Geobotany Studies
Basics, Methods and Case Studies

George Nakhutsrishvili
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Eva Spehn
Christian Körner *Editors*

Plant Diversity in the Central Great Caucasus: A Quantitative Assessment

Springer

Geobotany Studies

Basics, Methods and Case Studies

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Foreword

The Great Caucasus is well known for its spectacular flora. A rich topography and geology, steep climatic gradients, and the position between the flora regions of Asia, Europe, and the Mediterranean have contributed to evolution of this biodiversity hotspot. In total, 6350 vascular plant species occur in the Caucasus, including more than 2900 endemic species. The Great Caucasus represents all elevational vegetation belts from semideserts of the Caspian Sea depression (−28 m a. s. l.) to the nival belt of the ice-capped Mt. Elbrus (5642 m a.s.l.).

This book is based on extensive botanical-ecological research in the Central Great Caucasus, the Kazbegi region in particular. Community ecological field surveys during the last 50–60 years have created knowledge and an extensive vegetation database that is synthesized in this volume. Botanists have visited and surveyed the flora and vegetation of that region over more than 200 years. Most of these earlier works were facilitated by the ancient North-South road which crosses the Central Great Caucasus at its eastern border. Among the first who traveled in these mountains in 1770 was the naturalist J. A. Gueldenstaedt. Later, this region was visited by numerous outstanding botanists, like M. F. Adams, A. A. Mussin-Pushkin, J. J. F. W. Parrot, K. H. E. Koch, F. J. Ruprecht, G. F. R. Radde, N. A. Desulavi, A. Rehman, and B. F. Busch, who made valuable herbarium collections. The first botanical survey that took a community approach was that by Seifriz (1931) in the Kazbegi region in the early twentieth century. Detailed and systematic studies have begun only since 1928 when the prominent Georgian botanist A. Kharadze pioneered this field. She collected rich herbarium material and described many new species. She was assisted by the local resident botanist E. Khutsishvili. These rich collections laid the foundation for a first synopsis of the flora of vascular plants of the Kazbegi region (Sakhokia and Khutsishvili 1975). A number of regional assessments of flora and vegetation of this part of the Central Great Caucasus were published by Kharadze (1944, 1948a, b, 1965), Kimeridze (1965a, b), Sakhokia (1983), Nakhutsrishvili (1971, 1974, 1999, 2003, 2013), Gamtsemlidze (1979), Nakhutsrishvili and Gamtsemlidze (1984), Bedoshvili (1985), Nakhutsrishvili et al. (1990, 2005, 2006), Zazanashvili (1990), Kikvidze and Nakhutsrishvili (1998), Zazanashvili et al. (2000), Shetekauri (1999), Shetekauri et al. (2012), Tephnadze et al. (2014), and Abdaladze et al. (2015).

The Foundation of the “Kazbegi High-Mountain Research Station” in 1969 under the leadership of the well-known Georgian Botanist Niko Ketskoveli played a key role for the research activities in this area. Located at 1800 m a.s.l. at the oustskirts of the town of Kazbegi (now named Stepantsminda), this station became a focal point for decades of plant eclogical research. Soon, the Stepantsminda station attracted researchers from all over the world and became an international center for high-mountain research. In the 1970s, Prof. W. Larcher (University of Innsbruck, Austria) introduced experimental research in high-mountain plant ecology at this station which led to works by the Austrian scholars Prof. A. Cernusca and Prof. C. Körner and the establishment of a young generation of Georgian botanists under the leadership of Prof. Nakhutsrishvili (Gamkrelidze 1986; Sanadiradze 1986; Abdaladze 1987; Kikvidze and Abdaladze 1988). More recently, Prof. C. Körner and Dr. E. Spehn (University of Basel, Switzerland) facilitated research projects on the functional significance of biodiversity in the Kazbegi region. One outcome of these works was a project supported by the Swiss National Science Foundation in cooperation with the Swiss Agency for Development and Cooperation (SCOPES programme), the aim of which was a digital assessment of a 40-year series of phytosociological studies and collection of vegetation data in the Kazbegi region (in essence digitizing G. Nakhutzsrishvilis's field books), which is part of this book. The digital data cover the central part of the Great Caucasus range, specifically the geographical region of Kazbegi (1400–3700 m a.s.l.), Mamisoni Pass (2750–3650 m a.s.l.), and the subnival belt (3000–3750 m a.s.l.) of Mt. Elbrus. Prof. E. Hübl, Prof. F. Ehrendorfer, Prof. M. Fischer, Prof. O. Hegg, and Prof. A. Otte participated in vegetation surveys in the Kazbegi region.

With this volume, we hope to establish a reference for future botanical works in the Great Caucasus. The data collected here also represent a Georgian contribution to regional assessments of Biodiversity in the context of IPBES (the International Program on Biodiversity and Ecosystem Services). We also aimed at drawing a wider picture by comparisons with the European Alps. Hence, we also hope that larger scale surveys and comparative works in evolutionary biology and ecology will profit from this assessment. Last but not least, this volume compiles evidence that may assist in conservation policy for this fragile mountain world.

Tbilisi George Nakhutsrishvili
October 2016 Christian Körner

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A Geostatistical and Bioclimatological Comparison of the Central Great Caucasus and the Central Alps

1

Christian Körner and Jens Paulsen

1.1 Introduction

Although almost 3000 km apart, the Great Caucasus at the eastern edge of Europe and the Alps in central Europe share a common young geological age, an approximative W-E orientation, they both belong to the Eurasian mountain chain that formed and is still forming as a result of southern continents pushing northwards. Using a 1000 m elevation minimum, the Great Caucasus is stretching from 41° 15′ N to 43° 45′ N (central part at 43°N) and the Alps from 44° 10′ N to 47° 40′ N (central part at 46° 30′N), with both chains belonging to the temperate zone (Fig. 1.1). The Alps experience a stronger maritime and the Great Caucasus a more continental influence. Both ranges divide the weather systems into northern and southern climates, and both show strong precipitation gradients. In the Great Caucasus this is a NW-SE gradient, in the Alps (with some exceptions) a N-S gradient, ranging from around 2000 mm per year to less than 500 mm at places. Both mountain systems show a mass elevation effect ('massenerhebungseffekt'), with a higher elevation of isotherms in the interior parts compared to front ranges, and a dry, step-type climate in parts of their deep central valleys. Yet, the Caucasus forms a single main divide with a series of side valleys on either side, whereas the Alps have several chains in parallel, permitting a more pronounced mass elevation effect to occur in its interior valleys. The maximum elevation is similar, with the highest peak of the Great Caucasus, Mount Elbrus 5642 m, and that of the Alps, Mont Blanc 4809 m. Yet, some of the highest peaks in the Caucasus are former volcanoes (Mount Kasbek with 5047 m, is one of them, in the core study region of this volume), whereas in the Alps, all summits are tectonic summits.

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Fig. 1.1 The geographical position of the Great Caucasus and the Alps. The *cross-sectional lines* indicate the part that is considered 'central' in both mountain ranges. The content of this volume is focusing on that central part of the Great Caucasus

From a biogeographical point of view, these well separated mountain systems are interesting, because both are continental centers of biodiversity, they share a good deal (20–30%) of the same flora (the same or very closely related plant species), but also differ in the origin of other parts of their flora, with the Alps exhibiting a stronger influence of Arctic elements and the Caucasus showing a stronger affiliation to central Asia (see Chap. 3). Although the mountains of the Balkan and the Carpatians form a bridge that may have been stronger during glacial periods, the great geographic distance, as well as the moderate elevation of most of these intermitted mountains, and a missing mountainous continuum, caused a high degree of floristic separation. What happened to the widely separated, but partly common flora in these two mountain systems over the presumably several recent millions of years of isolation from each other? Which common traits have been retained, which got lost? This 'experiment by nature' opens fascinating terrain for evolutionary biologists.

Here, we offer a comparative, rather basic, geophysical assessment of the nature of these two mountain systems. The analysis should help bringing the geobotanical studies presented in this volume for the central Great Caucasus in perspective to what is known for the Alps, characterize the elevation structure and biogeographic belts of the two mountain systems from a climatological perspective, and define the geographical space this book is focussing on. We used the world topography and the climate data base by WorldClim for driving a bioclimatic model that permits stratifying biogeographic belts by climatic criteria (Körner et al. 2011; Paulsen and Körner 2014).

1.1.1 The Elevation Structure of the Great Caucasus and the Alps

The total area of the Caucasus and the Alps is 132,000 km^2 versus 188,000 km^2. This area is for the entire mountain system each, including all interior low elevation terrain and the hill slopes in the periphery. This is the area a physical atlas would show in brown (for higher) and yellow (for lower) mountain terrain. If a line is drawn by best guess around these mountain territories (a mountain 'polygon'), these are the numbers for areal coverage that emerge. We will discuss later how that area could be separated into 'true' mountain terrain and other terrain. The total mountain polygon area of these two mountains is thus, roughly 3 times and 4.5

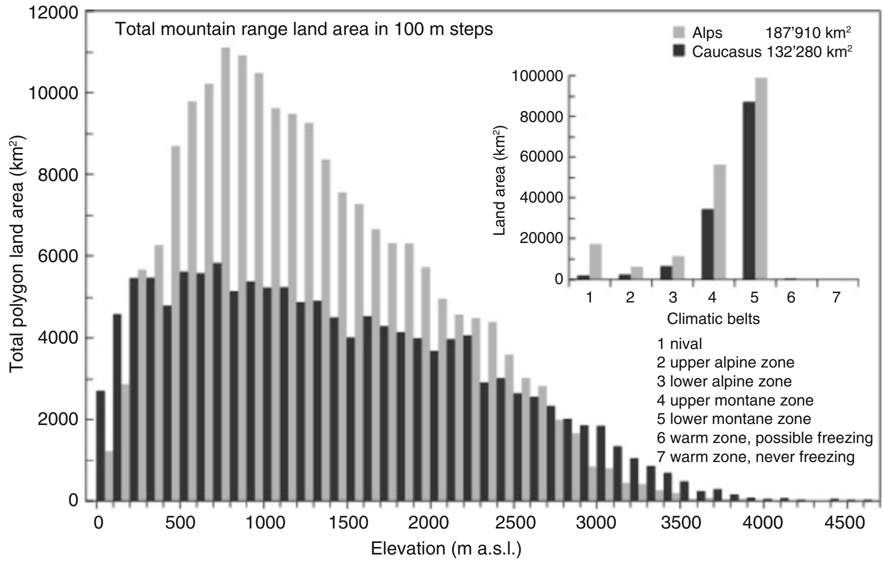

Fig. 1.2 Elevational distribution of land area in the Caucasus and the Alps, based on the entire mountain polygon area

times the size of Switzerland or almost 2 times and 2.5 times the size of the Republic of Georgia. If this land area is subdivided into terrain belonging to different elevations in 100 m steps from sea level upward, the most abundant elevations (greatest land area fractions) are found at 300–1500 m of elevation in the Great Caucasus (median around 800 m), and between 600 and 1200 m of elevation in the Alps (median around 800 m; Fig. 1.2).

The obviously skewed distribution towards high frequencies of lower elevations reflects the simple fact that these are geologically young mountains, with mountain terrain gradually shrinking as one moves upslope, which in itself bears a biogeographically interesting effect, namely that the land area available per climatic belt, on average, also narrows (Körner 2007). At smaller scales or in older mountains with high plateaus (e.g. Tibet) such elevation trends of land area are less continuous. Unexpectedly, that left skewed distribution in Fig. 1.2 is more pronounced for the Alps.

If the analysis is restricted to the central part in E-W direction (excluding the less high 'tails' of each range, also belonging to different climatic districts) and to elevations that come closer to what many people might consider 'proper' mountains, the picture changes. We first truncated the central parts as defined in Fig. 1.1 and then included all land area above a certain minimum elevation. This minimum elevation was obtained by first modelling the elevation of the potential upper treeline [using the model by Paulsen and Körner (2014)] and then subtracting 1000 m of elevation from the elevation of the local potential treeline in a 2.5′ grid of geographical resolution. Because the potential treeline is commonly above 2000 m

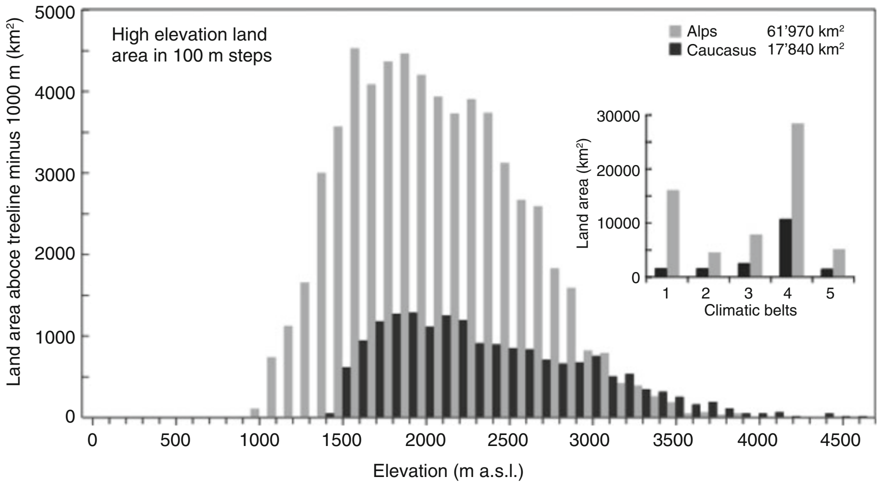

Fig. 1.3 Elevational distribution of land area in the central Great Caucasus and the central Alps as defined in Fig. 1.1, and within that central area, including all land that is above a line that is 1000 m below the respective upper potential limit of forest trees, the treeline, as obtained by a model (Paulsen and Körner 2014). By coincidence, this cuts off the elevations below ca. 1000 m a.s.l. in the Alps and below ca. 1500 m a.s.l. in the Great Caucasus. This procedure ensures comparisons of climatically similar strata, anchored at the potential (bioclimatic) treeline elevation

elevation in the Alps and above 2500 m in the Caucasus, this climate oriented procedure yields a lower delineation at ca. 1000 m a.s.l in the Alps and at ca. 1500 m a.s.l in the Great Caucasus. The land area above this lower limit is 17.800 km^2 in the section of the Great Caucasus defined as 'central' and 62.000 km^2 in the corresponding part of the Alps. This procedure includes (besides all terrain above the potential treeline) all of the upper montane belt (including so-called 'sub-alpine' land), but is disregarding much of what can be considered a lower montane belt and the so-called colline belt (Fig. 1.3). Since the E and W cut of the ranges just followed a pragmatic by eye procedure, simply meant to provide a basis at which the bioclimatic belts (see below) can properly be compared, these absolute land area sizes have not much meaning. This procedure excludes the semi-arid eastern (Caspian) and the wet western (Colchian) part of the Great Caucasus, and in the Alps, the lower elevation eastern part and the sub-Mediterranean western part.

1.1.2 A Bioclimatic Stratification of the Caucasus and the Alps

Based on the data as shown in Figs. 1.2 and 1.3, elevation in meters was replaced by a temperature regime that accounts for the position of the climatic treeline as modelled by Paulsen and Körner (2014), and using climate-only defined belts above and below the potential treeline. The phrase 'potential' treeline is important here, because in many parts of the Alps, and even more so in the Caucasus, trees are absent from the climate treeline due to land use (see next section for treeline).

It is important that a bioclimatological stratification of life zones (or belts) in mountains accounts for actual temperatures and is anchored at a robust biogeographic reference line that, if present, can be clearly depicted by an observer. As a life form-, rather than a species-limit, the potential treeline occurs globally at a similar isotherm, hence using this treeline isotherm also permits a global comparison. Neither do organisms respond to meters of elevation, nor do elevations match with the same temperature in different parts of the world, particularly when latitudinal contrasts come into play, or if the mass elevation effect is strong. For the details of this approach, we refer to Paulsen and Körner (2014) and a discussion in Körner (2012). In brief, it was found that trees can only grow at high elevation, when the seasonal mean temperature is above 6.4 °C over a growing season of at least 3 month, with days belonging to the growing season defined by a daily mean temperature of 0.9 °C or above (which includes warmer hours during a day and cooler ones at night). The season length algorithm also accounts for snow pack and water availability. The numbers and thresholds represent a best fit obtained by a global GIS based survey (Paulsen and Körner 2014) that confirmed an earlier survey using ground truth data (using data loggers; Körner and Paulsen 2004).

Using this concept, we can define the area covered by climatic belts for the Great Caucasus and the Alps for the terrain as defined either in Fig. 1.2 or 1.3. Note that growing season (GS) and the growing season temperature (GT) regime are defined here via the WorldClim data base, which is using climatic envelopes based on air temperature data from weather stations. The regional climate derived that way is a good proxy for what trees experience, but the microclimate among short stature plants may deviate substantially from such extrapolations (Scherrer and Körner 2009, 2011).

In this GIS analysis, the life zones (climatic belts) are defined as follows from top (highest) to bottom (lowest belt):

1. The nival belt: GS $\leq$ 10 days, with growing season as defined above
2. The upper alpine belt: GS 10–59 days, or at GS $>$59, seasonal mean GT $<$3.5 °C
3. The lower alpine belt: GS 60–93 days, or GT 3.5–6.4 °C
4. The upper montane belt: GS $\geq$ 94 days, GT 6.4–10.0 °C
5. The lower montane belt: GS $\geq$ 94 days, GT 10.0–15.0 °C
6. The colline belt: GS $\geq$ 94 days, GT $>$15.0 °C

There is no upper limit defined in 1, hence this category can include vast terrain with no higher plant life, depending on the height of a mountain. The temperature steps selected, convert to ranges of elevation (with some regional variation) of ca. 500 m for the lower alpine belt, ca. 550 m for the upper montane belt, and to ca. 900 m for the lower montane belt (applying a common T laps rate of 0.55 K per 100 m). Table 1.1 shows the land area falling in each of these climatic belts. The climatological range defined as lower montane includes terrain that largely falls

Table 1.1 Land area (km^2, in brackets %) of different climatic belts in the Great Caucasus and the Alps, separated by either the total polygon area ('total') as shown in Fig. 1.2, or for the central parts ('central-high') for elevations above a line 1000 m below the respective potential treeline position (as in Fig. 1.3)

Climatic belt	Total polygon		Central-high polygon	
	Caucasus	Alps	Caucasus	Alps
1	1979 (1.5)	16,840 (9.0)	1568 (8.8)	16,060 (25.9)
2	2378 (1.8)	5627 (3.0)	1555 (8.7)	4523 (7.3)
3	6230 (4.7)	10,772 (5.7)	2543 (14.3)	7843 (12.7)
4	34,229 (25.9)	55,877 (29.7)	10,720 (60.1)	28,418 (45.9)
5	86,960 (65.7)	98,607 (52.5)	1453 (8.1)	5126 (8.3)
6	501 (0.3)	185 (0.1)	–	–
Sum	132,276 (100)	187,909 (100)	17,839 (100)	61,969 (100)

1 for nival, 2 upper alpine, 3 lower alpine, 4 upper montane, 5 lower montane, 6 below 5. Note, the central-high category, includes only a small fraction of the lower montane belt, the reason, why the numbers become so small in 6.

below the 'treeline-minus-1000 m' criterion defined for the 'central-high' part of the Alps and the Great Caucasus.

The seemingly discontinuous trend in the nival belt is related to the thermal thresholds chosen and the fact that a lot of land area occurs in the land above, which was not further stratified into climatic belts. As can be see from Table 1.1, 31.8% of the land in the central Great Caucasus above ca. 1500 m a.s.l falls into alpine land and higher. In the Alps the climatically corresponding fraction above ca. 1000 m a. s.l is 45.9%. Correspondingly, two thirds (Caucasus) and about one half (Alps) of that terrain is 'montane'. The nival-and-above belt of the Alps is clearly much larger both in absolute and relative terms than that in the Caucasus. Conversely, the upper montane territory (including all so-called sub-alpine land) is much larger in relative terms in the central Great Caucasus. These relative contributions of climatic belts can be compared between the Alps and the Caucasus, because the lower limit of the land area used for this statistics was defined by one common lower bioclimatic boundary anchored at the climatic treeline. By these measures, the Alps have a greater fraction of 'very cold terrain', but most of this is beyond (above) the zone with a significant plant cover.

1.1.3 The Treeline Climate

Given that this bioclimatological assessment is anchored at the elevation of the potential treeline and the fact that there is a globally common treeline isotherm, it is of interest to explore the actual ground truth of the climate at the potential treeline in the Great Caucasus in comparison to that for the Alps, thus, validating the above assumptions. While the treeline is an obvious landscape feature of the Alps, this is not the case in the Caucasus. Millennia of pastoralism have led to the disappearance of the montane forest over large parts of the Great Caucasus, and gave way to vast

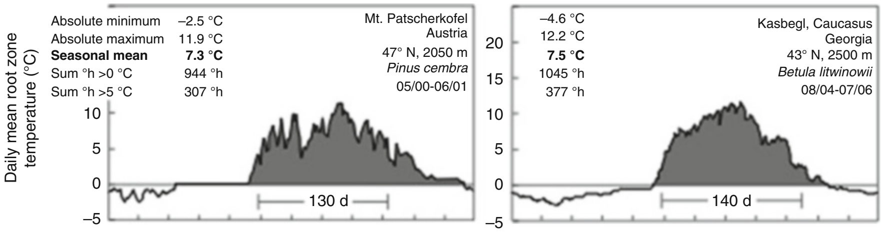

Fig. 1.4 The climate at the potential treeline in the central Great Caucasus and in the central Alps. For the Alps we show an example for Tyrol, but similar numbers were obtained at various other locations. Root zone temperature in complete shade corresponds to the weekly mean air temperature (see Körner and Paulsen 2004; Körner 2012)

grasslands of exceptional floristic diversity, a central theme of this volume. Only occasionally do isolated conifers (pines in inaccessible terrain) or *Betula litwinowii* thickets (maximum 3–4 m height) reach, what might represent a natural treeline position. For one of such locations we do have temperature records which were collected as part of a global survey (Fig. 1.4). The results do indeed place this location at 2500 m elevation at the foot of Mount Kasbek in a global context of treelines, with a seasonal mean temperature of 7.5 °C and a season length of 140 days. In comparison, temperatures recorded in the same way in the central Alps on Mount Patscherkofel, near Innsbruck, at 2050 m elevation, arrive at 7.3 °C and a season length of 130 days. A front range treeline site in the Swiss Alps at 1900 m a.s.l yielded 7.3 °C for a 150 day season.

Thus, we can conclude that the climatic treeline in the Great Caucasus occurs at the same isotherm as in the Alps, but at a ca. 400–500 m higher elevation. For the methods, how these temperatures were obtained, we refer the reader to Körner and Paulsen (2004). The fact that the seasonal mean temperatures at the climatic treeline at both the Caucasus and the Alps are ca 1 K warmer than the global mean treeline isotherm (corresponding to a ca. 150 m lower elevation), has two likely reasons: the global mean temperature for undisturbed, potential treelines includes some tropical sites with ca. 1 K lower temperatures at their seasonless treelines, and, the temperate zone in Europe has seen a 1.5 K climatic warming during the last 100 years, significantly exceeding the global mean climatic warming of 0.7–0.8 K. Hence, the current position of the high elevation limit of adult trees in Europe is likely to reflect a legacy of past, cooler climates, whereas both, ground truth climatic data and climate data bases for recent decades, reflect a substantial part of climatic warming during the past century, with the treeline position not yet tracking that climatic shift. It takes 50–100 years for trees to reach maturity at treeline. This also indicates that we should soon see significant examples of a climate driven upslope shift of the tree limit. Cohorts of young recruits above treeline should be growing into adult tree size, where soils and regional disturbance regimes permit.

These results permit a placement of field observations in climatic belts that can readily be compared with other parts of the world. A simple comparison by meters of elevation would not meet that requirement. In addition, we have no reason to assume that the strong microclimatic deviations between low stature plants and such atmospheric data as employed above, differ between the Great Caucasus and the Alps. We have focussed this analysis of bioclimatic life zones in the Alps and the Great Caucasus on temperature, because precipitation, though regionally variable, is not a prime driver of the bioclimate in the central part of both mountain systems as defined in Fig. 1.1. Exceptions are step-type, semi-arid climatic islands in interior valleys and gorges, such a large scale survey cannot capture.

1.1.3.1 Alpine Temperatures in the Great Caucasus in the Context of a Europe Wide Comparison

Since we have no year-round temperatures for open, high elevation grassland for the Great Caucasus, but grassland is the dominant vegetation in the upper montane (including the subalpine) belt and in the alpine belt, we here include results of a large European survey that covered the latitudes relevant here (Körner et al. 2003). This survey focused on alpine grassland ca 200–250 m above the climatic treeline, and it included 23 locations between Arctic and Mediterranean latitudes. For all practical reasons, the survey was built upon soil temperature in 10 cm depth. Such temperatures reflect the consequences of soil heat flux, driven by direct insolation on the short stature plant cover, and thus are closer to what plants experience than weather station data. These soil temperatures are also buffered against short term high and low excursions of air temperature, and also provide information on snow cover (related to the early and late season passing of a + 2 °C threshold). As can be seen in Fig. 1.5, seasonal mean temperatures under such alpine grassland 200–250 m above treeline and for the latitudes of the central Great Caucasus (eight sites between 41° 42′ to 44° 10′ N) are expected to be around 10.5 °C, which is 3 K warmer than corresponding temperatures at treeline (measured with the same method). The season length (as defined by the +2 °C threshold temperature) for these eight southern sites varies from 140 to 200 days, hence is as long or significantly longer as for trees at treeline.

It is well established that the actual life conditions in alpine grassland are warmer than in the crowns and the rooting zone of treeline trees (Körner 2012), hence, it does not come as a surprise that these grasslands are likely to operate around a 10.5 °C summer temperature compared to 7.5 °C at treeline. The reasons are purely physical. Trees are coupled to atmospheric conditions and low stature vegetation is decoupled aerodynamically. There is no reason to assume that the conditions in the alpine belt of the Great Caucasus deviate significantly from the data obtained for these eight southern European sites. In fact, the main message of the Europe wide assessment was that temperatures hardly vary among botanically defined alpine sites across a wide range of latitudes, and that local conditions

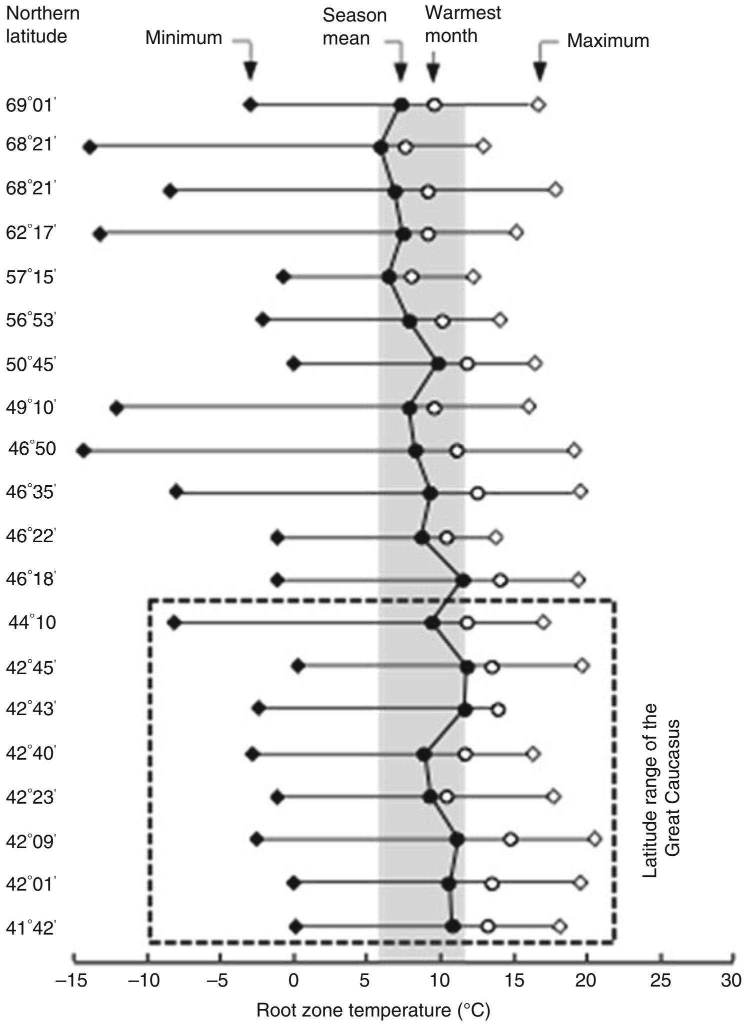

Fig. 1.5 A Europe-wide comparison of temperatures experienced by alpine vegetation, including the latitudes of the central Great Caucasus. For each latitude from left to right: absolute minimum, seasonal mean, warmest month mean, absolute maximum of temperature measured at 10 cm soil depth under grassland 200–250 m above the climatic treeline (from Körner et al. 2003)

(exposure) by far exceed the effect of latitude. The data evidence that treeless vegetation is substantially warmer than air temperature and that removing the montane forest, as has occurred over most of the central Caucasus, is also creating 'warmer' ecosystems, explaining the presence of many thermophilous taxa.

Vegetation of the Central Great Caucasus Along W-E and N-S Transects

2

George Nakhutsrishvili and Otar Abdaladze

The Great Caucasus covers a significant west to east climatic gradient along its main divide (see Chap. 1). The highlands of the western Caucasus are humid (up to 2200 mm of precipitation per year) and dominated by mesophilic taxa, the highlands of the eastern Caucasus are more continental, with dry summers and an increasing fraction of xerophylic taxa (<800 mm of precipitation per year). Half of the annual amount of precipitation falls on the cold season, therefore large areas of mountains are covered by perpetual snow and glaciers. The annual temperature amplitude is small. One of the features of the Caucasus high mountains, which distinguishes this mountain system from other mountains of Europe are sharp climatic and thus, vegetation changes over relatively small distances. An obvious example is a S-N transect along the 'Georgian Military Road'. This transect clearly shows how semi-desert vegetation becomes substituted by steppe, open arid woodland, mesophilous beech forest including the beech forest types with Colchic elements, then high mountain meadows, chiono- and kryophilous herbaceous and relict scrub communities even in snow-beds, and near-glacier micro-habitats. Within this transect local shelter by mountains can create is continental oroxerophilous vegetation islands. Interior valleys are protected from both cold and humid air mass penetration from the north explaining many relict xerophilous species of past xerothermic periods (Kharadze 1948).

The comparative analysis of the vegetation of two different macro-regions of the Great Caucasus, in particular, the western part of the Central Caucasus—Svaneti and Racha-Lechkhumi, and the Eastern part of the Central Caucasus—Kazbegi, indicates a clear difference between both regions. The major western landmark of the considered area is Mt. Ushba (4710 m) in Svaneti region, and major eastern

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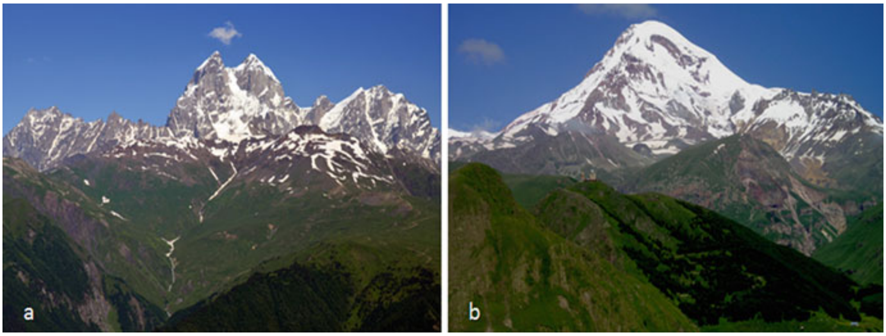

Fig. 2.1 (**a**) Mt. Ushba (4710 m a.s.l.; the major western landmark of the Central Great Caucasus; Svaneti region) and (**b**) Mt. Kazbegi (5047 m a.s.l.; the major eastern landmark of the Central Great Caucasus; Kazbegi region) (photos: O. Abdaladze)

landmark is Mt. Kazbegi (5047 m) in Kazbegi region (Fig. 2.1a, b). In the following we first provide a general floristic overview, followed by a description of individual vegetation units (Fig. 2.2).

2.1 Svaneti and Racha-Lechkhumi Regions

In Svaneti and Racha-Letshkhumi, mountain forests are well represented with characteristic Colchis elements. In particular, mountain coniferous forests with *Picea orientalis* and *Abies nordmanniana*, mixed deciduous forests of *Fagus orientalis* with *Rhododendron ponticum*, *Laurocerasus officinalis*, *Ilex colchica*, *Ruscus colchicus* as evergreen undergrowth. Here, as in the Colchis, at the upper tree limit, elfin woodlands ('Krummholz') are formed by *Fagus orientalis*, *Acer trautvetteri*, *Betula litwinowii*. On the southern slopes, *Pinus kochiana and Quercus macranthera* are common. In the highlands, shrubs are represented by *Rhododendron caucasicum*, *Salix kazbekensis* (wet slopes), *Juniperus communis* subsp. *hemisphaerica*, *J. sabina* (southern slopes). Subalpine tall herbfields are dominated by *Angelica tatianae*, *Heracleum ponticum*, *Cephalaria procera*, *Valeriana colchica*. The subalpine meadows consist of forbs, in particular, with endemics such as *Ranunculus helenae*, *R. lojkae*, *Pedicularis nordmanniana*, and others. Alpine meadows may exhibit a predominance *of Geranium gymnocaulon*, *Woronowia speciosa*, a plant typical of the Western Great Caucasus (Dolukhanov et al. 1946; Kharadze 1965; Gagnidze 1977; Gagnidze and Kemularia-Natadze 1985; Zazanashvili et al. 2000; Dolukhanov 2010; Margalitadze et al. 2015).

2.2 Kazbegi Region

The picture changes dramatically in the eastern part of the Central Great Caucasus—the Kazbegi region (Figs. 2.2, 2.3 and 2.4). It completely lacks the dark coniferous forests, the Colchis-type undergrowth, and the beech and alpine