

A vegetative key to the canopy trees of American Samoa, with notes on additional morphological and reproductive characters

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The high species diversity of the tree flora in tropical forests, although magnificent, is problematic for systematic treatments of ecological and evolutionary processes. Although great strides are being taken to botanically inventory even the most remote regions of the tropics (e.g. Wright *et al.* 1997), lack of secure tree identifications limits the scope of ecological studies relying thereon. Usually, identification keys rely on both vegetative and reproductive data to differentiate among species; however, it is often impossible to be present during phenological periods of all trees in a plot. Moreover, the tall physiognomy of most tropical trees makes remote identification based on minute floral characteristics difficult. An optimal situation would be to identify trees based on vegetative and physiognomic characteristics alone. Indeed, some notable works have added considerably to our ability to classify plants to family or genus based on vegetative characters (e.g. Gentry 1993, Keller 1996). The identification of tropical plants based on vegetative morphology, while clearly a challenging proposition, allows researchers to confidently ascertain taxonomic composition of tropical habitats during any time of the year.

The utility of vegetative characters for a key is greatest when the flora has low structural redundancy (i.e. is limited), yet is diverse enough for most researchers to require a reference. Such is the case for American Samoa (located the South Pacific Ocean, approximately 170° W and 14° S), which has a depauperate Asian tree flora compared with its continental stock, but is still diverse enough to be problematic for ecologists and other non-botanically oriented scientists. There are a number of publications containing botanical descriptions of Samoan plants (e.g. Christophersen 1935, Christophersen 1938, Parham 1972, Whistler 1992, Whistler 1995); unfortunately, none of these publications offers a key, so identification can still be a time-consuming and inefficient practice.

I present a dichotomous key to 56 canopy trees of Tutuila, American Samoa, based on vegetative (non-reproductive) characters only. A canopy tree is defined as one capable of reaching at least 15 m height. Following the key I provide additional characteristics of flower/fruit morphology, habitat preference, and/or physiognomy of most species, which provide further information for the secure identification of the tree in question (Appendix I). For fruit descriptions, I provide an estimate of fruit size (diameter or length). The genera *Diospyros* and *Dysoxylum* are exceedingly difficult to key out to species based on morphology; thus they are only differentiated to genus. However, the Appendix provides descriptions of more vegetative characters (not fully consistent, hence their exclusion from the key), as well as consistent reproductive characters that will assist the final determination of species. Also, because of few classifying characters in the Sapindaceae, I do not add additional characters for *Arytera*, *Elattostachys*, *Guioa*, and *Sapindus* in the Appendix. The key was constructed through field

work, reference to herbarium specimens housed at the Department of Marine and Wildlife Resources, and assimilation of data from literature sources (Christophersen 1935, 1938, Parham 1971, Whistler 1994). Nomenclature and authorities follows Whistler (1994).

The key is divided into two sections: one for littoral (coastal) species, and a second for lowland forest (upland) trees. The unique vegetation types of montane and trachyte scrub (Whistler 1980) are not included. 'Littoral' refers to species usually only found along the coastline or in mangrove forests. Exceptions to this rule are *Terminalia samoensis* and *Guettarda speciosa*, both of which are occasionally found in lowland forest. Conversely, a number of lowland species can also be found in littoral forest. Nevertheless, habitat overlap should not pose major problems during most applications.

The key is strongly biased towards indigenous and naturalized trees found in native forest. Tutuila has been inhabited for more than 2000 years (Hunt and Kirch 1997), and as a result some ornamental or culturally important canopy-sized trees (e.g. *Samanea samans* [Jacq.] Merr. [Fabaceae], *Ceiba pentandra* (L.) Gaertn. [Bombacaceae], *Casuarina equisetifolia* Linn. [Casuarinaceae]) have been introduced but are not naturalized. Those species are not included in the key. Introduced (*sensu* Whistler 1994) and naturalized trees included in this key follow (a question mark denotes uncertain status): *Adenanthera pavonina*, *Aleurites moluccana*, *Bischofia javanica* (?), *Cananga odorata* (?), *Canarium harveyi* (?), *Castilla elastica*, *Inocarpus fagifer*, *Instia bijuga*, *Paraserianthes falcataria*. Thus, possibly 9 of 56 species (16%) of the common canopy trees of Tutuila are naturalized exotics.

There is variability in phenotype that occasionally will confound the scientist. For example, the presence and quantity of latex in *Planchonella grayana* is variable. Therefore, *P. grayana* has been entered twice in the key: once with latex and once without. Moreover, leaf shape is used on occasion in this key. However, I attempted to minimize the potential for error by using only consistently robust leaf characters for differentiation. Nevertheless, to prevent misidentification, it is recommended that a variety of specimens are examined from a range of habitat conditions and tree ages. The key was designed to identify trees growing under 'normal' forest conditions and not in plantations.

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LITTORAL SPECIES (or inland at wetland sites)

1. Leaves simple

2. Leaves alternate or whorled

3. Leaves peltate.....*Hernandia nymphaefolia*

3. Leaves not peltate

4. Leaves elliptic*Pisonia grandis*

4. Leaves not elliptic

5. Leaves obovate

6. Leaves glossy, always green*Barringtonia asiatica*

6. Leaves not glossy, usually some leaves orange, red or yellow

7. Petiole apparent *Terminalia cataapa*7. Petiole very short, leaves subsessile *Terminalia samoensis*5. Leaves spatulate*Cerbera manghas*

2. Leaves opposite

8. Leaves elliptic, tree a mangrove *Bruguiera gymnorrhiza*

8. Tree not a mangrove

9. Leaves large, obovate, prominent venation*Guettarda speciosa*9. Leaves oval to oblong, dark green with fine secondary venation, milky sap*Calophyllum inophyllum*

1. Leaves compound (trifoliate)

10. Leaflets oval*Erythrina fusca*10. Leaflets broadly ovate*Erythrina variegata*

UPLAND SPECIES

1. Leaves simple
 2. Leaves alternate
 3. Leaves palmately lobed *Aleurites moluccana*
 3. Leaves not lobed
 4. Leaves peltate
 5. Insertion of petiole < 1 cm from leaf base, leaves slightly folded *Hernandia moerenhoutiana*
 5. Insertion of petiole > 1 cm from base
 6. Leaves glossy above *Macaranga stipulosa*
 6. Leaves dull, sometimes with soft dorsal spike at petiole insertion *Macaranga harveyani*
 4. Leaves not peltate
 7. Leaves pubescent *Castilla elastica*
 7. Leaves hairless
 8. Tree a banyan or growing hemiepiphytically
 9. Leaves shiny, stiff, slightly folded longitudinally at midrib *Ficus obliqua*
 9. Leaves dull, shaggy or slightly drooping (not stiff), darker than other banyan *Ficus prolixa*
 8. Tree not a banyan
 10. Leaves clearly lanceolate
 11. Margins undulate (appearing toothed); combrectaceous branching *Terminalia richii*
 11. Margins not undulate
 12. Leaves generally > 15 cm, trunk strongly fluted *Inocarpus fagifer*
 12. Leaves generally < 15 cm, trunk not fluted (but can be buttressed)
 13. Leaves in one plane; white/grey beneath *Alphitonia zizyphoides*
 13. Leaves appear whorled *Planchonella garberi*
 10. Leaves not lanceolate
 14. Tree with white (milky) sap sometimes in trunk, always in leaves
 15. Venation on ventral side of leaf not raised or apparent *Palaquium stehlinii*
 15. Venation on underside of leaf raised or apparent
 16. Midvein prominent, yellow, apparent from dorsal view *Planchonella grayana*
 16. Midvein and particularly secondary veins raised, no yellow *Planchonella samoensis*
 14. Tree lacking milky sap
 17. Leaf margins toothed or with paired basal glands
 18. Margins toothed *Elaeocarpus ulianus*
 18. Leaf with paired basal glands *Trichospermum richii*
 17. Leaf margins entire and without basal glands
 19. Tree with stilt roots *Myristica fatua*

- 19. Tree lacking stilt roots
 - 20. Leaves light green, translucent or nearly so; growing in high light, obviously heliophilic
 - 21. Leaves arising at end of twigs; base minutely cordate.....*Sterculia fanaiho*
 - 21. Leaves arising all along branches*Cananga odorata*
 - 20. Leaves dark green and opaque
 - 22. Bark dark grey, dark brown or black
 - 23. Trunk not buttressed, rough*Myristica hypargyrea*
 - 23. Trunk buttressed, wood extremely hard; twigs zigzag.....*Diospyros* sp.
 - 22. Bark not dark
 - 24. Petioles long, blade obelliptic or spatulate *Buchanania merillii*
 - 24. Leaves elliptic, prominent midvein below *Planchonella grayana*
- 2. Leaves opposite
 - 25. Leaves elliptic to oblong
 - 26. Leaf with prominent midvein; bark fissured; latex present in leaves*Calophyllum neo-ebudicum*
 - 26. Leaf lacking prominent midvein; bark mottled; leaf apex cuspidate; no latex*Syzygium inophylloides*
 - 25. Leaves oval to ovate
 - 27. Leaves coriaceous
 - 28. Twigs near terminus rounded*Syzygium clusifolium*
 - 28. Twigs squared*Syzygium dealatum*
 - 27. Leaves not coriaceous
 - 29. Terminus of branch is a conspicuous round stipule (reddish); lacks latex*Neonauclea forsteri*
 - 29. Lacks terminal stipule; secondary veins well-spaced; latex present*Alstonia pacifica*
- 1. Leaves compound (all leaves in this category are alternate)
 - 30. Leaves trifoliate*Bischofia javanica*
 - 30. Leaves pinnately compound
 - 31. Leaflets >3 cm in length
 - 32. Leaflets toothed
 - 33. Leaflets large and dentate*Pometia pinnata*
 - 33. Leaflets serrulate with some leaflets red*Garuga floribunda*
 - 32. Leaflets entire
 - 34. Leaflets broad, oval to ovate, length less than twice width
 - 35. Leaves paripinnate, slightly falcate*Instia bijuga*
 - 35. Leaves imparipinnate, odoriferous of turpentine when crushed*Canarium harveyi*
 - 34. Leaflet length more than twice width
 - 36. Tree with white latex and bark reddish brown; buttressed; some leaflets yellow.....*Rhus taitensis*
 - 36. Tree lacking latex

- 37. Leaves translucent, bark white and smooth, or white when scratched.....**Canarium vitiense**
- 37. Leaves opaque, bark not smooth and white
 - 38. Leaf bases with conspicuously swollen node (Meliaceae); leaflets generally elliptic
 - 39. Leaflets generally < 12, common in montane forest.....**Dysoxylum huntii**
 - 39. Leaflets generally > 12**Dysoxylum samoensis/maota**
 - 38. Leaf bases lacking conspicuous swollen node, leaflets generally lanceolate
 - 41. Leaflets clearly falcate**Elattostachys falcata**
 - 41. Leaflets subfalcate or straight
 - 42. Domatia present at base of leaflets**Guioa rhoifolia**
 - 42. Domatia not present
 - 43. Petioles winged (in saplings).....**Sapindus vitiensis**
 - 43. Petioles not winged**Arytera brackenridgei/ Elattostachys falcata**
- 31. Leaflets <3 cm in length
 - 44. Leaflets bipinnately compound **Paraserianthes falcataria**
 - 44. Leaflets only single-pinnately compound**Adenanthra pavonina**

APPENDIX I. Additional characteristics of lowland species, to aid identification. Nomenclature follows Whistler (1994). Fruit sizes are referred to parenthetically ('d' = approximate diameter when applicable).

Adenanthera pavonina L. (Fabaceae) - Fruits are twisted pods with small, bright red seeds ($d < 1$ cm). Leaflets elliptic to oval, some leaflets usually yellow. Typically found in disturbed forest.

Alphitonia zizyphoides (Spreng.) A. Gray (Rhamnaceae) - Slash has a dark red color beneath bark, beneath which wood is yellow. Fruits small ($d \approx 1$ cm) dark berries. Late secondary forest species that persists to mature-phase forest. Large canopy tree with layered branching pattern, distinctive from a distance.

Alstonia pacifica (Seem.) A.C. Smith (Apocynaceae) - Fairly common in submontane forest and trachyte scrub. Secondary veins are well-spaced.

Barringtonia asiatica A. Gray (Barringtoniaceae) - Flowers large, showy: many-stamened, fragrant with copious nectar; stamens white and red with yellow antherial head. Fruits large ($d \approx 10$ cm), four-sided.

Bischofia javanica Bl. (Euphorbiaceae) - Bark is brown and conspicuously flaky, fruits small ($d \approx 1$ cm) black berries. Leaves usually shiny and with undulating margins.

Bruguiera gymnorrhiza (L.) Lam. (Rhizophoraceae) - Only canopy-sized mangrove on Tutuila. Sympatric with *Rhizophora mangle*, which in other geographical areas can be large, but is not so on Tutuila. Fruits are viviparous, with an elongated, cylindrical hypocotyl.

Buchanania merillii (Christoph.) (Anacardiaceae) - Most conspicuous character for identification is the long petiole with obelliptic or spatulate leaves, appearing whorled. Also easily identified by blood-red outer cambium immediately beneath relatively thin grey bark. Fruits are flattened spheres ($d \approx 2-3$ cm) in axillary panicles, purple when mature.

Calophyllum inophyllum L. (Clusiaceae) - Flowers small and white with numerous yellow stamens centrally. Fruits subglobose and green ($d \approx 5$ cm).

Calophyllum neo-ebudicum Guillaumin (Clusiaceae) - Trunk has a slightly yellowish color, particularly in saplings. Leaves are coriaceous (generally very dark green) and exhibit extremely fine parallel secondary venation. New leaves are dark red; trees flushing new leaves are highly conspicuous. Flowers and fruits very similar to *C. inophyllum*, but fruits are smaller ($d \approx 3-4$ cm).

Canarium harveyi Seem. (Burseraceae) - Trees occasionally have stilt roots rather than buttresses. Easy to identify based on compound leaves with ovate leaflets that are very fragrant. Adult trees are generally clumped in populations; where this occurs seedlings are common.

Cananga odorata (Lam.) Hook. & Thoms. (Annonaceae) - Bark is light brown, very smooth, thin (can be scraped off with fingernail) and light green underneath. Branches on large trees tend to hang downward slightly. Flowers conspicuous: axillary, yellow-green, with long, separate waxy petals; highly fragrant.

Canarium vitiense A. Gray (Burseraceae) - Very common species in mature forests on hillsides; easily recognizable by smooth white bark often covered by mosses. If bark is not distinctively white, whiteness can be exposed by scraping off thin external layer with fingernail. Trees can be massive with thick straight boles. Often difficult to discriminate from *Rhus* on leaf morphology alone.

Cerbera manghas L. (Apocynaceae) - Flowers salverform, white with red throat. Fruits large (≈ 10 cm length), ellipsoid, red.

Diospyros spp. (Ebenaceae) - Difficult to discriminate between species vegetatively. *D. samoensis* A. Gray fruits are spherical ($d \approx 3$ cm) and yellow at maturity, with persistent 4-merous subtending calyx. *D. elliptica* (Forst.) P.S. Green fruits are ellipsoid ($\approx 2-3$ cm length) and yellow to orange at maturity. Generally, *D. samoensis* is much more common than *D. elliptica*. Leaf morphology is very similar, but *D. samoensis* leaves tend to be widest near the base, whereas *D. elliptica* tends to be wider near apex.

Dysoxylum spp. (Meliaceae) - Difficult to differentiate among species. *D. huntii* Merr. is common in upper elevations, usually with few (4-6) pairs of leaflets. *D. samoensis* tends to be red or orange beneath the bark, with a strong garlic odor to the slash. *D. maota* is generally yellowish beneath the bark, and with little or no garlic odor. *D. samoensis* leaflets tend to be rigid and planar; *D. maota* leaflets tend to hang downward, giving the leaves a 'tent' effect. *D. samoensis* A. Gray has smooth subglobose fruits in a downward hanging raceme; *D. maota* Reinecke has yellow wrinkled solitary fruits. Diameter of both fruits ≈ 3 cm each.

Elaeocarpus ulianus Christoph. (Elaeocarpaceae) - Fruits are ovoid and green (≈ 5 cm length). Single large flattened seed within, with a highly irregular/corrugated edge. Secondary veins bifurcate about 2/3 of the distance to the leaf margin; can easily be seen when looking toward the light.

Erythrina sp. (Fabaceae) - Both *E. fusca* Lour. and *E. variegata* L. have thorns on trunks, and very showy red flowers.

Ficus obliqua Forst. f. and **F. prolixa** Forst. f. (Moraceae) - Leaf descriptions in key refer to mature leaves only. Canopies can be very extensive, and obvious from a distance. *F. obliqua* can form a rather columnar trunk lacking a prolific adventitious root system. However, both species have been seen to produce an extensive net-like system of adventitious roots. *F. obliqua* fruits red; *F. prolixa* fruits green to brown. Fruits $\approx 1-2$ cm diameter.

Garuga floribunda Decne. (Burseraceae) - Difficult to discriminate from *Canarium vitiense* and *Rhus taitensis*. Toothed leaf margins distinctive, however. Tree relatively uncommon on Tutuila.

Guettarda speciosa L. (Rubiaceae) - Leaves are obovate as in *Terminalia*, with some leaves yellow to red, and much less thick than *Terminalia*. Distinguishable from *Terminalia* by lacking typical Combretaceous ('pagoda like') branching pattern. Flowers white and salverform and in cymes rather than on spikes (*Terminalia*). Fruits are brown and spherical rather than a flattened ovoid as in *Terminalia*.

Hernandia moerenhoutiana Guillemain (Hernandiaceae) - Leaves conspicuously trinerved. Fruit hollow (≈ 5 cm length), lantern-like (Whistler 1994), red to orange fleshy exocarp with single black spherical seed within.

Hernandia nymphaefolia (Presl.) Kub. (Hernandiaceae) - Leaves deltoid. Fruits are lantern-like (Whistler 1994): spherical (d $\approx$ 5 cm), hollow, with fleshy exocarp. Red to pale yellow, with a single spherical black seed.

Inocarpus fagifer (Parkinson) Fosb. (Fabaceae) - Trunk almost always highly fluted; fruit green, large (variable, but often $\approx$ 10 cm length), a laterally compressed sphere.

Instia bijuga (Colebr.) Kuntze (Fabaceae) - Bark is mottled; usually only found in groves. Known populations on Tutuila are at Fagamalo, Aloaoutouai, Nu'uuli (mangrove), Nu'usetoga Island (Masefau), Vatia, and at low elevations on most ridges of the American Samoa National Park.

Macaranga spp. (Euphorbiaceae) - *M. stipulosa* Muell. Arg. usually found in mature forest; *M. harveyani* (Muell. Arg.) Muell. Arg. mostly in very highly disturbed sites (e.g. plantations) and in urban areas.

Myristica spp. (Myristicaceae) - Underside of *M. fatua* leaves brown to gold; for *M. hypargyraea* underside is a pale green. Fruits very distinctive: subspherical capsule dehiscing into two equal halves, exposing a rugose seed covered in a bright red (*M. fatua* Houtt.) or orange (*M. hypargyraea* A. Gray) aril. Fruit sizes: *M. fatua* $\approx$ 3-4 cm length, *M. hypargyraea* $\approx$ 5 cm length. *M. fatua* is the most abundant tree in the forest, but usually is a mid-story tree. *M. hypargyraea* requires mature forest.

Neonauclea forsteri (Seem. ex Havil.) Merr. (Rubiaceae) - Small flowers contained on a terminal globose head (d $\approx$ 2-4 cm). Life forms of this species range from shrub-like individuals near roadside to massive canopy trees in mature forest. Establishes in secondary forest and persists to mature forest.

Palaquium stehlinii Christoph. (Sapotaceae) - Flowers are small ($\approx$ 2-3 cm length, including peduncle), solitary, and appear like "match sticks" (Trail 1994) along the branches. Fruit a large dull brown, subglobose or oblong fruit ($\approx$ 10 cm length). Seedlings have a distinctive brown, short petiole.

Paraserianthes falcataria (L.) I. Nielsen (Fabaceae) - Very large tree, layered branching pattern with flat-topped branches distinguishes it from other canopy species. In general only found at Fagasa Pass and on the hills to the West of Pago Pago.

Planchonella garberi Christoph. (Sapotaceae) - Fruit a globose purple berry (d $\approx$ 2-3 cm) with black, canoe-shaped seeds.

Planchonella grayana St. John (Sapotaceae) - Most obvious character is the prominent, thick yellow primary midvein on underside of elliptical leaf. Tree most abundant in forest near coastal areas. Fruit is a flesh-colored globose fruit (d $\approx$ 2-3 cm) with several shiny black seeds (Whistler 1994).

Planchonella samoensis H.J. Lam. ex Christoph. (Sapotaceae) - Trunk is brown and can be strongly buttressed; the bole is generally very straight and free of deformations. Tends to occur on valley floors. Fruit is ellipsoid ($\approx$ 5 cm length), turning red when mature.

Pometia pinnata Forst. (Sapindaceae) - Tree found only in Ottoville relict forest, on the rocky and very well-drained soils of the Tafuna Plain. Common timber species in Western Samoa.

Rhus taitensis Guillemain (Anacardiaceae) - Tree can have large buttresses with an extensive crown (one of the largest crowns in the forest aside from banyans). Most canopy trees have a handful of yellow leaflets. The presence of yellow leaflets in *Rhus* gives it a yellow-green color, which in combination with the layered branching, is very distinctive from a distance. Rachis is reddish. Latex slowly exudes from trunk after 1-2 minutes. Flowers small and white, flowering trees obvious from a distance. Fruit a small berry ($d \approx 1$ cm). Persistent secondary forest species.

Sapindaceae (excluding *Pometia*) - Includes *Arytera brackenridgei* (A. Gray) Radlk., *Elatostachys falcata* (A. Gray) Radlk., *Guioa rhoifolia* (A. Gray) Radlk. and *Sapindus vitiensis* A. Gray.

Sterculia fanaiho Setchell (Sterculiaceae) - Fruit a red, three-parted capsule, opening to reveal 2 or 3 spherical seeds. Species requiring disturbance or high light levels (e.g. gaps).

Syzygium clusifolium (A. Gray) C. Muell. and **S. dealatum** (Burkill) A.C. Smith (Myrtaceae) - Fruits ovoid and purple (≈ 4 cm length). Usually only in lowland forest near coastal areas.

Syzygium inophylloides (A. Gray) C. Muell. (Myrtaceae) - White flowers contain many short stamens; prolific flowering episodes (crowns can appear whitish from a distance during peak flowering). Fruit ovoid and yellow (≈ 6 cm length). Young leaves typically pink.

Terminalia catappa L. (Combretaceae) - Very large coastal tree recognizable by having many red or orange leaves, and 'pagoda-like' Combretaceous branching pattern. Tree very conspicuous from a distance. Flowers are contained on terminal spikes. Fruit shape is a moderately-sized (≈ 5 cm length) compressed ovoid (Whistler 1992), with a wing along the edge; red when mature.

Terminalia richii A. Gray (Combretaceae) - Seedlings and trees with combretaceous branching. Seedlings common in understory, but large trees are exceedingly rare; the largest known populations are on Tuasina Ridge at the West end of Tutuila, and on the Western Plateau. Otherwise, the tree is very rare on Tutuila.

Terminalia samoensis Rechinger (Combretaceae) - Same habitat requirements as *T. catappa*, but smaller stature. Petioles very short, fruits smaller than *T. catappa*. Tree rare on Tutuila.

Trichospermum richii (A. Gray) Seem. (Tiliaceae) - Rare tree on Tutuila, basal leaf glands make identification easy.