# Species Trials at the Waiakea Arboretum Hilo, Hawaii

George B. Richmond

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Pacific Southwest Forest and Range
Experiment Station - Berkeley, California
Forest Service - U. S. Department of Agriculture

## Acknowledgments

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A special tribute is due these and other farsighted members of the State Forester's office whose vision and energy have made this arboretum a reality.

Richmond, George B.

1963. Species Trials at the Waiakea Arboretum, Hilo, Hawaii. Berkeley, Calif., Pacific SW. Forest & Range Exp. Sta. 21 pp., illus. (U.S. Forest Serv. Res. Paper PSW- 4 )

Survival counts were made of 84 exotic tree species planted during 1956-1960 in a cleared rain-forest area near Hilo, Hawaii. Growth measurements were recorded for 5- and 6-year-old plantings. Most species had good survival, but some failed entirely. Soil depth was found to have a strong influence on rate of growth, but not on survival. Several valuable timber species showed remarkable growth. The report lists possibilities for future uses and contains recommendations for development of the arboretum.

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## Contents

*The Author*

**George B. Richmond,** a native of Missouri, was graduated from the University of Missouri with a B.S. degree in forestry in 1961, and an M.A. in plant ecology the following year. He worked at the Forest Service's research center in Springfield, Mo., and early in 1962 joined the Pacific Southwest Station's staff at Hilo, Hawaii, where he is conducting silvicultural research in forest tree plantations.

In 1956, the Hawaii Forestry Division established an arboretum of exotic tree species on a 20-acre portion of the Waiakea Forest Reserve near Hilo, Hawaii. The initial plantings were made that year, and others in 1957, 1959, and 1960. These exotic trees were planted to observe their survival and growth under local conditions. Of the 84 species planted, some have shown excellent survival and growth; others have failed completely.

This report gives the history, describes the habitat and present condition of the arboretum, and suggests possible future uses to which it may be put. Information in this report will be of value to foresters, botanists, and other scientists, and to students of nature as well. It may indicate areas in which more intensive investigations should be conducted.

In Hawaii, where so many kinds of forest trees have been introduced from other parts of the world, the value of the arboretum for study and demonstration is greater than in regions where forestry is based mainly on indigenous trees.

## Location, Climate, and Soil

The Waiakea Arboretum is about 6 miles south of Hilo, 0.3 mile northwest of the Stainback Highway (fig. 1). The arboretum access road joins the Stainback Highway at a point 3.1 miles southwest from where the latter connects with Hawaii Highway 11.

The arboretum site is about 800 feet above sea level. Annual precipitation is about 200 inches, occurring as rain and distributed rather evenly throughout the year. Average temperature is 70°F. Additional climatic data are presented in Appendix A.

The soil of the arboretum is of the Puna extremely stony-Kona rockland silt loam, low elevation complex.[1] It is a very rocky, silty clay loam derived from volcanic ash overlying pahoehoe lava. Pahoehoe outcrops occur over 25 percent of the surface. Soil depth ranges from 0 to 20 inches deep and averages 10 inches. Slope is 0 to 30 percent.

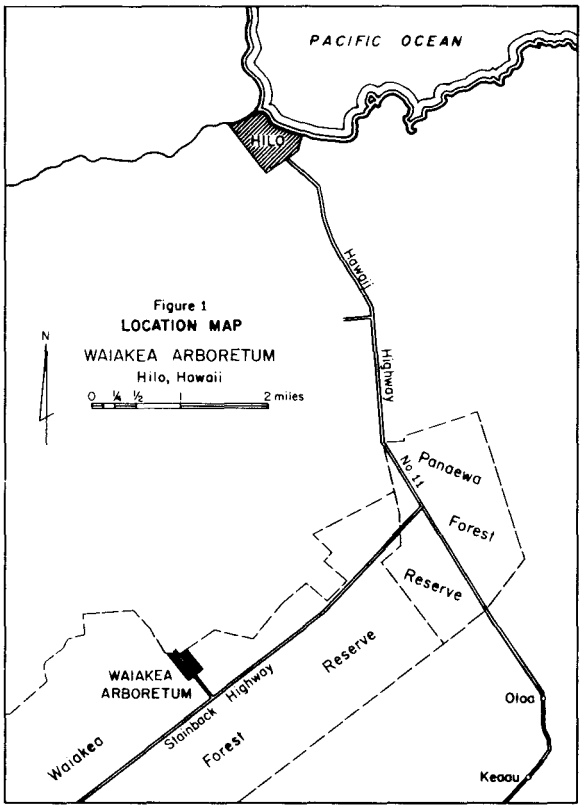


Figure 1
LOCATION MAP
WAIAKEA ARBORETUM
Hilo, Hawaii

[1]Ikeda, W. (n.d.) Unpublished report on file at Hilo Unit office, U.S. Soil Conservation Service, Hilo, Hawaii.

## Vegetation

Before the arboretum site was cleared, the wild overstory vegetation consisted of ohia[2] and scattered individuals of other native and introduced species, including loulu palm, lama, neneleau, and African tulip-tree, a naturalized, aggressive tree. The understory consisted of three kinds of Hawaiian treefern, with small trees or shrubs of guava, mamake, kukui, and trumpet-tree, the last-named being another naturalized, aggressive small tree. Treeferns comprised by far the most abundant members of the understory. Ground cover consisted of several species of ferns, shrubs, herbs, clubmosses, and mosses.

The arboretum site since clearing has been revegetated by plant communities consisting primarily of shrubs and small trees. Malabar melastome is the dominant member of these shrub communities, frequently forming pure stands as high as 15 feet, but sometimes sharing dominance with Indian pluchea, melochia, oi, and mamake. Other less common but important members of the shrub community are neneleau and trumpet-tree. Honohono occurs as a ground cover where shade and moisture are adequate. Other herbs and shrubs are present, but not in significant numbers. Ferns, grasses, and sedges form communities on sites not occupied by shrub communities.

The present invading vegetation has occupied the site for only a short period. Hence the various seral stages through which the vegetation may progress, and the nature of the climax community which would ensue if succession continued undisturbed cannot be predicted at this time. The arboretum plantings are, in some cases, beginning to exclude the shrubs. This pattern is particularly noticeable in the cases of the fast growing eucalypts and ironwoods. The more successful arboretum plantings probably will eventually eliminate much of the present shrub vegetation.

## History of the Arboretum

The Waiakea Arboretum was originally planned as an area to be used for trials of various exotic trees by the Hawaii Forestry Division, and is the property of that organization. Plantings were begun in the first unit in 1956 (maps, Appendix C). Units 2, 3, and 4 were planted in 1957, 1959, and 1960, respectively.

Wild vegetation was cleared from planting sites shortly before planting. The Kulani prison project of the Hawaii Department of Social Services cleared the land with bulldozers in preparation for tree planting. Much of the soil overlying the shallow pahoehoe was pushed into natural depressions which are common within the area. The bulldozed loose rocks, logs, treeferns, and lesser materials were also pushed into these depressions. The over-all effect was one of greater leveling of the land surface, but it caused a greater disparity in soil depths over closely adjacent points. Where the soil had been removed from the higher portions of the area, soil depths range from 0 to 8 inches. Where the soil, rock rubble, trees, and other vegetation were pushed into the depressions, soil depths are now much greater, exceeding 40 inches in many cases.

Planting stock for the arboretum was grown in the Hawaii Forestry Division tree nursery in Hilo. Many of the seeds for stock planted in unit 2 were brought to Hawaii by L. W. Bryan in 1956 upon his return from a trip to Australia and New Zealand. Seed source information in tables 1 and 2 is from his records and those of the Hawaii Forestry Division.

Seedlings were lifted from nursery flats or individual containers and transplanted by hand at the arboretum site. They averaged less than 1 year old when field planted. Trees were spaced 10 feet by 10 feet without regard to ground conditions. The single exception to this spacing is in unit 4 where the pines were spaced 8 feet by 8 feet. Seedlings were planted by employees of the Forestry Division under the supervision of L. W. Bryan, then district forester. Precision of spacing was of a high order, and greatly facilitated the locating of individual trees and remeasuring with a minimum of effort.

Plantings ranged in number from 3 to 600 individuals per species, usually arranged in blocks or strips. Species were identified by an embossed metal strip attached to a steel rod located at a corner of each planting.

[2]Common and scientific names of plant species mentioned in this report are found in Appendix B.

# Condition of Plantings in 1962

In April and May 1962, survival was observed and recorded in all four planting units. Heights and diameters of each planting were measured in units 1 and 2. Tree vigor and condition also were estimated in these two units. Survival of plantings in units 1 and 2 was good. In view of the diverse geographical origins and ecological requirements of the various species, much poorer survival would not have been surprising. Two of the species with poor survival, for example, are peppermint-gum and black peppermint, native to Tasmania, the first-named being a montane species.

Undoubtedly, many of the other species originated in habitats much different than that in the arboretum. Shallow soil and competition by wild vegetation probably contributed to mortality in many instances. Determination of the relative importance of the various factors affecting survival is beyond the scope of this report. On good sites, continued release of the slower growing species from competition with other vegetation probably would have reduced mortality and resulted in greater size and vigor. Release by cleaning was carried out through 1960.

Survival in the 1959 and 1960 plantings — units 3 and 4 — was poorer than in the older plantings. Many species in these plantings were pines which had low survival rates. All planting spots were inspected and the presence or absence of the planted tree was noted (table 1). As in units 1 and 2, heavy wild vegetation occupied the better sites and, in the case of most of the pines, seedlings failed to survive competition.

*Table 1. Survival of 1959-1960 plantings, Waiakea Arboretum, 1962*

| Scientific name | Common name | Trees planted | Trees surviving |
|---|---|---|---|
| UNIT 3 (PLANTED 1959) | | | |
| *Ackama paniculata* | Ackama | 90 | 33 |
| *Acacia longifolia* | Sydney acacia | 26 | 9 |
| *A. saligna* | goldwreath acacia | 10 | 10 |
| *A. sophora* | longleaf acacia | 10 | 1 |
| *Araucaria klinkii* | Klink araucaria | 18 | 18 |
| *Callitris cupressiformis* | drooping cypress-pine | 24 | 8 |
| *Casuarina oligodon* | soft yar | 11 | 7 |
| *C. papuana* | Papuan ironwood | 41 | 41 |
| *Eucalyptus cladocalyx* | sugar-gum eucalyptus | 14 | 0 |
| *E. maculata* | spotted-gum eucalyptus | 29 | 14 |
| *E. melliodora* | yellowbox eucalyptus | 20 | 0 |
| *E. nitens* | shining eucalyptus | 15 | 10 |
| *Flindersia brayleyana* | Queensland-maple | 114 | 103 |
| *Pinus ayacahuite* | Mexican white pine | 11 | 0 |
| *P. canariensis* | Canary-Island pine | 29 | 1 |
| *P. caribaea 'A'* | Caribbean pine | 6 | 6 |
| *P. caribaea 'B'* | Caribbean pine | 44 | 21 |
| *P. echinata* | shortleaf pine | 18 | 0 |
| *P. glabra* | spruce pine | 13 | 6 |
| *P. michoacana var. cornuta 'A'* | Michoacan pine | 20 | 1 |
| *P. michoacana var. cornuta 'B'* | Michoacan pine | 20 | 12 |
| *P. oocarpa* | eggcone pine | 10 | 5 |
| *P. occidentalis* | Cuban pine | 12 | 6 |
| *P. pinaster* | cluster pine | 6 | 0 |
| *P. sinensis var. yunnanensis* | Yunnan pine | 18 | 2 |
| *P. serotina* | pond pine | 12 | 6 |
| *P. taeda* | loblolly pine | 6 | 2 |
| UNIT 4 (PLANTED 1960) | | | |
| *Cupressus lusitanica* | Mexican cypress | 100 | 81 |
| *Eucalyptus diversicolor* | karri eucalyptus | 20 | 18 |
| *Pinus caribaea* | Caribbean pine | 100 | 38 |
| *P. echinata x taeda x wind* | (Common name not available) | 200 | 9 |
| *P. elliottii* | slash pine | 40 | 28 |
| *P. oocarpa* | eggcone pine | 150 | 123 |
| *P. insularis* | Philippine pine | 100 | 64 |
| *P. patula* | jelecote pine | 200 | 127 |
| *P. taeda* | loblolly pine | 100 | 61 |

Variations in growth rate within most species were large and to a marked degree reflected soil depth. Norfolk-Island-pine, monkey-pod, and Queensland-maple had the widest variation in growth rate (figs. 2, 3, 4, 5). For example, 6-year-old monkey-pod ranged from less than 5 feet tall and less than ½ inch diameter at breast height (d.b.h) on a poor site to 35 feet tall and over 8 inches d.b.h. on a good site. On poor sites almost all monkey-pod suffered heavily from dieback and general lack of thrift, while on the better sites there was almost no dieback or other evidence of poor vigor (figs. 6, 7).

As a group, the eucalypts exhibited greatest growth and vigor (fig. 8). One bangalay eucalyptus attained a height of 90 feet and a breast-height diameter of 8.5 inches in less than 5 years. One Australian toon, not part of the predetermined sample, was observed to have grown to 12.3 inches d.b.h. in a little less than 6 years.

Even though little growth was made on poor sites, many trees were still living when examined in 1962. This persistence can be explained perhaps by the abundance and good distribution of rainfall.

**Figure 2.—Six-year-old Norfolk-Island pine trees on a good site with soil to 40 inches deep are 21 feet tall. Heavy understory of melastoma, oi, treefern, and pluchea also indicate good growth potential of the deeper soils.**

**Figure 3. — Norfolk-Island-pine at Waiakea Arboretum. Poor site has limited the growth of this 6-year-old tree (left foreground) to 4 feet. Shallow soil over pahoehoe lava results in physiological arid-ity even in 200-inch annual rainfall. Re-placement of shrubs by grass indicates shallow soil.**

**Figure 4. — Four-year-old Queensland-maple, planted in 1957, 4.2 inches in diameter, located on good site at Waiakea Arboretum. The heavy cover of invading vegetation includes melastoma, oi, treefern, and trumpet-tree.**

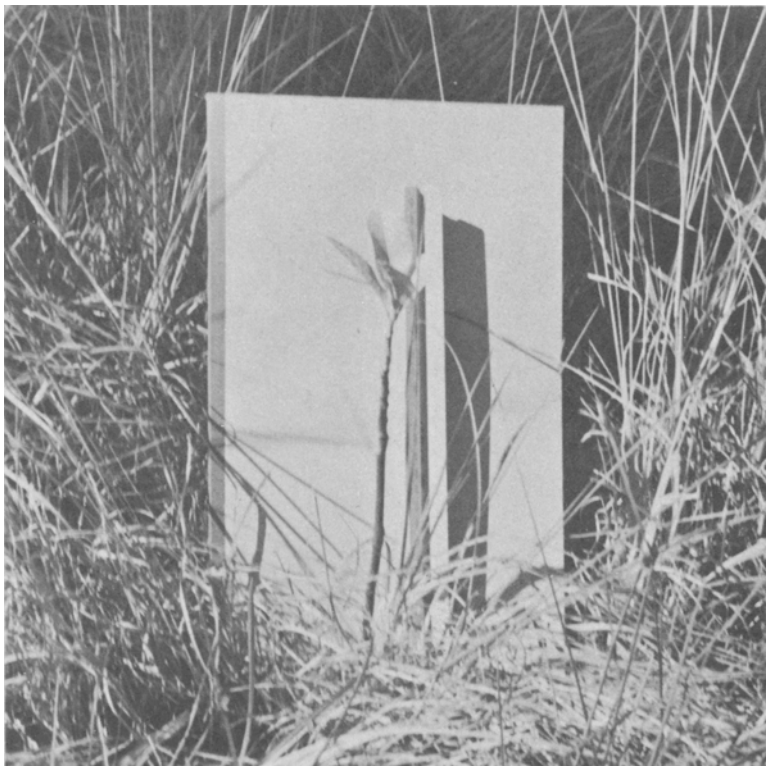


**Figure 5.—Queensland-maple, 4 years old, on poor site at Waiakea Arboretum. Depauperate seedlings in grass cover indicate shallow soil. This tree is located 30 feet from the tree in figure 4, and was planted at the same time. Scale for comparison is 10 inches in length. (Photo by M. F. Landgraf.)**

**Figure 6.—Monkey-pod on good site at Waiakea Arboretum. Six years old, these trees range from 5.5 to 8.5 inches diameter. Soil depths sometimes exceed 40 inches on these sites.**

**Figure 7.—Six-year-old monkey-pod on poor site at Waiakea Arboretum. Note die-back. Grass-fern vegetation indicates shallow soil of depths to 12 inches.**

**Figure 8. — Fast-growing rosegum eucalyptus is beginning to shade out competing wild vegetation. These gums are 4 years old and have attained diameters up to 7 inches.**

# Measurements

For the purposes of this report, a numbering system was adopted in which the tree in the northwest corner of a species planting was designated as number 1. Numbering then proceeded in the following sequence:

N. W. corner

| | | | |
|---|---|---|---|
| 1 | 10 | 11 | 20 |
| 2 | 9 | 12 | 19 |
| 3 | 8 | 13 | 18 |
| 4 | 7 | 14 | 17 |
| 5 | 6 | 15 | 16 |

Measurements were made of all or a portion of the trees in each planting in units 1 and 2, as indicated in the map (Appendix C). If a planting contained 30 or fewer trees, all trees were measured. If the planting contained more than 30 trees, a sample of 30 was measured. Several exceptions were made in special circumstances. In both monkey-pod and Norfolk-Island-pine, samples of 30 trees were taken from both the best and poorest portions of the plantings to illustrate the wide differences in size and vigor existing in a single planting. In the Australian toon planting and in planting "A" of tropical ash, samples numbered 44 and 45, respectively.

Species identification of the various plantings were not verified, but were accepted as listed in Hawaii Forestry Division records. It appears, however, that several individuals of pine plantings may require verification as to species.

Tree heights were measured in 5-foot classes and diameters were measured in ½-inch classes (tables 2 and 3). The general condition and vigor of each measured tree was estimated, using as criteria, height, amount and color of foliage, evidence of dieback, and crown size.

As measurements of the trees progressed, it became apparent that trees lacking in vigor and growing poorly were those which had been planted over very shallow pahoehoe. Conversely, those trees planted where natural depressions had been filled in with soil, rock, and vegetable matter were usually thrifty and grew vigorously. In view of this, soil depths were measured to determine the degree to which soil depth was related to growth. Depth was measured with a soil probe constructed from a 40-inch length of ½-inch steel rod pointed at the lower end. A handle crosspiece of ¾-inch steel pipe was brazed to the upper end of the rod.

Soil depths were measured under Norfolk-Island-pine (both good and poor sites), monkey-pod (good and poor), and Queensland-maple (planting "A") at trees which had been measured previously for height and diameter. The probe was forced into the soil to refusal at four points angularly equidistant and 1 foot or less from the tree. Maximum soil penetration among the four trials was recorded. The relationship of tree diameter to soil depth in the case of monkey-pod (good and poor sites combined) is illustrated in figure 9. Norfolk-Island-pine and Queensland-maple showed similar relationships.

The fractured state of the underlying pahoehoe was such that cracks near a tree might have provided opportunity for roots to penetrate farther than would be indicated by the general depth of the surrounding soil. Some cracks probably were not detected by probing. In such cases, tree growth and vigor would be greater than expected. On the whole, however, tree growth was related to or indicated relative soil depth. In probing on the better Norfolk-Island-pine area, we found that many rock fragments were larger than in the other areas checked. Many averaged 1 foot or more in diameter. These large rocks may have prevented the probe from penetrating deeper in many cases in which the vigor of the tree indicated greater soil depth than was measured.

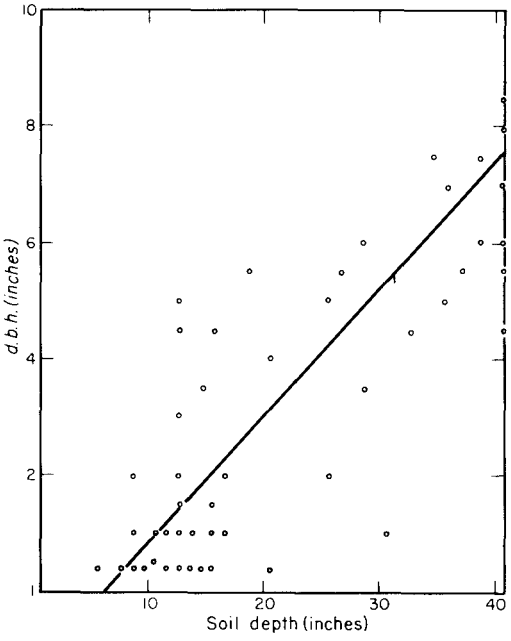



**Figure 9.—Relationship of diameter growth to soil depth for 6-year-old monkey-pod, Waiakea Arboretum, Hawaii.**

*Table 2. Survival and growth of 1956 plantings, Unit 1, Waiakea Arboretum, April-May 1962*

| Planting | Surviv-al | Height | | Diameter b.h. | | General condition, appearance | Trees measured | Seed source | Remarks |
|---|---|---|---|---|---|---|---|---|---|
| | | Average | Range | Average | Range | | | | |
| | *Percent* | *Feet* | *Feet* | *Inches* | *Inches* | | *Number* | | |
| *Araucaria excelsa*[1] (Norfolk-Island-pine) | 100 | 5 | <5-10 | - | <0.5-1.0 | Very poor | 30 | Hawaii | Mostly on pahoehoe |
| *Araucaria excelsa*[2] (Norfolk-Island-pine) | 100 | 10 | 5-20 | 1.0 | <0.5-3.5 | Fair | 30 | Hawaii | Good trees on rock rubble and tree-fern |
| *Araucaria angustifolia* (parana-pine) | 100 | 5 | - | - | - | Very poor | 3 | S. Amer-ica | |
| *Chamaecyparis lawsoniana* (Port-Orford-cedar) | 67 | 10 | - | 1.0 | - | Fair | 3 | U.S.A.[3] | |
| *Fraxinus uhdei 'A'*[4] (tropical ash) | 100 | 15 | 5-25 | 2.5 | 1.0-3.5 | Fair | 45 | Hawaii | Permanent growth plot trees (meas. May 1961). |
| *Fraxinus uhdei 'B'* (tropical ash) | 100 | 30 | 15-40 | 4.5 | 2.0-6.5 | Good | 32 | Hawaii | Rock rubble and treefern trunks on surface; mela-stoma understory |
| *Fraxinus uhdei 'C'* (tropical ash) | 94 | 25 | 15-30 | 3.5 | 2.0-5.5 | Good | 17 | Hawaii | Rockrubble and treefern trunks on surface; mela-stoma understory. |
| *Jacaranda mimosaefolia 'A'* (jacaranda) | 89 | 25 | 10-40 | 2.5 | <0.5-3.5 | Fair | 18 | Hawaii | Needs diam. growth to prevent bend-ing. |
| *Jacaranda mimosaefolia 'B'* (jacaranda) | 83 | 15 | 5-45 | 1.0 | <0.5-3.5 | Poor | 30 | Hawaii | Highly variable growth, bends when tall. |
| *Khaya nyasica* (nyassa khaya) | 93 | 10 | 5-20 | 2.0 | 1.5-4.0 | Fair | 14 | Florida | |
| *Peltophorum inerme 'A'* (yellow poinciana) | 97 | 20 | 5-35 | 2.0 | <0.5-4.0 | Poor | 17 | Hawaii | Variable, bends when tall. |
| *Peltophorum inerme 'B'* (yellow poinciana) | 96 | 15 | <5-30 | 1.5 | <0.5-3.5 | Poor | 26 | Hawaii | Variable, bends when tall. |
| *Pinus caribaea* (Caribbean pine) | 100 | 35 | 30-35 | 6.5 | 5.0-7.5 | Very good | 3 | U.S.A.[3] | |
| *Pinus elliottii 'A'* (slash pine) | 75 | 5 | - | | - | Poor | 4 | U.S.A.[3] | |
| *Pinus elliottii 'B'* (slash pine) | 100 | 10 | 5-10 | 1.0 | <0.5-1.5 | Poor | 6 | U.S.A.[3] | |

*See footnotes at end of table.*

*Table 2. Survival and growth of 1956 plantings, Unit 1, Waiakea Arboretum, April-May 1962, continued*

| Planting | Surviv-al | Height | | Diameter b.h. | | General condition, appearance | Trees measured | Seed source | Remarks |
|---|---|---|---|---|---|---|---|---|---|
| | | Average | Range | Average | Range | | | | |
| | *Percent* | *Feet* | *Feet* | *Inches* | *Inches* | | *Number* | | |
| *Pinus radiata* (Monterey pine) | 50 | 5 | - | - | | Poor | 6 | Hawaii | |
| *Samanea saman* (monkey-pod) | 93 | 5 | <5-10 | 1.0 | <0.5-2.0 | Very poor | 30 | Hawaii | Much dieback (meas. live wood only). |
| *Samanea saman*[2] (monkey-pod) | 100 | 25 | 10-35 | 5.0 | 1.5-8.5 | Good | 30 | Hawaii | Mostly on rock rubble and tree-fern trunks. |
| *Swietenia mahogani 'A'* (West Indian mahogany) | 85 | 10 | 5-25 | 1.0 | <0.5-2.5 | Poor | 40 | Hawaii | Much dieback and sprouting, forked, poor |
| *Swietenia mahogani 'B'* (West Indian mahogany) | 54 | 5 | 5-10 | - | - | Very poor | 13 | Hawaii | Leaves reddish, con-dition very |
| *Theohroma cacao* (cocoa) | 0 | - | | | - | Dead | 3 | Hawaii | Planting dead. |
| *Toona ciliata var. australis* (Australian toon) | 100 | 30 | 10-45 | 4.0 | 1,5-7.0 | Fair | 44 | Hawaii | Permanent growth plot trees (meas. May 1961). |

[1] *Poor site.*

[2] *Good site.*

[3] *U.S.A. denotes United States mainland.*

[4] *Letter suffixes such as 'A' denote separate plots.*

*Table 3. Survival and growth 1957 plantings in Unit 2,* Walakea *Arboretum, April-May 1962*

| Planting | Surviv-al | Height | | Diameter b.h. | | General condition, appearance | Trees measured | Seed source | Remarks |
|---|---|---|---|---|---|---|---|---|---|
| | | Average | Range | Average | Range | | | | |
| | *Percent* | *Feet* | *Feet* | *Inches* | *Inches* | | *Number* | | |
| *Araucaria klinkii* (Klink araucaria) | 100 | <5 | <5-5 | - | - | Very poor | 30 | New Guinea | Overtopped by melastoma and oi. |
| *Callitris calcarata* (black cypress-pine) | 100 | 15 | 10-20 | 1.5 | <0.5-3.0 | Fair | 10 | Australia | |
| *Callitris glauca* (white cypress-pine) | 40 | 15 | 5-20 | 1.0 | <0.5-2.5 | Very poor | 30 | Australia | Poor survival and growth. |
| *Callitris macleayana* (brush cypress-pine) | 70 | 5 | 5-10 | | <0.5-1.0 | Very poor | 30 | Australia | Overtopped by melastoma and oi. |
| *Castanospermum australe* (Moreton-Bay-chestnut) | 60 | <5 | - | - | - | Very poor | 5 | Hawaii | Greatest height was 1.5 ft. |
| *Casuarina cunninghamiana 'A'* (ironwood) | 97 | 35 | 25-45 | 4.0 | 2.5-6.5 | Good | 30 | Australia | |
| *Casuarina cunninghamiana 'B'* (ironwood) | 100 | 30 | 15-40 | 4.5 | 2.0-6.5 | Good | 30 | Australia | Rock rubble and tree fern trunks on surface; heavy melastoma understory. |
| *Casuarina cristata* (Bellah) | 90 | 10 | <5-20 | 1.0 | <0.5-2.5 | Very poor | 30 | Australia | |
| *Casuarina littoralis*[1] | 87 | 20 | 5-35 | 1.5 | <0.5-5.5 | Fair | 30 | Australia | |
| *Casuarina montana* (mountain ironwood) | 47 | 15 | 5-20 | 1.0 | <0.5-1.0 | Very poor | 30 | Hawaii | |
| *Casuarina nodiflora* (knot-flowered ironwood) | 53 | 25 | 15-45 | 3.0 | 2.0-4.0 | Poor | 30 | New Guinea | |
| *Casuarina suberosa 'A'* (black-she-oak casuarina) | 57 | 10 | 5-25 | 0.5 | <0.5-2.5 | Poor | 30 | Australia | Mostly on pahoehoe. |
| *Casuarina suberosa 'B'* (black-she-oak casuarina) | 96 | 30 | 10-45 | 2.5 | 1.0-6.0 | Fair | 30 | Australia | Vigorous but breaks and windthrows; producing seed. |
| *Cedrela odorata* (Spanish-cedar) | 61 | 15 | 5-30 | 2.0 | <0.5-5.0 | Poor | 31 | Hawaii | |
| *Eucalyptus acmenioides* (white-mahogany eucalyptus) | 57 | 20 | 10-30 | 2.0 | 0.5-3.5 | Poor | 30 | Australia | |
| *Eucalyptus alba* (ghost-tree eucalyptus) | 43 | 15 | 10-20 | 1.5 | 0.5-3.5 | Poor | 30 | Australia | Breaks at ground line; site has many treefern trunk. |
| *Eucalyptus bicolor*[2] | 8 | 10 | 10-15 | 0.5 | <0.5-1.0 | Very poor | 30 | Australia | From 34 to 38° S. latitude. |
| *Eucalyptus botryoides* (bangalay eucalyptus) | 97 | 50 | 20-90 | 5.5 | 1.0-8.5 | Very good | 30 | Australia | Persistent branches down to 8 to 12 feet. |
| *Eucalyptus campanulata* (stringybark peppermint eucalyptus) | 86 | 20 | 5-45 | 2.0 | <0.5-8.0 | Fair | 30 | Australia | Not uniform; heavy grass competition. |

See footnotes at end of table.

*Table 3. Survival and growth 1957 plantings in Unit 2, Waiakea Arboretum, April-May 1962, continued*

| Planting | Surviv-al | Height | | Diameter b. h. | | General condition appearance | Trees measured | Seed source | Remarks |
|---|---|---|---|---|---|---|---|---|---|
| | | Average | Range | Average | Range | | | | |
| | Percent | Feet | Feet | Inches | Inches | | Number | | |
| *Eucalyptus cloeziana* (gympie messmate eucalyptus) | 75 | 30 | 15-35 | 5.5 | 2.5-7.0 | Good | 8 | Aus-tralia | |
| *Eucalyptus coccifera* (peppermint-gum eucalyptus) | 0 | — | — | — | — | — | 20 | Aus-tralia | Entire planting died. Montane Tasmanian species. |
| *Eucalyptus deglupta 'A'* (Amammanit eucalyptus) | 100 | 35 | 15-50 | 4.0 | 1.5-7.0 | Good | 30 | Hawaii | Rock rubble and treefern trunks on surface; living treefern understory |
| *Eucalyptus deglupta 'B'* (Amammanit eucalyptus) | 100 | 30 | 10-40 | 3.5 | 0.5-6.0 | Good | 30 | Hawaii | Some trees on pahoe-hoe. |
| *Eucalyptus eugenioides* (white stringybark eucalyptus) | 70 | 15 | 10-25 | 1.5 | <0.5-3.5 | Poor | 20 | Aus-tralia | |
| *Eucalyptus eugenioides 'B'* (white stringybark eucalyptus) | 74 | 20 | 5-40 | 2.5 | <0.5-7.0 | Poor | 30 | Aus-tralia | Not uniform, some very good and some very poor. |
| *Eucalyptus fastigata* (brown-barrel eucalyptus) | 41 | 10 | <5-10 | 0.5 | <0.5-1.0 | Very poor | 22 | Aus-tralia | |
| *Eucalyptus grandis 'A* (rosegum eucalyptus) | 97 | 20 | 5-40 | 2.5 | <0.5-6.0 | Good | 30 | Aus-tralia | |
| *Eucalyptus grandis 'B* (rosegum eucalyptus) | 92 | 40 | 15-60 | 4.0 | 1.0-7.0 | Very good | 30 | Aus-tralia | Rock rubble and tree-fern trunks on sur-face; living tree-fern understory. |
| *Eucalyptus guilfoylei* (yellow tingle eucalyptus) | 70 | 20 | 10-30 | 2.0 | <0.5-4.0 | Fair | 30 | Aus-tralia | Crook and lean com-mon; stand not uni-form. |
| *Eucalyptus longifolia* (longleaf woolybutt eucalyptus) | 99 | 20 | 5-25 | 2.0 | <0.5-3.0 | Poor | 30 | Aus-tralia | |
| *Eucalyptus pellita* (slatyhide eucalyptus) | 92 | 30 | 5-45 | 3.5 | <0.5-7.0 | Good | 30 | New Zea-land | |
| *Eucalyptus propinqua* (graygum eucalyptus) | 92 | 20 | 5-45 | 2.0 | <0.5-5.0 | Fair | 30 | Aus-tralia | Heavy understory. |
| *Eucalyptus pulverulenta* (silverleaf eucalyptus) | 12 | 15 | 10-15 | 1.0 | 0.5-2.0 | Very poor | 30 | Aus-tralia | Juvenile leaves on the six survi-vors. |
| *Eucalyptus punctata 'A'* (leather-jacket eucalyp-tus) | 70 | 25 | 5-45 | 3.0 | <0.5-6.5 | Fair | 30 | New Zea-land | |

See footnotes at end of table.

*Table 3. Survival and growth 1957 plantings in Unit 2, Waiakea Arboretum, April-May 1962, continued*

| Planting | Survival | Height | | Diameter b. h. | | General condition, appearance | Trees measured | Seed source | Remarks |
|---|---|---|---|---|---|---|---|---|---|
| | | Average | Range | Average | Range | | | | |
| | *Percent* | *Feet* | *Feet* | *Inches* | *Inches* | | *Number* | | |
| *Eucalyptus punctata 'B'* (leather-jacket eucalyptus) | 97 | 45 | 20-65 | 4.0 | 0.5-7.5 | Good | 30 | New Zealand | More rock and treefern than at 'A', above. |
| *Eucalyptus radiata* (peppermint eucalyptus) | 77 | 30 | 10-45 | 3.5 | 0.5-5.5 | Good | 30 | Australia | Poor form, weeping habit, very ornamental |
| *Eucalyptus robertsonii* (narrow-leaf peppermint eucalyptus) | 60 | 5 | <5-5 | | - | Very poor | 15 | Australia | Mostly on pahoehoe. |
| *Eucalyptus robusta* (robusta eucalyptus) | 97 | 30 | 10-40 | 4.0 | 0.5-7.0 | Good | 30 | Hawaii | Poor trees are on pahoehoe. |
| *Eucalyptus rubida 'A'* (candlebark eucalyptus) | 50 | 20 | 10-30 | 2.5 | <0.5-6.5 | Very poor | 10 | Australia | Juvenile leaves, dieback, very poor form. |
| *Eucalyptus rubida 'B'* (candlebark eucalyptus) | 73 | 25 | 5-35 | 2.0 | <0.5-4.0 | Poor | 30 | Australia | Juvenile leaves, dieback, very poor form. |
| *Eucalyptus salicifolia* (black-peppermint eucalyptus) | 28 | 20 | 15-25 | 2.0 | 1.5-4.0 | Poor | 25 | Australia | A Tasmanian species. |
| *Eucalyptus saligna 'A'3* (saligna eucalyptus)3 | 100 | 25 | 10-45 | 3.0 | <0.5-6.5 | Good | 30 | New Zealand | Tends to crook at about 5 ft. high. |
| *Eucalyptus saligna 'B'* (saligna eucalyptus) | 98 | 40 | 10-60 | 4.5 | <0.5-8.0 | Very good | 30 | Australia | |
| *Eucalyptus torelliana 'A'* (cadagi eucalyptus) | 98 | 15 | 5-25 | 2.0 | 0.5-3.0 | Fair | 30 | Australia | Some trees flowering. |
| *Eucalyptus torelliana 'B'* (cadagi eucalyptus) | 98 | 20 | 10-30 | 3.0 | 1.0-6.5 | Good | 30 | Australia | Some trees flowering. |
| *Eucalyptus unidentified* (HN-11309) | 2 | - | 5-10 | | 0.5-1.0 | Very poor | 150 | Australia | Only two very poor survivors. |
| *Flindersia brayleyana 'A'* (Queensland-maple) | 89 | 10 | <5-25 | 1.0 | <0.5-2.5 | Very poor | 30 | Australia | |
| *Flindersia brayleyana 'B'* (Queensland-maple) | 83 | 20 | 5-35 | 3.0 | <0.5-5.0 | Good | 30 | Australia | |
| *Flindersia ifflaiana 'A'* (Cairns-hickory) | 53 | 5 | <5-15 | - | <0.5-1.5 | Very poor | 30 | Australia | Mostly on pahoehoe. |
| *Flindersia ifflaiana 'B'* (Cairns-hickory) | 50 | 10 | 5-20 | 1.0 | <0.5-2.0 | Very poor | 30 | Australia | Mostly on pahoehoe. |
| *Hibiscus elatus* (Cuban bast) | 95 | 15 | <5-25 | 2.0 | 1.0-4.5 | Fair | 20 | Hawaii | Tendency toward multiple stems. |
| *Pinus taeda 'A'* (loblolly pine) | 56 | 5 | <5-10 | <0.5 | <0.5-1.0 | Very poor | 16 | Hawaii | |

See footnotes at end of table.

*Table 3. Survival and growth 1957 plantings in Unit 2, Waiakea Arboretum, April-May 1962, continued*

| Planting | Surviv-al | Height | | Diameter b. h. | | General condition, appearance | Trees measured | Seed source | Remarks |
|---|---|---|---|---|---|---|---|---|---|
| | | Average | Range | Average | Range | | | | |
| | Percent | Feet | Feet | Inches | Inches | | Number | | |
| *Pinus taeda 'B'* (loblolly pine) | 80 | 5 | - | - | - | Poor | 5 | Hawaii | |
| *Pinus palustris* (longleaf pine) | 25 | 5 | <5-5 | - | - | Very poor | 20 | Hawaii | Five survivors, two in 'grass' stage. |
| *Pinus pinaster* (cluster pine) | 73 | 5 | <5-10 | - | - | Poor | 15 | Hawaii | |
| *Swietenia macrophylla* (Honduras mahogany) | 67 | 5 | <5-15 | 0.5 | <0.5-1.5 | Very poor | 24 | Panama, C.Z. | Mostly on tight pahoehoe |
| *Tectona grandis* (teak) | 82 | 5 | <5-2 | - | <0.5-2.0 | Very poor | 22 | Hawaii | Great variation in size and vigor. |
| *Tristania conferta* (brushbox) | 94 | 20 | 5-30 | 2.0 | <0.5-4.5 | Fair | 30 | Hawaii | Better trees growing on rock rubble and treefern. |

[1] Common name not available.

[2] *E. bicolor* A. Cunn. ex Hook. *E. largiflorens* F. Muell. *E. bicolor* Woolls = *E. bosistoana* F. Muell. Local records cite no authority for name so that positive identification of species cannot be made at this time. Descriptions in Penfold and Willis (Penfold, A. R., and Willis, T. L. The eucalyptus, botany, chemistry, cultivation, and utilization. 551 pp., illus. New York: Interscience Publishers, Inc. 1961 ) of vegetative characteristics of *E. largiflorens* and *E. bosistoana are* so similar and overlap to such a degree as to be of no value at this time.

[3] 'A' is Barrett's; 'B' is not Barrett's.

# Current and Future Use

The arboretum offers possibilities for studies in a number of forestry fields, including soils, genetics, and ecology. Other study opportunities may become apparent in the future.

Future plantings in the Waiakea Arboretum should be restricted to areas in which present plantings have failed owing to conditions other than soil depth or quality. An example is the area which was planted to peppermint-gum. Although this species failed, the vigor of the wild vegetation on the area indicates that site conditions are no more severe than on other areas which were successfully planted. Similar situations exist in certain other portions of the arboretum. Careful species selection probably would result in successful plantings.

Future plantings should be of uniform size insofar as is practicable. Twenty-five trees per planting are adequate for arboretum purposes. These trees should be planted in blocks, if possible. The 10-by 10-foot spacing should be maintained. This arrangement will not be optimal for all species, but appears to be an adequate compromise.

Expanding the arboretum by clearing adjacent areas is not recommended at this time. Other sites offer better opportunities with fewer soil and clearing problems.

Besides serving as a performance trial area, the Waiakea Arboretum is currently being used as a demonstration area for visiting foresters and other interested persons. A fertilization study, in cooperation with the University of Hawaii at Hilo, has been installed. Permanent growth plots have been established in the Australian toon planting and in planting "A" of tropical ash.

Use as a demonstration area may well be an important future function of the arboretum. its accessibility from Hilo, the population center of the Big Island, enhances its attractiveness to visitors and serves to promote interest in trees and in forestry. It also serves as an example of the effort being made to promote self-sufficiency in forest products in Hawaii.

# Appendices

## *A. Meteorological Influence at Waiakea Arboretum*

Climate at the Waiakea Arboretum is warm and humid — typical of the windward portions of the larger islands of Hawaii. Seasonal variations are slight. Since climatic data have not been gathered at the arboretum site, the information reported here covers conditions which prevail for the area in general (table 4). This is especially true of data on temperature, cloudiness, wind, and humidity, which were recorded at the Hilo Airport, some 7 miles northeast of the arboretum (table 5).

The topography of the island and its influence upon the prevailing northeast trade winds results in rapid changes in precipitation rates and cloud cover over closely adjacent points. Weather conditions at a given point, however, are remarkably uniform the year round.

**Precipitation.**—The arboretum lies near the 200-inch isohyet (fig. 10). Rain may be expected almost every day. Rain is nearly entirely orographic in type, caused by the lifting and cooling of warm, moist air masses. Generally, rainfall is gentle and steady, although occasional heavy downpours occur. Other forms of precipitation are not significant at the arboretum. Water condensed as dew is small compared with the large amounts of rainfall during all months of the year. Snow and frost do not occur.

**Temperature.**—Temperatures at the arboretum are similar to those at the Lyman Airport, Hilo. Altitudinal correction of about 2° F. is required for comparison purposes.[3] The constancy of temperature in Hilo is shown by the 14.8° F. difference between the mean daily maximum and minimum temperatures over a 56-year period, with daily extremes of 93° F. and 55º F. Average temperature is 72° F.

**Clouds.**—Clouds occur almost daily at the arboretum. Afternoons are usually more cloudy than mornings, there often being a complete cloud cover from near noon until after nightfall. At this low elevation clouds seldom form at ground level. Apart from their role in rainfall, the effect of the clouds is to reduce the intensity of insolation, with a concurrent reduction in evapo-transpiration.

**Wind.**—The force and direction of the wind at the arboretum has not been measured. The weather in Hawaii is, in general, influenced by the northeast trade winds. Occasional storms known as "Kona" storms occur, from the south or southwest. These may be accompanied by winds which can uproot large trees, particularly trees grown on soils overlying pahoehoe lava.

**Relative humidity.**—This factor has not been measured at the arboretum, but in view of other meteorological factors the values for relative humidity should be high, similar to humidity recorded at the Hilo airport.

[3]Assuming a wet adiabatic rate of 3º F. per 1,000 feet of elevation. Blair, A.. and Fite, R. C. Weather elements. Englewood Cliffs: Prentice-Hall, Inc., 414 pp., illus. 1957.

*Table 4. Precipitation, in inches, for selected points near Waiakea Arboretum, Hilo, Hawaii*[1]

| Gage & location relative to arboretum | Years of data | Annual precipitation | | Jan. | Feb. | Mar. | Apr. | May | Jun. | Jul. | Aug. | Sept. | Oct. | Nov. | Dec. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Waiakea Mill Camp 6, 2 mi. N El. 600 ft. | 17 | Max. | 236.5 | 33.9 | 33.1 | 50.3 | 35.3 | 23.0 | 18.8 | 22.9 | 33.2 | 27.5 | 30.2 | 22.4 | 46.8 |
| | | Med. | 167.8 | 9.5 | 10.9 | 16.8 | 16.7 | 12.2 | 8.7 | 13.7 | 11.2 | 8.8 | 10.9 | 13.6 | 13.8 |
| | | Min. | 121.5 | 0.9 | 1.0 | 3.2 | 5.5 | 4.8 | 4.7 | 5.5 | 6.6 | 6.0 | 3.3 | 4.5 | 2.1 |
| Waiakea SCD, 1 mi. NNW El. 1,010 ft. | 5 | Max. | 225.7 | 20.6 | 41.4 | 39.8 | 25.4 | 27.7 | 14.9 | 21.8 | 48.4 | 11.5 | 20.9 | 22.7 | 61.8 |
| | | Med. | 214.8 | 11.4 | 17.1 | 16.5 | 13.0 | 16.3 | 10.7 | 13.4 | 28.0 | 6.3 | 11.2 | 15.0 | 13.9 |
| | | Min. | 147.7 | 0.6 | 13.4 | 4.5 | 6.6 | 11.1 | 7.7 | 6.9 | 8.5 | 4.6 | 6.9 | 13.4 | 8.5 |
| Kaumana, 2 mi. NW El. 930 ft ft. | 18 | Max. | 250.2 | 49.6 | 44.0 | 83.8 | 49.8 | 23.8 | 15.9 | 32.8 | 51.1 | 27.2 | 24.0 | 44.7 | 58.9 |
| | | Med. | 185.0 | 9.6 | 13.5 | 18.1 | 13.7 | 15.4 | 7.6 | 14.7 | 20.4 | 8.6 | 14.6 | 16.1 | 11.0 |
| | | Min. | 136.9 | 0.5 | 2.8 | 6.3 | 4.9 | 5.2 | 4.5 | 7.2 | 5.5 | 4.0 | 6.8 | 11.0 | 7.1 |
| Kaumana, 2 mi. N El. 500 ft. | 34 | Max. | 271.2 | 65.7 | 43.6 | 57.5 | 34.9 | 28.2 | 25.0 | 33.8 | 48.7 | 33.1 | 20.6 | 42.6 | 53.1 |
| | | Med. | 160.6 | 10.6 | 8.6 | 12.9 | 15.7 | 12.1 | 8.4 | 12.5 | 13.1 | 10.7 | 10.3 | 14.2 | 15.3 |
| | | Min. | 92.0 | 0.1 | 1.7 | 2.0 | 1.4 | 2.2 | 3.2 | 5.6 | 3.6 | 2.5 | 2.4 | 3.5 | 1.9 |
| Waiakea, 5 mi. W El. 1,920 ft. | 22 | Max. | 300.5 | 39.2 | 35.1 | 42.9 | 34.7 | 34.3 | 27.9 | 37.5 | 43.3 | 34.7 | 31.0 | 32.9 | 42.8 |
| | | Med. | 206.1 | 13.4 | 16.1 | 23.9 | 18.8 | 16.9 | 12.5 | 16.6 | 15.1 | 12.4 | 13.8 | 16.4 | 12.4 |
| | | Min. | 136.6 | 1.2 | 0.6 | 3.3 | 6.6 | 2.2 | 4.5 | 9.4 | 9.8 | 4.5 | 5.0 | 1.0 | 3.1 |
| Kurtistown, 4 mi. SE El. 900 ft. | 6 | Max. | 206.8 | 21.2 | 36.9 | 33.6 | 22.0 | 25.2 | 12.9 | 19.0 | 35.5 | 12.2 | 32.3 | 24.0 | 61.9 |
| | | Med. | 183.2 | 11.5 | 16.0 | 14.6 | 12.1 | 15.7 | 9.7 | 11.5 | 16.8 | 6.7 | 12.1 | 19.9 | 12.6 |
| | | Min. | 126.4 | 0.9 | 9.2 | 7.7 | 4.8 | 8.1 | 6.4 | 6.7 | 7.7 | 5.0 | 6.3 | 11.8 | 7.8 |
| Olaa, 6 mi. ESE El. 280 ft. | 57 | Max. | 210.0 | 37.9 | 33.1 | 66.7 | 31.8 | 22.0 | 25.8 | 24.9 | 34.2 | 31.4 | 32.0 | 37.1 | 57.8 |
| | | Med. | 146.5 | 8.1 | 9.1 | 12.7 | 12.5 | 9.7 | 7.6 | 10.3 | 9.7 | 9.1 | 10.7 | 14.1 | 14.7 |
| | | Min. | 76.7 | 1.1 | 0.9 | 0.3 | 1.9 | 1.6 | 2.0 | 4.2 | 3.8 | 3.2 | 3.4 | 3.2 | 1.6 |
| Lyman Airport, 7 mi. NE El. 31 ft. | 19 | Max. | 168.4 | 48.3 | 32.0 | 55.2 | 33.6 | 21.9 | 23.6 | 27.1 | 35.5 | 25.1 | 28.2 | 40.1 | 54.1 |
| | | Med. | 139.2 | 7.0 | 8.5 | 11.9 | 11.8 | 7.9 | 6.1 | 9.5 | 10.6 | 8.5 | 9.4 | 11.4 | 12.8 |
| | | Min. | 82.9 | 0.8 | 0.9 | 0.9 | 1.5 | 1.2 | 2.0 | 4.3 | 3.6 | 3.5 | 2.4 | 2.7 | 0.8 |

[1] *Taliaferro, W. J. Rainfall of the Hawaiian Islands. Honolulu, Hawaii. Hawaii Water Authority, 394 pp., illus. 1959.*

*Table 5. Local climatological data for Hilo, Hawaii*[1]

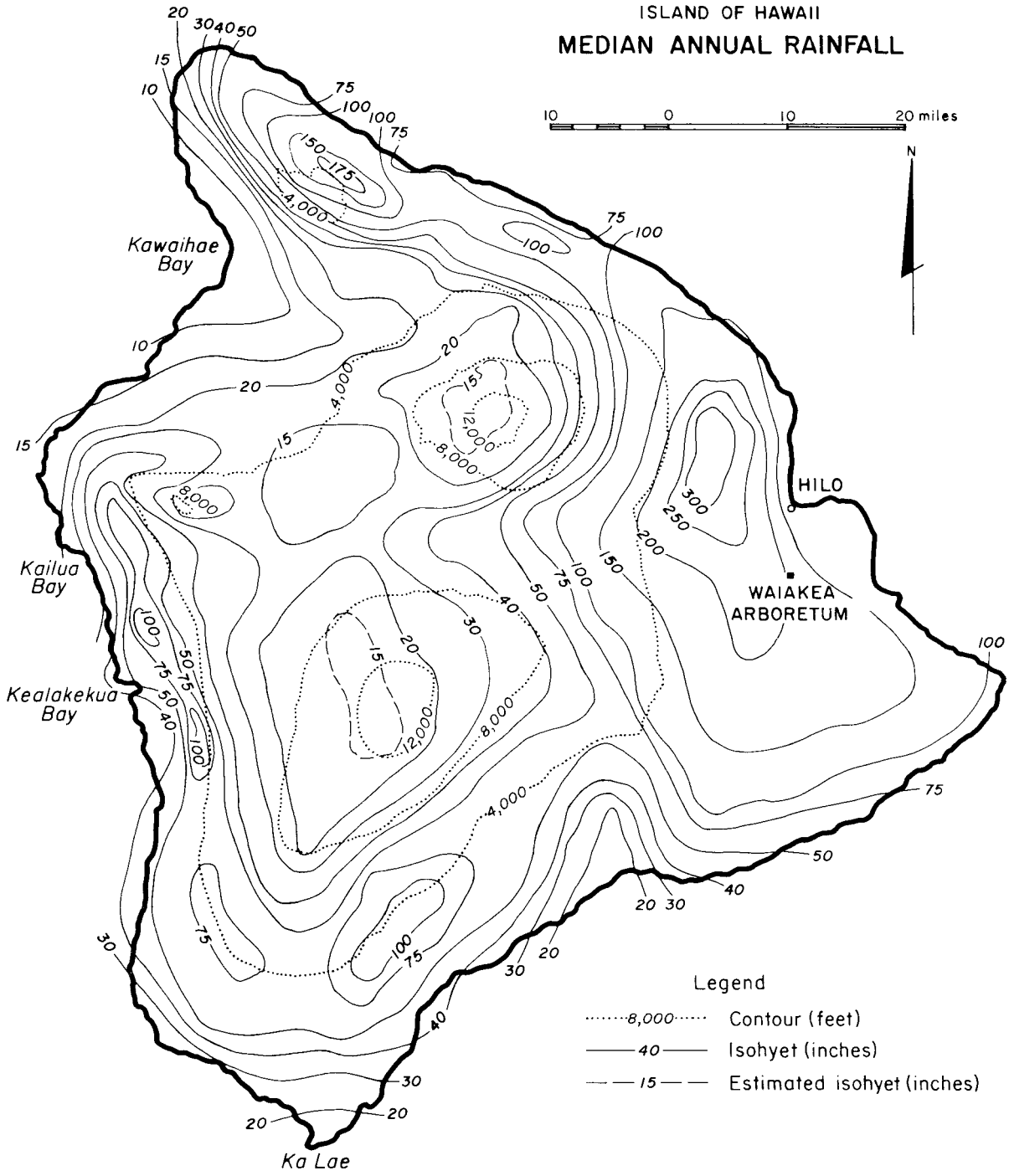
| Item | Jan. | Feb. | Mar. | Apr | May | Jun. | July | Aug. | Sept. | Oct. | Nov. | Dec. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **TEMPERATURE (DEGREES FAHRENHEIT)** | | | | | | | | | | | | |
| Normal monthly mean (from 1921 to 1950) | 70.4 | 70.7 | 70.8 | 71.6 | 73.1 | 74.4 | 74.8 | 75.4 | 75.3 | 74.5 | 73.0 | 71.4 |
| Extreme high (15 years) | 89 | 88 | 88 | 87 | 85 | 88 | 88 | 93 | 92 | 91 | 88 | 85 |
| Extreme low (15 years) | 55 | 55 | 55 | 56 | 58 | 60 | 62 | 63 | 62 | 62 | 58 | 56 |
| **CLOUD COVER** | | | | | | | | | | | | |
| Mean sky cover, percent, sunrise to sunset (15 years) | 6.8 | 7.1 | 7.7 | 8.2 | 8.2 | 7.5 | 7.6 | 7.9 | 7.1 | 7.4 | 7.6 | 7.4 |
| Clear, mean number of days (15 years) | 5 | 3 | 2 | 1 | 1 | 2 | 1 | 1 | 2 | 2 | 2 | 3 |
| Partly cloudy, mean number of days (15 years) | 11 | 10 | 10 | 7 | 9 | 11 | 12 | 9 | 12 | 11 | 9 | 10 |
| Cloudy, mean number of days (15 years) | 15 | 15 | 19 | 22 | 21 | 17 | 18 | 21 | 16 | 18 | 19 | 18 |
| Percent of possible sunshine (11 years) | 46 | 41 | 41 | 33 | 31 | 42 | 44 | 38 | 41 | 40 | 32 | 37 |
| **WIND (MILES PER HOUR)** | | | | | | | | | | | | |
| Mean hourly speed | 7.5 | 7.8 | 7.8 | 7.5 | 7.2 | 7.3 | 7.2 | 7.2 | 7.1 | 6.9 | 6.7 | 7.4 |
| **RELATIVE HUMIDITY (PERCENT)** | | | | | | | | | | | | |
| 2 a.m. 12 years | 85 | 86 | 87 | 87 | 89 | 88 | 88 | 89 | 87 | 87 | 88 | 86 |
| 8 a.m. 12 years | 80 | 82 | 81 | 82 | 81 | 79 | 82 | 83 | 80 | 81 | 83 | 82 |
| 2 p.m. 12 years | 67 | 69 | 67 | 69 | 69 | 65 | 67 | 70 | 66 | 68 | 71 | 71 |
| 8 p.m. 12 years | 84 | 84 | 83 | 84 | 83 | 82 | 82 | 84 | 63 | 86 | 86 | 86 |

[1] Based on records of the U.S. Weather Bureau, Lyman Airport, Hilo, Hawaii.

Figure 10

ISLAND OF HAWAII

## MEDIAN ANNUAL RAINFALL



## B. Species List

Several publications were used as sources of names and authorities for plant species mentioned in this report. Insofar as possible, scientific and common names agree with the *Provisional Check List of Some Common Native and Introduced Plants in Hawaii* by Bryan and Walker.[4] Nomenclature of the genus *Eucalyptus* when not supplied by Bryan and Walker follows that in *The Eucalyptus* by Penfold and Willis.[5]

TREES

| Common name | Scientific name |
|---|---|
| acacia, goldwreath | *Acacia saligna* Wendland |
| acacia, longleaf | *Acacia sophora* R. Br. |
| acacia, Sydney | *Acacia longifolia* Willd. |
| ackama | *Ackama puniculata* Engl. |
| araucaria, Klink | *Araucaria klinkii* |
| ash, tropical | *Fraxinus uhdei* (Wenzig) Lingelsheim |
| bast, Cuban | *Hibiscus elatus* Sw. |
| Bellah | *Casuarina cristata* |
| black peppermint | *Eucalyptus salicifolia* (Sol.) Cay. |
| brushbox | *Tristania conferta* R. Br. |
| Cairns-hickory | *Flindersia ifflaiana* F. Muell. |
| casuarina, black-she-oak | *Casuarina suberosa* Otto & Diel. |
| cocoa | *Theobroma cacao* L. |
| cypress, Mexican | *Cupressus lusitanica* Mill. |
| cypress-pine, black | *Callitris calcarata* A. Cunn. ex Mirb. |
| cypress-pine, brush | *Callitris macleayana* (F. Muell.) F. Muell. |
| cypress-pine, drooping | *Callitris cupressiformis* Vent. |
| cypress-pine, white | *Callitris glauca* R. Br. |
| eucalyptus, Amammanit | *Eucalyptus deglupta* Blume |
| eucalyptus, brown-barrel | *Eucalyptus fastigata* Deane & Maiden |
| eucalyptus, bangalay | *Eucalyptus botryoides* Sm. |
| eucalyptus, cadagi | *Eucalyptus torelliana* F. Muell. |
| eucalyptus, candlebark | *Eucalyptus rubida* Deane & Maiden |
| eucalyptus, ghost-tree | *Eucalyptus alba* Reinw. ex Blume |
| eucalyptus, graygum | *Eucalyptus propinqua* Deane & Maiden |
| eucalyptus, gympie messmate | *Eucalyptus cloeziana* F. Muell. |
| eucalyptus, karri | *Eucalyptus diversicolor* F. Muell. |
| eucalyptus, leather-jacket | *Eucalyptus punctata* DC |
| eucalyptus, longleaf woolybutt | *Eucalyptus longifolia* Link |
| eucalyptus, narrow-leaf peppermint | *Eucalyptus robertsonii* Blakely |
| eucalyptus, peppermint | *Eucalyptus radiata* Sled. ex DC |
| eucalyptus, peppermint-gum | *Eucalyptus coccifera* Hook. |
| eucalyptus, robusta | *Eucalyptus robusta* Sm. |
| eucalyptus, rosegum | *Eucalyptus grandis* Hill ex Maiden |
| eucalyptus, saligna | *Eucalyptus saligna* Sm. |
| eucalyptus, shining | *Eucalyptus nitens* Maiden |
| eucalyptus, silverleaf | *Eucalyptus pulverulenta* Sims. |
| eucalyptus, slatyhide | *Eucalyptus pellita* F. Muell. |
| eucalyptus, spotted-gum | *Eucalyptus maculata* Hook. |
| eucalyptus, stringybark peppermint | *Eucalyptus campanulata* R. T. Baker |
| eucalyptus, sugar-gum | *Eucalyptus cladocalyx* F. Muell. |
| eucalyptus, white-mahogany | *Eucalyptus acmenioides* Schau. |
| eucalyptus, white stringybark | *Eucalyptus eugenioides* Sieb. |
| eucalyptus, yellowbox | *Eucalyptus melliodora* A. Cunn ex Schau. |
| eucalyptus, yellow tingle | *Eucalyptus guilfoylei* Maiden |
| ironwood | *Casuarina cunninghamiana* Miguel. |
| ironwood, knot-flowered | *Casuarina nodiflora* |
| ironwood, mountain | *Casuarina montana* Jungh. |
| ironwood, Papuan | *Casuarina papuana* |
| jacaranda | *Jacaranda mimosifolia* D. Don |
| Khaya, Nyassa | *Khaya nyasica* Stapf. |
| kukui | *Aleurites moluccana* (L.) Willd. |
| Lama | *Diospyros sandwicensis* |
| mahogany, Honduras | *Swietenia macrophylla* King |
| mahogany, West Indies | *Swietenia mahogani* Jacq. |
| monkey-pod | *Samanea saman* (Jacq.) Merrill |
| Moreton-Bay-chestnut | *Castanospermum australe* A. Cunn. |
| Norfolk-Island-pine | *Araucaria excelsa* R. Br. |
| 'ohi'a-lehua | *Metrosideros collina* var. *polymorpha* (Gaud.) Rock |
| palm, loulu | *Pritchardia* spp. |
| parana-pine | *Araucaria angustifolia* |
| pine, Canary-Island | *Pinus canariensis* C. Smith |
| pine, Caribbean | *Pinus caribaea* Morelet. |
| pine, cluster | *Pinus pinaster* Soland. |
| pine, Cuba | *Pinus occidentalis* Swartz. |
| pine, egg-cone | *Pinus oocarpa* Schiede. |
| pine, jelecote | *Pinus Patula* Schlecht. & Chambers |
| pine, loblolly | *Pinus taeda* L. |
| pine, longleaf | *Pinus palustris* Miller |
| pine, Mexican white | *Pinus ayacahuite* Ehrenb. |
| pine, Michoacana | *Pinus michoacana* var. *cornuta* |
| pine, Monterey | *Pinus radiata* D. Don |
| pine, Philippine | *Pinus insularis* Endlich. |
| pine, pond | *Pinus serotina* Michx. |
| pine, shortleaf | *Pinus echinata* Mill. |
| pine, slash | *Pinus elliottii* Engelm. |
| pine, spruce | *Pinus glabra* Walt. |
| Port-Orford-cedar | *Chamaecyparis lawsoniana* (A. Murr.) Parl. |
| Queensland-maple | *Flindersia brayleyana* F. Muell. |
| soft yar | *Casuarina oligodon* |

[4]Bryan, L. W., and Walker, C. M. Provisional check list of some common native and introduced plants in Hawaii. U.S. Forest Serv. Pacific SW. Forest & Range Expt. Sta. Misc. Paper 69, 36 pp., 1962.

[5]Penfold and Willis, *op. cit.*

| Common name | Scientific name |
|---|---|
| Spanish-cedar | *Cedrela odorata* L. |
| teak | *Tectona grandis* L. |
| toon, Australian | *Toona ciliata* var. *australis* (F. Muell.) C. DC |
| treefern, Hawaiian | *Cibotium* spp. |
| trumpet-tree | *Cecropia peltata* L. |
| tulip-tree. African | *Spathodea campanulata* Beauv. |
| yellow-poinciana | *Peltophorum inerme* Roxb. |
| Yunnan pine | *Pinus sinensis* var. *yunnanensis* Shaw. |
| (common name not available) | *Casuarina littoralis* |
| (common name not available) | *Eucalyptus bicolor*[6] |

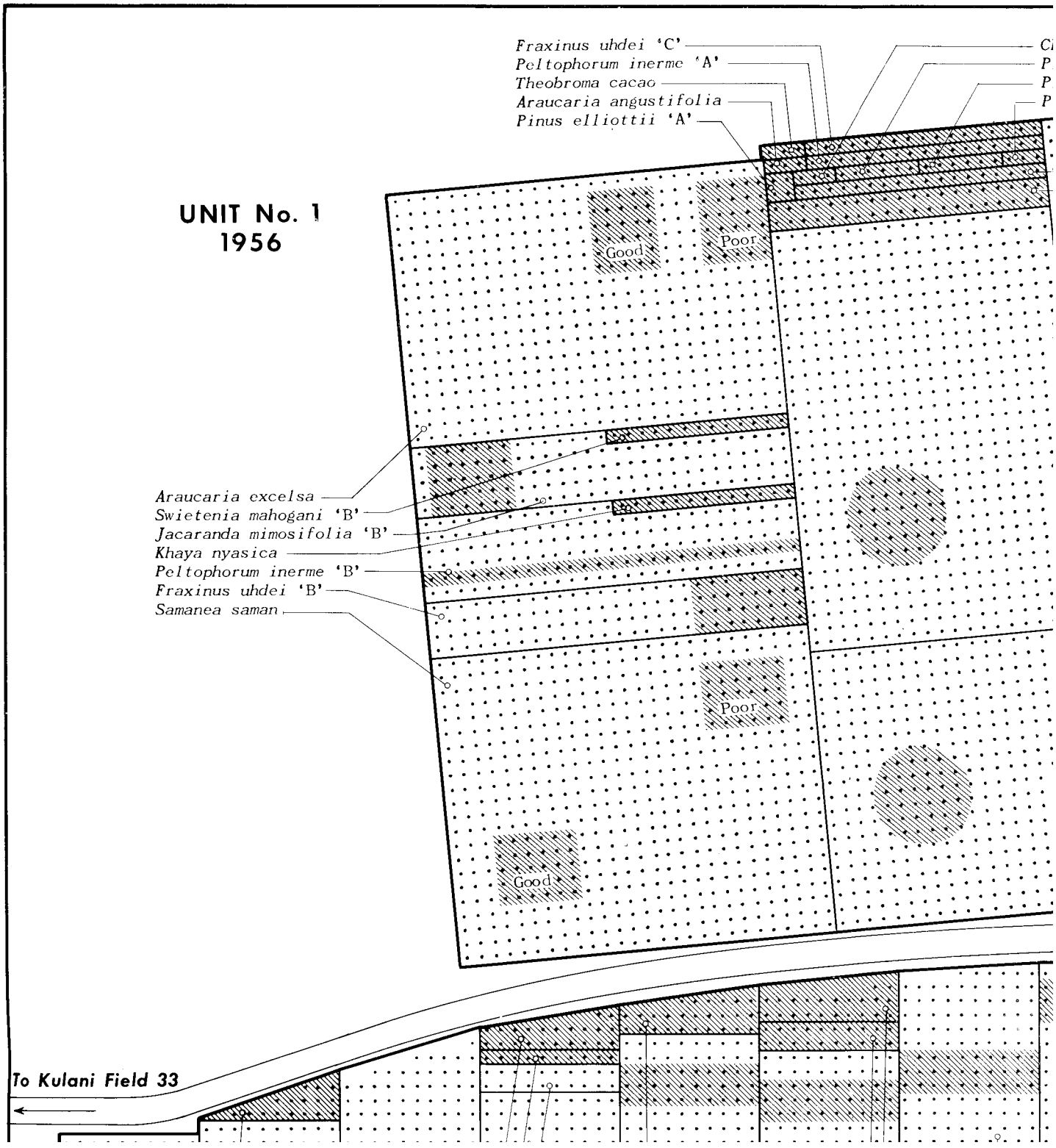
FERNS, SHRUBS, AND HERBS

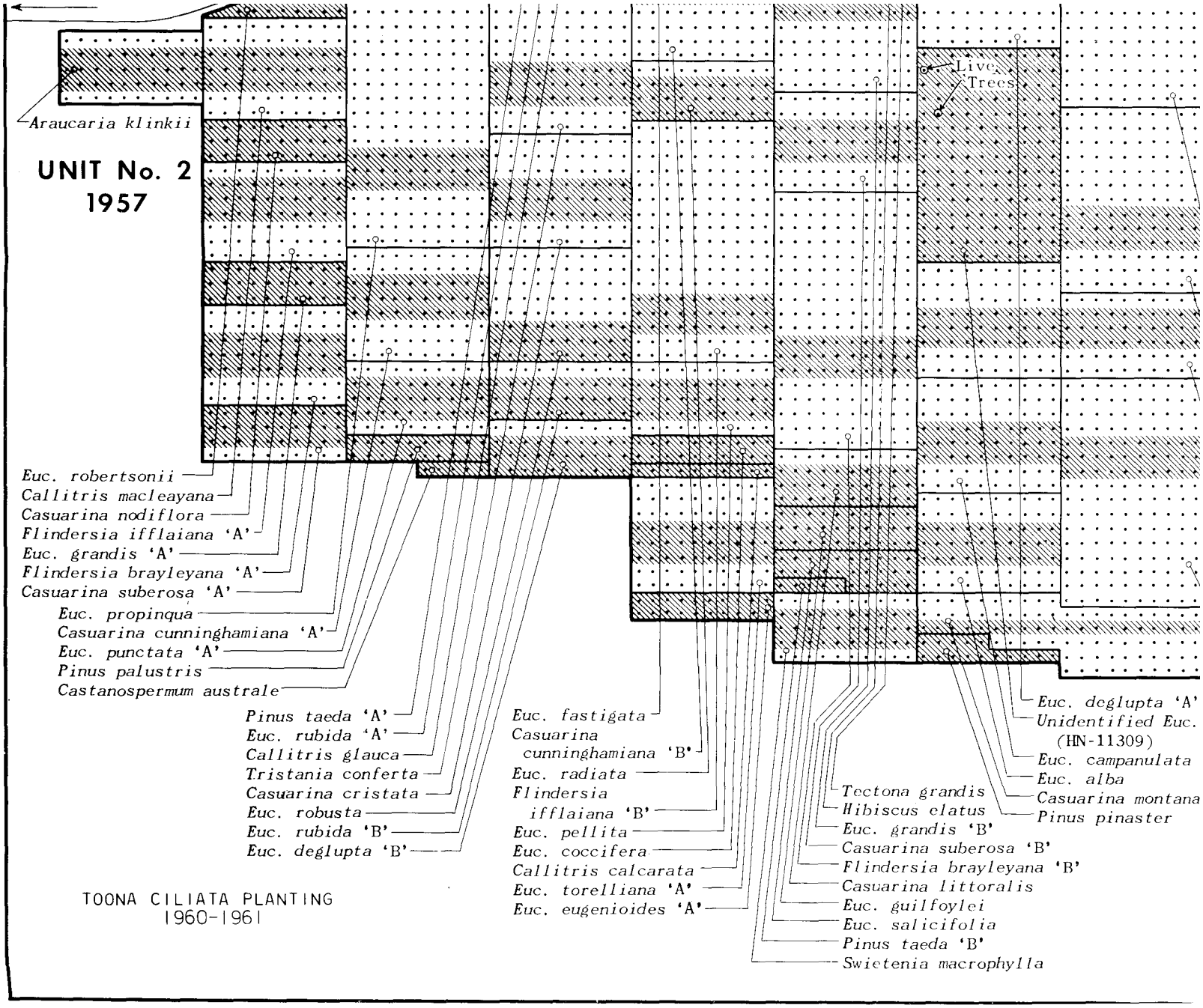
| Common name | Scientific name |
|---|---|
| guava | *Psidium guajava* L. |
| honohono | *Commelina diffusa* Burm. |
| mamaki | *Pipturus albidus* Rock |
| melochia | *Melochia indica* |
| melastome, Malabar | *Melastoma melabathricum* L. |
| neneleau | *Rhus chinensis* var. *sandwicensis* |
| oi | *Stachytarpheta jamaicensis* (L.) Vahl. |
| pluchea Indian | *Pluchea odorata* (L.) Cass. |

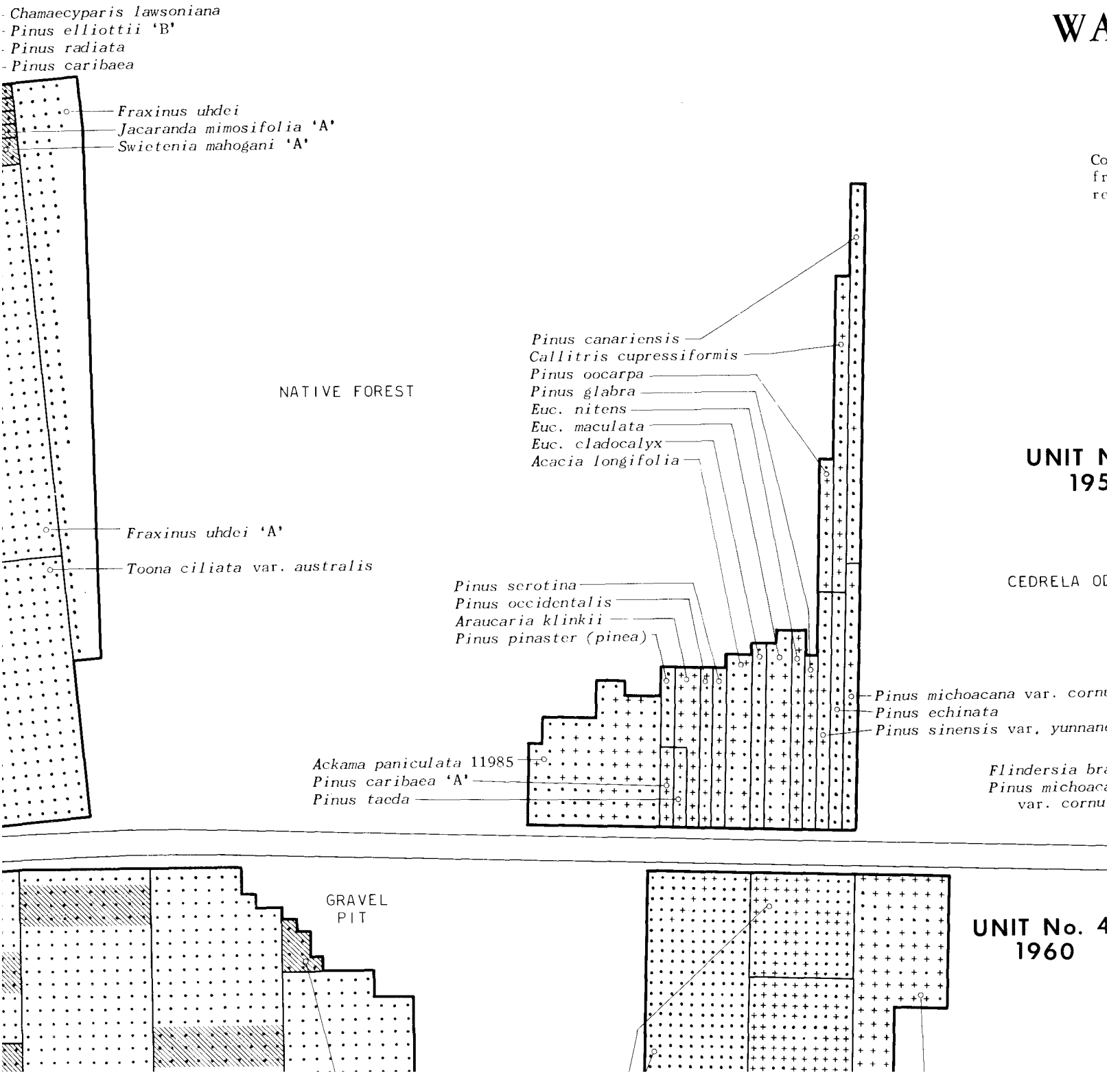
[6] *Eucalyptus bicolor* A. Cunn. ex Hook = *E. largiflorens* E. Muell. *E. bicolor* Woolls = *E. bosistoana* F. Muell.

Local records do not indicate the authority for the name *E. bicolor* and it is not known which species is meant. Specimens available do not exhibit sufficient characteristics to classify at present.

GPO 967-534


UNIT No. 1
1956
Fraxinus uhdei 'C'
Peltophorum inerme 'A'
Theobroma cacao
Araucaria angustifolia
Pinus elliottii 'A'
Araucaria excelsa
Swietenia mahogani 'B'
Jacaranda mimosifolia 'B'
Khaya nyasica
Peltophorum inerme 'B'
Fraxinus uhdei 'B'
Samanea saman
Good
Poor
Poor
Good
To Kulani Field 33


Araucaria klinkii
UNIT No. 2
1957
Live Trees
Euc. robertsonii
Callitris macleayana
Casuarina nodiflora
Flindersia ifflaiana 'A'
Euc. grandis 'A'
Flindersia brayleyana 'A'
Casuarina suberosa 'A'
Euc. propinqua
Casuarina cunninghamiana 'A'
Euc. punctata 'A'
Pinus palustris
Castanospermum australe
Pinus taeda 'A'
Euc. rubida 'A'
Callitris glauca
Tristania conferta
Casuarina cristata
Euc. robusta
Euc. rubida 'B'
Euc. deglupta 'B'
Euc. fastigata
Casuarina cunninghamiana 'B'
Euc. radiata
Flindersia ifflaiana 'B'
Euc. pellita
Euc. coccifera
Callitris calcarata
Euc. torelliana 'A'
Euc. eugenioides 'A'
Tectona grandis
Hibiscus elatus
Euc. grandis 'B'
Casuarina suberosa 'B'
Flindersia brayleyana 'B'
Casuarina littoralis
Euc. guilfoylei
Euc. salicifolia
Pinus taeda 'B'
Swietenia macrophylla
Euc. deglupta 'A'
Unidentified Euc. (HN-11309)
Euc. campanulata
Euc. alba
Casuarina montana
Pinus pinaster
TOONA CILIATA PLANTING
1960-1961




WA

Co
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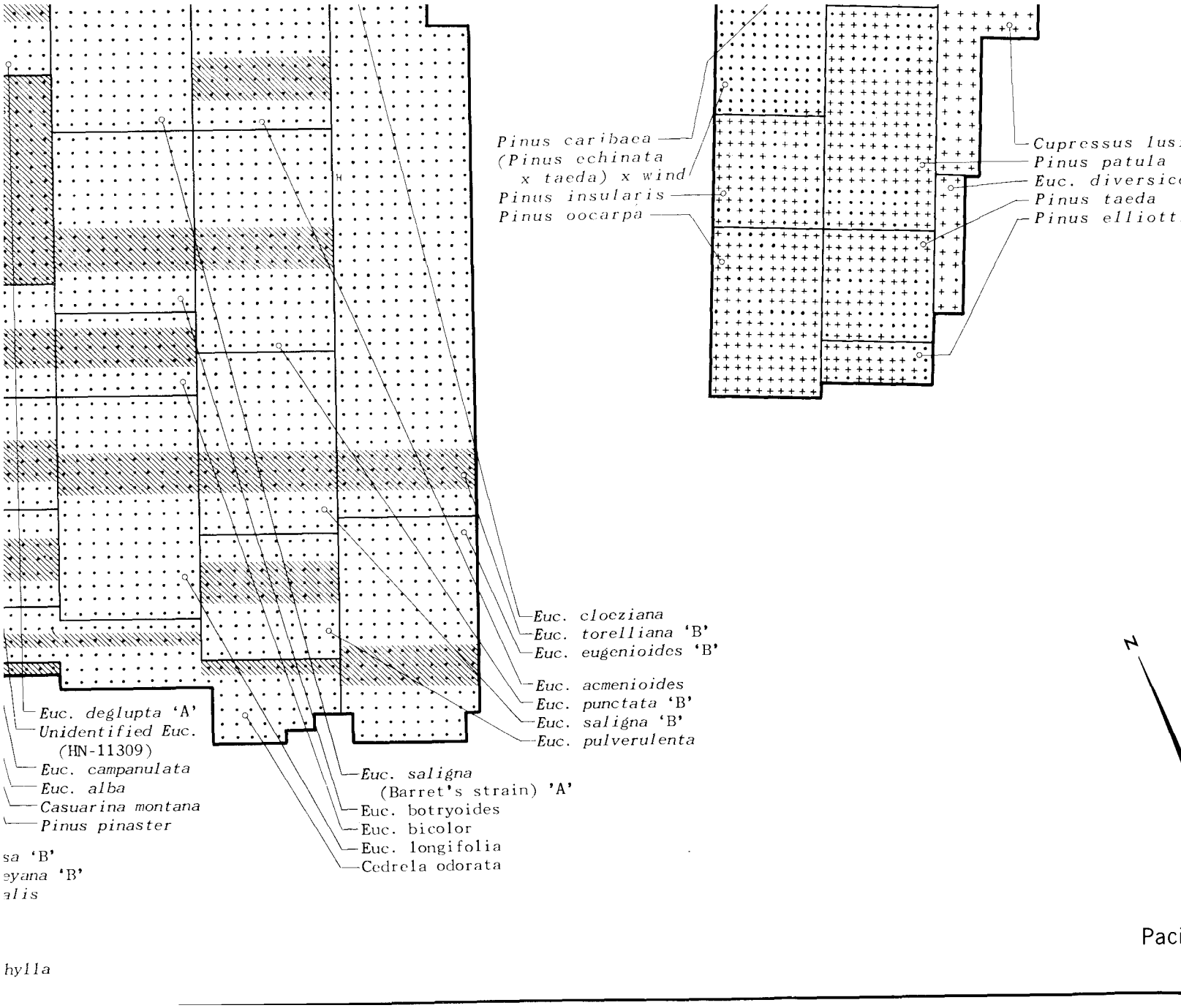
UNIT N
195

CEDRELA OD





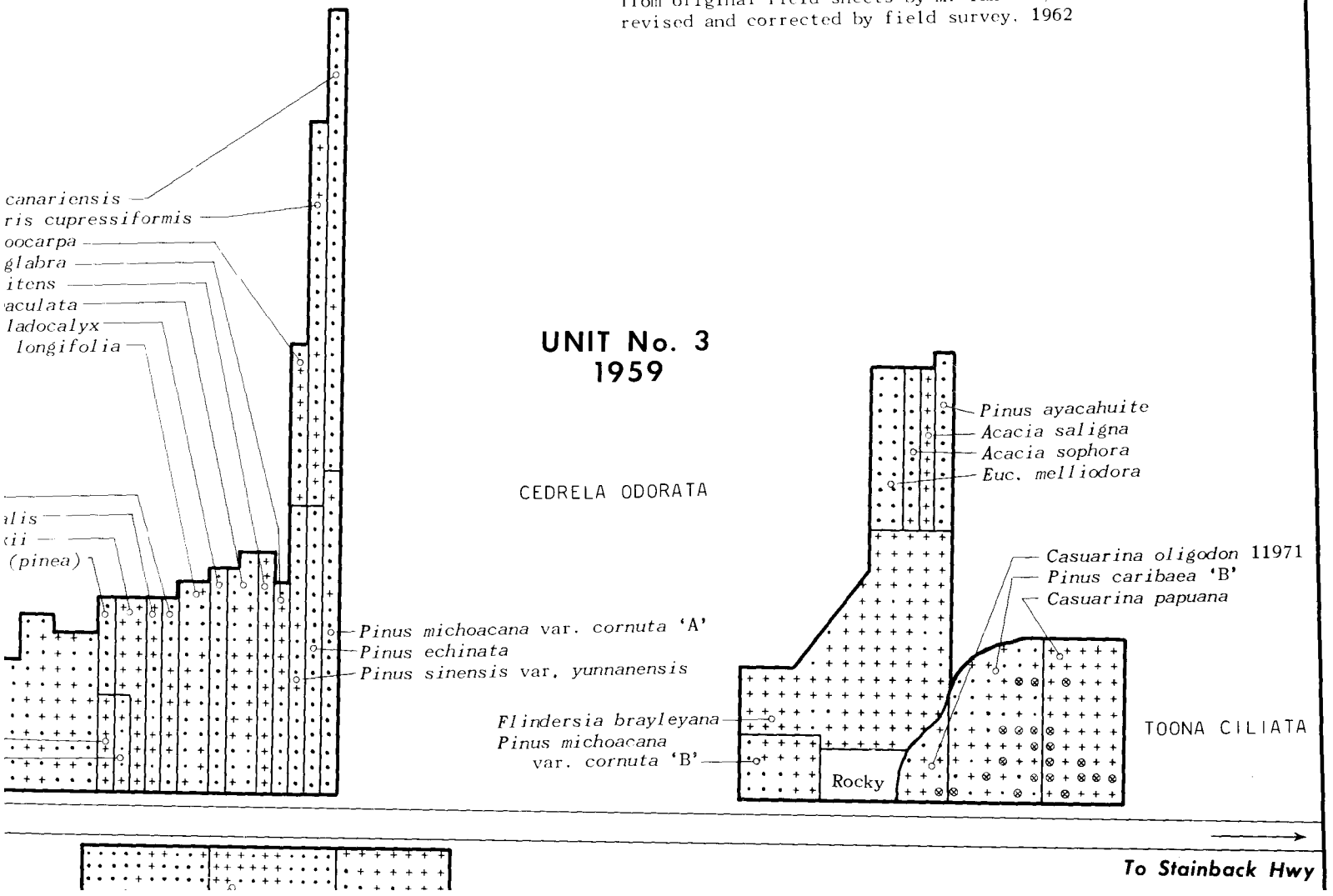

UNIT No. 4
1960

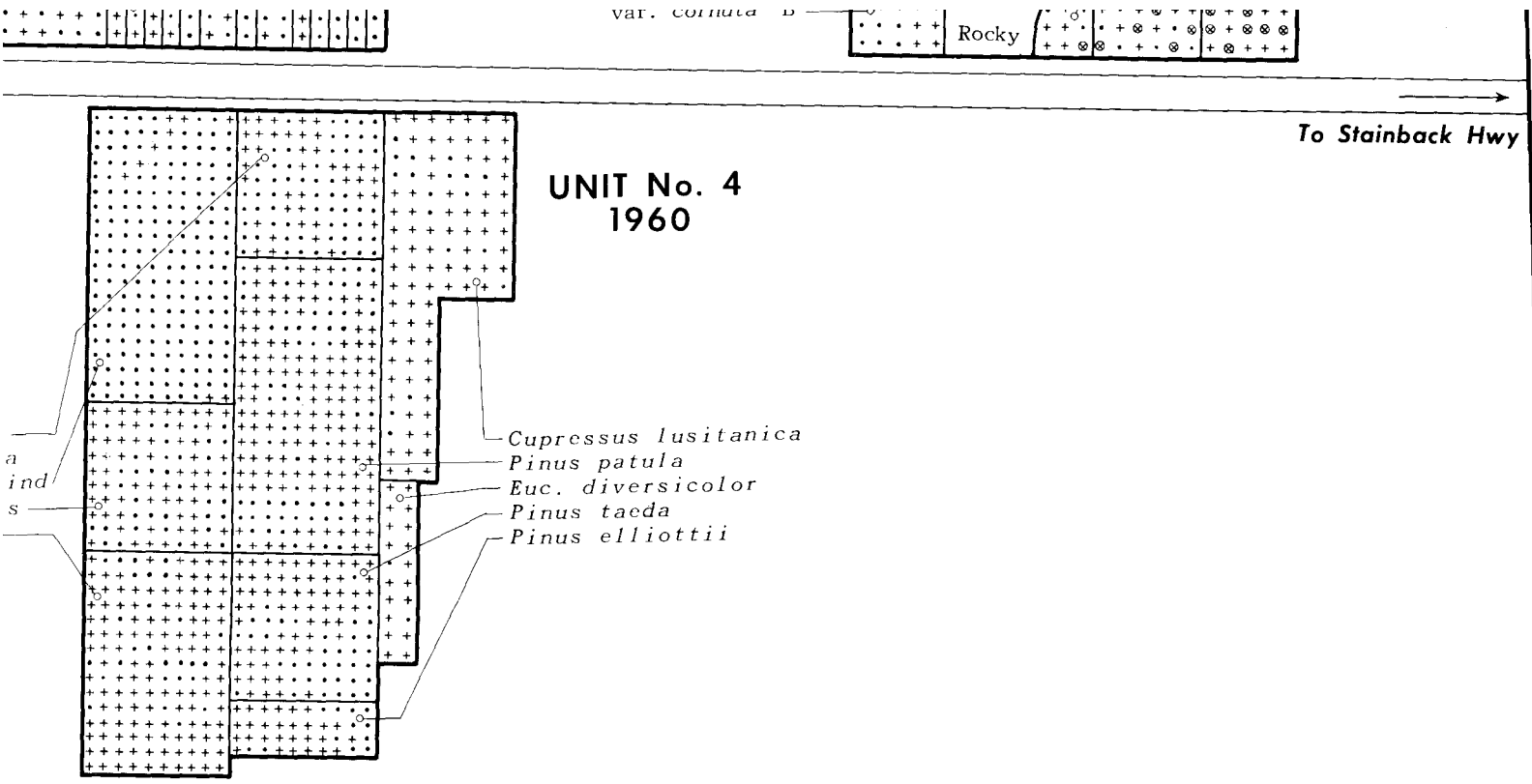

Pinus caribaea
(Pinus echinata
x taeda) x wind
Pinus insularis
Pinus oocarpa
Cupressus lusi
Pinus patula
Euc. diversico
Pinus taeda
Pinus elliott
Euc. cloeziana
Euc. torelliana 'B'
Euc. eugenioides 'B'
Euc. acmenioides
Euc. punctata 'B'
Euc. saligna 'B'
Euc. pulverulenta
Euc. deglupta 'A'
Unidentified Euc.
(HN-11309)
Euc. campanulata
Euc. alba
Casuarina montana
Pinus pinaster
Euc. saligna
(Barret's strain) 'A'
Euc. botryoides
Euc. bicolor
Euc. longifolia
Cedrela odorata
sa 'B'
eyana 'B'
alis
hylla
N
Paci

# WAIAKEA ARBORETUM

Hawaii Forestry Division

Compiled by G. D. Pickford and G. B. Richmond
from original field sheets by M. Takaoka,
revised and corrected by field survey. 1962






a
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a
na 'B'
des 'B'

des
'B'
'B'
enta

LEGEND

- Planted tree
- H or ⊗ No hole
- \+ Survivor(Units 3 & 4)
- Limit of measured block (Units 1 & 2)

N

0 80 160 240 feet

Pacific Southwest Forest and Range Experiment Station
Berkeley, California