

THE ORCHIDS OF TONGA, NIUE, AND THE COOK ISLANDS

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GEOGRAPHY, VEGETATION, AND FLORA

Tonga

Tonga, which lies at a latitude of 15–23° S and a longitude of 173–177° W, comprises about 150 islands with a total area of 697 km², with only about 36 of these islands currently inhabited. The islands of the archipelago are mostly coralline and “continental,” and lie on the eastern edge of the Asia-Australia Plate. The archipelago forms a double chain of islands running in a north-northeast direction with small, high, volcanically active islands to the west, and lower, larger, raised coral islands to the east. Uplifting of the edge of the Asia-Australia plate caused by subduction of the Pacific Plate under it has created the eastern limestone islands and resulted in volcanic activity that in turn created the western chain of volcanic islands. Ash from ancient volcanic eruptions later covered most of the limestone surface of the rest of the archipelago, resulting in deep fertile soil on many of the islands. Volcanic activity continues today in the western chain—on Tofua and Fonualei, and on underwater volcanoes that periodically erupt and come to the surface.

The main limestone islands are Tongatapu (257 km² in area, 80 m elevation; Fig. 1), ‘Eua (87 km², 330 m; Fig. 2), and Vava‘u (90 km², 200 m; Fig. 3). Numerous small, raised limestone islands known collectively as Ha‘apai lie between Tongatapu and Vava‘u. In the volcanic chain, the main islands of the southern part, going from south to north, are ‘Ata, Tofua (Fig. 4), Kao (Fig. 5), Late, and Fonualei; all of these are uninhabited (but Tofua often has a small temporary population). Kao, which lies adjacent to Tofua, has the highest elevation in Tonga (1046 m). The northern part of the volcanic chain comprises three islands, Niufo‘ou (Fig. 6), Niuatoputapu (Fig. 7), and Tafahi (Fig. 8), all of which are inhabited (See Figs. 63 & 64.)

Since Tonga is situated between the Tropic of Capricorn and the equator, its climate is tropical. There is little seasonal or diurnal temperature variation, although the winters are sometimes relatively cool. The average yearly temperature in Nuku‘alofa on Tongatapu is 23° C, with an average low of 22° C and an average high of 26° C. The islands to the north, i.e., Ha‘apai and Vava‘u, are a little warmer since they are closer to the equator. There is no pronounced dry season, but 60 to 70% of the rainfall occurs in the “wet” season (December to April). The southern islands average about 1700 mm of yearly precipitation, while the northern islands average about 2600 mm.

The vegetation. There have been several recent vegetation studies in Tonga, the earliest of which was a brief paper on the forests of ‘Eua (Straatsmans 1964). A more recent and comprehensive study of the vegetation of ‘Eua was done by Drake *et al.* (1996). Ten primary and secondary vegetation types were recognized on that island, and the best remaining lowland forest in Tonga is found in the

limestone areas that comprise the southeastern part of the island. Two other vegetation studies on Vava'u were carried out by Steadman *et al.* (1999a, 1999b). There have been three vegetation studies on Tongatapu, which has been highly disturbed by centuries of occupation and cultivation. The first was by Palmer (1988) on the only remaining patch of (disturbed) lowland forest on the island, and the second by Ellison (1990) on the vegetation of the Tongatapu outliers. The third was by Wiser *et al.* (2002), who studied forest fragments on the island. Whistler (1992) discussed the similarities of the vegetation of Samoa and Tonga.

Uhe (1974) published an analysis of the vegetation of the volcanic areas of Niuafu'ou, the only such study of the volcanic islands of Tonga. Sykes (1981) reported on the vegetation and flora of Late, but did not include any quantitative data. A comprehensive field study of the vegetation and flora of Kao and Tofua was carried out in 1982 by G. Buelow, but his work was discontinued and never published. More recently, however, a botanical survey was carried out in Ha'apai, with particular emphasis on Kao and Tofua (Park & Whistler 2001), since that area had been selected to be a conservation area. The uninhabited volcanic islands, especially Tofua, have some areas of undisturbed lowland forest. Cloud forest (Fig. 9), which is home to many of the Tongan orchid species, is found only on Tafahi, which is the second highest island of the archipelago. A fern-dominated vegetation on top of Kao (Fig. 10), the highest elevation in Tonga (1046 m), is also home to many orchids, especially terrestrial species, since trees are few in that habitat. A comprehensive description of the vegetation of the archipelago is found in the work by Mueller-Dombois and Fosberg (1998) on the vegetation of the Pacific Islands. Herbarium abbreviations cited herein follow those used in Index Herbariorum [http://sweetgum.nybg.org/ih/herbarium_list.php].

The Flora. The first botanical collections in Tonga date to the three Captain Cook expeditions (1773, 1774, 1777), and are stored at Kew (K). The next large collection was not made until over 60 years later, when the U.S. Exploring Expedition (USEE) visited Tonga in 1840 (Pickering 1876). This collection is housed mostly at the Smithsonian Institution (US). Another half century passed before further major collections were made—J.J. Lister (Hemsley 1894), who botanized in Tonga in 1888–1891, and C.S. Crosby (Burkill 1901), who botanized there in about 1894. These collections are stored at Kew. Another large collection made by H.E. Parks in 1921, which is stored at Kew, the University of California, Berkeley (UC), and the Bishop Museum (BISH) in Honolulu, has only been partially published (Yuncker 1959).

The five largest Tongan collections (which include between 1000 and 3300 specimens) have been made in the last sixty years. The first of these was by T.G. Yuncker in 1953, who, on the basis of his specimens and those of an earlier collector (Hurlimann in 1951), published a flora, *Plants of Tonga*, in 1959. Yuncker's collections are stored at the Bishop Museum. Another major Tongan collection was made by M. Hotta in 1961, but the manuscript of his work (Hotta 1962) has never been published. His specimens are stored in Kyoto (KYO), Japan.

More recently, G. Buelow, who worked in Tonga between *ca.* 1977 and 1982, compiled by far the largest collection of anybody (*ca.* 3300 numbers), but his work has never been published. His specimens are stored at Christchurch (CHR), New Zealand, and the Bishop Museum. At about the same time another significant, but smaller, collection was made by W.R. Sykes, which is a basis for his fern study of 'Eua (Sykes 1977) and a vegetation study of Late (Sykes 1981). However, Sykes' collection numbers to his specimens, which are stored at Christchurch, have never been published. The most recent large collection of Tongan plants was made by the present co-author (Whistler)



FIGURE 1. Tongatapu.



FIGURE 2. Eua.



FIGURE 3. Vava'u.



FIGURE 4. Tofua.



FIGURE 5. Kao.



FIGURE 6. Niuafo'ou.



FIGURE 7. Niuatoputapu.



FIGURE 8. Tafahi.



FIGURE 9. Cloud forest of Tafahi.



FIGURE 10. Fernland on Kao.



FIGURE 11. Niue.



FIGURE 12. Niue coastal zone.

during his work in Tonga (1984–present). Information from these collections and field work are the basis of a comparison of the vegetation of Tonga with that of Samoa (Whistler 1992), but little taxonomic work has been done on these specimens. His collections are stored at the University of Hawai‘i, Manoa campus (HAW) and elsewhere. In addition to these large collections, relatively small collections by H. Hurlimann and P. Kirch were used as a basis for a checklist of the flora of Niuatoputapu published by H. St. John (1977).

Floristically, Tonga is part of the “Fijian Region” that extends from the Santa Cruz Islands and Vanuatu to Niue (Takhtajan 1969). Lying in the eastern portion of this region, Tonga has a smaller native flora than the Melanesian islands to the west, which lie closer to the Indo-Malaysian source area. The flora of Tonga is very similar to that of the adjacent islands and archipelagos, particularly Samoa. It is estimated to comprise 340 native angiosperm species, only 3% of which are thought to be endemic to the archipelago (Whistler 1992). A total of 44 orchid species (43 native and one introduced) are reported from Tonga, only one of which, *Robiquetia tongaensis*, is endemic there.

Niue

Niue (Fig. 11) lies in the South Pacific Ocean at a latitude of 19° S and a longitude of 169° W, between Tonga to the west and the Cook Islands to the east (see Fig. 66). The flat, oval-shaped, limestone island, with an area of 260 km² and a maximum elevation of 69 m, was formed in recent geological times by the emergence and elevation of a coral atoll that sits atop a long-dormant undersea volcano. The outer portion or coastal zone (Fig. 12) of the island comprises several terraces formed during periods when the island paused during its emergence from the sea. This series of terraces is quite weathered in some areas and is marked in many places by deep crevices and rugged pinnacles. The central basin, which makes up the majority of the island, represents the former lagoon of the atoll. Its surface consists largely of jagged limestone, but some areas have a shallow layer of soil. Areas with deeper pockets of soil are favored by trees for the growth of dense lowland forests, but also by human inhabitants for the cultivation of food.

The climate in Niue is wet and tropical. The mean annual temperature is 25° C, with a mean diurnal range of 8° C. The mean maximum temperature ranges between 21 and 27° C. Rainfall is relatively heavy with a mean annual total of 2040 mm. The months from June to September are the driest, but even these months average at least 100 mm of precipitation. Humidity is nearly always high, averaging 89% at 9 a.m. Droughts occasionally occur, and cyclones periodically hit the island during the summer months (mostly November to April). The high rainfall and warm temperatures partly make up for the relatively poor soil conditions and allow the island (the central basin at least) to support a tropical rainforest and flora.

The Vegetation. Brief accounts of the vegetation were given by Frost and Berryman (1966), a timber survey by the Niue Forestry Section (1990), and Sykes (1970). Frost and Berryman divided the forest into three categories, “coastal forest,” “light and scattered forest,” and “merchantable forest,” but did not discuss non-forest vegetation. The Forestry Section report also did not deal with overall vegetation, but reiterated the three forest types of Frost and Berryman and added a fourth vegetation category, “open areas.” Sykes (1970) gave a brief account of the vegetation and noted that the island was originally covered with a rainforest of tall trees that formed a relatively dense canopy, below which was a relatively poorly developed shrub and herbaceous layer (Fig. 13). Because of the long period of human habitation and the modifications made during shifting agriculture, and, in more

recent times, by a timber industry, most of the mature forest has now been removed and replaced by secondary forest in various stages of development. This secondary forest, according to Sykes, is generally richer in species numbers than the mature forest. In addition to the forest types, Sykes also recognized “scrub” areas that are the extreme result of man’s activity. This vegetation, referred to by Yuncker (1943) as “thickets” and by Wright and van Westerndorp (1965) as “desert,” are typically dominated by the fern *Nephrolepis hirsutula*. A comprehensive description of the vegetation of the island is found in Mueller-Dombois and Fosberg (1998).

The Flora. The documentation of the flora of Niue began in 1774 with the visit of Captain James Cook. However, only four specimens were obtained (Sykes 1970). Another collection was made in 1876 by amateur botanist F. Jensen, but his specimens, which are stored at the Natural History Museum (BM), were only noted in recent times (St. John 1976) and it is likely that many of the specimens attributed to Niue were actually collected elsewhere (Whistler 1984). The next significant collection was made in about 1899 by H.F. Moore, but these specimens, which are at the Smithsonian, have apparently not been studied. Two years later another collection was made by S.P. Smith (Smith 1902), and is now at the herbarium of the Auckland War Memorial Museum (AK).

It was not until 1940 that a large and comprehensive collection of the flora of Niue was made. This was by T.G. Yuncker, who, on the basis of these collections, published *The Flora of Niue Island* in 1943. Another larger collection was made by W.R. Sykes in 1965, and is the basis for his *Contributions to the Flora of Niue* (Sykes 1970). Several years later Sykes made further collections on Niue, but these specimens have not been documented. The present co-author (Whistler) made a small collection on Niue during two trips in the mid-1980s and during field work in 1997, but these too have not yet been documented. They are stored at the University of Hawai‘i.

Like Tonga, Niue is floristically part of the “Fijian Region” that extends from the Santa Cruz Islands and Vanuatu to Niue (Takhtajan 1969). Lying at the eastern limit of this region, Niue has a smaller native flora than the Melanesian and Polynesian islands to the west, which lie closer to the Indo-Malaysian source region. Sykes estimated the size of the native vascular plant flora (flowering plants, ferns, and fern allies) at 175 species. Also present and listed by Sykes were a number of adventive or weedy species. In addition to the native species estimated by Sykes, several others were first recorded during a study by Whistler and Atherton (1997). A total of 17 species of native orchids are reported from Niue, none of them endemic to the island.

The Cook Islands

The Cook Islands are situated in the center of Polynesia east of Niue and nearly midway between Tahiti and Samoa, between 8° and 23° S and 156° and 167° W. (See Fig. 66.) The archipelago comprises twelve inhabited and three uninhabited islands. These islands fall geographically into two groups—the Southern Cooks and the Northern Cooks. The Southern Cooks, which are a westward extension of the Austral Islands, comprise the high islands of Rarotonga, Mangaia, Atiu, Ma‘uke, Miti‘aro, and Aitutaki, and the low coral islands of Palmerston, Takutea, and Manuae; the Northern Cooks comprise the low coral islands of Pukapuka, Nassau, Manihiki, Rakahanga, Penrhyn (Tongareva), and Suvarrow. The total area of the archipelago is 240 km², with the highest elevation of 652 m on Rarotonga (Fig. 14), which, with an area of 64 km², is the largest and only mountainous island in the archipelago. Aitutaki, to the north of Rarotonga, is a classic example of an “almost atoll,” with a small high island surrounded by a large lagoon. Mangaia and Ngaputuru (the



FIGURE 13. Inside Niue forest.



FIGURE 14. Rarotonga.



FIGURE 15. Mangaia.



FIGURE 16. Rarotonga interior.

collective name for Atiu, Ma'uke, and Miti'aro) are typical "makatea" islands comprised of uplifted limestone, except that the center (Fig. 15) is a highly eroded volcanic core.

The climate of the Cook Islands is warm and sunny all year round. The rainfall is moderate to heavy throughout the year, with November to March being particularly wet, and June to September being the driest period. On the main island of Rarotonga, the average annual precipitation is 2060 mm, with the highest rainfall in the mountainous interior and the lowest on the coast on the leeward (northwest) side of the island. The average yearly temperature on Rarotonga is 24° C, with an average low of 21° C and an average high of 27° C. Aitutaki and the Northern Cooks are noticeably warmer than Rarotonga. Droughts occasionally occur, and cyclones periodically hit the islands during the warm season (mostly November to April).

The Vegetation. The first quantitative study of the vegetation of the Cook Islands was carried out by M.D. Merlin (1985). He divided the upland forest vegetation of Rarotonga (Fig. 16) into a "Homalium montane slope forest" dominated by *Homalium acuminatum*, "a *Fagraea-Fitchia* ridge forest" dominated by *Fagraea berteroa* and *Fitchia speciosa*, and a "*Metrosideros* cloud forest" dominated by *Metrosideros collina*. The lowland and littoral forest has been almost entirely removed and replaced by villages and plantations, and the slopes leading up to the peaks are covered with a fern community dominated by false-staghorn fern (*Dicranopteris linearis*).

Merlin undertook a similar quantitative survey on the limestone areas of the "makatea" island of Mangaia (Merlin 1991), the second largest of the Cook Islands. He recognized four vegetation types: a mixed native forest dominated by *Elaeocarpus floridanus*, a disturbed mixed native forest dominated by *Hernandia moerenhoutiana* or coconuts, a *Pandanus* scrub dominated by *Pandanus tectorius*, and a *Barringtonia* forest dominated by *Barringtonia asiatica*. The inland volcanic areas of the island were highly disturbed by agriculture, and little native vegetation and few native plant species can be found there now. Three of the other islands of the archipelago—Miti'aro, Ma'uke, and Atiu—have a similar vegetation of native forest on a raised limestone reef surrounding a highly disturbed central volcanic part. A comparison of vegetation of these three islands and of Mangaia was made by Franklin and Merlin (1992). A qualitative study of the littoral vegetation of the reef islands on the southeast side of Rarotonga was made by Stoddart (1972), who also did similar studies of the reef islands of Aitutaki (Stoddart 1975A) and of the main island of Aitutaki (Stoddart 1975B). A comprehensive description of the vegetation of the archipelago is found in Mueller-Dombois and Fosberg (1998).

The Flora. The first significant collection of the flora of the Cook Islands was made by T.G. Cheeseman in 1899, who reported in a flora of Rarotonga (Cheeseman 1903) that only seven specimens had been collected there in the previous 80 years since Europeans first inhabited the islands. Cheeseman collected only on Rarotonga, since transportation to the outer islands was difficult at that time. His specimens are stored at Kew and Auckland. Several decades later, a second flora of Rarotonga was published (Wilder 1931), based upon collections made on the island from 1925 to 1929. Wilder's specimens are at the Bishop Museum. Thus, prior to the last 30 years, very few collections were made from the other islands. Since that time major collections have been made from the outer islands (and Rarotonga) by W.R. Sykes and by the present co-author (Whistler), but these have not been documented in the literature. Sykes' specimens are mostly at Christchurch, and Whistler's are mostly at the National Tropical Botanical Garden (PTBG) and the Bishop Museum, both in Hawai'i.

The flora of the Cook Islands is believed to total about 190 native species of flowering plants (Sykes, pers. comm.). Like Niue and Tonga to the west, the affinities of its flora are Indo-Malaysian. However, there is also a tropical American element best exemplified by *Fitchia speciosa* (Asteraceae). The rate of endemism is about 10%. A total of 13 species of native orchids are reported from the archipelago, 12 of these occurring on Rarotonga and 6 on the outer islands. Only one of these, *Habenaria amplifolia*, is endemic to the archipelago (Rarotonga). The flora is currently being studied by W.R. Sykes, and the final number of species and rate of endemism awaits his publication.