1 An Outline of Europe's Alpine Areas

G. Grabherr, L. Nagy and D.B.A. Thompson

Geographers, biologists, meteorologists, mountaineers and a large range of other groups of people each have their views on what is 'alpine'. Some think of particular mountains such as the 960-km-long Alps separating southern and central Europe, whilst others think of specific ranges such as the Tyrol, Pyrenees, or the Dinaric Alps. This book considers all of the 'alpine' areas of Europe, and defines qualifying ecosystems as those lying at or above the 'tree line'. We define the tree line as the connection between the highest elevation groups of trees [which form distinct patches and are at least of 3-m height, Körner (1999); Table 1.1]. This connecting line falls within the tree-line ecotone, which ranges from the timberline (the upper limit of the montane forest) and the tree species line (the upper limit of isolated individual trees). The tree line, as defined here, is a climate-driven boundary, often modified or displaced by land use activities. Given that climate-defined tree lines are sometimes absent, some authors have tried to define vegetation zones or belts by using climatic parameters alone (e.g. Holdridge 1947; Rivas-Martinez 1995). This should, however, be supported by true climate measurements such as those reported by ALPNET (Chap. 2).

Mountain ranges provide a variety of climatic conditions and ecosystems. Variation in topography and altitude create steep gradients in temperature, patchiness of moisture and nutrient availability, variable degrees of wind exposure and uneven, seasonal snow cover. In addition, variation in geological substrata, soil and cryological processes are among the major natural sources of habitat diversification. The biological richness of high mountain ecosystems is a result of the various combinations of these physiographic factors with the effects of human management. The biological richness of mountain biota exceeds that of many in the lowlands (Grabherr et al. 1995; Grabherr 1997). On a global scale, the alpine life zone covers ca. 3 % of the land area and accounts for about 4 % of all higher plant species (Körner 1995) whilst, on the European scale, the latter figure is ca. 20 % (Chap. 5). The associated macro- and micro-fauna also make a considerable contribution to the biological diversity of this life zone (Chaps. 12–17); for a review of microorganisms,

Ecological Studies, Vol. 167
L. Nagy, G. Grabherr, Ch. Körner,
D. Thompson (Eds.), Alpine Biodiversity in Europe

Table 1.1. Working definitions adopted for alpine areas in Europe and formally used by ALPNET

Feature	Definition adopted for ALPNET
Linear	
Line of closed arborescent vegetation	The line where the closed forest (cf. timber line or forest line) or abutting scrub (formed by e.g. *Pinus mugo, Alnus viridis, Genista*) ends, as seen from a distance
Tree line	The line where closed groups of trees taller than 3 m end. This is readily visible on many high mountains in N Europe
Tree species line	The line beyond which no individuals of a tree species occur
Altitudinal zone	
Tree-line ecotone	The zone between the forest line and tree species line
Alpine	The zone between the tree line and the upper limit of closed vegetation (cover >20–40 %); vegetation is a significant part of the landscape and its physiognomy
Lower alpine	The zone where dwarf-shrub communities are a significant part of the vegetation mosaic (incl. the thorny cushion formations of the Mediterranean mountains)
Upper alpine	The zone where grassland, steppe-like and meadow communities are a significant part of the vegetation mosaic
Nival	The zone of open vegetation above the upper alpine zone; no predominating life form with frequent cushion and small rosette plants; vegetation is not a significant part of the landscape and its physiognomy
Alpine-nival ecotone (subnival)	The transition between the upper alpine zone and the nival zone; coincides with the permafrost limit

see Broll (1998). As we shall see later in the book, much of this richness derives from particular facets of the alpine environment.

The definitions of elevation zones and boundaries adopted for ALPNET are listed in Table 1.1. These definitions aid the synthesis on a continent-wide scale by reducing the ambiguities associated with the different terms relating to altitude belts or zones (especially the sub-alpine). The tree-line ecotone is used synonymously with what is often called subalpine. As the term subalpine has been used for a wider altitude range than just the tree-line ecotone its use is avoided in this volume as far as possible. (For nomenclature traditionally used by researchers in the Alps, see, e.g., Löwe 1970; Reisigl and Keller 1987; Ellenberg 1988, 1996 or Ozenda 1994; and for Scotland, see Horsfield and Thompson 1996).

1.1 The Mountains of Europe

The mountains of Europe are of old worn-down or young rugged type (e.g. Hubbard 1937). The oldest are those of the Caledonian range: the Kiolen range of Norway and Sweden, and the Scottish Highlands, which date back to the Precambrian (~500 million years). The other old mountains of the Variscan or Hercynian system (Meseta, Massif Central, Vosges, the Black, Thuringian and Bohemian Forests, Harz and Erzgebirge, and the Sudetes) and of the Urals are of younger Palaeozoic (c. 355–290 million years) origin. The young, rugged mountains, such as the Sierra Nevada, Pyrenees, the Balearic mountains, the Alps, Apennines, Dinaric Alps, Carpathians, the mountains of Greece (incl. Crete) and the Caucasus, were largely shaped in the Cenozoic (ca. 1–12 million years), in most cases, by several uplifts. Some of the Hercynian massifs (parts of the N and S Carpathians, Corsica and Sardinia) were also involved in the Alpine folding. Past (e.g. Caucasus) and recent volcanism (Mt. Etna) was – and is – locally important.

The largest ranges include the Scandes, Urals, Caucasus, Carpathian mountains, Alps, Dinaric Alps together with the Hellenides, Apennines, and the Pyrenees-Cantabrian mountain complex (Ozenda 1994). The largest alpine areas are found in the highest ranges of the Alps and the Caucasus. The smaller ranges include the Sierra Nevada and the Baetic mountains, the central Iberian mountains, the Jura, Rhodope, and Balkan. Small alpine areas are also present in the central European Hercynian mountains.

Glaciation has played an important role in shaping landforms and watercourses, especially in the Highlands of Scotland, Scandes, Pyrenees and Alps. Glaciation occurred also in the Mediterranean mountains, although mostly restricted to the highest peaks. There is clear evidence of glaciation in, for example, Corsica (Gauthier 2000) and the Sierra Nevada (Gomez Ortiz and Salvador Franch 1998).

Elevation and relief have important implications for the amount of rainfall, the proportion of rain to snow, persistence of snow, temperature and exposure to sunshine. Geomorphology or relief may modify and locally overrule climatic factors in determining the ecology of an area. For example, steep slopes may impose topographic limits on the distribution of trees or closed grasslands at altitudes below their climatic limits. The main features of the individual ranges are listed in Table 1.2.

1.2 An Ecological Classification of Europe's Alpine Areas

For an ecological classification of Europe's high mountains two criteria are of particular relevance: (1) the geographical position of the different life zones, and (2) their elevation (Figs. 1.1 and 1.2). Four major types of alpine life zone can be distinguished: Mediterranean, temperate, boreal, and arctic (Fig. 1.1). The mountains of the Canary Islands and the Azores deviate in many respects from mainland Europe and are not considered in detail here. The regional accounts (Chaps. 3.1–3.10) provide comprehensive details on the alpine areas, and additional information is found in Ozenda (1985, 1994), Ellenberg (1988, 1996) and Wielgolaski (1997). Below we synthesise some of the over-arching points that help define common and contrasting features of Europe's alpine areas.

Boreal and arctic alpine environments receive moderate snow in winter and are characterised by severe frosts. In the summer, long days result in an extended light period that may selectively favour certain adapted plant species. The tree line in the European boreal mountains, in contrast to the conifer forest of the mountains of continental Siberia, is formed by birch (*Betula pubescens* spp. *czerepanovii*). Mixed dwarf-shrub heath with dwarf birch (*Betula nana*) and shrubby willows cover large areas within the tree-line ecotone. Above this, ericaceous dwarf-shrub heath (*Vaccinium* spp., *Empetrum hermphroditum*) appears, replaced at higher elevations by fell-fields with small cushion plants and creeping dwarf shrubs (e.g. *Diapensia lapponica*, *Loiseleuria procumbens*), sedges (e.g. *Carex bigelowii*) and rushes

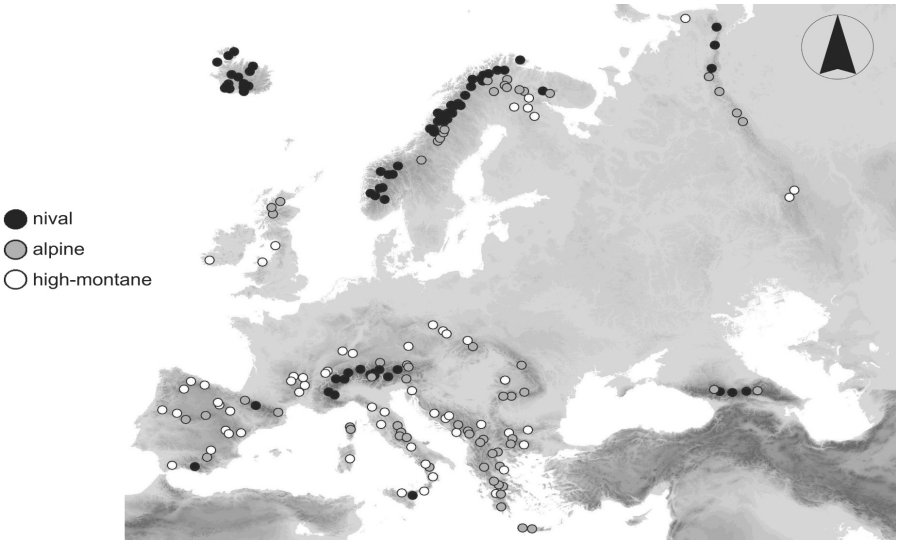

Fig. 1.1. Elevational characterisation of Europe's high mountains

(e.g. *Juncus trifidus*). The lack of deep snow cover allows cryoturbation, and solifluction and gelifluction on slopes, all of which are active on the fell-fields. Patterned ground expands over large areas. Huge desert-like, block fields, known as gol'tsy, are typical for the northern Ural Mountains. The smooth relief of most boreal mountains gives rise to glacier cover almost throughout the nival zone. A few nival plant assemblages can occupy sunny niches on some nunataks. The alpine zone in the arctic (e.g. the mountains of Spitsbergen) starts at sea level, where it is almost identical to the zonal tundra, which gradually grades into polar mountain desert. The mountains of Iceland are unique because of their volcanic nature, but show typical alpine elevation zones where not affected by human disturbance.

Temperate mountains are often characterised by heavy snow accumulation which provides protection from deep soil frost. A distinctive series of plant communities can be related to snow cover and snow lie. Avalanche pathways interrupt the tree line at many sites. The tree-line trees are coniferous species of alpine-boreal origin (*Larix decidua*, *Picea abies*, *Pinus cembra*). Some species are specific to particular parts, e.g. in the Pyrenees where *Pinus uncinata* is the only conifer at the tree line, in the Caucasus (with the endemic *Betula litwinowii* or *Picea orientalis* at the tree line), and the *Pinus mugo* scrub in the Eastern Alps, the Carpathians and the Dinarids (with *Alnus* scrub on snow-rich slopes). Temperate alpine vegetation consists of dwarf-shrub communities at and immediately above the tree line. Most areas of the alpine zone are occupied by a variety of graminoid-dominated communities that are commonly called alpine grasslands, although the predominance of sedges (*Carex* spp.) or rushes (*Kobresia=Elyna myosuroides*, *Juncus* spp.) indicates

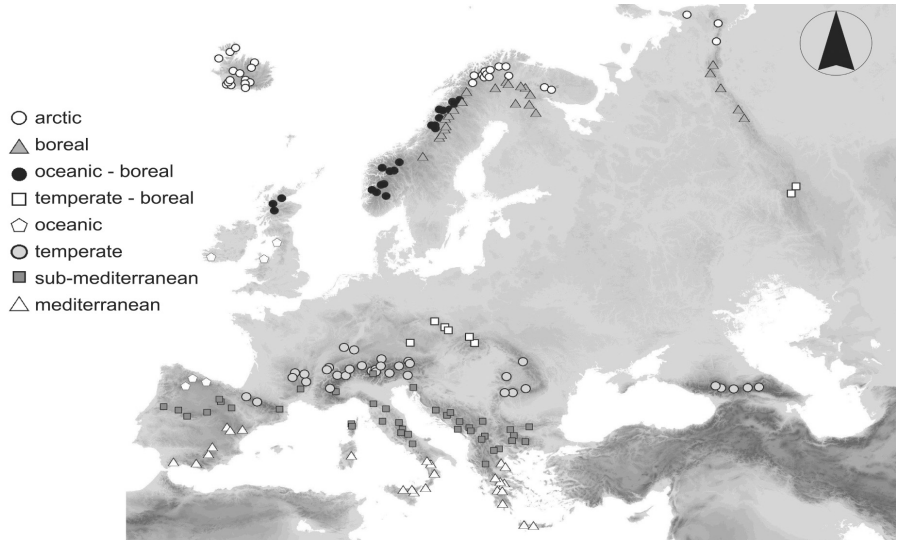

Fig. 1.2. Life zone classification of the European high mountains