| 47, 61 | Cogne Valley | Casolari Money |
| 60 | Cogne Valley | Up to Col Pousset |
| 62 | Cogne Valley | Vallone di Valeille, Casotto Arolla |
| 43 | Rhêmes Valley | Grange Chassettaz |
| 44 | Rhêmes Valley | Montagne di Entrelor |
| 45 | Rhêmes Valley | Above Montagne di Entrelor |
| 46 | Rhêmes Valley | Pian delle Feje |
| 47, 48, 49 | Rhêmes Valley | Vallone della Gran Vaudala |
| 51 | Rhêmes Valley | Mont Blanc |
| 53, 54 | Valsavarenche | Ripiano di Leviona |
| 55, 56 | Valsavarenche | Alpe di Lavassey |
| 57 | Valsavarenche | Casotto di Orvieille |
| 58 | Valsavarenche | Piano del Nivolet |

resistant to chronic disturbance despite their low diversity, as shown by Grabherr.

Shallower terrains with a better exposure, often S and SW between 2000 and 2600 m, are occupied by communities belonging to the *Festucetum halleri* association (table 12) with *Festuca halleri* as the dominant member. This species grows on humified, well-watered acid soil (pH 4-5.5) in areas where slopes of the order of 10-30° ensure good drainage. The other characteristic species are *Pedicularis kerneri*, *Silene acaulis* ssp. *exscapa* and *Bellardiochloa violacea*. These accompany *Geum montanum*, *Potentilla aurea*, *Carex sempervirens* and *Phyteuma hemisphaericum* (characteristic of the *Caricetalia curvulae* and the *Caricion curvulae*) as more abundant species. The relevés most representative of this situations are nos. 18, 28, 26 and 29, whereas nos. 41, 60, 42 and 52 display a substantial contingent of species characteristic of the *Elyno-Seslerietea* , such as *Myosotis alpestris*, *Alchemilla alpina*, *Galium pusillum* and *Trifolium thalii*, which provide evidence of a transition towards the *Trifolio thalii-Festucetum nigricantis* typical of basic substrates. The other relevés, too, comprise a few basophilous entities in their contingent of acidophilous species. It is clear that leaching of originally basic substrates has resulted in progressive colonisation by acidophilous species. The relevés with the largest number of these species are in Soana Valley, at San Besso, and in the Cogne Valley, near Col Lauson.

In the Central Alps, the *Festucetum halleri* is typically found in areas that are warmer than those occupied by the *Caricetum curvulae*. In the Park, as in other sites of the Western Alps however, this community grows on steeper slopes with discontinuities and more or less distinct steps, and shows a slightly different ecological behaviour. *Festuca halleri* itself seems to develop well even in these areas. The turf it forms is less dense and more loosely packed than that formed by *Carex curvula*. The species diversity of these communities is low, as in relevés 18, 28, 26, 29, where they are composed of few species owing to the high altitude, prolonged snow coverage and considerable streamwater erosion.

Elsewhere their diversity is greater than that of the *Caricetum curvulae*. This is partly due to the presence of species typical of other situations, particularly those of mown meadows, such as *Poa alpina*, *Anthoxanthum odoratum*, *Polygonum bistorta* and *Trifolium pratense* ssp. *frigidum*.

Areas between 2000 and 2600 m similar to those described, but with gentle slopes, are occupied by assemblages typical of zones degraded by cattle, sheep and wild animal grazing, with dominant *Nardus stricta* and *Trifolium alpinum* (table 13). *Nardus stricta* forms dense tussocks and dominates the community; it has considerable ecological plasticity, while its unpalatability allows it to spread over heavily grazed land. The first six relevés in the table show *Nardus stricta* as dominant with character species of the *Caricetea curvulae*, while at higher elevations (2200-2700 m) the presence of character species of the *Arrhenatheretea* and *Festuco-Brometea* is evidence of the transport of seeds by cattle taken up to pasture. Surveys 3, 19, 12 and 48 also include *Viola calcarata* and *Geum montanum* (*Nardion strictae* alliance), as well as other character species of the *Caricetalia curvulae* and the *Caricetea curvulae*, such as *Carex sempervirens*. In these relevés, *Trifolium alpinum*, another species typical of overgrazed, highly acidified pastures, is accompanied by *Nardus stricta*. The strong competition between these two species tends to exclude one or the other.

*Trifolium alpinum* has abundance-dominance index values of 4 and 5 in relevés 51, 59 and 7, and excludes most other species, whereas in those on the right of the table values are lower, and the communities include species characteristic of both acidic and basic bedrocks. The presence of *Nardus stricta* alone among the character species of the *Geo-Nardetum strictae* merely points to a tendency towards the constitution of this association, whereas its existence has never been unequivocably documented.

The widespread diffusion of *Nardus stricta* in the Park may be the cause of some concern with respect to the management of its wild animal population. Both ibexes and chamois have greatly increased in number over the past 15 years. The former, in particular, have reached the status of residents.

The second widespread vegetation type observed in the alpine pastures consists of communities with very high dominance of *Festuca varia* belonging to the *Pulsatillo albae-Festucetum variae* (*Festucion variae*, *Caricetalia curvulae*, *Caricetea curvulae*), typical of sunny, rocky slopes (table 14). Most of these herb rich communities are located between 2200 and 2500 m on S-SE facing, 30-40° slopes. Their characteristic species are *Festuca varia*, *Potentilla grandiflora* and *Ranunculus pyrenaeus*. GIACOMINI and PIGNATTI (1955) regard these communities as primitive compared with the climax associations of the *Caricion curvulae* or the *Nardion strictae*.

*Table 11* — Phytosociological relevés in alpine pastures (the *Caricetum curvulae*).

| Relevé no. | 16 | 61 | 9 | 62 | 14 | 50 | 54 | 13 | 21 | 25 | 22 | 23 | 17 | 24 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Altitude (m) | 2500 | 2400 | 2505 | 2320 | 2500 | 2405 | 2230 | 2420 | 2420 | 2420 | 2380 | 2390 | 2615 | 2190 |
| Exposure | NW | W | S | W | W | NW | NE | W | W | NW | SW | SW | SW | SW |
| Slope (°) | 10 | 10 | 10 | 25 | 5 | 10 | 10 | 10 | 45 | 5 | 20 | 20 | 45 | 5 |
| Herbaceous cover (%) | 80 | 90 | 60 | 70 | 90 | 90 | 90 | 60 | 80 | 40 | 45 | 80 | 70 | 70 |
| **ass. Caricetum curvulae** | | | | | | | | | | | | | | |
| *Carex curvula* | 4 | 4 | 2 | 3 | 3 | 4 | 4 | 3 | 1 | 2 | 1 | 3 | 2 | 2 |
| *Gentiana punctata* | + | . | + | + | . | . | + | . | . | . | . | . | . | . |
| *Hieracium granduliferum* | | | + | | | + | | + | | | + | + | + | + |
| **ass. Festucetum halleri** | | | | | | | | | | | | | | |
| *Festuca halleri* | 2 | 2 | 2 | 2 | 2 | . | + | 1 | + | . | + | . | . | . |
| *Silene acaulis* ssp. *exscapa* | 1 | + | . | + | . | + | . | . | + | 1 | + | . | 1 | + |
| *Minuartia sedoides* | + | . | 1 | . | 2 | + | . | . | + | 1 | . | . | 1 | . |
| *Hieracium glaciale* | + | 1 | . | . | + | . | + | . | . | . | . | . | . | . |
| **all. Caricion curvulae** | | | | | | | | | | | | | | |
| *Sempervivum montanum* | . | . | . | . | . | . | . | + | + | . | . | . | 2 | 1 |
| *Phyteuma hemisphaericum* | . | + | + | . | + | . | . | . | + | . | . | . | + | . |
| *Pedicularis rosea* | . | + | . | + | . | . | . | + | . | . | . | . | . | . |
| *Sempervivum arachnoideum* | . | . | 1 | . | . | . | + | . | . | . | . | . | . | . |
| *Avenula versicolor* | . | . | . | . | . | . | . | . | . | . | + | + | . | 1 |
| *Leucanthemopsis alpina* | + | . | . | | 2 | . | . | 2 | + | . | + | . | + | . |
| **ass. Geo-Nardetum strictae** | | | | | | | | | | | | | | |
| *Trifolium alpinum* | . | . | . | 1 | . | 2 | . | 1 | . | . | . | . | . | . |
| *Nardus stricta* | . | . | . | . | . | + | . | 1 | . | . | . | . | . | . |
| *Geum montanum* | . | . | . | . | + | + | . | + | . | . | . | . | + | . |
| **ass. Pulsatillo albae-Festucetum variae** | | | | | | | | | | | | | | |
| *Festuca varia* | . | . | . | + | . | . | . | . | . | . | . | . | . | . |
| *Potentilla grandiflora* | . | . | + | . | . | . | . | + | . | . | . | . | . | . |
| *Ranunculus pyrenaeus* | . | . | . | . | . | + | . | 2 | . | . | . | . | . | . |
| **ord. Caricetalia curvulae and cl.** | | | | | | | | | | | | | | |
| *Antennaria dioica* | . | + | + | . | . | . | . | + | . | . | . | . | . | + |
| *Veronica bellidiodes* | + | . | + | . | . | + | . | + | . | . | . | . | + | . |
| *Senecio halleri* | 2 | . | 1 | . | 1 | . | . | + | 1 | . | . | . | + | + |
| *Hieracium piliferum* | . | . | 1 | + | . | . | + | + | + | + | . | . | . | . |
| *Luzula lutea* | . | . | . | . | . | + | + | . | . | . | 1 | 2 | + | . |
| *Luzula spicata* | . | . | . | . | . | . | . | . | . | . | . | . | + | . |
| *Pedicularis kerneri* | + | . | . | . | + | . | . | . | . | . | . | . | 1 | . |
| *Carex sempervirens* | . | + | 1 | . | . | + | . | 2 | . | . | . | 1 | . | . |
| *Potentilla aurea* | + | . | . | . | 2 | . | + | + | . | . | . | . | . | . |
| *Juncus trifidus* | . | . | 1 | 2 | . | . | . | . | . | . | + | . | . | . |
| **cl. Elyno-Seslerietea** | | | | | | | | | | | | | | |
| *Minuartia recurva* | . | . | . | . | . | + | 2 | . | . | . | . | . | . | . |
| *Myosotis alpestris* | . | . | . | . | . | + | . | 1 | . | . | . | + | + | . |
| *Gentiana verna* | . | . | . | . | + | . | . | + | . | . | . | . | + | . |
| *Alchemilla alpina* | . | . | . | . | . | + | . | 2 | . | . | . | . | . | . |
| *Festuca violacea* | . | . | . | . | . | . | . | . | . | . | . | . | 1 | 2 |
| *Phleum alpinum* | . | . | . | . | . | . | + | . | . | . | . | . | . | . |
| **cl. Thlaspietea rotundifolii** | | | | | | | | | | | | | | |
| *Achillea erba-rotta* | . | . | + | + | . | . | . | . | . | . | . | . | 2 | . |
| *Cardamine resedifolia* | . | . | . | . | . | + | . | + | . | . | + | . | + | + |
| *Androsace alpina* | + | . | + | . | + | . | . | . | . | + | . | . | . | . |
| **companion species** | | | | | | | | | | | | | | |
| *Lotus alpinus* | . | . | 1 | + | + | . | + | + | . | . | . | 1 | + | . |
| *Anthoxanthum odoratum* | . | . | . | . | . | . | + | . | . | . | . | . | . | + |
| *Poa alpina* | + | + | . | + | + | . | . | + | . | . | . | . | 2 | . |
| *Vaccinium uliginosum* | . | . | . | 1 | . | . | . | . | 1 | . | 2 | 3 | 2 | . |
| *Leontodon pyrenaicus* | . | 2 | . | + | + | + | . | . | 1 | . | . | 1 | + | + |
| *Valeriana celtica* | + | 1 | . | 1 | . | + | . | . | 1 | + | + | . | + | . |
| *Astrantia minor* | . | . | . | + | . | . | . | . | + | + | + | + | . | . |
| *Polygonum viviparum* | . | 1 | . | 1 | . | . | . | . | . | . | 2 | . | . | . |
| *Plantago alpina* | . | . | . | . | . | 1 | 2 | . | . | . | . | . | . | . |
| *Thymus pulegioides* | . | . | . | . | . | . | 1 | . | . | . | . | . | . | . |
| *Salix herbacea* | . | + | . | . | . | . | . | . | . | . | 2 | . | . | . |

*Table 12* — Phytosociological relevés in alpine pastures (the *Festucetum halleri*).

| Relevé no. | 18 | 28 | 26 | 29 | 41 | 60 | 42 | 52 | 5 | 30 | 15 | 4 | 47 | 8 | 11 | 44 | 46 | 37 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Altitude (m) | 2400 | 2480 | 2480 | 2480 | 2590 | 2100 | 2580 | 2345 | 2500 | 2550 | 2270 | 2200 | 2350 | 2055 | 2050 | 2155 | 2403 | 2420 |
| Exposure | SW | SW | SW | SW | SE | NE | W | SW | NW | SW | W | W | NW | S | NW | W | SW | W |
| Slope (°) | 10 | 10 | 10 | 10 | 30 | 10 | 1 | 20 | 15 | 45 | 5 | 10 | 5 | 10 | 10 | 5 | 15 | 20 |
| Herbaceous cover (%) | 60 | 50 | 90 | 60 | 90 | 95 | 90 | 75 | 100 | 90 | 95 | 100 | 100 | 90 | 100 | 80 | 70 | 65 |
| **ass. Festucetum halleri** | | | | | | | | | | | | | | | | | | |
| *Festuca halleri* | . | 2 | . | 2 | 4 | 3 | 2 | 2 | . | . | 2 | + | 1 | 2 | . | 2 | 1 | 2 |
| *Pedicularis kerneri* | 1 | 1 | + | 2 | + | . | . | . | . | . | . | . | . | . | . | . | + | . |
| *Silene acaulis* ssp. *exscapa* | + | . | + | 1 | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| *Bellardiochloa violacea* | 1 | + | 2 | 2 | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| *Hieracium glaciale* | . | . | . | . | . | . | . | + | . | . | . | + | . | + | + | . | . | 2 |
| **all. Caricion curvulae, ord. and cl.** | | | | | | | | | | | | | | | | | | |
| *Cerastium arvense* ssp. *strictum* | . | . | . | . | . | . | . | . | . | . | + | . | . | . | + | . | + | . |
| *Geum montanum* | . | . | . | . | + | . | + | . | + | 2 | 3 | . | 2 | + | . | . | 2 | + |
| *Trifolium alpinum* | 2 | 1 | . | . | . | . | . | + | . | . | . | + | . | . | + | . | . | + |
| *Leucanthemopsis alpina* | . | . | . | . | . | . | . | . | . | 2 | . | + | + | . | . | . | . | 2 |
| *Minuartia sedoides* | . | . | + | 1 | . | . | . | . | . | . | + | + | . | . | . | . | . | . |
| *Carex curvula* | . | . | + | . | . | . | . | + | . | . | . | . | . | 2 | . | . | . | . |
| *Phyteuma hemisphaericum* | + | . | . | . | . | . | . | . | . | . | + | . | + | + | 2 | . | . | + |
| *Potentilla aurea* | . | . | . | . | . | + | + | + | . | 1 | . | . | . | + | . | . | . | . |
| *Carex sempervirens* | + | + | . | . | . | . | . | . | + | . | 2 | + | . | 1 | 1 | . | . | . |
| *Antennaria dioica* | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | 1 | . | 3 |
| *Sempervivum arachnoideum* | . | . | . | . | + | . | . | 1 | . | . | . | . | . | . | . | . | . | + |
| *Sempervivum montanum* | . | . | . | . | . | + | . | . | . | + | . | . | . | . | . | . | + | . |
| **cl. Elyno-Seslerietea** | | | | | | | | | | | | | | | | | | |
| *Myosotis alpestris* | . | . | . | . | + | + | + | + | + | 1 | . | + | . | + | + | . | + | . |
| *Alchemilla alpina* | . | . | . | . | . | . | + | . | 3 | . | 1 | 2 | . | . | . | . | . | . |
| *Galium pusillum* | . | . | . | . | + | + | + | + | . | . | . | . | . | . | . | . | + | . |
| *Anthyllis vulneraria* ssp. *alpestris* | . | . | . | . | + | . | . | . | . | . | . | . | . | . | . | 2 | . | . |
| *Gentiana verna* | . | . | . | . | + | . | + | . | + | + | . | . | . | . | . | . | + | + |
| *Trifolium thalii* | . | . | . | . | + | 2 | . | . | . | . | . | . | . | . | . | 1 | . | . |
| *Phleum alpinum* | . | . | . | . | . | + | 1 | . | . | . | + | . | . | . | + | . | . | . |
| *Pulsatilla alpina* | . | . | . | . | . | . | . | . | . | . | . | . | . | + | + | . | + | . |
| *Plantago maritima* ssp. *serpentina* | . | . | . | . | . | . | . | . | . | . | . | . | . | + | + | 2 | + | . |
| *Erigeron uniflorum* | . | . | . | . | . | . | . | . | . | . | + | . | . | + | + | . | . | . |
| *Minuartia verna* | . | . | . | . | . | . | . | . | . | . | . | . | . | + | + | . | . | . |
| *Agrostis alpina* | 2 | 2 | 3 | 2 | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| **cl. Arrhenatheretea** | | | | | | | | | | | | | | | | | | |
| *Poa alpina* | . | . | . | . | + | 1 | 1 | 1 | 2 | + | 2 | + | . | 1 | 1 | 1 | + | . |
| *Anthoxanthum odoratum* | . | . | . | . | . | + | . | . | . | . | + | . | 2 | + | 2 | . | . | . |
| *Polygonum bistorta* | . | . | . | . | . | . | . | . | + | . | . | + | . | . | + | . | . | . |
| *Trifolium pratense* ssp. *serpentina* | . | . | . | . | . | . | . | + | . | . | . | . | . | + | + | + | + | . |
| **companion species** | | | | | | | | | | | | | | | | | | |
| *Lotusalpinus* | . | . | . | . | + | . | 2 | 2 | 2 | + | + | 2 | + | + | + | . | + | + |
| *Plantago alpina* | . | . | . | . | 2 | 3 | 2 | 3 | . | + | . | . | . | . | . | . | . | . |
| *Polygonum viviparum* | 2 | 3 | 2 | . | . | . | . | . | + | . | . | 2 | 2 | 3 | 2 | . | + | . |
| *Alchemilla glaucescens* | . | . | . | . | . | . | 2 | . | + | . | + | . | . | 2 | 3 | . | 2 | . |
| *Ranunculus gracilis* | . | . | . | . | . | . | . | . | 3 | 4 | 2 | + | . | . | . | . | . | . |
| *Ranunculus montanus* | . | . | . | . | . | . | . | . | . | . | . | . | . | + | 2 | . | + | . |
| *Astrantia minor* | + | + | + | 1 | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| *Leontodon pyrenaicus* | 2 | + | . | . | . | + | . | . | + | . | + | 2 | + | . | . | 2 | . | . |
| *Hieracium pilosella* | . | . | . | . | 2 | . | . | . | . | . | . | . | . | . | . | 2 | 2 | . |
| *Salix herbacea* | . | . | . | . | . | . | . | . | . | . | . | 3 | 3 | . | . | . | . | . |
| *Sibbaldia procumbens* | . | . | . | . | . | . | + | . | + | + | . | . | 1 | . | . | . | . | . |
| *Cardamine resedifolia* | + | + | . | . | . | . | . | . | + | . | + | . | . | . | . | . | . | + |
| *Primula pedemontana* | + | + | + | + | . | . | . | . | . | . | . | . | . | + | . | . | . | . |

*Tab. 13* — Phytosociological relevés in alpine pastures with dominating *Nardus stricta* and *Trifolium alpinum*.

| | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Relevé no. | 58 | 55 | 57 | 56 | 6 | 20 | 3 | 19 | 12 | 48 | 2 | 53 | 51 | 59 | 7 | 45 | 49 | 27 | 43 | 1 | 10 |
| Altitude (m) | 23 | 21 | 22 | 21 | 27 | 24 | 26 | 22 | 24 | 23 | 20 | 23 | 21 | 22 | 20 | 22 | 23 | 25 | 22 | 20 | 20 |
| | 30 | 60 | 00 | 65 | 75 | 95 | 15 | 80 | 40 | 75 | 40 | 30 | 85 | 90 | 40 | 10 | 85 | 00 | 30 | 54 | 50 |
| Exposure | N | NW | E | NW | SW | SE | S | SW | W | SW | E | NE | NE | W | N | W | NW | W | W | SE | NE |
| Slope (°) | 20 | 15 | 10 | 20 | 5 | 20 | 5 | 3 | 15 | 3 | 20 | 30 | 5 | 5 | 15 | 10 | 7 | 20 | 5 | 5 | 10 |
| Herbaceous cover (%) | 95 | 100 | 90 | 100 | 100 | 90 | 95 | 85 | 60 | 95 | 100 | 100 | 100 | 95 | 90 | 70 | 80 | 90 | 80 | 90 | 100 |
| **all. Nardion strictae** | | | | | | | | | | | | | | | | | | | | | |
| *Nardus stricta* | 2 | 4 | 3 | 3 | 2 | 2 | 3 | 2 | 2 | 3 | . | . | . | . | . | . | . | . | . | . | . |
| *Viola calcarata* | . | . | . | . | . | . | + | . | + | + | . | . | . | . | . | . | + | . | . | . | . |
| *Leucanthemopsis alpina* | . | . | . | . | . | 1 | 1 | . | + | + | . | . | . | . | . | . | + | . | . | . | . |
| *Geum montanum* | + | . | . | . | + | 3 | + | . | + | + | . | . | + | . | + | 1 | + | . | + | . | . |
| **all. Caricion curvulae** | | | | | | | | | | | | | | | | | | | | | |
| *Festuca halleri* | . | . | . | . | . | . | 2 | . | + | 1 | 2 | . | . | . | + | 2 | 2 | + | 2 | 1 | 2 |
| *Luzula lutea* | . | + | . | . | . | . | . | . | . | . | . | . | . | . | . | 2 | 2 | 1 | 2 | . | . |
| *Hieracium piliferum* | . | . | . | . | . | . | + | + | + | . | . | . | . | . | . | . | . | + | . | . | . |
| *Carex curvula* | . | . | . | . | . | 2 | . | . | . | + | . | . | . | . | . | . | + | 2 | 2 | . | . |
| *Silene acaulis* ssp. *exscapa* | . | . | . | . | . | . | . | + | + | . | . | . | . | . | . | . | . | + | + | . | . |
| *Minuartia sedoides* | . | . | . | . | . | + | + | . | . | . | . | . | . | . | + | . | . | . | . | . | . |
| *Hieracium glaciale* | . | . | . | . | . | . | . | . | . | . | + | . | . | 1 | . | . | + | . | + | + | + |
| *Potentilla grandiflora* | . | 1 | . | + | . | . | . | . | . | . | . | . | 1 | + | . | . | . | . | . | 2 | . |
| *Cerastium arvense* ssp. *strictum* | . | . | . | . | . | . | . | . | . | . | . | . | . | . | + | . | . | . | + | . | + |
| *Centaurea uniflora* ssp. *nervosa* | . | . | + | . | . | . | . | . | . | . | . | . | . | . | + | . | . | . | + | 1 | . |
| **ord. Caricetalia curvulae** | | | | | | | | | | | | | | | | | | | | | |
| *Trifolium alpinum* | 3 | . | . | . | . | . | 2 | 2 | 2 | + | 1 | + | 4 | 5 | 4 | 1 | 1 | 2 | 3 | 3 | 2 |
| *Sempervivum montanum* | . | . | . | . | . | + | . | . | . | . | + | . | . | + | . | . | . | . | + | + | . |
| *Phyteuma hemisphaericum* | + | . | . | + | . | . | + | . | . | . | + | . | . | . | + | . | . | . | . | . | . |
| *Gentiana acaulis* | . | . | . | . | . | . | . | . | + | . | . | . | . | . | + | + | . | . | . | . | . |
| **cl. Caricetea curvulae** | | | | | | | | | | | | | | | | | | | | | |
| *Carex sempervirens* | 1 | . | . | . | + | . | 3 | 3 | 3 | 3 | 2 | . | + | 1 | 2 | . | . | . | . | 1 | + |
| *Potentilla aurea* | . | . | + | . | . | 2 | . | . | + | + | . | . | . | . | . | . | + | + | + | . | . |
| *Juncus trifidus* | . | . | . | . | . | . | . | 1 | . | . | . | . | . | . | . | . | . | 2 | . | . | . |
| *Arnica montana* | 2 | . | . | . | . | . | . | + | + | . | . | . | 1 | . | 2 | + | . | . | 2 | 1 | + |
| *Euphrasia minima* | + | + | . | + | . | . | . | . | . | . | + | . | . | . | . | . | . | . | . | . | . |
| *Botrychium lunaria* | . | . | . | + | . | . | . | . | . | . | . | . | + | . | . | + | + | . | + | . | . |
| *Antennaria dioica* | . | . | . | . | . | . | . | . | + | . | . | . | + | + | + | . | + | . | 1 | . | . |
| **cl. Elyno-Seslerietea** | | | | | | | | | | | | | | | | | | | | | |
| *Myosotis alpestris* | . | . | . | . | . | . | . | . | . | + | . | . | . | . | . | + | 1 | 2 | + | . | . |
| *Pulsatilla alpina* | . | . | . | . | . | . | . | . | . | + | . | . | . | + | + | 2 | 2 | . | + | + | + |
| *Androsace carnea* | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | + | + | . | + | . | . |
| *Gentiana verna* | . | . | . | . | . | . | . | . | . | + | . | . | . | . | . | . | + | + | . | . | . |
| *Plantago maritima* ssp. *serpentina* | . | . | . | . | . | . | . | . | . | . | . | . | . | . | + | 2 | . | . | . | . | + |
| *Minuartia recurva* | . | . | . | . | . | . | . | . | . | . | . | . | . | + | . | + | + | . | + | . | . |
| *Galium pusillum* | . | + | + | . | . | . | . | . | . | . | . | . | + | . | . | . | . | . | + | . | + |
| *Minuartia verna* | + | + | . | + | . | . | . | . | . | . | . | . | . | . | + | . | . | . | . | . | . |
| *Erigeron uniflorum* | . | . | . | . | . | . | . | . | . | . | . | . | . | . | + | . | . | + | . | . | + |
| *Phleum alpinum* | . | . | 1 | + | . | . | . | . | . | . | . | . | . | . | + | . | . | . | . | . | 1 |
| *Trifolium thalii* | . | . | . | 2 | . | . | . | . | . | . | . | . | . | . | . | . | . | . | + | . | . |
| **cl. Arrhenatheretea** | | | | | | | | | | | | | | | | | | | | | |
| *Poa alpina* | . | 1 | 2 | + | . | + | + | + | 2 | 1 | + | 1 | + | . | + | . | 2 | 1 | + | 3 | 2 |
| *Anthoxanthum odoratum* | 1 | + | . | + | + | . | . | + | 1 | . | . | + | + | + | + | . | + | . | . | . | . |
| *Campanula scheuchzeri* | + | + | . | + | . | . | . | . | . | . | . | + | . | . | . | . | . | . | . | . | . |
| *Trifolium pratense* var. *frigidum* | . | + | + | 2 | . | . | . | . | . | . | . | 1 | . | . | . | + | . | . | + | . | 3 |
| *Leontodon hispidus* | . | . | . | 2 | . | . | . | . | . | . | + | + | . | . | . | . | . | . | . | . | 1 |
| *Achillea millefolium* | . | . | + | . | . | . | . | . | + | . | . | . | . | . | . | + | . | . | . | . | . |
| **cl. Festuco-Brometea** | | | | | | | | | | | | | | | | | | | | | |
| *Lotus alpinus* | + | + | . | 2 | + | . | . | + | . | + | 1 | . | + | . | + | + | 2 | . | + | . | 1 |
| *Taraxacum erythrospermum* | 1 | + | 2 | + | + | . | . | . | . | . | . | . | . | . | + | . | . | . | . | . | . |
| *Thymus pulegioides* | . | . | + | + | . | . | . | . | . | . | . | . | + | . | . | + | . | . | . | . | . |
| **companion species** | | | | | | | | | | | | | | | | | | | | | |
| *Plantago alpina* | + | 1 | 2 | 1 | . | + | . | . | 1 | 2 | . | . | . | 2 | + | . | + | . | . | . | . |
| *Leontodon pyrenaicus* | + | 2 | . | . | + | . | 2 | 3 | + | + | . | . | . | . | 2 | + | + | . | . | . | . |
| *Polygonum viviparum* | + | . | . | . | + | . | . | 1 | . | 1 | . | + | + | . | . | . | . | . | . | . | . |
| *Ranunculus gracilis* | + | . | . | + | + | . | 1 | + | 1 | . | . | . | . | . | . | . | . | . | . | . | . |
| *Ranunculus montanus* | . | . | . | . | . | . | . | . | . | 2 | . | + | . | . | 1 | 1 | . | . | . | + | + |
| *Valeriana celtica* | . | . | . | . | . | . | . | + | . | . | + | . | . | . | . | . | + | + | . | . | . |
| *Astrantia minor* | . | . | . | . | . | . | . | + | . | . | 1 | . | . | . | + | . | . | . | . | + | + |
| *Festuca ovina* | 2 | . | 2 | + | . | 2 | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| *Juncus trifidus* ssp. *monanthos* | . | . | . | . | . | . | . | . | . | . | 1 | . | . | . | . | . | . | . | 1 | 1 | . |
| *Vaccinium uliginosum* | + | . | . | . | . | . | + | . | + | . | 4 | . | . | . | . | . | . | . | . | . | . |
| *Homogyne alpina* | 1 | . | . | . | + | . | . | . | . | + | . | + | . | . | . | + | . | . | . | . | . |
| *Hieracium pilosella* | . | . | + | . | . | . | . | . | . | . | . | . | + | . | . | + | . | . | . | . | . |
| *Alchemilla glaucescens* | . | + | 1 | . | . | . | . | . | . | . | . | . | . | . | + | . | . | . | . | + | + |
| *Primula pedemontana* | . | . | . | . | . | . | + | + | . | . | + | . | . | . | + | . | . | . | . | + | + |
| *Cardamine resedifolia* | . | . | . | . | . | . | + | + | . | + | . | . | . | . | . | . | . | . | . | . | . |

*Table 14* — Phytosociological relevés in alpine pastures (the *Pulsatillo albae-Festucetum variae*).

| Relevé no. | 35 | 39 | 31 | 32 | 38 | 40 | 33 | 34 | 36 |
|---|---|---|---|---|---|---|---|---|---|
| Altitude (m) | 2465 | 2315 | 2450 | 2420 | 2115 | 2455 | 2580 | 2505 | 2165 |
| Exposure | S | S | S | SW | W | S | SE | S | SE |
| Slope (°) | 15 | 30 | 45 | 30 | 30 | 45 | 45 | 10 | 25 |
| Herbaceous cover (%) | 100 | 95 | 90 | 90 | 100 | 65 | 40 | 75 | 100 |
| **ass.Pulsatillo albae-Festucetum variae** | | | | | | | | | |
| *Festuca varia* | 5 | 5 | 5 | 5 | 5 | 3 | 3 | 3 | 2 |
| *Potentilla grandiflora* | . | . | + | + | + | + | . | . | + |
| *Ranunculus pyrenaeus* | . | . | . | . | . | . | + | . | . |
| **ass. Festucetum halleri** | | | | | | | | | |
| *Festuca halleri* | + | . | + | + | . | + | 2 | 1 | . |
| *Sinene acaulis* ssp. *excapa* | . | . | . | 2 | . | . | . | + | . |
| *Minuartia sedoides* | . | . | . | + | . | . | + | . | . |
| *Hieracium glaciale* | 1 | . | + | 1 | + | . | + | . | + |
| **all. Caricion curvulae** | | | | | | | | | |
| *Sempervivum montanum* | + | . | + | . | . | . | + | . | + |
| *Phyteuma hemisphaericum* | . | . | + | + | + | + | . | + | + |
| *Sempervivum arachnoideum* | . | . | + | . | . | 1 | . | + | . |
| *Avenula versicolor* | . | + | . | . | . | . | . | 2 | . |
| *Leucanthemopsis alpina* | + | . | + | . | . | . | . | . | . |
| **ass. Geo-Nardetum strictae** | | | | | | | | | |
| *Trifolium alpinum* | 1 | + | + | 1 | + | . | 2 | 2 | 2 |
| *Nardus stricta* | 1 | 2 | 1 | . | . | . | . | . | + |
| *Geum montanum* | + | . | 2 | . | . | + | + | . | + |
| **ord. Caricetalia curvulae and cl.** | | | | | | | | | |
| *Antennaria dioica* | + | . | 1 | 1 | . | + | + | 1 | . |
| *Veronica bellidiodes* | + | . | + | + | . | + | . | + | . |
| *Senecio halleri* | . | . | . | + | . | . | + | + | . |
| *Hieracium piliferum* | . | + | . | . | + | . | + | + | . |
| *Luzula spicata* | . | . | + | . | . | . | + | . | . |
| *Pedicularis kerneri* | . | . | . | . | + | . | . | . | . |
| *Carex sempervirens* | . | 1 | 2 | + | . | . | 2 | 2 | 1 |
| *Potentilla aurea* | + | . | + | . | . | . | . | . | . |
| **cl. Elyno-Seslerietea** | | | | | | | | | |
| *Minuartia recurva* | + | . | + | + | . | + | . | 1 | . |
| *Myosotis alpestris* | . | . | . | . | + | . | . | . | . |
| *Gentiana verna* | . | . | . | . | . | . | . | + | . |
| *Alchemilla alpina* | . | . | . | . | . | . | . | . | + |
| *Phleum alpinum* | 1 | . | . | . | . | . | . | . | + |
| **cl. Thlaspietea rotundifolii** | | | | | | | | | |
| *Achillea erba-rotta* | . | . | + | + | . | 1 | + | + | + |
| *Cardamine resedifolia* | . | . | . | . | . | + | + | . | . |
| **companion species** | | | | | | | | | |
| *Lotus alpinus* | . | . | + | + | + | 1 | . | + | . |
| *Anthoxanthum odoratum* | + | . | + | + | 1 | 1 | + | 2 | 1 |
| *Poa alpina* | + | . | . | + | 2 | . | . | . | . |
| *Vaccinium uliginosum* | . | . | . | + | + | . | . | . | . |
| *Leontodon pyrenaicus* | . | . | . | . | 2 | . | . | . | . |
| *Valeriana celtica* | . | + | . | . | . | . | . | . | . |
| *Astrantia minor* | . | + | . | . | . | 1 | . | . | . |
| *Silene rupestris* | + | . | + | + | . | + | . | . | . |
| *Plantago alpina* | . | . | . | . | . | . | + | . | . |
| *Thymus pulegioides* | . | . | . | + | . | + | . | + | . |

LIST OF SYNTAXA MENTIONED IN THE TEXT

*Chenopodietea* Br.-Bl. in Br.-Bl. *et alii* 1952
weedy and nitrophilous vegetation

*Artemisietea vulgaris* Lohm., Preising et R. Tx. 1950
ruderal vegetation in abandoned areas

*Plantaginetea majoris* R.Tx et Preising 1950
trampled vegetation
*Plantaginetalia majoris* R.Tx. 1950
*Polygonion avicularis* Br.-Bl. 1931

*Arrhenatheretea* Br.-Bl. *et alii* 1947
mown meadows
*Arrhenatheretalia* Pawlowski 1928
*Arrhenatherion* Br.-Bl. 1925
*Poion alpinae* Oberd. 1950
*Polygono-Trisetion* Br.-Bl. et R.Tx. ex Marschall 1947
*Trisetetum flavescentis* Rübel 1911

*Epilobietea angustifolii* R.Tx. et Preising 1950
pioneer vegetation typical of forest clearings

*Festuco-Brometea* Br.-Bl. et R. Tx. ex Klica et Hadac 1944
dry grasslands

*Calluno-Ulicetea* Br.-Bl. et R.Tx. ex Klika et Hadac 1944
acidic grasslands and shrub communities of lower altitudes in particular in abandoned lands

*Querco-Fagetea* Br.-Bl. et Vlieger in Vlieger 1937
mesophilous and mesohygrophilous vegetation of broad-leaved woods
*Fagetalia sylvaticae* Pawlowski in Pawlowski *et alii*1928
*Luzulo-Fagion* Lohm. et R.Tx. in R. Tx. 1954
*Veronico urticifoliae-Fagetum* Montacchini 1972

*Vaccinio-Piceetea* Br.-Bl. in Br.-Bl. *et alii* 1939
conifer woods and dwarf-shrub vegetation
*Vaccinio-Piceetalia* Br.-Bl. in Br.-Bl. *et alii* 1939
*Vaccinio-Piceion* Br.-Bl. in Br.-Bl. *et alii* 1939
*Larici-Piceetum* (Br.-Bl. *et alii* 1954) Ellenberg et Klötzli 1972
*Luzulo nemorosae-Piceetum* (Schmidt et Gaisberg 1936) Br.-Bl. et Sissingh in Br.-Bl. *et alii* 1939
*Veronico urticifoliae-Piceetum* Gensac 1967
*Vaccinio-Rhododendretum ferruginei laricetosum* Lavagne 1968
*Calamagrostio villosae-Pinetum cembrae typicum* Filipello, Sartori et Vittadini 1980
*Calamagrostio villosae-Pinetum cembrae festucetosum flavescentis* Filipello, Sartori et Vittadini, 1980

*Elyno-Seslerietea* Br.Bl. 1948
alpine pastures on calcareous bedrocks
*Trifolio thalii-Festucetum nigricantis* Br.-Bl. in Br.-Bl. et Jenny 1926 corr. Grabherr, Geimler et Mucina 1993

*Caricetea curvulae* Br.-Bl. 1948
alpine pastures on acidic bedrocks
*Caricetalia curvulae* Br.-Bl. in Br.-Bl. et Jenny 1926
*Caricion curvulae* Br.-Bl.in Br.-Bl. et Jenny 1926
*Caricetum curvulae* Rübel 1911
*Festucetum halleri* Br.Bl. in Br.-Bl. et Jenny. 1926
*Festucion variae* Guinochet 1938
*Pulsatillo albae-Festucetum variae* Theurillat 1989 (=*Festucetum variae* Brock.-Jer. 1907)
*Nardion strictae* Br.Bl.in Br.-Bl. et Jenny 1926
*Geo-Nardetum strictae* Lüdi 1948

*Thlaspietea rotundifolii* Br.-Bl. 1948
vegetation on screes

*Salicetea herbaceae* Br.-Bl. 1948
snow-bed vegetation

# 6. RESULTS

## 6.1 EFFECTS OF TOURISM ON FLORA AND VEGETATION

### 6.1.1 SKI RUNS

Alpine skiing in the Gran Paradiso National Park is confined to two localities: Chanavey (Rhêmes Valley) and Cogne which is more important and the larger (fig. 10). The two ski runs in Chanavey laid out between 1974 and 1979 and fall through 265 m from a maximum altitude of 1985 m. They mainly face W-NW and rest on a gneiss moraine on the more wooded side of the valley, where the dominant species are *Pinus cembra* and *Picea abies*.

The Cogne runs date from 1963-69. They drop through 540 m from a maximum 2190 m and mostly face N-NW. They are also located on an extensive wooded slope with *Picea abies*, *Larix decidua* and *Pinus cembra*, and rest on a moraine composed of gneiss, prasinites and amphibolites. Earthmoving operations are still carried out from time to time at both Chanavey and Cogne, and so repeated attempts to establish a grass cover have achieved little success in many parts of the two areas.

The impact of ski pistes on vegetation has been the subject of several studies: SCHAUER (1981), WYL (1982), NASHBERGER, KOCH (1983), GRABHERR (1985) and GALLI, PIROLA (1987) and the rehabilitation of disturbed areas has been investigated by URBANSKA (1986), URBANSKA *et alii* (1987, 1988) and by GRABHERR *et alii* (1987, 1988). The main effects described in these papers are:

- marked reduction of the degree of plant cover, increasing in function of altitude, and sometimes to the point of total destruction when the profile of the terrain has been altered;
- drastic reduction of the total number of prior species;
- reduction of equitability;
- diffusion of some low-altitude ruderals;
- diminished root-mass. An analysis in Austria by SCHAUER (1981) found that this dropped from 800-2500 g dry matter/m$^2$ on alpine pastures and dwarf shrubs to 300-700 g dry matter/m$^2$ respectively;
- increased amounts of streamwater (this variable decreases exponentially with increases in the root-mass);
- soil erosion losses up to ten-fold greater than those observed on similar alpine pastures (HUNERWADER *et alii*, 1982; MORGAN, 1985);
- delayed spring growing season onset owing to excessive snow compaction.

It has been observed that of the plant communities most commonly damaged alpine pastures are the most resistant, whereas dwarf shrubs and formations typical of moist zones are the most sensitive. In alpine pastures, though, phytomass may decrease from

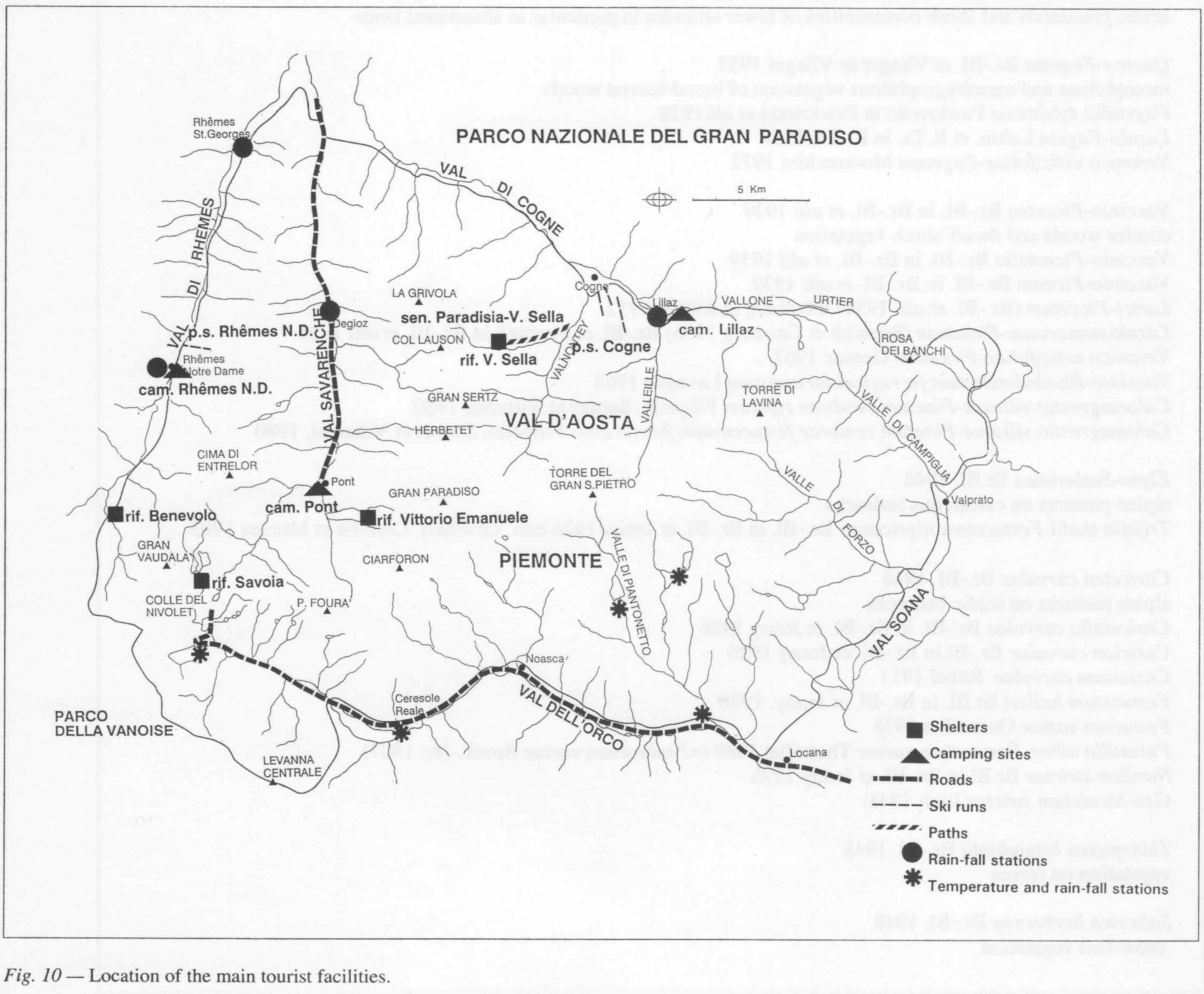


*Fig. 10* — Location of the main tourist facilities.

30 to 70 % (KOCK, SCHNITZER, 1980).

A census was made of the species beside the ski-runs in the two localities and the adjacent woodlands. The result of 8 relevés carried out at different altitudes in the centre of each run, 8 at its edge and 8 in the woodland five metres from the edges are listed as A, B and C respectively in table 15 (Chanavey) and 16 (Cogne). The most evident effect in both localities is the complete destruction of the prior vegetation in both the centre and the sides of the runs.

In the woodlands there is a marked incidence of character species of the *Vaccinio-Piceetea*, with *Larix decidua* and *Picea abies*, *Lonicera caerulea*, *Rhododendron ferrugineum* and *Juniperus communis* ssp. *nana*, and then *Hieracium murorum*, *Melampyrum sylvaticum*, *Calamagrostis villosa*, *Vaccinium myrtillus* and *Deschampsia flexuosa*. Other typical woodland species are found as occasionals or with low abundance-dominance indices in the centre and edges of the runs. In particular, *Larix decidua* seedlings always colonise the disturbed areas, even in the centre of the runs, due to their pioneer character and heliophily.

The *Epilobium angustifolium* community (with indices as high as 4) is very common at the edges of the runs, together with *Rubus idaeus*, which is also typical of the Aosta Valley roadsides. Character species of mown meadows such as *Trifolium pratense*, *Achillea millefolium*, *Dactylis glomerata*, *Phleum pratense* and *Lotus corniculatus*, are much less frequent in the centre and on the edges. In some central parts where earthmovers and

*Table 15* — Phytosociological relevés on the ski runs at Rhemes (A, center piste; B, edge; C, outside)

| Relevé no. | 1A | 2A | 3A | 4A | 5A | 6A | 7A | 8A | 1B | 2B | 3B | 4B | 5B | 6B | 7B | 8B | 1C | 2C | 3C | 4C | 5C | 6C | 7C | 8C |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Altitude (m) | 1985 | 1970 | 1930 | 1900 | 1850 | 1840 | 1780 | 1720 | 1985 | 1970 | 1930 | 1900 | 1850 | 1840 | 1780 | 1720 | 1985 | 1970 | 1930 | 1900 | 1850 | 1840 | 1780 | 1720 |
| Exposure | W | W | W | W | W | SW | W | SW | W | W | W | W | S | W | W | W | SW | SW | SW | SW | SW | W | W | W |
| Slope (°) | 10 | 20 | 30 | 40 | 8 | 10 | 20 | 8 | 30 | 40 | 45 | 45 | 45 | 15 | 15 | 20 | 15 | 30 | 25 | 30 | 10 | 35 | 15 | 20 |
| Tree cover (%) | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 10 | 5 | 10 | 50 | 40 | 60 | 30 | 30 |
| Shrub cover (%) | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 30 | 40 | 15 | 10 | 40 | 30 | 40 | 20 |
| Herbaceous cover (%) | 60 | 5 | 8 | 10 | 60 | 40 | 20 | 60 | 30 | 2 | 30 | 5 | 10 | 95 | 90 | 95 | 80 | 60 | 80 | 65 | 40 | 50 | 80 | 50 |
| **cl. Vaccinio-Piceetea** | | | | | | | | | | | | | | | | | | | | | | | | |
| *Pinus cembra* | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | 1 | . | 1 | 1 | . | . | . | . |
| *Larix decidua* | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | 1 | 1 | 1 | 2 | 2 | 2 | 3 | 2 |
| *Larix decidua* (shrub) | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | 1 | . | . | . | . | . | . |
| *Larix decidua* (seedlings) | + | 1 | 1 | 1 | + | + | 1 | . | + | 1 | + | + | . | . | . | . | . | . | . | . | . | . | . | . |
| *Picea abies* | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | 1 | 1 | 2 | 2 | 3 | 3 | . | 2 |
| *Picea abies* (shrub) | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | + | . | . | . | + | . | . | 2 |
| *Lonicera caerulea* | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | 2 | 2 | 2 | + | 2 | . | 2 |
| *Sorbus aucuparia* | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | 1 | 2 | 1 | + |
| *Rhododendron ferrugineum* | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | 2 | 2 | . | . | . | 2 |
| *Juniperis communis* ssp. *nana* | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | 3 | 3 | . | . | . | . | . | . |
| *Rubus saxatilis* | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | 1 | . | 1 | . |
| *Cotoneaster integerrimus* | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | 2 | . | . | . |
| *Hieracium murorum* | + | . | . | . | . | . | . | . | + | . | + | + | + | . | . | . | 1 | + | + | + | 1 | 1 | + | 1 |
| *Melampyrum sylvaticum* | . | . | . | . | . | . | . | . | 1 | . | + | + | . | + | . | . | 1 | 1 | + | 1 | 1 | . | . | 2 |
| *Calamagrostis villosa* | 2 | 1 | + | . | . | . | . | . | 2 | 1 | 1 | . | . | . | . | . | 4 | 3 | 2 | 2 | + | 2 | . | 3 |
| *Luzula sylvatica* | . | . | + | . | + | . | . | . | 1 | . | 2 | . | . | . | . | . | 2 | + | + | 1 | + | 1 | . | 1 |
| *Vaccinium myrtillus* | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | 1 | + | 4 | 1 | + | 1 | . | 1 |
| *Festuca flavescens* | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | 3 | 1 | . | 1 | . |
| *Oxalis acetosella* | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | 1 | + | + |
| **cl. Epilobietea angustifolii** | | | | | | | | | | | | | | | | | | | | | | | | |
| *Epilobium angustifolium* | + | + | + | + | 1 | 1 | + | . | . | . | 1 | + | 1 | 4 | 4 | 4 | . | . | . | . | + | . | . | . |
| *Rubus idaeus* | + | . | . | . | . | . | . | . | . | . | . | . | . | 1 | 2 | 2 | . | . | . | . | . | . | . | . |
| cl. **Arrhenatheretea** | | | | | | | | | | | | | | | | | | | | | | | | |
| *Trifolium pratense* | 2 | + | + | 1 | 3 | + | 2 | . | + | . | 1 | . | 1 | + | . | . | . | . | . | . | . | . | . | . |
| *Achillea millefolium* | + | . | + | . | + | + | + | + | . | . | . | . | . | . | + | + | . | . | . | . | . | . | . | . |
| *Dactylis glomerata* | 1 | 1 | + | + | 1 | + | 1 | . | . | 1 | . | 1 | + | . | . | . | . | . | . | . | . | . | 2 | . |
| *Phleum pratense* | 2 | + | 2 | 2 | 2 | + | 2 | . | 2 | 1 | 2 | 1 | 2 | . | + | . | . | . | . | . | . | . | 1 | . |
| *Alchemilla xanthochlora* | . | . | . | + | + | 1 | + | + | . | . | . | . | . | 1 | 2 | 1 | . | . | . | . | . | . | . | . |
| *Anthoxanthum odoratum* | 1 | . | . | . | + | + | + | . | + | . | . | 1 | + | + | + | + | + | + | . | . | 1 | . | . | + |
| *Festuca pratensis* | . | . | . | + | + | . | + | . | + | . | . | . | + | . | + | . | . | + | + | . | . | . | . | . |
| *Campanula scheuchzeri* | . | + | . | . | . | . | . | . | + | . | + | . | . | . | . | . | + | . | + | . | + | . | 1 | . |
| *Trisetum flavescens* | . | . | . | . | . | + | . | . | . | . | . | . | . | . | + | . | . | . | . | . | . | . | 1 | . |
| *Poa alpina* | . | . | . | . | . | 2 | . | + | . | . | . | . | . | + | + | + | . | . | . | . | . | . | . | . |
| *Lotus corniculatus* | 1 | 1 | 1 | 1 | 1 | + | 1 | . | 2 | 1 | + | 1 | 2 | . | . | . | 1 | . | . | . | . | . | . | . |
| **cl. Plantaginetea majoris** | | | | | | | | | | | | | | | | | | | | | | | | |
| *Trifolium repens* | + | + | 1 | 2 | 2 | + | 2 | . | 2 | . | 2 | 2 | . | . | . | . | . | . | . | . | . | . | . | . |
| *Lolium perenne* | . | + | + | + | + | . | + | . | + | . | + | + | 1 | . | . | . | . | . | . | . | . | . | . | . |
| *Polygonum aviculare* | . | . | . | . | . | . | . | 1 | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| *Spergularia rubra* | . | + | . | . | + | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| *Chamomilla suaveolens* | . | . | . | . | . | . | . | + | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| *Plantago major* | + | . | . | . | . | + | . | 3 | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| *Poa annua* | . | . | . | . | . | 2 | . | + | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| *Trifolium thalii* | . | . | . | . | . | 2 | . | 2 | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| **companion species** | | | | | | | | | | | | | | | | | | | | | | | | |
| *Poa nemoralis* | . | . | . | . | . | . | . | . | . | . | . | . | . | 2 | 1 | 1 | + | . | . | . | 1 | + | 2 | 1 |

*Table 16* — Phytosociological relevés on the ski runs at Cogne (A, center piste; B, edge; C, outside).

| Relevé no. | 1A | 2A | 3A | 4A | 5A | 6A | 7A | 8A | 1B | 2B | 3B | 4B | 5B | 6B | 7B | 8B | 1C | 2C | 3C | 4C | 5C | 6C | 7C | 8C |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Altitude (m) | 2190 | 2112 | 2060 | 2000 | 1900 | 1800 | 1750 | 1680 | 2190 | 2112 | 2060 | 2000 | 1900 | 1800 | 1750 | 1680 | 2190 | 2112 | 2060 | 2000 | 1900 | 1800 | 1750 | 1680 |
| Exposure | NE | NE | NE | N | NE | N | NE | NW | NE | E | NE | N | NE | N | NE | NW | NE | NE | NE | N | NE | N | NE | E |
| Slope (°) | 0 | 25 | 0 | 35 | 20 | 25 | 15 | 10 | 15 | 30 | 10 | 30 | 20 | 30 | 10 | 10 | 20 | 10 | 15 | 30 | 20 | 25 | 20 | 40 |
| Tree cover(%) | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 10 | 10 | 15 | 25 | 35 | 30 | 60 | 40 |
| Shrub cover (%) | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 60 | 35 | 80 | 60 | 15 | 30 | 15 | 30 |
| Herbaceous cover (%) | 5 | 15 | 70 | 60 | 30 | 30 | 25 | 40 | 15 | 10 | 35 | 40 | 40 | 70 | 90 | 20 | 30 | 55 | 20 | 80 | 60 | 70 | 40 | 80 |
| **cl. Vaccinio-Piceetea** | | | | | | | | | | | | | | | | | | | | | | | | |
| *Pinus cembra* | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | 1 | 1 | 1 | 2 | 1 | 1 | 1 | 2 |
| *Pinus cembra* (shrub) | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | 1 | 1 | 1 | 3 | 1 | 2 | 2 | . |
| *Pinus cembra* (seedlings) | . | . | + | 1 | . | . | . | . | . | . | . | + | . | . | . | . | 1 | . | + | . | . | . | . | . |
| *Larix decidua* | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | 1 | 1 | 1 | 1 | 2 | 1 | 3 | 1 |
| *Larix decidua* (shrub) | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | 1 | 1 | 2 | . | 2 | 2 | 1 |
| *Larix decidua* (seedlings) | + | 1 | 1 | 2 | . | . | . | . | + | 1 | 2 | 1 | . | 2 | 1 | 1 | . | . | . | 2 | . | . | . | . |
| *Picea abies* | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | 1 | 2 | 1 | 2 | 3 | 3 |
| *Picea abies* (shrub) | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | 2 | . | . | . | . | 2 |
| *Rhododendron ferrugineum* | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | 2 | 2 | 2 | 1 | 2 | + | 2 |
| *Juniperus communis* ssp. *nana* | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | 3 | . | 1 | . | 2 | 2 | 2 | . |
| *Vaccinium myrtillus* | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | 2 | . | 3 | . | . | . | . | . |
| *Luzula sylvatica* | . | . | + | + | . | . | . | . | . | . | 1 | + | . | + | . | . | 1 | 1 | 1 | + | 2 | + | + | + |
| *Calamagrostis villosa* | . | . | 3 | . | . | . | . | . | . | . | 1 | . | + | . | + | + | . | 2 | 1 | 3 | 3 | 2 | 3 | 3 |
| *Festuca flavescens* | . | . | + | + | . | . | . | . | . | . | + | 2 | . | 4 | . | . | + | 1 | 1 | 2 | 3 | 1 | 2 | + |
| *Vaccinium vitis-idaea* | . | . | + | . | . | . | . | . | + | . | + | 2 | . | . | . | . | . | + | 1 | 3 | 2 | 2 | 3 | 2 |
| *Hieracium murorum* | . | . | + | + | . | . | . | . | . | . | + | + | . | + | . | . | 1 | 1 | + | + | . | 2 | 2 | + |
| *Vaccinium myrtillus* | . | . | + | + | . | . | . | . | + | . | 1 | 2 | + | + | . | . | . | . | 2 | 3 | 2 | 3 | 2 | . |
| *Deschampsia flexuosa* | . | . | 2 | + | . | . | . | . | . | + | 1 | 1 | . | . | . | . | . | 2 | 1 | 1 | 1 | 2 | 1 | 2 |
| *Vaccinium uliginosum* | . | . | 2 | + | . | . | . | . | . | . | 2 | + | . | + | . | . | . | 1 | + | 2 | 1 | + | . | . |
| *Homogyne alpina* | . | . | + | . | . | . | . | . | . | . | . | . | . | . | . | . | . | + | + | + | 1 | . | . | . |
| *Melampyrum sylvaticum* | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | + | 2 | . |
| **cl. Epilobietea angustifolii** | | | | | | | | | | | | | | | | | | | | | | | | |
| *Epilobium angustifolium* | + | . | . | 1 | + | . | . | . | . | . | . | + | 2 | 1 | 5 | 2 | . | . | . | . | . | . | . | . |
| **cl. Caricetea curvulae** | | | | | | | | | | | | | | | | | | | | | | | | |
| *Agrostis rupestris* | 1 | 1 | . | . | + | . | + | 1 | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| *Festuca varia* | . | . | . | + | . | . | . | . | 3 | . | . | . | 2 | + | . | . | 1 | . | . | . | . | . | . | 2 |
| **cl. Arrhenatheretea** | | | | | | | | | | | | | | | | | | | | | | | | |
| *Achillea millefolium* | . | . | . | 1 | 2 | + | 1 | 1 | . | . | . | . | 2 | . | . | . | 1 | . | . | . | . | . | . | . |
| *Poa alpina* | 2 | 2 | . | . | 1 | 1 | . | . | 1 | 2 | . | . | 1 | 1 | . | + | . | + | . | . | . | . | . | + |
| *Trifolium pratense* | . | . | . | + | 1 | . | + | . | . | . | . | . | + | + | . | . | 1 | . | . | . | . | . | . | . |
| *Anthoxanthum odoratum* | . | + | 1 | 3 | . | . | . | . | . | . | + | + | + | . | . | + | . | . | . | + | . | . | . | . |
| *Agrostis capillaris* | . | . | . | . | . | . | . | . | . | . | . | . | 2 | . | 1 | 1 | . | . | . | . | . | . | . | . |
| *Alchemilla xanthochlora* | . | . | . | . | 2 | . | . | . | . | . | . | . | 1 | . | . | . | 1 | . | . | . | . | . | . | . |
| **cl. Plantaginetea majoris** | | | | | | | | | | | | | | | | | | | | | | | | |
| *Chamomilla suaveolens* | . | . | . | . | + | 4 | 2 | 4 | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| *Polygonum aviculare* | . | . | . | . | . | + | + | 2 | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| *Spergularia rubra* | . | + | . | . | . | + | 1 | 1 | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| *Plantago major* | . | . | . | . | . | . | + | 1 | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| *Poa annua* | . | . | . | . | + | 1 | + | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| *Trifolium repens* | . | . | . | + | 1 | . | 1 | + | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| *Tussilago farfara* | . | . | . | . | . | + | + | + | . | . | . | . | . | 2 | + | + | . | . | . | . | . | . | . | . |
| **companion species** | | | | | | | | | | | | | | | | | | | | | | | | |
| *Silene rupestris* | . | 1 | . | + | . | . | . | . | + | 1 | + | . | . | . | . | . | . | . | . | . | + | + | . | . |
| *Leucanthemum adustum* | . | . | . | . | + | . | . | . | . | . | . | . | 1 | . | . | . | . | . | . | . | . | . | . | . |
| *Taraxacum* gr. *hoppeanum* | 1 | . | . | + | . | + | . | . | + | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |

snow-ploughs pass frequently, they are accompanied by species typical of trampled areas, such as *Trifolium repens*, *Lolium perenne*, *Trifolium thalii* and *Chamomilla suaveolens*.

A total of 202 species were recorded at Chanavey, and 190 at Cogne. One hundred and twenty were common to both localities (see table 29). *Chamomilla suaveolens* was the only exotic (N-America). This species was cultivated in the Padua Botanical Gardens in 1842 and first reported as naturalised in Central Europe at about the same time. In Italy, it was initially noted at Trieste in 1896 (MARCHESETTI, 1896-97). It subsequently spread massively from the Tyrol into Val Pusteria and the Upper Adige Region at the beginning of this century (UGOLINI, 1920, 1923), and then to the Alps as a whole (CAPPELLETTI, 1940, 1941). In Piedmont, the first reports came from Sauze d'Oulx (Susa Valley) (CAPPELLETTI, 1941) and from Cogne in 1939 (BETTINI, 1942).

This extensive diffusion, especially in areas with vehicle traffic, such as the edges of roads and ski runs, depends from the fact that the species is annual or biennial, and every plant can produce from 5000 to 7000 seeds per year. It can also withstand rigid winter temperatures as a seed. Germination takes place from spring to late summer in wet soil, and in particular during thaw periods. It is encouraged by abrasion, such as that produced by the passage of wheeled traffic. Laboratory experiments (fig. 11) have shown that at 22 °C only 6% of seeds germinate in 32 days, whereas prior to roughening with glass-paper results in 78% germination in the same conditions. *Chamomilla suaveolens* also displays great resistance to soil compaction and is therefore found with other trampled vegetation species. This species is a stress-tolerant ruderal according to Grime's model, and hence a particular and rare example of this combination of secondary strategies.

It is a character species in *Polygono arenastri-Poetea annuae* Rivas-Martínez 1975 corr. Rivas-Martínez *et alii* 1991, which is related to annual trampled communities. As for the recent revision of trampled vegetation communities (MUCINA *et alii*, 1993) we prefer to maintain the referred traditional syntaxa transitorily since, for the study area, more precise identification of some entity (in particular *Polygonum aviculare-Polygonum arenastrum*) is still in course. The vegetational aspects,

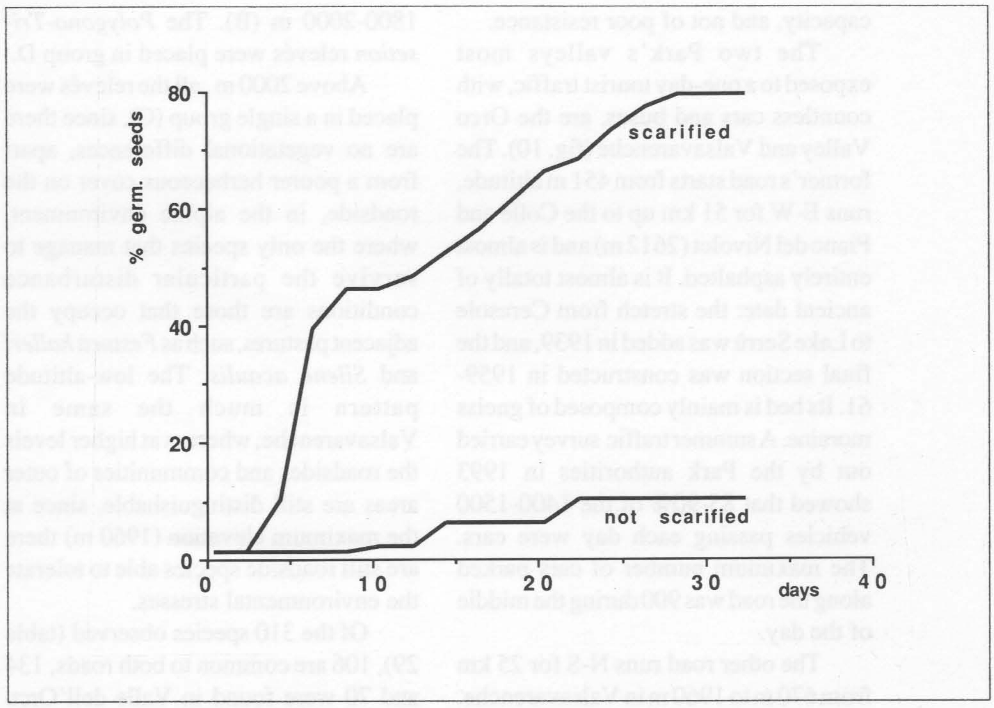


*Fig. 11* — Germinability of *Chamomilla suaveolens* seeds.

therefore, need to be verified after further consideration.

## 6. 1. 2 ROADS

Soil compaction and the upward migration of low-altitude propagules as a result of the passage of vehicles and tourists are the principal changes imposed on the Park's vegetation by the presence of roads. The main effect of trampling, in addition to mechanical destruction of the epigeal parts of plants, is alteration of the soil structure through reduction of the number of micropores and modification of the regular supply of water and available gases (SPOMER, 1980; LIDDLE, 1988). Packing of the soil can be measured in terms of bulk density, since the data are closely related to its texture. The values for Turin's public parks show a range of about 0.9-1 g $cm^{-3}$ in the first few cm from the surface in undisturbed areas to 1.6-1.7 g $cm^{-3}$ in places subjected to heavy foot traffic (MONTACCHINI, SINISCALCO, 1982). Plant communities exposed to trampling usually display a low herbaceous cover, low or very low floristic richness (4 or 5 resistant species: *Plantago major*, *Poa annua*, *Lolium perenne*, *Polygonum aviculare*, *Trifolium repens*), low equitability, delayed flowering and scanty production of seeds, often with diminished germination capacity.

All these effects are evident along the Park's roads at both low and high altitudes. In the first case, primary communities are replaced by secondaries with different flora and vegetation in keeping with the roadside ecosystem (LAUSI, NIMIS, 1985; BRANDES, 1988; LIDDLE, 1988; KOPECKY, 1988; SINISCALCO, MONTACCHINI, 1989). Roadsides at low altitudes with high degree of disturbance, but low compaction levels, are usually heavily invaded by exotics and channel their migration but the roads studied run at higher altitudes, and are practically devoid of migration along their verges. Apophytism, instead, is extensive as in other researches. (KOPECKY, 1978; KOPECKY, HEJNY, 1978). Highland trampling, on the other hand, greatly reduces the plant cover and may result in its total destruction (BELL, BLISS, 1973; SOMSAK *et alii*, 1979; PASSARGE, 1979; JURKO, 1983, BAYFIELD, 1985). Fruticose and crustose lichens are the most sensitive to trampling, followed in increasing order of resistance by mosses, though with high interspecific variations, dwarf shrubs (especially the ericaceous), broad-leaved herbaceous species and finally the grass-like species. *Carex curvula* displays good resistance to chronic disturbance (150 tourists a day throughout the vegetative period), whereas recolonisation is very long and sometimes impossible if the cover is destroyed (GRABHERR, 1982). The fragility of an alpine pasture, therefore, is an expression of the low resilience of its species, i.e. a low regeneration capacity, and not of poor resistance.

The two Park's valleys most exposed to a one-day tourist traffic, with countless cars and buses, are the Orco Valley and Valsavarenche (fig. 10). The former's road starts from 451 m altitude, runs E-W for 51 km up to the Colle and Piano del Nivolet (2612 m) and is almost entirely asphalted. It is almost totally of ancient date: the stretch from Ceresole to Lake Serrù was added in 1939, and the final section was constructed in 1959-61. Its bed is mainly composed of gneiss moraine. A summer traffic survey carried out by the Park authorities in 1993 showed that 85-90% of the 1400-1500 vehicles passing each day were cars. The maximum number of cars parked along the road was 900 during the middle of the day.

The other road runs N-S for 25 km from 670 m to 1960 m in Valsavarenche. It was all built long ago and is completely asphalted. Its bed consists of mixed moraine rocky material. This is derived from gneiss in the last section only.

Four samplings were carried out every 500 metres: 2 on the sides of the roads, and 2 about 10 metres further back. Tables 17-20 ( 17 and 19 out of text) illustrate the results of the 92 relevés carried out in Orco Valley and the 48 carried out in Valsavarenche. Tables 17 and 18 show the low-altitude observations, with the roadside data on the left. Character species of trampled communities are prevalent on the roadsides, with scattered *Chenopodietea* and *Artemisietea* species. Species typical of meadows are present and dominate further back.

The high elevations findings are set out in tables 19 and 20. The species of trampled habitats are present along the roadside, though only as far as 2000 m. Further up their place is taken by character species of the *Caricetea curvulae*, particularly *Festuca halleri* and *Silene acaulis*. Above 2000 m, apart from the roadsides, meadows give way to typical formations of alpine pastures with the same dominant species.

In Valsavarenche, on roadsides, *Epilobium angustifolium* and *Artemisia absinthium* formations occur while the other relevés represent meadows up to about 1550 m. Two multivariate analyses were made of the two sets of findings (figs. 12, 13). The relevés are plotted along the profile of the roads. In Orco Valley, the analysis grouped the roadside relevés up to 2000 m (group A) and the majority of those further back up to 1800-2000 m (B). The *Polygono-Trisetion* relevés were placed in group D.

Above 2000 m, all the relevés were placed in a single group (C), since there are no vegetational differences, apart from a poorer herbaceous cover on the roadside, in the alpine environment, where the only species that manage to survive the particular disturbance conditions are those that occupy the adjacent pastures, such as *Festuca halleri* and *Silene acaulis*. The low-altitude pattern is much the same in Valsavarenche, whereas at higher levels the roadsides and communities of outer areas are still distinguishable, since at the maximum elevation (1960 m) there are still roadside species able to tolerate the environmental stresses.

Of the 310 species observed (table 29), 106 are common to both roads, 134 and 70 were found in Valle dell'Orco and Valsavarenche only. A total of ten exotics were also noted: *Solidago gigantea* ssp. *serotina*, *Lepidium virginicum*, *Conyza canadensis*, *Erigeron annuus* and *Impatiens glandulifera* are present up to about 500-700 m, *Galinsoga parviflora*, *Oenothera biennis* and *Amaranthus retroflexus* to 800-900 m, whereas *Robinia pseudo-acacia* and *Chamomilla suaveolens* alone were found as high as about 1100 m and 1540 respectively. *Impatiens glandulifera* comes from the Himalayas, *Chamomilla suaveolens* and all other exotics are natives of N-America.

### 6. 1. 3 PATHS

The best-known path in the Park is that which runs from the Paradisia Alpine Garden (1700 m) at Valnontey, near Cogne, up to the Vittorio Sella Shelter (2584 m) and Col Lauson (3296 m). This ancient route was once the most frequented line of communication between Cogne Valley and Valsavarenche (fig. 10). It is a 1-1.5 m wide as far as the shelter, and then narrows to 50-70 cm. Work is periodically done to keep it in good repair. Its way lies through meadows at first, then through larch and spruce woods up the alp in which the shelter stands. The initial section runs over scree cones, the remainder over Augen Gneiss and gneiss moraine, except for the final stretch, which is composed of calcschists.

It is thought that some 800 to 1000 tourists use this path every day in July and August, and sometimes even twice as many, while during the rest of the year it is also much frequented by both hikers and skiers.

Four relevés (one on each side of the path and one 10 metres away both uphill and downhill) were carried out at roughly every 100 metres difference in elevation along the most frequented part of the path, namely that between Paradisia and the Vittorio Sella Shelter. The centre of the path was always free of vegetation.

The results of the pathside relevés (nos. 1-14) and those on either side (nos. 15-28) are illustrated in table 21 (out of text). In the first group (1700-1850 m), dominant *Artemisia absinthium* is accompanied by *Euphorbia cyparissias*, *Thymus pulegioides*, *Phleum hirsutum* and other character species of the *Festuco-Brometea* owing to the skeleton-rich substrate and the dry habitat with reduced water retention. The next three groups (nos. 3-8 and 17-22) come from conifer woods between 1980 and 2060 m. On the sides of the path, in the woods, *Euphorbia cyparissias* is dominant in the company of some *Arrhenatheretea* species, whose seeds are carried up from lower altitudes, and some *Vaccinio-Piceetea* species that are themselves dominant in the outer relevés, where they are accompanied by *Rubus idaeus*, *Picea abies*, *Juniperus communis* ssp. *nana*, *Luzula sylvatica*, *Vaccinium myrtillus*, etc.

Above the 2000 m elevation, the path runs along a steep, south-facing slope occupied by alpine pastures (relevés 9-14 and 23-28). As was observed beside the Val dell'Orco road, the pathside communities in disturbed and undisturbed highland zones do not differ from the floristic and vegetational points of view, apart from their percentage of total cover (edges 30-40%; outer areas 70-100%) and equitability.

The data were subjected to multivariate analysis (fig. 14) and the groups of relevés were plotted along the profile of the path. Up to 2060 m of altitude, there are differences between the pathside and the external findings, except in the four lowest relevés, where mown meadows run back from the edges, whereas at higher elevations the absence of differentiation enables all four relevés for each level to be treated as a single group. The absence of species typical of trampling beside the path at high altitudes may be due to a lack of seeds. This is hardly likely, however, since tourist

*Table 18* — Phytosociological relevés along the Valsavarenche road, lower section.

| Relevé no. | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 25 | 26 | 27 | 28 | 29 | 30 | 31 | 32 | 33 | 34 | 35 | 36 | 37 | 38 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Altitude (m) | 7 | 7 | 9 | 9 | 10 | 10 | 10 | 10 | 10 | 10 | 13 | 13 | 14 | 14 | 7 | 7 | 9 | 9 | 10 | 10 | 10 | 10 | 10 | 10 | 13 | 13 | 14 | 14 |
| | 50 | 50 | 00 | 00 | 10 | 10 | 60 | 60 | 75 | 75 | 50 | 50 | 00 | 00 | 50 | 50 | 00 | 00 | 10 | 10 | 60 | 60 | 75 | 75 | 50 | 50 | 00 | 00 |
| Exposure | W | W | SE | W | W | W | W | E | NW | NW | W | W | SW | SW | W | W | SE | W | W | W | W | E | NW | E | W | W | N | W |
| Slope (°) | 5 | 2 | 3 | 8 | 2 | 2 | 2 | 3 | 3 | 0 | 5 | 5 | 2 | 3 | 10 | 2 | 10 | 5 | 4 | 5 | 20 | 25 | 10 | 40 | 5 | 5 | 10 | 5 |
| Herbaceous cover (%) | 40 | 35 | 20 | 25 | 40 | 30 | 25 | 35 | 40 | 15 | 40 | 40 | 50 | 40 | 60 | 95 | 85 | 90 | 95 | 95 | 80 | 80 | 75 | 85 | 98 | 98 | 90 | 90 |
| **cl. Plantaginetea majoris** | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| *Plantago major* | + | + | 2 | . | 4 | 3 | 2 | . | 1 | 1 | 4 | 4 | 1 | . | + | . | . | . | . | . | . | . | . | . | . | . | . | . |
| *Trifolium repens* | + | + | 1 | . | 1 | . | 1 | . | + | . | . | + | 2 | 1 | 2 | 1 | . | . | . | . | . | . | . | . | 2 | . | 2 | + |
| *Poa annua* | . | . | . | 1 | . | . | . | . | + | . | . | . | + | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| *Polygonum aviculare* | + | . | 1 | . | 1 | 1 | . | . | + | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| *Lolium perenne* | . | . | 1 | . | 2 | 1 | . | . | . | . | . | 1 | 1 | . | + | . | . | . | . | . | . | . | . | . | . | . | . | . |
| *Cynodon dactylon* | + | . | . | . | + | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| *Agrostis stolonifera* | . | . | . | . | . | . | . | . | . | 3 | 1 | . | . | . | . | 1 | . | . | . | 1 | 1 | . | . | . | . | + | . | . |
| **cl. Chenopodietea** | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| *Diplotaxis tenuifolia* | + | . | + | . | + | + | + | . | . | . | . | . | . | . | + | . | . | . | . | . | . | . | . | . | . | . | . | . |
| *Solanum nigrum* | + | . | . | + | . | . | . | . | + | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| *Chenopodium album* | 2 | . | . | 2 | . | . | . | . | 1 | . | . | . | . | . | 2 | . | . | . | . | . | . | . | . | . | . | . | . | . |
| *Amaranthus retroflexus* | + | . | . | + | . | . | . | . | . | . | . | . | . | . | + | . | . | . | . | . | . | . | . | . | . | . | . | . |
| *Urtica dioica* | . | . | . | + | . | + | . | . | . | . | . | . | + | . | . | . | . | . | . | . | . | . | + | . | . | . | . | . |
| *Vicia cracca* | . | . | . | . | . | . | . | . | . | + | . | . | + | . | + | . | . | . | + | . | . | . | . | . | . | . | + | + |
| *Conyza canadensis* | + | . | + | . | . | . | . | . | . | . | . | . | . | . | + | . | . | . | . | . | . | . | . | . | . | . | . | . |
| **cl. Artemisietea** | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| *Artemisia vulgaris* | 1 | 4 | + | . | + | . | + | . | . | . | + | + | . | . | + | . | . | . | . | . | . | . | . | . | . | + | . | . |
| *Tussilago farfara* | . | . | . | . | . | . | . | . | . | . | . | . | + | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| *Chenopodium bonus-henricus* | . | . | . | . | . | . | . | . | . | . | . | . | 2 | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| *Eupatorium cannabinum* | + | . | . | . | . | . | . | . | . | . | . | . | . | . | 1 | . | . | . | . | . | . | . | . | . | . | . | . | . |
| *Echium vulgare* | + | . | + | . | . | . | . | . | . | . | . | 1 | . | . | + | . | . | . | . | . | . | . | . | . | . | . | . | . |
| **cl. Epilobietea angustifolii** | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| *Epilobium angustifolium* | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | + | . | . | . | . | . |
| *Rubus idaeus* | . | . | . | . | . | . | . | 1 | . | . | . | . | . | . | . | . | . | . | . | . | 1 | . | 1 | 3 | . | . | . | . |
| *Fragaria vesca* | . | . | . | . | . | . | . | + | . | + | . | . | . | . | . | . | . | . | . | . | . | . | . | + | . | . | . | . |
| **cl. Arrhenatheretea** | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| *Achillea millefolium* | . | . | . | . | 1 | + | 1 | . | + | . | 2 | + | . | . | 1 | 1 | 3 | 2 | 3 | 2 | . | . | . | 2 | . | + | . | . |
| *Taraxacum officinale* gr. | . | 1 | + | 1 | + | + | 1 | . | 1 | . | 1 | . | 1 | . | . | . | . | 1 | 2 | 2 | . | . | . | . | 2 | 2 | 1 | . |
| *Dactylis glomerata* | 1 | . | . | . | . | . | + | . | + | 1 | + | + | 2 | 2 | + | 2 | 1 | 2 | 2 | 2 | . | . | . | . | 2 | 2 | 3 | 1 |
| *Poa alpina* | . | . | . | . | . | . | . | . | . | . | 1 | + | . | . | . | . | . | . | . | . | . | . | . | . | . | + | . | . |
| *Trisetum flavescens* | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | 2 | + | 1 | 1 | 1 | . | . | . | . | 2 | 1 | + | + |
| *Alchemilla xanthochlora* | . | . | . | . | . | . | . | . | . | + | . | . | + | 1 | . | . | . | . | . | . | . | . | . | . | 2 | 1 | 2 | 1 |
| *Galium mollugo* | + | + | . | . | . | . | . | . | + | . | . | . | . | + | + | . | 1 | 1 | + | + | . | . | . | . | . | . | . | . |
| *Salvia pratensis* | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | 2 | + | 2 | . | 1 | . | . | . | . | . | . | . | . |
| *Trifolium pratense* | . | . | . | . | . | . | . | . | . | . | . | . | . | . | 2 | 3 | 1 | 3 | 2 | . | . | . | . | . | . | + | . | + |
| *Silene vulgaris* | + | . | . | . | . | + | . | . | . | . | . | . | + | 1 | + | 2 | 2 | . | . | 2 | . | . | . | . | . | 1 | 1 | + |
| *Daucus carota* | + | + | . | . | . | . | . | . | + | 1 | . | . | . | + | + | 2 | . | . | . | . | . | . | . | . | . | . | . | . |
| *Chaerophyllum hirsutum* | . | . | . | . | . | . | . | . | . | . | . | . | + | . | . | . | . | 1 | . | + | . | . | . | . | 2 | + | + | 1 |
| *Geranium sylvaticum* | . | . | . | . | . | . | . | . | . | . | . | . | . | + | . | . | . | . | 1 | . | . | . | . | + | 1 | 1 | 1 | + |
| *Heracleum sphondylium* | . | . | . | . | . | . | . | . | . | . | . | + | + | + | . | 2 | + | 2 | 2 | . | . | . | . | . | 3 | 3 | 2 | 3 |
| *Medicago lupulina* | . | . | . | . | + | + | . | + | . | . | . | . | . | . | + | . | . | . | . | . | . | . | . | . | . | . | . | . |
| *Arrhenatherum elatius* | . | . | . | . | . | . | . | + | . | . | . | . | . | . | . | . | . | . | 1 | 2 | . | . | . | . | . | . | . | . |
| *Plantago lanceolata* | + | 1 | . | . | 1 | 1 | . | . | . | . | . | . | . | . | + | 2 | 2 | 1 | . | . | . | . | . | . | . | . | . | . |
| *Tragopogon pratensis* | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | + | . | . | . | . | . | . | . | . | . | . |
| *Poa pratensis* | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | 2 | 1 | . | . | . | . | . | . | . | . |
| *Leontodon hispidus* | . | . | . | . | . | . | . | . | . | . | . | . | . | + | . | . | 1 | + | . | 1 | . | . | . | . | 1 | . | + | 1 |
| **cl. Festuco-Brometea** | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| *Plantago media* | . | . | . | . | . | . | + | . | . | . | + | + | . | + | . | . | . | . | . | 1 | . | . | . | . | . | . | + | 2 |
| *Artemisia absinthium* | 3 | . | . | . | . | . | . | . | + | . | . | . | + | 3 | . | . | . | . | . | . | . | . | . | . | . | . | 1 | . |
| *Lotus corniculatus* | . | . | . | . | . | . | + | + | . | . | + | . | . | . | . | 2 | 1 | . | . | 1 | . | . | . | . | . | . | . | . |
| *Onobrychis viciifolia* | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | 1 | . | . | . | . | 1 | . | . | . |
| *Pimpinella major* | . | . | . | . | . | . | . | . | . | . | . | . | . | + | . | . | + | . | + | . | . | . | . | . | . | . | + | 1 |
| *Medicago sativa* | + | + | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | 3 | . | . | . | . | . | . | . | . |
| *Sanguisorba minor* | . | . | . | . | . | . | + | . | . | . | . | + | . | . | . | . | . | . | . | . | . | . | . | + | . | . | . | . |
| *Ranunculus bulbosus* | . | . | . | . | . | . | . | . | . | + | . | . | . | . | . | . | . | 2 | . | . | . | . | . | . | 2 | 1 | . | . |
| *Euphorbia cyparissias* | . | . | . | . | . | . | . | + | . | . | . | + | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| **cl. Querco-Fagetea** | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| *Acer pseudoplatanus* | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | 2 | 2 | 2 | 3 | . | . | . | . |
| *Fraxinus excelsior* | . | . | . | . | . | . | . | 2 | . | . | . | . | . | . | . | . | . | . | . | . | 1 | . | 3 | 2 | . | . | . | . |
| *Rubus caesius* | . | 2 | . | . | . | . | + | . | . | . | . | . | . | . | + | . | . | . | . | . | 1 | . | 1 | . | . | . | . | . |
| **cl. Vaccinio-Piceetea** | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| *Picea abies* | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | 2 | . | 1 | . | . | . | . |
| *Sorbus aucuparia* | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | 2 | 1 | . | . | . | . | . | . |
| *Hieracium murorum* | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | 1 | . | . | . | . | . | . |
| *Larix decidua* | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | 1 | . | . | . | . |
| **companion species** | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| *Impatiens glandulifera* | + | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| *Robinia pseudacacia* | + | + | . | . | . | . | . | 3 | 3 | . | . | . | . | . | . | . | . | . | . | . | 3 | . | 3 | . | . | . | . | . |

*Table 20* — Phytosociological relevés along the Valsavarenche road, upper section.

| Relevé no. | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 39 | 40 | 41 | 42 | 43 | 44 | 45 | 46 | 47 | 48 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Altitude (m) | 1470 | 1470 | 1550 | 1550 | 1680 | 1680 | 1800 | 1800 | 1920 | 1920 | 1470 | 1470 | 1550 | 1550 | 1680 | 1680 | 1800 | 1800 | 1920 | 1920 |
| Exposure | W | W | SW | SW | W | W | SW | SW | E | E | W | W | SW | W | E | E | E | SW | E | E |
| Slope (°) | 1 | 1 | 1 | 1 | 3 | 3 | 2 | 5 | 2 | 5 | 3 | 2 | 2 | 2 | 15 | 40 | 15 | 15 | 10 | 5 |
| Herbaceous cover (%) | 10 | 30 | 25 | 20 | 30 | 35 | 30 | 45 | 30 | 35 | 80 | 80 | 90 | 90 | 80 | 90 | 85 | 75 | 80 | 80 |
| **cl. Plantaginetea majoris** | | | | | | | | | | | | | | | | | | | | |
| *Plantago major* | 1 | . | 2 | 2 | 2 | 4 | . | . | + | . | . | . | . | . | . | . | . | . | . | . |
| *Trifolium repens* | 1 | . | . | . | 1 | 1 | . | . | . | . | . | . | . | 1 | . | . | + | . | . | . |
| *Poa annua* | . | . | 1 | 1 | 1 | 1 | 1 | . | + | . | . | . | . | . | . | . | . | . | . | . |
| *Lolium perenne* | + | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| *Agrostis stolonifera* | . | 1 | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| **cl. Epilobietea angustifolii** | | | | | | | | | | | | | | | | | | | | |
| Epilobium angustifolium | . | . | . | . | . | + | 4 | 2 | 2 | 2 | . | . | . | . | . | . | . | . | . | . |
| Rubus idaeus | . | . | . | . | + | 2 | . | 1 | . | 1 | . | . | . | . | . | . | . | . | 2 | . |
| Fragaria vesca | . | . | . | . | . | . | . | . | . | . | . | . | . | . | 1 | . | . | . | . | . |
| **cl. Arrhenatheretea** | | | | | | | | | | | | | | | | | | | | |
| *Achillea millefolium* | 1 | 2 | . | . | . | . | 1 | 1 | 1 | 1 | . | 1 | 3 | 3 | . | . | 2 | 3 | . | . |
| *Taraxacum officinale* gr. | + | 1 | 1 | + | + | . | . | + | + | . | 1 | 2 | 2 | . | . | . | . | . | . | . |
| *Dactylis glomerata* | + | 1 | + | + | . | . | . | + | 1 | . | 2 | 2 | 1 | . | . | . | . | . | . | . |
| *Poa alpina* | . | . | + | + | 1 | 1 | 1 | . | 1 | . | . | . | + | . | . | . | . | . | . | . |
| *Chaerophyllum hirsutum* | . | + | + | . | . | . | . | . | . | . | + | + | 1 | . | . | . | . | . | . | 2 |
| *Geranium sylvaticum* | . | . | . | . | . | + | . | . | . | + | . | + | . | + | . | 1 | + | . | . | . |
| *Heracleum sphondylium* | . | + | + | + | . | . | . | . | . | . | 3 | 3 | 2 | 3 | . | . | . | . | . | . |
| *Trisetum flavescens* | . | . | . | . | . | . | . | . | . | . | 1 | 2 | . | . | . | . | . | . | . | . |
| *Alchemilla xanthochlora* | . | . | + | . | + | . | . | . | + | . | . | . | + | 1 | . | . | . | . | . | . |
| *Galium mollugo* | + | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| *Trifolium pratense* | + | . | . | . | . | . | + | . | . | . | . | 2 | . | . | . | . | . | . | . | . |
| *Silene vulgaris* | . | . | . | . | . | . | . | . | . | . | + | . | + | 1 | . | . | 1 | . | . | . |
| *Daucus carota* | . | + | + | . | . | . | . | . | . | . | 1 | 2 | . | . | . | . | . | . | . | . |
| *Medicago lupulina* | . | . | . | . | . | . | . | . | . | . | . | . | . | 1 | . | . | . | . | . | . |
| *Tragopogon pratensis* | . | . | . | . | . | . | . | . | . | . | 1 | + | + | . | . | . | . | . | . | . |
| *Poa pratensis* | . | . | . | . | . | . | . | . | . | . | . | . | + | . | . | . | . | . | . | . |
| *Leontodon hispidus* | + | . | . | . | . | . | . | . | . | . | . | + | . | + | . | . | + | . | . | . |
| **cl. Festuco-Brometea** | | | | | | | | | | | | | | | | | | | | |
| *Plantago media* | . | 1 | 1 | 1 | . | . | . | . | . | . | . | 1 | + | 2 | . | . | 3 | . | . | . |
| *Artemisia absinthium* | 2 | 3 | . | . | . | + | 2 | 4 | 3 | 3 | . | . | . | . | . | . | . | . | . | . |
| *Euphorbia cyparissias* | + | . | . | . | . | . | + | 1 | + | + | . | . | . | . | . | . | . | 1 | . | 2 |
| *Lotus alpinus* | . | . | . | . | . | . | . | . | . | . | . | . | . | . | 1 | . | + | . | . | + |
| *Onobrychis viciifolia* | . | . | . | . | . | . | . | . | . | . | + | + | 1 | 2 | . | . | . | . | . | . |
| *Pimpinella major* | . | . | . | . | . | . | . | . | . | . | . | + | + | + | . | . | . | . | . | . |
| **cl. Vaccinio-Piceetea** | | | | | | | | | | | | | | | | | | | | |
| *Festuca flavescens* | . | . | . | . | . | . | . | . | . | . | . | . | . | . | 2 | 3 | . | . | . | . |
| *Picea abies* | . | . | . | . | . | . | . | . | . | . | . | . | . | . | 2 | 1 | . | . | . | . |
| *Sorbus aucuparia* | . | . | . | . | . | . | . | . | . | . | . | . | . | . | 1 | 1 | . | . | . | . |
| *Arctostaphylos uva-ursi* | . | . | . | . | . | . | . | . | . | . | . | . | . | . | 1 | . | . | . | 2 | . |
| *Hieracium murorum* | . | . | . | . | . | . | . | . | . | . | . | . | . | . | 1 | 1 | . | . | . | . |
| *Larix decidua* | . | . | . | . | . | . | . | . | . | + | . | . | . | . | 2 | + | . | 2 | . | . |
| *Vaccinium myrtillus* | . | . | . | . | . | . | . | . | . | . | . | . | . | . | 2 | 2 | . | . | 2 | 3 |
| *Juniperus nana* | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | 2 | 3 | 3 |
| *Deschampsia flexuosa* | . | . | . | . | . | . | . | . | . | . | . | . | . | . | 2 | 2 | . | . | . | 2 |
| **cl. Thlaspietea rotundifolii** | | | | | | | | | | | | | | | | | | | | |
| *Rumex scutatus* | . | . | . | . | + | . | . | + | . | + | . | . | . | . | . | . | . | . | . | + |
| **companion species** | | | | | | | | | | | | | | | | | | | | |
| *Agrostis capillaris* | + | . | . | . | . | . | . | . | . | . | . | . | + | + | . | . | 1 | . | . | . |
| *Alchemilla alpina* | . | . | . | . | . | . | . | . | . | . | . | . | . | . | 2 | . | 2 | . | . | . |
| *Festuca varia* | . | . | . | . | . | . | . | 1 | . | . | . | . | . | . | . | . | . | 2 | 3 | 2 |
| *Laserpitium halleri* | . | . | . | . | . | . | . | + | . | . | . | . | . | . | . | . | . | 2 | 1 | 2 |

certainly bring up seeds, while in zones with higher bulk densities (parking and camping sites) these species are present, as well as at the Vittorio Sella shelter. A more probable explanation is that seeds are present, but seedlings cannot grow in the center of the path because the trampling is too intense, while at the sides the environment is too dry.

The flora as a whole is uniform with relatively few species (121 in all). The impact of the path is not felt 10 metres back from its edges.

These observations apply to paths at 1600-2000 m elevation when their routes are single and well defined and tourists do not stray from them. Nearly all the Park's touristic paths are clearly marked out and parallel tracks are rare.

### 6. 1. 4 SHELTERS

The four shelters most commonly used in the Park were selected (fig. 10). The Vittorio Sella one (2584 m) is located in Valnontey at the end of the path examined before. The Vittorio Emanuele (2732 m) is located at the beginning of the routes leading to the peaks of the Gran Paradiso Massif. The Benevolo Shelter is at 2285 m altitude and the Albergo Savoia is at 2532 m. A complete flora census was carried out for each shelter (table 29), together with 16 phytosociological relevés: 8 in used areas (the first 8 in table 22), 8 in undisturbed areas away from the shelters. The trampled areas were almost entirely deprived of vegetation. The few communities with a low plant cover (20-30% apart from one 80 % exceptions) are composed of species which tolerate trampling such as *Poa supina*, and are accompanied by some ruderals growing well above their usual altitudes. In the undisturbed areas around Benevolo the communities are typical of calcareous alpine pastures with the *Elyno-Seslerietea* species, together with species of lower elevation meadows. The communities around the other shelters are those typical of acid alpine pastures with dominant *Festuca halleri*. Fifty-two species were listed around Albergo Savoia, 48 at Vittorio Sella, 54 at Vittorio Emanuele and 57 around Benevolo. Five (*Poa alpina*, *Poa annua*, *Poa supina*, *Taraxacum* gr. *officinale* and *Trifolium thalii*) were common to all shelters. No exotic species were noted; some native species that normally grow at much lower altitude had evidently

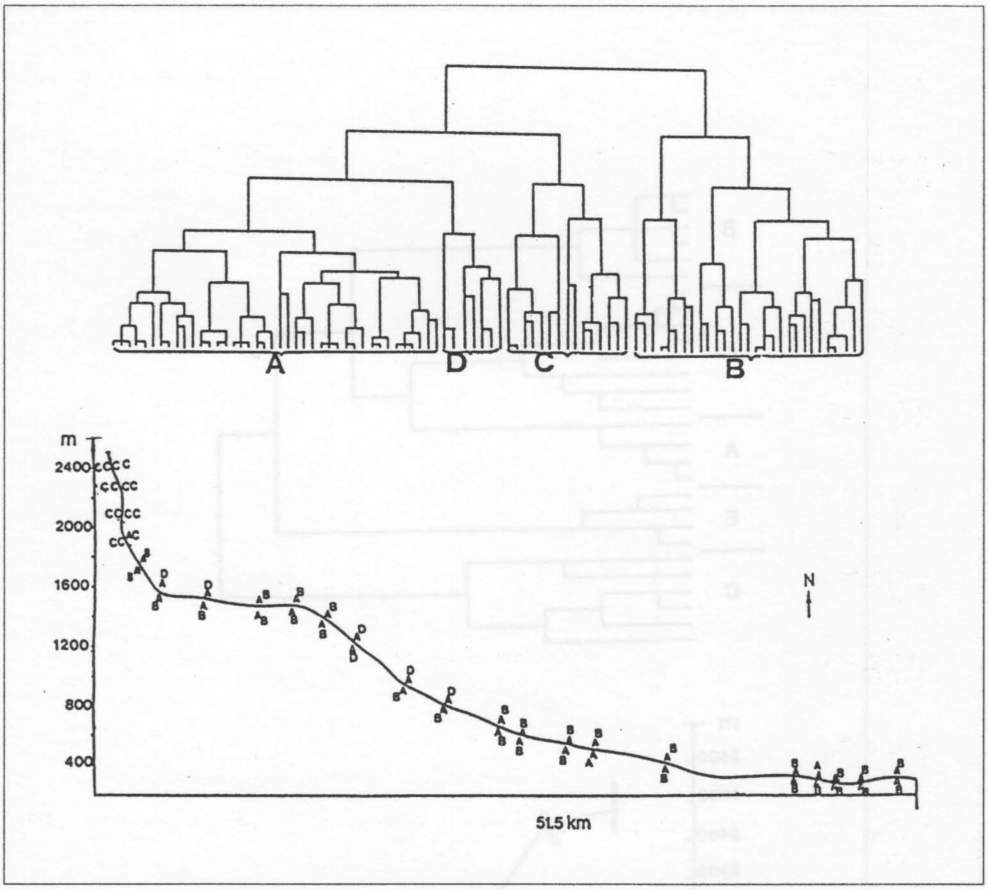


*Fig. 12* — Dendrogram of the relevés along the Orco Valley road and plot of their corresponding groupings.

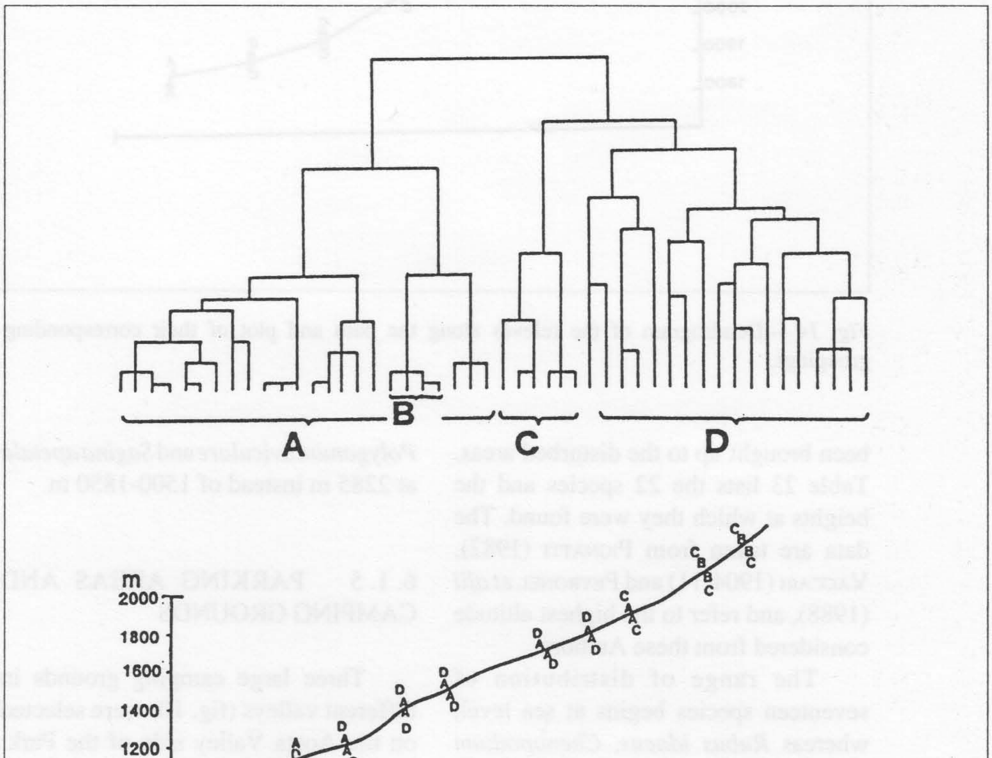


*Fig. 13* — Dendrogram of the relevés along the Valsavarenche road and plot of their corresponding groupings.

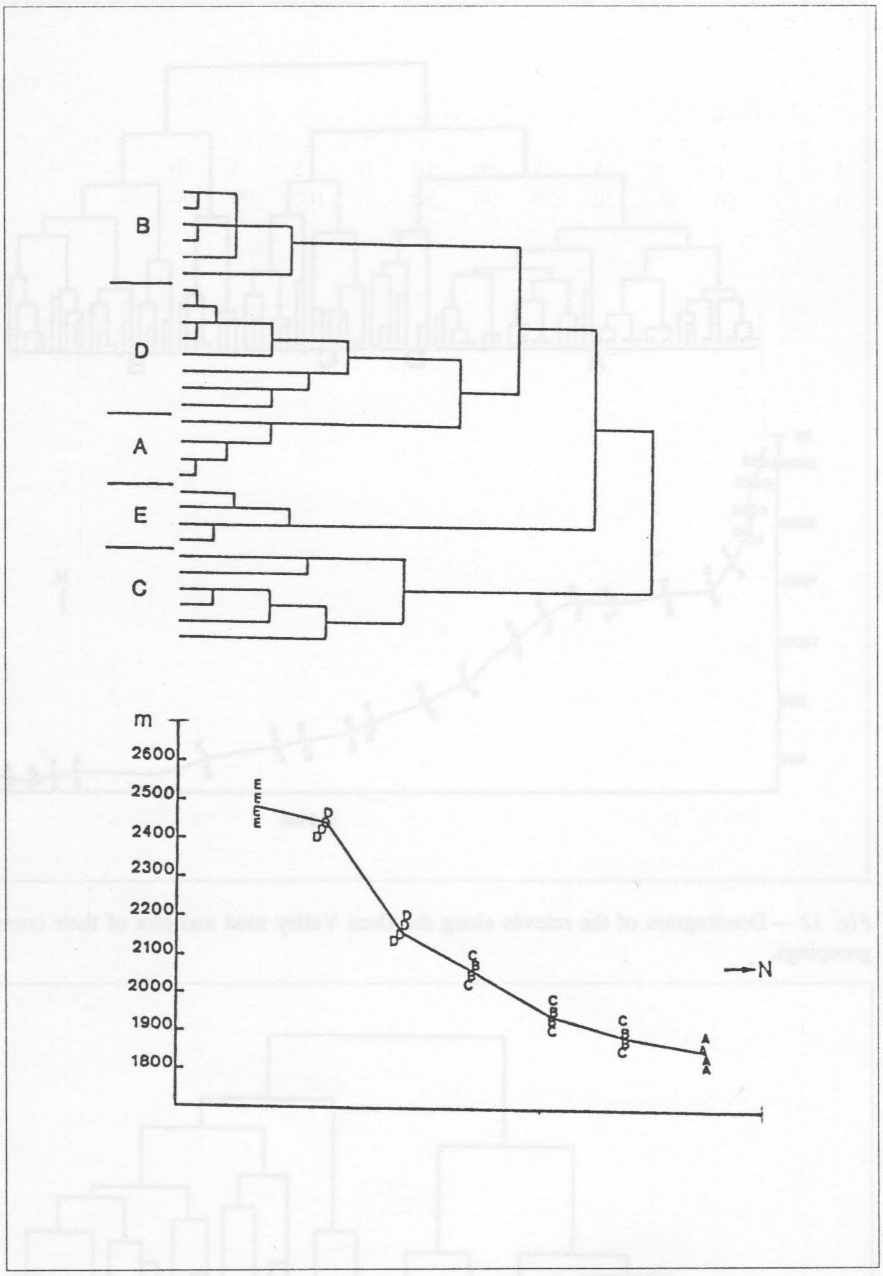


*Fig. 14* — Dendrogram of the relevés along the path and plot of their corresponding groupings.

been brought up to the disturbed areas. Table 23 lists the 22 species and the heights at which they were found. The data are taken from PIGNATTI (1982), VACCARI (1904-11) and PEYRONEL *et alii* (1988), and refer to the highest altitude considered from these Authors.

The range of distribution of seventeen species begins at sea level, whereas *Rubus idaeus, Chenopodium bonus-henricus, Epilobium angustifolium, Peucedanum ostruthium* and *Ligusticum mutellina* start at increasingly higher elevations. Five species were also found above their top most localities: *Festuca pratensis* at 2732 m compared with the 1800 m given in the literature, *Carduus nutans* at 2530 m instead of 1700, and *Capsella bursa-pastoris, Polygonum aviculare* and *Sagina apetala* at 2285 m instead of 1500-1850 m.

### 6. 1. 5 PARKING AREAS AND CAMPING GROUNDS

Three large camping grounds in different valleys (fig. 10) were selected on the Aosta Valley side of the Park: Rhêmes Notre Dame (about 1730 m), Lillaz (1620 m) at the head of the Cogne Valley, and Pont Valsavarenche (1970 m). On the Piedmontese side, an extensive parking area occasionally used by caravans and campers beyond Ceresole (about 2200 m) in Orco Valley was chosen in the absence of camping sites of any size.

Surveys were carried out in the disturbed and undisturbed parts of each area. Much of the surface was completely devoid of vegetation, and only a few areas had an herbaceous cover varying from 10 to 70 %.

The Pont Valsavarenche camping ground is surrounded by conifer woods with *Larix decidua* and *Picea abies* in the tree layer. Species of mown meadows are found in its used parts (table 24: relevés 1-4), together with others able to withstand trampling, whereas *Deschampsia flexuosa, Juniperus communis* ssp. *nana* and *Vaccinium myrtillus* were dominant in the undisturbed area.

The used zones at Rhêmes, Lillaz and Ceresole (table 25: relevés 6-9; 10-15; 16) display a similar pattern: dominance of species of trampled areas, along with a few individuals of mown meadows species. The undisturbed areas are occupied by species typical of mown meadows. The total number of species recorded ranges from 52 at Pont Valsavarenche to 62 at Ceresole, 83 at Lillaz and 87 at Rhêmes. *Chamomilla suaveolens* is the only exotic. Indicators of human impact were *Chenopodium album, Matricaria perforata, Urtica dioica, Polygonum aviculare, Plantago major, Lolium perenne, Poa annua* and *Rumex obtusifolius.*

### 6. 2 SPECIES DIVERSITY

Some species diversity and equitability indices were calculated for some relevés from ski-runs, paths, camping grounds, shelters and roads (table 26). In each situation relevés from disturbed and undisturbed areas were chosen. The STADIV program (GANIS, 1991) was used to process the abundance data of each relevé. Floristic richness was expressed directly as the number of species in the 10 $m^2$ of the relevé.

The number of species varies. Disturbed areas tend to present fewer species than the control areas, but the floristic richness values display a wide variability in any event.

Pielou's index J=H'/Hmax (1969), where H'=Shannon's entropy and Hmax = maximum entropy, was used to express equitability. This index ranges from 0 to 1 (1 corresponding to equidistribution of the species abundances). The values calculated for the disturbed areas are always lower than those for the controls.

Separate assessment of floristic

*Table 22* — Phytosociological relevés around the shelters.

| Relevé no. | 1 | 2 | 5 | 6 | 9 | 10 | 13 | 14 | 3 | 4 | 7 | 8 | 11 | 12 | 15 | 16 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Altitude (m) | 2285 | 2285 | 2530 | 2530 | 2580 | 2580 | 2730 | 2730 | 2285 | 2285 | 2530 | 2530 | 2580 | 2590 | 2730 | 2730 |
| Exposure | SW | S | SE | S | W | SW | SW | S | S | SW | SE | SE | W | SE | SW | SW |
| Slope (°) | 5 | 10 | 2 | 5 | 1 | 2 | 3 | 5 | 20 | 10 | 10 | 5 | 3 | 30 | 10 | 10 |
| Herbaceous cover (%) | 30 | 20 | 30 | 25 | 50 | 80 | 20 | 30 | 90 | 90 | 90 | 100 | 90 | 90 | 70 | 90 |
| **cl. Elyno-Seslerietea** | | | | | | | | | | | | | | | | |
| *Phleum alpinum* | + | . | + | . | 2 | + | . | . | + | + | . | . | 1 | . | . | |
| *Minuartia recurva* | . | . | . | . | . | . | + | + | . | . | . | . | . | + | . | |
| *Alchemilla alpina* | . | . | . | . | . | . | . | . | + | 1 | . | . | + | . | | |
| *Galium pusillum* | . | . | . | . | . | . | . | . | . | 1 | . | . | + | + | . | |
| *Gentiana verna* | . | . | . | . | . | . | . | . | . | 1 | . | . | + | + | . | |
| *Polygala alpestris* | . | . | . | . | . | . | . | . | . | 1 | . | . | . | + | | |
| *Anthyllis vulneraria* ssp. *alpestris* | . | . | . | . | . | . | . | . | . | 2 | . | . | . | + | | |
| *Myosotis alpestris* | . | . | . | . | . | . | . | . | . | . | . | . | + | + | | |
| **cl. Caricetea curvulae** | | | | | | | | | | | | | | | | |
| *Festuca halleri* | . | . | . | . | 1 | 3 | 2 | 2 | . | 1 | 1 | 1 | 2 | 4 | 2 | 3 |
| *Geum montanum* | . | . | . | . | . | . | . | . | . | + | + | + | + | + | 1 | 2 |
| *Trifolium alpinum* | . | . | . | . | + | . | . | . | . | . | 2 | 2 | . | . | 2 | 3 |
| *Agrostis rupestris* | . | . | + | . | . | . | . | . | . | . | 2 | 2 | . | . | 2 | 1 |
| *Alopecurus gerardii* | . | . | 1 | 1 | . | . | . | . | . | . | 2 | 2 | . | . | + | 1 |
| *Carex curvula* | . | . | . | . | . | . | . | . | . | . | 2 | 3 | . | . | 3 | 2 |
| *Anthoxanthum alpinum* | . | . | . | . | . | . | . | . | . | . | . | . | 2 | . | 1 | + |
| *Potentilla grandiflora* | . | . | + | . | . | + | . | . | . | + | . | . | . | . | . | |
| **cl. Salicetea herbaceae** | | | | | | | | | | | | | | | | |
| *Salix herbacea* | . | . | . | . | . | . | . | . | . | . | 1 | 2 | . | . | . | . |
| *Omalotheca supina* | . | . | . | . | . | . | . | . | . | . | 2 | 1 | . | . | . | . |
| **cl. Arrhenatheretea** | | | | | | | | | | | | | | | | |
| *Alchemilla xanthochlora* | + | + | + | + | 1 | 2 | . | . | 2 | 2 | + | 1 | 2 | . | . | . |
| *Poa alpina* | + | + | 2 | 2 | 1 | 2 | . | . | | 2 | . | . | 1 | + | . | . |
| *Taraxacum officinale* gr. | + | + | 1 | . | . | . | . | . | + | . | . | . | . | . | . | . |
| *Trifolium pratense* ssp. *frigidum* | + | . | . | . | . | . | . | . | + | 1 | . | . | . | . | . | . |
| *Achillea millefolium* | + | + | . | . | . | . | . | . | . | 2 | . | . | . | . | . | . |
| *Festuca pratensis* | . | . | . | . | . | + | . | + | . | . | . | . | . | . | . | . |
| *Pulsatilla halleri* | . | . | . | . | . | . | . | . | . | . | . | . | . | 1 | . | . |
| *Trifolium badium* | . | . | . | . | . | . | . | . | . | 2 | . | . | + | . | . | . |
| **cl. Plantaginetea majoris** | | | | | | | | | | | | | | | | |
| *Poa supina* | 2 | 2 | 2 | 2 | 2 | 2 | 3 | 2 | . | . | . | . | . | . | . | . |
| *Plantago major* | 2 | 3 | + | 2 | . | . | . | . | + | . | . | . | . | . | . | . |
| *Poa annua* | 2 | + | . | 1 | . | . | . | . | . | . | . | . | . | . | . | . |
| *Trifolium thalii* | + | + | + | . | 3 | . | + | + | + | + | . | . | 1 | . | . | . |
| *Trifolium repens* | + | . | . | . | + | . | . | . | . | . | . | . | + | . | . | . |
| *Spergularia rubra* | . | + | . | . | . | . | . | . | . | . | . | . | . | + | . | . |
| **cl. Chenopodietea** | | | | | | | | | | | | | | | | |
| *Urtica dioica* | + | + | . | . | . | . | + | . | . | . | . | . | . | . | . | . |
| *Carduus nutans* | . | . | + | . | . | . | . | . | . | . | . | . | . | . | . | . |
| *Capsella bursa-pastoris* | + | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| **cl. Artemisietea** | | | | | | | | | | | | | | | | |
| *Chenopodium bonus-henricus.* | . | . | . | . | . | . | . | + | . | . | . | . | . | . | . | . |
| **cl. Festuco-Brometea** | | | | | | | | | | | | | | | | |
| *Lotus alpinus* | . | . | . | . | . | . | . | . | . | . | . | . | 2 | + | + | 1 |
| *Plantago alpina* | . | . | . | . | . | . | . | . | . | . | . | . | 1 | 2 | . | . |
| *Colchicum alpinum* | . | . | . | . | . | . | . | . | . | . | . | . | 2 | + | . | . |
| *Festuca ovina* gr. | + | . | . | . | . | . | . | . | 3 | 1 | . | . | . | . | . | . |
| *Taraxacum hoppeanum* gr. | . | . | . | . | 1 | 1 | . | . | . | . | . | . | + | . | . | . |
| *Sibbaldia procumbens* | . | . | + | 1 | . | + | . | . | . | . | . | . | + | . | 1 | 2 |
| *Carex foetida* | . | . | + | . | . | . | . | . | . | . | . | . | . | . | . | . |
| *Sagina saginoides* | . | . | . | . | . | 1 | . | . | . | . | . | . | . | . | . | . |
| *Veronica alpina* | . | . | . | . | . | 2 | . | . | . | . | . | . | + | . | . | . |
| *Hutchinsia alpina* | . | . | . | . | . | . | . | . | . | . | . | . | . | . | 1 | . |
| *Ranunculus glacialis* | . | . | . | . | . | . | . | . | . | . | . | . | . | . | + | 1 |

Relevés 1, 2, 3, 4: Benevolo; 5, 6, 7, 8: Savoia; 9, 10, 11, 12: Vittorio Sella; 13, 14, 15, 16: Vittorio Emanuele.

*Table 23* – Species recorded above their usual altitude range around the shelters.

| Species | altitude range in the literature | V. Sella m 2580 | V. Emanuele m 2732 | Savoia m 2530 | Benevolo m 2285 |
|---|---|---|---|---|---|
| *Poa annua* | 0-2000 (2700) | * | * | * | * |
| *Festuca pratensis* | 0-1800 | * | * | | |
| *Trifolium repens* | 0-1800 (2753) | * | | | * |
| *Achillea millefolium* | 0-2200 | * | * | | * |
| *Rumex acetosella* | 0-2200 | * | | | |
| *Solidago virgaurea* | 0-2000 | | * | | |
| *Ligusticum mutellina* | 1800-2600 (3000) | * | * | * | |
| *Spergularia rubra* | 0-1500 (2200) | * | | | |
| *Urtica dioica* | 0-1800 (2300) | | * | * | |
| *Chenopodium bonus-henricus* | 500-2100 | | * | * | |
| *Taraxacum* gr. *officinale* | 0-1700 | | * | * | * |
| *Peucedanum ostruthium* | 1300-2000 (2700) | | * | | |
| *Carduus nutans* | 0-1700 | | | * | * |
| *Plantago major* | 0-1500 (2028) | | | * | * |
| *Capsella bursa-pastoris* | 0-1800 | | | | * |
| *Polygonum aviculare* | 0-1850 | | | | * |
| *Dactylis glomerata* | 0-2000 (2500) | | | | * |
| *Arabidopsis thaliana* | 0-2000 | | | | * |
| *Silene nutans* | 0-2000 | | | | * |
| *Sagina apetala* | 0-1500 | | | | * |
| *Rubus idaeus* | 100-2000 | | * | | |
| *Epilobium angustifolium* | 600-2500 | | | * | * |

*Table 24* — Phytosociological relevés in the Pont Valsavarenche parking area.

| Relevé no. | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| Altitude (m) | 1970 | 1970 | 1970 | 1970 | 1970 |
| Slope (°) | 0 | 0 | 0 | 0 | 5 |
| Exposure | - | - | - | - | SE |
| Herbaceous cover (%) | 50 | 70 | 50 | 30 | 80 |
| **cl. Arrhenatheretea** | | | | | |
| *Agrostis capillaris* | + | 1 | 2 | 1 | . |
| *Achillea millefolium* | 1 | 1 | 1 | 1 | . |
| *Taraxacum* gr. *officinale* | 1 | + | + | + | . |
| *Poa alpina* | 2 | 2 | 1 | 2 | . |
| *Alchemilla xanthochlora* | 1 | 2 | + | . | . |
| *Polygonum bistorta* | 1 | + | + | . | . |
| *Rumex alpinus* | . | 1 | . | . | . |
| *Dactylis glomerata* | . | + | . | + | . |
| **cl. Festuco-Brometea** | | | | | |
| *Festuca nigrescens* | 2 | 2 | 3 | 2 | . |
| *Plantago media* | + | . | . | . | . |
| *Euphorbia cyparissias* | . | . | . | . | 2 |
| *Thymus pulegioides* | . | . | . | . | + |
| *Lotus alpinus* | . | . | . | . | + |
| **cl. Caricetea curvulae** | | | | | |
| *Potentilla aurea* | 1 | . | 1 | + | . |
| *Laserpitium halleri* | . | . | . | . | 2 |
| *cl. Vaccinio-Piceetea* | . | . | . | . | . |
| *Deschampsia flexuosa* | . | . | . | . | 2 |
| *Juniperus communis* ssp. *nana* | . | . | . | . | 3 |
| *Vaccinium myrtillus* | . | . | . | . | 3 |
| **cl. Plantaginetea majoris** | | | | | |
| *Spergularia rubra* | 1 | . | . | + | . |
| *Plantago major* | . | . | . | + | . |
| *Trifolium thalii* | . | 1 | + | + | . |
| **companion species** | | | | | |
| *Hieracium piloselloides* | . | . | . | . | 2 |
| *Chaerophyllum hirsutum* | . | . | . | . | 2 |
| *Plantago alpina* | + | . | + | + | . |
| *Chenopodium album* | + | + | . | + | . |
| *Matricaria perforata* | + | + | + | . | . |
| *Urtica dioica* | . | + | . | . | . |
| *Rumex obtusifolius* | + | . | + | . | . |

Relevés 1, 2, 3, 4: used areas; 5: adjacent unused area.

*Table 25* — Phytosociological relevés in the Rhêmes and Lillaz camping grounds, and the Ceresole parking area.

| Relevé no. | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Altitude (m) | 1735 | 1735 | 1735 | 1735 | 1620 | 1620 | 1620 | 1620 | 1620 | 1620 | 2210 | 1735 | 1820 | 2210 |
| Slope (°) | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 15 |
| Exposure | - | - | - | - | - | - | - | - | - | - | - | - | W | W |
| Herbaceous cover (%) | 60 | 60 | 30 | 30 | 50 | 20 | 20 | 10 | 40 | 20 | 20 | 100 | 100 | 100 |
| **cl. Plantaginetea majoris** | | | | | | | | | | | | | | |
| *Poa annua* | 2 | 2 | 1 | 2 | 2 | 1 | + | 1 | 1 | + | . | . | . | . |
| *Plantago major* | 1 | 1 | 1 | 1 | 1 | + | 1 | . | + | + | 1 | . | . | . |
| *Trifolium repens* | 1 | + | 1 | + | 1 | 1 | 1 | . | 1 | 1 | . | . | . | 1 |
| *Lolium perenne* | + | 2 | 1 | . | 1 | + | + | . | . | . | . | + | . | . |
| *Chamomilla suaveolens* | 2 | . | . | . | . | . | + | + | + | + | . | . | . | . |
| *Spergularia rubra* | . | . | . | . | + | . | + | . | 1 | + | . | . | . | . |
| *Polygonum aviculare* | . | . | . | . | + | . | . | + | + | . | . | . | . | . |
| *Trifolium thalii* | . | + | + | . | . | . | . | . | . | + | + | . | . | . |
| *Agrostis stolonifera* | . | . | . | . | . | . | . | . | . | . | . | . | . | + |
| *Ligusticum mutellina* | . | + | . | + | . | . | + | . | . | + | . | . | . | . |
| **cl. Arrhenatheretea** | | | | | | | | | | | | | | |
| *Taraxacum* gr. *officinale* | + | + | + | + | + | + | + | + | + | + | 1 | + | + | + |
| *Alchemilla xanthochlora* | . | + | + | + | + | . | . | . | + | . | . | 1 | + | 2 |
| *Achillea millefolium* | + | 1 | + | . | + | . | . | . | 1 | 1 | . | + | + | 2 |
| *Poa alpina* | 1 | 1 | 1 | 1 | 2 | 2 | 2 | 2 | 1 | 1 | 2 | . | . | 1 |
| *Dactylis glomerata* | + | + | 2 | . | + | . | . | . | + | + | . | 3 | 2 | . |
| *Trisetum flavescens* | . | . | . | . | . | . | . | . | . | . | . | 2 | 2 | 2 |
| *Polygonum bistorta* | . | . | . | . | . | . | . | . | . | . | . | 2 | 2 | 2 |
| *Vicia cracca* | . | . | . | . | . | . | . | . | . | . | . | + | + | 2 |
| *Daucus carota* | . | . | . | . | . | . | . | . | . | . | . | 1 | 1 | . |
| *Ranunculus acris* | . | . | . | . | . | . | . | . | . | . | . | 1 | 1 | . |
| *Heracleum sphondylium* | . | . | . | . | . | . | . | . | . | . | . | 1 | . | 2 |
| *Poa pratensis* | . | . | . | . | . | . | . | . | . | . | . | 1 | + | 1 |
| *Geranium sylvaticum* | . | . | . | . | . | . | . | . | . | . | . | 1 | 1 | . |
| *Campanula rhomboidalis* | . | . | . | . | . | . | . | . | . | . | . | + | + | . |
| *Briza media* | . | . | . | + | . | . | . | . | . | . | . | 1 | . | . |
| *Leontodon hispidus* | . | . | . | + | . | . | . | . | . | . | . | 1 | . | . |
| *Lathyrus pratensis* | . | . | . | . | . | . | . | . | . | . | . | + | . | . |
| *Trifolium pratense* | . | . | . | . | . | . | . | . | . | . | . | . | . | 1 |
| *Tragopogon pratensis* | . | . | . | . | . | . | . | . | . | . | . | . | . | + |
| *Silene vulgaris* | . | . | . | . | . | . | . | . | . | . | . | . | . | + |

Relevés 6-9: Rhêmes camping ground, used areas; 10-15: Lillaz, used areas; 16: Ceresole, used area; 17: Rhêmes, unused area; 18: Lillaz, unused area; 19: Ceresole, unused area.

*Table 26* — Floristic richness, Pielou's index, Shannon's index and the N2 numbers of Hill's series.

| | floristic richness | Pielou's index | Shannon's index | N2 |
|---|---|---|---|---|
| *1 | 14 | 0.51 | 1.36 | 2.32 |
| o2 | 25 | 0.65 | 2.11 | 4.64 |
| *3 | 14 | 0.64 | 1.7 | 3.88 |
| o4 | 20 | 0.77 | 2.31 | 7.32 |
| *5 | 16 | 0.53 | 1.49 | 2.36 |
| o6 | 18 | 0.72 | 2.09 | 5.08 |
| *7 | 12 | 0.47 | 1.18 | 1.99 |
| o8 | 20 | 0.79 | 2.36 | 8.29 |
| *9 | 19 | 0.8 | 2.35 | 5.51 |
| o10 | 21 | 0.84 | 2.57 | 10.55 |
| *11 | 10 | 0.35 | 0.8 | 1.44 |
| o12 | 18 | 0.78 | 2.27 | 7.4 |
| *13 | 21 | 0.46 | 1.41 | 1.93 |
| o14 | 18 | 0.72 | 2.08 | 4.86 |
| *15 | 19 | 0.48 | 1.42 | 2.21 |
| o16 | 17 | 0.72 | 2.04 | 5.15 |
| *17 | 6 | 0.52 | 0.94 | 1.96 |
| *18 | 10 | 0.45 | 1.05 | 1.82 |
| o19 | 18 | 0.76 | 2.21 | 6.68 |
| *20 | 13 | 0.74 | 1.91 | 5.09 |
| o21 | 22 | 0.78 | 2.42 | 8.34 |
| *22 | 14 | 0.7 | 1.84 | 4.55 |
| o23 | 16 | 0.86 | 2.38 | 8.89 |
| *24 | 13 | 0.66 | 1.7 | 3.62 |
| o25 | 17 | 0.72 | 2.05 | 5.06 |
| *26 | 16 | 0.57 | 1.58 | 2.41 |
| o27 | 19 | 0.77 | 2.29 | 7.1 |
| *28 | 7 | 0.39 | 0.76 | 1.47 |
| o29 | 16 | 0.77 | 2.15 | 6.49 |
| *30 | 25 | 0.63 | 2.05 | 3.17 |
| o31 | 21 | 0.8 | 2.44 | 9.08 |

* = Disturbed areas; o = undisturbed areas. The corresponding phytosociological tables and relevé numbers are set out below:

| | | | |
|---|---|---|---|
| Nos. | 1-8 | ski runs: | Table 15, 1=2A; 2=2C; 3=4A; 4=4C. Table 16, 5=2A; 6=2C; 7=7A; 8=7C |
| Nos. | 9-16 | path: | Table 21, 9=1; 10=14; 11=6; 12=19; 13=7; 14=20; 15=8; 16=21 |
| Nos. | 17-19 | camping grounds: | Table 25, 17=6; 18=7; 19=17 |
| Nos. | 20-23 | shelters: | Table 22, 20=9; 21=11; 22=1; 23=3 |
| Nos. | 24-31 | roads: | Table 17, 24=1; 25=47; 26=2; 27=48; 28=3; 29=49; 30=19; 31=65 |

Floristic richness = no. of species per 10 m² N2 = Number N2 of Hill's series.

richness and equitability was followed by summary expression of species diversity to allow comparison with studies based on synthetic indices.

The indices chosen were those of Shannon and $N_2$ of Hill's series of numbers (1973) in keeping with Magurran's criterion (1988), namely that the best indices are those that display a greater ability to discriminate between similar conditions. The $N_2$ index is the reciprocal of the Simpson index. It is expressed in species units and represents the number of very abundant species in a given sample. The values given by both indices were always lower in the disturbed areas.

Dominance-diversity curves of some relevés, prepared from both disturbed and undisturbed areas (fig. 15), show the number of species present and their abundance percentages. There was a great difference between the abundance patterns of the disturbed and the undisturbed areas relevés. The DIVFIT program (GANIS, 1991) was used to determine the statistical fit between the distributions of the abundance values and those of the four theoretical models (geometric series, logarithmic series, broken-stick and lognormal). In the disturbed areas, there was a close fit with the geometric or the logarithmic model. The geometric series is typical of an "unsaturated" habitat whose niche spaces or hypervolumes are gradually and at regular intervals occupied by incoming species according to WHITTAKER's "niche preconquest" model (1965, 1972, 1975). Communities characteristic of disturbed areas are formed of few abundant species and many rare species, and are found in extreme environments or the young stages of a succession. The logarithmic model is very similar, except that niche occupancy now occurs at random intervals.

The curves for the undisturbed areas, on the other hand, fit the broken-stick and lognormal models, corresponding to situations with a more uniform distribution of abundances.

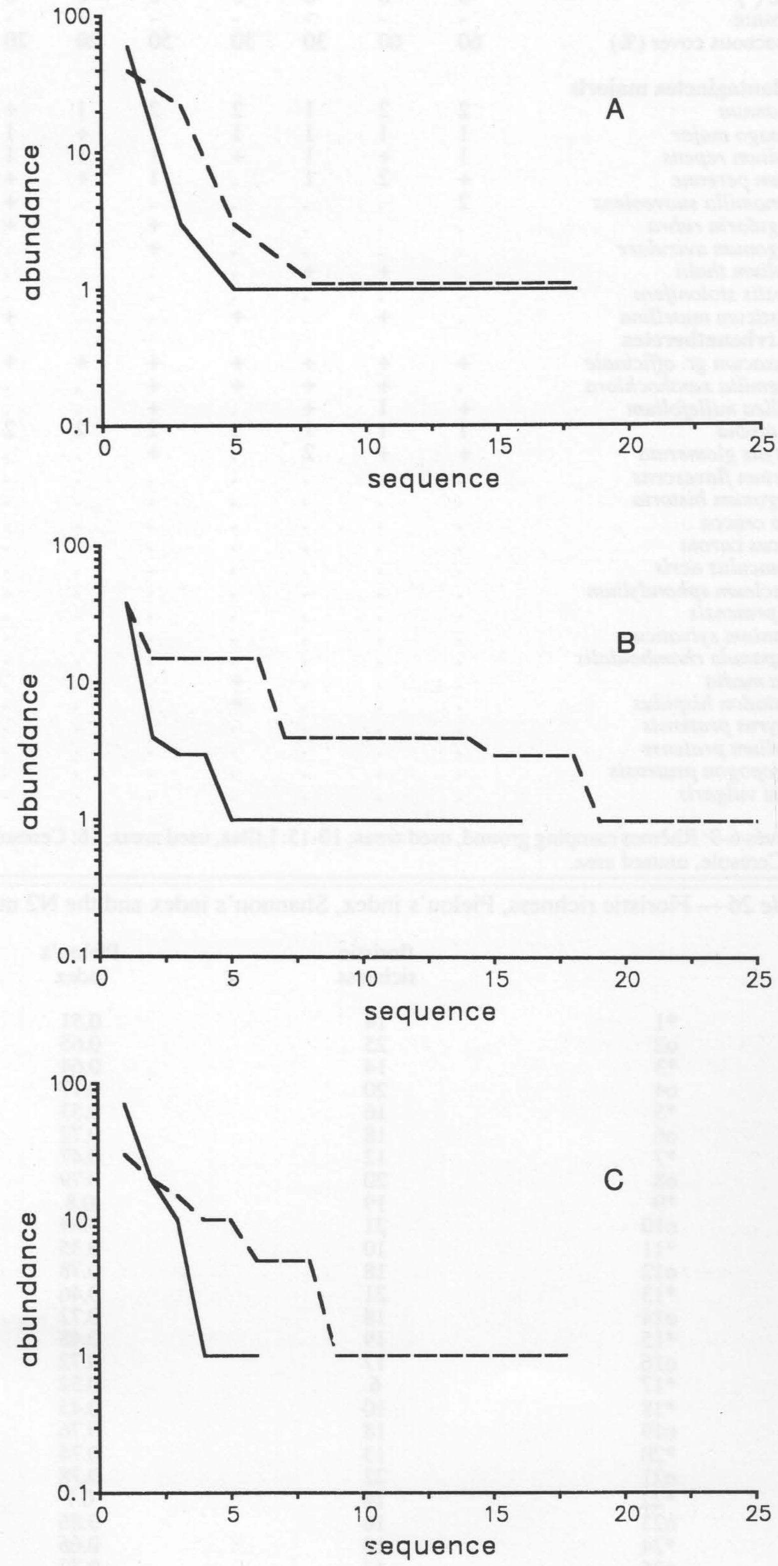


*Fig. 15* — Dominance-diversity curves for relevés of a disturbed area (full line) and an undisturbed area (dashed line) of the path (A), roads (B) and camping grounds (C), namely: path, nos. 2 & 15 (table 21); roads, nos. 19 and 65 (table 17); camping grounds, nos. 6 & 17 (table 25).

## 6.3 SOIL BULK DENSITY

Soil bulk density is readily measurable and the best yardstick for assessing changes in soil structure due to compaction. In flatland areas with very heavy foot traffic, it may reach 1.6 g cm$^{-3}$. As mentioned earlier, a variation of this kind is responsible for considerable changes in the regular supply of water and the circulation of gases, and hence in the vegetation pattern.

The bulk density data in table 27 clearly indicate that there is a mean increase in the disturbed areas.

## 6. 4 PLANT STRATEGIES

GRIME's model (1979) summarises the biological characteristics of a species and gives a clear indication of its response to the combined effect of stress and disturbance. A recent application of this model by HODGSON (1991) enables the phytosociological data gathered for a particular plant community to be analysed in functional terms through the determination of its dominant strategies and characteristics by plotting the strategies displayed by the species in a relevé (or group of uniform relevés) and their percentages on Grime's triangle.

The Gran Paradiso National Park data gave the following results (fig. 16). The dominant species in mown meadows at elevations of 1200-1600 m are mainly competitive, stress-tolerant, ruderal (C-S-R) strategists (46%), whereas the remainder are either competitive or competitive-ruderal species. Grazing and mowing reduce the mostly tall competitive species, whereas ruderal and stress-tolerant species are reduced due to the pressure of other plants. Altitude is a clear distinguishing factor in areas with little or no human impact: between 1400 and 1800-2000 m, there are woods with dominant competitive and stress-tolerant-competitive species, whereas in alpine pastures low temperatures and a persistent snow-cover result in the dominance of stress-tolerant species.

In the event of heavy disturbance, such as that along road verges, altitude is again a differentiating factor. At low levels, heavy disturbance plus low stress intensity allow the dominance of ruderal and competitive-ruderal strategists while external areas (mostly mown meadows) are occupied by C-S-R strategists (fig. 17). At high altitudes, very few species possess the characteristics needed to survive in the face of both intense stress and intense disturbance, namely the high growth rate and good production of seeds typical of ruderals coupled with tolerance of environmental stresses, which is usually achieved through a slow growth rate and a low resources allocation to reproduction.

In both disturbed and undisturbed areas, there is a dominance of stress-

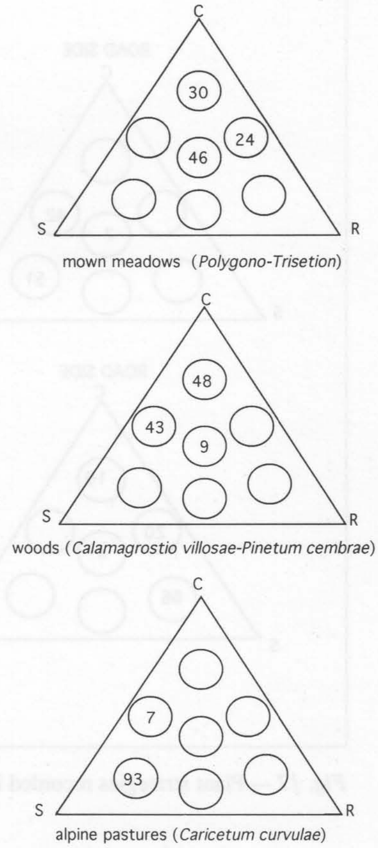


*Fig. 16* — Plant strategies recorded in the mown meadows, woods and alpine pastures species.

*Table 27* — Soil bulk density from all relevés along the path from Paradisia to the Vittorio Sella Shelter (a), near the shelters (b) and near the camping grounds and parking areas (c).

A

Path from the Paradisia garden to the Vittorio Sella shelter

| | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Relevé no. (verges) | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 |
| Soil bulk density (g/cm³) | 1.10 | 1.10 | 1.40 | 1.50 | 1.60 | 1.40 | 1.40 | 1.50 | 1.60 | 1.60 | 1.40 | 1.30 | 1.20 | 1.10 |
| Relevé no. (outer areas) | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 |
| Soil bulk density (g/cm³) | 1.00 | 1.10 | 0.80 | 0.90 | 1.00 | 0.90 | 0.90 | 0.80 | 1.10 | 1.10 | 1.00 | 1.30 | 0.90 | 0.80 |

B

Shelters

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Relevé no. (disturbed areas) | 1 | 2 | 5 | 6 | 9 | 10 | 13 | 14 |
| Soil bulk density (g/cm³) | 1.40 | 1.20 | 1.70 | 1.60 | 1.70 | 1.30 | 1.20 | 1.10 |
| Relevé no. (undisturbed areas) | 3 | 4 | 7 | 8 | 11 | 12 | 15 | 16 |
| Soil bulk density (g/cm³) | 0.90 | 0.80 | 1.10 | 1.20 | 1.20 | 1.10 | 0.80 | 1.00 |

C

Camping grounds and parking areas

| | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Relevé no. (disturbed areas) | 1 | 2 | 3 | 4 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 |
| Soil bulk density (g/cm³) | 1.20 | 1.10 | 1.00 | 1.30 | 1.40 | 1.50 | 1.30 | 1.50 | 1.20 | 1.30 | 1.20 | 1.60 | 1.50 | 1.60 | 1.60 |
| Relevé no. (undisturbed areas) | 5 | 17 | 18 | 19 | | | | | | | | | | | |
| Soil bulk density (g/cm³) | 0.80 | 1.00 | 0.90 | 1.10 | | | | | | | | | | | |

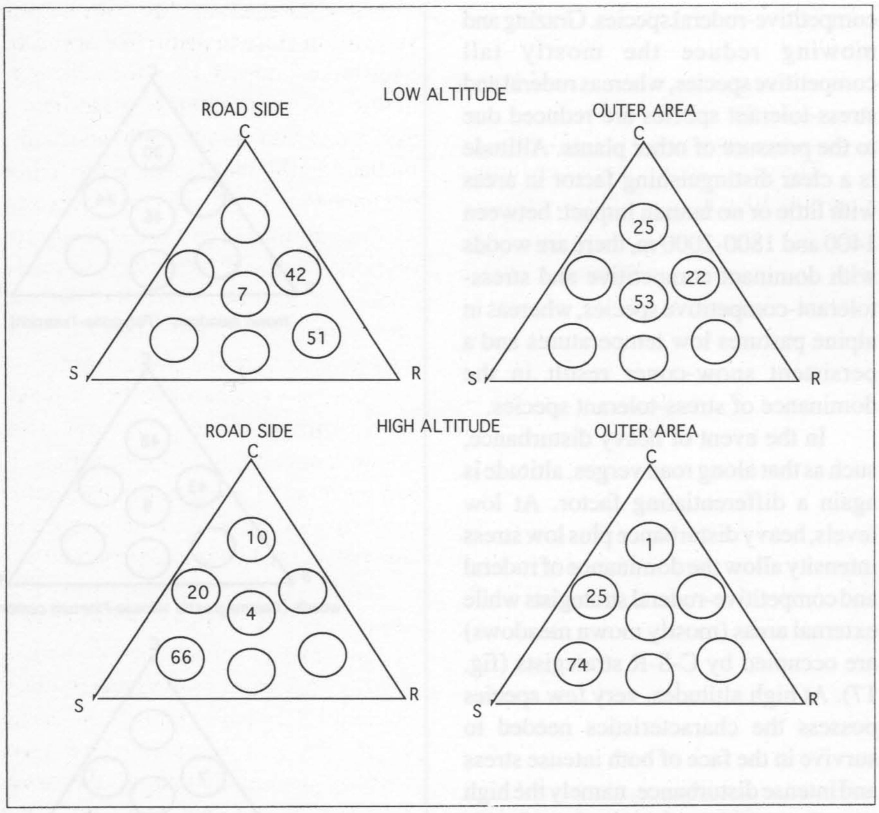


*Fig. 17* — Plant strategies recorded in species along low and high-altitude roadsides.

tolerant and competitive stress-tolerant species which stand up fairly well to chronic, though not destructive, disturbance. By contrast, the characteristics of ruderals make it impossible for them to live at high altitudes. The exotics are nearly all ruderals unable to overpass altitudes above 700-1000 m.

## 6.5 CHOROLOGICAL FINDINGS

The chorological spectra for the species recorded in the disturbed and undisturbed areas comprised in the ski run and road relevés are shown by way of example in table 28. Use has been made of the indications in PIGNATTI'S Flora d'Italia (1982), and some particular chorological groups have been combined to form more general groups.

Cosmopolitans, subcosmopolitans and adventitious species display greater percentage values in the disturbed areas, South European orophytes, arctic-alpine, and endemic species in the undisturbed areas. No significant differences were found for the other chorological groups.

Variations in the stress and disturbance gradients are responsible for combined effects. Up to 1000 m in altitude, the main aspect of the disturbed areas is the increase in adventitious and cosmopolitan species (as defined by Falinski). From 1000 to about 1800 m, the adventitious species disappear, the cosmopolitans increase, and the endemic and arctic-alpine species, where present, decline. At higher elevations (1800-2500 m), few cosmopolitans can survive, whereas many arctic-alpine and endemic species grow even in the disturbed areas. These species, in fact, are typical of scree habitats and spread into vegetation-free areas on account of the lower competitive ability needed to survive in these habitats compared with closed communities, such as alpine pastures.

Cosmopolitans, adventitious, endemic, arctic-alpine and south European orophytes are thus clearly linked to variations in the stress-disturbance gradient, in function of their individual strategies.

The adventitious species are ruderal

*Table 28* — Chorological spectra calculated for the disturbed and undisturbed area relevés.

| Species chorology | Cogne centre | Cogne outskirts | Rhêmes center | Rhêmes outskirts | Orco Valley lower part verge | Orco Valley lower part outer area | Orco Valley upper part verge | Orco Valley upper part outer area | Valsevarenche lower part verge | Valsevarenche lower part outer area | Valsevarenche upper part verge | Valsevarenche upper part outer area |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Cosmopolite and subcosmopolite | 24 | 5 | 28 | 4 | 4 | 28 | 29 | 17 | 32 | 2 | 35 | 11 |
| Orophytes | 28 | 29 | 14 | 15 | 7 | 1 | 19 | 24 | 2 | 5 | 9 | 11 |
| Exotic | 3 | . | 4 | . | 9 | 3 | 2 | . | 1 | 7 | . | . |
| Circumboreal | 17 | 24 | 14 | 19 | 22 | 23 | 21 | 22 | 2 | 15 | 26 | 17 |
| C- European | 3 | 5 | 7 | 12 | 2 | 3 | 9 | 14 | 7 | 5 | 4 | 11 |
| Eurasiatic | 3 | . | 18 | 19 | 7 | 1 | 2 | 3 | 1 | 21 | 9 | 8 |
| Eurosibiric | 13 | 23 | 11 | 15 | 4 | 7 | 2 | 3 | 2 | 1 | 4 | 15 |
| Paleotemperate | 3 | | 4 | 4 | 7 | 1 | 5 | 6 | 12 | 1 | 9 | 4 |
| Artic-alpine | 3 | 9 | . | 8 | . | . | 7 | 11 | . | . | . | 11 |
| Endemic | 3 | 5 | . | 4 | . | 3 | 2 | . | . | . | . | 7 |

and competitive-ruderal strategists, the cosmopolitans are mostly ruderal-competitive or competitive, while the majority of the endemic and arctic-alpine species are stress-tolerant. The south European orophytes display more varied strategies.

## CONCLUSIONS

This analysis of the most widespread vegetation types in areas of the Gran Paradiso National Park not yet subjected to the impact of tourism has shown that the influence of man's farming, pasturing and forestry operations is still readily detectable, even where such activities have been abandoned for dozens of years. At elevations of up to 1500 m, in particular, or even higher, meadows that are or were once regularly mown offer evidence of the upward migration of the low altitude species that draw more benefit from cutting and manuring than the high elevation species. The neighbouring woods, too, have not been felled for several decades and carry species typical of mown meadows that again bear witness to earlier human impact. The alpine pastures, on the other hand, do not display any floristic variations directly referable to either past or present synanthropization, even though their occasional downward spread below the natural level of the woods might suggest an extension induced by human activities.

The analysis of the vegetational types in undisturbed areas which were not subjected to tourism offered a yardstick with which to assess the completely different influence of what is now the main source of human impact in the Park, namely tourism. Its several forms have all been responsible for the following changes in the flora and vegetation.

1) **Destruction of vegetation.** This is the most evident outcome of tourism, one that becomes more marked and more persistent the higher one goes.

2) **Changes in the flora and vegetation up to an altitude of 1500-1600 m**. Substitution of the primary communities, composed of particular (sometimes endemic) native and stenotopic species, by secondary communities.

Substitution at these altitudes takes the form of floristic changes brought about by alteration of determinant environmental factors. The main causes are the earthmoving operations involved in the construction of ski runs or roads, and trampling, which alter the water budget and the structure of the soil.

The very few exotics rise no further than 800-1000 m and do not colonise the adjacent undisturbed formations. Only *Robinia pseudacacia* is occasionally found in roadside woods up to 1000 m, while the particular characteristics of *Chamomilla suaveolens* have allowed it to colonise areas crossed by vehicular traffic, such as ski runs, camping ground and parking areas, up to as high as 1800-2000 m.

3) **Changes in the flora and vegetation at altitudes of more than 1600 m**. At higher elevations, the changes in the flora become less striking as invasion by allochthonous species ceases. Apophytism allows native species typical of lower levels to rise as far as 1800-1900 m, while further up many naturally present species are unable to tolerate the disturbance and disappear. Disturbance results in destruction of the previous vegetation and not in its substitution, since many decades usually elapse before recolonisation takes place.

With the exception of *Chamomilla suaveolens*, exotics are totally absent, since they are mostly ruderals whose strategy permits their recolonisation of bald areas, but clashes with the stress-tolerance characteristics required to survive in the harsh conditions imposed by high altitudes.

4) **Variations in species diversity.** Floristic richness tends to diminish in highly disturbed areas. The considerable dissimilarity of the changes referable to this parameter, however, make it an unreliable indicator of the degree of anthropization of an area.

At low altitudes, there may be a greater richness owing to the arrival of species typical of disturbed areas, whereas this does not take place in the highlands. Species diffusion is always less uniform in disturbed as opposed to undisturbed areas on account of the reciprocal behaviour of the species and of the differences in their strategies. The general picture showed that species diversity decreases in disturbed areas. This parameter is thus a good indicator of the degree of human impact, though the fact that it also diminishes with increases in altitude means that it remains a merely relative index that can only be used to compare areas with similar soil conditions and at similar elevations.

5) **Changes in the flora and vegetation close to disturbed areas**. In undisturbed areas 8-10 m from the moderate or even intense disturbance associated with ski runs, paths and roads, midland and highland plant communities are unchanged, and can thus be classed as "resistant". Their sensitivity to disturbance, which is regarded by nearly all Authors as lower than that of flatland communities, must therefore be attributed to their lower resilience.

Contrary to what might be expected, woodland and alpine pastures communities in the Alps are characterised by relative stability as this term is used by Holling, i.e. a combination of resistance, resilience and persistence.

What may be drawn from this research is that the most serious effects of tourism and other types of human activity in alpine valleys are closely linked to the actual destruction of the vegetation, and not to moderate use coupled with limitation of the areas assigned for such activities, as in the case of paths, well-defined picnic areas or the clearings around huts and shelters.

Ski runs are a true source of long-lasting changes in the environment, not on account of the technical difficulties preventing rehabilitation after their construction, but above all because of the objective limitations imposed by the biological characteristics of species capable of surviving at high altitudes.

Generally speaking, therefore, the effects of human impact depend on the ratio between environmental stress and anthropic disturbance. If the stress is low, plant communities are composed of competitive species and the outcome of human impact will be their replacement by secondary communities partly composed of cosmopolitan, adventitious and eurytopic species, as defined by Falinski.

If the stress is high, communities are composed of stress-tolerant species: moderate human disturbance, therefore, does not lead to destruction; the primary communities persist, albeit with quantitative changes of the present species. On the other hand, if in the same stressed conditions high disturbance occurs, the primary communities are destroyed with no possibility of recolonisation, or at best very slow recolonisation by the species present before the disturbance occurs.

In every case, high disturbance leads to a reduction of species diversity, mainly as the result of diminished equitability.

*Table 29* — Species recorded in the areas subjected to human impact.

| | roads | | ski runs | | path | | shelters | | camping ground | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Species | Orco | Valsa. | Cogne | Rhem. | Laus | Savoia | Sella | Eman. | Benev. | Ceres. | Lillaz | Rhem. | Pont |
| **Equisetaceae** | | | | | | | | | | | | | |
| *Equisetum variegatum* Schleicher | | | x | | | | | | | | | | |
| **Ophioglossaceae** | | | | | | | | | | | | | |
| *Botrychium lunaria* (L.) Swartz | x | | | | | | x | | | | | | |
| **Hypolepidaceae** | | | | | | | | | | | | | |
| *Pteridium aquilinum* (L.) Kuhn | x | | | | | | | | | | | | |
| **Aspleniaceae** | | | | | | | | | | | | | |
| *Asplenium trichomanes* L. | x | | | | | | | | | | | | |
| **Athyriaceae** | | | | | | | | | | | | | |
| *Athyrium filix-femina* (L.) Roth | | | | | | x | | | | | | | |
| **Polypodiaceae** | | | | | | | | | | | | | |
| *Polypodium australe* Fee | | x | | | | | | | | | | | |
| *Polypodium vulgare* L. | x | | | | | | | | | | | | |
| **Pinaceae** | | | | | | | | | | | | | |
| *Picea abies* (L.) Karsten | x | x | x | x | x | | | | | | x | x | x |
| *Larix decidua* Miller | x | x | x | x | x | | | | | | x | x | x |
| *Pinus sylvestris* L. | | x | | | | | | | | | | | |
| *Pinus cembra* L. | | | | | | | | | | | | x | |
| **Cupressaceae** | | | | | | | | | | | | | |
| *Juniperus communis* L. | | | | | | | | | | | x | | |
| *Juniperus communis* L. ssp. *nana* Syme | | x | | x | x | | | | | | | | x |
| **Salicaceae** | | | | | | | | | | | | | |
| *Salix herbacea* L. | x | | | | | x | | | | | | | |
| *Salix breviserrata* B. Flod. | | | x | x | | | | | | | | | |
| *Salix caprea* L. | | x | x | x | | | | | | | x | | |
| *Salix helvetica* Vill. | | | x | | | | | | | | | | |
| *Salix eleagnos* Scop. | | | | | | | | | | | | x | |
| *Populus tremula* L. | | | | x | | | | | | | | | |
| *Populus nigra* L. | | x | | | | | | | | | | | |
| **Betulaceae** | | | | | | | | | | | | | |
| *Betula pendula* Roth | | x | x | x | | | | | | | x | x | |
| *Alnus viridis* (Chaix) DC. | | | | x | | | | | | | | x | x |
| **Corylaceae** | | | | | | | | | | | | | |
| *Corylus avellana* L. | x | x | | | | | | | | | | | |
| **Fagaceae** | | | | | | | | | | | | | |
| *Castanea sativa* Miller | x | | | | | | | | | | | | |
| **Urticaceae** | | | | | | | | | | | | | |
| *Urtica dioica* L. | x | x | x | x | x | x | | x | | | x | | |
| **Santalaceae** | | | | | | | | | | | | | |
| *Thesium alpinum* L. | | | x | x | | | | | | | | | |
| **Polygonaceae** | | | | | | | | | | | | | |
| *Polygonum aviculare* L. | x | x | x | x | | | | x | | | x | x | |
| *Polygonum lapathifolium* L. | x | x | | | | | | | | | | | |
| *Polygonum bistorta* L. | x | x | | x | | | | | | x | x | x | x |
| *Polygonum viviparum* L. | x | x | | | | | | | | | x | x | |
| *Polygonum alpinum* All. | x | | | | | | | | | | | | |
| *Bilderdykia convolvulus* (L.) Dumort | x | | | x | | | | | | | | | |
| *Oxyria digina* (L.) Hill. | x | | | x | | x | | x | | | | | |
| *Rumex acetosella* L. | x | | x | x | x | | x | | | x | x | | |
| *Rumex scutatus* L. | x | x | x | | x | | | | | x | | x | |
| *Rumex arifolius* All. | | | | x | | | | | | | | | |
| *Rumex alpinus* L. | | x | | | | x | | | | | | | x |
| *Rumex crispus* L. | | x | | | | | | | | | | | |
| *Rumex obtusifolius* L. | x | x | | | | | | | | | | x | |
| **Chenopodiaceae** | | | | | | | | | | | | | |
| *Chenopodium bonus-henricus* L. | x | x | | x | | x | | x | | | x | x | |
| *Chenopodium urbicum* L. | x | | | | | | | | | | | | |
| *Chenopodium album* L. | x | x | x | x | | | | | | | | x | |
| **Amaranthaceae** | | | | | | | | | | | | | |
| *Amaranthus retroflexus* L. | | x | | | | | | | | | | | |
| **Portulacaceae** | | | | | | | | | | | | | |
| *Portulaca oleracea* L. | | x | | | | | | | | | | | |

| | roads | | ski runs | | path | | shelters | | | camping ground | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Orco | Valsa. | Cogne | Rhem. | Laus | Savoia | Sella | Eman. | Benev. | Ceres. | Lillaz | Rhem. | Pont |
| Species | | | | | | | | | | | | | |
| **Caryophyllaceae** | | | | | | | | | | | | | |
| *Arenaria biflora* L. | . | . | . | . | . | x | . | . | . | . | | | |
| *Arenaria ciliata* L. | . | . | . | . | . | x | . | . | . | . | | | |
| *Arenaria serpyllifolia* L. | x | . | . | . | . | . | . | . | . | . | | | |
| *Moehringia muscosa* L. | . | . | x | . | . | . | . | . | . | . | | | |
| *Moehringia ciliata* (Scop.) Dalla Torre | x | . | . | . | . | x | . | . | . | . | | | |
| *Minuartia mutabilis* Schinz et Thell. | . | . | . | x | . | . | . | . | . | . | | | |
| *Minuartia recurva* (All.) Schinz et Thell. | x | . | x | . | x | . | x | . | . | . | | | |
| *Minuartia laricifolia* Schinz et Thell | x | . | x | . | . | . | . | . | . | x | . | | |
| *Minuartia sedoides* (L.) Hiern | x | . | . | x | . | . | . | x | . | x | | | |
| *Stellaria media* (L.) Vil. | x | x | . | . | . | . | . | . | . | . | | | |
| *Cerastium cerastioides* (L.) Britton | . | . | . | . | . | . | x | . | . | . | | | |
| *Cerastium arvense* L. | . | . | x | . | x | . | . | . | . | x | x | x | |
| *Cerastium alpinum* L. | . | . | . | . | . | x | . | . | . | | | | |
| *Cerastium glomeratum* Thuill. | . | . | . | . | . | . | . | | | | | x | . |
| *Cerastium arvense* L. ssp. *strictum* (Haenke) Gaudin | x | . | x | x | x | x | . | . | . | x | x | | |
| *Sagina saginoides* (L.) Karsten | . | . | . | x | . | x | x | . | x | . | . | x | |
| *Sagina apetala* Ard. | . | . | x | x | . | . | . | . | x | . | | | x |
| *Paronychia polygonifolia* (Vill.) DC. | . | . | . | . | . | x | . | x | . | . | | | |
| *Spergularia rubra* L. | x | . | x | x | . | . | x | . | . | . | x | | x |
| *Lychnis flos-jovis* (L.) Desr. | x | . | . | . | . | . | . | . | . | . | . | | |
| *Silene nutans* L. | x | . | x | . | x | . | . | . | x | . | . | | |
| *Silene otites* (L.) Wibel | x | . | . | x | x | . | . | . | . | . | | | |
| *Silene vulgaris* (Moench) Garcke | x | x | x | x | . | . | . | . | . | x | | | |
| *Silene acaulis* (L.) Jacq. | x | . | x | . | . | . | . | x | . | . | | | |
| *Silene acaulis* (L.) Jacq. ssp. *cenisia* (Vierh.) P. Fourn. | x | . | . | . | . | . | . | . | . | . | | | |
| *Silene rupestris* L. | x | . | x | x | x | . | x | . | . | | | | |
| *Silene alba* (Miller) E.H.L. Krause | x | x | . | . | . | . | . | . | . | . | . | | |
| *Silene dioica* (L.) Clairv. | x | x | . | . | . | . | . | . | . | . | . | | |
| *Gypsophyla repens* L. | . | . | . | . | . | . | . | . | x | . | . | | |
| *Saponaria officinalis* L. | x | . | . | . | . | . | . | . | . | . | . | | |
| *Dianthus seguieri* Vill. | . | . | . | . | x | . | . | . | . | . | . | | |
| *Dianthus sylvestris* Wulfen | . | x | . | . | . | . | . | . | . | . | . | | |
| *Dianthus carthusianorum* L. | . | . | x | . | . | . | . | . | . | . | . | | x |
| **Ranunculaceae** | | | | | | | | | | | | | |
| *Trollius europaeus* L. | . | . | . | . | . | . | . | . | . | . | . | x | |
| *Pulsatilla alpina* (L.) Delarbre ssp. *apiifolia* (Scop.) Nyman | . | . | . | . | . | x | x | . | . | . | | | |
| *Pulsatilla alpina* (L.) Delarbre | x | . | . | x | . | . | . | . | . | . | | | |
| *Pulsatilla vernalis* (L.) Miller | . | . | . | . | x | . | . | . | . | . | | | |
| *Pulsatilla halleri* (All.) Willd. | . | . | . | . | x | . | x | . | . | . | . | | |
| *Clematis vitalba* L. | x | x | . | . | . | . | . | . | . | . | | | |
| *Ranunculus repens* L. | x | . | . | . | . | . | . | . | . | . | | | |
| *Ranunculus acris* L. | x | x | x | x | . | . | . | . | x | . | x | x | |
| *Ranunculus montanus* Willd. | . | . | x | . | . | x | x | . | x | | | | |
| *Ranunculus bulbosus* L. | x | x | . | x | . | . | . | . | . | . | | | |
| *Ranunculus alpestris* L. | . | . | . | . | . | . | x | . | | | | | |
| *Ranunculus glacialis* L. | x | . | . | . | . | . | . | x | . | . | | | |
| *Ranunculus pyrenaeus* L. | . | . | . | . | . | . | . | x | . | . | | | |
| *Thalictrum foetidum* L. | . | x | . | . | . | . | . | . | . | . | | | |
| **Berberidaceae** | | | | | | | | | | | | | |
| *Berberis vulgaris* L. | . | x | x | . | x | . | . | . | . | . | x | | x |
| **Papaveraceae** | | | | | | | | | | | | | |
| *Chelidonium majus* L. | x | . | . | . | . | . | . | . | . | . | . | | |
| **Cruciferae** | | | | | | | | | | | | | |
| *Arabidopsis thaliana* (L.) Heynh. | . | . | . | . | . | . | . | . | x | . | | | |
| *Rorippa sylvestris* (L.) Besser | . | . | x | . | . | . | . | . | . | . | | | |
| *Rorippa palustris* (L.) Besser | x | . | x | . | . | . | . | . | . | | | | |
| *Arabis hirsuta* (L.) Scop. | . | x | . | . | . | . | . | . | x | | | | |
| *Arabis allionii* DC. | x | . | x | . | . | . | . | . | x | . | . | | |
| *Arabis alpina* L. | . | . | . | . | . | x | . | . | x | . | . | | |
| *Alyssum alyssoides* (L.) L. | . | . | . | . | x | . | . | . | . | | | | |

| | roads | | ski runs | | path | shelters | | | | camping ground | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Orco | Valsa. | Cogne | Rhem. | Laus | Savoia | Sella | Eman. | Benev. | Ceres. | Lillaz | Rhem. | Pont |
| Species | | | | | | | | | | | | | |
| *Alyssum montanum* L. | . | . | . | . | x | . | . | . | . | . | . | . | . |
| *Alyssum alpestre* L. | . | . | . | . | . | . | x | . | . | . | . | . | . |
| *Draba fladnizensis* Wulfen | . | . | . | x | . | . | . | . | . | . | . | . | . |
| *Capsella bursa-pastoris* (L.) Medicus | x | . | x | x | . | . | . | . | x | . | x | x | . |
| *Hutchinsia alpina* (L.) R.Br. | . | . | x | . | . | . | . | x | . | . | . | . | . |
| *Thlaspi rotundifolium* (L.) Gaudin | . | . | x | . | . | . | . | x | . | . | . | . | . |
| *Biscutella laevigata* L. | x | x | x | . | x | . | . | . | . | x | x | x | . |
| *Lepidium virginicum* L. | x | . | . | . | . | . | . | . | . | . | . | . | . |
| *Diplotaxis tenuifolia* (L.) DC. | . | x | . | . | . | . | . | . | . | . | . | . | . |
| **Crassulaceae** | | | | | | | | | | | | | |
| *Sempervivum arachnoideum* L. | x | . | . | . | x | . | x | x | . | . | . | . | . |
| *Sempervivum montanum* L. | . | . | x | . | x | . | . | . | . | . | . | . | . |
| *Sempervivum tectorum* L. | . | x | . | . | x | . | . | . | x | . | . | . | . |
| *Sedum anacampseros* L. | x | . | . | . | . | . | . | . | . | . | . | . | . |
| *Sedum ochroleucum* Chaix ssp. *montanum* (Sang. et Perr.) D.A. Webb | . | . | x | . | . | . | . | . | . | . | . | . | . |
| *Sedum sexangulare* L. | x | . | . | . | . | . | . | . | . | . | . | . | . |
| *Sedum album* L. | . | . | . | . | . | . | . | . | . | . | x | . | . |
| *Sedum dasyphyllum* L. | x | . | . | . | . | . | . | . | . | . | . | . | . |
| *Sedum hirsutum* All. | . | . | . | . | . | . | x | . | . | . | . | . | . |
| *Sedum annuum* L. | x | . | x | . | x | . | . | x | . | . | . | . | . |
| *Rhodiola rosea* L. | . | . | . | x | . | . | . | . | . | . | . | . | . |
| **Saxifragaceae** | | | | | | | | | | | | | |
| *Saxifraga cuneifolia* L. | . | . | x | . | . | . | . | . | . | . | . | . | . |
| *Saxifraga bryoides* L. | . | . | x | . | . | . | . | x | . | . | . | . | . |
| *Saxifraga exarata* Vill. | x | . | x | . | . | . | . | x | . | . | . | . | . |
| *Saxifraga oppositifolia* L. | x | . | . | . | . | . | . | . | . | . | . | . | . |
| *Saxifraga paniculata* Miller | . | . | x | . | . | . | . | . | . | . | . | . | . |
| **Rosaceae** | | | | | | | | | | | | | |
| *Rubus saxatilis* L. | . | . | . | x | . | . | . | . | . | . | . | . | . |
| *Rubus idaeus* L. | x | x | x | x | x | . | . | x | . | x | x | x | . |
| *Rubus caesius* L. | . | x | . | . | . | . | . | . | . | . | . | . | . |
| *Rosa pendulina* L. | x | . | . | x | . | . | . | . | . | . | . | . | . |
| *Rosa canina* gr. | . | . | . | x | . | . | . | . | . | x | x | . | . |
| *Agrimonia eupatoria* L. | x | . | . | . | . | . | . | . | . | . | . | . | . |
| *Sanguisorba minor* Scop. | . | x | . | . | x | . | . | . | x | . | . | . | . |
| *Geum reptans* L. | x | . | . | . | . | . | . | x | . | . | . | . | . |
| *Geum montanum* L. | . | . | . | . | . | . | x | x | . | . | . | x | . |
| *Potentilla argentea* L. | x | x | x | x | x | . | . | . | . | . | . | . | . |
| *Potentilla grandiflora* L. | x | x | . | x | x | . | . | . | . | . | x | . | . |
| *Potentilla crantzii* (Crantz.) G. Beck | . | . | x | . | . | . | . | . | x | . | . | . | . |
| *Potentilla aurea* L. | x | . | . | . | x | . | . | . | . | . | . | x | x |
| *Potentilla reptans* L. | x | x | . | . | . | . | . | . | . | . | . | . | . |
| *Sibbaldia procumbens* L. | x | x | . | . | . | x | x | x | . | x | . | . | . |
| *Fragaria vesca* L. | x | x | x | x | x | . | . | . | . | . | . | . | . |
| *Alchemilla pentaphyllea* L. | . | . | . | . | . | x | x | . | x | . | x | . | . |
| *Alchemilla alpina* L. | . | x | . | . | . | . | x | . | x | x | x | . | x |
| *Alchemilla xanthochlora* Rothm. | x | x | x | x | x | . | . | . | . | . | x | x | x |
| *Sorbus aucuparia* L. | . | x | . | x | . | . | . | . | . | . | x | . | . |
| *Sorbus aria* (L.) Crantz | . | x | . | . | . | . | . | . | . | . | . | . | . |
| *Cotoneaster integerrimus* Medicus | . | . | x | x | x | . | . | . | . | . | . | . | . |
| *Prunus dulcis* (Miller) D.A.Webb | . | x | . | . | . | . | . | . | . | . | . | . | . |
| *Prunus spinosa* L. | . | x | . | . | . | . | . | . | . | . | . | . | . |
| *Prunus mahaleb* L. | . | x | . | . | . | . | . | . | . | . | . | . | . |
| **Leguminosae** | | | | | | | | | | | | | |
| *Laburnum anagyroides* Medicus | x | . | . | . | . | . | . | . | . | . | . | . | . |
| *Robinia pseudacacia* L. | x | x | . | . | . | . | . | . | . | . | . | . | . |
| *Astragalus penduliflorus* Lam. | . | x | . | . | x | . | . | . | . | . | . | . | . |
| *Astragalus glycyphyllos* L. | x | . | . | . | . | . | . | . | . | . | . | . | . |
| *Oxytropis campestris* (L.) DC. | x | . | . | . | x | . | . | . | . | . | . | x | . |
| *Vicia cracca* L. | x | x | . | x | . | . | . | . | . | x | x | x | . |
| *Vicia sepium* L. | . | x | . | x | . | . | . | . | . | . | . | . | . |
| *Lathyrus vernus* (L.) Bernh. | x | . | . | . | . | . | . | . | . | . | . | . | . |

| | roads | | ski runs | | path | | | shelters | | | camping ground | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Orco | Valsa. | Cogne | Rhem. | Laus | Savoia | Sella | Eman. | Benev. | Ceres. | Lillaz | Rhem. | Pont |
| Species | | | | | | | | | | | | | |
| *Lathyrus pratensis* L. | . | x | x | . | . | . | . | . | . | . | . | x | . |
| *Melilotus officinalis* L. | . | x | . | . | . | . | . | . | . | . | . | . | . |
| *Melilotus alba* Medicus | x | . | . | . | . | . | . | . | . | . | . | . | . |
| *Medicago lupulina* L. | x | x | . | . | . | . | . | . | . | . | . | . | . |
| *Medicago sativa* L. | x | x | . | x | . | . | . | . | . | . | . | . | . |
| *Trifolium alpinum* L. | x | . | . | . | . | x | . | x | . | . | . | . | . |
| *Trifolium montanum* L. | . | . | . | . | x | . | . | . | . | . | . | . | . |
| *Trifolium repens* L. | x | x | x | x | x | . | x | . | x | x | x | x | . |
| *Trifolium pallescens* Schreber | x | . | . | x | x | . | . | . | . | x | . | . | . |
| *Trifolium thalii* Vill. | x | . | x | x | . | x | x | x | x | x | x | x | x |
| *Trifolium badium* Schreber | x | . | x | . | x | . | x | . | x | . | x | . | x |
| *Trifolium arvense* L. | x | . | . | . | . | . | . | . | . | . | . | . | . |
| *Trifolium pratense* L. var. *frigidum* Gaudin | x | . | . | . | x | x | . | . | x | x | . | . | . |
| *Trifolium pratense* L. | x | x | x | x | . | . | . | . | . | x | x | x | . |
| *Lotus corniculatus* L. | x | x | x | x | x | . | . | . | . | . | x | x | . |
| *Lotus alpinus* (DC.) Schleicher | x | x | x | x | x | . | . | x | . | . | x | x | x |
| *Anthyllis vulneraria* L. | . | x | x | . | x | x | x | . | x | x | . | x | x |
| *Hippocrepis comosa* L. | . | . | . | x | . | . | . | . | . | . | . | . | . |
| *Onobrychis viciifolia* Scop. | . | x | . | . | . | . | . | . | x | . | . | x | . |
| **Oxalidaceae** | | | | | | | | | | | | | |
| *Oxalis acetosella* L. | x | . | . | x | . | . | . | . | . | . | . | . | . |
| **Geraniaceae** | | | | | | | | | | | | | |
| *Geranium sanguineum* L. | . | x | . | . | . | . | . | . | . | . | . | . | . |
| *Geranium sylvaticum* L. | x | x | . | x | . | . | . | . | x | . | x | x | x |
| *Geranium pusillum* L. | x | . | . | . | . | . | . | . | . | . | . | . | . |
| *Geranium robertianum* L. | x | . | . | . | . | . | . | . | . | . | . | . | . |
| **Euphorbiaceae** | | | | | | | | | | | | | |
| *Euphorbia dulcis* L. | . | x | . | . | . | . | . | . | . | . | . | . | . |
| *Euphorbia cyparissias* L. | . | x | x | x | x | . | . | . | x | . | x | . | x |
| **Polygalaceae** | | | | | | | | | | | | | |
| *Polygala alpestris* Rchb. | . | . | . | . | . | . | x | . | . | . | . | . | . |
| **Aceraceae** | | | | | | | | | | | | | |
| *Acer pseudoplatanus* L. | . | x | x | . | . | . | . | . | . | . | . | x | . |
| **Balsaminaceae** | | | | | | | | | | | | | |
| *Impatiens glandulifera* Royle | . | x | . | . | . | . | . | . | . | . | . | . | . |
| **Rhamnaceae** | | | | | | | | | | | | | |
| *Rhamnus catharticus* L. | . | x | . | . | . | . | . | . | . | . | . | . | . |
| **Thymelaceae** | | | | | | | | | | | | | |
| *Daphne mezereum* L. | . | . | . | x | . | . | . | . | . | . | . | . | x |
| **Guttiferae** | | | | | | | | | | | | | |
| *Hypericum perforatum* L. | x | . | . | . | . | . | . | . | . | . | . | . | . |
| **Violaceae** | | | | | | | | | | | | | |
| *Viola hirta* L. | . | . | . | x | x | . | . | . | . | . | . | . | . |
| *Viola reichenbachiana* Jordan | . | . | . | x | . | . | . | . | . | . | . | . | . |
| *Viola canina* L. | . | . | . | x | . | . | . | . | . | . | . | . | . |
| *Viola calcarata* L. | . | x | . | . | . | . | . | . | . | . | . | . | . |
| *Viola arvensis* Murray | . | x | . | . | . | . | . | . | . | . | . | . | . |
| **Cistaceae** | | | | | | | | | | | | | |
| *Helianthemum nummularium* (L.) Miller | x | x | . | . | x | . | . | . | x | . | . | . | . |
| **Onagraceae** | | | | | | | | | | | | | |
| *Oenothera biennis* L. | x | . | . | . | . | . | . | . | . | . | . | . | . |
| *Epilobium angustifolium* L. | x | x | x | x | . | . | . | . | . | . | x | x | x |
| *Epilobium dodonaei* Vill. | x | . | . | x | . | . | . | . | . | . | . | x | . |
| *Epilobium montanum* L. | . | . | x | . | . | . | . | . | . | . | . | . | . |
| **Umbelliferae** | | | | | | | | | | | | | |
| *Chaerophyllum hirsutum* L. | x | x | . | x | . | . | . | . | . | . | x | x | x |
| *Chaerophyllum villarsii* Koch | . | x | . | . | . | . | . | . | . | x | . | . | . |
| *Anthriscus sylvestris* (L.) Hoffm. | x | . | . | . | . | . | . | . | . | . | . | . | . |
| *Pimpinella major* (L.) Hudson | x | x | . | . | . | . | . | . | . | . | . | . | . |
| *Pimpinella saxifraga* L. | . | . | . | . | x | . | . | . | . | . | x | . | . |
| *Aegopodium podagraria* L. | . | . | . | . | . | x | . | . | . | . | . | . | . |
| *Bupleurum stellatum* L. | . | x | . | . | . | . | . | . | . | . | . | . | . |
| *Bupleurum ranunculoides* L. | . | . | . | . | x | . | x | . | . | . | . | . | . |

| | roads | | ski runs | | path | shelters | | | | camping ground | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Orco | Valsa. | Cogne | Rhem. | Laus | Savoia | Sella | Eman. | Benev. | Ceres. | Lillaz | Rhem. | Pont |
| Species | | | | | | | | | | | | | |
| *Carum carvi* L. | . | . | x | . | . | x | . | . | . | . | . | . | . |
| *Ligusticum mutellina* (L.) Crantz | x | x | . | . | . | x | . | x | . | . | x | x | x |
| *Peucedanum cervaria* (L.) Lapeyr. | x | . | . | . | x | . | . | . | . | . | . | . | . |
| *Peucedanum ostruthium* (L.) Koch | . | . | . | x | . | . | . | x | . | . | . | . | . |
| *Heracleum sphondylium* L. | x | x | . | x | . | . | . | . | . | x | x | x | . |
| *Laserpitium latifolium* L. | . | . | . | x | . | . | . | . | . | . | . | . | x |
| *Laserpitium halleri* Crantz | x | x | . | x | x | . | . | . | . | . | . | . | x |
| *Daucus carota* L. | x | x | . | . | . | . | . | . | . | x | x | x | x |
| **Pyrolaceae** | | | | | | | | | | | | | |
| *Pyrola minor* L. | . | . | x | . | . | . | . | . | . | . | . | . | . |
| **Ericaceae** | | | | | | | | | | | | | |
| *Rhododendron ferrugineum* L. | x | . | x | x | x | . | . | . | . | x | . | x | x |
| *Loiseleuria procumbens* (L.) Desv. | x | . | . | . | . | . | . | . | . | . | . | . | . |
| *Arctostaphilos uva-ursi* (L.) Sprengel | x | x | . | x | . | . | . | . | . | . | . | . | x |
| *Vaccinium vitis-idaea* L. | . | . | x | x | . | . | . | . | . | . | . | . | . |
| *Vaccinium uliginosum* L. | x | . | x | . | . | x | . | x | . | . | . | . | . |
| *Vaccinium myrtillus* L. | . | x | x | x | x | . | . | . | . | . | x | x | x |
| **Empetraceae** | | | | | | | | | | | | | |
| *Empetrum nigrum* L. | . | . | x | . | . | . | . | . | . | . | . | . | . |
| **Primulaceae** | | | | | | | | | | | | | |
| *Primula veris* L. | . | x | . | . | . | . | . | . | . | . | . | . | . |
| *Androsace obtusifolia* All. | . | . | x | . | . | . | . | . | . | . | . | . | . |
| *Soldanella alpina* L. | x | . | . | . | . | . | . | . | . | . | . | . | . |
| **Plumbaginaceae** | | | | | | | | | | | | | |
| *Armeria maritima* (Miller) Willd. ssp. *alpina* (Willd.) P. Silva | . | . | . | . | x | . | . | . | . | . | . | . | . |
| *Armeria alliacea* (Cav.) Hoffmanns. | x | . | . | x | . | . | . | . | . | . | . | . | . |
| **Oleaceae** | | | | | | | | | | | | | |
| *Fraxinus excelsior* L. | x | x | . | . | . | . | . | . | . | . | . | . | . |
| **Gentianaceae** | | | | | | | | | | | | | |
| *Gentiana punctata* L. | . | . | . | x | . | . | . | . | . | . | . | . | . |
| *Gentiana verna* L. | x | x | . | . | x | . | x | . | x | . | . | . | . |
| *Gentiana brachyphylla* Vill. | x | . | . | . | . | . | . | . | . | x | . | . | . |
| *Gentiana nivalis* L. | . | . | . | . | x | . | . | . | x | . | . | . | . |
| *Gentianella campestris* (L.) Borner | x | . | . | . | . | . | . | . | . | . | . | . | . |
| *Gentianella amarella* (L.) Borner | . | . | . | . | x | x | . | . | . | . | . | . | . |
| **Asclepiadaceae** | | | | | | | | | | | | | |
| *Vincetoxicum hirundinaria* Medicus | . | x | . | . | . | . | . | . | . | . | . | . | . |
| **Rubiaceae** | | | | | | | | | | | | | |
| *Asperula cynanchica* L. | x | . | . | . | . | . | . | . | . | . | . | . | . |
| *Galium verum* L. | . | . | x | . | . | . | . | . | . | . | . | . | . |
| *Galium mollugo* L. | x | x | . | x | x | . | . | . | . | x | x | x | . |
| *Galium album* Miller | . | . | x | x | x | . | . | . | . | . | . | . | . |
| *Galium lucidum* All. | x | x | . | . | x | . | . | . | . | . | . | . | . |
| *Galium anisophyllon* Vill. | . | . | x | . | . | . | . | . | . | . | . | . | . |
| *Galium pusillum* L. | . | . | x | . | x | . | x | . | . | . | . | . | . |
| *Galium aparine* L. | . | . | . | x | . | . | . | . | . | . | . | . | . |
| **Convolvulaceae** | | | | | | | | | | | | | |
| *Convolvulus arvensis* L. | x | x | . | . | . | . | . | . | . | . | . | . | . |
| **Boraginaceae** | | | | | | | | | | | | | |
| *Echium vulgare* L. | x | . | . | . | . | . | . | . | . | . | . | . | . |
| *Myosotis alpestris* F.W.Schmidt | x | . | . | x | . | . | x | x | . | x | . | . | . |
| **Verbenaceae** | | | | | | | | | | | | | |
| *Verbena officinalis* L. | . | x | . | . | . | . | . | . | . | . | . | . | . |
| **Labiatae** | | | | | | | | | | | | | |
| *Ajuga pyramidalis* L. | . | . | . | x | . | . | . | . | . | . | . | . | . |
| *Teucrium chamaedrys* L. | x | x | . | . | x | . | . | . | . | . | x | . | . |
| *Scutellaria alpina* L. | x | x | . | x | . | . | . | . | . | . | . | . | . |
| *Galeopsis tetrahit* L. | x | x | . | x | x | . | . | . | . | . | . | . | . |
| *Lamium purpureum* L. | x | x | . | . | . | . | . | . | . | . | . | . | . |
| *Stachys recta* L. | . | x | . | . | x | . | . | . | . | . | . | . | . |
| *Prunella vulgaris* L. | x | . | . | . | . | . | . | . | . | . | . | . | . |
| *Satureja montana* L. | . | . | . | . | x | . | . | . | . | . | . | . | . |

| | roads | | ski runs | | path | | shelters | | camping ground | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Orco | Valsa. | Cogne | Rhem. | Laus | Savoia | Sella | Eman. | Benev. | Ceres. | Lillaz | Rhem. | Pont |
| Species | | | | | | | | | | | | | |
| *Acinos alpinus* (L.) Moench | . | x | . | . | x | . | . | . | . | x | . | | x |
| *Calamintha nepeta* (L.) Savi ssp. *glandulosa* (Req.) P. W. Ball | x | . | . | . | . | . | . | . | . | . | . | . | . |
| *Thymus pulegioides* L. | x | . | x | . | x | . | . | . | x | . | x | x | . |
| *Thymus alpestris* Tausch | . | . | x | x | . | . | . | . | . | . | . | . | . |
| *Thymus serpyllum* L. | x | x | . | x | . | . | . | . | . | . | . | . | . |
| *Mentha longifolia* (L.) Hudson | x | . | . | . | . | . | . | . | . | . | . | . | . |
| *Salvia glutinosa* L. | x | . | . | . | . | . | . | . | . | . | . | . | . |
| *Salvia pratensis* L. | x | x | . | . | . | . | . | . | . | . | . | . | . |
| **Solanaceae** | | | | | | | | | | | | | |
| *Solanum nigrum* L. | . | x | . | . | . | . | . | . | . | . | . | . | . |
| *Solanum dulcamara* L. | x | . | . | . | . | . | . | . | . | . | . | . | . |
| **Scrophulariaceae** | | | | | | | | | | | | | |
| *Verbascum phlomoides* L. | . | . | . | . | x | . | . | . | . | . | . | x | . |
| *Verbascum thapsus* L. | x | . | . | x | . | . | . | . | . | . | . | . | . |
| *Scrophularia canina* L. | x | . | . | . | . | . | . | . | . | . | . | . | . |
| *Chaenorrhinum minus* (L.) Lange | . | x | . | . | . | . | . | . | . | . | . | . | . |
| *Linaria vulgaris* Miller | . | x | . | . | . | . | . | . | . | . | x | . | . |
| *Linaria alpina* (L.) Miller | x | . | . | . | . | . | . | x | . | . | . | . | . |
| *Veronica serpyllifolia* L. | . | . | . | . | . | x | . | . | . | . | . | . | . |
| *Veronica alpina* L. | . | . | . | . | . | . | x | . | . | . | . | . | . |
| *Veronica fruticans* Jacq. | . | . | x | x | x | x | . | x | x | . | . | . | . |
| *Veronica fruticulosa* L. | . | . | . | . | x | . | . | . | . | . | . | . | . |
| *Veronica urticifolia* Jacq. | . | . | . | . | x | . | . | . | . | . | . | . | . |
| *Veronica officinalis* L. | . | . | x | x | . | . | . | . | . | . | . | . | . |
| *Veronica chamaedrys* L. | . | . | . | x | . | . | . | . | x | . | . | . | . |
| *Veronica verna* L. | x | . | . | . | . | . | . | . | . | . | . | . | . |
| *Melampyrum sylvaticum* L. | x | . | x | x | . | . | . | . | . | x | . | | x |
| *Euphrasia picta* Wimmer | . | . | . | . | . | . | . | . | . | . | x | . | . |
| *Euphrasia stricta* D. Wolff | x | x | . | . | x | . | . | . | . | . | . | . | . |
| *Euphrasia alpina* Lam. | x | x | x | . | . | x | . | . | . | . | . | . | . |
| *Euphrasia salisburgensis* Funck | . | x | . | . | . | . | . | . | . | . | . | . | . |
| *Bartsia alpina* L. | x | . | . | . | . | . | . | . | . | . | . | . | . |
| *Pedicularis verticillata* L. | . | . | x | . | . | . | . | . | . | . | . | . | . |
| *Pedicularis tuberosa* L. | x | . | . | . | . | . | . | . | . | . | . | . | . |
| *Pedicularis kerneri* Dalla Torre | . | . | . | . | . | . | x | x | . | . | . | . | . |
| *Rhinanthus minor* L. | x | . | . | . | . | . | . | . | . | . | . | . | . |
| **Plantaginaceae** | | | | | | | | | | | | | |
| *Plantago major* L. | x | x | x | x | . | x | . | . | x | x | x | x | x |
| *Plantago maritima* L. ssp. *serpentina* (All.) Arcangeli | x | x | x | . | x | x | . | . | x | . | x | | |
| *Plantago alpina* L. | . | . | . | . | x | . | x | . | . | . | . | . | x |
| *Plantago media* L. | x | x | x | x | . | . | . | . | . | . | x | x | x |
| *Plantago atrata* Hoppe | x | . | . | . | . | . | . | . | . | . | . | . | . |
| *Plantago lanceolata* L. | x | x | . | . | . | . | . | . | . | . | . | . | . |
| **Caprifoliaceae** | | | | | | | | | | | | | |
| *Sambucus racemosa* L. | x | . | . | x | . | . | . | . | . | . | . | x | . |
| *Viburnum lantana* L. | . | x | . | . | . | . | . | . | . | . | . | . | . |
| *Valeriana tripteris* L. | . | . | . | x | . | . | . | . | . | . | . | . | . |
| *Lonicera caerulea* L. | . | . | . | x | x | . | . | . | . | . | x | . | . |
| *Lonicera nigra* L. | . | x | . | . | . | . | . | . | . | . | . | . | . |
| **Valerianaceae** | | | | | | | | | | | | | |
| *Valeriana celtica* L. | . | x | . | . | . | . | . | . | . | . | . | . | . |
| **Dipsacaceae** | | | | | | | | | | | | | |
| *Knautia arvensis* (L.) Coulter | . | x | . | . | . | . | . | . | . | . | . | . | . |
| *Scabiosa columbaria* L. | x | . | . | . | x | . | . | . | . | . | . | . | . |
| **Campanulaceae** | | | | | | | | | | | | | |
| *Campanula barbata* L. | . | . | . | x | x | . | . | . | . | . | . | . | x |
| *Campanula glomerata* L. | . | x | . | . | . | . | . | . | . | . | . | . | . |
| *Campanula thyrsoides* L. | . | . | . | . | x | . | . | . | . | . | . | . | . |
| *Campanula rapunculoides* L. | . | x | . | x | . | . | . | . | . | . | . | . | . |
| *Campanula rhomboidalis* L. | x | x | . | x | . | . | . | . | . | . | x | x | . |
| *Campanula stenocodon* Boiss. et Reuter | . | x | . | . | . | . | . | . | . | . | . | . | . |
| *Campanula scheuchzeri* Vill. | x | x | x | x | x | x | . | . | . | x | x | x | . |

| | roads | | ski runs | | path | shelters | | | | camping ground | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Orco | Valsa. | Cogne | Rhem. | Laus | Savoia | Sella | Eman. | Benev. | Ceres. | Lillaz | Rhem. | Pont |
| Species | | | | | | | | | | | | | |
| *Phyteuma ovatum* Honckeny | . | . | . | x | . | . | . | . | . | . | . | . | . |
| *Phyteuma michelii* All. | . | . | . | x | . | . | . | . | . | . | x | . | . |
| *Phyteuma scorzonerifolium* Vill. | . | . | . | . | x | . | . | . | . | . | . | . | . |
| *Phyteuma betonicifolium* Vill. | x | x | . | x | x | . | . | . | . | . | . | . | . |
| *Phyteuma hemisphaericum* L. | x | . | . | . | . | x | . | x | . | x | . | . | . |
| *Jasione montana* L. | . | . | . | . | x | . | . | . | . | . | . | . | . |
| **Compositae** | | | | | | | | | | | | | |
| *Eupatorium cannabinum* L. | . | x | . | . | . | . | . | . | . | . | . | . | . |
| *Solidago virgaurea* L. | x | x | x | x | . | . | . | x | . | . | . | . | . |
| *Solidago gigantea* Aiton ssp. *serotina* (O. Kuntze) Mc Neill | x | . | . | . | . | . | . | . | . | . | . | . | . |
| *Aster alpinus* L. | . | . | . | . | . | . | . | . | x | . | . | . | x |
| *Erigeron annuus* (L.) Pers. | x | . | . | . | . | . | . | . | . | . | . | . | . |
| *Erigeron acer* L. | x | . | . | x | x | . | . | . | . | . | . | . | . |
| *Erigeron alpinus* L. | x | . | x | x | x | . | . | x | x | . | . | . | . |
| *Conyza canadensis* (L.) Cronq. | x | x | . | . | . | . | . | . | . | . | . | . | . |
| *Omalotheca sylvatica* (L.) Schultz Bip. | . | . | x | . | . | . | . | . | . | . | . | . | . |
| *Omalotheca supina* (L.) DC. | . | . | x | . | . | x | . | . | . | . | . | . | . |
| *Gnaphalium luteo-album* L. | . | . | . | x | . | . | . | . | . | . | . | . | . |
| *Antennaria dioica* (L.) Gaertner | . | . | x | . | . | . | . | . | . | . | . | . | . |
| *Bidens tripartita* L. | x | . | . | . | . | . | . | . | . | . | . | . | . |
| *Galinsoga parviflora* Cav. | x | x | . | . | . | . | . | . | . | . | . | . | . |
| *Achillea erba-rotta* All. | x | . | x | x | x | . | . | x | . | . | . | . | . |
| *Achillea millefolium* L. | x | x | x | x | x | . | x | x | x | . | . | . | . |
| *Matricaria perforata* Merat | . | . | x | x | . | . | . | . | . | . | . | x | . |
| *Chamomilla suaveolens* (Pursh) Rydb. | x | . | x | x | . | . | . | . | . | . | x | x | . |
| *Tanacetum vulgare* L. | x | . | . | . | . | . | . | . | . | . | . | . | . |
| *Leucanthemopsis alpina* (L.) Heywood | . | . | . | . | . | . | . | x | . | . | . | . | . |
| *Leucanthemum adustum* (Koch) Gremli | x | . | x | x | x | x | . | . | . | . | . | x | . |
| *Leucanthemum vulgare* Lam. | x | x | . | x | . | . | . | . | . | . | x | x | . |
| *Artemisia vulgaris* L. | x | x | . | . | . | . | . | . | . | . | . | x | . |
| *Artemisia absinthium* L. | . | x | x | x | x | . | . | . | . | x | . | x | . |
| *Artemisia umbelliformis* lam. | . | . | x | . | . | . | . | . | . | . | . | . | . |
| *Artemisia glacialis* L. | . | . | . | . | x | . | . | . | . | . | . | . | . |
| *Artemisia campestris* L. | x | . | . | . | . | . | . | . | . | . | . | . | . |
| *Tussilago farfara* L. | x | x | x | x | . | . | . | . | . | . | x | x | . |
| *Petasites albus* (L.) Gaertner | x | x | . | . | . | . | . | . | . | . | . | . | . |
| *Homogyne alpina* (L.) Cass. | . | . | x | x | . | . | . | . | . | . | . | . | . |
| *Adenostyles alpina* (L.) Bluff et Fingert. | . | . | . | . | . | . | . | x | . | . | . | . | . |
| *Doronicum grandiflorum* Lam. | . | x | . | . | . | . | . | . | . | . | . | . | . |
| *Senecio halleri* Dandy | . | . | . | . | . | . | . | x | . | . | . | . | . |
| *Senecio doronicum* L. | . | . | . | x | x | . | . | x | x | x | . | . | . |
| *Senecio jacobaea* L. | . | . | x | . | . | . | . | . | . | . | . | . | . |
| *Senecio viscosus* L. | . | . | x | . | . | . | . | . | . | . | . | . | . |
| *Calendula officinalis* L. | x | . | . | . | . | . | . | . | . | . | . | . | . |
| *Carlina vulgaris* L. | x | . | . | . | . | . | . | . | . | . | . | . | . |
| *Carlina acaulis* L. | x | x | . | x | x | . | . | . | . | x | x | x | . |
| *Arctium lappa* L. | x | x | . | . | . | . | . | . | . | . | . | . | . |
| *Cardus nutans* L. | x | . | x | x | x | x | . | . | x | . | x | . | . |
| *Carduus defloratus* L. | . | x | . | . | . | . | . | . | . | . | . | . | . |
| *Cirsium spinosissimum* (L.) Scop. | . | . | . | . | . | x | . | . | . | . | . | . | . |
| *Cirsium arvense* (L.) Scop. | x | . | x | . | . | . | . | . | . | x | . | . | . |
| *Centaurea jacea* L. | x | x | . | . | . | . | . | . | . | x | x | . | . |
| *Centaurea uniflora* Turra ssp. *nervosa* (Willd.) Bonnier et Hayens | x | . | . | x | x | . | . | . | . | . | x | x | x |
| *Centaurea montana* L. | x | . | . | . | . | . | . | . | . | . | . | . | . |
| *Tolpis staticifolia* (All.) Schultz Bip. | . | . | x | . | . | . | . | . | . | . | . | . | . |
| *Leondodon pyrenaicus* Gouan ssp. *helveticus* (Merat) Finch et P. D.Sell | . | . | x | . | . | . | . | . | . | . | . | . | . |
| *Leontodon autumnalis* L. | . | . | x | . | . | . | . | . | . | . | x | x | . |
| *Leontodon hispidus* L. | x | x | x | x | . | . | . | . | x | . | . | x | . |
| *Tragopogon pratensis* L. | x | x | . | . | . | . | . | . | . | x | . | x | . |
| *Sonchus asper* (L.) Hill | x | . | . | . | . | . | . | . | . | . | . | . | . |

| Species | roads | | ski runs | | path | shelters | | | | camping ground | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Orco | Valsa. | Cogne | Rhem. | Laus | Savoia | Sella | Eman. | Benev. | Ceres. | Lillaz | Rhem. | Pont |
| *Lactuca serriola* L. | . | x | . | . | . | . | . | . | . | . | . | . | . |
| *Lactuca perennis* L. | . | . | . | . | x | . | . | . | . | . | . | . | . |
| *Prenanthes purpurea* L. | . | . | . | x | . | . | . | . | . | . | . | . | . |
| *Taraxacum hoppeanum* gr. | . | . | x | . | x | x | x | x | x | | | | x |
| *Taraxacum officinale* gr. | x | x | x | x | x | x | . | x | x | x | x | x | x |
| *Crepis aurea* (L.) Cass. | x | . | . | . | . | . | . | . | . | . | . | . | . |
| *Crepis setosa* Haller fil. | x | . | . | . | . | . | . | . | . | . | . | . | . |
| *Hieracium tardans* Peter | . | . | . | . | x | . | . | . | . | . | . | . | . |
| *Hieracium pilosella* L. | x | x | . | x | x | . | x | . | . | x | . | x | . |
| *Hieracium glaciale* Reyn. | . | . | . | . | . | . | . | . | . | . | x | . | . |
| *Hieracium piloselloides* Vill. | . | . | x | . | . | . | . | . | x | . | . | . | x |
| *Hieracium murorum* gr. | . | . | x | x | x | . | . | . | . | . | x | . | x |
| *Hieracium piliferum* Hoppe | . | . | . | . | . | . | . | x | . | . | . | . | . |
| *Hieracium glanduliferum* Hoppe | x | . | . | . | . | . | . | . | . | . | . | . | . |
| **Liliaceae** | | | | | | | | | | | | | |
| *Veratrum album* L. | . | . | . | x | . | . | . | . | . | . | . | . | . |
| *Colchicum alpinum* DC. | . | . | . | . | . | . | x | . | . | . | . | . | . |
| *Colchicum autumnale* L. | . | x | . | x | . | . | . | . | . | . | . | x | . |
| *Lilium martagon* L. | . | . | . | x | . | . | . | . | . | . | . | . | . |
| *Maianthemum bifolium* (L.) F.W.Schmidt | . | . | . | x | . | . | . | . | . | . | . | . | . |
| **Juncaceae** | | | | | | | | | | | | | |
| *Juncus trifidus* L. | x | . | . | . | . | . | . | . | . | . | . | . | . |
| *Juncus compressus* Jacq. | . | . | . | x | . | . | . | . | . | . | . | . | x |
| *Juncus bufonius* L. | . | . | . | . | . | . | . | x | . | . | . | . | . |
| *Luzula campestris* (L.) DC. | x | . | x | . | x | . | . | . | . | . | . | . | . |
| *Luzula multiflora* (Retz.) Lej. | . | . | . | x | . | . | . | . | . | . | . | . | . |
| *Luzula sudetica* (Willd.) DC. | . | . | . | x | . | . | . | . | . | . | . | . | . |
| *Luzula spicata* (L.) DC. | x | . | . | . | x | x | x | . | . | . | . | . | . |
| *Luzula sylvatica* (Hudson) Gaudin | . | . | x | x | x | . | . | . | . | . | . | . | . |
| *Luzula sieberi* Tausch | . | . | x | . | . | . | . | . | . | . | . | . | . |
| *Luzula lutea* (All.) DC. | x | . | . | . | . | . | . | . | x | . | . | . | . |
| *Luzula nivea* (L.) DC. | x | x | x | . | . | . | . | . | . | . | . | . | . |
| *Luzula alpino-pilosa* (Chaix) Breistr. | . | . | . | . | . | . | . | x | . | . | . | . | . |
| **Gramineae** | | | | | | | | | | | | | |
| *Festuca pratensis* Hudson | . | . | x | x | . | . | x | x | . | . | . | x | . |
| *Festuca flavescens* Bellardi | x | x | x | x | x | . | . | . | . | . | . | . | . |
| *Festuca varia* Haenke | x | x | x | . | x | . | . | . | . | . | . | . | . |
| *Festuca haeterophylla* Lam. | x | . | . | . | . | . | . | . | . | . | . | . | . |
| *Festuca violacea* Schleicher | . | . | . | . | x | . | . | x | . | . | . | . | . |
| *Festuca nigrescens* Lam. | . | . | . | . | . | . | . | . | . | . | . | . | x |
| *Festuca rubra* L. | x | x | x | x | x | . | . | . | . | . | x | . | . |
| *Festuca halleri* All. | x | . | x | . | x | x | x | x | . | x | . | . | . |
| *Festuca ovina* L. | x | x | x | . | . | . | . | . | x | . | . | x | . |
| *Festuca cinerea* Vill. | x | . | . | x | . | . | . | . | . | . | . | . | . |
| *Festuca arvensis* Auquier | . | . | x | . | x | . | . | . | . | . | . | . | . |
| *Lolium perenne* L. | x | x | x | x | . | . | . | . | . | . | x | x | . |
| *Poa annua* L. | x | x | x | x | . | x | x | x | x | x | x | x | . |
| *Poa supina* Schroder | x | . | . | . | . | x | x | x | x | x | | | |
| *Poa trivialis* L. | x | x | . | x | . | . | . | . | . | x | x | . | . |
| *Poa pratensis* L. | x | x | x | . | . | . | . | . | . | . | x | x | . |
| *Poa cenisia* All. | . | . | . | . | . | . | . | . | x | . | . | . | . |
| *Poa chaixi* Vill. | . | . | x | . | . | . | . | x | . | . | . | . | . |
| *Poa palustris* L. | . | . | . | . | . | . | . | . | . | . | . | . | . |
| *Poa glauca* Vahl | . | . | x | . | . | . | . | . | . | . | . | . | . |
| *Poa nemoralis* L. | x | . | x | x | x | . | . | . | . | . | . | . | . |
| *Poa alpina* L. ssp. *vivipara* (L.) Arcangeli | x | . | . | . | . | . | . | . | . | . | . | . | . |
| *Poa alpina* L. | x | x | x | x | x | x | x | x | x | x | x | x | x |
| *Bellardiochloa violacea* (Bellardi) Chiov. | . | . | . | x | . | . | . | . | . | . | . | . | . |
| *Dactylis glomerata* L. | x | x | x | x | . | . | . | . | x | . | x | . | x |
| *Briza media* L. | x | x | . | . | x | . | . | . | . | . | . | . | . |
| *Sesleria albicans* Kit. | . | . | . | . | . | . | . | . | x | . | . | . | . |
| *Bromus tectorum* L. | x | . | . | . | . | . | . | . | . | . | . | . | . |
| *Bromus inermis* Leysser | . | x | . | x | . | . | . | . | . | . | . | . | . |

| Species | roads | | ski runs | | path | shelters | | | camping ground | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Orco | Valsa. | Cogne | Rhem. | Laus | Savoia | Sella | Eman. | Benev. | Ceres. | Lillaz | Rhem. | Pont |
| *Bromus erectus* Hudson | . | x | . | . | . | . | . | . | . | . | . | x | . |
| *Bromus arvensis* L. | . | . | . | x | . | . | . | . | . | . | . | | |
| *Bromus hordeaceus* L. | x | . | . | . | . | . | . | . | . | . | . | | |
| *Brachypodium sylvaticum* (Hudson) Beauv. | . | x | . | x | . | . | . | . | . | . | . | | |
| *Brachypodium pinnatum* (L.) Beauv. | x | . | . | . | . | . | . | . | . | . | . | | |
| *Elymus caninus* (L.) L. | x | x | x | x | . | . | . | . | . | . | . | | |
| *Elymus repens* (L.) Gould | x | x | x | x | . | . | . | . | . | . | x | | |
| *Hordeum murinum* L. | x | x | . | . | . | . | . | . | . | . | . | | |
| *Avenula versicolor* (Vill.) Lainz | x | x | . | x | . | . | . | x | . | x | x | x | x |
| *Arrhenatherum elatius* (L.) Beauv. | x | x | . | . | . | . | . | . | . | . | . | | |
| *Koeleria vallesiana* (Honckeny) Gaudin | . | . | . | . | x | . | . | . | . | | | | |
| *Koeleria hirsuta* Gaudin | . | . | . | . | . | . | . | . | x | . | | | |
| *Trisetum distichophyllum* (Vill.) Beauv. | . | . | . | . | x | . | . | . | x | | | | |
| *Trisetum flavescens* (L.) Beauv. | x | x | . | x | . | . | . | . | . | x | x | x | |
| *Deschampsia caespitosa* (L.) Beauv. | x | . | x | x | . | x | . | . | x | x | . | . | |
| *Deschampsia flexuosa* (L.) Trin. | x | . | x | x | x | . | . | x | . | x | x | x | x |
| *Anthoxanthum alpinum* A. e D. Love | . | . | . | . | . | . | x | x | x | x | | | |
| *Anthoxanthum odoratum* L. | x | x | x | x | x | . | . | . | . | x | x | x | x |
| *Holcus mollis* L. | x | . | . | . | . | . | . | . | . | . | | | |
| *Agrostis canina* L. | . | . | . | . | x | . | . | | | | | | |
| *Agrostis rupestris* All. | . | . | x | . | . | x | . | . | . | . | . | | |
| *Agrostis agrostiflora* (G.Beck) Rauschert | x | . | . | . | . | . | . | . | . | . | . | | |
| *Agrostis capillaris* L. | x | x | x | x | x | . | . | . | . | x | x | x | x |
| *Agrostis stolonifera* L. | x | x | . | . | . | . | . | . | . | x | . | | x |
| *Calamagrostis villosa* (Chaix) J.F.Gmelin | . | . | x | x | . | . | . | . | . | . | | x | |
| *Phleum pratense* L. | x | . | x | x | . | . | . | . | x | | x | x | |
| *Phleum alpinum* L. | x | . | . | x | . | x | x | . | x | | | x | x |
| *Phleum hirsutum* Honckeny | . | . | . | . | x | . | . | . | . | . | | | |
| *Alopecurus gerardii* Vill. | x | . | . | . | . | x | . | . | | | | x | |
| *Nardus stricta* L. | x | x | x | . | . | . | . | . | . | x | | | |
| *Eragrostis minor* Host | x | . | . | . | . | . | . | . | . | . | | | |
| *Cynodon dactylon* (L.) Pers. | x | x | . | . | . | . | . | . | . | . | | | |
| *Echinochloa crus-galli* (L.) Beauv. | . | x | . | . | . | . | . | . | . | . | | | |
| *Setaria viridis* (L.) Beauv. | . | x | . | . | . | . | . | . | . | . | . | . | |
| **Cyperaceae** | | | | | | | | | | | | | |
| *Schoenus nigricans* L. | x | . | . | . | . | . | . | . | . | x | | | |
| *Carex foetida* All. | . | . | . | . | . | x | . | . | . | . | | | |
| *Carex echinata* Murray | x | . | . | x | . | . | x | x | . | | | | |
| *Carex frigida* All. | . | . | . | . | . | x | x | . | . | | | | |
| *Carex curvula* All. | x | . | . | . | x | x | . | x | . | x | | | |
| *Carex pallescens* L. | . | . | . | x | . | . | . | . | . | . | . | | |
| *Carex sempervirens* Vill. | x | x | . | x | . | . | . | . | x | . | . | | |
| **Orchidaceae** | | | | | | | | | | | | | |
| *Nigritella nigra* (L.) Reichenb. fil. | . | . | . | . | . | . | x | . | . | . | | | |
| **mosses** | | | | | | | | | | | | | |
| *Dicranum fuscescens* Sm. | . | x | x | x | . | . | . | . | . | x | . | . | |
| *Polytrichum formosum* Hedw. | x | . | . | x | . | . | . | . | . | . | . | . | |
| *Tortula muralis* Hedw. | . | . | x | x | x | . | x | . | . | x | x | | |
| *Rhytidiadelphus triquetrus* (Hedw.) Warnst. | . | . | x | x | . | . | . | . | . | . | . | . | |
| *Pleurozium schreberi* (Brid) Mitt. | . | . | x | . | . | . | . | . | . | . | . | . | |
| *Hylocomium splendens* (Hedw.) Br. Eur. | x | . | . | x | . | . | . | . | . | . | . | . | |
| *Brachythecium reflexum* (Starke) Br. Eur. | . | . | x | . | . | . | . | . | . | . | . | . | |
| *Dicranum scoparium* Hedw. | . | . | . | x | . | . | . | . | . | . | . | . | |
| *Barbilophozia hatcheri* (Evans) Loeske | . | . | . | . | x | . | . | . | . | . | . | . | |
| *Plagiochila porelloides* (Torrey) Lindenb. | . | x | . | . | . | . | . | . | . | . | . | . | |
| *Pogonatum urnigerum* (Hedw.) P. Beauv. | . | x | x | . | . | . | . | . | . | . | . | . | |
| **lichens** | | | | | | | | | | | | | |
| *Peltigera canina* (L.) Willd. | x | . | x | x | x | . | x | . | . | . | . | x | . |
| *Cetraria islandica* (L.) Ach. | x | x | x | x | x | . | x | . | . | x | x | | x |
| *Cladonia furcata* (Huds.) Schrad. | . | . | x | x | . | . | x | x | . | . | x | | |
| *Myurella* sp. (Brid) Lindb. | . | . | x | . | . | . | x | . | . | . | . | . | |

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SUMMARY

Progressive abandonment of many parts of the Alps by their resident populations has resulted in decreasing relevance of silvicolture and pasture once typical of human occupation. At the same time, tourism has become more and more important with an intensive exploitation of relatively small areas devoted to ski-runs, roads, parking zones and camping sites.

The aim of this study is to illustrate the effects of tourism on flora and vegetation of the Gran Paradiso National Park. This was founded in 1922 (the first in Italy) and covers an area of 70.000 hectares. Its geological substrate, climate and land use are fully representative of much of the Western Alps. An account is given of its use, both past and present, and a phytosociological assessment of the Park's woodlands, meadows and pastures is used to form a general picture of its "natural" vegetation for comparison with the areas dominated by tourism.

The different touristic structures lead to similar effects of varying intensity on flora and vegetation. Variations in the low and mid-altitude flora (up to 1500-1600 m) are generally in accordance with the patterns envisaged in Falinski's definition of synanthropization, such as replacement of specific components by non-specific (cosmopolitan) ones, of native species by newcomers and of stenotopic by eurytopic species. Alien species are few and always found below the 1000 m line: to advance higher in the disturbed areas they would need to be at the same time ruderal and stress-tolerant (following Grime); they should be characterised by two distinctly conflicting strategies. By contrast, certain native species have moved upwards through apophytism: those typical of meadows, in particular, are found as high as 1800-2000 m of altitude. Variations in the flora decrease in significance with altitude. Many species that cannot tolerate disturbance have disappeared and their place has not been taken by others. Stress-tolerant alpine species display good resistance to chronic disturbance (e.g. repeated trampling), but little or no resilience after destruction on account of their slow growth rates and the difficulties imposed by seed reproduction.

These changes in the flora have led to variations in vegetation. At low and medium altitudes, secondary communities have taken the place of primaries, while total or partial destruction with sparse and very slow recolonisation is observed at higher levels.

Disturbance generated great changes in species diversity. Species richness generally decreases, but is very variable, whereas equitability always diminishes in disturbed areas, and is thus a good indicator of the degree of human impact. Diversity variation in different environments and at different altitudes, however, even in the absence of disturbance, means that diversity indices must be compared only if calculated in similar edaphic conditions and at similar altitudes.

A common feature of all the touristic facilities was that plant communities were not subject to alterations of any kind even at short distances (8-10 m) from a source of disturbance. They were thus characterised by remarkable stability, using this term according to Holling of a combination of resistance, resilience and persistence.

Ski runs were responsible for the most serious effects owing to destruction of the vegetation and reshaping of the terrain. Other facilities were accompanied by moderate land use and less significatnt effects.

Generally speaking the effects of human impact are determined by the relation between environmental stress and disturbance provoked by human activities. If the stress is low, plant communities are composed of competitive species, and disturbance results in the replacement of primary communities by secondaries. If the stress is intense, they are composed of stress-tolerant species, and hence destruction of the primary communities will take place with no possibility of recolonisation, or sparse and very slow recolonisation by species already present prior to the disturbance.

The boundary between low-medium and high stress in the studied zones lies in a very clear 1900-2000 m belt. This finding provides a precise indication that management of Alpine areas should seek above all to prevent destruction of the vegetation above this threshold. The difficulty of recolonisation at greater altitudes stems from the biological limits of the plant species concerned. These, of course, cannot be overcome even by using the most efficient rehabilitation methods.

## RIASSUNTO

Negli ultimi decenni, nelle Alpi, si è assistito ad un diffuso abbandono delle pratiche silvo-pastorali e, contemporaneamente, ad un'utilizzazione intensa di alcune zone limitate dovuta alla presenza di piste da sci, strade, parcheggi, campeggi e rifugi.

Lo scopo di questo lavoro è di evidenziare gli effetti di queste strutture turistiche su flora e vegetazione nel Parco Nazionale del Gran Paradiso; il Parco, il primo ad essere istituito in Italia (1922), ha superficie di 70000 ha e ben rappresenta la situazione di molte zone delle Alpi occidentali per substrato geologico, per clima e per uso del territorio.

Per avere un quadro della situazione di riferimento non sottosposta all'influsso del turismo si è studiata la vegetazione con il metodo fitosociologico in boschi, prati falciati e pascoli e parallelamente si è indagato sull'utilizzazione passata ed attuale del territorio per individuare con precisione, in ogni zona, l'uso silvo-pastorale.

Le strutture turistiche studiate, pur nella loro varietà, causano effetti simili che determinano analoghe variazioni, di intensità diversa, su flora e vegetazione. A bassa e media quota (fino a 1500-1600 m) le modificazioni seguono le regole indicate nella definizione di sinantropizzazione di Falinski, e cioè la sostituzione di specie particolari (endemiche) con cosmopolite, di native con esotiche e di stenotopiche con euritopiche. Pochissime avventizie sono state censite, e sempre solo sotto i 1000 m di quota: per diffondersi più in alto nelle zone disturbate dovrebbero essere contemporaneamente ruderali e stress-tolleranti (secondo Grime), ed essere cioè caratterizzate da strategie nettamente in contrasto tra loro. Si è osservata invece una risalita in quota di specie native, secondo il fenomeno dell'apofitismo: in particolare specie tipiche dei prati falciati sono state trovate fino a 1800-2000 m. Con l'aumentare della quota le variazioni floristiche risultano sempre meno importanti: si osserva solo la scomparsa di molte specie e non una loro sostituzione.

Anche per la vegetazione si osserva la sostituzione di popolamenti primari con secondari a bassa e media quota e, in alta quota, la distruzione totale o parziale con scarsa e lentissima ricolonizzazione.

Si sono inoltre rilevati notevoli cambiamenti della diversità specifica in relazione al disturbo: la ricchezza floristica in genere diminuisce dimostrandosi però molto variabile; l'equitabilità invece diminuisce sempre in aree disturbate ed è un buon indice del grado di antropizzazione di un'area. La variazione dei valori di diversità specifica tra ambienti e quote differenti, anche in condizioni indisturbate, implica però che debbano essere confrontati indici di diversità specifica calcolati in condizioni edafico-altitudinali simili.

In tutte le strutture studiate si è rilevato che, a distanze anche ridotte (8-10 m) dalla sorgente di disturbo, ma in assenza dello stesso, le comunità vegetali non sono soggette ad alterazioni di alcun tipo e sono quindi caratterizzate da notevole stabilità se, con questo termine, si intende (secondo Holling) un insieme di resistenza, resilienza e persistenza.

Le piste da sci causano i problemi più gravi mentre le altre strutture sono caratterizzate da effetti più moderati nello spazio e nel tempo.

Più in generale i risultati permettono di affermare che gli effetti dell'antropizzazione dipendono dal rapporto esistente tra stress ambientale e disturbo antropico. Se lo stress ambientale è basso, i popolamenti sono costituiti da specie competitive e allora il disturbo antropico implica sostituzione dei popolamenti primari con secondari. Se lo stress è forte i popolamenti sono caratterizzati da specie stress-tolleranti e allora si avrà distruzione dei popolamenti primari senza possibilità di ricolonizzazione o con ricolonizzazione lentissima da parte di specie già presenti prima del disturbo. Nelle zone alpine studiate il limite tra stress ambientale basso-medio e alto si pone in una fascia ben precisa tra 1900 e 2000 m di quota. Da questo dato si ricava una chiara indicazione per una gestione del territorio nelle Alpi che minimizzi gli impatti, in cui si deve evitare la distruzione della vegetazione sopra questa soglia edafico-altitudinale.



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CONTENTS

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*Table 3* — Phytosociological relevés in the mown meadows.

| Relevé no. | 20 | 22 | 21 | 18 | 19 | 23 | 13 | 12 | 2 | 3 | 15 | 31 | 16 | 17 | 1 | 28 | 30 | 2 | 3 | 15 | 31 | 16 | 17 | 1 | 28 | 30 | 29 | 25 | 5 | 24 | 26 | 11 | 27 | 7 | 14 | 9 | 10 | 6 | 4 | 8 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Altitude (m) | 1350 | 1470 | 1400 | 900 | 1010 | 1550 | 1723 | 1615 | 1620 | 1690 | 1565 | 1580 | 1575 | 1650 | 1620 | 1545 | 1620 | 1620 | 1690 | 1565 | 1580 | 1575 | 1650 | 1620 | 1545 | 1620 | 1600 | 1721 | 1850 | 1620 | 1735 | 1830 | 1870 | 1800 | 2095 | 1760 | 1810 | 1840 | 1700 | 1840 |
| Exposure | W | W | N | SE | NW | W | E | W | W | W | W | N | W | E | SW | W | SW | W | W | W | N | W | E | SW | W | SW | SW | W | SW | W | E | SW | NW | N | W | S | SW | SW | E | NW |
| Slope (°) | 5 | 2 | 10 | 3 | 2 | 2 | 2 | 7 | 3 | 10 | 25 | 20 | 10 | 5 | 15 | 1 | 10 | 3 | 10 | 25 | 20 | 10 | 5 | 15 | 1 | 10 | 1 | 1 | 5 | 2 | 3 | 5 | 10 | 2 | 3 | 3 | 3 | 10 | 3 | 15 |
| Herbaceous cover (%) | 100 | 80 | 90 | 90 | 95 | 90 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 90 | 90 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 90 | 90 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 90 |
| **all. Arrhenatherion** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| *Dactylis glomerata* | 2 | 2 | 3 | 2 | 2 | 1 | + | + | 2 | 2 | 2 | 2 | 3 | 2 | . | 2 | 3 | 2 | 2 | 2 | 2 | 3 | 2 | . | 2 | 3 | 2 | + | 2 | 2 | 2 | . | . | . | . | . | . | . | . | . |
| *Heracleum sphondylium* | 3 | 3 | 2 | 1 | 2 | 2 | 2 | + | + | . | . | . | . | . | . | . | . | + | . | . | . | . | . | . | . | . | . | + | . | . | + | . | + | . | . | . | . | . | . | . |
| *Rumex acetosa* | . | . | . | . | . | . | + | . | 2 | + | + | + | + | . | . | + | . | 2 | + | + | + | + | . | . | + | . | + | + | 2 | . | . | . | . | + | 1 | . | . | 2 | 2 | 1 |
| *Galium mollugo* | . | . | . | 1 | + | . | . | . | . | . | . | + | . | . | . | + | + | . | . | . | + | . | . | . | + | + | + | . | . | . | . | . | . | . | . | . | . | . | . | . |
| *Arrhenatherum elatius* | . | . | . | . | 1 | . | . | . | . | . | + | . | + | . | . | . | . | . | . | + | . | + | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| *Phleum pratense* | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | + | + | + | . | + | . | . | 2 | . | . | . | . | . | 1 |
| *Tragopogon pratensis* | . | 1 | . | + | . | + | . | . | + | . | . | . | + | + | + | . | . | + | . | . | . | + | + | + | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| *Pimpinella major* | . | 1 | 1 | . | + | + | + | . | . | . | . | . | 1 | . | . | . | . | . | . | . | . | 1 | . | . | . | . | . | + | . | . | + | . | . | . | . | . | . | . | . | . |
| **all. Polygono-Trisetion** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| *Polygonum bistorta* | . | . | . | . | . | 2 | 1 | 1 | . | 2 | + | 1 | + | . | . | 2 | 2 | . | 2 | + | 1 | + | . | . | 2 | 2 | 2 | 3 | 2 | 3 | 1 | 4 | 1 | 3 | 2 | 1 | 2 | 2 | 3 | 1 |
| *Trisetum flavescens* | 2 | 2 | 2 | 1 | 1 | + | 3 | . | 2 | 3 | 3 | 3 | 3 | 3 | 2 | . | . | 2 | 3 | 3 | 3 | 3 | 3 | 2 | . | . | . | 1 | 2 | 2 | 2 | | 2 | 2 | 3 | + | . | . | + | + |
| *Geranium sylvaticum* | 1 | 1 | 1 | . | 1 | . | 2 | 1 | + | + | 2 | 2 | 1 | . | . | . | . | + | + | 2 | 2 | 1 | . | . | . | . | + | + | + | 1 | . | . | . | . | + | . | . | . | 3 | 3 |
| *Alchemilla xanthochlora* | 1 | . | 2 | . | . | + | + | + | . | + | + | . | + | + | . | + | . | . | + | + | . | + | + | . | + | . | . | + | 1 | + | . | . | . | + | + | 1 | 3 | 2 | + | + |
| *Campanula rhomboidalis* | . | + | . | . | + | . | + | + | + | . | + | . | + | + | . | . | . | + | . | + | . | + | + | . | . | . | . | + | . | + | + | . | + | . | . | . | . | . | + | . |
| *Phyteuma betonicifolium* | . | . | . | . | . | . | . | . | + | + | . | . | . | . | + | . | . | + | + | . | . | . | . | + | . | . | . | . | . | . | . | . | . | + | . | . | . | . | . | . |
| *Campanula scheuchzeri* | . | . | . | . | . | . | . | . | . | . | . | + | . | . | . | + | . | . | . | . | + | . | . | . | + | . | . | . | . | . | . | . | . | + | + | . | . | . | . | . |
| *Trollius europaeus* | . | . | . | . | . | . | . | . | . | . | . | . | + | . | . | . | . | . | . | . | . | + | . | . | . | . | . | . | . | + | . | . | + | . | . | . | . | . | 2 | . |
| *Silene dioica* | . | . | . | . | . | . | + | . | . | . | + | . | + | . | . | . | . | . | . | + | . | + | . | . | . | . | . | . | . | . | + | . | . | . | . | . | . | . | . | . |
| **all. Poion alpinae** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| *Poa alpina* | . | . | . | . | . | + | . | . | . | . | . | . | . | . | + | 2 | 1 | . | . | . | . | . | . | + | 2 | 1 | + | + | . | . | + | + | 1 | . | 2 | 2 | 1 | + | . | . |
| *Trifolium pratense* ssp. *frigidum* | . | . | . | . | . | . | . | . | + | + | . | + | . | . | . | 2 | 2 | + | + | . | + | . | . | . | 2 | 2 | 2 | 2 | 2 | . | 2 | 2 | 3 | + | . | . | + | + | . | . |
| *Trifolium badium* | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | + | . | . | + | . | + | . | + | . | . | . | . | . |
| *Phleum alpinum* | . | . | . | . | . | . | . | + | . | . | . | + | . | . | . | + | + | . | . | . | + | . | . | . | + | + | . | . | . | . | . | + | + | . | + | . | . | 2 | + | + |
| *Festuca violacea* | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | 2 | . | . | 1 | . | + | 1 | . | . |
| *Crepis aurea* | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | + | . | . | . | . | + | 2 | . | . | . | . | . |
| **cl. Arrhenatheretea** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| *Ranunculus acris* | . | . | . | . | . | . | + | . | . | . | + | + | . | . | . | + | + | . | . | + | + | . | . | . | + | + | + | + | + | 1 | + | . | + | + | 2 | . | . | + | . | + |
| *Trifolium pratense* | . | 1 | . | 3 | 2 | . | 2 | 2 | 1 | + | + | . | + | . | . | . | . | 1 | + | + | . | + | . | . | . | . | . | . | . | 2 | . | . | . | . | . | . | . | . | . | . |
| *Trifolium repens* | 2 | . | 2 | . | . | . | 3 | . | + | . | . | . | . | 2 | . | 2 | 2 | + | . | . | . | . | 2 | . | 2 | 2 | 2 | 2 | . | + | + | . | + | + | . | 2 | . | + | . | . |
| *Leontodon hispidus* | 1 | 1 | + | 1 | . | . | 2 | 2 | . | + | + | . | + | + | . | + | + | . | + | + | . | + | + | . | + | + | . | 2 | . | + | + | + | 2 | 2 | 1 | . | . | . | + | . |
| *Taraxacum officinale* | 2 | 2 | 1 | 1 | 2 | 2 | + | . | + | . | + | . | . | + | . | + | + | + | . | + | . | . | + | . | + | + | . | 1 | + | + | + | . | . | . | . | + | 2 | 3 | . | . |
| *Poa pratensis* | . | . | . | . | 2 | + | + | . | . | . | + | . | + | . | . | . | + | . | . | + | . | + | . | . | . | + | . | . | + | + | + | . | . | + | . | . | . | 2 | . | . |
| *Vicia cracca* | . | + | 1 | . | + | . | + | + | + | 1 | 1 | . | + | . | . | . | + | + | 1 | 1 | . | + | . | . | . | + | . | + | . | + | 2 | . | + | . | . | . | . | . | + | . |
| *Agrostis capillaris* | . | . | 2 | . | . | 1 | 2 | 2 | . | . | +. | . | + | . | . | . | . | . | . | +. | . | + | . | . | . | . | . | 2 | . | . | 2 | . | + | . | . | . | . | . | . | . |
| *Daucus carota* | . | 2 | . | . | . | . | + | + | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | + | . | 1 | + | . | . | . | . | . | + | . | . | . |
| *Rhinanthus alectorolophus* | . | . | . | . | . | . | . | + | 2 | 3 | . | . | . | . | 2 | + | . | 2 | 3 | . | . | . | . | 2 | + | . | 1 | . | . | . | + | . | . | + | . | . | . | . | . | . |
| *Silene vulgaris* | . | . | 1 | . | . | + | . | + | 2 | + | 1 | . | . | 2 | . | . | . | 2 | + | 1 | . | . | 2 | . | . | . | . | . | + | . | . | . | + | . | . | . | . | . | . | + |
| *Veratrum album* | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | + | . | + | . | . | . | . | 3 |
| *Lotus corniculatus* | . | . | . | . | . | . | . | . | . | + | . | . | . | . | . | . | . | . | + | . | . | . | . | . | . | . | + | . | . | . | . | . | . | . | . | . | . | + | + | . |
| *Plantago lanceolata* | . | . | . | 1 | . | . | . | . | + | + | . | . | + | . | . | . | . | + | + | . | . | + | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| *Colchicum autumnale* | . | . | . | . | . | . | . | . | . | . | . | . | + | . | . | . | . | . | . | . | . | + | . | . | . | . | . | . | . | +. | . | . | . | . | . | . | . | . | 1 | . |
| *Festuca pratensis* | . | . | . | . | . | . | . | . | . | . | 2 | . | + | . | . | . | . | . | . | 2 | . | + | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| *Lathyrus pratensis* | . | . | . | . | . | . | 1 | . | . | . | . | . | . | + | . | . | . | . | . | . | . | . | + | . | . | . | . | + | . | . | + | . | . | . | . | . | . | . | . | . |
| *Chaerophyllum villarsii* | . | + | . | . | . | 1 | . | . | . | . | . | 1 | . | . | . | + | . | . | . | . | 1 | . | . | . | + | . | + | . | . | . | . | . | + | . | . | . | . | . | . | . |
| *Briza media* | . | . | . | . | . | 1 | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | + | . | . | . | . | . | . | . | + | . | . | + | . | . |
| **cl. Caricetea curvulae** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| *Potentilla grandiflora* | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | + | . | . | . | 2 | . | + | . | . |
| *Centaurea jacea* ssp. *nervosa* | . | . | . | . | . | . | . | . | . | . | + | . | . | . | . | . | . | . | . | + | . | . | . | . | . | . | . | . | . | . | . | + | . | . | . | + | . | . | . | . |
| *Cerastium arvense* ssp. *strictum* | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | + | 1 | . | . | . | . | . | . | . | + | 1 | + | . | . | . | . | . | . | + | + | . | . | 1 | . | . |
| *Crepis conyzifolia* | . | . | . | . | . | . | . | . | . | + | . | . | + | . | . | . | . | . | + | . | . | + | . | . | . | . | . | . | . | . | . | . | . | + | . | . | . | . | . | . |
| **companion species** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| *Chaerophyllum hirsutum* | 2 | . | + | 1 | 2 | . | + | 3 | 1 | 2 | 1 | . | + | . | . | . | . | 1 | 2 | 1 | . | + | . | . | . | . | . | . | + | . | . | . | . | . | . | . | + | . | 2 | . |
| *Deschampsia caespitosa* | . | . | . | . | . | . | . | . | . | . | . | + | . | . | . | . | + | . | . | . | + | . | . | . | . | + | + | + | . | . | . | . | . | . | . | . | . | + | . | . |
| *Onobrychis viciifolia* | 1 | 1 | . | . | . | 1 | 1 | . | . | . | + | . | 3 | . | . | . | . | . | . | + | . | 3 | . | . | . | . | . | . | . | . | 2 | . | + | . | . | . | . | . | . | . |
| *Plantago media* | . | 1 | + | . | . | 1 | . | + | . | . | + | . | . | . | . | + | . | . | . | + | . | . | . | . | + | . | + | . | + | . | + | . | . | . | + | . | . | + | . | . |
| *Colchicum alpinum* | . | . | 1 | . | . | . | . | . | . | . | . | . | . | + | . | . | . | . | . | . | . | . | + | . | . | . | . | + | . | . | + | . | . | . | . | . | . | . | . | . |
| *Festuca ovina* gr. | . | . | . | . | . | . | . | 3 | . | . | . | + | . | 1 | . | 2 | 1 | . | . | . | + | . | 1 | . | 2 | 1 | 2 | . | . | . | . | . | 1 | . | . | . | . | . | . | . |
| *Ranunculus montanus* | . | . | . | . | . | . | . | + | . | . | . | . | . | + | . | . | . | . | . | . | . | . | + | . | . | . | . | . | . | . | . | . | . | 3 | . | + | + | . | . | . |
| *Anthoxanthum odoratum* | . | . | 1 | . | . | + | 1 | . | 3 | 1 | . | 2 | . | + | + | + | . | 3 | 1 | . | 2 | . | + | + | + | . | + | + | . | . | + | . | + | . | + | + | + | . | + | + |
| *Plantago maritima* ssp. *serpentina* | . | . | . | . | . | . | . | + | . | . | . | . | . | . | . | + | . | . | . | . | . | . | . | . | + | . | . | . | . | . | . | . | . | . | . | + | . | . | . | . |
| *Galium pusillum* | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | + | . | + | + | . | . | . | . |
| *Euphrasia salisburgensis* | . | . | . | . | . | . | + | . | . | . | + | . | . | . | . | . | . | . | . | + | . | . | . | . | . | . | . | . | . | + | . | . | . | . | + | . | . | . | . | . |
| *Dianthus carthusianorum* | . | . | . | . | + | . | + | . | . | + | . | . | . | . | 2 | . | . | . | + | . | . | . | . | 2 | . | . | . | . | . | . | . | + | . | . | + | . | . | . | . | . |

*Table 19* — Phytosociological relevés along the Orco Valley road, upper section.

| Relevé no. | 25 | 26 | 27 | 28 | 29 | 30 | 31 | 32 | 33 | 34 | 35 | 36 | 37 | 38 | 39 | 40 | 41 | 42 | 43 | 44 | 45 | 46 | 71 | 72 | 73 | 74 | 75 | 76 | 77 | 78 | 79 | 80 | 81 | 82 | 83 | 84 | 85 | 86 | 87 | 88 | 89 | 90 | 91 | 92 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Altitude (m) | 1480 | 1480 | 1490 | 1490 | 1540 | 1540 | 1610 | 1610 | 1710 | 1710 | 1825 | 1825 | 2000 | 2000 | 2210 | 2210 | 2300 | 2300 | 2420 | 2420 | 2580 | 2580 | 1480 | 1480 | 1490 | 1490 | 1540 | 1540 | 1610 | 1610 | 1710 | 1710 | 1825 | 1825 | 200 | 200 | 2210 | 2210 | 2300 | 2300 | 2420 | 2420 | 2580 | 2580 |
| Exposure | SW | SW | SW | SW | W | W | E | E | SW | SW | S | S | S | S | W | W | W | W | W | W | W | W | SW | SW | SW | SW | W | W | E | E | SW | SW | S | S | S | S | W | W | W | W | W | W | W | W |
| Slope (°) | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 2 | 3 | 3 | 5 | 0 | 5 | 5 | 0 | 0 | 3 | 5 | 5 | 5 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 2 | 3 | 3 | 5 | 0 | 5 | 5 | 0 | 0 | 3 | 5 | 5 | 5 |
| Herbaceous cover (%) | 35 | 55 | 40 | 15 | 70 | 30 | 10 | 15 | 10 | 5 | 15 | 35 | 55 | 50 | 15 | 40 | 35 | 25 | 5 | 15 | 15 | 20 | 100 | 80 | 100 | 85 | 90 | 95 | 90 | 80 | 90 | 80 | 75 | 95 | 100 | 100 | 90 | 90 | 95 | 95 | 85 | 85 | 90 | 85 |
| **cl. Plantaginetea majoris** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| *Trifolium repens* | . | . | + | + | . | + | + | . | . | 1 | . | + | . | . | . | . | . | . | . | . | . | . | . | . | 2 | . | 2 | 1 | 2 | 2 | . | . | . | 1 | . | . | . | . | . | . | . | . | . | . |
| *Poa annua* | + | 1 | + | . | + | + | + | . | . | . | 1 | . | + | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | + | . | . | . | . | . | . | . | . | . |
| *Plantago major* | + | + | + | . | + | + | + | . | + | 1 | 1 | + | + | . | . | . | . | . | . | . | . | . | . | . | . | + | . | . | . | . | . | . | . | + | . | . | . | . | . | . | . | . | . | . |
| *Polygonum aviculare* | . | + | + | + | . | + | + | . | 1 | . | 1 | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| *Spergularia rubra* | . | . | . | . | . | . | + | . | 1 | 1 | 1 | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| *Trifolium thalii* | . | . | . | . | . | . | . | . | 2 | . | . | . | . | 3 | . | . | . | 2 | 1 | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| *Chamomilla suaveolens* | . | . | . | . | 3 | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| *Agrostis stolonifera* | . | . | . | . | . | . | . | . | + | . | . | . | . | + | + | . | . | . | . | . | . | . | . | . | 1 | 2 | . | . | . | . | . | 2 | . | . | . | . | . | . | . | . | . | . | . | . |
| **cl. Chenopodietea** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| *Urtica dioica* | 3 | + | + | . | + | 2 | 1 | . | . | . | + | + | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| *Capsella bursa- pastoris* | + | + | + | + | . | . | + | . | . | . | . | + | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| *Chenopodium album* | . | . | 1 | 1 | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| **cl. Artemisietea** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| *Echium vulgare* | 1 | 2 | + | 2 | + | + | 2 | 2 | + | + | + | + | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | + | + | . | . | . | . | . | . | . | . | . | . | . |
| *Chenopodium bonus-henricus* | . | . | . | + | 2 | + | . | 2 | . | . | . | + | . | . | 2 | + | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| **cl. Epilobietea angustifolii** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| *Epilobium angustifolium* | . | 3 | . | . | . | + | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| **cl. Arrhenatheretea** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| *Poa alpina* | + | + | . | + | . | + | + | . | 1 | . | + | + | 1 | + | 1 | 1 | 1 | 1 | 1 | . | + | 1 | . | . | + | 1 | . | 1 | . | . | 2 | . | 1 | 2 | . | 1 | 2 | + | . | 2 | 1 | . | 2 | . |
| *Taraxacum officinale* gr. | + | + | + | . | 1 | + | . | 1 | . | + | . | + | . | . | + | . | + | + | + | 2 | + | . | . | . | 1 | 1 | . | . | 1 | + | . | 1 | . | + | . | . | . | . | . | . | . | . | . | . |
| *Achillea millefolium* | . | + | 1 | 1 | 1 | 1 | 1 | 1 | . | + | + | 2 | 3 | 1 | + | + | . | . | . | . | . | . | 2 | . | 2 | 2 | . | 2 | 2 | + | 2 | 2 | 2 | 2 | 2 | 2 | . | . | . | . | . | . | . | . |
| *Trifolium pratense* | + | . | . | . | + | . | + | . | + | . | . | 1 | + | . | . | . | . | . | . | . | . | . | + | . | . | 2 | 2 | 1 | 3 | 2 | . | . | . | 1 | . | . | . | . | . | . | . | . | . | . |
| *Alchemilla xanthochlora* | . | . | . | + | + | + | . | + | . | . | . | . | 1 | + | . | + | . | + | . | . | . | . | . | . | . | 1 | 2 | 2 | 1 | 2 | . | 2 | . | 2 | 2 | 2 | + | + | . | + | . | . | . | 1 |
| *Dactylis glomerata* | . | . | . | + | 2 | 2 | + | + | . | . | + | 2 | 1 | . | . | . | . | . | . | . | . | . | . | . | 2 | 2 | 2 | . | 2 | 2 | . | . | . | 2 | . | 2 | . | . | . | . | . | . | . | . |
| *Trisetum flavescens* | . | . | . | . | + | + | . | + | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | 3 | 1 | . | 2 | 1 | 2 | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| *Polygonum bistorta* | . | . | . | . | . | . | . | . | + | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | 3 | 2 | 2 | 2 | 2 | 2 | . | 2 | . | 2 | 2 | 2 | . | . | . | . | . | . | . | . |
| *Trifolium pratense* ssp. *frigidum* | . | . | . | . | . | . | . | . | . | . | . | . | + | + | 1 | + | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | 2 | + | 2 | 2 | . | . | . | . | . | . |
| *Agrostis capillaris* | . | . | . | . | + | . | 1 | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | + | + | + | + | . | . | . | + | . | . | . | . | . | . | . | . | . | . |
| *Heracleum sphondylium* | . | . | . | . | . | . | + | + | . | . | . | . | . | . | + | . | . | . | . | . | . | . | . | . | . | . | 3 | 2 | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| *Silene vulgaris* | . | . | + | + | . | . | . | . | . | . | . | + | + | . | . | . | . | . | . | . | . | . | . | . | . | . | + | + | . | . | . | . | . | + | . | . | . | + | . | . | . | . | . | . |
| *Campanula rhomboidalis* | . | . | . | . | . | + | . | + | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | + | . | . | . | . | . | . | . | . | . | . | . | . |
| *Campanula scheuchzeri* | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | + | . | . | + | . | . | . | . | . | . |
| *Galium mollugo* | . | . | . | . | + | . | . | + | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| *Poa pratensis* | . | . | . | . | . | . | . | + | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | 2 | . | 1 | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| *Chaerophyllum hirsutum* | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | 2 | . | + | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| **cl. Festuco-Brometea** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| *Plantago media* | . | . | . | + | . | . | . | + | + | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | + | . | . | . | + | . | 2 | . | . | + | . | . | . | . | . | . | . | . | . | . |
| *Lotus alpinus* | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | + | . | + | . | . | + | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | 2 | + | . | . | . | . | . | . |
| *Lotus corniculatus* | + | . | . | . | . | . | . | + | . | . | . | . | + | . | . | . | . | . | . | . | . | . | + | . | . | . | . | 2 | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| **cl. Vaccinio-Piceetea** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| *Deschampsia flexuosa* | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | 2 | 2 | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| *Larix decidua* | . | + | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | + | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| **cl. Caricetea curvulae** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| *Plantago maritima* ssp. *serpentina* | + | + | . | . | . | . | . | . | . | . | + | + | + | 1 | . | 1 | + | + | + | . | . | . | + | . | . | . | . | . | . | . | . | . | . | . | 2 | . | 2 | . | . | . | . | . | . | . |
| *Myosotis alpestris* | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | + | + | + | . | . | + | + | + | 1 |
| *Phleum alpinum* | . | . | . | . | . | . | . | . | . | . | . | + | . | + | . | . | . | . | . | . | . | . | . | . | + | . | . | . | . | . | . | 2 | . | + | + | . | . | + | . | . | . | . | . | . |
| *Carex curvula* | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | 2 | 2 | + | 1 | 1 | 2 |
| *Festuca halleri* | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | 2 | 1 | 1 | 2 | 1 | + | . | . | . | . | . | . | . | . | . | . | . | . | . | . | 2 | . | . | 2 | 2 | 2 | 2 | 2 |
| *Silene acaulis* | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | + | . | + | 1 | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | 2 | 1 | 2 | 2 |
| *Festuca varia* | + | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | 2 | . | 2 | . | . | . | . | . | . | . | . | . | . | . |
| *Potentilla grandiflora* | . | . | . | . | . | . | . | . | . | . | . | + | . | + | . | . | + | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | + | . | . | . | . | . | + | 1 | . | . | . | . |
| **cl. Salicetea herbaceae** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| *Salix herbacea* | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | 3 | 2 | 2 |
| **cl. Thlaspietea rotundifolii** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| *Rumex scutatus* | 1 | 1 | 3 | 2 | . | . | . | . | + | . | . | + | + | + | . | + | + | . | . | . | . | . | . | . | . | . | . | . | . | . | . | + | . | . | . | . | . | . | . | . | . | . | . | . |
| *Oxyria digina* | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | 2 | 2 | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | 1 | . |
| *Ranunculus glacialis* | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | + | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | 1 | 1 |
| **companion species** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| *Potentilla argentea* | . | . | . | . | . | . | + | + | + | + | + | + | + | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | + | 1 | 1 | 1 | . | . | . | . | . | . | . | . | . | . |
| *Thymus serpyllum* gr. | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | + | . | . | . | . | . | . | . | . | . | . | . | . | 2 | + | + | . | . | . | . | . | . |
| *Carlina acaulis* | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | + | 2 | . | . | 2 | . | . | . | . | . | . | . | . | . | . | . | . | . | . | 1 | . | . | . | . | . | . |
| *Leucanthemum adustum* | . | . | . | . | . | . | . | . | . | . | . | . | . | . | + | . | + | + | . | + | 1 | + | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | + | . | . | . | 1 | . |

*Table 17* — Phytosociological relevés along the OrcoValley road, lower section.

| Relevé 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 | 47 | 48 | 49 | 50 | 51 | 52 | 53 | 54 | 55 | 56 | 57 | 58 | 59 | 60 | 61 | 62 | 63 | 64 | 65 | 66 | 67 | 68 | 69 | 70 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Altitude (m) | 470 | 470 | 490 | 490 | 510 | 510 | 520 | 520 | 540 | 540 | 630 | 630 | 720 | 720 | 770 | 770 | 790 | 790 | 870 | 870 | 1050 | 1050 | 1260 | 1260 | 470 | 470 | 490 | 490 | 510 | 510 | 520 | 520 | 540 | 540 | 630 | 630 | 720 | 720 | 770 | 770 | 790 | 790 | 870 | 870 | 1050 | 1050 | 1260 | 1260 |
| Exposure | S | S | SW | SW | SW | SW | SW | SW | W | W | W | W | W | W | S | S | SW | SW | SW | SW | SW | SW | SW | SW | S | S | SW | SW | SW | SW | SW | SW | W | W | W | W | W | W | S | S | SW | SW | SW | SW | SW | SW | SW | SW |
| Slope (°) | 5 | 3 | 0 | 2 | 3 | 5 | 10 | 10 | 3 | 3 | 3 | 3 | 5 | 5 | 5 | 5 | 2 | 2 | 5 | 5 | 10 | 10 | 3 | 0 | 5 | 3 | 0 | 2 | 3 | 5 | 10 | 10 | 3 | 3 | 3 | 3 | 5 | 5 | 5 | 5 | 2 | 2 | 5 | 5 | 10 | 10 | 3 | 0 |
| Herbaceous cover (%) | 60 | 60 | 40 | 25 | 40 | 20 | 35 | 40 | 35 | 50 | 45 | 30 | 55 | 15 | 15 | 30 | 15 | 5 | 25 | 20 | 30 | 40 | 30 | 15 | 95 | 98 | 100 | 100 | 100 | 95 | 80 | 100 | 95 | 90 | 100 | 90 | 100 | 95 | 95 | 90 | 95 | 100 | 100 | 100 | 85 | 90 | 95 | 80 |
| **cl. Plantaginetea majoris** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| *Trifolium repens* | . | . | + | + | . | + | . | . | . | . | + | + | + | . | . | . | + | . | + | . | . | . | 2 | . | 1 | 2 | 2 | 2 | + | 2 | . | 2 | 2 | . | 2 | 2 | 3 | . | 2 | 2 | 3 | 1 | 2 | 2 | . | 2 | . | . |
| *Plantago major* | . | . | + | + | . | 4 | + | . | . | 1 | 1 | . | 1 | . | . | . | + | 1 | + | . | . | + | 2 | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | + | . | . | . | . | . | . | . | . | . |
| *Lolium perenne* | + | . | 1 | . | 1 | 1 | . | + | 1 | + | . | . | + | . | . | . | + | 1 | . | . | . | + | 1 | . | . | . | . | . | + | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| *Polygonum aviculare* | . | . | . | . | 1 | . | + | . | . | + | . | . | + | . | . | . | + | 1 | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | + | . | . | . | . | . |
| *Poa annua* | . | . | . | . | . | 1 | + | . | 1 | . | + | . | . | . | . | . | . | 1 | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| *Chamomilla suaveolens* | . | . | . | . | . | . | . | . | 2 | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| **cl. Chenopodietea** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| *Rumex acetosella* | . | . | . | . | . | . | . | . | . | . | + | + | . | + | . | . | 2 | . | + | + | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | + | . | . | . | . | . | . | + |
| *Urtica dioica* | + | . | . | . | 1 | . | . | . | . | . | . | . | . | . | + | . | + | . | . | 1 | . | 1 | . | . | . | . | . | . | . | . | 2 | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| *Chenopodium album* | . | . | . | + | 4 | . | . | . | . | . | . | . | . | . | . | . | 2 | . | + | 2 | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| *Capsella bursa-pastoris* | . | . | . | + | + | . | . | . | . | . | . | . | . | . | + | . | + | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| *Galinsoga parviflora* | . | . | . | . | + | . | + | . | . | . | . | . | + | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| *Sonchus asper* | . | . | . | + | . | . | + | . | . | . | . | . | . | . | + | . | . | . | . | + | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| *Oenothera biennis* | . | . | . | + | . | . | . | . | . | . | 4 | 3 | . | . | . | . | + | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| **cl. Artemisietea** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| *Artemisia vulgaris* | + | 2 | . | 2 | + | . | . | + | + | + | . | 1 | . | 2 | 2 | 1 | . | . | 1 | . | . | 3 | . | . | . | . | . | . | . | . | 1 | . | . | . | . | . | . | + | . | . | . | . | . | . | . | . | . | . |
| *Erigeron annuus* | + | . | + | + | . | + | + | + | . | . | + | . | + | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | + | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| *Arctium lappa* | . | . | . | 1 | + | . | . | 3 | + | . | . | . | . | . | . | . | + | . | . | . | . | + | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| *Rumex obtusifolius* | . | . | . | . | + | . | 1 | + | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| *Echium vulgare* | + | . | . | . | . | . | . | . | . | . | + | 2 | . | . | . | . | 1 | . | 2 | . | 1 | 1 | + | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| **cl. Epilobietea angustifolii** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| *Holcus mollis* | . | + | . | . | + | 1 | . | . | . | + | + | . | . | . | . | . | . | . | . | . | . | . | . | . | . | + | 1 | . | . | 2 | . | . | . | + | + | . | . | . | . | . | . | . | . | . | . | . | . | . |
| **cl. Arrhenatheretea** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| *Achillea millefolium* | 2 | 3 | 1 | 1 | 1 | + | . | + | . | 2 | . | + | 2 | . | 2 | + | 1 | . | + | 1 | . | . | + | 1 | 3 | 1 | . | 1 | . | 2 | . | 2 | 2 | . | 2 | . | 1 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | . | 2 | . | . |
| *Agrostis capillaris* | . | . | . | + | + | + | . | + | + | + | . | . | . | . | . | . | . | . | . | . | . | + | + | . | . | . | . | . | 3 | . | 3 | . | . | . | . | . | 1 | 3 | . | . | 1 | 1 | 2 | . | . | 1 | . | . |
| *Taraxacum officinale* gr. | + | 1 | 1 | 1 | . | . | + | + | + | . | . | . | 1 | . | . | . | . | . | + | . | . | . | . | . | 1 | + | 1 | 1 | + | . | . | 2 | 2 | 2 | 2 | + | . | . | 1 | . | . | 1 | . | 1 | . | 1 | . | . |
| *Centaurea jacea* | + | + | . | . | + | . | . | . | . | . | + | . | + | . | + | . | + | . | . | . | . | . | . | . | 1 | . | . | . | 1 | 1 | . | + | 1 | . | + | . | 1 | . | + | + | 1 | + | . | + | . | . | . | . |
| *Galium mollugo* | + | + | + | . | + | + | . | . | . | . | + | . | . | . | . | . | . | . | . | . | . | . | . | . | 1 | 1 | + | 1 | + | + | 1 | + | 1 | + | + | 1 | + | . | . | + | + | . | . | + | . | . | . | . |
| *Dactylis glomerata* | 1 | + | . | + | . | . | . | . | . | . | . | . | + | . | + | . | . | . | . | . | . | . | . | . | 2 | 2 | . | 1 | 2 | . | . | . | . | 2 | . | 3 | 1 | . | 1 | 2 | 2 | 2 | 3 | 3 | . | 2 | . | . |
| *Chaerophyllum hirsutum* | . | . | . | . | . | . | . | + | + | . | . | . | + | . | + | . | . | . | + | . | . | . | . | . | + | . | . | . | . | . | . | . | + | + | 1 | . | + | . | + | + | + | 1 | + | + | . | 2 | . | . |
| *Trifolium pratense* | 2 | . | . | . | . | . | + | . | . | . | . | . | 3 | . | . | . | + | . | . | . | . | . | . | . | 1 | 2 | 3 | 3 | 2 | . | . | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 1 | 1 | 2 | 2 | 2 | . | 2 | . | . |
| *Arrhenatherum elatius* | . | 1 | + | . | + | . | + | . | . | . | 2 | . | . | . | . | . | . | . | . | . | . | . | . | . | . | 2 | 2 | . | 2 | 3 | . | 2 | 2 | 3 | . | . | 2 | . | . | . | . | . | . | . | . | . | . | . |
| *Daucus carota* | + | + | . | + | + | . | + | . | . | . | 1 | . | + | . | . | . | . | . | . | . | . | . | . | . | + | . | . | . | + | . | . | . | . | . | . | . | + | . | + | . | 1 | . | . | . | . | . | . | . |
| *Ranunculus acris* | + | + | + | . | + | . | + | . | + | . | . | . | + | . | + | . | . | . | . | . | . | . | . | . | + | + | . | 1 | + | . | . | + | + | + | + | 1 | + | . | . | + | . | + | + | . | . | . | . | . |
| *Silene vulgaris* | + | 1 | 1 | . | + | . | . | . | . | . | . | . | . | . | . | . | . | . | + | . | . | . | . | . | 1 | 1 | 1 | . | + | 1 | . | + | 1 | 1 | . | + | . | 1 | . | + | . | 1 | 1 | . | . | 2 | . | + |
| *Heracleum sphondylium* | + | . | . | . | . | . | . | . | . | . | . | . | + | . | . | . | . | . | + | . | . | . | . | . | . | + | . | 2 | + | + | . | + | + | + | 1 | . | + | . | . | 3 | . | 2 | 2 | 2 | . | . | . | . |
| *Leontodon hispidus* | . | . | + | . | . | . | . | . | . | . | . | . | . | . | . | . | . | + | . | . | . | . | . | . | . | . | . | 1 | + | . | . | . | . | . | . | . | + | . | + | . | . | + | . | . | . | . | . | . |
| *Poa pratensis* | . | . | . | . | . | . | . | . | . | . | . | . | + | . | . | . | . | . | . | . | . | . | . | . | . | + | . | 2 | 1 | . | . | 1 | + | + | + | 2 | . | . | 1 | . | 2 | 2 | 1 | . | . | . | . | . |
| *Alchemilla xanthochlora* | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | + | . | . | . | . | . | . | 1 | . | . | . | . | . | . | . | . | . | . | . | . |
| *Campanula rhomboidalis* | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | + | + | + | . | . | + | . | + | . | . | + | . | . | . | . | . | . | + | . | + | . | . | . | . |
| *Campanula scheuchzeri* | . | . | . | . | . | . | . | . | . | . | . | + | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | + | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| *Polygonum bistorta* | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | 3 | . | 1 | . | . | . | . | . | . | . | 2 | 2 | 2 | . | . | 1 | . | 2 | . | 1 | . | . | . | . |
| *Trisetum flavescens* | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | 1 | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | 1 | 2 | . | 3 | . | . | 1 | . | . | . | . | . | . |
| *Poa alpina* | . | . | . | . | . | . | . | . | . | . | . | . | . | + | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| *Plantago lanceolata* | 1 | . | + | . | . | . | + | . | . | 2 | + | + | . | . | . | . | . | . | . | . | . | + | + | . | . | . | 2 | 2 | + | 2 | . | . | 2 | 2 | 2 | 2 | . | . | 1 | 2 | 2 | 1 | 1 | 1 | . | . | . | . |
| **cl. Festuco-Brometea** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| *Lotus corniculatus* | + | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | + | + | + | 1 | . | . | . | . | . | . | + | . | . | . | . | . | . | . | . | . | 1 | . | . | . | . | . | . |
| *Artemisia campestris* | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | + | . | . | 1 | 1 | 2 | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | + | . | 1 | 1 |
| **cl. Vaccinio-Piceetea** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| *Deschampsia flexuosa* | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | 2 | 2 |
| *Larix decidua* | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | 2 | . | 2 | 2 |
| **companion species** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| *Rumex scutatus* | . | . | . | . | . | . | . | + | . | . | . | . | . | . | 1 | 3 | . | . | . | . | 3 | . | + | 2 | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| *Elymus repens* | . | . | . | + | . | . | 3 | . | + | + | . | . | . | . | . | . | . | . | + | . | . | . | . | . | . | . | . | . | . | . | 1 | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| *Thymus serpillum* gr. | . | . | . | . | . | . | . | . | . | . | . | . | . | + | . | 1 | . | . | . | . | + | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | + | . |
| *Potentilla argentea* | . | . | . | . | . | . | . | . | . | . | . | + | . | . | . | . | . | . | + | . | . | + | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | 1 | . | . |
| *Robinia pseudacacia* | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | + | + | . | . | . | . | . | . | . | . | + | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |

*Table 21* — Phytosociological relevés along (nos. 1-14) and beside (nos.15-28) the path.

| Relevé 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 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Altitude (m) | 1850 | 1850 | 1890 | 1890 | 1940 | 1940 | 2060 | 2060 | 2150 | 2150 | 2450 | 2450 | 2475 | 2475 | 1850 | 1850 | 1890 | 1890 | 1940 | 1940 | 2060 | 2060 | 2150 | 2150 | 2450 | 2450 | 2475 | 2475 |
| Exposure | E-SE | SE | SE | SE | S | S | E-SE | SE | S | S | S | S | S | S | S | SE | SE | SE | S | S | E-SE | E-SE | S | S | S | S | S | S |
| Slope (°) | 50 | 30 | 45 | 40 | 40 | 40 | 15 | 20 | 45 | 45 | 30 | 35 | 30 | 40 | 50 | 40 | 45 | 45 | 40 | 40 | 15 | 15 | 30 | 35 | 30 | 30 | 20 | 20 |
| Tree and shrub cover (%) | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 60 | 40 | 40 | 50 | 30 | 30- | - | - | - | - | - | - |
| Herbaceous cover (%) | 25 | 30 | 40 | 45 | 30 | 25 | 30 | 30 | 40 | 40 | 30 | 40 | 30 | 40 | 90 | 85 | 90 | 90 | 100 | 90 | 80 | 90 | 90 | 100 | 80 | 75 | 70 | 75 |
| **cl. Arrhenatheretea** | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| *Poa alpina* | . | . | + | + | + | . | + | + | + | + | + | + | + | 1 | . | . | . | . | . | . | + | . | . | . | . | . | 2 | 1 |
| *Achillea millefolium* | . | . | . | . | . | 1 | 3 | + | + | . | + | . | + | . | . | . | . | . | . | . | . | . | . | . | 1 | . | . | . |
| *Trifolium pratense* | . | . | . | + | + | + | 1 | + | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| *Phyteuma betonicifolium* | . | . | + | + | . | . | . | . | . | . | . | . | . | . | . | . | . | + | . | + | . | 1 | . | . | . | . | . | . |
| *Trifolium pallescens* | . | . | + | + | . | . | . | . | . | . | . | . | . | . | . | . | 1 | 2 | . | . | . | . | . | . | . | . | . | . |
| *Alchemilla vulgaris* | . | . | . | . | . | . | . | . | . | . | + | . | + | + | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| *Taraxacum officinale* | . | . | . | . | . | . | . | + | . | . | + | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| *Campanula scheuchzeri* | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | + | + | . | . | . | . | . | . | . | . | . | . |
| *Briza media* | . | . | . | . | . | . | . | . | . | . | + | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| *Silene vulgaris* | . | . | . | . | + | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| *Trifolium pratense* ssp. *frigidum* | . | . | . | . | . | . | . | . | . | . | . | . | 2 | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| *Agrostis capillaris* | . | . | . | . | . | . | 1 | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| *Trifolium badium* | . | . | . | . | . | . | . | . | . | . | . | . | . | . | + | . | . | . | . | . | . | . | . | . | . | . | . | . |
| **cl. Festuco-Brometea** | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| *Euphorbia cyparissias* | + | + | 4 | 4 | 2 | 4 | 2 | 3 | 1 | 2 | 2 | 4 | . | . | 2 | 2 | . | . | . | . | . | . | 2 | . | . | 1 | . | . |
| *Thymus pulegioides* | + | + | . | . | . | . | . | . | + | + | + | + | + | . | + | 1 | . | . | . | . | . | . | . | 1 | + | . | 1 | 1 |
| *Teucrium chamaedrys* | . | . | . | . | . | . | . | . | + | . | + | + | . | . | . | . | . | . | . | . | . | . | 1 | 1 | 1 | + | . | . |
| *Koeleria vallesiana* | . | . | . | . | . | . | . | . | 2 | 1 | + | 1 | . | . | . | . | . | . | . | . | . | . | . | 3 | 3 | 1 | . | . |
| *Pulsatilla halleri* | . | . | . | . | . | . | . | . | + | . | . | + | + | + | . | . | . | . | . | . | . | . | 1 | + | . | . | . | . |
| *Lotus alpinus* | + | . | . | . | + | . | . | . | . | . | + | . | + | . | . | . | . | . | . | . | . | + | + | . | . | . | . | . |
| *Galium album* | . | + | . | . | . | + | . | . | . | . | + | . | . | . | + | . | + | . | . | . | . | . | . | . | . | . | . | . |
| *Sanguisorba minor* | + | . | . | . | . | . | . | . | . | . | . | . | . | . | + | . | . | . | . | . | . | . | + | + | . | . | . | . |
| *Artemisia absinthium* | 4 | 4 | . | . | . | . | . | . | . | . | . | . | . | . | 2 | 2 | . | . | . | . | . | . | . | . | . | . | . | . |
| *Phleum hirsutum* | 1 | + | . | . | . | . | . | . | . | + | . | . | . | . | . | 1 | . | . | . | . | . | . | . | . | . | . | . | . |
| **cl. Vaccinio-Piceetea** | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| *Festuca flavescens* | . | . | 1 | + | 2 | . | . | 1 | . | . | . | . | . | . | . | . | 3 | 3 | 3 | 3 | 2 | 3 | . | . | . | . | . | . |
| *Deschampsia flexuosa* | . | . | 1 | 2 | 2 | . | 1 | . | . | . | . | . | . | . | . | . | 2 | 2 | 2 | 2 | 2 | 1 | . | . | . | . | . | . |
| *Hieracium murorum* | . | . | + | + | + | . | . | + | . | . | . | . | . | . | . | . | . | 1 | 2 | + | . | . | . | . | . | . | . | . |
| *Larix decidua* | . | . | . | . | . | . | + | . | . | . | . | . | . | . | . | . | 1 | 2 | 2 | 2 | 2 | 2 | . | . | . | . | . | . |
| *Viola hirta* | . | . | . | . | . | 1 | + | + | . | . | . | . | . | . | . | . | 2 | . | 1 | 1 | + | 2 | . | . | . | . | . | . |
| *Rubus idaeus* | . | . | . | . | . | 1 | . | . | . | . | . | . | . | . | . | . | . | . | 2 | 1 | 1 | . | . | . | . | . | . | . |
| *Picea excelsa* | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | 2 | 3 | 1 | . | . | . | . | . | . | . | . |
| *Juniperus communis* ssp. *nana* | . | . | . | . | . | . | . | + | . | . | . | . | . | . | . | . | . | . | . | . | . | 1 | . | . | . | . | . | . |
| *Luzula sylvatica* | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | 2 | . | . | . | . | . | . | . | . | . | . |
| *Vaccinium myrtillus* | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | 2 | . | . | . | . | . | . | . | . | . | . |
| *Cotoneaster integerrimus* | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | + | . | . | . | . | . | . | . | . | . | . |
| *Rhododenron ferrugineum* | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | 1 | . | . | . | . | . | . | . |
| *Lonicera caerulea* | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | 1 | . | . | . | . | . | . | . |
| **cl. Elyno-Seslerietea** | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| *Biscutella laevigata* | + | + | . | . | . | . | . | . | + | + | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| *Senecio doronicum* | + | . | . | . | . | . | . | . | + | + | + | 1 | . | . | 1 | 1 | . | . | . | . | . | 1 | 1 | + | 1 | 1 | . | . |
| *Acinos alpinus* | . | . | . | . | . | . | + | + | . | . | . | . | + | + | . | . | . | . | . | . | . | . | + | + | + | 2 | . | . |
| *Anthyllis vulneraria* ssp. *alpestris* | . | . | . | . | . | . | . | . | . | . | . | . | 1 | + | . | . | . | . | . | . | . | . | + | + | . | . | 2 | 2 |
| *Erigeron alpinus* | . | . | . | . | . | . | . | . | . | . | . | . | + | + | . | . | . | . | . | . | . | . | . | . | . | + | + | 1 |
| *Plantago maritima* ssp. *serpentina* | + | + | . | . | . | . | . | . | . | . | . | . | . | . | 1 | 2 | . | . | . | . | . | . | . | . | . | . | . | . |
| *Bupleurum ranunculoides* | . | . | . | . | . | . | . | . | + | . | . | . | + | + | . | . | . | . | . | . | . | . | . | + | . | . | . | . |
| *Minuartia recurva* | . | . | . | . | . | . | . | . | . | . | . | . | . | + | . | . | . | . | . | . | . | . | . | . | . | . | + | + |
| *Oxytropis campestris* | . | . | . | . | . | . | . | . | . | + | . | . | . | . | . | . | 1 | + | . | . | . | . | . | . | . | . | . | . |
| *Gentiana verna* | . | . | . | . | . | . | . | . | . | . | . | . | . | + | . | . | . | . | . | . | . | . | . | . | . | . | + | + |
| **cl. Caricetea curvulae** | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| *Festuca varia* | 2 | 1 | . | . | . | 2 | . | . | 3 | 3 | . | 1 | 3 | . | 3 | 3 | . | . | . | . | . | . | 3 | 3 | 3 | 3 | . | . |
| *Centaurea uniflora* ssp. *nervosa* | + | + | . | . | . | . | . | . | 1 | . | + | + | . | . | 1 | 1 | . | . | . | . | . | 1 | 2 | 1 | . | + | . | . |
| *Trifolium montanum* | . | . | + | + | . | + | . | . | . | + | . | . | . | . | . | . | 1 | . | . | 1 | . | + | . | . | + | . | . | . |
| *Sempervivum arachnoideum* | . | . | . | . | . | . | . | . | . | . | . | + | . | . | + | . | . | . | . | . | . | . | + | + | + | . | 1 | 2 |
| *Laserpitium halleri* | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | 1 | 3 | . | . | . | . | + | 1 | 2 | . | + | . | . |
| *Potentilla aurea* | . | . | . | . | . | . | . | . | . | + | . | + | . | . | . | . | . | . | . | . | . | . | . | . | . | + | 2 | 2 |
| *Potentilla grandiflora* | . | . | . | . | . | . | + | + | . | + | . | . | . | . | . | . | . | . | . | . | . | + | . | . | . | . | . | . |
| *Carex curvula* | . | . | . | . | . | . | . | . | . | . | . | . | 1 | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| *Festuca halleri* | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | 3 | 2 |
| **companion species** | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| *Hieracium pilosella* | . | 1 | . | . | . | . | + | . | 2 | 2 | . | + | . | . | 2 | 1 | . | . | . | . | . | . | . | 2 | . | + | . | . |
| *Dianthus seguieri* | + | + | . | . | . | . | . | . | . | + | . | . | . | . | + | . | . | . | . | . | . | . | . | . | . | . | . | . |
| *Plantago alpina* | . | . | . | . | . | . | . | . | . | . | . | . | . | 1 | . | . | . | . | . | . | . | . | . | . | . | . | 1 | 2 |
| *Trifolium repens* | . | . | + | + | . | . | . | . | . | . | . | . | . | . | . | . | . | 1 | . | . | . | . | . | . | . | 2 | . | . |
| *Silene rupestris* | . | + | + | + | . | . | . | . | . | . | + | . | . | . | + | . | . | . | . | . | . | . | . | . | 2 | 1 | . | . |
| *Sempervivum tectorum* | . | . | . | . | . | . | . | . | . | . | . | + | . | . | . | + | . | . | . | . | . | . | . | . | . | 1 | . | . |
| *Cerastium arvense* | . | . | . | . | . | . | . | . | + | + | . | . | . | . | . | + | . | . | . | . | . | . | . | + | . | . | . | . |
| *Carlina acaulis* | . | . | . | . | 1 | + | . | . | 1 | . | + | + | + | + | . | . | . | . | . | . | . | . | . | . | 1 | . | 2 | 3 |
| *Leucanthemum adustum* | . | + | + | + | + | + | . | . | . | . | + | . | . | . | . | . | 1 | + | + | . | . | . | + | + | 1 | + | . | . |
| *Hieracium glaciale* | . | . | . | . | . | . | . | . | . | . | . | . | + | + | . | . | . | . | . | . | . | . | . | . | . | . | 2 | 1 |
| *Anthoxanthum odoratum* | . | + | . | . | . | . | . | . | + | . | . | + | . | + | . | . | . | . | . | . | . | . | + | + | 1 | + | . | . |

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