

**Vegetation Classification Support
for the National Park of American Samoa (NPSA)
in American Samoa**

TASK AGREEMENT NO. J2132090328

Prepared by

Art Whistler, Ph.D.

**Contracted to
The University of Hawaii, Manoa
Honolulu, Hawaii**

**For
National Park Service
Pacific West Regional Office**

August 2009

INTRODUCTION

Samoa is a volcanic archipelago situated in the South Pacific Ocean at a latitude of 13–15° south (11° when Swains Island is included) and a longitude of 168–173° west, and runs in a west-northwest direction east of Fiji, north of Tonga, south of Tokelau, and west of Niue and the Cook Islands. Its nine inhabited islands and several uninhabited islets, plus two distant coral islands (Swains Island, which is inhabited, and Rose Atoll, which is not), have a total area of ca. 3100 km².

The archipelago is divided politically into the independent nation of Samoa (a term that is ambiguous, since it refers to the archipelago as well), and American Samoa, which is an unincorporated territory of the United States. The two are separated by a strait 64 km wide. American Samoa comprises five main volcanic islands and two atolls. The largest of these islands is the rugged, deeply embayed Tutuila (55 mi², 142 km² area; 2,031 ft (619 m) elevation, where the capital of American Samoa, Pago Pago, is located. Lying off its southeastern end is the small, inhabited tuff cone island of ‘Aunu‘u, which has an area of less than 2 km². Approximately 100 km to the east lie the islands known collectively as Manu‘a, comprising Ta‘ū (17 mi², 44 km²; 3050 ft, 930 m), Ofu (1.9 mi², 5 km²; 1624 ft, 495 m), and Olosega (1.5 mi², 4 km²; 2100 ft, 640 m). Just 87 m (140 km) to the east of Ta‘ū lies uninhabited Rose Atoll, and 210 mi (320 km) north lies Swains Island, which is home to a small population. The current population of American Samoa is over 60,000. This number is rapidly rising, with very little flat or arable land to conveniently accommodate the burgeoning population (Craig 1993).

The National Park of American Samoa is distributed across three separate islands: Tutuila, Ofu-Olosega (actually, two islands joined by a bridge), and Ta‘ū. Of the park’s 9000 acres (36 km²), 7970 acres (32.3 km²) are on land and 2550 acres (10.3 km²) are in the ocean. The largest terrestrial unit of the park is on Tutuila, comprising a continuous area on the north-central coast of the island from the top of Alava Ridge to the north coast between the villages of Fagasā and Afono. The second largest terrestrial unit comprises most of the eastern portion of the island of Ta‘ū, from the east coast up to the highest summit at Mt. Lata at 3050 ft (930 m) elevation. The smallest of the three terrestrial units comprises most of the southeast coast of Ofu, from the top of the ridge down to the shoreline.

GEOLOGY

The Samoan archipelago is volcanic in origin and “oceanic,” i.e., it was formed from basaltic lavas rising from the ocean floor of the Pacific basin beyond the continental islands to the west. It was born in isolation and has never had a connection to any other land area, unlike its two nearest significant neighbors, Tonga to the south and Fiji to the west, both of which are on the other side of the “andesite line” (a line that circumscribes the central Pacific area whose ocean floor comprises andesite rock) and are therefore “continental.” The archipelago originated in the Pliocene, and the islands were sequentially formed in a generally easterly direction by a series of “hot spot” eruptions, starting with Savai‘i, at over 2 million years of age, Tutuila at 1.26 million years, and Ta‘ū at about 100,000 years (Keating 1992). Nevertheless, the most recent periods of surface volcanic activity have occurred historically on Savai‘i (in ca. 1760 and 1902–1911). The most recent terrestrial volcanism in American Samoa occurred on the Tafuna plane, after the Polynesian settlement of the islands. Additionally, a submarine eruption was recorded in Manu‘a in 1866, and another one was recently detected (1999) in this area. Two studies,

Stearns (1944) for Tutuila and Stice & McCoy (1968), have described the geology of American Samoa.

In addition to the lava flows and cinder deposits that cover much of Samoa, another type of rock is also significant. This rock, called tuff (pronounced “tough”), exists mostly in the form of volcanic cones formed in coastal areas (coastal hills or offshore islets), where rising lava comes into contact with surface water, causing tremendous steam explosions that deposit a mixture, sometimes in layers, of volcanic rocks, ash, and bits of coral. Examples do not occur within the NPSA boundaries. A second type of volcanic rock, trachyte, does, however, occur within the park. Trachyte areas are the cores and associated dikes of ancient volcanoes that have survived long after the surrounding volcanic rock has eroded away. The three most obvious examples of trachyte “plugs” found on Tutuila are Mt. Matafao (at 2133 ft, 650 m), Mt. Pioa (1712 ft, 522 m), and Mt. Tau (1250 ft, 385 m), but all of these are outside of the NPSA boundaries. The only area of trachyte within the NPSA boundaries comprises the hill known as Maugaotula (ca. 770 ft, 235 m) and its extension north to Pola Uta Point behind the village of Vatia. The soil derived from the weathered trachyte is a soft, fine-grained, generally light-colored rock composed predominately of potassium feldspar.

Another type of surface present in American Samoa is alluvium, which is any sedimentary material deposited by flowing water, as in a riverbed, flood plain, or delta. Alluvial deposits are common in valleys bordered by steep ridges, and are or were covered with a particular type of lowland forest. Related to this are talus slopes, which are sloping accumulations of debris found at the bases of cliffs and steep slopes. Talus slopes, typically composed of rocks and boulders, are often covered with a forest similar to that found in alluvial valleys. Good examples of talus slopes within the NPSA boundaries can be found in Manu‘a on the southern coast of Ofu and eastern coast of Ta‘ū.

After volcanic rock is deposited, it is slowly broken down by the action of plants and the weather to form soil. Soil is often classified by the size of particles that comprise it. The largest particles are called sand, the smaller ones silt, and the smallest ones clay. Most soils are comprised of a combination of these three sizes. Soils with a predominance of sand are much more porous than clay soils, and hold larger accumulations of water and air in the interstitial spaces. Older soils tend to be clay soils. Soils on steep slopes retain less water than those on gentle slopes and plains, mainly because of the effects of gravity. The soils of American Samoa have been detailed in Nakamura (1984).

CLIMATE

Since the Samoan archipelago is situated between the tropic of Capricorn and the equator, it has a tropical maritime climate. Typical temperatures, which are strongly moderated by the surrounding ocean, are usually between 67 and 88° F (19–31° C) throughout the coastal areas, and the average annual temperature is about 81° F (27° C). In Āpia, a coastal city on the north-central coast of ‘Upolu, the highest temperature ever recorded was 93° F (34° C) and the lowest was 63° F (17° C). As is typical of the tropics, the average diurnal range, which in Samoa is about 13° F (7° C), exceeds the less than 3.5° F (2° C) difference between the average daily temperature of winter (June to September) and summer (December to March). Temperature decreases with increasing elevation.

The relative humidity is constantly high throughout the islands, averaging over 80%. It is highest during the summer months and lowest during the winter months, but the difference

between the two is only a few percentage points. The southeasterly trade winds blow for most of the year, particularly during the winter months. These are often replaced by northwesterly winds in the summer months. Summer is the most uncomfortable time in American Samoa because of the combination of higher humidity, more rainfall, and greater temperatures.

Rainfall is heavy throughout the archipelago, with an average annual precipitation of at least 95 inches (2400 mm) in all places on the main islands. There is a distinct rain-shadow effect, wherein the moist trade winds are blocked by the mountainous topography, but since the islands run in a direction roughly parallel to the prevailing southeasterly trade winds, the rainfall difference between the windward side (the southern and eastern sides) and the leeward sides (the northern and western sides) is not as dramatic as those of Hawai‘i, for example, where there are extreme differences between the two. The highest recorded rainfall in the lowlands of the archipelago is probably in Pago Pago Harbor on Tutuila, where moist air rising over a high ridge (Mt. Pioa, a.k.a. Rainmaker Mountain) produces a yearly average total of nearly 5000 mm. Rainfall increases with increasing elevation. The highest rainfall in American Samoa is probably at the summit of Ta‘ū within the NPSA boundaries, but no rain gauges have ever been placed there.

The rainfall in Samoa is somewhat seasonal, with half of the annual total occurring from December to March. The driest season is winter (June to September), but there is no real dry season, since even in the driest places (which, as noted earlier, are on the leeward or northern and western sides of the islands) all months average over 4 inches (100 mm) of precipitation. Droughts of varying duration occasionally occur, but these do not have much permanent effect on most of the vegetation. However, the 1998 El Niño drought was memorable because of the subsequent forest fires that ravaged the parched northwestern coast of Savai‘i. Periodic cyclones hit the islands; although there has been a recent rash of destructive cyclones (Tusi in 1987, Ofa in 1990, and Val in 1991), serious ones average less than one a decade. Cyclone Val, however, was the worst one ever recorded in Samoa, and has had a major and lasting impact on the vegetation of the islands, particularly on Savai‘i and ‘Upolu.

FLORA

Although Samoa has the second largest native flora in tropical Polynesia (behind Hawai‘i), its approximately 550 angiosperm species is less than a third as large as that of Fiji located 700 miles to the west. A number of publications have dealt with the Samoa flora, most notably Christophersen (1935, 1938) for the flora of the whole archipelago, Setchell (1924) for the flora of Tutuila, Yuncker (1945) for the flora of Manu‘a, Whistler (2005) for the flora of American Samoa, Christensen (1943) for the ferns of the archipelago, and Cribb and Whistler (1996) for the orchids of the archipelago. The native vascular flora of American Samoa is now estimated to be about 343 flowering plants, 135 ferns, and 9 fern allies. These are listed in the Whistler 2005 report, with a few additions collected since then. The rate of endemism in Samoa is about 30%, but the local endemism for American Samoa is only about 1%, i.e., only about 1% (seven or eight species) of the flora of American Samoa is endemic to the Territory. Another 200 or so species of vascular plants (all angiosperms) have been introduced and naturalized in American Samoa. Some of these were brought in by Polynesians (“Polynesian introductions”) prior to the European Era, but most were brought in during recent times (“modern introductions”) after about 1830. Some of these were “intentional introductions” brought in with a purpose in mind (e.g., food plants, like breadfruit and taro), while others were “unintentional introductions” that were

inadvertently brought in stuck to the clothing or livestock of the Polynesian voyagers (and which have since become “weeds”).

VEGETATION

Prior to 1974, very little had been published about the vegetation of American Samoa, and most of the available material, such as Setchell’s work on Tutuila (1924), was prepared as an afterthought to other botanical studies the authors were pursuing, or were observations made in related, non-botanical studies. Nelson (1964) took a brief look at the forests of Tutuila. However, beginning in 1976, studies on the wetlands of American Samoa (Whistler 1976), the proposed protected area at Ottoville on Tutuila (Whistler 1993), and a dissertation on the vegetation of “Eastern Samoa” (Whistler 1980) increased the knowledge. The latter, which until recently was the most comprehensive vegetation study of American Samoa, was based on 41 study plots sampled in American Samoa in 1975–1977 and is partially covered in Amerson et al. (1982). A mapping of the vegetation of American Samoa, based mostly on aerial photographs, was done by Cole et al. (1988). That was followed by a comprehensive botanical survey of the Ta’ū Unit of the National Park of American Samoa (Whistler 1992b) and one for the Tutuila and Ofu-Olosega Units (Whistler 1994). Permanent plots were later established in the NPSA on Tutuila and Ta’ū (Whistler 1995). Another recent paper discussed the vegetation dynamics in lowland rainforest in American Samoa (Webb and Fa’aumu 1999).

American Samoa has been inhabited for nearly 3000 years and has been extensively modified by human activity. This disturbance has led to the loss of much of the native vegetation that once covered the islands, but it is less disturbed than virtually all the other major islands and archipelagoes in Polynesia. Even so, over half of its native vegetation has been severely altered by human activity and natural catastrophes, much of it occurring in the last few decades, as an increasing population, local agriculture, and recent destructive cyclones have taken their toll. To make some kind of sense out of the patterns of plant distribution in American Samoa, the vegetation of the NPSA is divided here into eight plant communities shown in Table 1 (from Whistler 2002).

Table 1. Plant communities in the National Park of American Samoa.

1. LITTORAL STRAND
2. LOWLAND RAINFOREST
3. MONTANE RAINFOREST
4. SUMMIT SCRUB
5. MONTANE SCRUB
6. SECONDARY FOREST
7. MANAGED LAND VEGETATION
8. SUCCESSIONAL VEGETATION

A plant community is a unit of similar vegetation distinguished from other plant communities by its structure and habitat. The mangrove community, for example, is a forest occurring in saline conditions on the coast, so it is defined by both structure (forest) and habitat (saline conditions). Many of the plant communities are further divided into “associations” based upon their flora—usually upon their dominant plant or plants. The coastal marsh community in

Samoa, for example, which comprises herbaceous wetlands situated near the coast, is subdivided into six associations based upon which species are dominant (none of which are found in the NPSA). A marsh may be comprised of a single association or several, each of which dominates in a certain set of habitat conditions. Different authors studying different areas of the Pacific or the world use different schemes to distinguish the vegetation patterns, so the plant communities and associations recognized here are not identical to those recognized by other authors working in Samoa, in other areas of the Pacific, or elsewhere in the tropics, but debating the merits of the different systems is beyond the scope of this book.

Littoral Strand Community

The Littoral Strand community comprises the vegetation found on the immediate shores of American Samoa, and occurs in all three of the National Park units on Tutuila, Ofu-Olosega, and Ta'ū. It is not homogeneous since several zones usually can be distinguished. Some authors classify these zones into plant communities because of the difference in physical structure, but because of their narrow extent, their commonalities, and the indistinct boundaries between the zones, they are best considered together as a single community, Littoral Strand.

The seaward margin of littoral vegetation is typically dominated by herbaceous plants—grasses, sedges, and creeping vines. A zone of shrubby vegetation often occurs inland from this, and farther inland, a forest zone. A zone dominated by screwpine (*Pandanus tectorius*) also occurs on some coasts, usually just seaward of littoral forest. In some cases, the trees on the seaward margin of littoral forest are wind-pruned into shrubs, especially in south- and east-facing areas exposed to the prevailing winds, making the littoral forest structurally but not floristically similar to vegetation described as littoral shrubland. The boundaries between existing vegetation types may be distinct, but more typically they are indistinct or uneven.

The scarcity of available water, high temperatures, salt spray, occasional inundation by high waves, and lack of soil discourage all but the hardiest plant species from growing in the Littoral Strand. Although rainfall in the area is sufficient for most areas with normal soil development, little water is retained in the cracks in the barren lava rock or porous sand, and only the most drought-resistant species can survive. Proximity to the sea allows sea winds and occasional high waves to deposit salt on the exposed rock, producing relatively high ground salinity, preventing all but halophytes (“salt-plants”) from becoming established.

Herbaceous Strand Zone

This is the herbaceous vegetation occurring in littoral areas and is limited inland by littoral shrubland or littoral forest, and seaward by the high-tide mark of the ocean. It is sometimes further subdivided into “rock strand” and “sand strand” based on differences in substrate and species composition, but this dichotomy is weak because these two subdivisions are so limited in area that intermediates between them exist, and many littoral herbaceous species occur in both. Herbaceous strand on rocky coasts is often dominated by creeping grasses (most typically *Lepturus repens*), creeping or clump-forming sedges, and succulent herbs. This association is recognized throughout the Pacific and is sometimes called *Lepturus* strand. The most typical geological landforms providing suitable habitats for rocky herbaceous strand include cliff-bound coasts, rocky, jutting headlands, and sea stacks. The NPSA areas on north coast of Tutuila and the south coast of Ta'ū both have this type of vegetation.

Herbaceous strand on rocky shores occurs on the flat land just inland from the cliffs. The proximity of the vegetation to the cliff edge is determined by the degree of exposure, and in extreme cases, a barren rock zone runs between the cliff edge and the herbaceous strand vegetation. On straight, unexposed coasts, herbaceous strand may extend up to the sea-cliff edge and is sometimes so narrow as to be virtually non-existent; *Pandanus* scrub may occur directly on the cliff edge in these situations. These rocky coasts are typically dominated by grasses, sedges, herbs, and sometimes vines that grow from the rock cracks and depressions, or occasionally in thin layers of sand deposited by waves over a rock surface. This cover can be dense or can be limited to narrow patches restricted to rock cracks. The most characteristic species are the grass *Lepturus repens*, the small sedges *Fimbristylis cymosa* and *Cyperus stoloniferus*. Other grasses occasionally found here include *Paspalum vaginatum*, which is more characteristic of mudflats and mangrove forest margins, and *Ischaemum murinum*, which is uncommon in the NPSA. Also common in some places are the swamp fern *Acrostichum aureum*, which is more typical of coastal marshes and mangrove forest margins. Succulent herbs are sometimes common in the herbaceous strand of rocky coasts, particularly *Portulaca samoensis*. Vines, such as *Vigna marina* (beach pea) and *Ipomoea pes-caprae* (beach morning-glory), which are more typical of sandy beaches, are also frequently found in more hospitable rock cracks.

Herbaceous strand on sandy beaches is usually dominated by littoral vines, most typically *Ipomoea pes-caprae*. This same prostrate vine is dominant in similar habitats throughout the tropics, and comprises an association sometimes called “*Ipomoea* strand” in recognition of this prevalence. The herbaceous vegetation occupies the upper portion of sandy beaches, usually on reef-protected areas where sand is accumulating. Sandy beaches are ideally suited as sites for villages, and many have been converted for this purpose and severely disturbed over the many centuries of human occupation. However, even sandy beaches in villages may retain a somewhat disturbed herbaceous strand several feet wide. In addition to *Ipomoea pes-caprae*, other common vine species include *Vigna marina* and *Canavalia rosea*. A second typical life form on sandy beaches is that of creeping native littoral grasses, represented by *Lepturus repens*, *Thuarea involuta*, *Paspalum vaginatum*, and *Stenotaphrum micranthum*. A third typical life form is that of succulent herbs, which in Samoa is represented mostly by *Portulaca* spp., *Hedyotis* spp., and *Chamaesyce chamissonis*.

Littoral Shrubland

This is the native shrubby vegetation occurring on the seaward margin of littoral forest or *Pandanus* scrub, as well as on exposed, windswept ridges and slopes where conditions are too harsh for littoral forest trees. Littoral shrubland is found on NPSA lands on all three islands, but its overall area is very small. It is usually situated very near the shore, but sometimes forms a wider zone extending some distance inland. Sometimes the boundary between this zone and littoral forest is quite distinct, but often the two intergrade into each other. Littoral shrubland may also sometimes occur directly on the shore when herbaceous strand is absent.

Littoral shrubland is dominated by shrubby species up to 6 ft (2 m) or more in height, but these are sometimes prostrate, dwarfed, or wind-pruned by the action of strong, salty sea winds. Littoral shrubs are generally intolerant to shade, and hence, they are rarely found inside littoral forest. The two most characteristic species are *Scaevola taccada* (scaevola) and *Wollastonia biflora* (beach sunflower). These plants often form monodominant associations, but many

littoral shrublands are dominated by a mixture of species. *Scaevola* often forms monodominant associations all across the tropical Pacific. Other species characteristically found here are *Ficus scabra* and *Dendrolobium umbellatum*. Two ferns, *Acrostichum aureum* (swamp fern) and *Phymatosorus grossus*, are also found in littoral shrubland.

Pandanus Scrub Zone

This is the scrub forest vegetation dominated by *Pandanus tectorius* (screwpine) found on rocky or sandy shores. This is intermediate between littoral shrubland and littoral forest, but cannot readily be included in either. It is completely absent from most shores, but in more favorable places where it does occur, screwpines may form a mono-dominant zone roughly parallel to the coast and 3 to 100 ft (1–30 m) in width. When dense, it is traversed only with great difficulty because of the thorny screwpine trunks, numerous spreading prop roots, and tough, narrow leaves with thorny margins and midribs. In exposed places, this vegetation consists of low plants, but in some protected places it may form a scrub forest up to 25 ft (8 m) or more in height. It is best represented in the NPSA on the southeast corner of Ta'ū.

Pandanus scrub stands typically exclude all other trees and are virtually devoid of ground cover species, climbers, and epiphytes. The lack of ground cover may be due to the thick accumulation of litter from decaying trunks and fallen leaves under the screwpine trees, or to the shade produced by the dense canopy. In less favorable areas, where the trees do not form a continuous canopy, they are often mixed with herbaceous strand or littoral shrubland species.

Littoral Forest Zone

This is the forest found directly on the seashore and dominated by trees that owe their distribution and dispersal directly or indirectly to the effects of the sea. It occurs on nearly all undisturbed shores of the main islands, but its total area is small, since it rarely occupies a zone more than 165 to 300 ft (50–100 m) wide. It predominates in areas at 3 to 33 ft (1–10 m) elevation, but may extend higher, particularly on steep rocky coasts, as on the southern coast of Ta'ū and the northern coast of Tutuila, both of which are in the NPSA. Farther inland, it is replaced by lowland slope forest on flat to gently sloping coasts and by coastal forest on steep, rocky coasts. Only occasionally is slope or coastal forest situated directly on the shore, without benefit of a protective barrier of littoral forest.

A number of tree species are characteristic of this forest, the most common of which are *Barringtonia asiatica* (fish poison tree), *Calophyllum inophyllum* (Alexandrian laurel), and *Pisonia grandis*. Forests not dominated by any of the three are sometimes called mixed littoral forests. Other littoral trees, such as *Hernandia nymphaeifolia* (Chinese-lantern tree), *Erythrina variegata* (coral tree), *Terminalia catappa* (tropical almond), and *Terminalia samoensis*, may occasionally dominate in Samoan littoral forests. Littoral forest trees are infrequently found very far inland, probably because they cannot compete with lowland forest trees in these situations. Although coconuts palms are common and sometimes dominant on Polynesian shores, they occur mostly in or near villages and in coastal plantations. They are uncommon in undisturbed littoral forests, and even less frequent in those on rocky shores.

The floor of littoral forest is typically open and easily traversed. Shrubs are virtually absent, since those species adapted to littoral conditions (i.e., littoral shrubs) are usually heliophytes that are restricted to the sunny forest margins. Ground cover is also minimal because of the dense

shade of the canopy, the dry rocky or sandy soil, and the salty sea air. The dominant ground cover species is typically *Asplenium nidus* (bird's-nest fern). Epiphytes are relatively scarce in littoral forest. Those present are mostly on ascending or horizontal branches of trees away from the immediate shore. The two most common epiphytes are *Asplenium nidus* and *Phymatosorus grossus*, which appear to be equally at home as epiphytes or terrestrial plants. Lianas and other climbers are also relatively scarce in littoral forest. The most frequently encountered species are *Ipomoea macrantha*, *Epipremnum pinnatum*, *Mucuna gigantea* (sea bean), *Entada phaseoloides* (St. Thomas bean), *Derris trifoliata*, and *Canavalia cathartica*. By far the most common of the vines is *Ipomoea*, which is also frequently found growing prostrate in open areas on the beach.

Barringtonia Littoral Forest Association

This is littoral forest dominated by *Barringtonia asiatica*, a huge, spreading. This is the most common type of littoral forest on high Pacific islands westward into Melanesia, particularly on rocky shores, where it often forms nearly pure stands. It also sometimes dominates on inland slopes where coastal forest would normally be expected, and on coasts and in bays where coral rubble is being deposited. In this latter situation, the trees form a narrow zone beginning at the top of the coral rubble beach ridge, with the branches extending up to or over the water's edge; in such cases, herbaceous strand and littoral shrubland species may be entirely absent. Good examples occur in the NPSA on the southeast coast of Ta'ū and the north coast of Tutuila.

Calophyllum Littoral Forest Association

This forest is dominated by *Calophyllum inophyllum* (Alexandrian laurel), and typically dominates above the cliffs of old lava flows. The best example in the NPSA occurs on the north coast of Tutuila.

Pisonia Littoral Forest

This is the littoral forest dominated by *Pisonia grandis*, a huge, spreading tree. Unlike other littoral forest trees, *Pisonia* littoral forest typically occurs on sandy areas of atolls and uninhabited places on high islands. The distribution of *Pisonia* littoral forest is strongly correlated with that of seabird colonies, most likely attributable to the specialized mode of seed dispersal of *Pisonia*. The soil is usually high in phosphate and nitrate, due to the excretions of seabirds over long periods of time, but *Pisonia* thrives in this habitat. Where the forest does occur, it can form a tall, dense, nearly pure stand, as it does on Rose Atoll. The south part of the eastern side of Ta'ū in the NPSA has this kind of forest.

Lowland Rainforest Community

Lowland Rainforest (sometimes shortened to Lowland Forest in the literature) occurs in the lowlands of American Samoa from near sea level to perhaps 2000 ft (600 m) elevation, depending upon location. The climate in this forest is very equable, with an estimated 100 to 300 inches (2500–7500 mm) of rainfall per year, depending upon elevation and location. The temperature is always warm, only occasionally exceeding 86° F (30° C) or going below 59° F (15° C). Humidity is relatively high and constant, rarely falling below 70% anywhere in

American Samoa. This high humidity allows for an abundance of epiphytes and ground cover species, particularly at the higher elevations and locations farther inland.

Lowland Rainforest is composed of a great number of tree species, although not nearly as many as in most areas of Tropical Rainforest in Melanesia and Southeast Asia to the west or in tropical America to the east. Because so many tree species are present, each of which acts independently from the others and responds differently to variation in environmental factors, it is nearly impossible to subdivide Lowland Rainforest in a meaningful way. There are very few distinct boundaries; following a gradual environmental gradient, such as elevation, the forest undergoes a gradual floristic and often structural change with no recognizable boundaries between forest types. Attempts even to separate and map Lowland Rainforest from Montane Rainforest are on shaky ground, and are based mainly on the distribution of *Dysoxylum huntii*.

Perhaps the best way to visualize Lowland Rainforest is as a mosaic of areas in which different species tend to dominate. The mosaic units may correspond to areas of past disturbance, such as those caused by agriculture or periodic cyclones that may differentially fell the forest. The mosaic units may also (or instead) correspond to subtle soil differences related to patterns of ancient lava flows not discernible to the untrained eye, differences in topography, or they may even be caused to some degree by a sampling bias (it may depend upon where plots are laid out in what appears to be homogeneous forest).

The types of Lowland Rainforest recognized by earlier authors usually have a taxonomic basis, i.e., they are based upon characteristic species. The main problem with this is that some forests do not have a distinct dominant species, being co-dominated instead by several species. Instead of basing the classification just upon taxonomic criteria, e.g., dominant tree species, the first subdivision of Lowland Rainforest currently in use (Whistler 2002) is based upon topography, with four categories recognized in American Samoa. These divisions may be further divided into “associations” by affixing a genus name in front, such as *Diospyros* Coastal Rainforest for coastal forests dominated by one or both of the common *Diospyros* species. It must be kept in mind, however, that this method also has its problems, and there will never be an entirely satisfactory classification of Samoan Lowland Rainforests since these types of vegetation are *natural* phenomena and classification is usually *artificial*. Classifications are constructed for the convenience of those studying the subject and may not always reflect reality.

Coastal Lowland Rainforest

The area occupied by Coastal Lowland Rainforest (often shortened in the literature to Coastal Forest) is situated on the more exposed portions of some coasts adjacent to, but never directly on, the shore. It differs from Littoral Forest in being dominated by medium-sized tree species whose seeds, borne in edible fruits, are usually dispersed by birds rather than by sea water, and by its more inland location. It differs from other types of Lowland Forest by its shorter stature and distinctive flora. It is typically dominated by species of *Diospyros* and *Syzygium*. Two species of the ebony genus, *Diospyros elliptica* and *Diospyros samoensis*, typically predominate in number of individuals if not actual “dominance” (based on total stem area). In actuality, the type of forest is intermediate between Littoral Forest and Lowland Rainforest, but is more similar to the latter. It typically occurs on the lower portions of ridges and slopes on steep coasts of American Samoa, as in the NPSA on the north coast of Tutuila. Coastal Lowland Rainforest has also been reported from Niuatoputapu Island in Tonga (Whistler 1992a), and perhaps occurs elsewhere in Tonga and Fiji. Several other trees are also commonly

found in here—*Erythrina variegata* (coral tree), *Barringtonia asiatica* (fish-poison tree), and *Terminalia catappa* (tropical almond)—which are typical Littoral Forest species.

The floor of Coastal Lowland Rainforest is open and easily traversed. The ground cover is denser than is typical in Littoral Forest, but is sparser than that of the other types of rainforest. The dominant part of the ground cover often comprises seedlings of the dominant trees. Also common are the fern *Asplenium nidus* (bird's-nest fern), the monocot herb *Tacca leontopetaloides* (Polynesian arrowroot), the fern *Phymatosorus grossus*, and the vine *Derris trifoliata*. Epiphytes are also relatively sparse, and most of those present are either ferns or orchids. Climbers are moderately common.

Ridge Lowland Rainforest

Lowland Ridge Rainforest (often referred to in the literature as Ridge Forest) is the type of native Lowland Rainforest that occurs on the mountainous parts of Tutuila that have the appropriate topography—ridges on weathered volcanics. It has previously been distinguished in American Samoa as *Asi* Ridge Forest (Whistler 1980) and *Syzygium* Forest (Mueller-Dombois & Fosberg 1998). The “*Syzygium*” and “*asi*” refer to one of the dominant species, *Syzygium inophylloides*, but to single this species out is somewhat misleading since several other species typically share dominance with it, particularly *Calophyllum neo-ebudicum*, *Canarium vitiense*, and sometimes *Intsia bijuga*. *Canarium mafoa*, *Diospyros samoensis*, and *Buchanania merrillii* are also common and sometimes even dominant on the ridges. Ridge Lowland Rainforest originally covered most of Tutuila, which is largely comprised of ridges and valleys. The best example of this in American Samoa is found on Tutuila, especially on the north-facing slope of the island between Fagasā and Āfono within the boundaries of the NSPA.

The climatic conditions in Ridge Lowland Rainforest are basically the same as those in other types of Lowland Rainforest, but the soil factors are different. The clay soils characteristic of the ridges are derived from highly weathered volcanic rock, and are apparently less permeable and drier than the younger, more rocky soils elsewhere in the lowlands. The drier soils may be due, at least in part, to geography, since this forest is usually on moderately steep to steep slopes where drainage and runoff are likely to be rapid. The relative dryness of the soil is reflected in the relatively sparse ground cover (unless the canopy is open) and indirectly by the paucity of epiphytes, particularly epiphytic mosses. The canopy in this forest is mostly 60 to 80 ft (18–25 m) in height, and the trees are probably more densely packed than in other types of Lowland Rainforest.

One noteworthy (based on commercial importance anyway) variation of Ridge Lowland Rainforest is characterized by the presence or dominance of *Intsia bijuga*, the most valuable timber tree in Samoa. Except for the presence of *Intsia*, these ridges have a flora nearly identical to that found on the adjacent ridges that lack *Intsia*.

At lower elevations on the Tutuila ridges, the forest floor is relatively open and is floristically similar to Coastal Lowland Rainforest, with species such as the ferns *Davallia solida* (leather fern), *Phymatosorus grossus*, and *Asplenium polyodon*, and the scandent shrub *Alyxia stellata* predominating. On narrow ridges, or where past disturbance has been significant, more light reaches the forest floor, allowing for an increase in ground cover, chiefly of large, coarse ferns and *Freycinetia storckii* (‘ie‘ie). On some of the ridges, open areas are dominated by the false-staghorn fern *Dicranopteris linearis*. The epiphytes in Ridge Lowland Rainforest are moderate in amount, with the most frequent species being *Davallia* spp., *Humata* spp.,

Dendrobium spp., *Hoya australis*, *Asplenium nidus* (bird's-nest fern), and *Phymatosorus grossus*. Climbers and lianas are also common, although the species typical of Lowland and Montane Rainforest are noticeably absent. The dominant liana is probably *Alyxia bracteolosa*, with lesser amounts of *Freycinetia* spp. and *Gynochtodes epiphytica*.

Valley Lowland Rainforest

Valley Lowland Rainforest (often called Valley Forest in the literature) is the Lowland Rainforest typically located on flat to moderately steep slopes of lowland alluvial valleys. It also often occurs on coastal talus slopes away from the immediate coast and on protected inland areas of tuff cone islands, but usually not on ridges, and is sometimes difficult to distinguish from mature Secondary Forest. This vegetation type has previously been named Valley Lowland Forest (Whistler 1994a), *Dysoxylum* Forest (Whistler 1992a; Mueller-Dombois & Fosberg 1998), and *Mamala* Lowland Forest (Whistler 1980), all in reference to its typical location (in valleys), the most characteristic genus (*Dysoxylum*), or one of the two characteristic dominant species (*Dysoxylum samoense*, *mamala*). The term “*Dysoxylum* Forest” by itself can be a little confusing, since the dominant tree of Montane Rainforest, *Dysoxylum huntii*, belongs to the same genus. The best remaining examples of Valley Lowland Rainforest occur in the NPSA on Ta'u, where it covers a narrow strip between the Littoral Forest and the top of the cliff along the eastern coast, and in steam valleys in small, uninhabited bays in the NPSA on the north coast of Tutuila.

Valley Lowland Rainforest is usually dominated by *Dysoxylum samoense* and/or *Dysoxylum maota*, alone or in combination. The vegetation extends from near sea level up to several hundred ft in elevation, where the two species of *Dysoxylum* are gradually replaced in Montane Rainforest by a third species of the genus, *Dysoxylum huntii*, or at lower elevations by other Lowland Forest species. When *Dysoxylum* Lowland Forest occurs farther inland, away from the influence of the sea, other important canopy trees more characteristic of other types of lowland forest become common, such as *Planchonella samoensis*, *Terminalia richii*, *Inocarpus fagifer* (Tahitian chestnut), and *Bischofia javanica*. In addition to canopy trees, several subcanopy trees are typical of Valley Lowland Rainforest, the most common being *Myristica inutilis*, *Diospyros samoensis*, and *Sterculia fanaiho*. *Myristica inutilis* is often the most numerous tree species in Valley Lowland Rainforest and other lowland forests, but is replaced (or at least joined) by the related *Myristica hypargyrea* at higher elevations. The latter species, however, is not present in Manu'a.

The ground cover of this forest is usually moderate to heavy. The herbaceous species, along with an abundance of saplings and small trees, makes this forest appear much less open than Littoral Forest or Coastal Lowland Rainforest. In inland areas, the dominant ground cover species is often *Lomagramma cordipinna*, a creeping fern equally at home on the ground or climbing high up on tree trunks. In areas closer to the coast, the dominant species is typically *Asplenium nidus* (bird's-nest fern) and other ferns, as well as vines and lianas that creep along the forest floor and climb up tree trunks.

Epiphytes, mostly orchids and ferns, are also common in inland areas, but are sparser in places near the coast. The most frequently encountered orchids are *Dendrobium dactylodes* and *Dendrobium biflorum*; the most common ferns are *Asplenium nidus* (bird's-nest fern), *Phymatosorus grossus*, and several other ferns. Climbers, both lianas and trunk-climbers, are also common. Climbers ascend trees by wrapping around tree trunks, while trunk-climbers

ascend trees by means of adventitious roots that adhere to the bark. Trunk-climbers may eventually lose their connections to the ground and become epiphytic. The most common lianas are *Mucuna gigantea* (sea bean), *Faradaya amicum*, *Entada phaseoloides* (St. Thomas bean), and *Gynochtodes epiphytica*. Less common species include *Hoya australis*, *Hoya pottsii*, *Jasminum didymum*, and *Derris trifoliata*. The most common trunk climbers are *Piper graeffei*, *Epipremnum pinnatum*, and the ferns *Lomagramma cordipinna* and *Arthropteris repens*. Herbaceous vines such as *Mikania micrantha* (mile-a-minute vine), *Dioscorea bulbifera* (bitter yam), and *Zehneria* spp. are also sometimes found climbing over smaller trees in the forest.

Slope Lowland Rainforest

Slope Lowland Rainforest is the type of Lowland Forest that covers the area of Samoa not already discussed under the other types. “Slope” is a somewhat ambiguous descriptive word, since this forest may occur on lowland plains as well, but other possible names seem equally unsuitable. One feature all members of this assemblage have in common is the presence and often dominance of *Syzygium inophylloides*, but many other species are also present and sometimes dominate. Slope Lowland Rainforest is replaced at higher elevations by Montane Rainforest. Since it favors the more fertile soil of the lowlands, most of the Slope Lowland Rainforest has been cut down for agricultural and forestry purposes.

There is much variation in rainfall in Slope Lowland Rainforest, since the forest can extend from near sea level to over 2000 ft (600 m) elevation in places, but annual precipitation probably ranges from 100 to 200 inches (2500–5000 mm) annually. The soil is deeper than that of other types of Lowland Rainforest, and is generally moister and richer than that of adjacent Lowland Ridge Forest. These ideal growing conditions may be the reason why this kind of forest is one of the most floristically diverse of vegetation types in American Samoa. The majority of native Samoan trees are found here, which is not surprising since the forest has such a broad elevational range.

In some Slope Lowland Rainforests on Tutuila, *Planchonella samoense* is dominant and *Syzygium inophylloides* is second. On Ta‘ū, *Syzygium* probably ranks first because *Planchonella* is not found in Manu‘a. Other typical and important canopy trees in the Slope Lowland Rainforest include *Canarium vitiense*, *Calophyllum neo-ebudicum*, *Dysoxylum samoense*, *Dysoxylum maota*, *Garuga floribunda*, *Neonauclea forsteri*, and *Endiandra elaeocarpa*. The most common tree in many of these forests is *Myristica inutilis*, but this is a subcanopy species. *Diospyros samoensis* can also be common as a subcanopy tree, but only at low elevations and fairly near the sea. Several other canopy trees found here are better classified as secondary rather than primary forest trees, including *Rhus taitensis*, *Dendrocnide harveyi*, *Neonauclea forsteri*, *Cananga odorata* (perfume tree), *Alphitonia zizyphoides*, *Macaranga stipulosa*, and *Elattostachys falcata*. Areas with high concentrations of these species were probably disturbed sometime in the past and have persisted without successfully reproducing. Large banyans are some times found in this forest, especially *Ficus obliqua*.

The ground cover in Slope Lowland Rainforest is moderate to dense, and as in other well-watered forests, is dominated by ferns and tree seedlings. Probably a majority of the terrestrial fern species in Samoa occur here. This includes *Asplenium nidus* (bird-nest’s fern), *Angiopteris evecta* (king fern), *Asplenium polyodon*, *Tectaria dissecta*, and *Lomagramma cordipinna*. Terrestrial orchids are numerous and a majority of the species occurring in Samoa are found in this zone, but overall they have little dominance since they are small and tend to be scattered in

distribution. Grasses and sedges are infrequent, except along trails and in disturbed patches, since most of them are light-requiring species. Climbers and epiphytes are fairly abundant. The numerous species of epiphytes are mostly orchids and ferns, but they do not approach the density found in the Montane Forest, which is much wetter. The most common trunk-climbers are *Freycinetia* spp. (3 species), *Piper graeffei*, and *Rhaphidophora graeffei*. The most common lianas include *Faradaya amicorum*, *Embelia vaupelii*, *Mucuna glabra*, *Morinda myrtifolia*, and *Gynochtodes epiphytica*.

Many Slope Lowland Rainforests on relatively recent substrates are marked by gullies created by the incessant forces of nature, and these may extend a considerable distance downslope from the higher elevations. The streambeds of these *alia*, as they are called, are typically devoid of trees, although forest lines their banks. They are dry for most of the year, and contain streams only during and shortly after heavy rains.

Montane Forest Community

Montane Rainforest is the tropical rainforest covering the mountain slopes and plateaus of the higher islands of American Samoa, and is typically dominated by the native tree *Dysoxylum huntii*. Botanically, its upper boundary corresponds to the elevation where *Reynoldsia* spp. and other high-elevation trees replace *Dysoxylum huntii* in dominance, and the lower boundary to where a number of Lowland Rainforest trees are replaced by *Dysoxylum huntii*. It is difficult to accurately determine the elevational range of this community, since it varies considerably from place to place, probably because of geographical factors. The lower boundary may go as low as 1320 ft (400 m), and the upper as high as 4000 ft (1200 m) or more (in independent Samoa). Montane Rainforest occurs in only a few places on Tutuila since the island has a maximum elevation of 2031 feet (619 m). Most of the Montane Rainforest in the NPSA occurs on the slopes of Ta'ū above 1640 ft (500 m). Its elevational boundaries are by no means distinct, because of the way the dominant species appear and disappear with varying elevation, and this can lead to problems in classification of some forest areas. An undisturbed slope up running from the shore up the mountain tops would not be easy to divide into Lowland and Montane Rainforest because of the absence of a distinct boundary.

The two environmental factors most affecting the Montane Rainforest, and which distinguish it from Lowland Rainforest, are prevailing cool temperatures and high rainfall. Using a decrease of 0.6° C per 100 m increase in elevation suggested by Wright (1963), the mean temperature is probably 3.5 to 13° F (2–7°C) cooler than at sea level based on the limits of 1313 to 3937 ft (400–1200 m) elevation. The seasonal variation is small—probably less than 3° C from winter to summer. The cooler temperatures at higher elevations may be the main factor allowing for the presence of some subtropical “austral” genera (e.g., *Weinmannia* and *Ascarina*) in the flora. Annual precipitation, mostly orographic in origin, is probably between 450 and 900 cm per year, depending upon elevation and exposure. There is no real dry season since no month has less than 40 cm of rainfall, and humidity is always high. Clouds form nearly every day and the ground and vegetation are usually wet. These factors contribute to the profusion of terrestrial and epiphytic herbaceous species, particularly mosses, ferns, and orchids.

Montane Rainforest is shorter in stature than Lowland Rainforest, probably averaging mostly between 50 to 60 ft (15 and 18 m) in height. The trees are apparently more closely spaced than in Lowland Rainforest and the ground cover is moderate to heavy. Montane Rainforest probably has the richest flora of any community of Samoa. The most dominant

species by far is *Dysoxylum huntii*. Also common are *Syzygium samoense*, *Cyathea* spp. (tree ferns), *Hernandia moerenhoutiana*, *Weinmannia affinis*, and *Astronidium pickeringii*. Typical Lowland Rainforest species, such as *Planchonella samoensis*, *Syzygium inophylloides*, *Palaquium stehlinii*, and *Calophyllum neo-ebudicum*, are also common here. Most of the nine species of tree ferns (*Cyathea* spp.) native to Samoa are found in this forest, usually where the canopy has been disturbed. At higher elevations on Ta'ū, the three *Cyathea* species native to the island are particularly common, since cyclones appear to have done extensive damage to much of the upland region of the island.

The floor of Montane Rainforest is less open than that Lowland Rainforest. Dominant species include ferns such as *Asplenium nidus*, *Lomagramma cordipinna*, *Diplazium* spp., and *Dicksonia brackenridgei*. A majority of Samoa's nearly 100 orchids occur in this forest, either as epiphytes or terrestrial species. Members of one dicot genus *Elatostema*, which probably number over a dozen, are also common as terrestrial herbs in Montane Rainforest.

Woody lianas are relatively uncommon; the most frequently encountered species are *Mucuna glabra*, *Alyxia* spp., *Hoya* spp., *Gynochtodes epiphytica*, and *Faradaya amicornum*. They are often difficult to identify in the field, however, because their woody, cable-like stems are leafless except in the canopy. Trunk climbers are very abundant, more so than in the Lowland Rainforest. The most common species are *Piper* spp., *Freycinetia* spp. (particularly *Freycinetia storckii*), *Medinilla samoensis*, *Rhaphidophora graeffei*, and *Lomagramma cordipinna*.

Epiphytes are also abundant (more so than in the Lowland Rainforest) and nearly all them are either ferns or orchids, other than *Peperomia* spp. of the pepper family (Piperaceae). Some of the most abundant epiphytic ferns are *Asplenium nidus* (bird's-nest fern), and *Lomagramma cordipinna*, *Phymatosorus grossus*. Filmy ferns of the genera *Hymenophyllum* (6 species in Samoa) and *Trichomanes* (19 species) are particularly common and sometimes cover tree trunks in combination with various moss and leafy liverwort species. The most abundant epiphytic orchids are *Dendrobium* spp., *Bulbophyllum* spp., *Phreatia* spp., *Liparis* spp., *Glomera montana*, and *Coelogyne lycastoides*.

Summit Scrub Community

The summit of Ta'ū at about 3050 ft (930 m) elevation is adjacent to a steep cliff that extends along the entire southern side of the island. The moisture-laden southeast trade winds that ascend these cliffs cool when rising, producing prodigious amounts of precipitation. This results in the upper portion of the island usually being cloaked in clouds during the daytime. The vegetation at the summit is virtually untouched by man, because it is too remote, too wet, and too cool to be used by villagers. It is rarely even visited, especially after the tremendous damage caused by Cyclone Tusi (1987) made access to the area very difficult.

The vegetation of this montane region of Ta'ū is classified as a "summit scrub community." It is restricted in Samoa to this island, and nothing quite like it has been reported from elsewhere in the region. Instead of montane or cloud forest that would be expected at this elevation, the vegetation is scrubby and dominated by ferns, climbing vines, shrubs, and scattered, stunted trees covered with epiphytes. Botanists have visited this area only a few times and very little is

known of its extent. A map in Cole et al. (1988) shows summit scrub covering about a third of the island, but the area was not ground-truthed and three major cyclones have since hit the archipelago. Its margins are probably very indistinct from that of the surrounding montane forest, into which it may indistinctly intergrade. Summit scrub is structurally very similar to montane scrub, but floristically its affinity is with montane or cloud forest, or at least the understory of montane or cloud forest. It differs from montane scrub most notably in the total near absence of *Dicranopteris linearis* (false staghorn fern), which is characteristic of montane scrub, and by the presence of montane and cloud forest trees.

Short trees, many of them dead occur scattered among the tangle of ferns, shrubs, small trees, and sprawling vines that cover the whole summit area. Tree ferns, especially *Cyathea medullaris* and *Cyathea decurrens*, are particularly common. The common tree species include *Syzygium samoense*, *Reynoldsia lanutoensis*, *Ficus godeffroyi*, *Dysoxylum huntii*, *Ascarina diffusa*, *Astronidium pickeringii*, *Melicope vatiana*, *Meryta macrophylla*, *Sarcopygme pacifica*, and *Weinmannia affinis*. Shrubs and small tree species are also particularly common, the most frequent being *Melastoma denticulatum*, *Psychotria garberiana*, *Cyrtandra angustivenosa*, *Cyrtandra pulchella*, and *Cyrtandra longipedunculata*. The latter three are endemic to the archipelago, and the *Psychotria garberiana* is endemic to Manu'a. Another shrub common here is the introduced *Clidemia hirta* (Koster's curse), which in some places may be one of, if not the, most abundant ground cover species.

The ground cover in summit scrub is thick and is difficult to distinguish from the rest of the stunted vegetation. Because of the large amount of wet, decaying vegetation, many species are equally at home on the scattered trees and on the ground. By far the most abundant species (at least in eastern portion of this vegetation) is *Freycinetia storckii* ('ie'ie), a coarse, climbing vine related to screwpines (*Pandanus* spp.). It forms most of the tangle that makes passage through the vegetation so difficult. Ferns comprise a large portion of the vegetation, even when tree ferns are excluded. The most common terrestrial species are *Blechnum vulcanicum*, *Dicksonia brackenridgei*, *Lastreopteris davalloides*, *Asplenium multifidum*, and several other species of *Asplenium*. Most of the herbaceous flowering plants are orchids, such as *Liparis* spp., *Calanthe hololeuca*, and *Phaius tankervilleae*. Terrestrial dicots are less frequent, perhaps the most common one being *Elatostema grandifolium*.

Epiphytes, especially mosses, are also abundant, since the heavy rainfall, high humidity, and cool weather are ideal for their growth. Also common are delicate "filmy ferns" belonging to the fern family Hymenophyllaceae that are adapted to moist conditions prevalent in the higher elevations in Samoa, and most cannot survive even the short periods of drought characteristic of lower elevations. Other common fern species include *Ctenopteris* spp., *Oleandra neriiformis*, and *Humata serrata*. Epiphytic orchids are also plentiful in this habitat, including two thirds of the 43 species recorded on the island. Particularly abundant are climbing species, such as *Pseuderia ramosa* and *Glomera montana*. Dicot epiphytes are few, with *Peperomia reineckei* being one of the most common species. Climbers are uncommon, except for *Freycinetia* spp., which can dominate when a canopy is absent. The high number of fern and orchid species present here gives this community one of the highest rates of biodiversity of any plant community in Samoa.

Montane Scrub Community

Montane scrub comprises the vegetation on the summits and slopes, and ridges of trachyte plugs and dikes on the island of Tutuila (Whistler 2002) in American Samoa. These areas of trachyte are the cores and associated dikes of ancient volcanoes that have survived long after the surrounding volcanic rock has eroded away. The only similar kind of vegetation found in Polynesia occurs on the upper portions of Ra'iatea in the Society Islands (Whistler 2002). The uniqueness of montane scrub vegetation was first noted by Pickering (1876), who visited Tutuila in 1839. Four of the largest areas of montane scrub on Tutuila are Matafao (at 2067, 630 m), Mt. Pioa (1712 ft, 522 m), Mt. Tau (1263 ft, 385 m), and Maugaotula (ca. 770 ft, 235 m). The latter, which is situated in Vatia village and extends along a trachyte dike north to Polauta Point and Polauta Island, is the only example of this plant community found in the NPSA.

The soil, derived from the weathered trachyte, is a soft, fine-grained, generally light-colored rock composed predominately of potassium feldspar. Trachyte is nutrient-poor and typically low in calcium, magnesium, and phosphorus. This highly weathered rock is conspicuous for its light color visible from a distance on some of the steep, sparsely vegetated slopes. In places, the slopes of these trachyte plugs are so steep that periodic landslips leave parts of the slopes barren. Setchell (1924) described the vegetation of the montane scrub forest as being xerophytic, but because of the abundance of epiphytic growth on the trees, it does not appear that this description is entirely accurate at least in regards to rainfall.

Montane scrub looks superficially like the summit scrub community found at the higher elevations of Ta'ū, but is quite different floristically. Its scattered, stunted trees mostly less than 20 ft (6 m) in height are embedded in a dense matrix comprising small trees, shrubs, ferns, and lianas. Dominant or characteristic species include *Rapanea myricifolia*, *Metrosideros collina*, *Astronidium pickeringii*, and *Spiraeanthemum samoense*. The ground cover is a dense tangle 3 to 5 ft (ca. 1–1.5 m) high, composed mostly of ferns and coarse-leafed monocots. Common species include the ferns *Dipteris conjugata* (a species not known from any other plant community or island in Samoa), *Dicranopteris linearis* (false-staghorn fern), and *Davallia epiphylla*; the sedge *Machaerina falcata*; and the coarse vine related to screwpine, *Freycinetia storckii*. Other less common but still typical species are ground orchids, such as *Pseuderia ramosa*, *Calanthe hololeuca*, and *Spathoglottis plicata*; and ferns such as *Blechnum vulcanicum*, *Blechnum orientale*, *Oleandra neriiformis*, *Cyathea* spp., *Culcita straminea*, and *Lycopodium cernuum* (a club moss).

Epiphytes abound in this community, especially at the moister, higher elevations (less so in the NPSA). The most common and abundant angiosperm epiphytes are orchids, including *Coelogyne lycastoides*, *Glomera montana*, *Liparis* spp., *Dendrobium* spp., *Bulbophyllum* spp., and *Phreatia* spp.; and ferns, including *Elaphoglossum feejeense*, *Oleandra neriiformis* (which also grows on the ground), and filmy ferns in the family Hymenophyllaceae. Mosses and lichens are also abundant on many trees, where they thrive in the moist, sunny habitat.

Secondary Forest Community

Secondary Forest is forest typically dominated by fast-growing trees with small, easily dispersed seeds that require relatively sunny conditions for germination and/or establishment. This kind of forest covers large areas of American Samoa, particularly in the lowlands below about 1650 ft (500 m) elevation. Although superficially similar in structure to Lowland Rainforest, its population structure and flora are quite different. Secondary Forest trees dominate the canopy, but other species—particularly ones that can germinate and become

established in shady conditions (and which usually have larger seeds)—typically dominate the smaller size classes. Without further disturbance, the sunny conditions required for germination and establishment of Secondary Forest species will no longer be present, and the slower-growing canopy tree species that dominate the smaller size classes will eventually prevail when the larger secondary forest trees of the canopy age and die. After a long period, the climax forest that develops will be virtually indistinguishable from primary forests in the area.

The most common secondary forest tree species include *Rhus taitensis*, *Alphitonia zizyphoides*, *Bischofia javanica*, *Elatostachys falcata*, *Dysoxylum samoense*, *Dysoxylum maota*, *Neonauclea forsteri*, and *Pometia pinnata*. The first four are typical secondary forest species, while the latter four are also dominant or component species of primary forests. Another large tree, *Paraserianthes falcataria* is common in some disturbed places in central Tutuila, including parts of the NPSA there. Secondary forest does not always form large tracts; it sometimes occurs in small patches in a mosaic pattern in climax forest, either in sites of former “swiddens” (agricultural plots) or in openings created by natural tree falls. Trees typically found in these small areas are *Dendrocnide harveyi*, *Macaranga stipulosa*, *Girardinia celastroides*, and *Cyathea* spp. (tree ferns). Several other trees are common as subcanopy or understory species of Secondary Forest, the most important being the native trees *Glochidion ramiflorum*, *Flacourtia rukam*, *Hibiscus tiliaceus*, and *Kleinhovia hospita*, and the alien trees *Adenanthura pavonina* (red-bead tree), *Castilla elastica* (Panama rubber tree), and *Cananga odorata* (perfume tree).

In the earlier stages of secondary forest development, sunlight reaching the forest floor may be greater than in primary forest, since the canopy has not had sufficient time to fully develop. This causes a proliferation of some terrestrial and climbing species that are otherwise insignificant in undisturbed forest. Not only is the ground cover more plentiful, but the dominant species tend to be heliophytes (sun-loving plants), such as the fern *Nephrolepis hirsutula* (sword fern), rather than shade-loving species.

Several different types of Secondary Forest may be recognized in Samoa, the most common being one dominated by *Rhus taitensis*, sometimes together with *Alphitonia zizyphoides*. *Rhus* Secondary Forest exhibits a characteristically stratified canopy easily recognizable in aerial photographs, and is particularly common on the lowland hills and ridges on Tutuila. It apparently becomes established in areas of former cultivation or where severe disturbance (e.g., a hurricane) has occurred. *Rhus* is also sometimes present in small amounts in Lowland Rainforest, probably as a result of gap replacement.

Another type of secondary forest occurs on talus slopes, where landslips and falling rocks lead to continual disturbance. An example of this can be found on the cliffs that line the eastern coast of Ta‘ū within the NSPA. The dominant trees here are often *Dysoxylum samoense* and *Hibiscus tiliaceus* (beach hibiscus). This type of forest is sometimes called a “disclimax forest” since, because of continual natural disturbance (landslides and erosion in this case), it never achieves a climax condition, which at that low elevation on Ta‘ū, would probably be dominated by *Syzygium inophylloides*. *Hibiscus* also commonly forms thickets in what otherwise appears to be climax forest, and probably owes most of its occurrence in these situations to ancient plantings by Samoans. Another example of disclimax vegetation can be found on the steep slopes or cliffs below the aerial tramway station on the northern side of Pago Pago harbor at about 1600 ft (490 m) elevation. This area is dominated by *Neonauclea forsteri*, *Spiraeanthemum samoense*, *Metrosideros collina*, and other small-seeded species that maintain their importance by colonizing landslips. Disclimax vegetation also occurs on the slopes on Ofu behind the NPSA there.

Managed Land Vegetation Community

Managed Land Vegetation comprises the vegetation on land actively managed by man for his uses, including paved and unpaved roads, roadsides, village greens (*malae*), plantations, and pastures. It also includes land where timber has just been felled, since this is a form of management (even though the active management may end after the tree felling). When trees are felled, the land may be converted into permanent plantations or utilized for a short while for growing crops. But American Samoan soils, like others in the tropics, are characteristically poor in minerals, and much of the available mineral content is tied up in the trees. When the trees are felled and burned or left to rot, the minerals suddenly released into the soil are quickly washed away or are used up by the crop plants. After a few crop cycles, the harvest becomes greatly diminished and the land is abandoned or planted with permanent tree crops, which (compared to taro) are less demanding on the soil. Active management prevents disturbed land from returning to its natural plant cover and promotes the dominance of cultivated plants (which are wanted) and weeds (which are not). The amount of management, in the form of weeding (mechanical means, hand-weeding, or herbicides), determines whether the cultivated or weedy plants will dominate; once active management ends, herbaceous weeds soon dominate.

A weed may be defined as any plant growing where it is not wanted. This definition is based on both where the plant is growing and on its economic impact on man's activities, rather than on the intrinsic properties of the plant itself. Over 250 plants can be classified as weeds in Samoa (Whistler 1988b), most of which are non-native species ("aliens") and occurring in American Samoa.

Weeds are typically heliophytes ("light-plants"), plants that thrive only in sunny conditions; consequently, they are uncommon in undisturbed forests. Most weeds are alien rather than native species, while most of the shade-tolerant plants present in Samoan forests are native. When land is managed, such as when plantations are maintained and weeded, weeds (and intentionally grown species) will dominate until the management has ended or until secondary forest trees and shrubs shade out the alien plants after a period of plant succession.

When a forest is felled for timber or is destroyed by cyclone or fire, the first invaders are predominantly alien weeds, which have very effective methods of dispersal. The presence of plumed fruits that float on the wind is one effective mechanism; it is employed by plants such as *Mikania micrantha* (mile-a-minute vine) and *Crassocephalum crepidioides*. A second mechanism comprises dry fruits that cling to clothing, fur, or feathers; it is employed by weeds such as *Bidens alba* (beggar's-tick), *Desmodium incanum* (Spanish clover), *Hyptis pectinata* (comb hyptis), and *Triumfetta rhomboidea*. A third mechanism comprises fruits that are eaten and dispersed by birds; it is employed by weeds such as *Clidemia hirta* (Koster's curse), *Lantana camara* (lantana), *Passiflora foetida* (wild passion-fruit), and *Physalis angulata* (wild Cape-gooseberry).

Weeds do not all have the same requirements and occur differentially in different habitats. Village greens (and nowadays, golf courses) are typically dominated by *Axonopus compressus* (carpet grass), *Chrysopogon aciculatus* (golden beardgrass), *Desmodium incanum* (Spanish clover), and other low-growing plants that can survive periodic mowing or cutting. Frequently mowed roadsides have a weed flora similar to that of village greens. If infrequently mowed, the dominant species are often large grasses and shrubs such as *Clerodendrum chinense* (Honolulu rose). Grassy unpaved roads are often dominated by *Eleusine indica* (goose grass) and other

species that can withstand foot and vehicular traffic and occasional cutting. Croplands are often dominated by *Chamaesyce hirta* (garden spurge), *Hyptis rhomboidea* (mint weed), and *Bidens alba* (beggar's-tick). Crops in wetlands (i.e., taro fields) are often typically dominated by weeds such as *Commelina diffusa*, the native sedge *Rhynchospora corymbosa*, and *Ludwigia octovalvis* (willow primrose). Pastures are often dominated by *Mimosa pudica* (sensitive plant), *Stachytarpheta urticifolia* (blue rat's-tail), and other plants unpalatable to cattle. If the pasture is wet, the dominant plant is often *Brachiaria mutica* (California grass). The floor of disturbed forests is often dominated by *Clidemia hirta* (Koster's curse), *Mikania micrantha* (mile-a-minute vine), and *Dioscorea bulbifera* (bitter yam). Forest clearings are often dominated by *Paspalum conjugatum* (T-grass), *Oplismenus compositus* (basket grass), and other herbaceous species. Overall, the most common weed in Samoa is *Mikania micrantha*, with *Paspalum conjugatum* probably a close second.

8. SUCCESSIONAL VEGETATION

Successional Vegetation is the scrubby vegetation found on recently disturbed land or recently abandoned Managed Land Vegetation. The first stage following abandonment or severe disturbance is dominated by herbaceous adventive plants (weeds). This stage, in turn, is followed by one in which new shrub or tree invaders eventually dominate for awhile. In managed land vegetation, the woody species are eliminated or at least inhibited by cutting or weeding, but when management ends, the woody plants can become established and grow above the herbaceous plants, producing shade that is unfavorable for the growth of most of the smaller plants beneath them. Vines, however, can avoid being shaded out (for a while at least) by climbing on the shrubs and trees to maintain their place in the sun.

The dominant trees of successional vegetation are fast-growing, light-loving species, most of which are short and do not reach the height of typical forest trees. When taller tree species eventually overtop the shorter ones and shade them out, there is a transition to the next community, secondary forest, but the line between the two is necessarily indistinct. Although classified as a community here, Successional Vegetation can also be viewed as an intermediate stage between Managed Land Vegetation and Secondary Forest, but this is a problem inherent to the goal of classification of vegetation into discrete units.

The most characteristic trees of Successional Vegetation in American Samoa are *Pipturus argenteus*, *Macaranga harveyana*, *Omalanthus nutans*, *Trema cannabina*, *Kleinhovia hospita*, and *Hibiscus tiliaceus* (beach hibiscus), all of which (except perhaps the last one) are native. Other species common in some places are the modern introductions *Leucaena leucocephala* (wild tamarind) and *Psidium guajava* (guava), and the native *Maoutia australis*, *Melastoma denticulatum*, *Mussaenda raiateensis*, and *Morinda citrifolia* (Indian mulberry). Tree ferns (*Cyathea* spp.) are also important in Successional Vegetation. Five species of *Cyathea* are found in American Samoa, but the most common of these in the lowlands is *Cyathea lunulata*. The slopes behind the coastal area of the NPSA on Ofu are steep cliffs nearly barren in some places. This is probably best considered to be successional vegetation that in the long run never changes into anything else.

REFERENCES CITED

- Amerson, A.B., Jr., W.A. Whistler, and T.D. Schwaner. 1982. Wildlife and wildlife habitat of American Samoa. U. S. Department of the Interior, Washington D.C. 2 vols. Mimeograph.
- Christensen, C. 1943. A revision of the Pteridophyta of Samoa. B. P. Bishop Museum Bulletin 177: 1–138.
- Christophersen, E. 1935, 1938. Flowering plants of Samoa. B. P. Bishop Museum Bulletin 128: 1–221. II. 154: 1–77.
- Cole, T.G., C.D. Whitesell, W.A. Whistler, N. McKay, and A.H. Ambacher. 1988. Vegetation survey and forest inventory, American Samoa. Pacific Southwest Forest and Range Experiment Station, Berkeley. 14 pp.
- Craig, P. 1993. How many people can American Samoa support? Biological Report Series 42: 4–5. Department of Marine and Wildlife Resources, American Samoa.
- Cribb, P. and W.A. Whistler. 1996. The orchids of Samoa. Kew Gardens, London. 141 pp.
- Keating, B.H. 1992. The geology of the Samoan Islands. *In* Keating, B.H. and R.B. Bolton (eds.), Geology and offshore mineral resources of the central Pacific basin. Springer-Verlag, N.Y., p. 127–178.
- Mueller-Dombois, D. and F.R. Fosberg. 1998. Vegetation of tropical Pacific islands. Springer-Verlag, New York. 737 pp.
- Nakamura, S. 1984. Soil survey of American Samoa. Soil Conservation Service, Washington D.C. 95 pp.
- Nelson, R.E. 1964. A look at the forests of American Samoa. U. S. Forest Service Research Notes, PSW 53: 1–14.
- Pickering, C. 1876. The geographical distribution of animals and plants in their wild state. (From USEE, Vol. 19, pt. 2: 276–311). Naturalists' Agency, Salem, Mass.
- Setchell, W.A. 1924. American Samoa. Part I. Vegetation of Tutuila Island; Part II. Ethnobotany of the Samoans; Part III. Vegetation of Rose Atoll. Publications of the Carnegie Institute of Washington 341 (Department of Marine Biology 20): 1–175.
- Stearns, H.T. 1944. Geology of the Samoan Islands. Bulletin of the Geology Society of America 55: 1279–1332.
- Stice, G.D. and F.W. McCoy. 1968. The geology of the Manu'a Islands, Samoa. Pacific Science 22: 427–457.
- Webb, E.L., and Fa'aumu, S. 1999. Diversity and structure of tropical rain forest of Tutuila, American Samoa: effects of site age and substrate. Plant Ecology 144: 257–274.
- Whistler, W.A. 1976. Wetland vegetation of American Samoa. Report submitted to the U.S. Army Corps of Engineers, Honolulu. 94 pp. (Mimeograph)
- Whistler, W.A. 1980. The vegetation of eastern Samoa. Allertonia 2(2): 45–190.
- Whistler, W.A. 1992a. The vegetation of Samoa and Tonga. Pacific Science 46 (2): 159–178.
- Whistler, W.A. 1992b. Botanical inventory of the Ta'u portion of the National Park of American Samoa. Technical Report. 83. Cooperative National Park Resources Study Unit, Honolulu. 85 pp. Mimeograph.
- Whistler, W.A. 1993. Botanical survey of the Ottoville lowland forest, Tafuna, Tutuila, American Samoa. Report prepared for the Government of American Samoa. 58 pp. Mimeograph.
- Whistler, W.A. 1994. Botanical inventory of the proposed Tutuila and Ofu portions of the National Park of American Samoa. Technical Report 87. Cooperative National Park Resources Study Unit, Honolulu. 142 pp. Mimeograph.

- Whistler, W.A. 1995. Permanent forest plot data from the National Park of American Samoa. Cooperative National Park Resources Study Unit, Honolulu. 65 pp. Mimeograph.
- Whistler, W.A. 2002. The Samoan rainforest: a guide to the vegetation of the Samoan Archipelago. Isle Botanica, Honolulu. 169 pp.
- Whistler, W.A. 2005. Plants of concern in American Samoa. U.S. Fish and Wildlife Service, Honolulu. [Mimeograph and CD] 127 pp.
- Yuncker, T.G. 1945. Plants of the Manua Islands. B. P. Bishop Museum Bulletin 184: 1–73.