Plant and Vegetation 17

Jalil Noroozi *Editor*

Plant Biogeography and Vegetation of High Mountains of Central and South-West Asia

Springer

Chapter 2
The Hindu Kush/Afghanistan

Siegmar-W. Breckle and M. Daud Rafiqpoor

Abstract Afghanistan is a mountainous country in C Asia with connections to S Asia. The main mountain ranges are the Hindu Kush with several partly isolated ranges, which diverge from NE to the W and SW. Deep valleys, basins and very high mountains form a complex mosaic of sites with contrasting climatic conditions. The Hindu Kush has significantly higher elevational belts than the Alps, the Caucasus, and the Iranian mountains. Thus, the ecological conditions are very diverse and are the reason for a high biodiversity and very diverse vegetation cover. The climate is high continental with hot summers and cold winters. Most regions are rather dry or even arid, having precipitation only during fall, winter or spring. However, the SE facing parts of the Hindu Kush in Nuristan, Nangarhar and Paktia (Safed Koh) receive additional summer-rains by monsoonal influence. Phytogeographically, those regions with their Himalayan influence had dense forests, whereas most other parts of the Hindu Kush have predominantly Irano-Turanian species with open woods, steppes or semi-deserts often with thorny cushion plants. The family Asteraceae has the most genera and species, and the genus *Astragalus* has the highest number of species. The upper elevational belts are home to some Siberian and boreal floristic elements. The most recent estimations of species numbers for Afghanistan are about 5000 species and 25% endemism.

Abbreviations

C	Central
E	East
K	Kelvin (Δ°C)
N	North

S.-W. Breckle (✉)
Department of Ecology, Bielefeld University, Bielefeld, Germany
e-mail: sbreckle@gmx.de

M. D. Rafiqpoor
Botanical Institute, University of Bonn, Bonn, Germany

J. Noroozi (ed.), *Plant Biogeography and Vegetation of High Mountains of Central and South-West Asia*, Plant and Vegetation 17,
https://doi.org/10.1007/978-3-030-45212-4_2

S	South
W	West
ITCZ	inner tropical convergence zone
NP	National Park
PET	Potential Evapotranspiration
P	Precipitation

2.1 Introduction

About half of Afghanistan is at altitudes of over 2000 m a.s.l. The highest point of the country lies in the main peak of the E Hindu Kush (Nowshaq, 7485 m a.s.l.) on the Afghan-Pakistan border, Tirich Mir being the highest peak of the Hindu Kush (7708 m a.s.l., in Chitral, Pakistan). Afghanistan has also a part of the Pamir plateau (Wakhan area) in the province of Badakhshan (Frankenberg et al. 1983).

The main high mountain range of Afghanistan is the Hindu Kush, the greater part of the E Hindu Kush is glaciated. Because of the altitudinal decrease from E to W, the W Hindu Kush harbours only a few glaciers. But here are many snow patches in the glacial cirques, primarily on N-facing slopes. In contrast, the E Hindu Kush sends downwards long glaciers to the valleys from the nival belt. In the glacial cirques of the W Hindu Kush (and also in Kohe Baba), active rock glaciers emerge from the accumulated snow patches in combination with frost debris and moraine material.

Further to the W, the Hindu Kush gradually declines and changes into the mountains of C Afghanistan with its main block Kohe Baba (its summit Shah Fuladi is at 5050 m a.s.l.). The country's C mountain has the form of a fan (Fig. 2.1) with its handle at the Salang-pass. It corresponds with the Late Cimmerian terrane mosaic which is subdivided by a fan-shaped bundle of E- to NE-trending faults into a series of blocks wedging out towards the NE. These are, from NW to SE: the Farah flysch basin; the Waras–Panjaw ophiolitic suture zone; the Helmand and Arghandab zones of the Helmand continental block; and the Kandahar Basin in the Spin Boldak area, truncated by the Chaman Fault System against the Himalayan realm (Breckle and Rafiqpoor 2010; Siehl 2017). This mountain range, with a steady decrease in altitude to W and SW, forms a spreading range with the main heights between 2500 and 4500 m a.s.l. The mountain block of C Afghanistan has the general feature of a huge, old, flat surface ("peneplain") with some higher summits giving the impression of smoothly rounded divides in which numerous wide and narrow V-shaped valleys (Schekari, Khenjan, Salang, Panjsher, Ghorband, Helmand, Hari Rud, and Arghandab) have been incised. Separate from the mountainous region of C Afghanistan to the W and NW, the Ferozkoh and the massifs of Paropamesus and Tirbande Turkistan rise to moderate heights between 2500 and 3500 m a.s.l.

In the nival belt of the Afghan high mountains the recent glaciation encompasses all the areas above the climatic snow line. In the E Hindu Kush the glaciated landscape extends from 4800 m a.s.l. upwards. In the W Hindu Kush on the other hand only the areas over 5100/5200 m a.s.l. are recently glaciated (Rathjens 1978). The

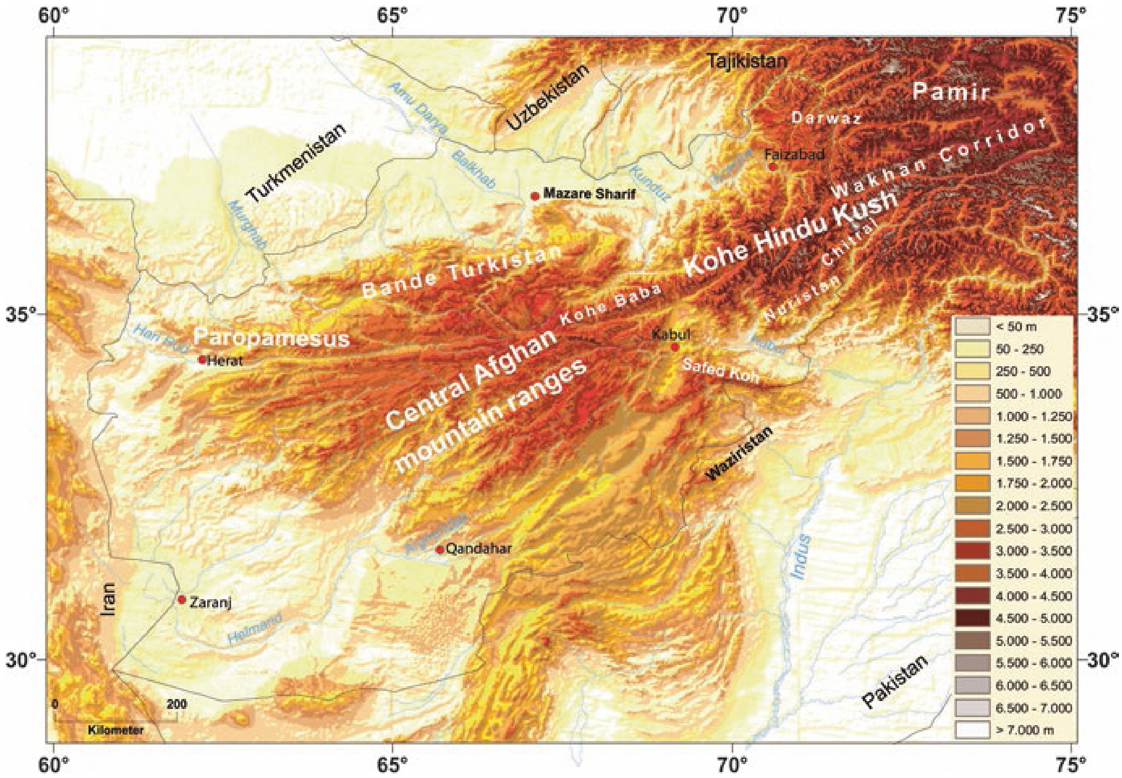

Fig. 2.1 Geography and main mountain systems of Hindu Kush and other high mountains in Afghanistan

nival belt which partly covers the summit regions of Hindu Kush, especially on N-facing slopes, is mainly characterized by an ice cover sending downwards up to 10 km long valley glaciers (Rathjens 1972). Whilst the recent glaciation is concentrated in the E Hindu Kush, in the W Hindu Kush and also in parts of the Afghan C mountains and in Kohe Baba there are only some snow patches in the former glacial cirques, particularly on N-facing slopes above 4800 m a.s.l. Only a few of these snow patches survive the extreme daily solar radiation in summer, forming penitent fields. The glaciated high mountain regions of the Hindu Kush and Kohe Baba receive their main rainfall in winter (Rafiqpoor 1979; Rathjens 1980).

Depending on the mountain exposure, in the Hindu Kush and Kohe Baba, as well as in the other mountainous regions of C Afghanistan, a very broad subnival and alpine altitudinal belt is located below the snow line and reaches downwards to 3300–3400 m a.s.l. This belt is at least 1400–1500 m wide (Rathjens 1978), and is characterized by forms and processes of recent solifluction. In the subnival altitudinal belt of the Hindu Kush and Kohe Baba, block glaciers are widespread and are mainly common in the humid and cool N exposures.

Here we present a synthetic view on the highly diverse vegetation and flora of the Hindu Kush mountains and underline the geological and climatological precondition. Its flora and vegetation are the result of a long history and evolution.

2.2 Geology

Laying in the W end of the Himalayan Orogenic Belt, the geology of Afghanistan is very complex (see Geolog. Map in Rafiqpoor and Breckle 2010) comprising of a complex assemblage of tectonic and stratigraphical differentiated crustal blocks separated by great fault zones (Kaever 1972; Wolfart and Wittekindt 1980; Quraischi 2014; Siehl 2017).

According to Quraischi (2014) and Siehl (2017) there are three main tectono-stratigraphic units in Afghanistan:

- The N Afghanistan-Tajik Platform, to which the Bande Turkestan and Feroz Koh belong. It was part of the Asian continental landmass and was affected by the upper Paleozoic Hercynian (Varician) orogeny.
- Areas S of the Harirod-C Badakhshan fault system (the Afgh. C mountain and the main part of Hindu Kush) up to the N and W of the Chaman and Konar faults were once part of Gondwana and accreted to the S margin of Eurasia during the Mesosoic Kimmerian orogeny.
- The mountain ranges to the S and E of the Chaman and Konar faults with the Suleiman mountains and the Kohe Baba are part of the Alpidic-Himalayan orogenic segment originating from the collision of the Indian and Eurasian Plates.

According to their geologic history, each of these units incorporate different rock types from sedimentary up to high metamorphic and intrusive rocks.

The pedological conditions in Afghanistan are much more complicated than soil maps can indicate. In the treatment of soil regions in Afghanistan, where necessary, also the bedrocks, topo-climate and vegetation in their three-dimensional arrangement should be taken into consideration. The extreme contrasts in soil quality in Afghanistan are a result of the varied topography, the petrological basis, the climatic differentiation in its hypsometric arrangement and the vegetation cover (Salem and Hole 1969, 1973).

The high altitudes of the Hindu Kush and the mountainous region of C Afghanistan are characterized by weak soil formation. Developed on frost debris, they are very young soils and still without any clear differentiation in the soil profile. In the zone of frost debris at the upper periglacial altitudinal belt of the Hindu Kush – and partly also of the mountainous region of C Afghanistan – directly below the recent snow line, large amounts of frost debris accumulate at the foot of the steep rock walls. From these debris masses, in combination with moraine material and snow rests, rock glaciers arose as periglacial mesoforms predominantly in the cirques of the N-facing slopes. In the subnival altitudinal belt of the Hindu Kush and in the Afghan C mountainous region, as well as in Ferozkoh, thin layers of raw soils of the cold mountain climates are developed between the snow line (4800–5100 m a.s.l.) and the lower limit of the alpine belt (3300–3400 m a.s.l.), predominantly on N expositions.

The very diverse geological and pedological conditions cause together with other non-organic factors (climate, hydrology, geomorphology) a very high 'geodiversity' as basis for a high degree of biodiversity of the country (Breckle and Rafiqpoor 2019).

2.3 Climate

The climate of the Hindu Kush is high continental with cold winters and hot summers (Flohn 1969). The altitudinal belts of climate and vegetation in the Afghan mountains are in accord with the accentuated topography of Afghanistan. The altitudinal belts of climate in general are characterized by the vertical temperature and precipitation gradients. In vertical direction, there is a temperature range of almost 22 K between the hot desert climate (e.g., Zaranj: 250 m a.s.l., annual mean 21.8 °C) and the main ridge of the Hindu Kush (e.g., Salang pass: 3366 m a.s.l., mean annual temperature − 0.3 °C). This is equivalent to about 0.74 K/100 m, which corresponds to a nearly dry adiabatic temperature gradient.

In all parts of Afghanistan except the very SE, the temperatures in winter are below 0 °C and frost is a common feature (Fig. 2.2). The interior mountain valleys exhibit absolute extremes of −50 °C. Only the basin of Jalalabad has very rare frosts and here subtropical and even tropical fruits can be grown. This is the very basis of the Hindu Kush on the SE side (see below also profile Fig. 2.23). The foothills on the N side exhibit temperature extremes in January of about −20 °C to −25 °C.

Precipitation also exhibits a dramatic difference between the desertic lowlands and the almost year-round cold parts of the high mountains of the Hindu Kush. The combination of this accentuated hypso-metrical change of temperature and precipitation is the basis for a rather broad pattern of various climatic types within the

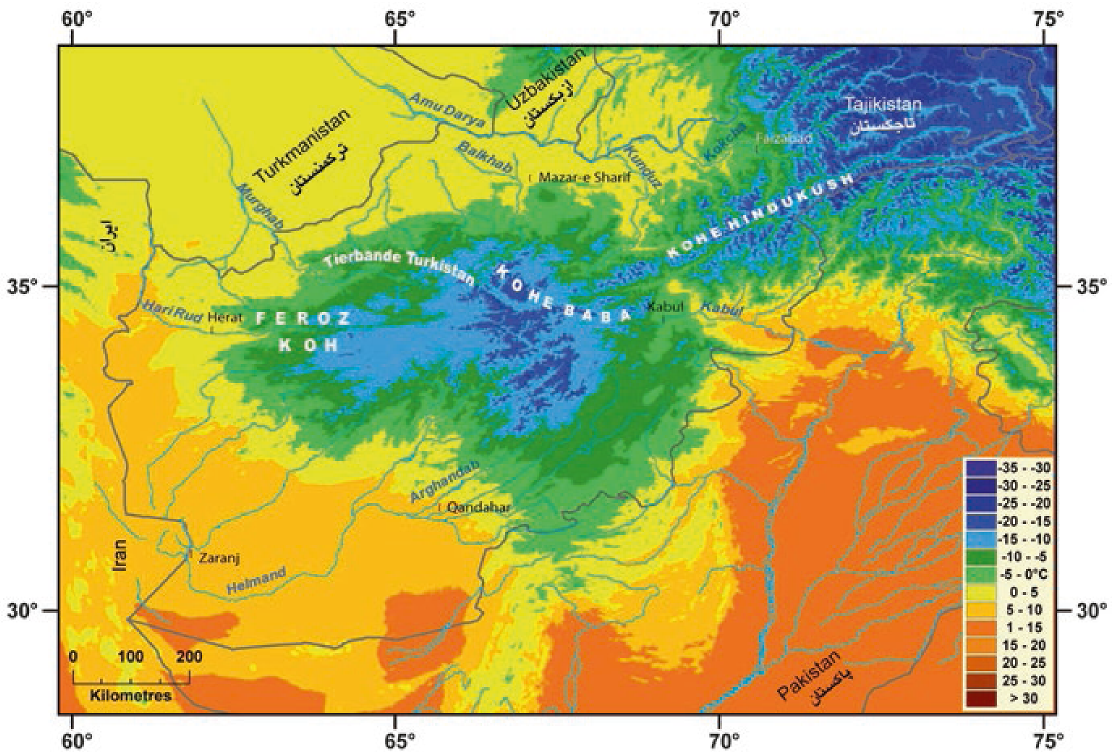

Fig. 2.2 Mean temperatures of January in Afghanistan and adjacent regions (After Breckle and Rafiqpoor 2010)

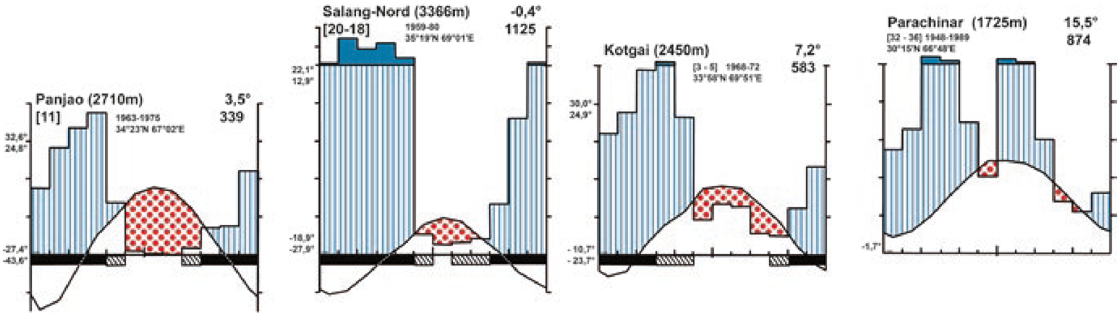

Fig. 2.3 Ecological climatic diagrams of Hindu Kush area

country and specifically within the various altitudinal belts which show a typical asymmetry of the altitudinal belts of vegetation.

The Hindu Kush lies in the sub-tropical dry winter-rain zone of the Old World. The cyclones which hike from the Atlantic Ocean eastwards and deploy on their pathway rainfall from the European Mediterranean via Turkey, the E Mediterranean and Iran and affect the high mountains of Afghanistan. Finally, in the W Himalaya they completely lose their energy. The cyclo-genesis over the Hindu Kush is more pronounced in spring; from this the rain-exposed mountain flanks in N and C Afghanistan benefit. The maximum rainfall is therefore, at most meteorological stations, in March and April (Rafiqpoor and Breckle 2010). In summer, the E parts of Afghanistan come under the influence of the tropical summer monsoon circulation (Sivall 1977; Rafiqpoor 1979; Breckle and Rafiqpoor 2019).

Regarding the distribution patterns of rainfall, three main landscape units of the Hindu Kush can be defined. They differ from each other depending on their general topography:

1. The high mountains of the Hindu Kush (over 4500 m a.s.l.) with more than 700 mm mean annual rainfall (Fig. 2.3b, Salang area).
2. The mountainous region of C Afghanistan including Kohe Baba, Ferozkoh and Tirbande Turkistan (4500–1250 m a.s.l.) with 700–200 mm mean annual rainfall (Fig. 2.3a, Panjao).
3. A narrow strip at the E part of the Hindu Kush and the Safed Koh comes under the influence of the Indian summer monsoon where a secondary maximum of rainfall occurs. This region has 500 to more than 1000 mm mean annual precipitation (Fig. 2.3c,d, Kotgai, Parachinar). In this so-called "summer rain-strip", the basins of Jalalabad and Laghman receive yearly <500 mm rainfall.

On the high plateaus of the country's C mountain region between 200 and 300 mm of precipitation (Fig. 2.3a: Panjao) are recorded, in the wind protected basins and large valleys, something less. Due to their exposure against the rain-bearing winterly winds, the N slopes of the Hindu Kush, Parapamesos and Tirbande Turkistan and Kohe Baba receive much more moisture than their S slopes lying in the rain shadows. The station Salang-Nord (3366 m a.s.l., 1125–1027 mm)

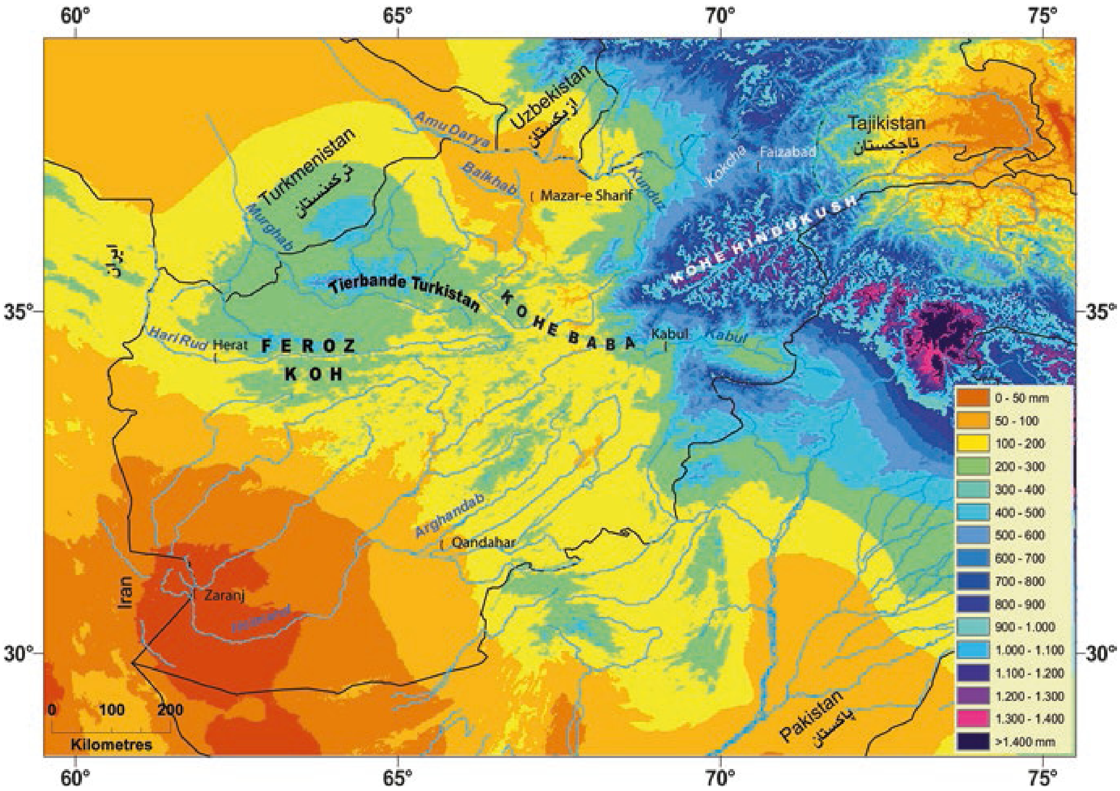

Fig. 2.4 Annual precipitation in Hindu Kush and Afghanistan (After Breckle and Rafiqpoor 2010)

(Fig. 2.3b) represents rainfall conditions in the high Afghan mountains. The annual rainfall in Afghanistan is shown in Fig. 2.4.

The inter-montane basins of E Afghanistan, such as the basins of Jalalabad, Kabul, and Kohistan (Roostai 2018), have annual rainfalls of between 250 and 400 mm. They are crossed by large rivers (Ghorband, Salang, Panjer, Kabul, Logar, and Tagab) with huge amounts of water and high loads of erosion.

2.4 Flora and Phytogeography

The most comprehensive source of information on the flora of the Hindu Kush is the monumental multi (100!)-authored Flora Iranica (Fl. Ir.) edited by Rechinger (1963–2015). It includes almost all accessible collections from the area and is now nearly completed with 181 fascicles of plant families published. However, understandably, the older volumes are outdated. The Flora of Pakistan has in a similar way covered almost all plant families and 217 fascicles (now all on-line) have been published; it started in 1970. Additionally, many research papers on the flora and vegetation of various parts and floristic lists from several expeditions have been published, e.g., on the Hindu Kush (Kitamura 1960, 1964; Gilbert 1968), on the Wakhan corridor (Podlech and Anders 1977), the Bande Amir area (Dieterle 1973).

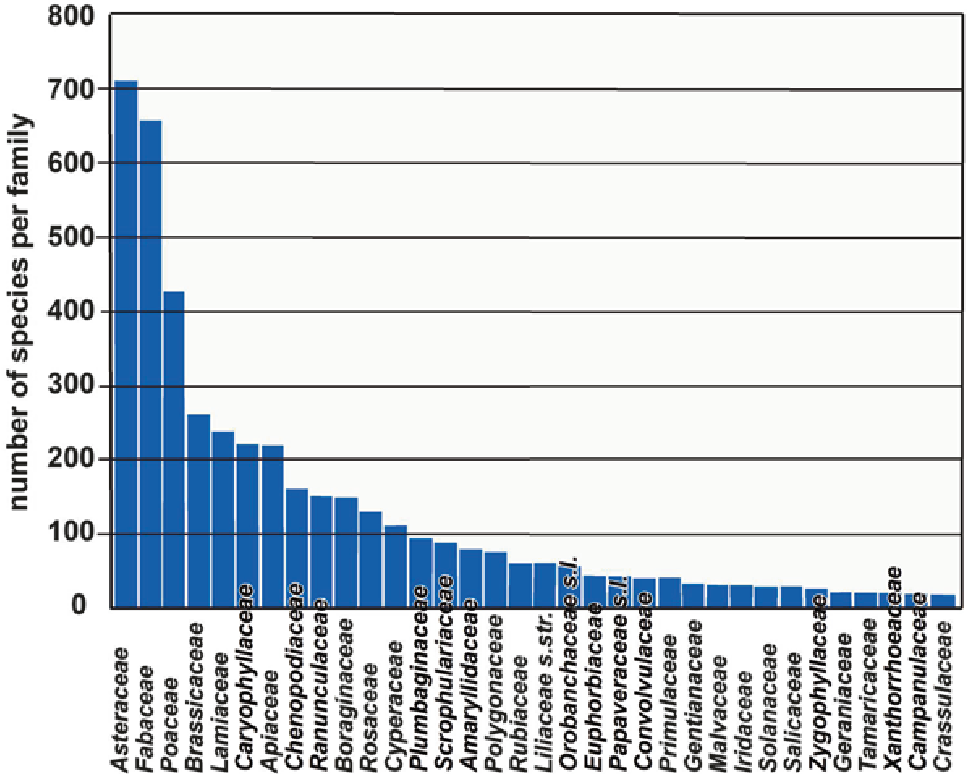

Fig. 2.5 Number of species in the large families of vascular plants in Afghan Hindu Kush (After Breckle et al. 2013)

More recently a checklist of the Afghan flora was published (Breckle et al. 2013) as a follow-up to the Field Guide "Flora and Vegetation" with 2000 coloured photographs of about 1200 species (Breckle and Rafiqpoor 2010). Answering the question, how many plant species do we have in Afghanistan or in the various mountain parts of the country is now easier as a result of this checklist (Breckle et al. 2013). In it, c. 5000 species of vascular plants are recognized. The following figures give some statistical data as a quantitative survey according to species, genera and families. Figure 2.5 indicates the number of species in the larger plant families. It clearly shows that the seven largest plant families account for more than half of all Afghan species. Figure 2.6 gives the number of genera in the larger plant families. Again, the seven largest families have more than half of all genera. But the sequence of families differs: Leguminosae (Fabaceae) are only on fifth place now, Gramineae (Poaceae) move to third place. Figure 2.7 indicates the number of species within the larger genera of Afghanistan. There are 12 genera with more than 40 species each, by far the largest being *Astragalus* with c. 320 species but *Cousinia* with 147 is also substantial. Whether *Oxytropis* really merits third rank is questionable: many species are only known from single gatherings and with better material may turn out to be synonyms. Somewhat similar is the situation with *Taraxacum.* Other species-rich genera are *Acantholimon, Allium* and *Silene*. With *Artemisia*, very common in many vegetation types, the taxonomic situation is very complex and urgently would need a detailed study.

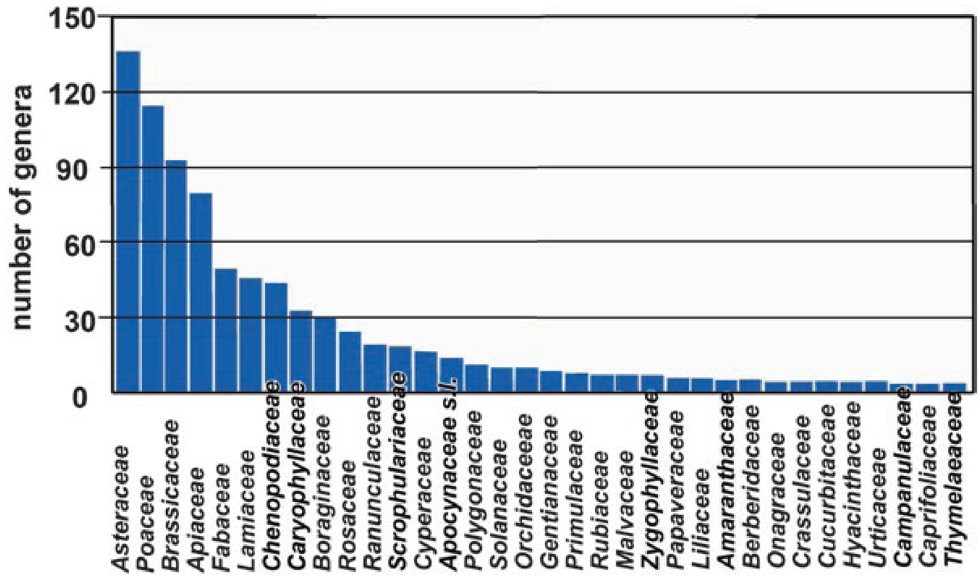

Fig. 2.6 Number of genera in the large families of vascular plants in Afghan Hindu Kush (After Breckle et al. 2013)

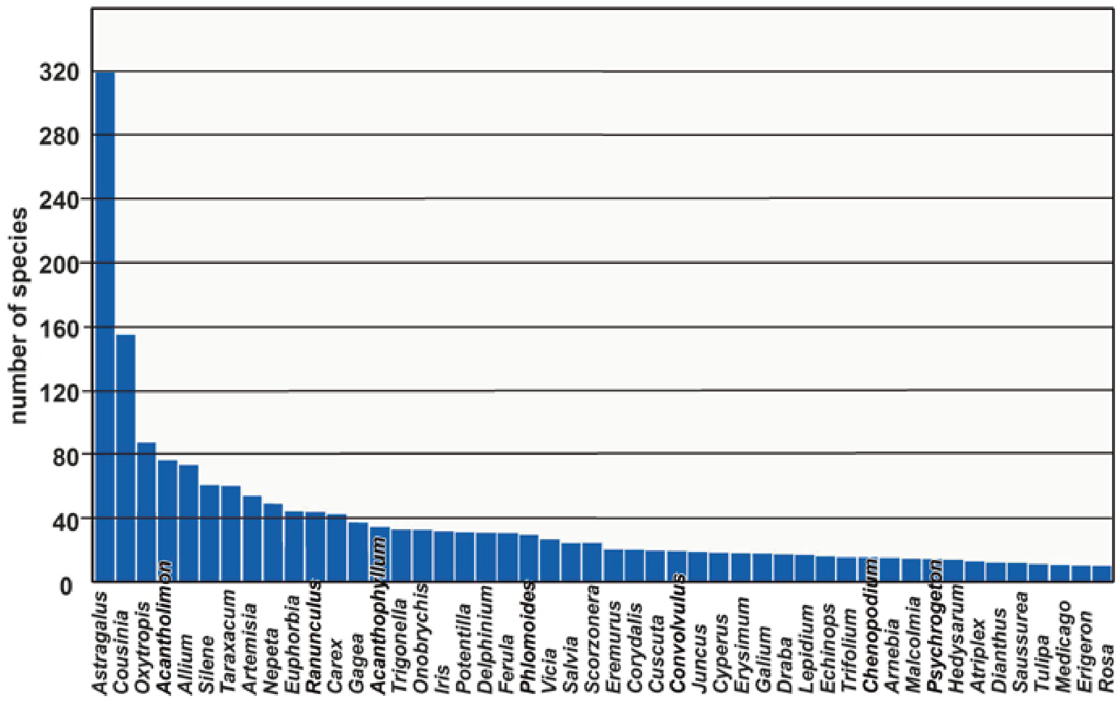

Fig. 2.7 Number of species in the large genera of vascular plants in Afghan Hindu Kush (After Breckle et al. 2013)

Table 2.1 gives a summary of the main statistics of the Afghan flora. In brackets, we give estimated numbers for the Hindu Kush. From the total number of taxa in Afghanistan with c. 5000 species, there might be about 3600 species restricted to the Hindu Kush mountain area and the degree of endemism is 24% considering that their distribution is restricted to Afghanistan and closely connected mountains

Table 2.1 Number of families, genera, species, taxa and endemics in the Afghanistan flora (percentage in round brackets), estimated figures for the Hindu Kush mountain area [in square brackets]

Taxon group	Number of families	Number of genera	Number of species	Number of taxa	Number of endemics and sub-endemics (%)
Pteridophytes	12 [11]	26 [16]	50	60 [39]	0 [0]
Gymnosperms	4 [4]	8 [7]	24	24 [17]	2 (8%) [2 (11%)]
Monocotyledons	28 [21]	198 [157]	822	846 [665]	78 (9.0%) [52 (7.8%)]
Dicotyledons	106 [93]	863 [648]	3945	4130 [2935]	1138 (27.8%) [675 (23.0%)]
Total (Vascular Plants)	**150 [129]**	**1095 [828]**	**4841**	**5060 [3655]**	**1218 (24.1%) [729 (19.9%)]**
Marchantiophyta (Hepaticae)	12	16	24	24	
Bryophyta (Musci)	28	87	228	244	
Anthocerotaceae (Hornworts)	1	1	1	1	
Total (Bryophytes)	**41**	**104**	**253**	**269**	**?**
Lichenophyta				**262**	

(Chitral). These figures depend on the delimitation of the mountain area. Regarding only species of the Hindu Kush mountain area, endemism is somewhat less with 20% (Table 2.1).

The number of vascular plant species is distinctly high, though overall Afghanistan is a rather arid country with extensive deserts and semi-deserts. But this is mainly because of the high geo-diversity of the mountain ranges and the diversity of habitats. Groombridge (1992) gave an estimate of 3500 species of vascular plants and 30–35% endemism, and suggested that an additional c. 5–10% of species might be found in future. With the new data from Breckle et al. (2013), about 5000 taxa are known from the whole country and about 3600 from the mountain regions of the Hindu Kush.

The link between species numbers and altitude is shown in Fig. 2.8. It clearly demonstrates the trend of decreasing species numbers with increasing altitude, which is a very general rule for almost all mountains (Körner 1999; Breckle 1981; Lauer et al. 2001; Agakhanjanz and Breckle 2002).

Though the bryophyte flora (Kürschner et al. 2020) is less studied and is in an arid country like Afghanistan not really covering large areas, available data show that it is typical to have the highest number of bryophyte species recorded from middle altitudes (Fig. 2.9). This is not only due to the fact that collecting there may have been most intensive, but we also may assume that at middle elevations there is

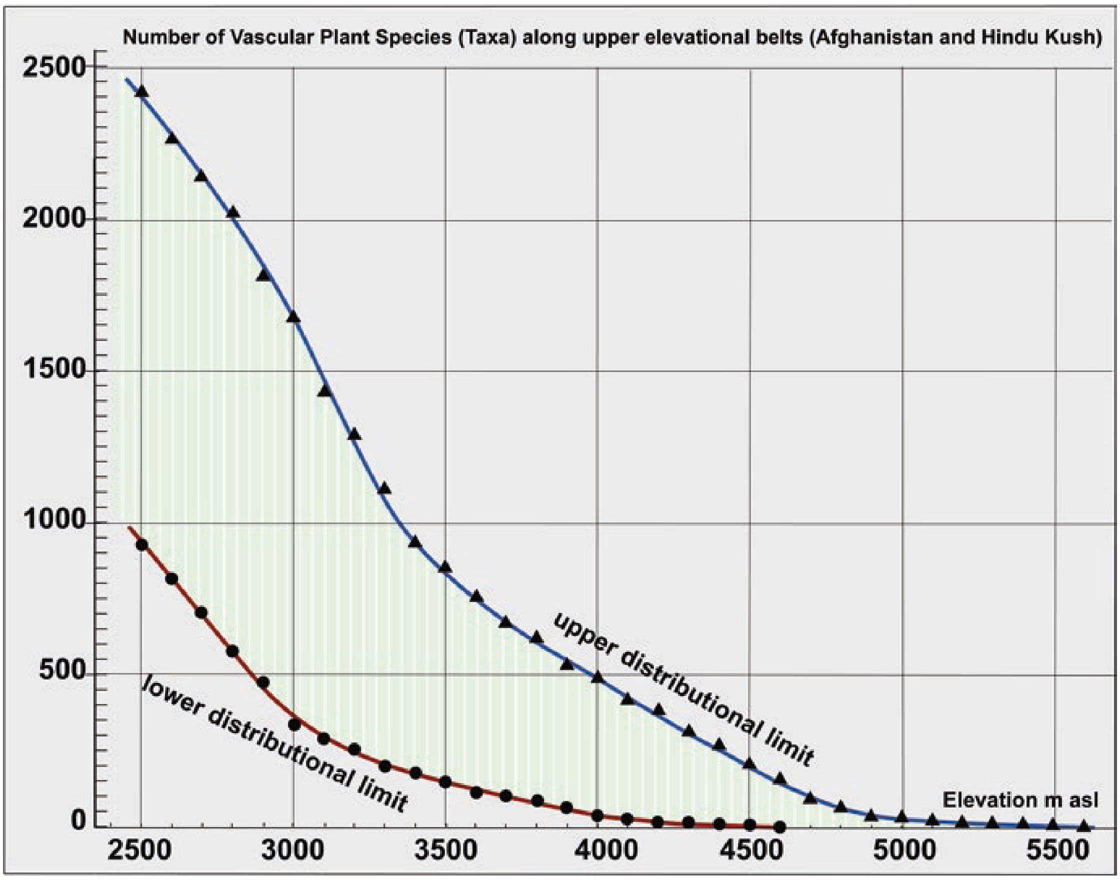

Fig. 2.8 Species numbers of vascular plants in relation to altitude of the Afghan mountains with lower and upper limits (Derived from Breckle and Rafiqpoor 2010)

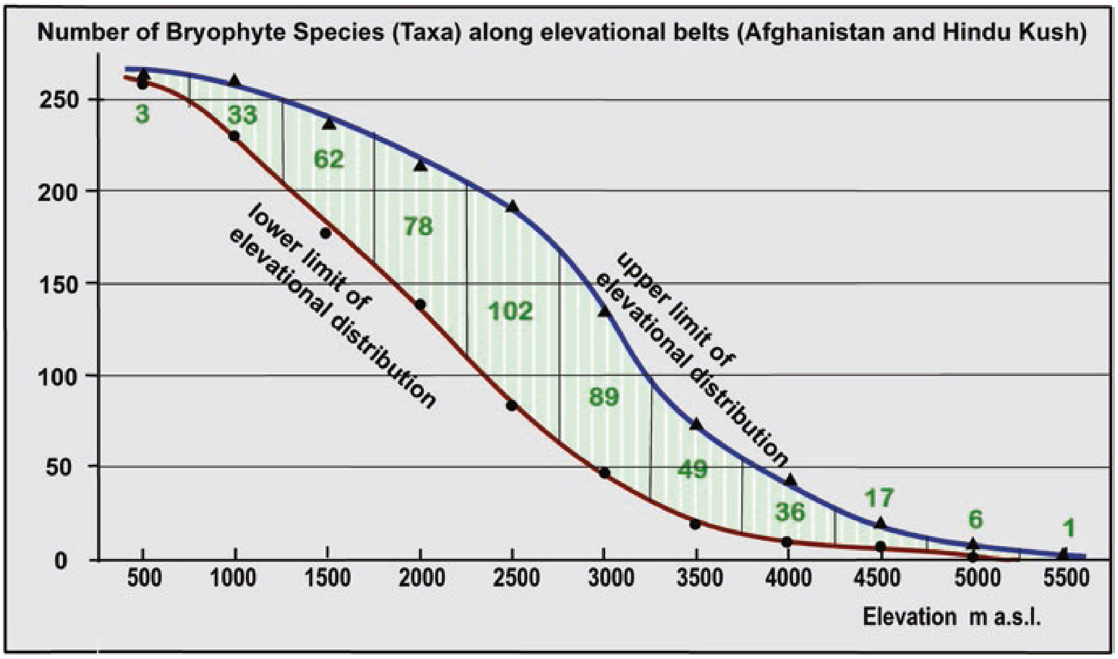

Fig. 2.9 Species numbers of bryophytes in relation to altitude of the Afghan mountains with lower and upper limits (Derived from Kürschner et al. 2020)

a maximum diversity of bryophytes. But certainly, as the overall range of many Afghan plant species is as yet not known, our knowledge is still rather limited.

Diverse ecological conditions, ranging from hot deserts and humid subtropical regions to high alpine regions, have favoured the establishment of a complex and varied flora and vegetation. However, the composition of the flora and the vegetation structure are also greatly influenced by a long history of over-exploitation. This has led not only to the almost complete loss of forests and woods but also to widespread degradation of formerly rich woodland and semi-desert ecosystems. Grazing by sheep and especially goats, as well as cutting down of trees and uprooting of shrubs, even dwarf shrubs, have not only greatly reduced the coverage of the vegetation, but also have changed its composition and floristic diversity.

With regard to the plant geographical aspects and distribution patterns of plant species (chorotypes), most parts of Afghanistan and its mountains belong to two very different phytogeographical regions: the Irano-Turanian floristic region with c. 92% of the country's surface, and the Sino-Japanese (Himalayan) floristic region with c. 7%. In both of them, the temperature conditions are rather similar, but they are sharply separated by the amount and seasonal distribution of rainfalI. Two smaller parts of the country belong to other floristic regions or show at least strong admixtures of species from adjacent regions. Species of the Saharo-Sindian region intrude into the lower altitudes of S- and E-Afghanistan. But only in the hot and dry Jalalabad basin they are so numerous and dominant that the area should be included in that phytogeographical region; this area comprises just the subtropical SE exposed foothills of the Hindu Kush.

In the upper belts of the high mountain areas, the number of C-Asian elements increases. The eastern part of the Wakhan is often considered as the SW extension of the C-Asian floristic region. That region extends eastwards along the Karakorum and N of the Himalayas to C- and NE-China, and northwards to S-Siberia.

Every elevational belt has its own phytogeographical characteristics. In the lowlands, Saharo-Sindian plants may prevail, in the lower mountains Irano-Turanian elements, in the eastern parts Himalayan species, in the higher mountain belts more C-Asian and Eurasian species, and in the alpine and nival belt some boreal and even arctic elements occur. Within these chorotypes, any particular species has acquired an individual distributional area according to its particular ecological requirements, evolutionary age, and widely differing dispersal abilities. The topography has greatly contributed to the high number of endemic species, particularly among mountain plants of the montane belt with less effective modes of dispersal. However, though the overwhelming majority of plant species belong to one or the other chorotype, there are rather many that are distributed in more than one phytogeographical region. For instance, many annuals that are adapted to summer drought occur in both the Mediterranean and the Irano-Turanian region. Other species were able to reach suitable habitats even if those areas are geographically widely separated from each other. This applies in particular to plant species of high mountain areas. Below we give just a few examples of the various chorotypes, mainly of the more conspicuous plants.

In parallel with the tremendous diversity of habitats in the Irano-Turanian floristic region, from different types of lowland semi-deserts up to montane woodlands and alpine meadows, the distribution pattern varies considerably. Most large genera, as e.g., *Astragalus, Cousinia, Acanthophyllum, Acantholimon, Allium, Eremurus* and *Eremostachys,* as well as smaller ones like *Ephedra,* occur in all elevational belts, but with different constituent species. Examples of typical Irano-Turanian genera that radiated into most diverse ecosystems are shown in the isoflor-maps. The isoflor-maps of *Eremurus*, *Eremostachys* and *Acantholimon* indicate, with their high species-numbers, the relevant centres of evolution (Hedge and Wendelbo 1970a). The unusually high species diversity in, e.g., *Astragalus, Cousinia, Acantholimon, Acanthophyllum, Allium*, *Eremostachys, Eremurus* and *Dionysia* is attributable to the fact that, due to genetic isolation, in the same altitudinal belt ecologically corresponding species have evolved in different mountain systems.

With its Himalayan subregion, the Sino-Japanese region extends into E-Afghanistan. Like the Irano-Turanian area, it also includes altitudinal belts with a large variety of ecological niches. Though species diversity per square kilometer certainly is much higher than in the Irano-Turanian area, the species number of the total area is smaller, simply as a result of the limited surface. In outline, the geographical distribution of the species belonging to that chorotype in Afghanistan is comparatively uniform because in the respective parts of the country the different altitudinal belts are particularly close to each other. However, their eastern extensions vary greatly and most are restricted to the Himalayas or even to the W-Himalaya. A large number of mesophytic and moderately xerophytic trees, shrubs and perennials belong here, as, e.g., *Cedrus deodara* (Himalayan cedar), the pines *Pinus gerardiana* (Fig. 2.10) and *P. wallichiana*, the oaks *Quercus baloot*, *Q. dilatata* and *Q. semecarpifolia*, the shrubs *Indigofera gerardiana* (Fabaceae), *Plectranthus rugosus* (Lamiaceae) and *Syringa emodi* (Oleaceae), the grasses *Stipa brandisii* and *Piptatherum munroi*. Not surprisingly, only rather few species of that floristic element are endemic or subendemic in E-Afghanistan, such as *Gymnospermium sylvaticum* (Podophyllaceae), *Pertya aitchisonii* and *Saussurea afghana* (both Asteraceae) in the most mesophytic evergreen broad-leaved oak forests, *Rhododendron afghanicum* as undergrowth in the upper coniferous forests, and *R. collettianum* (Fig. 2.19d) in the subalpine juniper scrub. These isolated endemics indicate that the Himalayan forests did not recently invade the area. Fossilized leaves, needles and cones of Himalayan trees growing today only further east, such as the thermophilous pine *Pinus roxburghii,* and many other fossil leaves from a rather humid vegetation, have been found in marl sediments at the Latahband pass east of Kabul. They indicate that in the relatively recent past, probably in the Early Pleistocene, they grew appreciably further west, indicating a higher monsoonal activity and a warmer climate (Breckle 1967).

The Saharo-Sindian floristic region and the corresponding chorotype are much less homogeneous than the others. Though the climatic conditions in the belt from the W-Sahara to the southern foothills of the Hindu Kush in N-Pakistan, which are characterized by high aridity, very hot summers and rather mild but not frost-free winters, are very similar, the distribution pattern of the plant species differs

Fig. 2.10 Slopes with dry conifer forests of *Pinus gerardiana*, Nuristan, E Afghanistan (photo SWB)

considerably, due to the very long distances covered by this belt and the varying climatic history in the individual parts of the area. Only in the lowland area around Jalalabad in Nangarhar province and, less significantly, around Khost in Paktya province, many Saharo-Sindian species occur that require more favourable winter temperatures and somewhat higher rainfall: e.g. the deciduous thorny shrubs and small trees *Acacia modesta* (Mimosaceae), *Zizyphus nummularia* and *Z. oxyphylla* (Rhamnaceae) and the evergreen shrubs *Calotropis procera*, *Periploca aphylla* and *Rhazya stricta* (all three in Apocynaceae). Another southern element is represented by mostly sclerophytic trees and shrubs that have their centre of distribution in an area stretching from the driest parts of the westernmost Himalayas southwards along the foothills of the Suleiman Range, through the lower mountains of Pakistani Baluchistan to the higher ranges along the eastern and southern margin of the Arabian peninsula, like *Reptonia buxifolia* (Sapotaceae), the palm *Nannorrhops ritchieana*, *Gymnosporia royleana* (Celastraceae) and *Dodonaea viscosa* (Sapindaceae). The typical decrease in the number of species with increasing elevation is shown comparably in Fig. 2.11 for the Hindu Kush, the Caucasus and the Alps.

The alpine and nival belts are more or less continuously present in the eastern section of the Afghan Hindu Kush and become more scattered towards the west, with an outlier in the Kohe Baba massif in C-Afghanistan. There, floristic elements

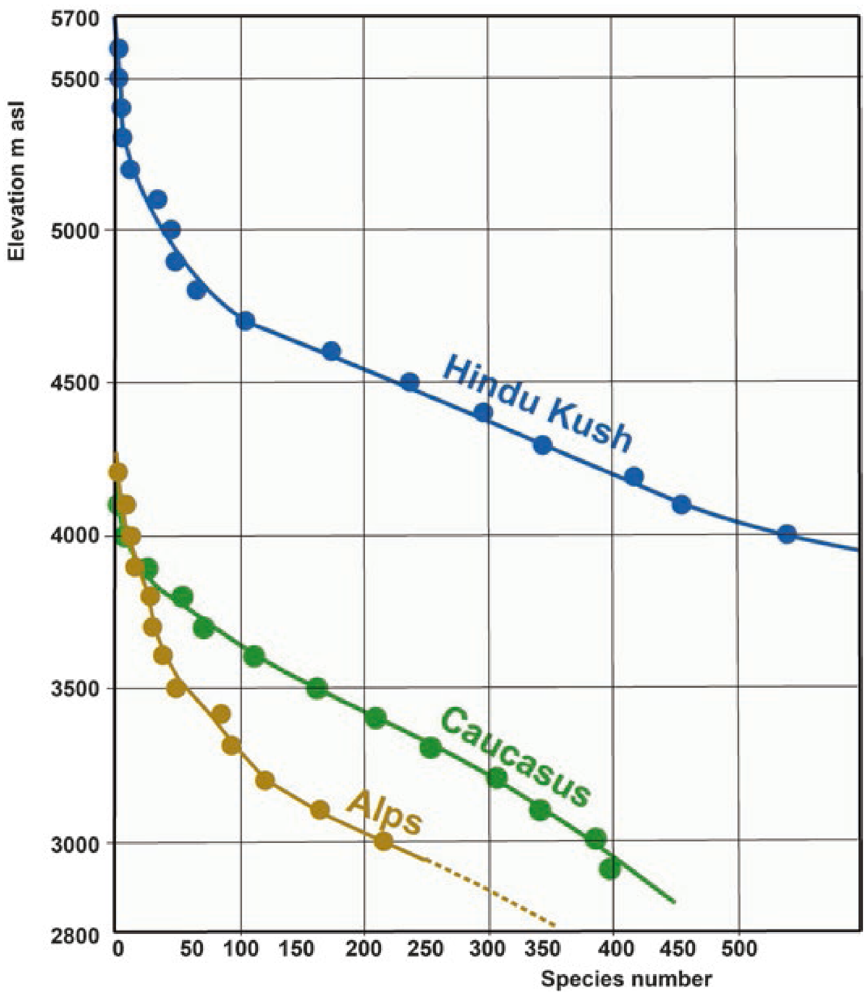

Fig. 2.11 Floristic drainage in mountains: Species numbers of vascular plants in relation to altitude of the Hindu Kush, Caucasus and Alps (After Breckle et al. 2018)

of the C-Asian, the Himalayan and the high Irano-Turanian mountains occur partly side by side and together with species that have wider distributional ranges. The number of widespread species of the Hindu Kush which are common with the Alps, the Caucasus mountains and/or the Himalayas is indicated in Fig. 2.12.

The high alpine and nival flora had been checked by Breckle (1988) according to their chorological character along elevational belts. It turned out that endemism is sharply decreasing, which is in contrast to some other mountains. The highest percentage of species is recorded, however, from several C Asian Mountains and the Himalayas (Fig. 2.13). The alpine belt is especially rich in species with a rather wide distribution, such as Euro-Siberian or even boreal and arctic (Breckle 1974, 1988; Breckle and Rafiqpoor 2011). We can distinguish the following groups:

(a) Cosmopolitan (or almost so) high mountain species, e.g., *Luzula spadicea, Oxyria digyna, Polygonum viviparum, Phleum alpinum* and *Androsace* species
(b) Circum-boreal mountain species partly extending into the Arctic, e.g., *Cerastium cerastoides, Cystopteris fragilis* incl. *C. dickieana, Lloydia serotina*

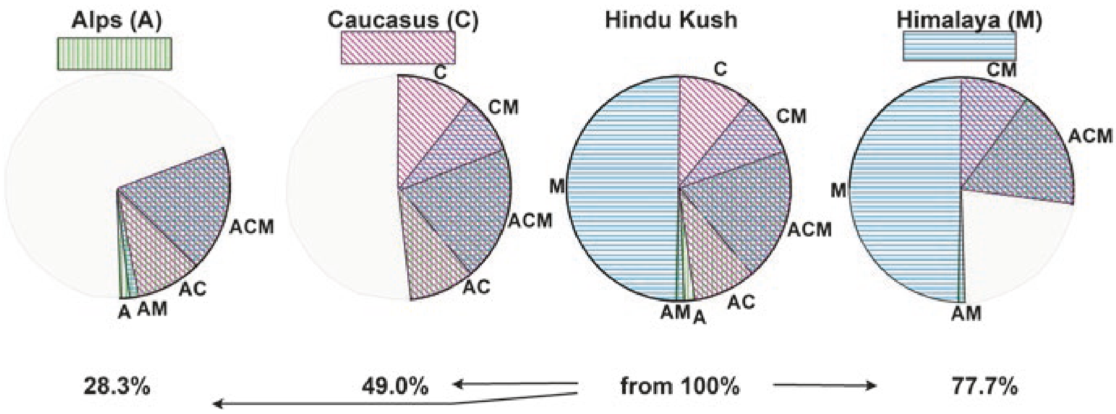

Fig. 2.12 Percentage numbers of widespread species of the Hindu Kush common in Caucasus (C, red), the Alps (A, green) and the Himalayas (M, blue) (After Breckle et al. 2018)

Chorological group:

Altitudinal Range :	cosmopolit. (worldwide in Mtns.)	Northern Hemisphere Mtns., Arctic	Central- and Middle Asian Mtns.	C-, Middle Asian Mtns. , Himalaya	Himalayan	endemic
> 5400 m NN	-	10	20	40	30	-
5200 - 5400 m	5	15	15	45	20	-
5000 - 5200 m	6	16	14	38	24	2
4800 - 5000 m	4	14	14	36	28	4
4500 - 4800 m	3	10	14	32	28	13
4000 - 4500 m	2	10	11	28	27	22

Fig. 2.13 Percentage of chorological groups from the alpine-nival flora of the Afghan Hindu Kush above 4000 m a.s.l. (After Breckle 1988)

(c) Species restricted to some Asiatic and North American mountains and in parts of the Arctic, e.g., *Epilobium latifolium*, *Smelowskia calycina*, *Koenigia islandica*
(d) Central Asian high mountain species occurring in most C Asian mountain systems, on the Tibetan plateau, the Trans-Himalaya and Himalaya, such as *Delphinium brunonianum* and *Sibbaldia cuneata*, but not in the Himalaya as e.g., *Chorispora macropoda* and *Primula algida*

(e) Species restricted to the Afghan mountains, the Pamirs, the Karakorum and the W Himalaya, such as *Anaphalis nubigena, Juncus membranaceus*, *Lamium rhomboideum, Primula macrophylla* and *Rheum tibeticum*
(f) Species endemic to the Hindu Kush and some Iranian mountains (Zagros, Alburs, and partly extending into the Caucasus) are among others, such as *Gentiana umbellata, Polygonum serpyllaceum* and *P. thymifolium* (Breckle et al. 2018)
(g) Species endemic to the Pamir-Alay and the Hindu Kush, such as *Didymophysa fedtschenkoana*, *Polygonum myrtillifolium, Polygonum chitralicum, Waldheimia tridactylites* and some *Nepeta*-species
(h) Narrow endemics of the Hindu Kush and parts of the Wakhan, or even restricted to one of the Afghan mountains, e.g., *Aconitum rotundifolium, Corydalis metallica, Gentiana longicarpa, Gynophorea (Erysimum) weileri, Potentilla coelestis, P. collettiana* and *Rhododendron afghanicum (*subalpine)

In the upper elevational belts, as in boreal and arctic regions, the predominant life-form is hemicryptophyte (Fig. 2.14). Only below 4000 m a.s.l. chamaephytes become more prominent. Annuals and geophytes are rare.

For further references on the still tentative plant geographical subdivision of the area and floristic elements see among others Hedge and Wendelbo (1978, Afghanistan), Browicz (1997, Iran and the wider area), Breckle (2004, high mountain flora), Cox and Moore (2005, worldwide) and Agakhanjanz and Breckle (1995 floristic history).

Live form : / Altitudinal Range:	Phanerophytes	Nano-Phanerophytes	Chamaephytes	Hemicryptophytes	Biennial Species	Annuals (Therophytes)	Geophytes	Parasitic species	Hydrophytes
> 5400 m NN	-	-	10	70	10	-	10	-	-
5200 - 5400 m	-	-	16	74	5	-	5	-	-
5000 - 5200 m	-	-	12	71	8	6	4	-	-
4800 - 5000 m	-	-	12	72	6	5	4	-	-
4500 - 4800 m	-	1,6	11,7	69,2	4,0	6,5	6,5	-	0,4
4000 - 4500 m	0,1	2,8	17,1	61,2	2,3	9,1	7,2	0,1	0,1

Fig. 2.14 Live form spectra of the alpine-nival flora of the Afghan Hindu Kush above 4000 m a.s.l. (After Breckle 1988)

2.5 Endemism

An endemic taxon is defined as one which is only found in a distinct area or location and nowhere else in the world. The definition requires that the area in which the species is endemic be defined: such as a "site endemic" (e.g. just on one hill), a "national endemic" (e.g. found only within the border of the state of Afghanistan), a "geographical range endemic" (e.g. found in the Hindu Kush region, which may however cover also parts on Pakistan territory: "subendemic").

The percentage of endemism for the whole country is about 25%; for the mountain region it is less, about 20%. This may be due to the fact, that endemism always is defined for a specific area. But the Hindu Kush ranges are connected with the Pamirs and the Karakoram in the east, thus, a rather high portion of species exhibits a wider distribution in adjacent mountains.

Quite a number of species from the montane belts are endemics: their occurrence is restricted to the Afghan mountains though some might just penetrate into adjacent mountain areas of Pakistan or Tajikistan. Only a limited number of these endemics occur all over the country in their typical altitudinal zone, such as *Salvia rhytidea*; most are restricted to smaller areas.

In some plant families, but not in the grasses, the percentage of Afghan endemic species is rather high (Hedge and Wendelbo 1970a; Breckle et al. 2013). Many of the endemics are very isolated, at least morphologically, such as *Pseudodraba* (*Draba*) *hystrix, Pyramidium griffithianum, Halarchon vesiculosus* and *Salvia pterocalyx*. Iran and Turkey have larger totals of flowering plants than Afghanistan, but the Afghan endemics are, in general, taxonomically more isolated. For example, Turkey has very many more species of *Salvia* than does Afghanistan, and many more endemics, but the majority of them have clear allies in that country. In contrast, Afghanistan has relatively few endemics of *Salvia,* and it is hard to pinpoint taxonomical allies of those endemics. Furthermore, there are endemics at specific and generic level that can, objectively, be classified as "isolated" or "narrow". *Draba* and *Salvia* are certainly very distinct in this respect.

The thorny cushions (*Acantholimon, Acanthophyllum, Onobrychis* etc.) also exhibit a rather high degree of endemism in the Afghan mountains. Some examples of rates of endemism in plant families and genera are given in Table 2.2. In some of the Afghan plant families, the ratio of endemics is rather high. In some other families, many species are more widespread. Some high alpine genera as e.g. *Draba* exhibit only very low rates of endemism, while others are very specialized and have small distributional areas, e.g. *Dionysia*.

Some endemic genera are listed by Sales and Hedge (2013). These are in Apiaceae: *Gongylotaxis, Kandaharia, Mastigosciadium, Pinacantha, Pyramidoptera* and *Registaniella;* in Asteraceae: *Chamaepus* and *Tiarocarpus;* in Brassicaceae: *Cyphocardamum, Pseudodraba* and *Veselskya*; in Caryophyllaceae: *Kabulianthe, Ochotonophila, Pentastemonodiscus* and *Scleranthopsis;* in Chenopodiaceae*: Halarchon;* in Papaveraceae*: Cryptocapnos* and in Plumbaginacae: *Bamiania* and *Bukiniczia.* They do not include a few genera that are subendemic,

Table 2.2 Plant families and genera in Afghanistan with high endemism ratios

Plant family/resp. genus	Country endemics (Afghanistan) %	Subendemics (Afghanistan and closely related adjacent regions) (%)	Total (%)
Acantholimon	75.0	17.1	92.1
Dionysia	91.7	0	91.7
Plumbaginaceae	66.7	12.9	79.6
Cousinia	67.5	10.4	77.9
Oxytropis	51.7	13.8	65.6
Onobrychis	45.4	18.2	63.6
Astragalus	48.8	4.7	53.5
Iridaceae	40.0	5.7	45.7
Nepeta	28.8	15.3	44.1
Lamiaceae	29.3	13.4	42.7
Boraginaceae	26.5	13.6	40.1
Primulaceae	34.9	4.6	39.6
Apiaceae	28.3	9.1	37.4
Amaryllidaceae (incl. *Allium*)	27.6	9.2	36.8
Caryophyllaceae	24.9	8.3	33.2
Ranunculaceae	22.1	3.4	25.5
Brassicaceae	14.6	8.3	22.9
Draba	5.9	0	5.9

After Breckle et al. (2013)

such as *Kurramiana* (Gentianaceae), *Calyptrosciadium* and *Scrithacola* (Apiaceae) and *Polychrysum* (Asteraceae). However, this certainly is not a definitive list of endemic genera, because our taxonomic knowledge is still proceeding.

Sales and Hedge (2013) gave also a broader overview of generic endemism throughout SW Asia; 161 genera were listed as endemic. In that publication SW Asia was defined to include, in addition to the countries normally included in that area, the Caucasus and parts of C Asia (Pamir-Alay and Tian Shan). Three families, Apiaceae, Asteraceae and Brassicaceae, had by far the greatest number of endemic genera, between them accounting for over 120 genera. The grass and legume families had very few. The paper emphasized the major importance of SW Asia as a global hotspot, especially the Afghanistan/C Asiatic part of it. It also considered a few of the larger non-endemic genera in Afghanistan with respect to their ranges in adjacent countries. Surprisingly, the distributions of individual species differed markedly. In, for example, *Acantholimon, Acanthophyllum, Allium* and *Nepeta* there were remarkably few species that were common to wider areas, such as Afghanistan, Takijistan, Iran or Turkey. *Acantholimon* has 76 species in Afghanistan and none of them occur also in Turkey. This fact emphasises the importance, when discussing endemism, of considering it from a broader geographical viewpoint and not just per country.

There are two subcategories of endemism – palaeo-endemism and neo-endemism. A palaeo-endemic species is thought to have been widespread formerly but is now restricted to a smaller area and is morphologically rather isolated. A neo-endemism is a relatively young species that has recently arisen and become reproductively isolated, or one of hybrid origin and now classified as a separate species; such species occur in smaller areas. Many of the Afghan endemic species can be designated as neo-endemics (Hedge and Wendelbo 1970a), especially in genera which are still actively evolving new species, as in *Astragalus, Acantholimon, Eremostachys, Oxytropis, Taraxacum* etc. In contrast, four genera that are good candidates for classification as palaeo-endemics are *Halarchon* (Chenopodiaceae), *Pseudodraba* (Brassicaceae), *Pyramidoptera* (Apiaceae) and *Veselskya* (Brassicaceae). At least morphologically, they are clearly isolated from other genera, but whether future molecular research will support this designation remains to be seen.

2.6 Major Vegetation Types

The most extensive study dealing with the whole country and incorporating earlier results is that by Freitag (1971a, b). With regard to the high mountain vegetation, it was supplemented by papers of Breckle (1971a, b, 1973, 1974, 1975), Breckle and Frey (1974). Here we present an updated account that includes some so far unpublished information. During recent decades Afghanistan's flora and vegetation have been much studied, though mainly before the Soviet military intervention and subsequent civil wars (Breckle et al. 2017, 2018).

Except for some weeks from spring to early summer, outside of the irrigated areas which cover about 5% of the country's surface and the few forest areas, the plant cover of Afghanistan has a poor visual appearance and looks rather uniform. For most of the year, when seen from a distance, plant life appears to be almost completely absent, and the monotonous grey or brown colours of the landscapes seem to be caused by the barren soil or rock surfaces. This is caused by the strongly seasonal and predominantly semiarid climate in combination with the long-lasting destructive influence of man on the plant cover.

The survey of the broadly defined vegetation types given here focuses on two aspects: the 'Potential Natural Vegetation' (Fig. 2.15) as it would exist without the influence of man in natural habitats; and the 'actual vegetation' as it is today as a result of man's destructive impacts. The country-wide survey by Freitag (1971a, b) resulted in two maps of the potential natural vegetation: (1) a country-wide map that was largely adapted by Nedjalkov (1983a, b), and slightly modified by Breckle (2007); (2) a detailed map showing the much more diversified easternmost part of the mountainous country in higher resolution both with regard to scale and vegetation types (in Freitag 1971a).

Other authors mainly dealt with the actual vegetation (Pelt 1967). Gilli (1969, 1971) studied the vegetation, mainly around Kabul; Nedjalkov (1983a, b) described some vegetation types from the forest region in Kunar province in E-Afghanistan, while much earlier Neubauer (1954a) and Volk (1954) gave a survey on the vegetation and studied the forests (Neubauer 1954b) in Nuristan and Rathjens also in

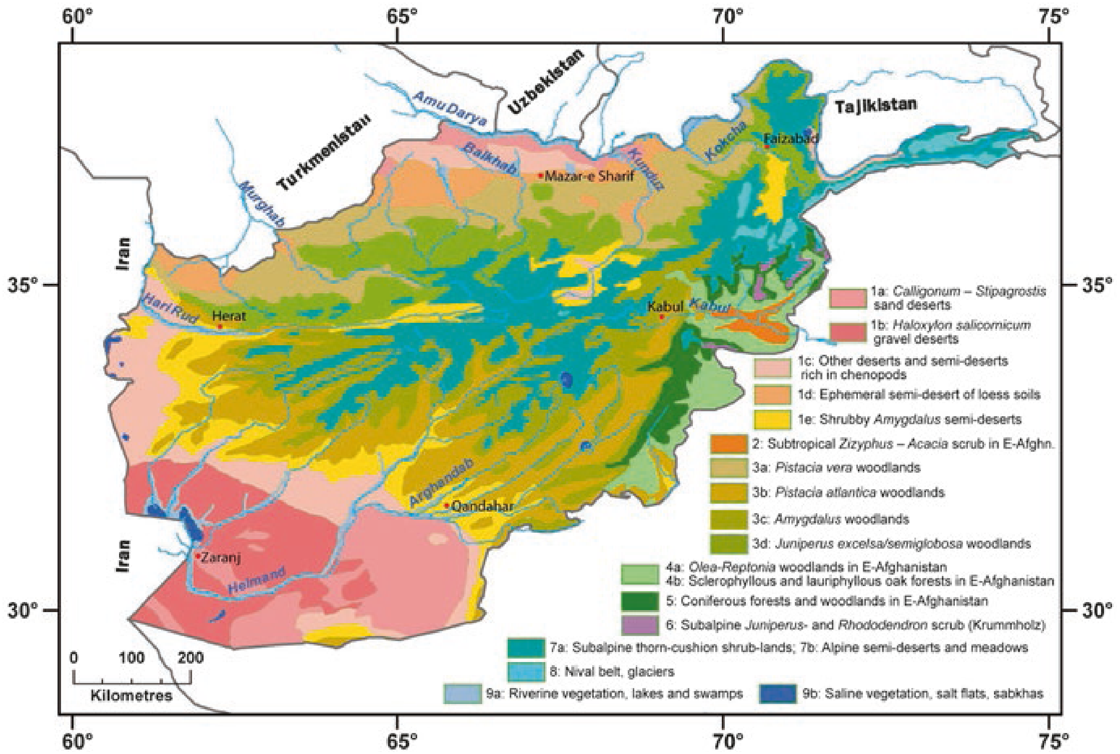

Fig. 2.15 Potential natural vegetation of Afghanistan (After Freitag 1971, Breckle and Rafiqpoor 2010)

Paktia (Rathjens 1974). The ecological conditions of forests were reviewed by Afghanzada (1970). Mountain vegetation and the flora of the C-Hindu Kush were studied by Frey and Probst (1978, 1982); Pavlov and Gubanov (1983) and some others.

For classifying the vegetation cover the potential natural vegetation is chosen here. It indicates the vegetal resources of the various parts of the country as determined by climate and soil. Furthermore, it shows to what extent the vegetation could be restored by application of careful and conscious practices of land use, though sometimes, or often, only in the long run. It applies to "normal habitats" which are defined as being flat to moderately sloping, not receiving additional water-supply.

The most important sources for information about the composition, structure and geographical distribution of the natural vegetation gained decades ago were:

- the few remnants of little disturbed vegetation all over the country but preferably those in remote and inaccessible areas;
- some intentionally protected small plots (e.g., pistachio and pine woodlands); the surroundings of tombs and shrines ("ziarat");
- and some rare, written documents.

Natural vegetation cover is often replaced by substitute plant communities caused by human activities. In fact, the vegetation of the country is much more diversified, due to its mountainous character. The common rocky sites have their peculiar plant communities, as do scree-covered slopes or naturally eroding slopes in weak marly sediments. Caused by their geographic or topographic isolation, these communities, made up of highly specialized plant species, are particularly rich in narrow-ranged endemics. They cannot be dealt with in this survey. The main zonal vegetation categories on standard ecological sites are shown in the map (Fig. 2.15) under No. 1 to No. 8.

Those with the predominant influence of one ecological factor, namely additional water supply or high salinity (river valleys, lakes, swamps and saline flats), are summarized in the map in Fig. 2.15 under category No. 9. They represent azonal vegetation types, since here the zonal climate is less decisive than the predominant ecological factor (water, salt, gypsum, heavy metals, etc.) causing peculiar habitats.

Vegetation types occurring in the Afghan mountains are described below mainly after Freitag et al. (2010).

2.6.1 Shrubby or Sub-shrubby Chenopod Deserts and Semi-deserts (Fig. 2.15: 1c)

A number of rather different plant communities with predominance or high percentages of chenopodiaceous shrubs and sub-shrubs occur at lower altitudes of S-Afghanistan as well as along the W and N periphery where rainfall scarcely exceeds 150–200 mm. But they also dominate in drier basins and valleys of the C- and E-Afghanistan mountains where locally rocks rich in gypsum reach the surface, as in the Bamyan (Fig. 2.16a) and Ajar valleys, parts of the Ghorband valley and in the lower Gomal valley. Important species are, among others, shrubby or sub-shrubby chenopods as *Halothamnus subaphyllus, Salsola arbuscula, S. montana, S. gemmascens*, locally *S. maracandica, Seidlitzia rosmarinus*, several species of *Artemisia,* in particular *A. oliveriana* and *A. sieberi*, and the shrubs *Cousinia deserti, Ephedra sarcocarpa, E. strobilacea, Zygophyllum atriplicoides* and *Z. eurypterum,* and. Depending on soil structure, in spring-time ephemerals and hemicryptophytes can contribute considerably to the diversity of these open communities.

On loess-covered foothills in the N the grass-cover is significant with several heavily grazed species (*Festuca, Poa*), mainly characterized by *Carex stenophylla,* giving a steppe-like appearance.

2.6.2 Shrubby Amygdalus *Semi-deserts (Fig. 2.15: 1e)*

Close to the foothill areas of S- and W-Afghanistan as well as in drier interior valleys of the Hari Rud, Kokcha, Surkhab etc., where rainfall varies between c. 150 and 250 mm, different but closely related spiny *Amygdalus* species (*A. eburnea, A. erioclada*) that usually grow up to 0.5–1.5 m are the most significant plants in open

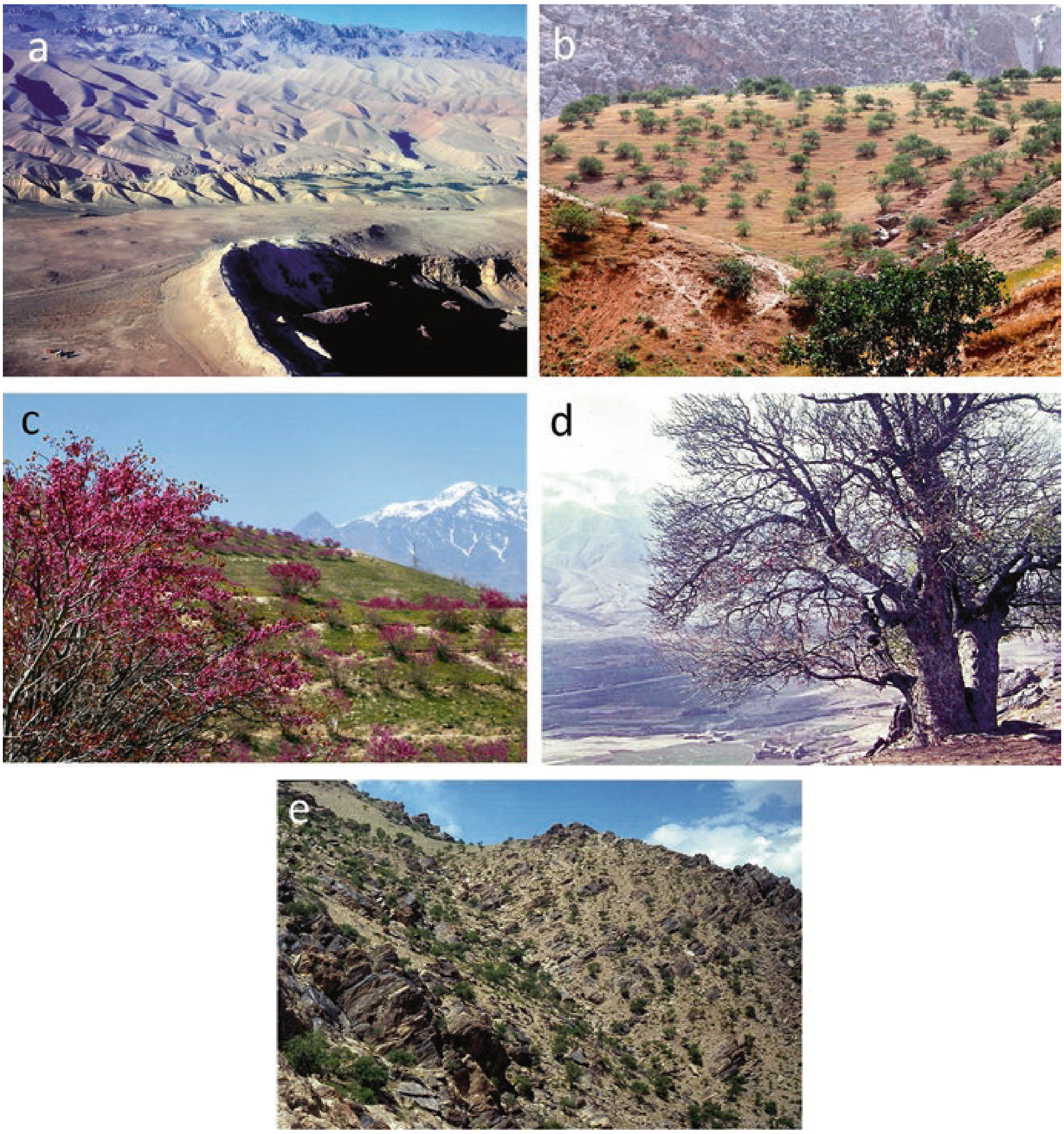

Fig. 2.16 (**a**) Dragon valley, SW of Bamyan, is an inner-mountain valley, which is very dry and characterized by a local chenopod desert with *Salsola maracandica, Anabasis* and *Arthrophytum* species, 2800 m a.s.l. (photo SWB); (**b**) Open stands of *Pistacia vera*, strongly grazed, N parts of Marmul-Mtns., 650 m a.s.l., N Afghanistan (photo M Keusgen); (**c**) *Cercis griffithii* (Caesalpiniaceae), is one of the conspicuous shrubs, sometimes forming small trees, which may have covered in former centuries all lower montane slopes of N Hindu Kush and mountain slopes from Tajikstan to E Iran (photo M Keusgen); (**d**) Old large *Pistacia cabulica (P. atlantica)* trees, Khorogh Koh, at Ziarat W of Kabul, indicating the good potential of tree stands on slopes around Kabul (photo SWB); (**e**) Open woodland with *Amygdalus kuramica*, Qarabagh, Wardak, C Afghanistan (photo H Freitag)

semi-desert shrub-lands. They are accompanied by a high number of other low shrubs like *Ephedra intermedia*, dwarf shrubs of *Acanthophyllum, Diaphanoptera* (in W), *Acantholimon, Cousinia* and *Artemisia*, perennial grasses like *Stipa hohenackeriana,* many hemicryptophytes and numerous annuals and geophytes.

Overgrazing effects are usually less conspicuous here because, by their spiny morphology, most woody plants are well protected both against grazing animals and fuel-collecting villagers. Sometimes the density of sub-shrubs has even increased, in particular in the case of the widespread *Cousinia stocksii* community in S- and W-Afghanistan.

2.6.3 Subtropical **Zizyphus – Acacia** *Scrub (Fig. 2.15: 2)*

The semi-desert scrub and dry thorn savannah of the distinctly semi-arid (c. 150–300 mm) and hot Jalalabad basin shows strong subtropical influence by the spiny deciduous shrubs and small trees of *Zizyphus nummularia* and *Acacia modesta*, mixed with such evergreen unpalatable shrubs as *Periploca aphylla, Rhazya stricta, Calotropis procera*, *Ephedra ciliata*, and *Withania coagulans* (Solanaceae). In the comparatively densely populated region, these strongly armed or unpalatable species most likely have gained a higher coverage at the cost of perennial grasses like *Chrysopogon aucheri, Hyparrhenia hirta, Tetrapogon villosus* and *Stipagrostis* spp. Most other species of the herbaceous layer are likewise unpalatable, as the annuals *Stipa capensis* (Poaceae) and *Cleome viscosa* (Capparidaceae), the perennials *Aerva javanica* (Amaranthaceae) and the tiny desertic *Salvia* species as *Salvia aegyptiaca, S. santolinifolia* and *S. trichocalycina,* and also *Farsetia edgeworthii, Convolvulus spinosus* and even *Haloxylon salicornicum* may be found. This scrub community represents, at the SE side, the lowest dry belt of the mountains. Slightly higher *Pistacia khinjuk, Periploca aphylla, Ephedra intermedia* and *Cerasus verrucosa* may be part of an open formation with many dwarf shubs and geophytes, as well as the succulent *Caralluma aucheriana*.

2.6.4 **Pistacia vera** *Communities (Fig. 2.15: 3a)*

The foothills, lower and medium altitudes (c. 600–1500 m a.s.l.) in N-Afghanistan, where rainfall fluctuates between c. 300 and 500 mm, are the areas of several woodland types dominated by the deciduous *Pistacia vera* (Fig. 2.16b). It coincides with the upper part of the broad loess belt, and on these soils the communities show their most typical structure. Size and coverage of the trees that have flat crowns and often several stems vary from shrub-like 2–3 m up to 6 (10) m, according to the water supply and grazing intensity. In higher altitudes, on northern slopes or on other more mesic habitats, the coverage can reach up to 40% and other deciduous trees might appear like *Amygdalus bucharica, Celtis caucasica, Cercis griffithii* (Fig. 2.16c)*, Acer semenowii, Fraxinus xanthoxyloides* and the woody liana *Ephedra foliata*. On loess soils, the herbaceous layer is meadow-like and made up of a multitude of perennial and annual grasses, together with large-leaved composites like

Codonocephalum grande and *Cousinia umbrosa*; also Lamiaceae such as *Phlomis bucharica* and *Salvia pterocalyx* occur.

The first geophytes appear at the end of March: *Anemone bucharica, Corydalis aitchisonii* and *Eranthis longestipitata*; later are such showy *Eremurus* species as *E. bucharica, E. olgae* and *E. regelii*, together with *Bellevalia atroviolacea, Bongardia chrysogonum* and *Ungernia trisphaera*. Several smaller woodland areas were protected for centuries by the village people in order to safeguard their pistachio nut-collecting as a considerable source of income. However, during recent decades their area and/or the density of trees have greatly decreased. Removal of trees at first led to higher productivity of the most valuable herb layer but overgrazing favoured less palatable species, in particular wormwoods like *Artemisia prasina, A. diffusa* and *A. oliveriana*. From large areas at higher altitudes, natural vegetation has disappeared because of rain-fed agriculture (lalmi).

2.6.5 **Pistacia atlantica** *Communities (Fig. 2.15: 3b)*

In W-, S- and E-Afghanistan, at altitudes from c. 1000–2000 m a.s.l. and mean precipitation of c. 250–450 mm, the natural vegetation is represented by *Pistacia atlantica* communities. *P. atlantica* is a robust, long-lived tree (Fig. 2.16d) with a thick trunk and a rounded or somewhat flattened crown. Size and coverage of trees as well as the associated species depend strongly on site conditions and on the geographical location. Additional tree species such as *Cercis griffithii* (Fig. 2.16c), *Fraxinus xanthoxyloides* and *Ficus johannis* occur here and there. Because of the predominating skeletal soils, shrubs and subshrubs, like *Amygdalus spinosissima, Cerasus bifrons, Astragalus* spp. (in particular *A. koshubensis*) and *Artemisia* spp. are often common at the expense of perennial and annual herbs. Some of the common perennial hemicryptophytes are the grasses *Stipa arabica* and *Piptatherum vicarium*, as well as *Salvia leriifolia,* sometimes *Adonis turkestanicum* (Fig. 2.17a).

Among geophytes, the showy *Fritillaria imperialis* (Fig. 2.17b), *Eremurus stenophyllus* (Fig. 2.17c), and *Tulipa* spp. are particularly conspicuous, besides *Anemone biflora, A. petiolulosa, A. tschernjaewii, Corydalis afghanica, Iris stocksii, I. cabulica,* various *Allium* species (Fig. 2.17d) and *Arum korolkowii*. Degradation mainly resulted in open low shrublands dominated by spiny *Astragalus* or by unpalatable *Artemisia* species with an increasing coverage of small, prostrate annuals.

2.6.6 **Amygdalus** *Communities (Fig. 2.15: 3c)*

From c. 2000–2800 m a.s.l., in areas with higher precipitation, longer-lasting snow cover and more moderate summer temperatures, the *Pistacia atlantica* woodlands are gradually replaced by the communities of *Amygdalus kuramica* (Fig. 2.16e) (E-Afgh) and *A. browiczii* (= *A. zabulica)* (SE- to W- Afgh). They reach up to the

Fig. 2.17 (**a**) *Adonis turkestanicum* (Ranunculaceae), a large flowering, perennial *Adonis* of shady slopes and good soils, here near Yarwan, Badakhshan, 2870 m a.s.l. (photo M Keusgen); (**b**) *Fritillaria imperialis* (Liliaceae), a very showy geophyte of montane and subalpine rocky slopes in Iran and Afghanistan (photo I Hedge and P Wendelbo); (**c**) *Eremurus stenophyllus* (Xanthorrhoeaceae), one of the most widespread steppe-lilies of the area, on montane slopes in all Afghan mountain regions (photo I Hedge and P Wendelbo); (**d**) *Allium mirum* (Alliaceae), an endemic geophyte to Afghan mountains with two large leaves and a short stalked huge inflorescence, here from Panshir Valley, 1950 m a.s.l. (photo M Keusgen)

tree line. The trees are bushy, with rounded crowns, and rarely exceed 3–5 m. Other tree species are usually absent but the loose shrub layer includes many species of *Rosa, Colutea, Cerasus, Cotoneaster, Rhamnus, Berberis, Sageretia thea* subsp. *thea, Spiraea, Ephedra* etc. Common herbaceous perennials are, among many others, *Salvia bucharica* and *S. rhytidea, Eremurus aitchisonii* and *E. korshinskyi* (Fig. 2.18a), *Rheum ribes*, large *Ferula jaeschkeana* (Fig. 2.18b) and many *Cousinia* spp. These communities reach up to the timber line, which however, is often obscured by the removal of trees. Overgrazing has often favoured the expansion of thorny cushion subshrubs. In areas where all the cushions and sub-shrubs are removed as brushwood, a final stage of degradation results in an open *Leucopoa karatavica* grassland with low productivity and poor in species.

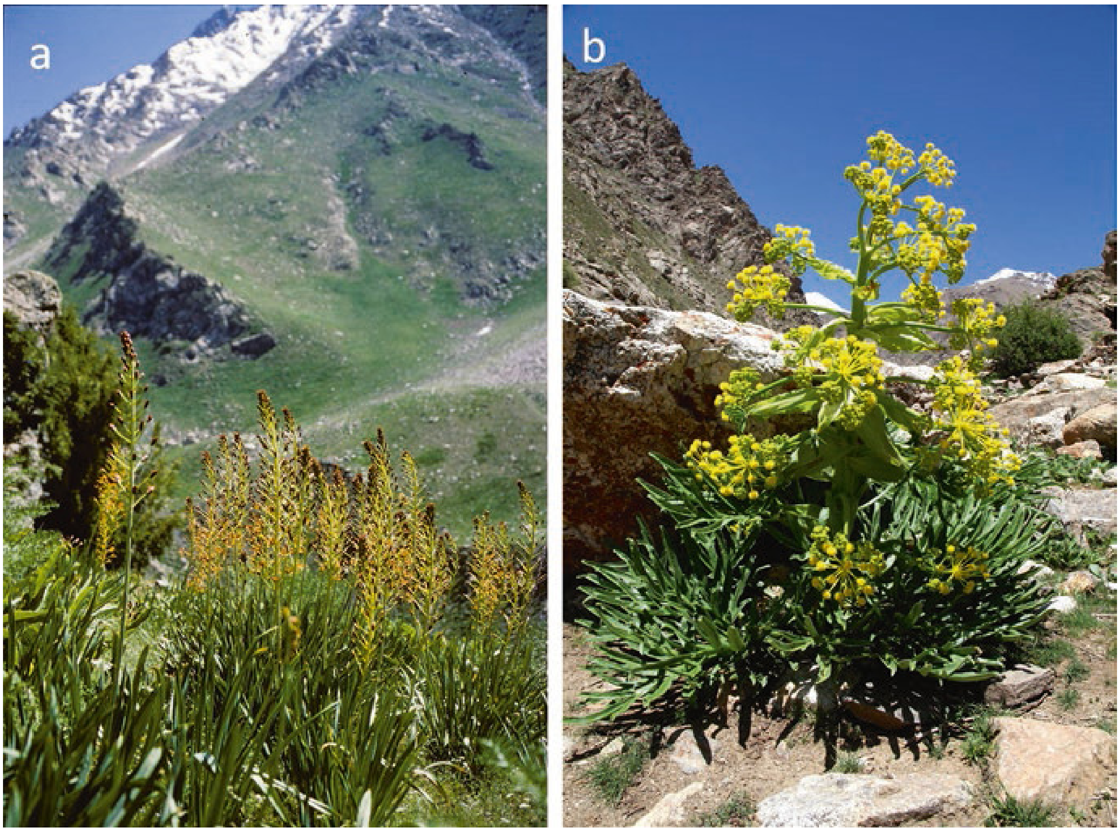

Fig. 2.18 (**a**) *Eremurus korshinskyi* (Xanthorrhoeaceae), another large geophytic steppe, one of many species in Hindu Kush (photo I Hedge and P Wendelbo); (**b**) *Ferula jaeschkeana* (Apiaceae), a huge hapaxanthic herb, related to the old medicinal plant species *F. assa-foetida*, common on montane slopes of Hindu Kush, Parandi Valley, Panshir (photo M Keusgen)

2.6.7 Juniperus excelsa/semiglobosa *Communities (Fig. 2.15: 3d)*

In N-Afghanistan, above c. 1400 m a.s.l. the deciduous *Pistacia vera* woodlands grade into evergreen *Juniperus excelsa* communities (Fig. 2.19a) that form a belt up to the tree line at 2900 m a.s.l. (W-Afgh) to c. 3200 m a.s.l. (NE-Afgh). In altitude, they correspond to the *Amygdalus* communities. They re-occur at higher altitudes in E-Afghanistan, in particular in Paktya, where they replace the *Cedrus* forests in drier areas from c. 2800–3500 m a.s.l. However, due to the different precipitation regimes in both regions, the structure of the shrub-layer and the herbaceous layers varies considerably. In N-Afghanistan, the precipitation is much higher, with approximately 450–1000 mm, most of it as snow; the winter rains are often prolonged until June, but the summer is dry as everywhere in the Irano-Turanian region. These conditions allow a rich shrub, dwarf shrub and herbaceous vegetation to develop, with each layer depending on the others, as long as the slopes are not too steep and unstable.

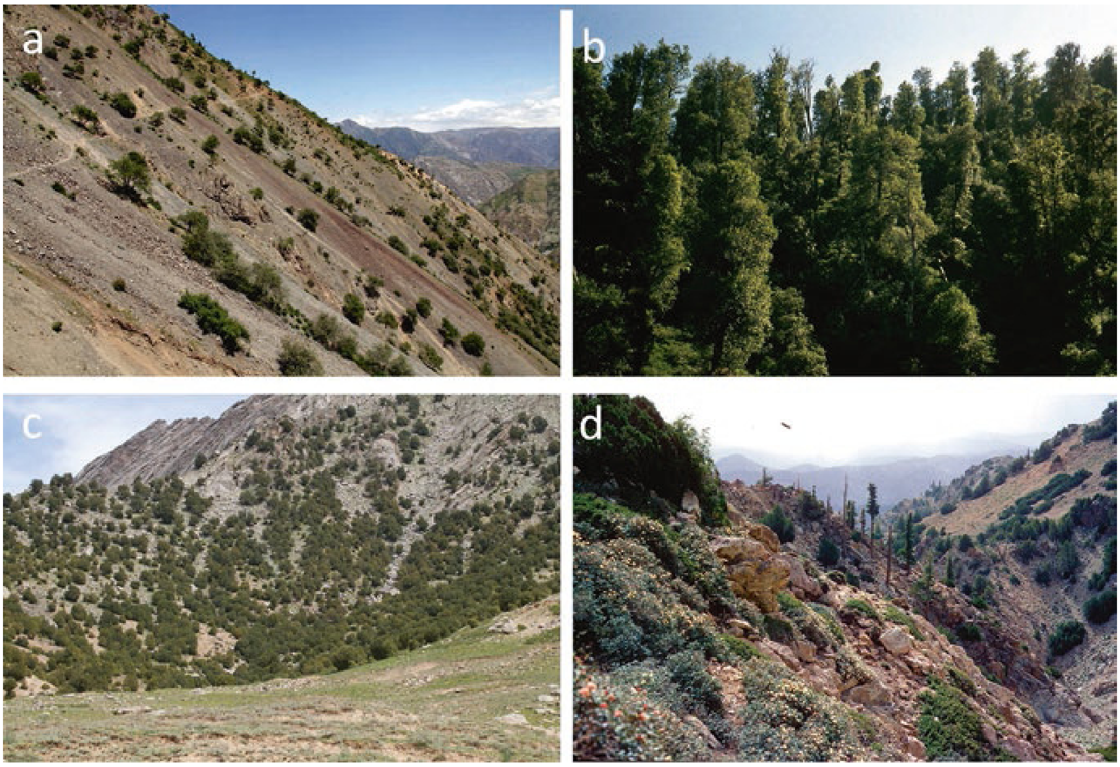

Fig. 2.19 (**a**) Open tree stands of *Juniperus* (*J. semiglobosa, J. seravschanica*) on mountain slopes W of Shingan, 2025 m a.s.l., NE Afghanistan (photo M Keusgen); (**b**) Evergreen oak forest with *Quercus baloot*, Panshir Valley, E Afghanistan (photo M Keusgen); (**c**) Dense high montane *Quercus dilatata* forest at Darah Nur (2100 m a.s.l.), Nangahar prov., E Afghanistan (photo H Freitag); (**d**) Dense Krummholz vegetation under monsoon influenced summer climate with *Rhododendron collettianum* shrubs above Paiwar Kotal (3200 m a.s.l.) with highest climbing trees at tree line (*Cedrus, Picea, Juniperus*), Safed Koh, E Afghanistan (photo I Hedge and P Wendelbo)

Cutting of trees for charcoal production or natural die-back favours the shrubs, and when they are cleared, on deeper soils the herbaceous layer might expand into veritable meadows which are locally harvested for hay. Under optimal conditions, the trees might grow up to 12 m and together with the rich shrub layer the coverage can go up to c. 80%.

In NE- and E-Afghanistan, the common *Juniperus excelsa* is usually accompanied by *J. semiglobosa*. The latter often outnumbers the former species in the subalpine belt. Common shrubs are *Lonicera nummulariifolia* (often as a small tree), *Ephedra equisetina*, different species of *Rosa, Berberis, Colutea, Prunus, Cerasus* and *Cotoneaster*. The shaded ground is loosely covered by thin-leaved, delicate annuals such as *Alliaria petiolata, Geranium rotundifolium, Impatiens parviflora, Lepyrodiclis holosteoides* and *Parietaria lusitanica*. Prominent geophytes are, e.g., *Eremurus furseorum, E. spectabilis* and *Allium*-species like *A. rosenbachianum, Iris microglossa, I. fosteriana,* and many *Gagea* species.

Important hemi-cryptophytic plants are, among others, *Prangos pabularia* and *Codonocephalum grande*. On loess soils, after clearing the trees and shrubs, the latter two species greatly expand in meadows formed by floristically rich and productive substitute communities. In contrast, on slopes covered with scree all layers are much reduced, and deciduous trees like *Celtis caucasica, Fraxinus xanthoxyloides, Acer turkestanicum* and *Amygdalus kuramica* (Fig. 2.16e) widely replace the junipers, while tall hapaxanthic *Ferula* species (Fig. 2.18b) become dominant in the herbaceous layer, together with *Rheum ribes*.

The *Juniperus* communities in E-Afghanistan receive less winter rain but sometimes additional summer rain. Common shrubs are *Ephedra major* subsp. *procera, Ephedra gerardiana* and *Ribes orientale*. The herbaceous layer is dominated by more xerophytic species, like the perennial grasses *Stipa turkestanica, Piptatherum baluchistanicum, Psathyrostachys caduca, Poa* spp., and species of *Cousinia, Ferula* and *Artemisia*. After the destruction of trees, *Artemisia glanduligera* often occupies large areas with thorn-cushion species invading from the subalpsubalpine belt.

2.6.8 Evergreen Broad-Leaved Reptonia/Olea *Woodland in E-Afghanistan (Fig. 2.15: 4a)*

Around the basins of Khost and Jalalabad, in areas from about 800–1300 m a.s.l. and rainfall from c. 300–500 mm, the *Reptonia buxifolia-Olea ferruginea* community forms structurally rich woodlands of widely differing coverage. Addional sclerophytic tree and shrub species are *Nannorrhops ritchieana, Gymnosporia royleana, Sageretia thea* subsp. *brandrethiana, Ephedra pachyclada* and *Dodonaea viscosa* which grow together with deciduous trees and shrubs as *Pistacia khinjuk, Acacia modesta*, and *Ebenus stellatus*. A particularly striking feature of these woodlands is the high coverage of perennial, subtropical tussock grasses like *Tetrapogon villosus, Dichanthium annulatum, Cymbopogon parkeri, Hyparrhenia hirta, Heteropogon contortus* and *Aristida cyanantha*; they greatly increase in coverage after destruction of the woody component. Most of them start sprouting with the onset of the summer rains and can give the landscape the aspect of a lush tropical savannah between July and September, whereas in the same period in interior Afghanistan, because of the climatic dryness, most plant life activity has completely ceased. This may partly also result from the fact, that a number of those grasses are C4-grasses with very high photosynthetic capacities at high temperatures.

2.6.9 Sclerophyllous and Lauriphyllous Oak Forests in E-Afghanistan (Fig. 2.15: 4b)

The *Quercus baloot* communities occur adjacent to the former in altitudes from 1300–2100 m a.s.l. and rainfall from c. 350–600 mm. Depending on water supply and soil conditions, they might form forests, with the individual trees up to 15 m high (Fig. 2.19b), or shrubby woodlands, but most of the latter are caused by intensive cutting of twigs for feeding domestic animals during winter (Breckle and Kull

1971), and by selective felling of whole trees as *Quercus baloot* yields very valuable fire wood (Freitag 1982). Accompanying woody species are the trees *Amygdalus kuramica* and *Pistacia khinjuk*, the lianas *Lonicera griffithii* and *Rosa brunonii*, and the shrubs *Daphne mucronata* (, *Plectranthus rugosus, Perovskia atriplicifolia* and *Salvia cabulica*. These forests and woodlands have disappeared from large areas, and their place is taken by shrub communities of *Perovskia atriplicifolia* and *Sophora griffithii*, or, when even more degraded, by different *Artemisia* (e.g., *Artemisia kurramensis*) communities. The westernmost remnants of *Quercus baloot* forests have survived in the Panjshir valley to the N of Kabul, and a few tall trees were observed at Top Dara above the Kohe Daman basin near Charikar. Historical records of *Q. baloot* also exist from the Latahband pass, some 25 km E of Kabul (Breckle and Kull 1971). It might well be that those forests covered most of this area centuries ago.

In the semi-humid to humid areas of Nuristan and around the Safed Koh, from c. 1900 m a.s.l. upwards, with higher amounts of summer rain, *Q. baloot* is replaced, at first by the mesophytic *Q. dilatata* (Fig. 2.19c) and higher up, about 2900 m a.s.l., by *Q. semecarpifolia* which forms dense forests of 8–20 (25) m in height. Common associates of these true Himalayan forests are, e.g., the deciduous trees *Juglans regia, Celtis caucasia, Acer turkestanicum, Diospyros lotus, Pyrus pashia*, the woody climbers *Rosa brunonii* and *Lonicera griffithii*, and shrub species like *Corylopsis jacquemontiana, Indigofera gerardiana, Cotoneaster rosea, C. aitchisonii* and *Rubus niveus*. In higher altitudes, *Taxus contorta, Viburnum cotinifolium* and *Abelia triflora* have been observed. The luxuriant herbaceous layer includes other mesophytic Himalayan species, like *Strobilanthes urticifolius, Nepeta erecta, Polygonum amplexicaule, Rumex dentatus, Salvia nubicola*, the grasses *Brachypodium sylvaticum, Piptatherum munroi* and *Piptatherum aequiglume*, several annual species of *Impatiens* and even hygrophilous tall ferns like *Dryopteris ramosa, Dryopteris stewartii, Diplazium tomentosum, Dreparia (Athyrium) allantodioides* and *Pteris cretica*. Lianas are *Rosa brunonis, Hedera helix* and *Clematis*. Under less humid conditions, the evergreen oaks form mixed stands with the tall *Pinus wallichiana*.

2.6.10 Temperate Coniferous Forests and Woodlands in E-Afghanistan (Fig. 2.15: 5)

Woodlands and forests of different Himalayan conifers gradually replace the broad-leaved evergreen forests when mean precipitation is too low, or when the growth period becomes too short at higher altitudes. This also explains the occurrence of broad transitional zones. In altitudes from 2100–2500 m a.s.l., *Pinus gerardiana* woodlands (Fig. 2.10) alternate with the *Quercus baloot* communities. The trees are usually 5–12 m tall and might cover 15–70% of the ground. Locally these woodlands are protected (similar to the *Pistacia vera* woodlands) for “nut” collecting.

The seeds are important in the internal and external trade. Due to strong root competition, intact plant communities are rather poor floristically, but in natural openings and after logging a rather rich shrub layer might be found with *Sophora griffithii, Amygdalus spinosissima, Caragana ulicina, Berberis calliobotrys, Daphne mucronata, Cotoneaster afghanicus, Rosa ecae* and other Rosaceae.

Higher up, from 2500–3100 m a.s.l. in mountain systems that receive c. 450–600 mm mean precipitation, mainly in winter, *Cedrus deodara* communities take the place of *Pinus gerardiana* woodlands in between the more xerophytic *Juniperus* woodlands (Fig. 2.19a) and the mesophytic, mixed *Quercus-Pinus wallichiana* forest communities. On steeper slopes, the *Cedrus deodara* communities occur as woodlands, but under optimum conditions, the usually mono-specific tree layer may be 25–35 m tall and reach coverage of 80%. The thin shrub layer is more or less restricted to clearings and usually consists of *Lonicera quinquelocularis, Berberis calliobotrys, Cotoneaster* spp. and *Ribes orientale*. The herbaceous layer is also open and varies much according to water supply and shade. Usually, it includes a prominent grassy component, with *Carex cardiolepis, Piptatherum angustifolium* and *Poa aitchisonii*. As *Cedrus deodara* provides the most valued timber wood in Afghanistan and adjacent Pakistan, the forests have been exploited or over-exploited for decades and are almost completely destroyed in most of the area. They are replaced by stable but poor *Artemisia* communities with prevailing *A. bicolor* and/or *A. glanduligera*.

At the same altitude but with a much higher summer rainfall, usually above the broad-leaved evergreen oak forests, in a few more humid parts of Nuristan and on the upper slopes of the Safed Koh, mixed *Abies-Picea* forests are distributed. They consist of *Abies pindrow* (upper montane), *A. spectabilis* (subalpsubalpine) and *Picea smithiana;* they are 15–30 m high and often include individual trees of *Quercus semecarpifolia* and *Pinus wallichiana*. Due to the shade in intact communities, the shrub and herbaceous layers are poorly developed. They contain a number of mesophytic species like *Pertya aitchisonii, Salvia nubicola, Nepeta pinetorum, Saussurea afghana, Rumex nepalense, Lilium polyphyllum* and *Cicerbita aitchisoniana*. On unstable slopes and in small valleys close to the tree-line the conifers are locally replaced by a *Betula jacquemontii* community.

2.6.11 Subalpine **Juniperus-** *and* **Rhododendron** *Scrub (Krummholz, Elfinwood) (Fig. 2.15: 6)*

In the wettest parts of Nuristan, from the timberline at 3200–3300 m a.s.l. up to c. 4000 m a.s.l., *Abies spectabilis, Picea* and *Quercus semecarpifolia* are replaced by a dense 1 m high *Juniperus squamata* community (Schickhoff 2005). Sub-ordinate components of this dense Krummholz thicket (Fig. 2.19d) are *Rosa macrophylla, Ribes alpestre, R. villosum, Rubus irritans, Lonicera webbiana* and *Rhododendron collettianum* (Fig. 2.19d). The herbaceous layer is similar to that of the subalpine *Abies* forest.

On lower sites at the Safed Koh and in the upper Laghman area, just below the treeline, in the upper montane and subalpine belt, the very rare *Rhododendron afghanicum* occurred, but is most probably now extinct at this site in Afghanistan (Breckle 1972; Hedge and Wendelbo 1970b; Larsen 2009; Muhammad et al. 2017).

Where summer rain is somewhat less abundant and *Abies* is replaced by *Picea* at the timberline, as in most parts of Nuristan and around the Safed Koh, the *Juniperus communis* subsp. *nana* community takes the place of the former. It is only 40–60 cm high and has a patchy structure, with the clearings covered by thorn-cushions like *Cousinia kuramensis, Cicer macracanthum, Onobrychis spinosissima* and numerous hemicryptophytes related to or identical with those of the cushion shrub communities.

2.6.12 Subalpine Thorn-Cushion Shrublands (Fig. 2.15: 7a)

Plant communities dominated by thorn cushion plants (Fig. 2.20) represent a broad upper vegetation belt in higher mountain systems of Afghanistan where summer rain is absent and where the soil water supply completely depends on moisture from melted snow. It is part of a vast tragacanthic belt from Spanish (Sierra Nevada) and Moroccan mountains (Atlas) until the Himalaya. These very peculiar shrublands extend from the timberline located at c. 2800–2900 m a.s.l. in the W parts and 3300–3500 m a.s.l. in the NE and E parts up to 3800 to 4000 m a.s.l. and play an important role as summer pastures. Most predominant species belong to spiny species of *Cousinia, Astragalus* (Fig. 2.20a,c)*, Acantholimon* (Fig. 2.20a)*, Onobrychis* (Fig. 2.20b)*, Acanthophyllum* and *Cicer*, but species composition varies between the different mountain systems, and the proportion of endemics is particularly high. Here the evolution of many of those tragacanthic species has taken place. Other common dwarf shrubs are *Artemisia* spp., *Ephedra gerardiana, Rhamnus prostrata*, and *Krascheninnikovia ceratoides*. The herb layer includes many palatable grasses, as e.g., *Piptatherum laterale, Poa araratica, Koeleria* spp. and *Festuca* spp. Together with many legumes, such as species of *Astragalus, Oxytropis* and *Trigonella.* It provides important grazing resources, together with *Platytaenia lasiocarpa, Trigonella koelzi, Rindera neubauerei, Winklera silaifolia* etc. One of the most striking plants is the steppe lily *Eremurus kaufmannii*. Most likely, the often strong grazing pressure has resulted in a marked increase in thorn-cushion plants and in the tufted grass *Leucopoa karatavica* beyond their original occurrence.

2.6.13 Alpine Semi-deserts, Steppes and Meadows (Fig. 2.15: 7b)

The borderline between subalpine and the alpine vegetation is not readily discernible, except in the wetter parts of E-Afghanistan where it is marked by the upper border of the juniper scrub. In most areas, the thorn-cushion plants of the subalpine

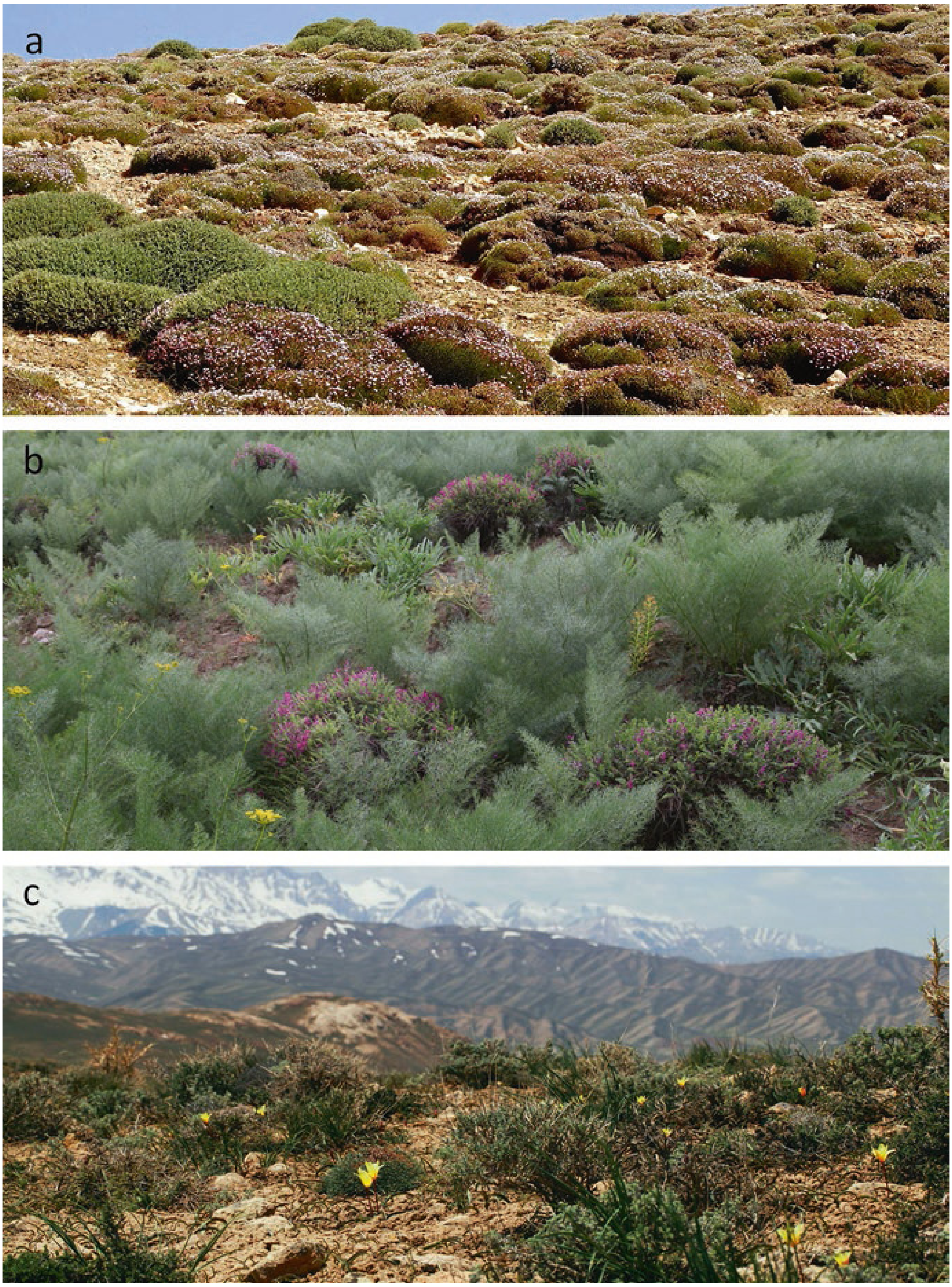

Fig. 2.20 (**a**) Thorn-cushion shrub-land at Dashte Nawor (3300 m a.s.l.) with *Acantholimon* and other tragacanthic species (photo H Freitag); (**b**) *Onobrychis cornuta* (Fabaceae), a typical tragacanthic cushion shrub, widely distributed in the Flora Iranica region, here with many giant herbs, like *Prangos pabularia* (photo M Keusgen); (**c**) Open subalpine sub-shrub vegetation with many *Artemisia* species, with *Kraschennenikovia, Astragalus* and *Acantholimon* and many geophytes, being summer grazing patches of nomads (photo M Keusgen)

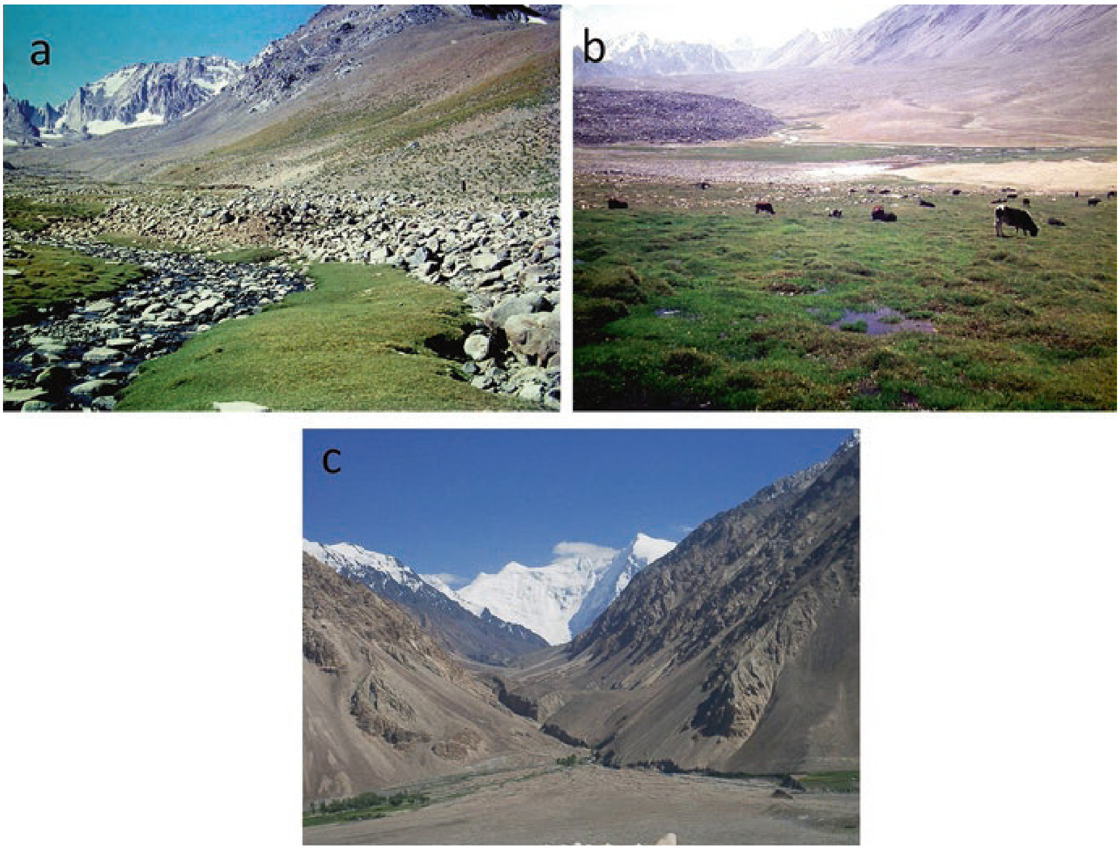

Fig. 2.21 (**a**) Vegetation mosaic at a small creek with snow melt water with patches of *Kobresia* meadows and open scree vegetation, 4200 m a.s.l., Fuladi Valley, Kohe Baba (photo SWB); (**b**) Yaks grazing on high alpine pastures and snow patches near Wazit pass, Wakhan, 4400 m a.s.l. (photo SWB); (**c**) The E Hindu Kush range with Noshaq (7480 m a.s.l.), seen from Tajik side, indicating all higher elevational belts and specialized irrigation systems in Abe Panj Valley of E Afghanistan (photo M Wennemann)

belt are step-wise replaced by smaller-sized species of the same genera, and also the species composition of the herbaceous layer changes gradually. Genuine alpine meadows dominated by grasses and a greater variety of herbs are restricted to the C- and E-Hindu Kush and the Pamirs because these areas receive more summer rainfall (Huss 1978; Breckle 2004). Consequently, they are heavily used for summer pasture during the short summer (2 months), usually by nomad (koochi) people. Elsewhere, even on deeper soils, the vegetation is rather open, except for wet sites along creek borders (Fig. 2.21a), head-waters and swamps (Fig. 2.21b) below melting snow fields; there alpine meadows exist. Because of the steep topography, delayed soil formation, and the locally long-lasting snow cover, even small areas might show a high diversity of plant communities. Vast stretches look almost devoid of vegetation as they consist of rocks, blocks and scree. The total number of species occurring in the upper belts (above 3900 m a.s.l.) in the Hindu Kush and Afghan mountains is about 542 vascular plant species from 188 genera (Breckle et al. 2018), see also Figs. 2.8 and 2.11.

2.6.14 Nival Belt (Fig. 2.15: 8)

Approaching the snow line at c. 4800–5000 m a.s.l. (N exposed slopes) to 5400 m a.s.l. (S exposed), everywhere the coverage and numbers of species decrease significantly. In the nival belt single plants survive amidst bare rock and on scree slopes (Fig. 2.21c). However, on S-facing rocky slopes in the Hindu Kush even dwarf woody plants like *Juniperus semiglobosa* and *Lonicera microphylla* can be found above 5000 m a.s.l., as well as the fern *Cystopteris dickieana* (Breckle 1974, 1988). There are almost 40 species recorded from above 5000 m a.s.l. (Breckle 1974, 2017, 2019; Breckle et al. 2017, 2018), see Table 2.3 and Fig. 2.8. The highest altitudinal record of a vascular plant in Afghanistan is the beautiful *Primula macrophylla* in the C-Hindu Kush at 5600 m a.s.l. *Sibbaldia cuneata* is also known from about 5500 m a.s.l. Several other Brassicaeae also reach high alpine to subnival elevations, like *Solmslaubachia flabellata*, and *S. surculosum* or *Draba*. Mosses and lichens occur on all rocky substrates – even up to the highest peaks. Among the bryophytes, 6 species are recorded from 4750 m a.s.l. and above, with *Didymodon luridus* at 5630 m a.s.l. being the highest recorded. A coherent nival belt occurs only in the higher parts of the Pamirs, the Hindu Kush and the Kohe Baba range.

The typical decrease in number of species (Figs. 2.8 and 2.11) with increasing altitude for various mountains in SW and C-Asia was shown by Breckle (1974) and by Noroozi et al. (2008) (see also Körner 1999). The average snow line in the W-Hindu Kush is at c. 4900–5200 m a.s.l., in Wakhan between 5000 and 5300 m a.s.l. (see also Grötzbach and Rathjens 1969; Rathjens 1972, 1978; Breckle and Frey 1976a, b); in some parts, as in the Salang region, it is below 4800 m a.s.l. The eternal snow and cover of glaciers in summer often shows the typical “Penitentes” formation resulting from the high solar radiation sometimes with reddish snow-algae (*Chlamydomonas nivalis*).

Briefly, we have to mention the **azonal vegetation** (Figs. 2.9a,b and 2.15) with special soil conditions or additional water supply along creeks, ponds and lakes. The delimitation is often quite distinct as can be seen in meadows fed by snow melt water (Fig. 2.21a,b).

2.6.15 Vegetation Profiles

In the C-Afghan mountains, the altitudinal zonation of the vegetation along a profile between Zaranj and Amu Darya via Kohe Baba (Fig. 2.22), shows a relatively simple structure (Breckle et al. 2013). The lowlands of Sistan and the Registan in the S and SW-Afghanistan harbour *Calligonum-Stipagrostis-, Haloxylon salicornica-* and Chenopodiaceae-semi-deserts. With 10–12 thermal vegetation months and very sparse rainfall (<100 mm), the climate is extremely harsh. This vegetation formation includes all areas below 950 m a.s.l. In the foothill areas between 950 and 1200 m a.s.l., a narrow belt of a semi-desert formation of *Amygdalus* shrubs exists.

Table 2.3 The highest plant species in the Afghan mountains (Hindu Kush) from 4800 m a.s.l. upwards; the nival flora (after Breckle et al. 2018)

Family	Species	Max (m)
Pottiaceae (Bryo.)	*Didymodon luridus* Hornsch.	5630
Primulaceae	*Primula macrophylla* D. Don var. *macrophylla*	5600
Asteraceae	*Allardia (Waldheimia) tridactylites* (Kar.&Kir.) Sch.-Bip. ssp *tridactylites*	5400
Rosaceae	*Sibbaldia cuneata* Kunze	5400
Saxifragaceae	*Saxifraga hirculus* L. ssp *alpina* (Engler) Podl.	5400
Asteraceae	*Saussurea glacialis* Herder	5300
Saxifragaceae	*Saxifraga komarovii* Los.	5300
Apiaceae	*Aulacospermum stylosum* (C.B.Clarke) Rech.f. & H.Riedl	5200
Asteraceae	*Psychrogeton andryaloides* (DC.) Novopokr. var *denudans* (Botsch.) Grierson	5200
Asteraceae	*Saussurea gnaphalodes* (Royle) Sch.-Bip.	5200
Brassicaceae	*Solmslaubachia flabellata* (E.Regel) Al-Shehbaz	5200
Lamiaceae	*Nepeta pamirense* Franch.	5200
Ranunculaceae	*Delphinium brunonianum* Royle	5200
Woodsiaceae (Pter.)	*Cystopteris fragilis* Bernh. ssp *dickieana* (Sim.) Hook.f.	5100
Cyperaceae	*Carex pseudofoetida* Kük. In Ostend. ssp *afghanica* Kukkonen	5100
Asteraceae	*Leontopodium ochroleucum* Beauv.	5100
Boraginaceae	*Eritrichium canum* (Benth.) Kitam.	5100
Brassicaceae	*Chorispora macropoda* Trautv.	5100
Brassicaceae	*Draba altaica* (C.A.Mey.) Bunge	5100
Brassicaceae	*Smelowskia calycina* (Willd.) C.A.Mey.	5100
Brassicaceae	*Solmslaubachia surculosa* (N.Busch) D.German & Al-Shahbaz	5100
Caryophyllaceae	*Silene himalayensis* (Rohrb.) Majundar ssp. *himalayensis*	5100
Grimmiaceae (Bryo.)	*Coscinodon cribrosus* (Hedw.) Spruce	5100
Lamiaceae	*Nepeta glutinosa* Benth.	5100
Lamiaceae	*Nepeta paulsenii* Briq.	5100
Lamiaceae	*Thymus linearis* Benth. ssp *linearis*	5100
Poaceae	*Alopecurus himalaicus* Hook.f.	5100
Polygonaceae	*Rheum tibeticum* Maxim.	5100
Rosaceae	*Pentaphylloides dryadanthoides* (Juz.) Sojak	5100
Rosaceae	*Potentilla desertorum* Bunge	5100
Brassicaceae	*Draba korshinskyi* (O.Fedtsch.) Pohle	5060
Cyperaceae	*Carex nivalis* Boott.	5050
Brassicaceae	*Allardia tridactylites* (Kar.&Kir.) Sch.-Bip. ssp *glabra* (Decne.) Podl.	5050
Apiaceae	*Ligusticum afghanicum* Rech.f.	5000
Asteraceae	*Psychrogeton olgae* (Regel & Schmalh.) Nevski	5000
Brassicaceae	*Solmslaubachia linearis* (N.Busch) Al-Shehbaz	5000
Caryophyllaceae	*Cerastium cerastioides* (L.) Britton	5000

(continued)

Table 2.3 (continued)

Family	Species	Max (m)
Encalyptaceae (Bryo.)	*Encalypta vulgaris* Hedw.	5000
Fabaceae	*Astragalus melanostachys* Benth. (§ *Brachycarpus* Boriss.)	5000
Fabaceae	*Oxytropis platonychia* Bunge	5000
Grimmiaceae (Bryo.)	*Grimmia laevigata* (Brid.) Brid.	5000
Primulaceae	*Androsace villosa* L. (*s.l.*)	5000
Ranunculaceae	*Ranunculus shaftoanus* (Aitch. & Hemsl.) Boiss.	5000
Rosaceae	*Potentilla gelida* C.A.Mey.	5000
Salicaceae	*Salix karelinii* Turcz.	5000
Saxifragaceae	*Saxifraga sibirica* L.	5000
Asteraceae	*Spathipappus griffithii* (C.B.Clarke) Tzvelev	4950
Asteraceae	*Ajania tibetica* (Hook.f. & Thoms.) Tzvelev	4900
Bryaceae (Bryo.)	*Bryum dichotomum* Hedw.	4900
Ditrichaceae (Bryo.)	*Distichium inclinatum* (Hedw.) Bruch & Schimp.	4900
Poaceae	*Koeleria litvinowii* Domin	4900
Poaceae	*Trisetum clarkei* (J.D.Hook.) R.R.Stewart	4900
Fabaceae	*Astragalus chargusanus* Freyn (§ Caprini DC.)	4900
Onagraceae	*Chamerion angustifolium* (L.) Holub	4900
Polygonaceae	*Oxyria digyna* (L.) Hill	4900
Poaceae	*Koeleria litvinowii* Domin	4900
Poaceae	*Trisetum clarkei (*J.D.Hook.) R.R.Stewart	4900
Apiaceae	*Semenovia radiata* (Rech.f. & H.Riedl) Alava	4800
Asteraceae	*Artemisia leucotricha* Ladygina	4800
Asteraceae	*Aster flaccidus* Bunge	4800
Asteraceae	*Erigeron petroiketes* Rech.f.	4800
Asteraceae	*Leontopodium nanum* (Hook.f.& Thoms.)Hand.-Mzt.	4800
Asteraceae	*Senecio korshinskyi* Krasch.	4800
Boraginaceae	*Pseudomertensia primuloides* (Dcne.)Riedl	4800
Brassicaceae	*Christolea crassifolia* Cambess.	4800
Brassicaceae	*Crucihimalaya crassifolia* (Hook.f.& Thoms.) Al-Shebaz et al.	4800
Brassicaceae	*Didymophysa fedtschenkoana* E.Regel	4800
Brassicaceae	*Erysimum erosum* O.E.Schulz	4800
Campanulaceae	*Campanula cashmeriana* Royle	4800
Crassulaceae	*Rhodiola recticaulis* Boriss.	4800
Cyperaceae	*Kobresia royleana* (Nees)Boeck.	4800
Gentianaceae	*Aliopsis pygmaea* (Regel & Schmalh.) Omer & Qaiser	4800
Juncaceae	*Luzula spicata* (L.) Don ssp. *mongolica* Novikov	4800
Parnassiaceae	*Parnassia palustris* L.	4800
Plumbaginaceae	*Acantholimon diapensioides* Boiss.	4800
Poaceae	*Festuca pamirica* Tzvelev	4800
Primulaceae	*Primula capitellata* Boiss.	4800

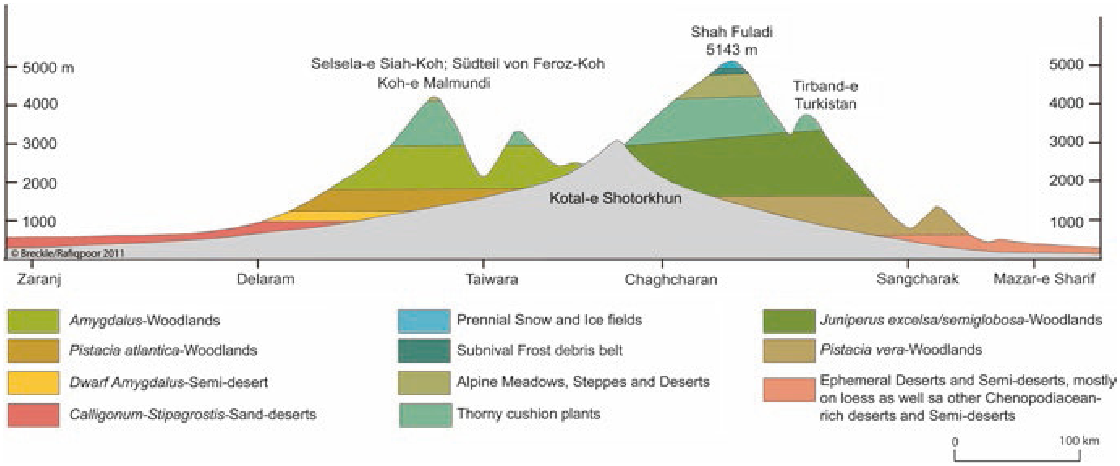

Fig. 2.22 Profile of vegetation belts along the western parts of Afghan Hindu Kush (After Breckle and Rafiqpoor 2010)

This formation is very typical only for W-, SW- and parts of E-Afghanistan. Along the major valleys (Hari Rud, Khash Rud, Helmand) this formation extends far into the mountain body. The *Amygdalus*-shrubs grow for 7–9 thermal vegetation months and in fairly arid conditions (P = 150–250 mm). Dominant shrubs are *Amygdalus cf. eburnea* in the W and the above-mentioned valleys, and *Amygdalus cf. erioclada* in the E area.

At heights of 1200–1600 m a.s.l., the altitudinal belt of the deciduous trees and open *Pistacia atlantica*-woodlands occurs in the form of a wide semi-circle between Herat and Kabul (mostly *P. atlantica* subsp. *cabulica*; at lower level in the E *P. khinjuk*).

Cercis griffithii, found on the edge of the Hari Rud valley and in the vicinity of Kabul (Fig. 2.16c), also belongs to this altitudinal belt. The climate is, with a thermal vegetation period of 7–9 months, rather warm and rainfall increases up to about 250–350 mm. Between 1600/1800 and 2900 m a.s.l., the altitudinal belt of the *Amygdalus*-woodlands (Fig. 2.16e) follows with c. 5–6 thermal vegetation months and under rather semi-humid conditions (P = 400–500 mm).

Their distribution area of the *Amygdalus*-woodlands penetrates along the Ghorband-, Salang- and Panjir valleys in the Hindu Kush mountains. Dominant species are *Amygdalus browiczii* (in W), A. *kuramica* (E, SE) and *Pistacia atlantica* (E, Fig. 2.16d). In the upper parts of this altitudinal belt, with increasing rainfall and a further shortening of the thermal growing season, isolated trees may occur on the SW slopes of the C-Afghan mountains at about 2900 m a.s.l., at the potential timberline – which hardly ever is visible. This formation gradually leads to the formation of the typical thorn-cushion plants, a belt between about 2900–3600 (4000) m a.s.l. Here, with a markedly short thermal growing season and even semi-humid conditions, *Onobrychis, Acantholimon, Artemisia, Ephedra* and various species of *Astragalus* dominate. The altitudinal belt of the alpine vegetation, found roughly between 4000 and 4500 m a.s.l., is a mosaic of semi-deserts and steppe with meadow patches. Above 4500 m a.s.l. with a very short thermal vegetation period and under relatively humid conditions, the narrow subnival belt is situated. The all year-round cold-humid subnival belt with frost debris extends in the C-Afghan mountains from c. 4500 m a.s.l. almost up to the summit regions of the Kohe Baba. The very narrow nival belt is concentrated only at the summit regions of the Kohe Baba (Shah Foladi: 5050 m a.s.l.), where, only on the main N facing slopes, small glaciers and snow patches persist in summer. In the Afghan mountains, the availability of moisture in the altitudinal belts above the timberline is not a consequence of high rainfall but results from the year-round low temperature which restricts the potential evapotranspiration (PET).

As indicated above, the altitudinal vegetation belts are in accordance with the asymmetric arrangement of climatic altitudinal zones (Breckle and Rafiqpoor 2019). Coming from the nival and subnival belts, we arrive, on the NE slopes of the mountains at about 4000 m a.s.l., in the altitudinal belt with the upper-most thorn-cushion shrubs. This zone is confined from the top as well as from bottom. Their altitudinal limits lie, compared to the SW side of the mountain, about 100–300 m higher. The altitudinal belt of the relatively uniform *Juniperus excelsa* open forest on the N slope of the mountain extends c. 1700–1800 m in amplitude. A corresponding counterpart of these forests is absent on the SW side of the mountain as well as in many intra-montane basins and valleys. A drier formation of *Amygdalus* woodland replaces it (see above). The reason for this is probably the slight increase in rainfall at the N-side of the mountain (c. 500–1200 mm depending on the region and exposition, Freitag 1971a) and a reduced average solar radiation as a result of the so-called crest-asymmetry (Klaer 1974, 1977), a special feature of the high mountains of the winter rain sub-tropics.

The *Juniperus excelsa*-open forests change downwards at about 1600 m a.s.l. into the altitudinal belt of the *Pistacia vera*-community (Fig. 2.16b), specific to the northern slopes of the C Afghan mountains. A shrubby *Amygdalus* formation of the lower elevations is not developed here, because the somewhat more favourable moisture supply is sufficient for the growth of *Pistacia*-woodlands. Below 600 m a.s.l., the climate for the growth of a *Pistacia vera*-community is obviously too dry. From here to the N, the ephemeral semi-deserts of the loess zone start, often rich in Chenopodiaceae, and they extend up to the Amu Darya.

Different and quite complicated (see Breckle and Frey 1974) is the altitudinal zonation of the climate and vegetation on the E side of the Hindu Kush and the Safed Koh, where the influence of the Indian summer monsoon is apparent. In Fig. 2.23 the slightly complicated altitudinal belts of vegetation along a profile between Jalalabad and the Amu Darya is schematically depicted.

In the semi-arid C part of the Jalalabad basin (P = <150–300 mm), under a long to very long thermal growing season, a dry quasi-tropical vegetation of *Zizyphus-Acacia*-community with grasses is developed. This community covers the entire basin, as well as its surrounding mountains in an altitudinal belt between 500 and 800 m a.s.l. Next up in the E, especially in Paktya province, also an area with a long thermal vegetation period but with subhumid conditions, between 800 and 1300 m a.s.l., an altitudinal belt of a sclerophyllous vegetation type with *Reptonia buxifolia* is found, which in its upper section is mixed with *Olea ferruginea*. In the

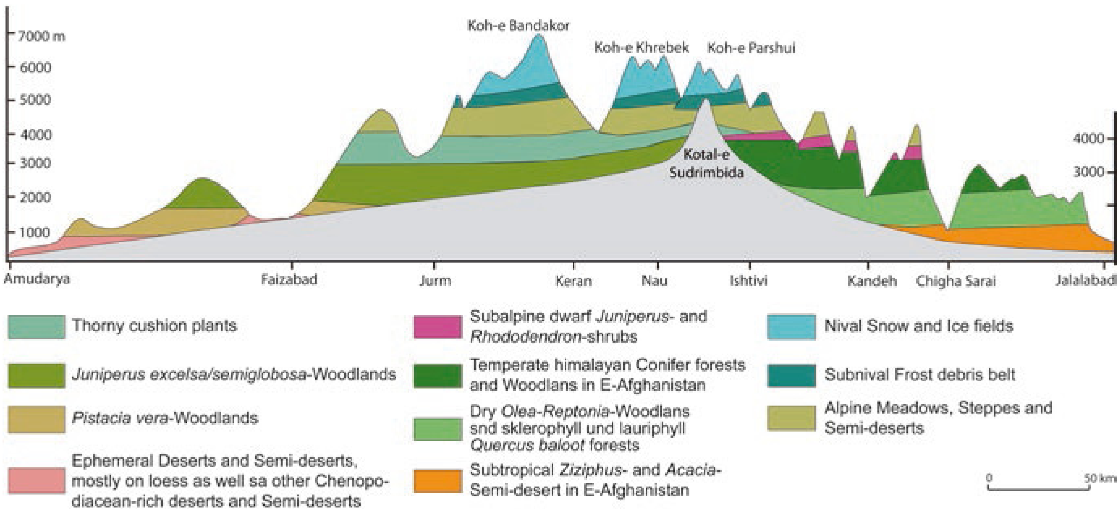

Fig. 2.23 Profile of vegetation belts along the eastern parts of Afghan Hindu Kush (After Breckle and Rafiqpoor 2010)

drier parts of this vegetation belt in the W a plant community of *Pistacia khinjuk* and *Salvia cabulica* is developed between 800 and 1100 m a.s.l. This altitudinal belt changes upwards, with a fairly sharp border, into the typical community of *Quercus baloot* (Fig. 2.19b) growing under a relatively long thermal growing season and sub-humid conditions. Its altitudinal distribution ends at around 2100 m a.s.l. and alters, with decreasing precipitation, towards the W into an *Amygdalus* woodland in the regions W of Kabul. The last stands of *Quercus baloot* to the west are found in Charikar, Tangi Gharu and the Lataband pass east of Kabul (Freitag 1971a; Breckle 2007). In the moist parts of the E slopes, above the altitudinal belt of *Q. baloot* with 5–6 thermal vegetation months and in fairly humid conditions, we find dense forests of *Q. dilatata* (Fig. 2.19c). In drier sites further W and in the inner valleys, the *Quercus baloot*-forests are replaced upwards by *Pinus gerardiana* forests. *Quercus dilatata* and *P. gerardiana* forests merge at about 2400 m a.s.l., depending on the moisture supply, either into the *Quercus semecarpifolia* forests (further E) or to the *Cedrus deodara* forests (further W). The two latter forest types whose growth climates possess a wide hygrothermal amplitude (3–6 thermal and 7–12 hygric vegetation months), lead at about 2900 m a.s.l. into the *Pinus-Abies* forests of the cool moist upper-montane belt (2900–3300 m a.s.l.). Under semihumid conditions, and by an always intermediate to short thermal growing season, *Juniperus* forms the upper timberline both on the E side of the C-Hindu Kush, as well as on Safed Koh. The *Juniperus* forest of the E forms a narrow altitudinal belt between 3300 and 3500 m a.s.l. This formation changes upward under the decrease in temperature to thorn-cushion plant formations, which occupy, under the short to very short thermal growing season, an altitudinal range between 3500 and 4000 m a.s.l. on the W side of the mountain.

On the humid E side of the mountains (and in Afghanistan only there) at the foot of this altitudinal level, i.e. in the vicinity of the tree line, a narrow belt of Krummholz formations with shrubby *Juniperus* and/or *Rhododendron* (Fig. 2.19d) is developed.

The centre of the altitudinal belt of alpine mats lies between 4100 and 4600 m a.s.l. Above 4600 m a.s.l. begins the subnival frost debris belt with a very short thermal growing season. The latter changes roughly above 5100–5200 m a.s.l. into the vegetation-free nival belt with permanent snow and glaciers and only isolated sites suitable for plant growth.

Even in the C-Hindu Kush, all ecological altitudinal limits on both sides of the mountains have an asymmetric structure. On the N side of the mountain the snow line is at c. 4800–5000 m a.s.l., on the S side some hundred m higher. Other ecological altitudinal limits lie, in contrast to the humid SE side of the mountain, at least 200–400 m lower. Also along this profile the arrangement of the vegetation belts on the N flank of the Hindu Kush is simpler than on its SE side. On the N flank of the mountain, below the potential timberline there, three distinct altitudinal belts are developed on top of each other. The altitudinal belt of thorn cushion sub-shrubs is followed lower down by the altitudinal belt of the *Juniperus*-open forests (Fig. 2.19a), then by the *Pistacia vera*-community which changes at about 800–600 m a.s.l. into the "steppe" and semi-deserts of the loess zone in the N.

2.7 Conservation

The Year 2010 was declared the International UN-Year of Biodiversity. SW-Asia is a major area for the wild progenitors of crop plants. For millennia this has been known, as demonstrated by the list of economic plants mentioned in the Holy Quran, as well as in the Bible (Musselman 2007; Barthlott et al. 2016; Barthlott 2018; Barthlott and Rafiqpoor 2018). More than 80 plant species are mentioned in the Bible or Quran. Afghanistan shares a great deal of this natural heritage of fruits, grains, grasses, trees, flowers, and fragrances. A more stable political situation in the future would greatly help Afghanistan to develop a sound and sustainable agricultural system, as well as a system of natural protection areas including National Parks and/or Biosphere reserves to conserve the country's high biodiversity and mountainous vegetation patterns. There have been several attempts to establish a regime of nature conservation but the long war against the Soviet Union and the subsequent civil war situation did not yet allow these goals to be achieved.

The various natural vegetation formations of the Hindu Kush represent a rich pattern. Land-use (agriculture, grazing, browsing, fuel collecting, mining, roads and settlements) changes the natural plant cover to a great extent (Eswaran et al. 2001; Grötzbach 1982). The rich landscape and ecosystem patterns need to be conserved by a system of nature conservation areas. This was already proposed by Petocz and several co-workers (Petocz and Skogland 1974; Petocz and Larsson 1977; Petocz et al. 1978; Shank and Larsson 1977; Shank et al. 1977). Here we give a short description of the proposed protected areas for the long term, being aware that this goal may be reached only in the distant future, and probably rather modified according to the realistic possibilities of a future Afghan nature conservation agency.

The system of protected areas should represent most of the typical landscapes and vegetation formations of the country, which then also are the basis for game reserves and wildlife conservation areas. However, we have to be aware that Afghanistan is a country in which man and his domestic animals have exercised an intensive and strong ecological impact for millennia. Given the semi-desert climate with sufficient rainfall, it may well have been that most parts of the country may have once been covered by trees (Freitag 1971a, b) prior to human settlements.

Two areas in Afghanistan are especially critical for biodiversity preservation: the „Wakhan Corridor" has some of the last relatively pristine wild life habitats and wild life populations left in Afghanistan, while the „Hazarajat Plateau" has some of the most important existing and potentially protected areas in Afghanistan.

The Great Pamir extends over about 5500 km^2 of the Wakhan (Fig. 2.21b), separated from the E Hindu Kush range with its extremyly high peaks (Noshaq area up to 7400 m a.s.l.) (Fig. 2.21c) by the Abe Panj Valley, part of the upper Amu Darya river system. A considerable part of the western Great Pamir was once included in the so-called "Great Pamir Wildlife Reserve" encompassing about 679 km^2. Although designated a reserve, it has never been legally established, and between 1968 and 1977 functioned as a hunting reserve for foreigners, managed by the Afghan Tourist Organization. Before that, part of the area was protected being a royal hunting reserve of the former king Muhammad Zahir Shah.

In a 2004 survey of wildlife in the Wakhan, it was recommended that the eastern tip of the Little Pamir should be designated as a strictly protected area (about 250 km^2). This area is at present not used by herders, and thus the habitat is in excellent condition and does not conflict with human use patterns. There is also no barrier between it and the proposed Shaymak Reserve in Tajikistan, enabling Marco Polo sheep to move freely back and forth.

The eastern tip of the „Waghjir Valley" (about 300 km^2), is at present uninhabited and used only for yak grazing in winter. There Marco Polo sheep cross the Yuli Pass between China and Afghanistan in winter and the presence of snow leopards and species such as wolf, brown bear and Asian ibex was assessed. It was also recommended that this area should be designated as a reserve with yak grazing allowed to continue but other activities prohibited.

In the Hazarajat Plateau region, Bande Amir is often described as one of the great wonders of the world. Consisting of six crystal blue lakes separated by a series of natural, white travertine dams in a unique step-like system, and surrounded by spectacular red limestone cliffs. It was identified as a National Park in 1973.

Some future areas which deserve a protection status encompass the Ajar- Valley or gorge, the granite massif of Salang, as well as the Kohe Baba summit (Shah Fuladi 5050 m a.s.l.). They show on their north-facing slopes signs of the last glacial maximum in the form of well-developed side and end moraines and recent active geomorphological processes, and merit protection in addition to their high mountain flora.

Some of the necessary next steps concerning nature conservation and sustainable management of vegetation and wildlife, which were identified by WCS1, need to be:

Table 2.4 List of proposed protected areas of Afghanistan (based on various sources and our own experience). Existing designated Reserves are underlined. The total area of all proposed reserves would cover about 42,360 km^2, equivalent to about 6.5% of total land area of Afghanistan [NP = National Park]

Reserves	Afghan Province, Area	Altitude (m a.s.l.)	Approx. size (km^2)	Vegetation type acc. to Fig. 2.15	Main characteristics
Ajar Valley	Bay	2000–3800	400	1e, 3c, 7	Wildlife Reserve
Great Pamir	Bak, Wakh	4000–6000	679.38	7, 8	Wildlife Reserve, rich flora and vegetation
Dashte Nawor	Gha	3200–4800	700 NP 75 (lake)	7, 9a, 9b	Wildlife Reserve, Wetland, waterfowl sanctuary
Abe Istada	Gha	1950–2100	270	9b, 3b	Wildlife Reserve, Wetland, waterfowl sanctuary
Bande Amir	Bay	2900–3832	410 (NP)	7, 9a	Wildlife Reserve, Wetland, NP Unique natural Monument
Western Nuristan	Kun, Lag, Bak	1100–6300	5200	4b, 5, 2, 4a, 6, 7, 8	Monsoonal influenced forests types, up to high mountain belts, rich unique flora, wildlife
Hamune Puzak	Nim	475	>350	1b, 9a, 9b	Wildlife Reserve, Wetland
Imam Sahib and Darqad	KDZ, Tak	350–470	400	1a, 1d, 9a	Wildlife Reserve, Wetland, Tugai Forests of Amu Darya
Northwestern Badakhshan, Darwaz	Bak	2500–4400	800	3a, 3a, 7	Semi-humid woodlands and mountains, unique flora
Little Pamir including Lake Zorkol, Lake Chaqmatin	Bak, Wakh [Taj, Pak, China]	4000–5900	2000	8, 7	Transboundary Reserve, Wildlife Reserve, Wetland
Waghjir Valley Pamir	Bak, [Pak, China]	3800–5500	300	8, 7	Transboundary Reserve, Wildlife Reserve, Wetland
Registan Desert	KDH	900–1100	18,000	1a, 1c, 1e	Arid sand-desert area, desert wildlife
North Salang	Bal	1600–3600	350	3d	Open *Juniperus* woodlands
Lake Hashmat Khan	KBL	1793	1.91	9a, 9b	Wildlife Reserve, Wetland, Waterfowl sanctuary
Taiwara, Kohe Malmond	Gho, Far	2000–4200	800	3b, 3c	Unique flora and vegetation, Limestone massifs, Geo-Heritage

(continued)

Table 2.4 (continued)

Reserves	Afghan Province, Area	Altitude (m a.s.l.)	Approx. size (km^2)	Vegetation type acc. to Fig. 2.15	Main characteristics
Paghman	KBL, Paw	1800–4000	200	3c	Open *Cercis* woodlands and high mountains
Mir Samir	Kap	3500–6800	450	8, 7	Arid high mountain, glaciation
Safed Koh	Pay, [Pak]	2600–4700	250	4, 5, 6, 7, 8	Humid high mountain, rich and unique forests and Krummholz
Gulran Reserve	Her, Bag	250–1000	10,000	1d, 3a	Wildlife Reserve, *Pistacia vera*- woodlands
Moqor-Chaman Lineament, from Moqor to Spinboldak	Zab, [Pak]	1300–2500	400	3b, 3c	Marked Tectonic Lineament
Salang Granite area at the summit of Kotale Salang	Paw, Bal	1600–3700	200	3c, 3d, 7	Granit, recent glacial and periglacial activity, rich alpine vegetation
Shah Fuladi, the summit range of Kohe Baba	Bay	2000–5500	200	7, 8	Old glacial and recent peri-glacial activity, rich alpine vegetation

- Perform wildlife surveys, socio-economic surveys, and rangeland assessments at each existing or potential protected area site.
- Develop and enact Wakhan protected area initiatives, including updating the "Great Pamir" Wildlife Reserve management plan and officially designating the "Little Pamir" Protected Area and Waghjir Protected Area.
- Develop and enact Hazarajat protected area initiatives, including updating the Band-e Amir National Park management plan and officially designating the Ajar Valley Wildlife Sanctuary.
- Further develop a Trans-boundary Peace Park Initiative between Afghanistan, Pakistan, Tajikistan, and China.
- Review policies and legislation affecting wild-life, wild lands, and protected areas.
- Develop a plan for forest and wildlife assessments for Nuristan, Kunar, Paktika, Khost, and Paktia.

Keeping the above-listed needs in mind, Table 2.4 gives a list of proposed protected areas with some of their characteristics. The existing or at least declared Reserve Areas only correspond to about 0.3% of the total land area of Afghanistan. For a sound national conservation system, it has to be enlarged significantly (Farhadi 2008; Shank 2006) within all projects of the national development strategy.

These designated reserves are not only for wildlife conservation and waterfowl sanctuaries, but also include proposed reserves for unique landscapes, geomorphology and vegetation types, especially woodlands and forests.

2.8 Final Remarks

The Afghan mountains including Hindu Kush are rich in plant species. The continental and arid conditions are the reason for broad vegetation belts and a very high snow-line. The E and SE exposed mountain ridges attract summer rains and thus exhibit distinct forest belts with closed forests and a Himalayan-influenced rich flora. However, centuries of grazing by settlers as well as by nomads, hunting, and more intensified agriculture by modernized irrigation systems have caused and continue to cause a decline in biodiversity and a change of vegetation cover to desertified semi-deserts in many mountain regions.

In general, our knowledge on flora and vegetation of the Hindu Kush is fairly good. There are still important priorities: a more accurate knowledge of the number of species and their distribution particularly in the mountain regions. There has been much research on plants and vegetation for a rather long time, often jointly by foreign scientists with Afghan counterparts. But the last war and decades of civil wars made field work difficult or impossible. Hopefully, in future, in Afghanistan peace and better living conditions may prevail.

Acknowledgements Without the help of local people, many friends and collegues, it would have been impossible to do all the field work and data processing on flora and vegetation of Afghanistan. We acknowledge very much all the direct or indirect help of many people and institutions at Faculty of Science/Kabul, University of Bonn and Bielefeld University. All co-workers in the former Department of Ecology at University of Bielefeld were a good and reliable team, to whom we say many thanks. Special thanks are due to Ian C. Hedge for many years of intensive cooperation and for his help in smoothing this text as well as Uta Breckle for cooperation, many discussions and for critical proof reading.

References

Afghanzada A (1970) Ecological conditions of forests in Afghanistan. Stage d'études sur les études intégrées et l'écologie et l'amenagement des terrains de parcours. CAZRI Jodhpur

Agakhanjanz OE, Breckle S–W (1995) Geographische Modellierung der Gebirgsflorogenese Eurasiens. In: Geographische Aspekte des Zusammenwirkens der Gesellschaft mit der Natur. Russ Geogr Ges, 4–5 [Russ], St. Petersburg

Agakhanjanz OE, Breckle S–W (2002) Plant diversity and endemism in high Mountains of Central Asia, the Caucasus and Siberia, chapter 9. In: Körner C, Spehn E (eds) Mountain biodiversity – a global assessment. Parthenon Publ Group, Boca Raton, New York etc, pp 117–127

Barthlott W (2018) Ökologie und Religion – Über die Potenziale einer mächtigen Partnerschaft In: Jahrbuch für Ökologie 2017/2018. Hirzel Publishers, Stuttgart, pp 103–117. https://jahrbuch-oekologie.de/jahrbuch-oekologie-2017-2018-2/

Barthlott W, Rafiqpoor MD (2018) Biodiversität im Wandel zwischen Evolution, Migration, Kultur und Religion. In: Frohn H-W, Wickert F (eds) Naturschutz sozial, interkulturell und inkludierend?! BfN-Script, vol 514. Bundesamt f. Naturschutz, Bonn, pp 71–85

Barthlott W, Obholzer J, Rafiqpoor MD (2016) Pflanzen der Heiligen Bücher Bibel und Koran. BfN-Skripten 448, ISBN 978-3-89624-185-6, 106 S

Breckle S–W (1967) Fossile Pflanzenreste am Latahband–Pass in Afghanistan. Science (Kabul) 4:16–21

Breckle S–W (1971a) Ökologie und Mikroklima in der alpinen Stufe des afghanischen Hindukusch. Ber Deutsch Bot Ges 84:721–730

Breckle S-W (1971b) Vegetation in alpine regions of Afghanistan. In: Davis PH, Harper PC, Hedge IC (eds) Plant life of south-west Asia. Botanical Society of Edinburgh, Edinburgh, pp 107–116

Breckle S–W (1972) Alpenrosen im Hindukusch? Jahrb Ver Schutze Alpenpflanzen und –tiere 37:140–146

Breckle S–W (1973) Mikroklimatische Messungen und ökologische Beobachtungen in der alpinen Stufe des afghanischen Hindukusch. Bot Jahrb Syst 93:25–55

Breckle S–W (1974) Notes on Alpine and Nival Flora of the Hindu Kush, East Afghanistan. Bot Not (Lund) 127:278–284

Breckle S–W (1975) Ökologische Beobachtungen oberhalb der Waldgrenze des Safed Koh (Ost–Afghanistan). Vegetatio (Acta Geobotanica) 30:89–97

Breckle S–W (1981) Zum Stand der Erforschung von Flora und Vegetation Afghanistans. In: Rathjens C (ed) Neue Forschungen in Afghanistan. Leske, Opladen, pp 87–104

Breckle S–W (1988) Vegetation und Flora der nivalen Stufe im Hindukusch. In: Grötzbach E (Hrsg): Neue Beiträge zur Afghanistanforschung, Schriftenreihe der Stiftung Bibliotheca Afghanica, 6 (Liestal), pp 133–148

Breckle S–W (2004) Flora, Vegetation und Ökologie der alpin–nivalen Stufe des Hindukusch (Afghanistan). In: Breckle S–W, Schweizer B, Fangmeier A (eds) Proceed. 2nd Symposium AFW Schimper–Foundation: results of worldwide ecological studies. Stuttgart–Hohenheim, pp 97–117

Breckle S–W (2007) Flora and vegetation of Afghanistan. Basic Appl Dryland Res (BADR) 1(2):155–194

Breckle S-W (2017) Floristic analysis of the subnival-nival vegetation of Hindu Kush and Caucasus. Species recorded from the high alpine and nival zones (>3900m) of the Hindu Kush mountains (Afghanistan). Bielefelder Ökologische Beiträge (BÖB) 21:32–47

Breckle S-W (2019) Vegetation, Climate and Soil – worldwide ecological and geobotanical studies. Progr Bot 80:1–63

Breckle S–W, Frey W (1974) Die Vegetationsstufen im Zentralen Hindukusch. Afghan J (Graz) 1:75–80

Breckle S–W, Frey W (1976a) Beobachtungen zur heutigen Vergletscherung der Hauptkette des Zentralen Hindukusch (Afghanistan). Afghan J (Graz) 3:95–100

Breckle S–W, Frey W (1976b) Die höchsten Berge im Zentralen Hindukusch. Afghan J (Graz) 3:91–95

Breckle S-W, Kull U (1971) Osmotische Verhältnisse und Zuckergehalte im Jahresgang bei Bäumen Ost-Afghanistans. I. *Quercus baloot* Griffith.- Flora B 160:43–59

Breckle S-W, Rafiqpoor MD (2010) Field guide Afghanistan – flora and vegetation. Scientia Bonnensis/Bonn, Manama, New York, Florianopolis, 864 pp

Breckle S-W, Rafiqpoor MD (2011) Vielfalt der Flora und Vegetation Afghanistans. Geogr Rundsch 63(11):40–50

Breckle S-W, Rafiqpoor MD (2019) Vegetation und Klima. Springer Spektrum. 484 S

Breckle S-W, Hedge IC, Rafiqpoor MD (2013) Vascular plants of Afghanistan – an augmented checklist. Scientia Bonnensis/Bonn, Manama, New York, Florianopolis, 598 pp

Breckle S-W, Fayvusch G, Murtazaliev R, Nakhutsrishvili G (2017) Floristic analysis of the subnival-nival vegetation of Hindu Kush and Caucasus. Bielefelder Ökologische Beiträge (BÖB) 21:7–31

Breckle S-W, Hedge IC, Rafiqpoor MD (2018) Biodiversity in Afghanistan. In: Pullaiah T (ed) Global biodiversity, Asia, vol 1. Apple Academic Press, Waretown, pp 33–92
Browicz K (1997) Chorology of trees and shrubs in SW Asia and adjacent regions. Phytogeogr Anal. Poznan, 18 pp
Cox CB, Moore PD (2005) Biogeography. An ecological and evolutionary approach, 7th ed. Blackwell, 428 pp
Dieterle A (1973) Vegetationskundliche Untersuchungen im Gebiet von Band-e Amir (C–Afghanistan). Diss Bot 24, 87 pp
Eswaran H, Lal R, Reich PF (2001) Land degradation: an overview. In: Bridges EM, Hannam ID, Oldeman LR, Pening DE et al (eds) Responses to land degradation. Proc 2nd international conference on land degradation and desertification, Khon Kaen, Thailand. Oxford Press, New Delhi
Farhadi A (ed) (2008) Afghanistan – national development strategy. Govt of the Islamic Republic of Afghanistan, 266 pp
Flohn H (1969) Zum Klima und Wasserhaushalt des Hindukuschs und der benachbarten Hochgebirge. Erdkunde 23:205–215
Frankenberg P, Lauer W, Rafiqpoor MD (1983) Zur geoökologischen Differenzierung Afghanistans. In: Lauer W (ed) Beiträge zur Geoökologie von Gebirgsräumen in Südamerika und Eurasien. Abhandlungen d Math–nat Klasse d Akad d Wissenschaften u d Literatur, Mainz, pp 52–71
Freitag H (1971a) Die natürliche Vegetation Afghanistans. Beiträge zur Flora und Vegetation Afghanistans. Vegetatio, Bd 22, H 4–5:255–344
Freitag H (1971b) Studies on the natural vegetation of Afghanistan. In: Davis PH, Harper PC, Hedge IC (eds) Plant life of south west Asia. Bot Soc Edinburgh, Edinburgh, pp 89–106
Freitag H (1982) Mediterranean characters of the vegetation in the Hindu Kush Mts., and their relationship between sclerophlous and laurophyllous forests. Ecol Mediterranea 8:381–388
Freitag H, Hedge IC, Rafiqpoor MD, Breckle S-W (2010) Flora and vegetation geography of Afghanistan. In: Breckle S-W, Rafiqpoor MD (eds) Field guide Afghanistan – flora and vegetation. Scientia Bonnensis/Bonn, Manama, New York, Florianopolis, pp 79–115
Frey W, Probst W (1978) Vegetation und Flora des Zentralen Hindūkuš (Afghanistan). Beihefte Tübinger Atlas d Vorderen Orients, Reihe A (Naturw), 3, Reichert/Wiesbaden, 126 pp
Frey W, Probst W (1982) Zwischen Tagab und Alisang. Eine vegetationskundliche Exkursion im westlichen Grenzgebiet des monsunbedingten Waldgürtels auf der SE-Abdachung des Zentralen Hindukusch. Afghan J (Graz) 9:62–72
Gilbert OL (1968) A general account of high altitude vegetation in the Samir valley. In: James A (ed) Environmental research in the Samir valley of the Hindu Kush 6. 4 Newcastle, pp 1–6
Gilli A (1969) Afghanische Pflanzengesellschaften I. Xerophile Pflanzengesellschaften. Vegetatio 16:307–375
Gilli A (1971) Afghanische Pflanzengesellschaften II. Die mesophilen und hygrophilen Pflanzengesellschaften im sommertrockenen Gebiet. Vegetatio 23:199–234
Groombridge B (ed) (1992) Global biodiversity – status of the earth's living resources. Chapman & Hall/London, 585 pp
Grötzbach E (1982) Naturpotential und Probleme seiner effektiven Nutzung in Afghanistan. Geodynamik 3:141–168
Grötzbach E, Rathjens C (1969) Die heutige und jungpleistozäne Vergletscherung des Afghanischen Hindukusch. Zeitschr Geomorph, N.F. Suppl 8:58–75
Hedge IC, Wendelbo P (1970a) Some remarks on endemism in Afghanistan. Israel J Bot 19:401–417
Hedge IC, Wendelbo P (1970b) A note on the rhododendrons of Afghanistan. Rhododendron Yearbook 1970:177–181
Hedge IC, Wendelbo P (1978) Patterns of distribution and endemism in Iran. Notes RBG Edinb 36:441–464

Huss H (1978) Zur Vegetation des Wakhan und Großen Pamir. In: De Grancy RS, Kostka R (eds) Grosser Pamir – Österreichisches Forschungsunternehmen 1975 in den Wakhan–Pamir, Afghanistan. Adeva/Graz, pp 167–192

Kaever M (1972) Geology. In: Kraus W (ed) Afghanistan – Natur, Geschichte und Kultur, Staat, Gesellschaft und Wirtschaft. Erdmann Verlag, Basel, pp 12–21

Kitamura S (1960) Flora of Afghanistan. Results of the Kyoto University expedition to the Karakoram and the Hindu Kush 2. Kyoto, 486 pp

Kitamura S (1964) Plants of West Pakistan and Afghanistan. Results of the Kyoto University scientific expedition to the Karakoram and Hindu Kush, 1955, 3, Kyoto, 283 pp

Klaer W (1974) Kritische Anmerkungen zur neueren Literatur über Blockgletscherprobleme. Heidelberger Geogr Arb 40:275–291

Klaer W (1977) Zur Morphogenese und Formendynamik innerhalb des periglazialen Stockwerkes der Hochgebirge Vorderasiens. In: Poser H (ed.): Formen, Formengesellschaften und Untergrenzen in den heutigen periglazialen Höhenstufen der Hochgebirge Europas und Afrikas zwischen Arktis und Äquator. Abh Akad Wiss Göttingen, Math–Phys Klasse, 3 F 31:261–274

Körner C (1999) Alpine plant life. Functional plant ecology of high mountain ecosystems. Springer, Berlin, 344 pp

Kürschner H, Lüth M, Frey W (2020) Field guide Afghanistan –mosses and liverworts. Flora and augmented checklist. Medienhaus Alfter, 386 pp

Larsen OL (2009) Per Wendelbo – en norsk plantejeger – og reintroduksjonen av to sjeldne rhododendronarter. Lapprosen 12(3):11–13

Lauer W, Rafiqpoor MD, Theisen I (2001) Physiogeographie, Vegetation und Syntaxonomie des Páramo de Papallacta (Ostkordillere Ecuador). Erdwissenschaftliche Forschung, Bd. 39. Franz Steiner Verlag, Stuttgart

Muhammad S, Alam J, Izaz F, Iqbal Z et al (2017) Evaluation of the conservation status of *Rhododendron afghanicum* Aitch. & Hemsl.; a narrow endemic species of Pakistan. Pak J Bot 49:1387–1394

Musselman LJ (2007) Figs, dates, laurel, and myrrh: plants of the bible and the Quran. Timber Press, Portland, 336 pp

Nedjalkov ST (1983a) Ecological classification of vegetation cover of Afghanistan. In: Sokolov VE (ed) Ecology and biogeography in Afghanistan. Moscow, pp 30–53. [in Russian]

Nedjalkov ST (1983b) Woody shrub vegetation of region Konarha. In: Sokolov VE (ed) Ecology and biogeography in Afghanistan. Moscow, pp 76–100. [in Russian]

Neubauer HF (1954a) Versuch einer Kennzeichnung der Vegetationsverhältnisse Afghanistans. Ann Naturhist Mus Wien 60:77–113

Neubauer HF (1954b) Die Wälder Afghanistans. Angew Pflanzensoz 54:494–503

Noroozi J, Akhani H, Breckle S–W (2008) Biodiversity and phytogeography of the alpine flora of Iran. Biodivers Conserv 17:493–521. (online/pdf)

Pavlov VN, Gubanov IA (1983) Geobotanic features of the mountain Afghanistan. In: Sokolov VE (ed) Ecology and biogeography in Afghanistan. Moscow, 54–75. [in Russian]

Pelt J–M (1967) Aperçus sur la végétation et la flore de l'Afghanistan. Bull Assoc Philom Alsace Lorraine 13:227–231

Petocz RG, Larsson JY (1977) Ecological reconnaissance of western Nuristan with recommendations for management. Unpubl. UNDP/FAO report, Fo: Do/Afg/74/016, Field Doc 9, 63 pp

Petocz RG, Skogland T (1974) Report on the status of Bande–e Amir National Park. Unpubl FAO/UNDP report Fo: Dp/Afg/72/005

Petocz RG et al (1978) Report on Afghan Pamir (3 parts). Unpubl FAO report Fo: Dp/Afg/74/016 F.Doc 5–7, 33+42+35 pp

Podlech D, Anders O (1977) Florula des Wakhan (Nordost–Afghanistan). Mitt Botan Staatssamml München 13:361–502

Quraischi A (2014) Afghanistan – natural condition and resources: geology. In: Dittmann A (ed) National atlas of Afghanistan. Scientia Bonnensis, Bonn, pp 10–11

Rafiqpoor MD (1979) Niederschlaganalysen in Afghanistan – Versuch einer klimaräumlichen Differenzierung des Landes. Diplomarbeit, Geogr Inst Univ Bonn

Rafiqpoor MD, Breckle S-W (2010) The physical geography of Afghanistan. In: Breckle S-W, Rafiqpoor MD (eds) Field guide Afghanistan – flora and vegetation. Scientia Bonnensis, Bonn, Manama, New York, Florianópolis, pp 23–78

Rathjens C (1972) Fragen der horizontalen und vertikalen Landschaftsgliederung im Hochgebirgssystem des Hindukusch. Erdwissenschaftliche Forschung 4: 205–220. Wiesbaden

Rathjens C (1974) Die Wälder von Nuristan und Paktia. Geogr Zeitschr 62:295–311

Rathjens C (1978) Klimatische Bedingungen der Solifluktionsstufe im sommertrockenen Hochgebirge, am Beispiel des afghanischen Hindukusch. Z Geom NF, Suppl Bd 30:132–142

Rathjens C (1980) Klima und Landschaft des Hochgebirges in den sommertrockenen Subtropen am Beispiel des afghanischen Hindukusch. Tüb Geogr Stud, Band 80:41–50

Rechinger KH, resp. Rechinger W (eds) (1963–2015) Flora Iranica, No 1–181ff. Akad Druck– und Verlagsanstalt/Graz

Roostai AH (ed) (2018) Probleme der Wasserversorgung in der Stadt Kabul – Die Bedeutung der Regeneration der Kareze in Afghanistan. in Roostai AH: مشکلات کمبود آب در شهر کابل – اهمیت احیای کاریزها در افغانستان. DCM-Druck Center Meckenheim. ISBN 978-3-00-059443-4. Ein Buch in Dari-Sprache, 204 S

Salem MZ, Hole FD (1969) Soil geography and factors of soil formation in Afghanistan. Soil Sci 107:289–295

Salem MZ, Hole FD (1973) Properties of certain soils of Afghanistan. Soil Sci 116:178–190

Sales F, Hedge IC (2013) Generic endemism in south-west Asia; an overview. Rostaniha 14(1):22–35

Schickhoff U (2005) The upper timberline in the Himalayas, Hindu Kush and Karakorum: a review of geographical and ecological aspects. In: Broll G, Beate K (eds) Mountain ecosystems studies in tree line ecology. Springer, Berlin, Heidelberg, pp 275–354

Shank CC (2006) A biodiversity profile of Afghanistan in (2006) A component of the national capacity self-assessment (NCSA) in national adaption programme of action (NAPA) for Afghanistan, 169 pp

Shank CC, Larsson JY (1977) A strategy for the establishment and development of Band–e–Amir National Park. Unpubl FAO report, Fo: Dp/Afg/74/016, Field Doc, 37 pp

Shank CC, Petocz RG, Habibi K (1977) A preliminary management plan for the Ajar Valley wildlife reserve. Unpubl UNDP/FAO report, Fo: Do/Afg/74/016, Field Doc, 35 pp

Siehl A (2017) Structural setting and evolution of the Afghan orogenic segment – a review. In: Burnet M-F, McCann T, Sobel ER (eds): Geological Evolution of Central Asian Basin and the Western Tien Shan Range. Geol Soc Lond, Spec Publ 427(1):57–88

Sivall TR (1977) Synoptic–climatological study of the Asian summer monsoon in Afghanistan. Geograf Annaler 59A:67–87

Volk OH (1954) Klima und Pflanzenverbreitung in Afghanistan. Vegetatio 5(6):422–433

Wolfart R, Wittekindt HP (1980) Geologie von Afghanistan. Beiträge zur regionalen Geologie der Erde, vol 14. Borntraeger, Stuttgart, 500 pp