

Monograph on
**Endemism in the
Highlands and Escarpments
of Angola and Namibia**



Angola Cave-Chat *Xenocopsychus ansorgei*
Photo: M Mills

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An overview of plant endemism on the highlands of Namibia

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ABSTRACT

Over 700 of Namibia's nearly 4,000 seed plants are endemic to the country and, of these endemics, the distributions of more than 100 were found to be restricted to highlands with elevations over 1,500 masl. The families with the most highland endemics are Apocynaceae, Asteraceae, Leguminosae and Scrophulariaceae with life forms varying from herbs and shrublets to succulents. Species restricted to specific mountain ranges are listed and the highlands of importance to plants are mapped. No noticeable concentration of endemic highland plants occurs, with many being rare with restricted habitats at specific elevations.

Keywords: endemism, highlands, Namibia, plants

INTRODUCTION

The number of taxa in Namibia, and especially the recorded number of endemics is constantly changing as research progresses. To date, over 700 of Namibia's nearly 4,000 indigenous species of seed plants are endemic to the country. When taxa that occur marginally into neighbouring countries (near-endemics) are added, this number rises to over 1,400 species. Mapping the distributions of individual taxa show discernible range patterns and over 100 endemics were found to be restricted to highlands at elevations over 1,500 masl. Only plants occurring on highlands, and not on plains or lower-lying areas, were included in this analysis.

METHODS

There is sufficient information on the taxonomy and distribution of the Namibian endemic flora to allow a provisional assessment of geographical ranges and affinities because the information is housed on Craven and Kolberg (ongoing), a BRAHMS8 database (University of Oxford 2023) which is partly online. The data include lists of plants endemic or near-endemic to Namibia, as well as occurrence records from literature and specimens housed in many herbaria. The database needed some updating and additions for this evaluation.

Our taxonomic decisions are based on morphological and distributional data, and only phylogenetic analyses that are linked to these data. Our accepted names allow for identification within the Namibian context and are practical for our work and that of other users. Worksheets accompanying Irish (2002) were used to identify mountains and mountain groups with elevations over 1,500 masl within the area of

highlands and escarpments defined in Mendelsohn and Huntley (2023). QGIS, which is incorporated into BRAHMS8, was used to overlay specimen records with shapefiles of highlands and specific mountains. Overlapping ranges were evaluated. Relationships, gaps, life forms and the status – threat, protection, listing under the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES 2023) – of highland endemics were documented. Mountain names and shapefiles follow the Atlas of Namibia Team (2022).

Results are discussed under eight highland areas, each with a map showing the specific highlands, mountains and inselbergs within the general area of highlands and escarpments (Mendelsohn & Huntley 2023). Species endemic to highlands in Namibia, their protection and international recognition are listed in Appendix 1, while the complement of endemic species of each highland area, mountain and inselberg is listed in Appendix 2.

HIGHLAND AREAS IN NAMIBIA

Seven groups of highlands with co-occurring endemic plant species, as well as their own complement of endemic plants, have been identified. An eighth group of highlands comprises those without known endemic flora. Each group is discussed, on the pages that follow, alongside a map that illustrates the highlands included in the group.

1. Central and southeastern highlands: Auas Mountains, Brandberg, Erongo Mountains, Gamsberg, Groot Karasberge, Khomas Hochland, Naukluft Mountains, Otjiveraberge (also known as the Neudamm Hochland), Spitzkoppe and Tirasberge

2. Highlands with restricted endemic flora associated mainly with the central and southern highlands: Awasisberge, Central Group, Hakosberge, Naos, Nubib and Tsaris Mountains
3. Baynes, Otjihipa and Zebra mountains
4. Huns Mountains – Orange River valley
5. Waterberg and Otavi Mountains
6. Inselbergs in the southwest: Aurusberg, Klinghardt Mountains, Kowisberge and Obib
7. Escarpment and plateaus
8. Highlands and inselbergs without known endemic flora: Brukkaros Mountain, Dikke Willem, Etendeka Mountains, Huab Outliers, Middle Ugab, Otjikondavirongo, Paresis Mountains, Rantberge, Rooirand and Swakop–Khan ranges.

Group 1: Central and southeastern highlands

Some of the highest mountains in Namibia share range-restricted species, first documented by Hilliard (1994) after a study of the *Manuleae*. Subsequent research and fieldwork by the two authors (Craven and Kolberg) confirmed that mountains in central and southeastern Namibia with co-occurring species include the Auas Mountains, Brandberg, Erongo Mountains, Gamsberg, Khomas Hochland, Groot Karasberge, Naukluft Mountains and Tirasberge (Figure 1). A few range-restricted plants may also occur on Mount Etjo or Nubisberge and, due to more recent targeted fieldwork and recent literature, additional records of localities and species have been added to this list.

One species, known from most of these highlands is *Lightfootia dinteri*. Two taxa, one published in 1910 and the other in 1922, were given this name by different authors. One taxon is a synonym of *Wahlenbergia denticulata* (Lammers 1995) which occurs from Kenya to South Africa, while the other is an intriguing, taxonomically unresolved species only found in Namibia. This is not the first time a Namibian endemic species has been excluded from a taxonomic treatment and, although it would be easy to transfer the name, this plant may not even be a *Wahlenbergia* as it differs in many aspects and needs taxonomic study.

The genus *Namacodon* is endemic to Namibia and the one species *N. schinzianum* is known from the Auas, Erongo and Naukluft mountains and from the Gamsberg. Like *Lightfootia*, it belongs to the Campanulaceae, a family that is not species rich or generally noteworthy in Namibia. The Apocynaceae

and Scrophulariaceae families have the most endemic taxa on these highlands, with each having about seven co-occurring species. Most of the Apocynaceae endemics are localised succulents. The endemic taxa belonging to the Scrophulariaceae are more likely to be herbs or dwarf shrubs and some are relatively widespread, even being found on other highlands or at lower elevations as well. This brings to light some of the challenges in determining a strict division of taxa according to highlands, as some species such as *Jamesbrittenia heucherifolia* are montane in Namibia but occur near sea level in Angola (Hilliard 1994). The monogeneric *Manuleopsis*, was previously associated with these central and southeastern highlands of Namibia, but the species *M. dinteri* is now known to be common and more widespread and is found as far north as the Omavanda Mountain in the Baynes–Otihipa mountain group. The only indigenous *Nicotiana* species in southern Africa is limited to the Brandberg, Spitzkoppe and Erongo Mountains. A species of *Tetradenia* from the central highlands, presently included in *T. brevispicata*, may be a distinct highland endemic taxon. The bryophyte flora of the Namibian highlands also showed the distribution to be concentrated on these central and southern highlands (Russell & van Rooy 1986).

Notes on endemic plant species specific to each of the mountains making up the central and southeastern highlands area follow below.

Brandberg

Over 480 indigenous seed plants occur on the Brandberg with about 90 Namibian endemics of which nine are limited to the mountain itself. Another ten are also found on other mountains in the central and southern highlands area, particularly the Erongo

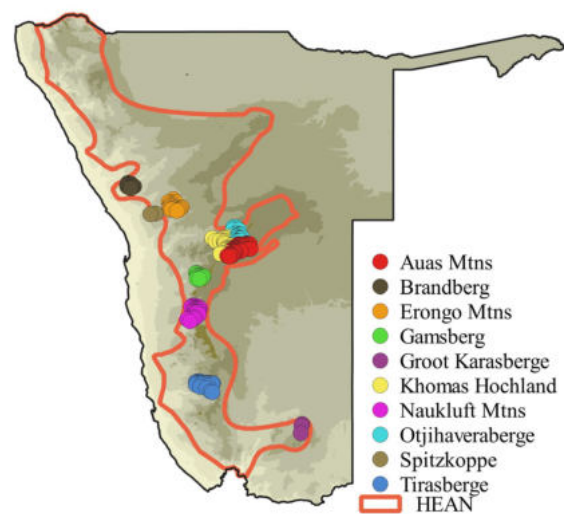


Figure 1: Central and southeastern highlands of Namibia making up Group 1 of the highland areas of Namibia. (HEAN is the area of highlands and escarpments defined by Mendelsohn and Huntley (2023).)

Mountains and the Gamsberg escarpment. Four members of the Asteraceae family are restricted to the Brandberg and are found at the summit: *Anisopappus brandbergense*, *Felicia gunillae*, *Nidorella nordenstamii* and *Pentzia tomentosa*. The last three have only been collected in a few years of high rainfall (1963, 1974 and 2000) with decades between collections. That Nordenstam, a specialist on the Asteraceae, collected all the type specimens in years of abnormally high rainfall, poses the question as to whether collecting by specialists in favourable conditions would not yield more localised endemics? *Anisopappus brandbergense* has been found at elevations from about 1,850 masl to the Amis River which is below 900 masl.

The different peaks of the Brandberg – Horn, Numas Spitz, Aigub and Königstein – although isolated from one another by some distance, may have the same endemic species, such as *Euphorbia monteiroi* subsp. *brandbergensis* and *Plumbago wissii* known from Königstein and on Aigub (2,550 masl), as well as a possible new species of *Cyathula*. Unfortunately, no taxonomic research is currently being undertaken on genera that may have endemic species on these highest peaks. A subspecies of *Lithops gracilidelineata* occurring at 2,300–2,400 masl and previously recorded as endemic is now, according to recent taxonomic work (Jainta 2019), considered part of a more widespread species.

A Brandberg endemic not at the summit, but at high elevations is *Adromischus schuldtianus* subsp. *brandbergensis*. *Hermannia merxmulleri* and the more common *Ruellia brandbergensis* can be found lower down. Another endemic almost at the base is *Eragrostis aristata* and although few specimens have been collected to date, they are restricted to the mountain.

Moisel (1982) noted altitudinal variations of plants in Orabeswand and Craven and Craven (2000) expanded this survey to other parts of the mountain. Certain species, for example *Ruellia brandbergensis*, were found to occur at higher elevations on the northern side of the mountain (e.g., at Sonsusib) than on the southern side.

Erongo Mountains

A geophyte *Afrosolen erongoensis*, only known from the type collection, and a succulent *Lithops weneri* are the only two species endemic to the Erongo Mountains on Farm Ameib. The dwarf shrub *Corchorus merxmulleri* also occurs on the Brandberg, while the shrub *Dombeya rotundifolia* var. *velutina* is probably only found here and on the Naukluft Mountains. Eight other highland endemics on the Erongo Mountains co-occur with a few other mountains.

Spitzkoppe

There are no endemic species restricted to the Spitzkoppe. This is possibly because Spitzkoppe is mainly a granite rock unable to support many plants. It does share *Nicotiana africana* and *Euphorbia monteiroi* subsp. *brandbergensis* with the Brandberg and Erongo Mountains.

Gamsberg

The Gamsberg is most well known for having an endemic shrub *Euryops walterorum* that occurs in numbers only on the plateau. Species diversity varies with aspect and elevation and the plateau is not as diverse as the slopes. More endemic species, like *Othonna brandbergensis*, are recorded on the Gamsberg Pass which runs down the escarpment, a little distance from the actual mountain tabletop. Highland endemics that occur here are also found mostly on the Brandberg to the west and the Auas Mountains to the east.

Naukluft Mountains

There are probably five plants endemic to the Naukluft range. *Anginon streyi* is found just below the plateau, while *Commicarpus squarrosus* var. *fruticosus* has also only been found once on the mountain slope and *Aloe argenticauda* is also not on highest areas. *Jamesbrittenia pilgeriana* and *Sisymbrium dissitiflora* appear to be limited to this mountain at about 1,500 masl. Another 14 species endemic to the highlands of Namibia also occur here.

Tirasberge

Two of the three plants restricted to the Tirasberge are stem succulents of the Apocynaceae family, namely *Larryleachia tirasmontana* and *Huernia plowesii*, while *Hoodia ruschii* is also found at Tsaris. *Namaquanula bruynsii*, a geophyte in family Amaryllidaceae, has rarely been collected and then from 1,850 masl. Four other woody highland endemics occur here and co-occur on the Gamsberg and the Naukluft and Auas mountains. There are more succulent species here than on other highlands and interestingly none of these occurs on the Brandberg or Groot Karasberge as well.

Groot Karasberge

There are five taxa endemic to the Groot Karasberge: *Adromischus schuldtianus* subsp. *juttae*, *Hoodia juttae*, *Panicum pearsonii*, *Stapelia pearsonii* and *Tulbaghia karasbergensis*. *Nemesia karasbergensis* has only been collected twice and possibly further south, while the collecting data for *Crassula ausensis* subsp. *giessii* may be erroneous. There are also very few collections of *Euphorbia baliola*, for which no mention of elevation is given.

Auas Mountains, Khomas Hochland and Otjihaveraberger (Neudamm Hochland)

There are a few highland endemics restricted to this area. However, the plateau needs further evaluation which is likely to increase the numbers of endemics here. *Hibiscus discophorus* is on the Auas Mountains and in the Otjihavera area, while *Caroxylon mirabile* (although probably at lower elevations) and *Afrosolen avasmontanus* seem to be only on the Khomas Hochland and plateau. *Heteromorpha papillosa* collections need to be verified, but it appears this species also only occurs here. *Ebracteola montis-moltkei* is also found on the Gamsberg.

Group 2: Awasibberge, Central Group, Hakosberge, Naos, and Nubib and Tsaris Mountains

Most of these highlands (Figure 2) have their own restricted endemic species. For example, *Jamesbrittenia giessii* only occurs on Mount Etjo in the Central Group, and *Jamesbrittenia fimbriata* is on Nubib Mountains. There are also some that are on other central and southern highlands, like *Ruschia axthelmiana* which grows on the Naos and on the Gamsberg escarpment. *Cucumis clavipetiolatus* is found on the Nubib Mountains and on Brandberg, while *Othonna brandbergensis* which is recorded as growing at elevations above 1,640 masl, occurs on Satanskop, the Awasibberge, the Brandberg and the Gamsberg. *Searsia volkii* and *Commicarpus squarrosus* var. *fruticosus* also occur on the Tsaris Mountains, as well as the Naukluft Mountains. The widespread but key central highland species, *Lightfootia dinteri*, is also found on Etjo and Naos mountains. Some species on the Etjo Mountains are also found on the Waterberg.

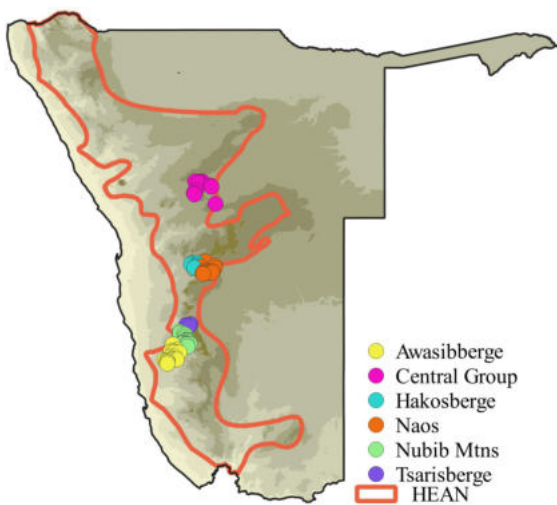


Figure 2: Awasibberge, Central Group, Hakosberge, Naos, Nubib and Tsaris Mountains making up Group 2 of the highland areas of Namibia. (HEAN is the area of highlands and escarpments defined by Mendelsohn and Huntley (2023).)

Group 3: Baynes, Otjihipa and Zebra mountains

Eight range-restricted species have been recorded for this mountain group (Figure 3). No endemics from here are found further south in Namibia, but two have been found in Angola and more are expected. Recent research on Omavanda Mountain has increased the number of range-restricted plants, however, more fieldwork in Angola is needed for a proper evaluation of the taxonomy and ranges. Growth forms of plants include succulents, such as *Baynesia lophophora*, *Stapelia remota*, *Aloe huntleyana* and *A. omavandae*, to perennials, like *Aeollanthus rydingianus*. The shrub, *Hibiscus merxmulleri* has only been collected twice and might occur only at lower elevations. *Maerua kaokoensis* is included in this group, but it may be found at lower elevations.



Figure 3: Baynes, Otjihipa and Zebra mountains making up Group 3 of the highland areas of Namibia. (HEAN is the area of highlands and escarpments defined by Mendelsohn and Huntley (2023).)

Group 4: Huns Mountains – Orange River valley

There are several interesting endemic species around the Huns Mountains and, to the east, the arid mountains along the Orange River (Figure 4). A few monocotyledons have been found on Sonberg, with an elevation of nearly 1,000 masl, but the highest recorded is *Xenoscapa grandiflora* on Hohenzollern, at about 1,500 masl. Very few monocotyledons occur at high elevations in this area, although some are also found in the Aus vicinity and on the Huib-Hoch Plateau, but these need to be verified as highland endemics. On the western side of the Huns Mountains, plants may be influenced by mist from the sea, while the eastern side is drier and very rugged with low rainfall. Most of the species here are woody, but often with succulent leaves. They are mostly dwarf shrubs and shrubs, with some geophytes and

herbs. Many may remain leafless for years, but the vegetation transforms completely after rain, especially after an abnormally good rainy season when a completely different complement of species may grow. Succulent species from the succulent desert in the west have even been recorded on the summit of the Huns Mountains after exceptionally high rains.

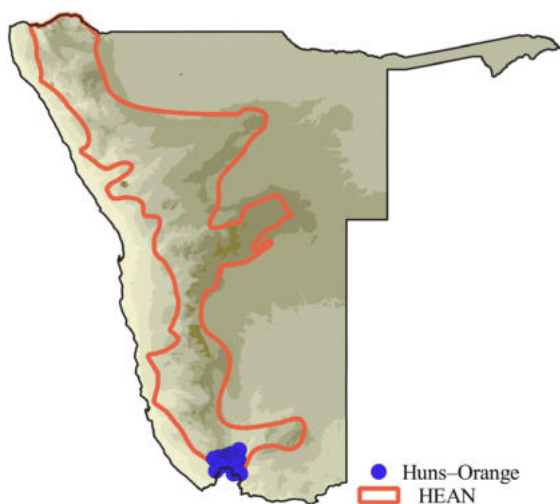


Figure 4: Huns Mountains and the Orange River valley making up Group 4 of the highland areas of Namibia. (HEAN is the area of highlands and escarpments defined by Mendelsohn and Huntley (2023).)

Group 5: Waterberg and Otavi Mountains

There are at least four endemics occurring only on the Otavi Mountains (Figure 5), namely *Jamesbrittenia dolomitica*, *Elephantorrhiza schinziana*, *Brachystelma recurvatum* and *Euphorbia otavibergensis*. Three plants are endemic to the Waterberg: *Eriospermum citrinum*, *Jamesbrittenia acutiloba* and *Helichrysum fleckii* subsp. *volkii*. These two areas also share a few endemics such as *Dintera pterocaulis*, *Barleria jubata*, *Decorsea dinteri*, *Eriosema harmsiana* and *Crassocephalum coeruleum*. Genus *Jamesbrittenia* is significant, and some extend into Angola.

Although a few wide-ranging highland endemics found on the Waterberg (Figure 5) and Otavi Mountains may also be found further south on the Brandberg, Groot Karasberge and Tiras Mountains, there are notably more co-occurrences on the Auas mountains, such as *Lobelia hereroensis*, which may also be in the Erongo Mountains. No Otavi Mountains or Waterberg endemics have been found on the Baynes Mountains, Khomas Hochland or Naukluft Mountains.

Group 6: Southwestern inselbergs

Mountains in the former Sperrgebiet – Aurusberg, Boegoeberg, Klinghardt Mountains, Kowisberge and Obib (Figure 6) – are more botanically diverse than the surrounding plains and, although excluded from the highlands and escarpments of Angola and Namibia (HEAN) defined by Mendelsohn and Huntley (2023) due to their low elevations, they are worth mentioning. No endemic is confined to just one mountain, but there are localised endemic plants on Aurusberg, Boegoeberg and the Klinghardt

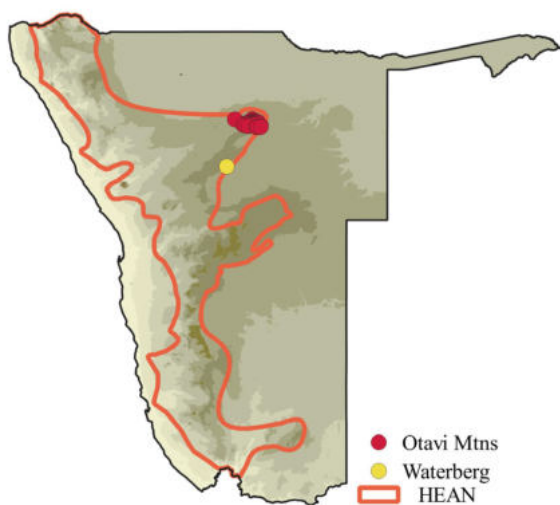


Figure 5: Waterberg and Otavi Mountains making up Group 5 of the highland areas of Namibia. (HEAN is the area of highlands and escarpments defined by Mendelsohn and Huntley (2023).)

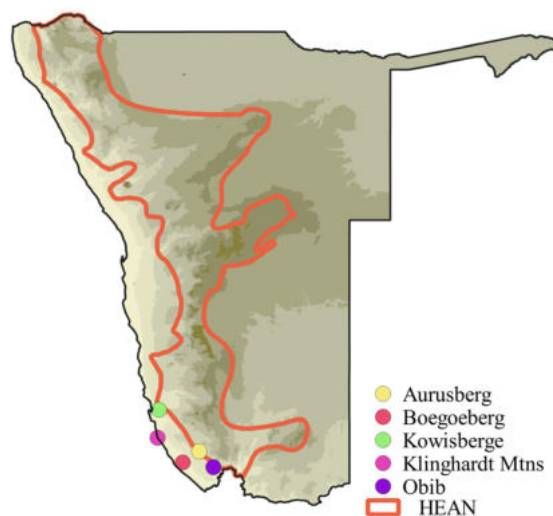


Figure 6: Inselbergs in the southwest making up Group 6 of the highland areas of Namibia. (HEAN is the area of highlands and escarpments defined by Mendelsohn and Huntley (2023).)

Mountains. Unfortunately, despite a great deal of botanical research in the area, elevation records are limited, and certain mountains still need to be better explored to compare the floras. At the summit of Aurusberg, *Crassula aurusbergensis* occurs, but it is not limited to this mountain. *Senecio herreianus* seems to be restricted to Boegoeberg, but this may be because of limited collecting on other mountains.

Group 7: Escarpments and plateaus

Some endemic species are known to be restricted to escarpments and plateaus (Figure 7), but these areas need further study before species can be listed. Evaluation of possible endemics is hampered by a lack of precise location and especially elevation data.

Some known endemics include *Lotononis pallidirosea* in the Schwarzrand and *Leobordea mirabilis* that has only been collected three times in the Aus vicinity. This latter area has several localised endemics, probably because of the combined effects of substrate, coastal mist and cool air preventing plants here from reaching further inland.

Group 8: Highlands without known endemic flora

Between the Otjihipa–Baynes mountains in the north and the Brandberg in the south there are scattered smaller mountains and inselbergs with numerous western-flowing rivers and tributaries in between. These include those shown in Figure 8 – Brukkaros Mountain, Dikke Willem, the Etendeka Mountains, the Paresis Mountains, Rantberg, Rooirand, and the Huab River outliers, those around the middle Ugab River, Otjikondavirongo and Swakop and Khan

rivers. Collection data for many Namibian endemic species in the area were analysed and the results show that the endemics grow on the slopes of the mountains, as well as on the plains. No endemics have been recorded from the highest peaks – Okonjeje (in the middle Ugab group) and Omuhiva (in the Otjikondavirongo Mountains) – even though they are over 1,800 masl. The most probable explanation for this is that the scattered individual highlands making up the groups are relatively low and the many catchment areas allow for dispersal of plants from higher ground to the surrounding lower elevations. This is in stark contrast to the area south of the Gamsberg where there are few rivers and localised endemics do occur.

The Etendeka range is made up of basalts and, like the basalt on the Brandberg, they bear no range-restricted species. No highland endemics have been found on Brukkaros, Dikke Willem or Omatako inselbergs, or co-occurring elsewhere.

The Klein Karasberge were well collected by Dinter in the early 1920s and several interesting species occur here, but his locality data are limited and imprecise, and no information on elevation was given. This area needs more fieldwork to evaluate its flora and assess whether any are endemic to highlands.

Noteworthy mountains

Some mountains mentioned in the text are mapped separately because they are of importance, either for having an interesting complement of species or, in three cases mentioned in Group 8 (Okonjeje and Omuhiva) for having no endemic taxa collected there yet, despite their high elevations. See Figure 9.

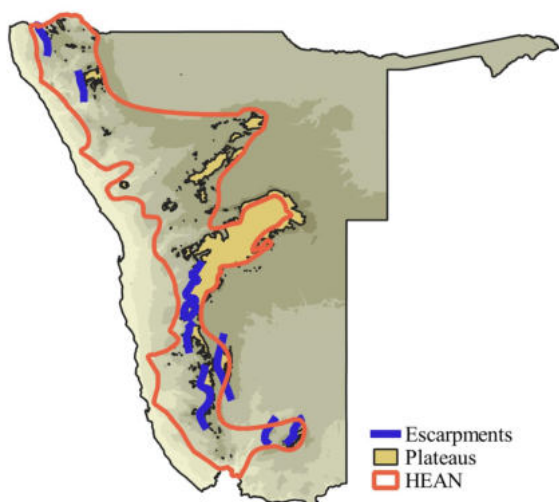


Figure 7: Escarpments and plateaus making up Group 7 of the highland areas of Namibia. (HEAN is the area of highlands and escarpments defined by Mendelsohn and Huntley (2023).)

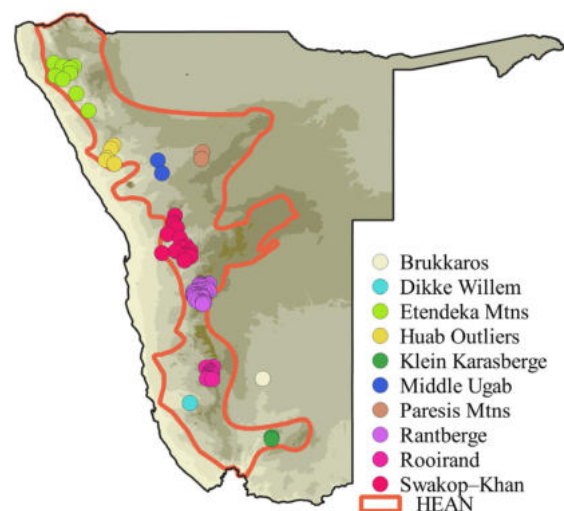


Figure 8: Highlands without known endemic flora making up Group 8 of the highland areas of Namibia. (HEAN is the area of highlands and escarpments defined by Mendelsohn and Huntley (2023).)

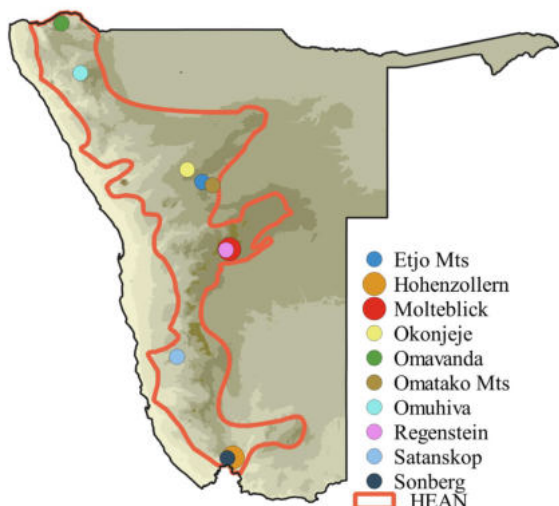


Figure 9: Noteworthy mountains mentioned in the text. (HEAN is the area of highlands and escarpments defined by Mendelsohn and Huntley (2023).)



Figure 10: The floristic groups of Namibia, of which three fall within Namibia's highlands and escarpments (HEAN) defined by Mendelsohn and Huntley (2023).

FLORISTIC GROUPS

Three of the nine floristic groups identified (Craven 2009) fall within the HEAN (Figure 10). Each group is defined by having endemic taxa and co-occurring species found here and not elsewhere in Namibia, and by climatic and topographical features. The Highlands group is made up of taxa occurring over a disjointed landscape over 1,500 masl with summer rainfall. The Huns-Orange group is 900–1,500 masl, rainfall is low and erratic, and the area is crossed by the Konkiep, Fish and Orange rivers. The Kaoko group is mainly 1,200–1,500 masl and has annual summer rainfall up to 350 mm in the eastern parts.

Taxa only endemic to higher elevations in these highlands are discussed in this paper. Many more species are endemic to these floristic groups, but they are not included here as they also occur at lower elevations; they will, however, be useful in understanding possible movements and relationships of the endemic species. See Figure 10.

ORIGINS AND EVOLUTIONARY RELATIONSHIPS AND PATTERNS

There is some evidence for the relationships and the age of the flora of Namibia's highlands from studies of present plant localities and palaeopalynological research. Studies of fossil pollen by Scott *et al.* (1991) suggest a close connection between the flora of the Khomas Hochland and the Highveld of South Africa. This is confirmed by present locality data, for example *Passerina montana* and *Seriphium plumosum*. Although not endemic, both are only found at the summit of Moltkeblick on the Auas Mountains, with *Seriphium plumosum* (previously *Stoebe*) also

on Regenstein in Namibia but they also occur on the eastern escarpment in South Africa and maybe on the Angolan Planalto. The occurrence of *Passerina* in Namibia was considered to represent a relict of the Cape Floristic Region (Rennie 1936) until Bredenkamp and van Wyk (2006) identified specimens as *P. montana*, a species not found in the Cape. They postulated that both species originated in the Cape Floristic Region and formed part of a previously wider northern temperate Afromontane grassland-dominated vegetation during the Quaternary of which relicts remained (Bredenkamp & van Wyk 2006). The disjunctions observed today are believed to be due to environmental changes. *Passerina* pollen has also been identified in hyrax middens in the Brandberg (Scott *et al.* 2004) although there are no extant plants now.

While taxa at elevations above 1,700 masl are related to the Great Escarpment of southern Africa, those above 1,500 masl are related to the highlands of the eastern parts of South Africa (Bredenkamp & van Wyk 2006). For example, *Chasmatophyllum musculinum* which occurs on the Groot Karasberge is disjunct to the Free State Province of South Africa. The distribution of genus *Cineraria*, which stretches from the mountainous areas of Namibia and southern Angola, to much higher elevations in the mountains of tropical East Africa and the Drakensberg in South Africa (Cron *et al.* 2008) may also provide some interesting insights into the origins of highland taxa. However not all taxa found only on one mountain in Namibia and then outside the country may provide clues to the evolutionary past as some may be present due to human use, for example, *Erythrophysa alata* in the Naukluft Mountains and *Trema orientalis* in the Erongo Mountains.

One study that did show patterns of endemism that point to the concept of highland refugia is that of the genus *Lotononis*. Subsequent speciation in and around the centres identified in the study are thought to explain the localised distribution of the species and most of the sections (van Wyk 1991).

The *Nicotiana* genus is known from semi-arid habitats in Australia and South America, and the species in Namibia is now considered to be most closely related to a group from Australia and New Caledonia and may be an endemic relict of considerable age (Knapp *et al.* 2004). Tobacco is also a *Nicotiana* species, and the genus has been well researched, however, this species, *N. africana*, has caused some headaches and information about its origins in Namibia are still debated.

Not many molecular studies have included Namibian taxa and no highland endemics have been evaluated. Although research on a few widespread genera points to the oldest taxa in Namibia occurring in the vicinity of the Huns Mountains (Craven 2009), none of these are highland species.

Plant species distributions contribute greatly towards understanding origins and evolutionary relationships, especially in the absence of other mechanisms. It is possible that the Groot Karasberge would have been included in the study of the Great Escarpment of southern Africa (Clark *et al.* 2011) if the authors had considered the co-occurring taxa.

CONSERVATION, AND THREATENED AND PROTECTED SPECIES

Highland species protected by the Forest Act (No. 21 of 2001) and/or the Nature Conservation Ordinance (No. 4 of 1975) and amendments, CITES and/or have IUCN threat categories are listed in Appendix 1. Over 22 species are protected. One plant has been evaluated as 'Endangered' and three as 'Vulnerable' using the IUCN categories. About 14 are of 'Least Concern', but 12 are listed as being 'Data Deficient'.

Fires are possibly the most serious threat to endemic highland plants. Fires reach the highest areas and directly affect the diversity and structure of the surroundings. One of the biggest problems is the misplaced belief that fires are natural and good for the veld in all areas of Namibia. The reality is that some species, like *Dichrostachys cinerea*, the well-known encroaching sickle bush spreads rapidly after fire and can take over the habitats of local species, including endemics. No research has to date been carried out on the effects of fire on seed germination, establishment, resprouting or recovery of indigenous plants and there are no studies on monitoring burnt areas for taxa diversity changes.

Some highland endemics are sought after by collectors, but many are not charismatic and are at risk rather because of a lack of appreciation of their value. Fences preventing game movements and overstocking of livestock and game, as well as the use of helicopters to supply water, food and equipment so that increased numbers of people can reach the summit of sensitive areas, like the Brandberg and Otjhipa Mountains, threaten the endemic flora.

Mountaintops are commonly used for telecommunication stations and even water reservoirs. Environmental impact assessments, which are often based on desk-top studies, usually miss the highland endemics because they seldom include a well-trained botanist that can correctly identify taxa and threats.

GAPS AND PRIORITIES

Further studies are needed to verify information and fill in knowledge gaps about Namibia's highland plant endemics. This will require sound taxonomy and accurate and complete locality data. This overview has highlighted the lack of elevation data on many herbarium specimens, as well as accurate locality and habitat data, especially for the escarpments and plateaus.

Following further examination of taxa, specimens and literature, targeted fieldwork identified from this review is required. Closer examination of collections and identifications made in years of outstanding rainfalls in Namibia, e.g., in 1963, 1974, 2000, 2010 and 2022, is important. Some endemics have only been collected after episodic rain events which may occur once a decade or century. These conditions may also have resulted in variations of true species that are now described as new taxa.

Very little is known about mosses and ferns restricted to highlands, and the number of endemics is not known. Furthermore, although lichens are not plants, they are very diverse and important organisms that need to be highlighted for further study. In Namibia, lichen investigations have focused on the Namib Desert, and the Waterberg is the only mountain that has been considered in more detail. Lichens may have been the first organisms to colonise the Waterberg sandstone and could be centuries old (Wessels 1989). At least one, *Acarospora elegans* is known to be endemic. It grows on south-facing vertical cliffs in an unusually shaded spot for this genus. Although most lichens known are cosmopolitan, more endemic species are expected to be added to the list after further study.

The relationships and origins of some plant species have been suggested based on distribution patterns inside and outside the country. Possible reasons for the evolution of other species on highlands still need

to be explored and defined. The view that species evolved on these highlands when climatic changes occurred that divided existing populations may not be true for plants. It is important that the differences between the biota in a multidisciplinary study of this nature be acknowledged.

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Appendix 1: Plant species endemic to highlands in Namibia.

Taxon	Family	Life form	Protection ^a	IUCN ^b	CITES ^c	Status ^d	Highland ^e
<i>Adromischus schuldianus</i> subsp. <i>brandbergensis</i>	Crassulaceae	shrublet	P			E	BB
<i>Aeollanthus rydingianus</i>	Lamiaceae	shrublet				N	BO, Huila
<i>Afrosolen avasmontanus</i>	Iridaceae	geophyte				E	KH
<i>Afrosolen erongoensis</i>	Iridaceae	geophyte				E	E
<i>Aloe argenticauda</i>	Asphodelaceae	aloe	P	LC	II	E	N
<i>Aloe huntleyana</i>	Asphodelaceae	aloe	P		II	E	BO
<i>Aloe kaokoensis</i>	Asphodelaceae	aloe	P		II	E	BO
<i>Aloe meyeri</i>	Asphodelaceae	aloe	P		II	N	HO
<i>Aloe omavandae</i>	Asphodelaceae	aloe	P		II	E	BO
<i>Aloe pavelkae</i>	Asphodelaceae	aloe	P		II	E	HO
<i>Aloe viridiflora</i>	Asphodelaceae	aloe	P	LC	II	E	A, BB, G
<i>Anginon streyi</i>	Apiaceae	shrub				E	N
<i>Barlosappus brandbergensis</i>	Asteraceae	shrublet				E	BB
<i>Barleria jubata</i>	Acanthaceae	shrublet		VU B2		E	OW
<i>Barleria lanceolata</i> subsp. a	Acanthaceae	shrublet		LC		E	AV
<i>Baynesia lophophora</i>	Apocynaceae	stem succulent				E	BO
<i>Brachystelma pruniosum</i>	Apocynaceae	geophyte				N	BO
<i>Brachystelma recurvatum</i>	Apocynaceae	geophyte		DD		N	OW
<i>Calobota obovata</i>	Leguminosae	shrub		DD		E	A, G, TI
<i>Caroxylon mirabile</i>	Amaranthaceae	shrublet		DD		E	KH
<i>Commiphora otjihipana</i>	Burseraceae	tree				E	BO
<i>Commicarpus squarrosus</i> var. <i>fruticosus</i>	Nyctaginaceae	shrublet				E	N, TS
<i>Corchorus merxmulleri</i>	Malvaceae	shrublet				E	BB, E
<i>Cordylogyne argillicola</i>	Apocynaceae	geophyte		EN		E	A, E
<i>Crassocephalum coeruleum</i>	Asteraceae	herb				E	OW
<i>Crassula aurisbergensis</i>	Crassulaceae	succulent	P			E	SW inselbergs
<i>Crassula ausensis</i> subsp. <i>giessii</i>	Crassulaceae	succulent	P			E	K
<i>Crotalaria aurea</i>	Leguminosae	herb		DD		E	A, G
<i>Crotalaria kolbergii</i>	Leguminosae	suffrutex		DD		E	KH, TI, Escarp
<i>Cucumis clavipetiolatus</i>	Cucurbitaceae	creeper				E	BB, G, Nubib
<i>Cyphostemma bainesii</i>	Vitaceae	tree	F	LC		E	G, T
<i>Cyphostemma juttae</i>	Vitaceae	tree	F	LC		N	O, Angola
<i>Decorsea dinteri</i>	Leguminosae	twiner				E	OW
<i>Dintera pterocaulis</i>	Scrophulariaceae	herb		NT		E	OW
<i>Dombeya rotundifolia</i> var. <i>velutina</i>	Malvaceae	shrub or tree		LC		E	E, N
<i>Ebracteola montis-moltkei</i>	Aizoaceae	succulent	P			E	A, G
<i>Elephantorrhiza schinziana</i>	Leguminosae	shrub		DD		E	OW
<i>Eragrostis aristata</i>	Poaceae	graminoid				E	BB
<i>Eriocephalus klinghardtensis</i>	Asteraceae	shrublet				E	SW inselbergs
<i>Eriosema harmsiana</i>	Leguminosae	geophyte				E	OW
<i>Eriospermum citrinum</i>	Eriospermaceae	geophyte				E	OW
<i>Eriospermum strachaniae</i>	Eriospermaceae	geophyte				E	HO
<i>Eriospermum volkmanniae</i>	Eriospermaceae	geophyte		DD		E	OW
<i>Euphorbia baliola</i>	Euphorbiaceae	stem succulent		DD	II	E	K
<i>Euphorbia cornelliae</i>	Euphorbiaceae	herb			II	E	HO
<i>Euphorbia monteiroi</i> subsp. <i>brandbergensis</i>	Euphorbiaceae	stem succulent		LC	II	E	BB, E, SP
<i>Euphorbia otavibergensis</i>	Euphorbiaceae	tree			II	E	OW
<i>Euryops walterorum</i>	Asteraceae	shrub				E	G
<i>Felicia gunillae</i>	Asteraceae	shrublet				E	BB
<i>Haemanthus avasmontanus</i>	Amaryllidaceae	geophyte		NT		E	A
<i>Helichrysum fleckii</i> subsp. <i>volkii</i>	Asteraceae	shrublet				E	OW

Taxon	Family	Life form	Protection ^a	IUCN ^b	CITES ^c	Status ^d	Highland ^e
<i>Hermannia merxmuelleri</i>	Malvaceae	shrub				E	BB
<i>Heteromorpha papillosa</i>	Apiaceae	shrub				E	OW, KH, A
<i>Hibiscus discophorus</i>	Malvaceae	herb				E	A, Otjihavera
<i>Hibiscus merxmuelleri</i>	Malvaceae	shrub				E	BO
<i>Hoodia juttae</i>	Apocynaceae	stem succulent	P	LC		E	K
<i>Hoodia ruschii</i>	Apocynaceae	stem succulent	P			E	TI, TS
<i>Huernia plowesii</i>	Apocynaceae	stem succulent	P	LC		E	TI
<i>Hymenodictyon kaokoensis</i>	Rubiaceae	shrub		VU D1D2		E	BO
<i>Indigofera merxmuelleri</i>	Leguminosae	shrub				E	HO low
<i>Jamesbrittenia acutiloba</i>	Scrophulariaceae	shrublet				E	OW
<i>Jamesbrittenia dolomitica</i>	Scrophulariaceae	shrublet				E	OW
<i>Jamesbrittenia fimbriata</i>	Scrophulariaceae	shrublet				E	Nubib
<i>Jamesbrittenia fragilis</i>	Scrophulariaceae	herb				E	OW, A, E
<i>Jamesbrittenia giessii</i>	Scrophulariaceae	shrublet				E	Central group
<i>Jamesbrittenia heucherifolia</i>	Scrophulariaceae	shrublet				N	BO
<i>Jamesbrittenia hyperioides</i>	Scrophulariaceae	herb				E	A, G, N
<i>Jamesbrittenia pilgeriana</i>	Scrophulariaceae	herb				E	N
<i>Larryleachia tirasmontana</i>	Apocynaceae	stem succulent	P	LC		E	TI
<i>Lavrania haagnerae</i>	Apocynaceae	stem succulent	P			E	Escarp
<i>Lightfootia dinteri</i>	Campanulaceae	shrublet				E	BB, E, G, KH, N, K
<i>Lithops wernerii</i>	Aizoaceae	succulent	P	VU D2		E	E
<i>Lobelia hereroensis</i>	Campanulaceae	herb		VU B1 ab (iii)c(iv)		E	E, OW
<i>Lotononis pallidirosea</i>	Leguminosae	herb		DD		E	A, N, Escarp
<i>Maerua kaokoensis</i>	Capparaceae	tree				E	BO
<i>Microloma hereroense</i>	Apocynaceae	twiner				E	BB, G, N, S
<i>Moraea graniticola</i>	Iridaceae	geophyte				E	AV
<i>Namacodon schinzianum</i>	Campanulaceae	shrublet		LC		E	A, E, G, N
<i>Namaquanula bruynsii</i>	Amaryllidaceae	geophyte				E	TI
<i>Nemesia karasbergensis</i>	Scrophulariaceae	herb				E	K
<i>Nicotiana africana</i>	Solanaceae	shrub		LC		E	BB, E, SP
<i>Nidorella nordenstamii</i>	Asteraceae	herb				E	BB
<i>Ocimum sebrabergensis</i>	Lamiaceae	shrub		VU D1		E	BO
<i>Othonna brandbergensis</i>	Asteraceae	suffrutex				E	BB, G, KH, Awasib
<i>Oxalis schaeferi</i>	Oxalidaceae	geophyte				E	AV
<i>Panicum pearsonii</i>	Poaceae	graminoid				E	K
<i>Pelargonium vanderwaltii</i>	Geraniaceae	shrublet				E	BO
<i>Pentatrichia rehmsii</i> subsp. <i>avasmontana</i>	Asteraceae	shrublet		LC		E	A, KH, G, W
<i>Pentatrichia rehmsii</i> subsp. <i>rehmsii</i>	Asteraceae	shrublet		VU D1		E	O
<i>Pentzia tomentosa</i>	Asteraceae	suffrutex				E	BB
<i>Plumbago hunsbergensis</i>	Plumbaginaceae	shrub				E	HO
<i>Plumbago wissii</i>	Plumbaginaceae	suffrutex				E	BB
<i>Ruellia brandbergensis</i>	Acanthaceae	shrub				E	BB
<i>Ruschia axthelmiana</i>	Aizoaceae	succulent	P			N	A, KH, K, Naos
<i>Schizostephanus gossweileri</i>	Apocynaceae	shrub				N	BO
<i>Searsia volkii</i>	Anacardiaceae	shrub or tree				E	N, Rantberg
<i>Senecio herreianus</i>	Asteraceae	herb				E	SW inselbergs
<i>Senecio windhoekensis</i>	Asteraceae	herb				E	A, G, KH
<i>Sisymbrium burchellii</i> var. <i>dinteri</i>	Brassicaceae	herb		DD		E	A, N

Taxon	Family	Life form	Protection ^a	IUCN ^b	CITES ^c	Status ^d	Highland ^e
<i>Sisymbrium dissitiflora</i>	Brassicaceae	herb		DD		E	N
<i>Stachys dinteri</i>	Lamiaceae	herb				E	N, TI
<i>Stapelia pearsonii</i>	Apocynaceae	stem succulent	P			E	K
<i>Stapelia remota</i>	Apocynaceae	stem succulent	P			E	BO
<i>Strumaria speciosa</i>	Amaryllidaceae	geophyte				N	HO
<i>Tetradenia kaokoensis</i>	Lamiaceae	shrublet				E	BO
<i>Thesium xerophyticum</i>	Thesiaceae	parasite or hemi-				E	OW, A, G
<i>Trachyandra ensifolia</i>	Asphodelaceae	geophyte				E	HO, Escarp
<i>Tulbaghia karasbergensis</i>	Amaryllidaceae	geophyte				E	K
<i>Xenoscapa grandiflora</i>	Iridaceae	geophyte				E	HO

Taxa mentioned in the text, but are not highland endemics:

Taxon	Family
<i>Chasmatophyllum musculinum</i>	Aizoaceae
<i>Erythrophysa alata</i>	Sapindaceae
<i>Manuleopsis dinteri</i>	Scrophulariaceae
<i>Passerina montana</i>	Thymelaeaceae
<i>Seriphium plumosum</i>	Asteraceae
<i>Tetradenia brevispicata</i>	Lamiaceae
<i>Trema orientale</i>	Cannabaceae

^a Protection under: F = Forestry legislation; and P = Nature Conservation Ordinance.

^b IUCN category: DD = Data Deficient; EN = Endangered; LC = Least Concern; NT = Not Threatened; and VU = Vulnerable.

^c CITES: II = Appendix II of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES).

^d Status: E = endemic; and NE = near-endemic.

^e Highland: A = Auas Mountains; AV = Aus vicinity; BB = Brandberg; BO = Baynes–Otjihipa; E = Erongo Mountains; Escarp = escarpment; G = Gamsberg; HO = Huns Mountains – Orange River valley; K = Karasberge; KH = Khomas Hochland; N = Naukluft Mountains; O = Otavi Mountains; OW = Otavi Waterberg; SP = Spitzkoppe; SW inselbergs = southwestern inselbergs; TI = Tirasberge; TS = Tsaris Mountains; and W = Waterberg.

Appendix 2: Highlands in Namibia and their complement of endemic species. An asterisk (*) indicates that a species is restricted to the mountain indicated.

Highland area	Endemic species	
1. Central and southern highlands		
Brandberg	<i>Adromischus schuldianus</i> subsp. <i>brandbergensis</i> * <i>Aloe viridiflora</i> <i>Anisopappus brandbergensis</i> * <i>Corchorus merxmuelleri</i> <i>Cucumis clavipetiolatus</i> <i>Eragrostis aristata</i> * <i>Euphorbia monteiroi</i> subsp. <i>brandbergensis</i> <i>Felicia gunillae</i> *	<i>Hermannia merxmuelleri</i> * <i>Lightfootia dinteri</i> <i>Microlooma hereroense</i> <i>Nicotiana africana</i> <i>Nidorella nordenstamii</i> * <i>Othonna brandbergensis</i> <i>Pentzia tomentosa</i> * <i>Plumbago wissii</i> * <i>Ruellia brandbergensis</i> *
Erongo	<i>Afrosolen erongoensis</i> * <i>Corchorus merxmuelleri</i> <i>Cordylogyne argillicola</i> <i>Dombeya rotundifolia</i> var. <i>velutina</i> <i>Euphorbia monteiroi</i> subsp. <i>brandbergensis</i>	<i>Jamesbrittenia fragilis</i> <i>Lightfootia dinteri</i> <i>Lithops wernerii</i> * <i>Lobelia hereroensis</i> <i>Nicotiana africana</i>
Spitzkoppe	<i>Euphorbia monteiroi</i> subsp. <i>brandbergensis</i> <i>Nicotiana africana</i>	<i>Microlooma hereroense</i>
Gamsberg	<i>Aloe viridiflora</i> <i>Calobota obovata</i> <i>Crotalaria aurea</i> <i>Cucumis clavipetiolatus</i> <i>Cyphostemma bainesii</i> <i>Ebracteola montis-moltkei</i> <i>Euryops walterorum</i> *	<i>Jamesbrittenia lyperioides</i> <i>Lightfootia dinteri</i> <i>Microlooma hereroense</i> <i>Othonna brandbergensis</i> <i>Pentatrachia rehmi</i> subsp. <i>avasmontana</i> <i>Senecio windhoekensis</i> <i>Thesium xerophyticum</i>
Naukluft	<i>Aloe argenticauda</i> * <i>Anginon streyi</i> * <i>Commicarpus squarrosus</i> var. <i>fruticosus</i> <i>Dombeya rotundifolia</i> var. <i>velutina</i> <i>Jamesbrittenia lyperioides</i> <i>Jamesbrittenia pilgeriana</i> * <i>Lightfootia dinteri</i>	<i>Lotononis pallidirosea</i> <i>Microlooma hereroense</i> <i>Searsia volkii</i> <i>Sisymbrium burchellii</i> var. <i>dinteri</i> <i>Sisymbrium dissitiflora</i> * <i>Stachys dinteri</i>
Tiras Mountains	<i>Calobota obovate</i> <i>Crotalaria kolbergii</i> <i>Cyphostemma bainesii</i> <i>Hoodia ruschii</i>	<i>Huernia plowesii</i> * <i>Larryleachia tirasmontana</i> * <i>Namaquanula bruynsii</i> * <i>Stachys dinteri</i>
Karasberge	<i>Crassula ausensis</i> subsp. <i>giessii</i> * <i>Euphorbia baliola</i> * <i>Hoodia juttae</i> * <i>Lightfootia dinteri</i> <i>Nemesia karasbergensis</i> *	<i>Panicum pearsonii</i> * <i>Ruschia axthelmiana</i> <i>Stapelia pearsonii</i> * <i>Tulbaghia karasbergensis</i> *
Auas Mountains, Khomas Hochland, Otjihaveraberge	<i>Afrosolen avasmontanus</i> * <i>Aloe viridiflora</i> <i>Calobota obovata</i> <i>Caroxylon mirabile</i> * <i>Cordylogyne argillicola</i> <i>Crotalaria aurea</i> <i>Crotalaria kolbergii</i> <i>Ebracteola montis-moltkei</i> <i>Haemanthus avasmontanus</i> * <i>Heteromorpha papillosa</i>	<i>Hibiscus discophorus</i> * <i>Jamesbrittenia fragilis</i> <i>Jamesbrittenia lyperioides</i> <i>Lotononis pallidirosea</i> <i>Namacodon schinzianum</i> <i>Othonna brandbergensis</i> <i>Pentatrachia rehmi</i> subsp. <i>avasmontana</i> <i>Ruschia axthelmiana</i> <i>Senecio windhoekensis</i> <i>Sisymbrium burchellii</i> var. <i>dinteri</i>
2. Group of highlands		
Tsaris Mountains	<i>Commicarpus squarrosus</i> var. <i>fruticosus</i>	<i>Cucumis clavipetiolatus</i>
Nubib	<i>Hoodia ruschii</i>	<i>Jamesbrittenia fimbriata</i> *
Central Group, Etjo mountains	<i>Jamesbrittenia giessii</i>	

Highland area	Endemic species	
Awasibberge	<i>Othonna brandbergensis</i>	
Naos	<i>Ruschia axthelmiana</i>	
Rantberg	<i>Searsia volkii</i>	
3. Baynes, Otjihipa and Zebra mountains		
	<i>Aeollanthus rydingianus</i> <i>Aloe huntleyana</i> * <i>Aloe kaokoensis</i> * <i>Aloe omavandae</i> * <i>Baynesia lophophora</i> * <i>Brachystelma pruniosum</i> * <i>Commiphora otjihipana</i> * <i>Hibiscus merxmuelleri</i> *	<i>Hymenodictyon kaokoensis</i> * <i>Jamesbrittenia heucherifolia</i> * <i>Maerua kaokoensis</i> * <i>Ocimum sebrabergensis</i> * <i>Pelargonium vanderwaltii</i> * <i>Schizostephanus gossweileri</i> * <i>Stapelia remota</i> * <i>Tetradenia kaokoensis</i> *
4. Huns Mountains–Orange River valley		
	<i>Aloe meyeri</i> * <i>Aloe pavelkae</i> * <i>Eriospermum strachaniae</i> * <i>Euphorbia cornelliae</i> * <i>Indigofera merxmuelleri</i>	<i>Plumbago hunsbergensis</i> * <i>Strumaria speciosa</i> * <i>Trachyandra ensifolia</i> <i>Xenoscapa grandiflora</i> *
5. Otavi Mountains and Waterberg		
	<i>Acarospora elegans</i> * <i>Barleria jubata</i> * <i>Brachystelma recurvatum</i> * <i>Crassocephalum coeruleum</i> * <i>Cyphostemma juttae</i> <i>Decorsea dinteri</i> * <i>Dintera pterocaulis</i> * <i>Elephantorrhiza schinziana</i> * <i>Eriosema harmsiana</i> * <i>Eriospermum citrinum</i> * <i>Eriospermum volkmaniae</i> *	<i>Euphorbia otavibergensis</i> * <i>Helichrysum fleckii</i> subsp. <i>volkii</i> * <i>Heteromorpha papillosa</i> <i>Jamesbrittenia acutiloba</i> * <i>Jamesbrittenia dolomitica</i> * <i>Jamesbrittenia fragilis</i> <i>Lobelia hereroensis</i> <i>Pentatrichia rehmi</i> subsp. <i>avasmontana</i> <i>Pentatrichia rehmi</i> subsp. <i>rehmi</i> * <i>Thesium xerophyticum</i>
6. Southwestern inselbergs		
	<i>Crassula aurusbergensis</i> *	<i>Senecio herreianus</i> *
7. Escarpments		
	<i>Barleria lanceolata</i> subsp. <i>a</i> * <i>Crotalaria kolbergii</i> <i>Lavrana haagnerae</i>	<i>Lotononis pallidirosea</i> <i>Moraea graniticola</i> * <i>Trachyandra ensifolia</i>