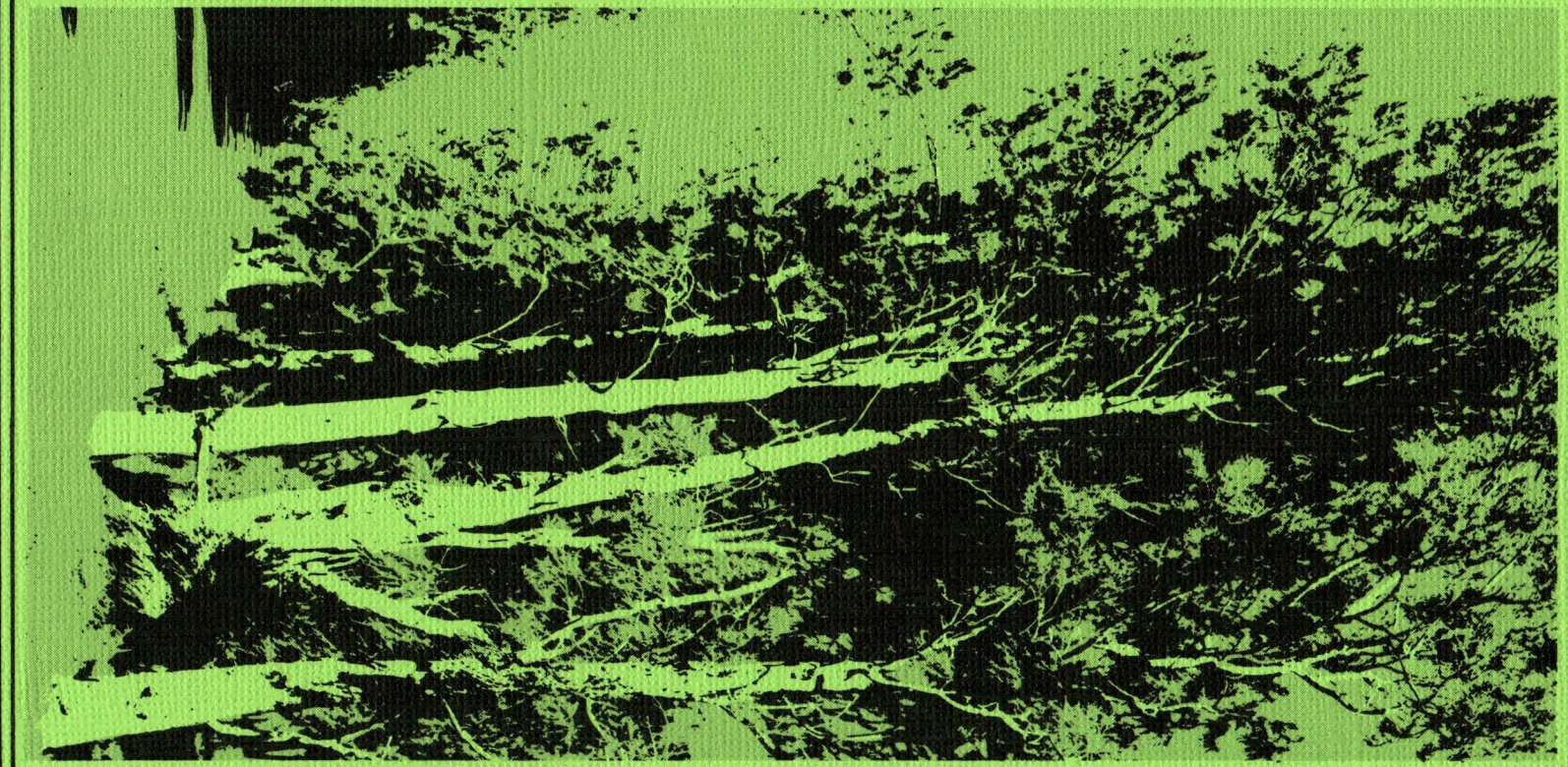
TREES AND SHRUBS FOR windbreaks in hawaii



Cooperative Extension Service University of Hawaii Circular 447

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TREES AND SHRUBS FOR WINDBREAKS IN HAWAII

Gordon T. Shigeura and Wade W. McCall

Introduction

Hawaii's normal tradewinds blow 250 days or more each year, averaging 8 to 20 miles an hour with occasional gusts of 40 miles an hour or more. In addition to the normal northeasterly trades, storm winds from other and varied directions with velocities up to 80 miles an hour or more may occur. These winds affect all areas in the state and make advisable the use of barriers or windbreaks for the protection of crops, animals, and people. Windbreaks protect plants from the adverse effects of wind on growth, pollination, and shape of trees and they can prevent breakage of limbs and other parts of the crop plant. They protect animals from the discomfort of wind and allow them to make more thrifty use of food and environment. They protect the soil from erosion and reduce air pollution due to wind-carried soil and other materials. Windbreaks also help protect people so they may live more comfortably, and work more easily. In addition, plants used for windbreaks beautify and improve the environment and reduce noise pollution.

Windbreaks may be either planted trees or shrubs or constructed materials which provide the necessary protection.

The purpose of this publication is to provide information needed for selection of plants suitable for windbreak use in Hawaii. Species of windbreak plants are grouped into three categories: (1) Tall, upright trees primarily adapted for orchard or shelter belt use; (2) small trees and shrubs for use in the protection of small crops, vegetables, and homesites; and (3) salt-tolerant trees and shrubs used primarily as salt-wind barrier or in shoreline landscaping. In addition, miscellaneous plants suitable for windbreak use are listed. Species in each category are given in alphabetical order of common names.

TALL, UPRIGHT TREES

Brisbane boxwood
Tristanea conferta **R. Br.**
(Figure 1)

An upright, low-branching, dense tree capable of growing as high as 100 feet in 10 years. It is a very versatile tree adapted to the various soil and rainfall conditions found in Hawaii. It is very drought tolerant and especially adapted to dry areas. The root system is strong and massive. Where desirable, the trees can be topped, or some of the large lateral limbs can be cut back to permit new watersprout growth that serves exceedingly well as a low windbreak. Because of its regrowth and low branches, the boxwood can also be used as an outside row tree in a multiple row windbreak, or by itself in its own multiple row windbreak. Propagation is by seeds. Recommended space between plantings is 10 to 15 feet in the row and 10 to 15 feet between rows.

Chinese fir
Cunninghamia lanceolata **Hook.**
(Figure 2)

A handsome, dense, upright, pyramidal, and very ornamental evergreen capable of attaining heights of 100 feet or more. It is very well adapted to elevations above 2,000 feet in Hawaii. The leaves are sharply pointed and can become a nuisance in handling. The foliage on the lower branches, which persists for a long time, makes it an excellent windbreak as well as an animal barrier when so used. It can be planted by itself in a single or multiple row windbreak, or it can be planted with *Cryptomaria japonica* as the center tree in a multiple row. Recommended space between plantings is 10 to 15 feet in the row and between rows. Propagation is by seeds.

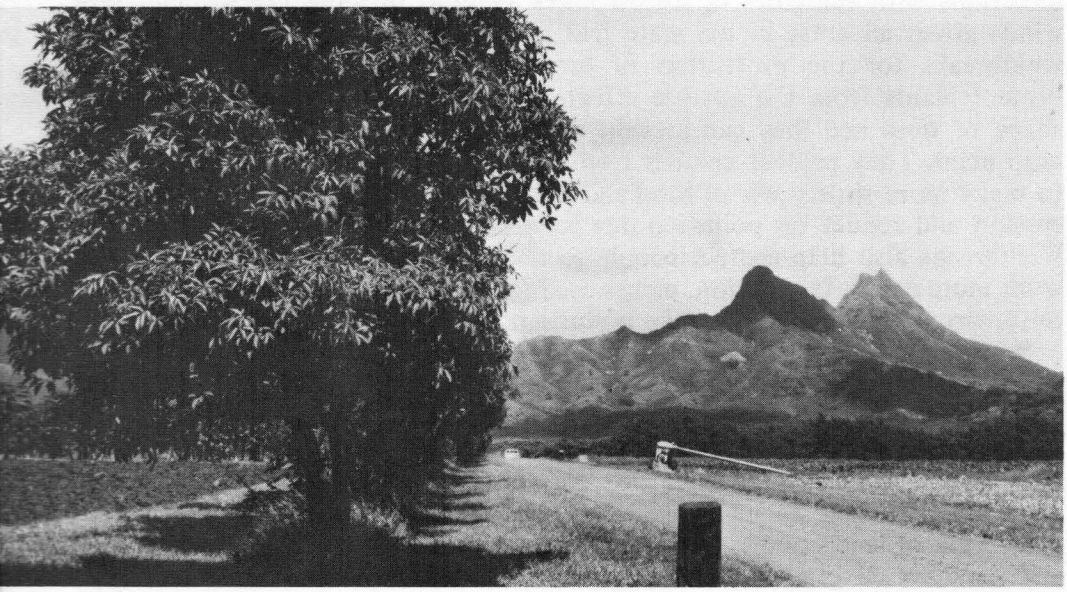

Figure 1. A single row windbreak of Brisbane boxwood, *Tristanea conferta*, with well-foliaged lower branches affording excellent protection to papaya.

Figure 2. Chinese fir, *Cunninghamia lanceolata,* particularly well adapted to higher elevations in the state.

Figure 3. Full-foliaged Japanese sugi, *Cryptomaria japonica,* used to give complete protection to a ranch house in the Volcano area on the Island of Hawaii.

Japanese sugi
Cryptomaria japonica **Dow.**
(Figure 3)

A highly ornamental, pyramidal evergreen in the Orient, growing well in the islands above 1,500-foot elevations. In the upper elevations in Hawaii where species choice is limited, it serves as a good windbreak with branches low on the tree trunk. It can attain heights of 75 feet and should be spaced about 10 feet apart, either in single or multiple rows. In a multiple row windbreak it may be planted as an inside row tree along with *Cunninghamia lanceolata* as the outside row tree. It requires heavy fertilization on poor soil. It is relatively insect- and disease-free. Excellent rows of trees are growing on the main highway at Volcano, 29½ miles from Hilo. Propagation is by seeds.

Java plum
Eugenia cuminii **Lam. syn.** *E. jambolana*
(Figure 4)

A dense, medium-sized tree with glossy-green lanceolate leaves, and one of the better windbreak trees to use in Hawaii by itself or in a multiple row windbreak. It is capable of becoming 70 feet high in 10 years with reasonably good care. It is a very efficient grower under adverse conditions of soil and drought. It also grows along the seashore and is somewhat salt tolerant. Although the small stems high on the tree do break off, the main structural branches can withstand strong winds. Regrowth at the small breakage develops bushier and heavier canopies, making for a totally better windbreak. Java plum has a strong root system which does not seem to compete with crops growing nearby. Generally a low-elevation plant, it thrives very well below 1,500-foot elevations; at 2,500 feet it does not grow very well. Propagation is by seeds. Recommended space between plantings is 5 to 10 feet.

Figure 4. A row of Java plum, *Eugenia cuminii*, used to protect a macadamia nut orchard. Note the dense, low-foliaged characteristic of the species.

Lawson's cypress
Chamaecyparis lawsoniana **(Andr.) Parl.**
(Figure 5)

A dense tree suitable for use at higher elevations in Hawaii, usually about 50 feet high, and growing very luxuriantly between 2,500- and 6,000-foot elevations. Its branches are dense, spreading, and persistent. Its pyramidal habit of growth, with full branches down to ground level, makes it choice for use as an outside row tree to give low protection in a multiple row windbreak, together with another tall species for the center row. It can also be used by itself in a single row windbreak. It should be spaced 10 to 15 feet apart in the row. The tree can be planted on marginal soil, and it responds to heavy fertilization. It is relatively insect- and disease-free. Propagation is by seeds.

Long-leaf ironwood
Casuarina glauca **Sieb.**
(Figure 6)

In general growth and appearance *Casuarina glauca* resembles *C. equisetifolia,* the short-leaf ironwood. The major differences are that this species has needles about 1 to 1½ feet long or twice as long as needles of *C. equisetifolia,* and that it propagates very easily from exposed or damaged root runners. This latter characteristic limits its general use as windbreak to planting in open areas where ground and slope coverage is important and the tendency to propagate by root is unimportant. The species, attaining heights of about 100 feet, grows very well up to about 3,000-foot elevations in Hawaii. At Honokaa Sugar Company long-leaf ironwoods were planted on the exposed ridges running down the hillside to protect the macadamia trees. After 30 to 40 years of growth the windbreak trees are now badly crowding the macadamia trees in some areas by spreading through root propagation. A systematic effort is being made to eliminate the crowding windbreak. The species is also especially salt tolerant and may be used along exposed coastal area as a shade tree or a salt-wind barrier. In especially windblown areas, this species can serve as an erosion-control plant. The tree is very hardy and does not seem to be affected by insects or diseases. Propagation is by seeds or root runners. When used in a row-type windbreak, recommended space between plantings is 10 to 15 feet.

Figure 5. Lawson's cypress, *Chamaecyparis lawsoniana,* used as a thick barrier in Kamuela, Hawaii.

Figure 6. Long-leaf ironwood, *Casuarina glauca,* planted at Honokaa on the exposed knolls and ridges to protect macadamia nut trees.

Figure 7. Mango, *Mangifera indica,* planted along homesite boundary for protection as well as for the fruits they bear.

Figure 8. A single row windbreak of Monterey cypress, *Cupressus macrocarpa,* used to protect vegetable crops in Kamuela. Note the low and dense branches touching the ground.

Mango
***Mangifera indica* L.**
(Figure 7)

A large, erect, spreading tree, 30 to 90 feet high with luxuriant dense foliage that can serve as a good wind barrier. The tree is very strong with a massive surface root system not easily uprooted. The branches are very difficult to break even in a severe windstorm. In Hawaii, the mango is generally a low-elevation tree suited to warm climate, planted primarily for the fruits. However, because of its delicious fruits, some trees are found growing up to 1,000-foot elevations on Oahu and 2,000-foot elevations in Kona. Although mango is not recommended for planting as a windbreak, when it is found growing on the land to be cultivated it should be used, even temporarily, until the planted windbreaks are established. Propagation is by seeds.

Monterey cypress
***Cupressus macrocarpa* Hartw.**
(Figure 8)

A horizontally branched, spreading evergreen which may attain heights of 70 feet when grown under ideal conditions. This tree is used extensively in windbreak plantings in Kamuela and seems to be well adapted to areas above 2,000-foot elevation. It does not grow as rapidly as *C. lusitanica* and is more bluish-green in leaf color. This species seems to have weak roots that do not penetrate or fracture rocky subsoils. It tends to blow over very easily in a mild windstorm. In spite of this weakness it may be used in a multiple row windbreak in higher elevations as the outside tree because of its persistent lower branches. Recommended space between plantings is 10 to 12 feet. Propagation is by seeds.

Natural Forest Stand
(Figure 9)

Generally, orchards in Hawaii are on marginal land made up basically of aa or soft pahoehoe lava which must be cleared and/or rooted with a bulldozer. Lands overgrown with tall shrubs, such as guava *(Psidium guayava),* firebrush *(Myrica faya),* melastoma *(Melastoma malabathricum),* and Christmas berry *(Schinus terebintifolia),* and submarginal for sugarcane or pineapple production or ranching are now being reclaimed for orchard use. Although using the natural stand of vegetation on the land as windbreak is not considered the best procedure to follow, it has repeatedly been shown to be very desirable and beneficial. Using the natural stand of ohia lehua trees *(Metrosideros collina,* sub sp. *polymorpha)* in the Puna area (Figure 9) for protecting papaya trees has proved beneficial. In the Volcano area, the natural mixed vegetation with ohia predominating has been a very effective windbreak. In the Kau area the Christmas berry bush has been very effective in reducing losses to vegetable crops. The value of using natural vegetation for windbreaks, whenever possible, cannot be overemphasized. This practice is recommended for permanent windbreaks as a temporary measure while a permanent planted windbreak is being established.

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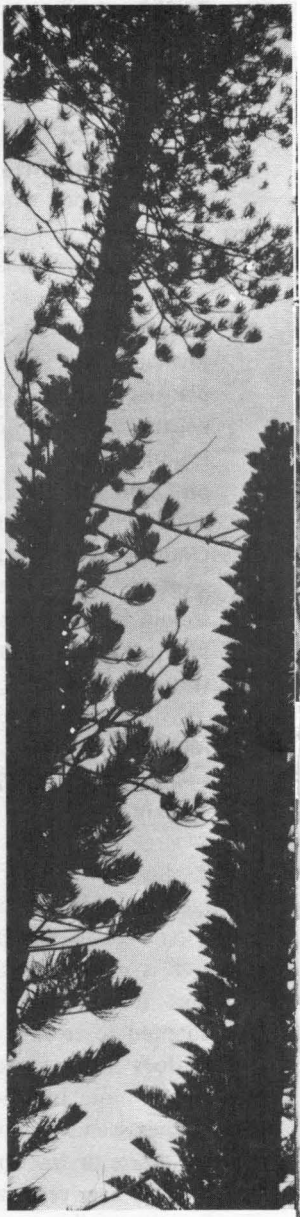

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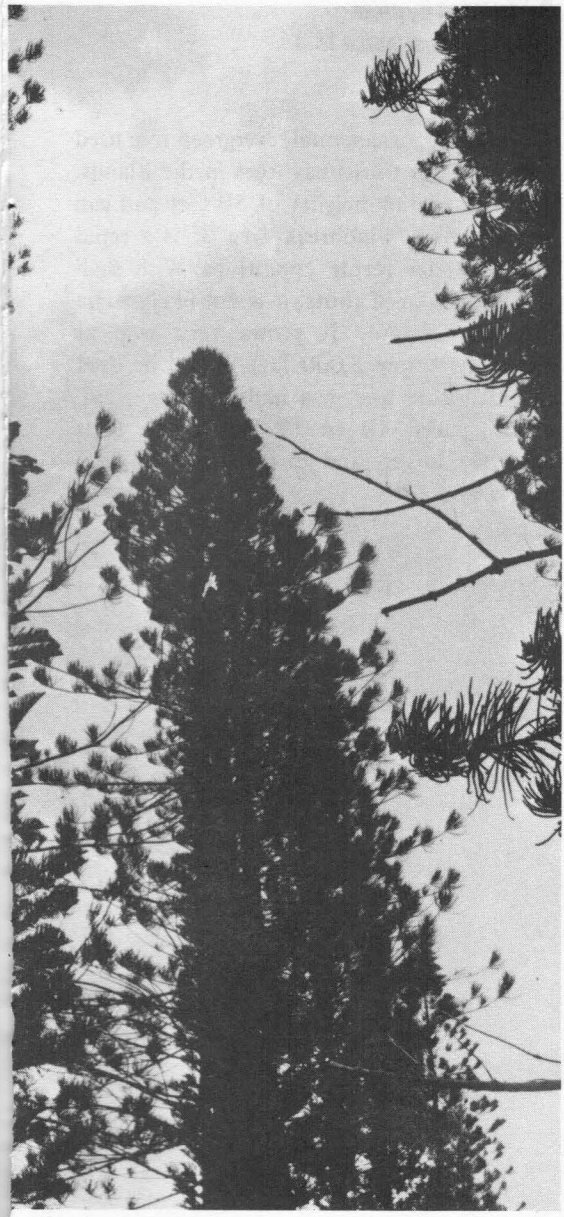
Figure 9. Papaya trees being protected by a natural forest stand, made up primarily of ohia lehua trees, left standing when the forest was cleared for papaya planting.

Figure 10. Twenty-year-old Norfolk Island pines, *Araucaria excelsa*, used to protect macadamia nut trees at Keaau Orchard.

Figure 11. Norfolk Island pines, *Araucaria excelsa*, showing shorter regrowth branches on bole stripped by strong wind.



Norfolk Island pine
***Araucaria excelsa* (Lamb) R. Br.**
(Figures 10, 11)

A handsome, columnar, cone-shaped tree with flat lateral branches in whorls spaced at regular intervals throughout the entire length of the tree trunk. The spaces between whorls of branches may be as wide as 18 inches. Although the tree establishes itself slowly at first, growth is comparatively rapid after the first 3 or 4 years. The Norfolk Island pine responds to heavy fertilization when grown in poor soil. Under good growing conditions, as in Puhi, Kauai, the trees at maturity become 150 feet tall with a trunk diameter at the base of 3 feet. This species does very well up to 3,000-foot elevations. In the cold Volcano area at 4,000 feet, growth is slow and subnormal. When exposed to hurricane winds the windward branches may be stripped or broken off at the bole, or the tree terminal can be completely snapped off or decapitated (Figure 11). New growth at these breakages does occur, forming stubby and dense lateral branches and multiple terminal growths. This species is extremely drought resistant and salt tolerant. Occasionally, Norfolk Island pines are found growing only a few feet away from the ocean waves. The species is relatively insusceptible to insect or disease injury and very easy to grow. A yet-to-be-identified gummy exudation, although not too severe, has been found on trees at Keaau Orchard. Norfolk Island pine is especially adapted for use by itself, or as the center row tree in a multiple row windbreak, spaced 10 to 15 feet apart in the row and between rows. Propagation is either by seeds or terminal cuttings. Seeds should be harvested and planted in loose sand or in a good compost mixture while still green. The viability of dry brown seeds is considerably less than that of green seeds. Seed trees should also be marked since seed viability seems to vary from tree to tree.

Paper bark
Melaleuca leucadendron **L.**
(Figure 12)

A medium-sized tree, conspicuous for its many layers of spongy bark, used extensively for windbreaks in Hawaii. It is not adapted to marshy conditions where *Eucalyptus robusta* grows well, nor is it adapted to aa lava where average rainfall is less than 80 inches per year. The roots are surfaced and can become a nuisance and a hindrance when the trees are used as a windbreak for vegetable crops. With macadamia, which tends to be deeper rooted, paper bark seems to be compatible even at close planting. Paper bark can be planted in a multiple row windbreak by itself or as an outside row tree in multiple rows with other species in the center row. Under ideal conditions the tree can attain heights of 75 feet in 15 years. The paper bark can be pruned when desired to form a windbreak closer to the ground (Figure 12). It grows well up to 2,500-foot elevations. The spongy bark is very combustible and can become a fire hazard. Propagation is by seeds. Recommended space between plantings is 5 to 8 feet.

Portuguese cypress
Cupressus lusitanica **Mill**
(Figure 13)

A spreading, ornamental, evergreen tree used especially for Christmas trees in the islands. The tree attains heights of 50 feet and can be used as a windbreak tree. It is a rapid grower under fertile conditions. With shallow and surfaced roots, it is not likely to be drought tolerant. It grows very well at elevations below 3,000 feet. It can be used as an outside tree in a multiple row windbreak spaced 10 to 12 feet apart. It is relatively insect- and disease-free. Propagation is by seeds.

Figure 12. Paper bark, *Melaleuca leucadendron*, closely planted and trained to afford low protection.

Figure 13. Portuguese cypress, *Cupressus lusitanica*, used to protect macadamia nut trees at Keaau Orchard.

Red ironbark
Eucalyptus sideroxylon **Cunn.**
(Figure 14)

A very drought-resistant eucalyptus capable of growing in very poor and dry soil. This species can be identified by its brownish-black bark starting at the base of the tree, progressively going up the bole as the tree matures. Being a much slower grower than the other eucalypts, it should be planted as an outside row tree in a multiple row windbreak and spaced about 7 to 8 feet apart. The species grows well up to 4,000-foot elevations. A beautiful stand of red ironbark can be seen on the highway to Kona—just beyond the Saddle-Waimea Road junction. Propagation is by seeds.

Short-leaf ironwood
Casuarina equisetifolia **L.**
(Figure 15)

A rapid-growing tree which can attain heights of 100 feet in 10 years and particularly good as the center row tree in a multiple row windbreak. When so used it should be spaced 10 to 15 feet apart in the row. Its open, light, and feathery drooping branches form a canopy of foliage which tends to sway and "hum and whistle" even with a light wind blowing through it. Usually found below 2,500 feet, this species is very tolerant to salt breezes, also very drought resistant. It grows very well in all types of soil, particularly well in brackish and alkaline soils where only a few species can survive. On exposed and rocky lands it responds to fertilization. The accumulation of old leaves under the tree seems to inhibit germination of weed seeds. Its root system is massive and aggressive but primarily on the surface and does not seem to compete in growth with macadamia trees. Unlike *C. glauca*, long-leaf ironwood, this species does not propagate new plants from root runners. Majestic rows of short-leaf ironwood grow along the mountain road to Kohala (Figure 15) and a beautiful stand of trees flourishes throughout MacKenzie Park in Puna. The tree is relatively disease- and insect-free and very easy to grow. Propagation is by seeds or volunteer seedlings found close to the growing trees.

Figure 14. Red ironbark, *Eucalyptus sideroxylon,* used in a multiple row windbreak in the dry areas of Kau.

Figure 15. Short-leaf ironwood, *Casuarina equisetifolia,* on both sides of the mountain road to Kohala.

Silver oak, silky oak
***Grevillea robusta* Cumm.**
(Figure 16)

A handsome, upright tree, very drought resistant, which will grow well even when neglected. It can attain heights of 150 feet with reasonable care in deep soil and responds to fertilization in poor soil. In the exposed, dry, eroded hillside slopes of Waimea, Kauai, the trees are growing relatively poorly. It does very well up to 3,000- to 4,000-foot elevations. In dense plantings the trees tend to lose their lower branches, which results in trees with tall canopies supported by branchless boles 15 to 30 feet tall. The root anchorage is exceedingly strong, so that occasionally stem or bole breakage rather than uprooting of trees occurs in a windstorm. It is an excellent center tree in a multiple row windbreak with a bushier tree on the outside row. Recommended space between plantings is 12 to 15 feet. Production of seeds begins when the trees are very young. Viability of seeds in pasture and open terrain is so good that the tree can become a weed and a nuisance if not controlled. Propagation is by seeds.

Small cone ironwood
***Casuarina cunninghamiana* L.**
(Figure 17)

This species is quite similar to the *C. equisetifolia* or short-leaf ironwood in its open growth habit, and can be used as a center row tree in a multiple row windbreak spaced 10 to 15 feet apart. It is a fast-growing tree reaching heights of 70 to 80 feet and very highly wind resistant. Its drooping branches hang down under the weight of the densely matted needle clusters at the branch ends. The needles are shorter, finer, and more bluish-green than those of *C. equisetifolia.* The tree grows very well on soils of poor fertility, an indication of its massive, penetrating root system. It grows well below 2,000 feet and seems to be both drought and salt tolerant. It also seems to be quite free from disease or insect infestations. Propagation is by volunteer seedlings or by seeds. This species does not propagate by root runners.

Figure 16. A row of silver oaks, *Grevillea robusta*, growing along the old highway at Pahala and now used to protect the recently planted macadamia nut trees.

Figure 17. Small cone ironwood, *Casuarina cunninghamiana*, growing extremely well in the high-rainfall Hilo area. (Photograph courtesy H. C. Shipman.)

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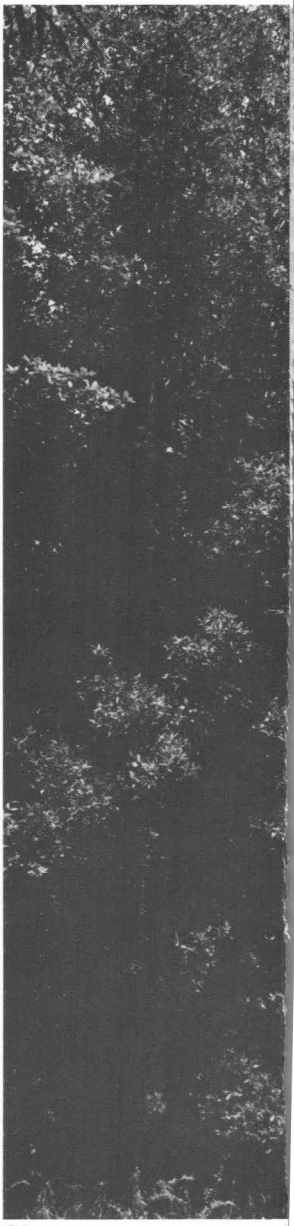

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Figure 18. A dense row of swamp mahogany, *Eucalyptus robusta*, used on the ranges in Kamuela to protect cattle.

Figure 19. A eucalypt topped and pruned to give needed protection at the base of windbreak row.

Figure 20. The dense foliage of a row of turpentine trees, *Syncarpia laurifolia*, provides protection to macadamia nut trees in Kohala, Hawaii.

Swamp mahogany
Eucalyptus robusta **Sm.**
(Figure 18)

A tall, symmetrical tree that, although particularly adapted to wet and swampy conditions, grows very efficiently under all soil conditions found in Hawaii. Swamp mahogany is a very fast grower that can be topped and pruned to produce succulent water sprout growth to give added protection at the base of tree (Figure 19). Although an excellent center row windbreak tree, the main bole sometimes breaks in a strong wind. However, after a period of time regrowth at the breakage point makes the tree an excellent windbreak affording better coverage and protection. The swamp mahogany does well up to 4,000 feet. Propagation is by seeds. Recommended space between plantings is 10 to 15 feet.

Turpentine tree
Syncarpia laurifolia **Ten.**
(Figure 20)

A tall, dense tree which seems to be adapted to the windward area on the Island of Hawaii up to 2,000 feet in elevation. The turpentine tree is a fast grower and can become a dense tree 50 feet high in 10 years. The branches on the lower portions of the tree persist and afford good protection for a long time. It is excellent either as a center or an outside row tree in a multiple row windbreak, or by itself in multiple rows. A very versatile and efficient grower on exposed knolls in Kohala and on volcanic aa at Keaau Orchard. Its strong, aggressive root system does not seem to compete with sugarcane or macadamia nuts growing nearby. Propagation is by seeds. Recommended space between plantings is 10 to 12 feet.

Banana
Musa paradisica **L.**
(Figure 21)

One of the more important commercial fruits in Hawaii. The varieties bluefield, apple, ice cream, and lady finger belong to the group of trees which are 10 to 15 feet high, very aggressive in growth habit, and make dense growth clumps or bunches to provide a good wind barrier. Except bluefield, these varieties are not affected by Panama wilt, *Fusarium oxysporum* form *Cubense*, and can survive even though neglected. With minimum care the species not only thrives and serves as windbreak but produces edible fruits for home consumption or marketing. The banana thrives in heavy rainfall. There seems to be no upper limit to the amount of rainfall that banana will tolerate. In dry areas with rainfall less than 50 inches, irrigation is necessary for optimum growth. Recommended space between plantings is 5 to 7 feet when used primarily as a windbreak. Propagation is with sucker shoots originating at the bases of trees.

Beefsteak, copper leaf
Acalypha wilkesiana **Muell-Arg.**
var. *marginata* **W. Miller**
(Figure 22)

In Hawaii the common names "beefsteak" and "copper leaf" are used to designate the whole genus of *Acalypha*, encompassing the many color forms, varieties, and species of the genus. The performance of each variety differs markedly from the other varieties and only one is suitable for windbreak purposes. The acceptable variety is *marginata.* It has simple, medium-sized leaves, ovate in general shape, with acute to obtuse leaf apex and serrated or saw-toothed leaf margin. The distinctive appearance of *marginata* is that each leaf is fringed with a lighter-colored pinkish margin about ¼ inch wide. With proper trimming and care the shrub can become a dense, solid, and vigorous barrier 12 to 15 feet high. It is very drought tolerant and seems to adjust itself to various soil, water, and growth conditions. It seems also to be able to compete and grow vigorously under a heavy leaf canopy or in competition with the massive tree root system of other species. A striking feature of this variety is that rose beetles, which generally favor acalyphas, do not seem to bother it. It grows well up to 4,000-foot elevations. Propagation is by cuttings. Recommended space between plantings is 2 to 3 feet.

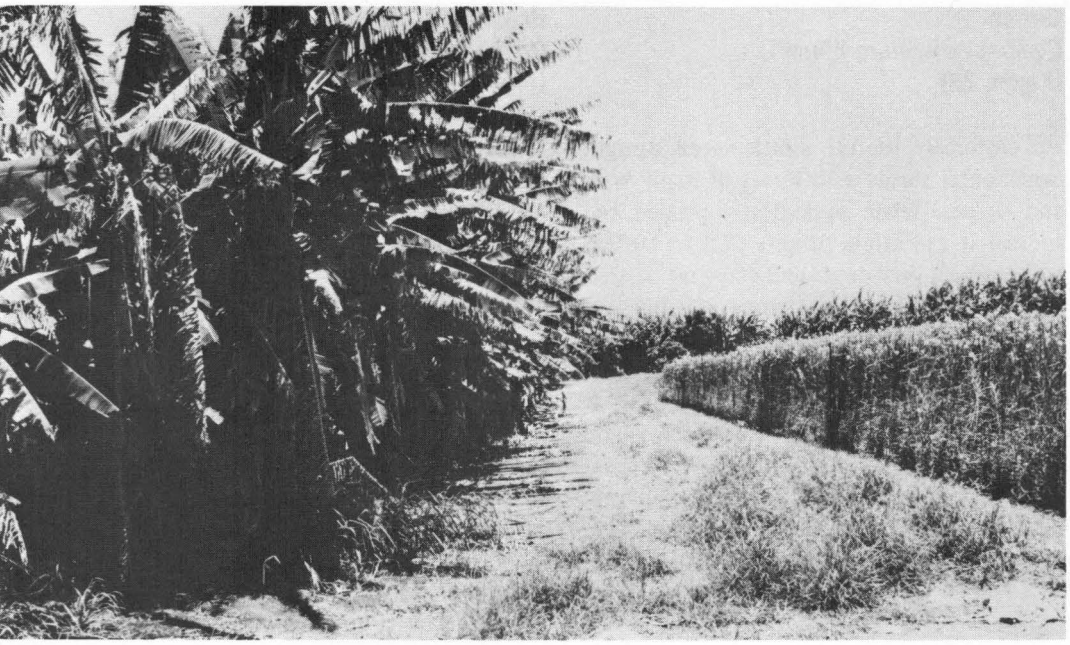

Figure 21. A mixed stand of tall, edible bananas being used to give protection to the very delicate 'Miss Joaquim' vanda orchids in the Hilo area.

Figure 22. Beefsteak plant, *Acalypha wilkesiana* var. *marginata*, used as a low, dense shrub to protect tomatoes.

Croton
Codium variegatum **Blume**
(Figure 23)

An extremely useful, multicolored, upright ornamental shrub with leaves of many sizes and shapes. When periodically pruned and trained it can attain heights of 8 to 10 feet to become a very dense and effective barrier. The shrub prefers rich, loamy soil but can survive and grow under more adverse conditions. The crotons should be given good care with adequate fertilization and watering. It is especially useful around homesites where color, protection, and privacy are desired. Propagation is usually by green or mature wood cuttings. When used for windbreaks, recommended space between plantings is 3 to 5 feet.

Dracaena
Dracaena deremensis warnecki **Engler**
(Figure 24)

The dracaenas are plants that are often mistaken for the cordylines (ti) and pleomeles because of similarity in growth and appearance. Some botanists have divided the general group of dracaenas into three genera distinguished by differences in the flower. Unlike the tis and pleomeles, the warnecki dracaena is more columnar and upright, denser, and more confined in growth habits. It is well adapted to the high-rainfall East Hawaii areas. This plant can be used very advantageously in situations where panax is generally used. It is relatively insect- and disease-free, and will persist and afford excellent protection with proper cultural care for a long time. A related species, *D. fragrans,* is often used in similar situations. Propagation is by stem cuttings 6 to 8 inches long planted in rows 1 foot apart between cuttings.

Figure 23. Croton, *Codium variegatum,* pruned and trained to hedge height affording privacy as well as protection from wind.

Figure 24. *Dracaena deremensis warnecki* used advantageously to protect anthurium flowers in the Puna area of Hawaii.

Golden-fruited palm, areca
Chrysalidocarpus lutescens **(Bory) Wendl.**
(Figure 25)

The areca palm grows in "bunch-grass" clumps of sturdy, upright, and ringed stems which can attain heights of 25 feet or more. The rings on the stem are leaf sheath scars enclosing primitive or aborted leaf buds which do not develop. Exceptions are those buds at the base of the stem clusters which do form new plants to give the palm the bushy effect. The areca is relatively slow-growing and is not recommended as a windbreak plant. However, it should be used when available, until a more suitable and permanent windbreak can be planted in its place. Propagation is by seeds.

Heliconia
Heliconia humilis **Jacq.**
(Figure 26)

A dense ornamental herb about 10 feet high grown especially for its foliage and flower bracts. The dense growth of stems emerging at ground level affords near-perfect wind protection for small crops or for homesites. The rhizomes of the heliconia are not aggressive and are more or less confined, and this adds to its desirability as a windbreak plant. Except for fertilization, very little maintenance is needed when the plant is used primarily as a windbreak. Plants should be spaced 5 feet apart. Old stems may be permitted to die within the growth to serve as its own mulch cover. The plants are disease-free but they may be infested by mealy bugs and scales. Propagation is by root division.

Figure 25. The golden-fruited palm, *Chrysalidocarpus lutescens,* being used along the driveway to a homesite.

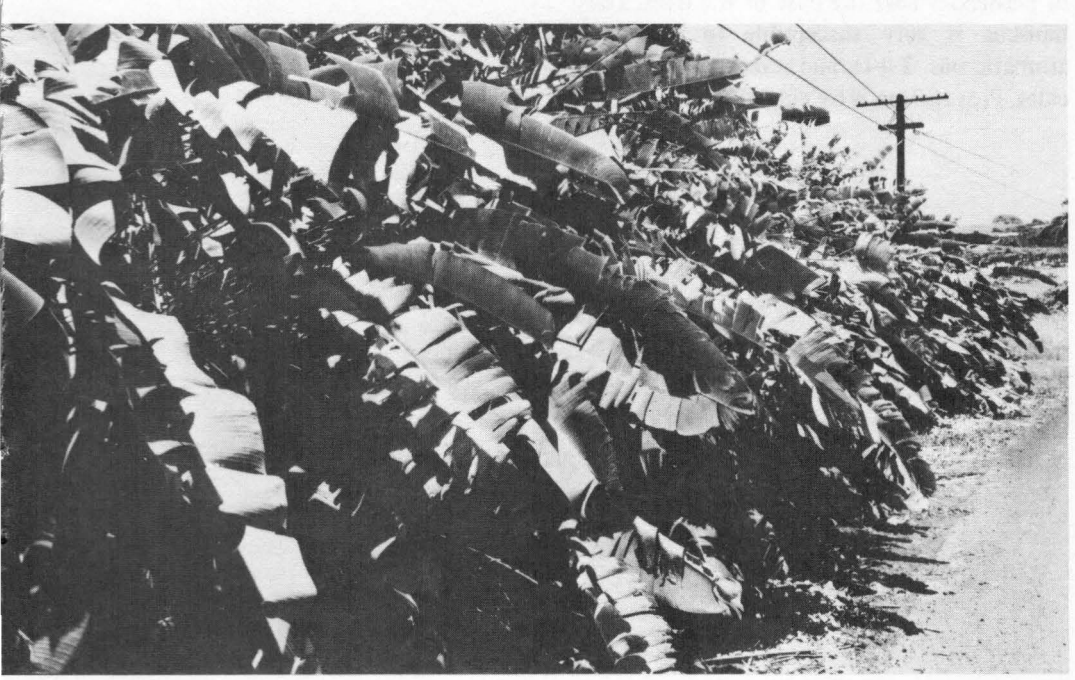

Figure 26. *Heliconia humilis* used for protection of potted nursery plants and erosion control on hillside.

Hibiscus
Hibiscus **sp.**
(Figure 27)

The many varieties of hibiscus are very vigorous, treelike, and profusely growing shrubs which can attain heights of 15 to 20 feet. Although the species thrives best in rich soil, it can survive under a variety of adverse conditions and is used quite commonly as a windbreak or a hedge plant. The species *H. rosa-sinensis* is exceedingly vigorous, and it is not uncommon to find it as one of two surviving shrubs (the other being *Northopanax guilfoylei* Merr.) in old plantation campsites throughout the islands. The tall caney varieties are excellent wind barriers when properly pruned and trained. Recommended space between plantings is 2 feet. Hibiscus, in general, can be grown well up to 4,000 feet in elevation. When used as a windbreak, insect and disease control is a minor problem but extreme care should be taken on the use of herbicides near the base of the trees. The hibiscus is very susceptible to activated aromatic oils, 2,4-D, and several other herbicides. Propagation is by cuttings.

Koa haole
Leucaena leucocethala **(Lam.) de Wit.**
(Figure 28)

Koa haole, a hardy legume, is a common roadside plant in Hawaii, particularly usable in low, arid areas where only a few drought-tolerant plants can be selected for windbreaks. A shrub capable of becoming a small tree 15 to 20 feet high, it can be managed into a small bush 8 to 10 feet high to protect low crops. Its deep tap root permits cropping within 3 to 5 feet of the windbreak row. Somewhat salt tolerant and primarily a low-elevation plant, it can grow satisfactorily in elevations as high as 1,500 feet. Propagation is by scarified seeds. Recommended hedge row spacing is 3 to 5 feet between plantings.

Figure 27. Tall and dense hibiscus used to protect Chinese bananas.

Figure 28. Koa haole, *Leucaena leucocethala (L. glauca)*, affords excellent protection for low and medium-sized crops.

Mock orange
Murraya exotica **L.**
(Figure 29)

One of the most common and popular hedge plants in Hawaii. It grows well in rich, loamy soil but needs liberal fertilization in poor soil. The plant is upright and can grow as high as 12 feet. It can easily be pruned and trained to be an effective windbreak for small crops or homesites. The root system is very strong with both lateral and tap roots going deep into the soil. It is considerably drought tolerant but tends to defoliate under stress of arid conditions. Watering after such a stress brings on new growth which again forms a full barrier. Seedlings should not be planted closer than 2 to 3 feet apart. Propagation is by seeds or terminal cuttings rooted in a mist house.

Oleander
Nerium oleander **L.**
(Figure 30)

A multicolored ornamental, a fast-growing, very durable, and versatile plant with many uses in landscaping. When used as a windbreak for homesites and small crops, the rank development of many branches from the base of the plant should be encouraged. Subsequently, some of this rank growth can be topped or pruned at various heights. Regrowth from these toppings forms a vertical canopy which can become a very effective barrier. Oleander requires deep soil and liberal fertilization and watering for optimum growth and effectiveness. Space between plants should not be very much less than 5 to 6 feet. Mealy bugs and scales often adversely affect the oleander. One or two sprayings of malathion or some other scale and mealy bug insecticide will remedy these conditions. New plants are easily propagated with young stem cuttings.

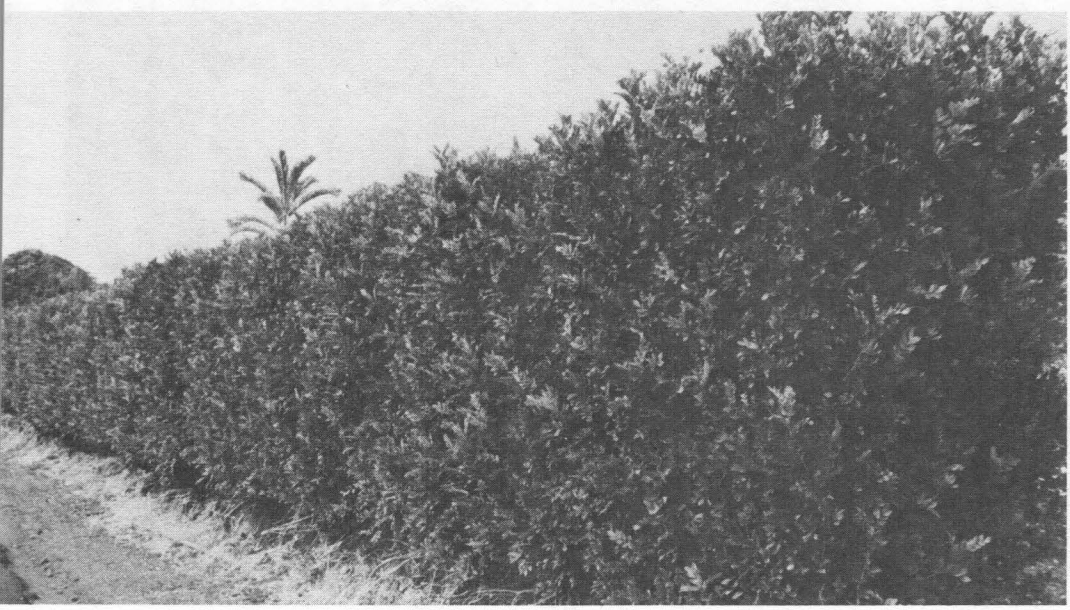

Figure 29. Mock orange, *Murraya exotica*, used as a hedge for privacy, protection, and for its esthetic value.

Figure 30. The many colorful cultivars of oleander, *Nerium oleander*, are used extensively for protection, privacy, beauty, and as a wind barrier.

Figure 31. Panax, *Northopanax guilfoylei*, used along house-lot boundary affording privacy as well as serving as a wind barrier.

Panax
Northopanax guilfoylei **Merr.**
(Figure 31)

One of the best plants to use as a space-economizing wind barrier hedge. The panax can be pruned and trained to any desired height from 3 to 15 feet. The caney stems growing from the original stem cutting form a dense hedge often 6 stems deep or 1½ feet wide. In training the plant to serve as a wind barrier, the long stems are cut at various heights above ground. Full regrowths from these cuttings make this plant effective as a windbreak for small crops and homesites. The panax grows very well even in poor soil and readily responds to good fertilization practice. Except that ground termites can get into the dead wood portion of the stem to destroy the plant, it is not seriously affected by insects. Plantings should be 1 foot apart in the row. Propagation is by cuttings.

Shell ginger
Alpinia nutans **(Andr.) Roscoe**
(Figure 32)

A (very) ornamental plant with individual leafy stems originating at the ground and forming a full and excellent protective barrier 5 to 7 feet high. The rhizomes are not aggressive and spreading as in some other gingers. The species does very well from sea level to 2,500-foot elevations. At sea level it is somewhat salt tolerant. The plant is very versatile and adapts itself well to all types of soil and fertility conditions, and it responds well to fertilization. Old stems may be permitted to die within the growth and serve as mulch cover. It is very insect- and disease-free. Recommended space between plantings is 5 feet. Propagation is by root division.

Figure 32. Shell ginger, *Alpinia nutans*, used as a wind barrier along a track field.

Ti
Cordyline terminalis **(L) Kunth**
(Figure 33)

A common and versatile shrubby plant in Hawaii, grown extensively since early times for its many uses. Ti has always played an important role in the life of the Hawaiians. The leaves were used for house thatch, raincoats, sandals, and hula skirts. They have also served as plates and wrappers for food. In hukilau fishing, the dry leaves are fastened to long dragnets to drive fish to shallow water. From the thick, massive, cormlike roots, high in levulose sugar content, the Hawaiian drink okolehao is made.

The single stem of the ti plant, branched or unbranched, grows as high as 12 to 15 feet. The narrow oblong leaves, 1 to 2 feet long and 5 to 6 inches wide, are clustered at the terminals of the stem. Occasionally, the stem terminal differentiates and forms a flower panicle. This change of growth results in the formation of multiple terminals on subsequent regrowth.

For windbreaks the cane stem terminal cuttings can be planted in single or multiple rows with plants spaced 1 to 2 feet apart in the rows and between rows. In a multiple row planting, stem canes 3 to 4 feet long can be planted in the center row and 1- to 2-foot canes in the outside rows. An effective wind barrier 4 to 5 feet high can be established with reasonable care within 6 months. Density of the windbreak can be controlled by pruning the stems at different heights to force multiple branching that would fill in the void created by such pruning.

The ti is an excellent windbreak for homesites and for the protection of small crops. The roots are basically tap and do not seem to compete with low crops growing within 3 feet of the barrier. It is also very adaptable to the various growth conditions in the islands. In dry areas irrigation is necessary to maintain growth at its optimum. In sandy and rocky areas fertilization and denser plantings may be necessary to produce adequate protection. Propagation is by cuttings.

Wild olive
Olea **sp. syn.** *Olea europa* **L.**
(Figure 34)

The common green wild olive, often used as a broad and deep hedge on the Island of Hawaii, has often been referred to erroneously as *Olea europa,* a plant which has been cultivated for its edible fruit in Europe since Biblical times. The true *Olea europa* is a tall shrub or a small tree occasionally reaching heights of 50 feet. Instead of having glossy green leaves like the wild olive, *O. europa* has leaves that are dull green on the upper surfaces and silvery on the lower. The wild olive of Hawaii is a low, full, and multibranched shrub used mainly as a tall hedge to afford privacy around the homesite and driveways. It does not produce edible fruits. The shrub is very vigorous and grows reasonably well in poor soil or in dry areas. It responds to watering and fertilization very well. When properly pruned and trained it can attain heights of 10 to 12 feet and provides excellent protection as a windbreak. It grows well up to 4,000-foot elevations. Seedlings should not be planted closer than 5 to 6 feet apart in order not to overcrowd each plant. Propagation is by seeds or volunteer seedlings.

Figure 33. Multirow wind barriers of ti, *Cordyline terminalis*, used to give protection to the delicate 'Miss Joaquim' vanda orchid.

Figure 34. Wild olive, *Olea* sp., used along main Kamuela highway to provide privacy and beauty and act as a wind barrier.

SALT-TOLERANT TREES AND SHRUBS

Athel tamarisk
Tamarix aphylla **Karst.**
(Figure 35)

A shrub or small tree about 30 feet high growing especially well on the saline flats in Hawaii. It seems to thrive in high salinity soil. It is found growing very well on the low salt flats in the Kaunakakai area of Molokai and on the shallow, saline, and calcareous soil found along the beaches at Puako on the Island of Hawaii. On the other hand, the tamarisk does not grow well in loamy soil with 50 inches of rain or in aa lava with 80 inches of rain. The tamarisk resembles the casuarinas but with less feathery and shorter leaves clustered on the twigs. Its leaves are grayish-blue instead of green. The tree grows upright. It can be pruned and trained into a low hedge or a full wind barrier 20 feet high. Propagation is by seeds or stem cuttings.

Beach heliotrope, tree heliotrope
Messerschimidia argentea **(L.F.) Johnston;**
synonym, *Tournefortia argentea* **L.**
(Figure 36)

A small, wide, umbrella-shaped tree 20 feet in height found growing along the seashore. It is quite tolerant of salt breezes and saline soil conditions. The bark is deeply furrowed and the leaves, covered with silky white hairs, are clustered at the thick ends of branches. The tree is one of the few species that may be planted on shoreline properties for windbreak or landscape purposes. With its bland foliage the tree is gracefully attractive and lends itself very well to mixed plantings including other colorful foliage plants. The beach heliotrope may be mass-planted and the branches permitted to intertwine. Recommended space between plantings is 3 to 5 feet.

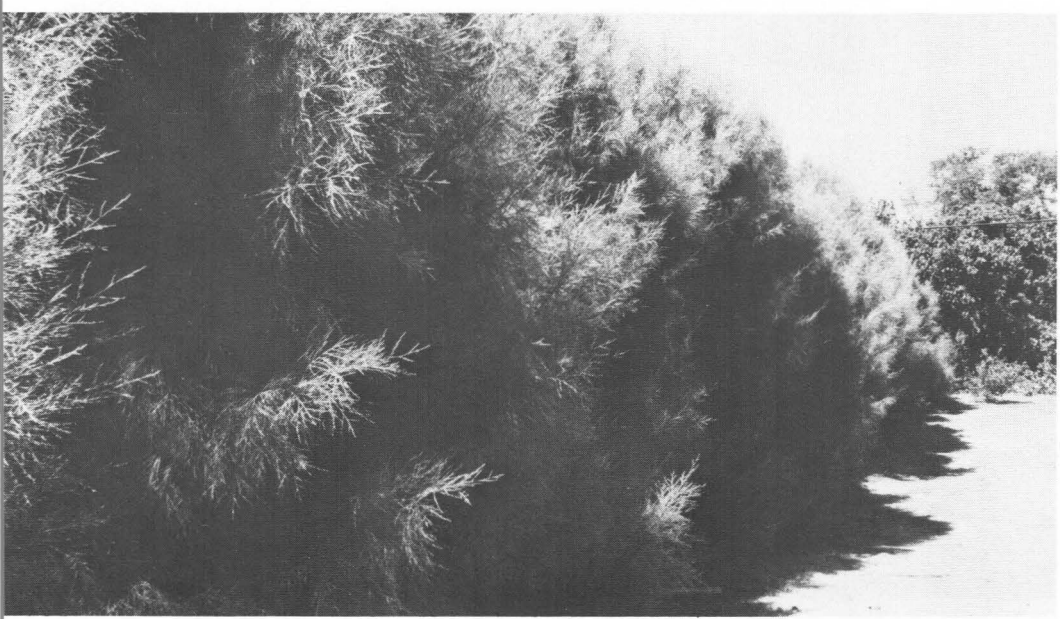

Figure 35. Athel tamarisk, *Tamarix aphylla*, used as a wind barrier in the saline flats at Puako, Hawaii.

Figure 36. Beach heliotrope, *Messerschimidia argentea*, a very durable, salt-tolerant small tree found growing along shorelines on the Island of Hawaii.

Beach naupaka
Scaevola frutescens **(Mill) Drause**
(Figure 37)

A vigorous, spreading, succulent shrub 3 to 10 feet high growing along the shorelines and homesites in Hawaii as ornamental plantings, hedges, or windbreaks. It is exceedingly salt tolerant and can be found growing practically in salt water. The low branching habit of the shrub makes it an excellent ground cover. The shrub is very versatile, very easy to maintain, and can grow under very adverse drought and fertility conditions. Except for a root rot disease, the plant is practically insect- and disease-free. Propagation is by seeds and cuttings. Recommended space between plantings is 3 to 4 feet.

Blue vitex
Vitex trifolia **L. var.** *variegata*
(Figure 38)

An aromatic shrub, very hardy, 8 to 10 feet high with dense drooping branches, quite extensively planted as hedges or windbreaks along shoreline properties. The variety *variegata* is distinguished from the other vitexes by its white-margined leaflets. The shrub is very salt and drought tolerant and grows luxuriantly in salt flats with hardly any care. Propagation is by cuttings. Recommended space between plantings is 2 to 3 feet.

Figure 37. Beach naupaka, *Scaevola frutescens*, growing under the shade of false kamani and coconut trees at the water's edge in Keaukaha, Hawaii.

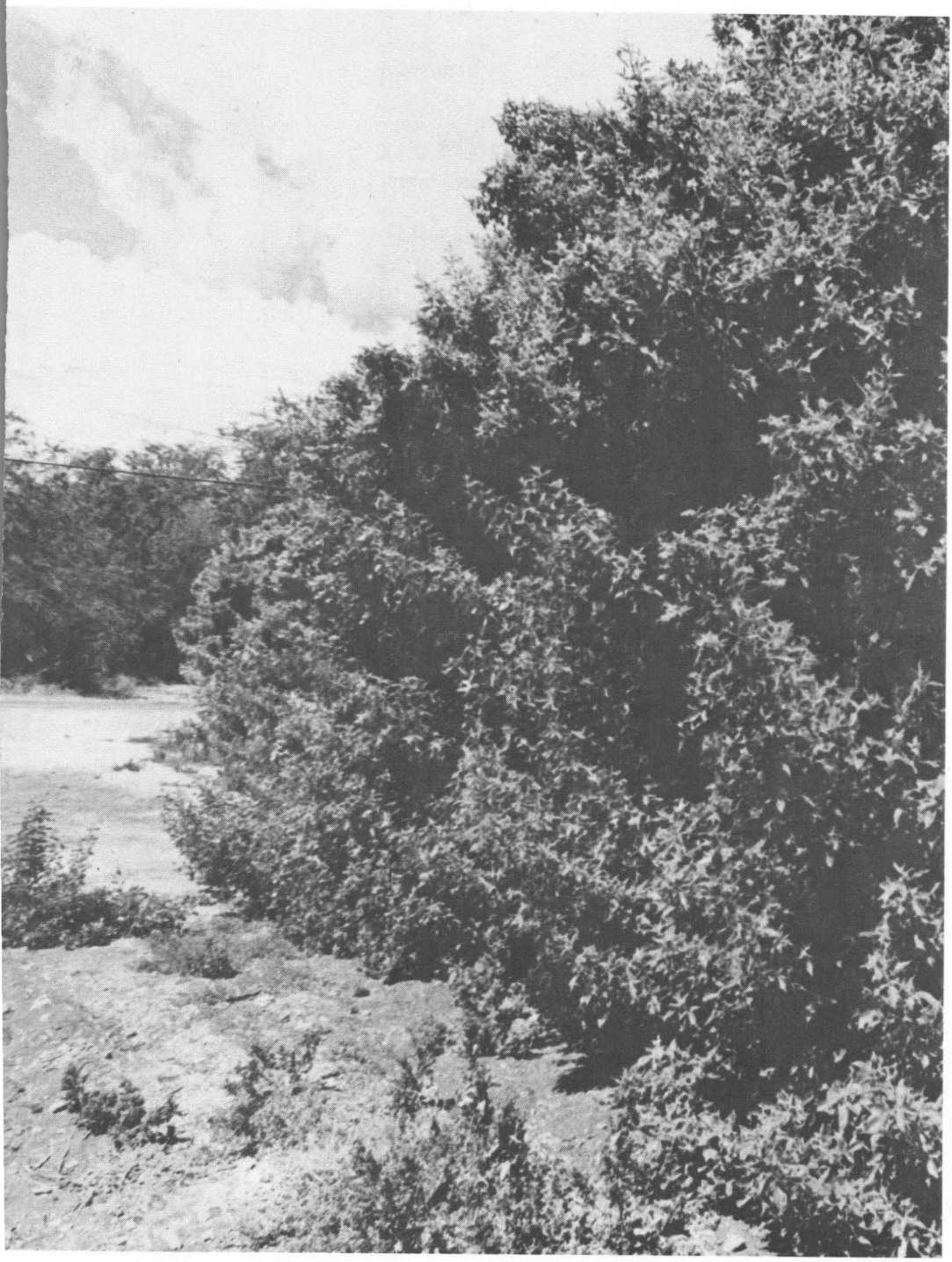

Figure 38. Blue vitex, *Vitex trifolia*, growing luxuriantly in the saline Puako house-lot area on Hawaii.

Coconut
Cocos nucifera **L.**
(Figure 39)

The most important and versatile palm of the tropics, highly tolerant to salinity and wind. It is not uncommon to find the coconut growing in saline sand along the seashore with the sea water wetting the trunk of trees. The coconut can also tolerate extreme neglect and can be found growing in shallow pockets of soil or on pahoehoe slabs with very little soil (Figure 39). The coconut is a slow starter, but growth seems to accelerate as the roots develop and penetrate the substrate. Ultimately it can attain heights exceeding 100 feet. In dry areas, coconut may require some irrigation. Its massive root system permits transplanting with relative ease. It is an excellent palm for wind- or salt-break when planted in a mass by itself or with some other palms in multiple rows. In Hawaii, the coconut is adapted to areas below 2,000-foot elevation. A small industry of making coconut hats from the young terminal fronds has brought about some losses of trees. Propagation is by seeds. Coconuts can be planted as close as 5 feet apart in a mass-planted windbreak.

False kamani
Terminalia catappa **L.**
(Figure 40)

False kamani is a low-branching and very salt-tolerant tree especially adapted to and noticeably growing in tidewater and along windy coastal areas. Away from the salt wind the trees are generally larger, more vigorous, and luxuriant, attaining heights of 75 feet. The branches are generally horizontal with a rosette of thick, large, elliptical leaves at the terminal of branches. The tree is essentially evergreen, but rose beetles seem to be seasonally attracted to the young succulent leaves. Main roots of trees are usually on the soil surface (Figure 41). Trees can be planted as close as 10 feet apart, permitting branches to intertwine. Propagation is by seeds or volunteer seedlings.

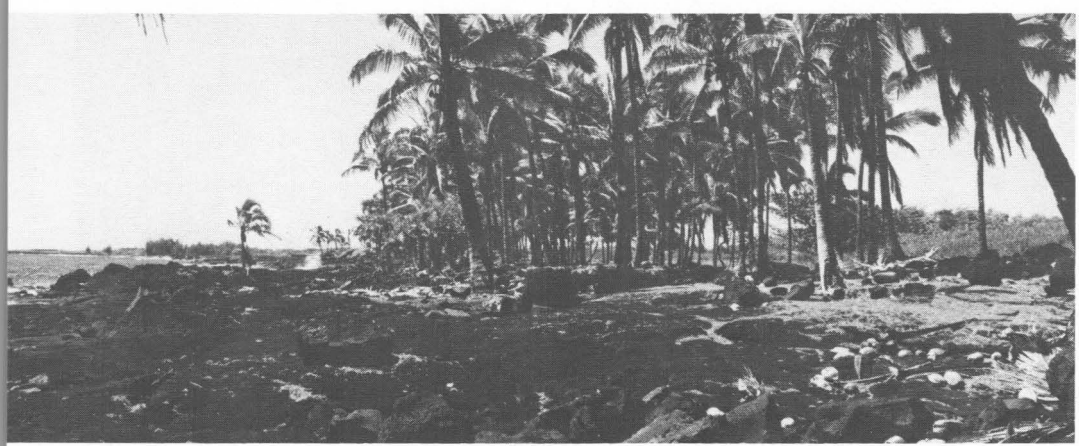

Figure 39. Coconuts, *Cocos nucifera,* growing on pahoehoe slabs along exposed shoreline at Keaau, Hawaii. (Photograph courtesy H. C. Shipman.)

Figure 40. False kamani, *Terminalia catappa,* growing along the tidal flats in the Keaukaha area of Hilo.

Figure 41. False kamani, *Terminalia catappa,* showing its massive and extensive surface roots.

Hau
Hibiscus tiliaceus **L.**
(Figure 42)

A low, gnarled, and crooked tree of low to medium height found growing especially well as a salt-wind barrier along the exposed shorelines, or found actually growing in marshy, brackish tidewater. It is also found growing over riverbanks with its branches low on or in the water. The older trees spread horizontally over the ground in huge thickets to form an impenetrable network of trunks and branches. The hau can also be found as part of a homesite landscaping, indicating its versatility (Figure 42). In old Hawaii, the hau wood was used, among other things, for canoe outriggers and to start fires by rubbing it with the harder olomea wood. More recently, the hau wood has been used as fishnet floats because of its durability and lightness. The hau is particularly useful as a salt-wind barrier and a ground cover tree in high-salinity areas. Propagation is by seeds or stem cuttings.

Kamani
Calophyllum inophyllum **L.**
(Figure 43)

The true kamani is a handsome, low-branching, and highly salt-tolerant tree found on the salty coastal areas growing down to the water's edge. In exposed coastal areas the trees appear to lean and grow away from the prevailing salt wind. This is due to the dense young regrowth that occurs after the young terminals are burned by the salt. The seaward regrowth tends to protect the inner branches from the salt breeze, permitting a stronger growth in this protected area. The constant progression of this cause and effect of protection and regrowth brings about the leaning growth. However, in areas away from the salt breeze the trees are upright and can attain heights of 50 to 60 feet. The tree is adaptable to relatively poor sites but responds very well to fertilization. It is primarily a salt barrier tree particularly useful where few other trees are capable of tolerating the salty winds. Plantings can be spaced as close as 10 feet apart permitting tree branches to intertwine to form heavy canopies of foliage growth. The species is relatively insect- and disease-free. The species is slow growing but hardy and easily propagated by seeds. Usable volunteer seedlings are plentiful under older trees.

Figure 42. A hedge of hau, *Hibiscus tiliaceus,* used as a wind barrier and for the protection and privacy it gives.

Figure 43. A gnarled and majestic kamani, *Calophyllum inophyllum,* growing along the exposed shores at Pohoiki, Hawaii.

Figure 44. Madagascar olive, *Noronhia emarginata*, growing along a road in Haena, Kauai. (Photo courtesy Dennis Ikehara.)

Madagascar olive
Noronhia emarginata **(Lam.) Poir.**
(Figure 44)

An evergreen tree particularly adapted to the lowlands and the seashores. It does very well as a salt barrier along with false and true kamani. To the inexperienced this tree can be mistaken for kamani because the leaf structure, shape, and color of these two species are quite similar. In dense plantings it can grow as high as 50 feet. In open areas the trees seem to branch out into a sprawling growth affording good low protection. Propagation is by seeds or seedlings which volunteer very readily under the trees. Recommended space between plantings is 5 to 8 feet.

Milo
Thespesia populnea **L.**
(Figure 45)

Milo is a thick-barked, low-branching, and heavy-canopied shade tree usually found growing in sandy and rocky soils along the shoreline. Occasionally, the tree can be found actually growing in brackish or tidewater areas, appearing very well adapted to saline and waterlogged conditions. Its salt tolerance makes it one of the few trees that can be used advantageously along the coastal area. The tree attains a maximum diameter of about 2 feet at the base and a height of about 30 feet. In old Hawaii, the attractive wood was used to make calabashes for poi. In modern times the milo has been used quite extensively in woodworking, furniture making, and in wall paneling. The tree produces an abundant supply of viable seeds which germinate very readily in its native waterlogged conditions. These seedlings can be easily transplanted.

Figure 45. Milo, *Thespesia populnea*, growing very luxuriantly in the tidewater flats at Pohoiki, Hawaii.

Figure 46. Scotch attorney, *Clusia rosea*, found growing along the highway in the Keaukaha area of Hilo, Hawaii.

Scotch attorney, signature tree
Clusia rosea **Jacq.**
(Figure 46)

Primarily a dense and low shrub, the Scotch attorney can be pruned into a low tree about 20 feet high to afford excellent protection as a windbreak along shoreline homesites, where it is known to be very salt tolerant. The smooth, leathery leaves are very persistent and remain on the tree for 2 to 3 years. It is not uncommon to find trees in the yard with leaves bearing "signature" markings imbedded with a sharp object by someone interested in leaving something behind. It seems to be a very thrifty grower, not requiring too much handling or care. Generally a low-elevation tree, it can grow well up to 2,000-foot elevations. Propagation is by seeds or volunteer seedlings growing under a tree. Recommended space between plantings is 5 to 8 feet.

Sea grape, shore grape
Coccoloba uvifera **L.**
(Figure 47)

A large, glossy-leaved tropical shrub with flexuous or twisting branches, especially adapted to growing along the shoreline. When well cared for, it attains a height of 20 feet, with hanging branches touching the ground. The leaves are very persistent and are retained on very old branches, making the species a very choice windbreak tree along the exposed coastal area. A versatile tree, it grows well with little care in clayey soil, volcanic ash, or simply broken coral and shells. If desired it can be planted in a mixed planting to afford low protection. It is relatively disease- and insect-free. Recommended space between plantings is 5 to 8 feet.

Figure 47. Sea grape, *Coccoloba uvifera,* used as a thick hedge to provide privacy and to serve as a wind barrier.

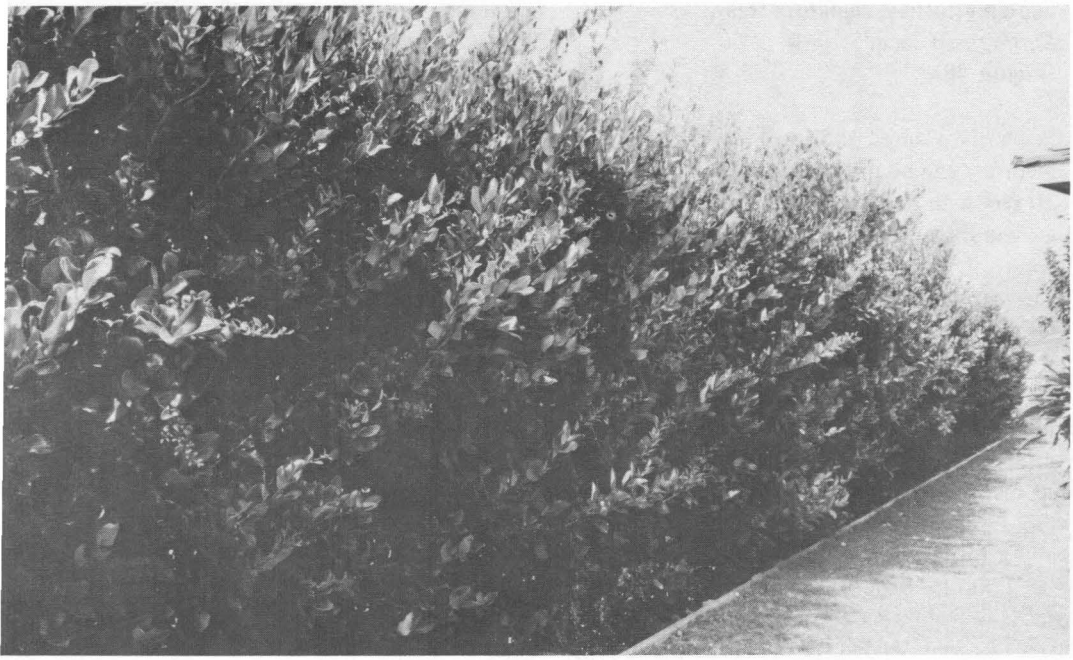

Figure 48. An aggressively dense hedge of tobira, *Pittosporum tobira*, used for privacy and protection from the wind.

Tobira
Pittosporum tobira Ait.
(Figure 48)

A very versatile, hardy, and leathery-leaved evergreen shrub used quite extensively in landscaping in Hawaii. It is usually planted in borders or on hillsides where growing conditions are somewhat adverse. It responds well to fertilization. It is also quite salt tolerant and can be especially useful along the shore where very few plants can survive. The shrub attains heights of 10 to 12 feet, and by judicious pruning can be trained to form a reasonably good barrier. Except for mealy bug, it is reasonably insect- and disease-free. Recommended space between plantings is 2 to 3 feet. Propagation is by seeds or mature wood cuttings.

Figure 49. Pigeon pea, *Cajanus indicus,* used to protect low vegetable crops.

Figure 50. Corn, *Zea mays,* used to protect vegetables as well as for its ears of corn for home use.

Figure 51. Sunflower, *Helianthus annuus*, used to protect vegetable crops in Lalamilo, Hawaii.

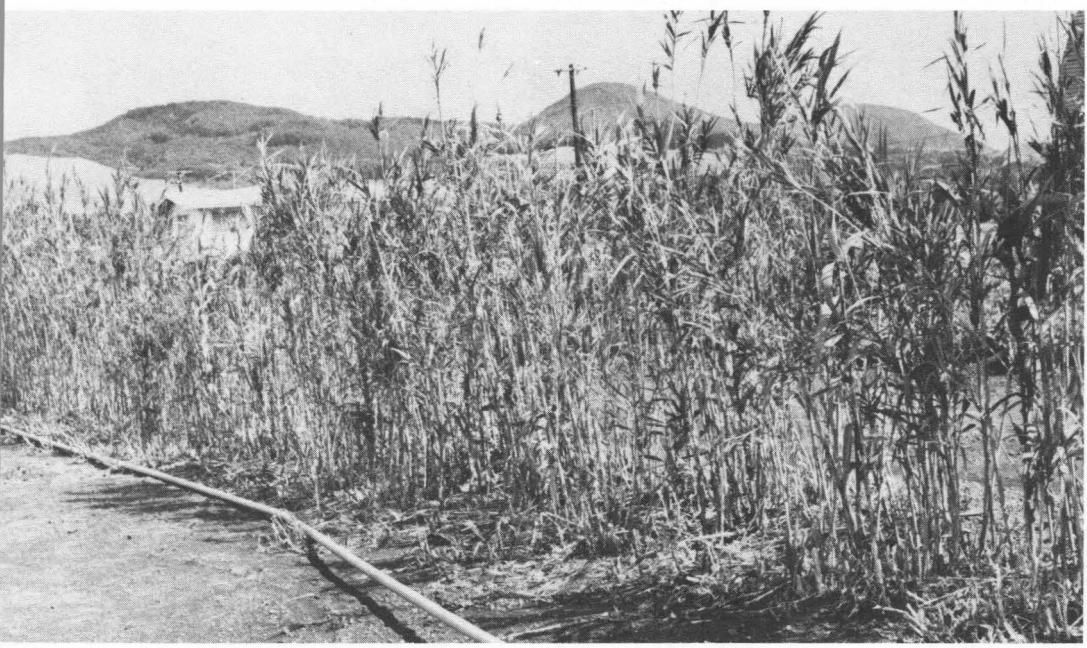

Figure 52. Napier grass, *Pennisetum purpureum,* used as a wind barrier in Lalamilo, Hawaii.

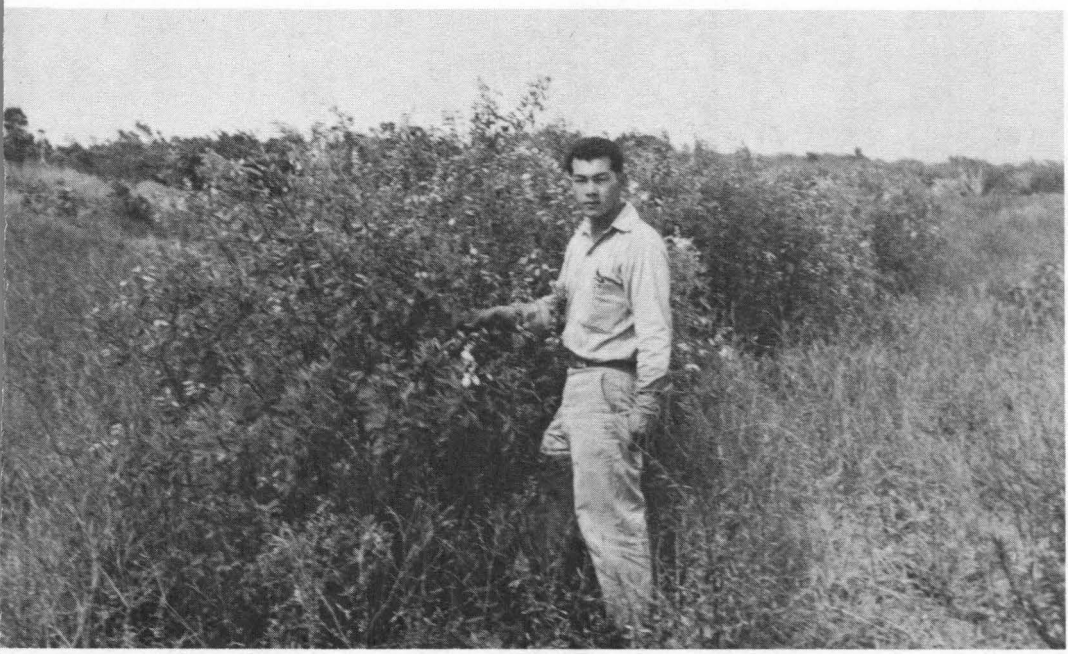

Figure 53. Giant crotolaria, *Crotolaria* sp., used in the windbreak trial of the C. Brewer Land Utilization Project in Kau.

Figure 54. Sugarcane, *Saccharum officinarum*, used in the windbreak trial of the C. Brewer Land Utilization Project in Kau.

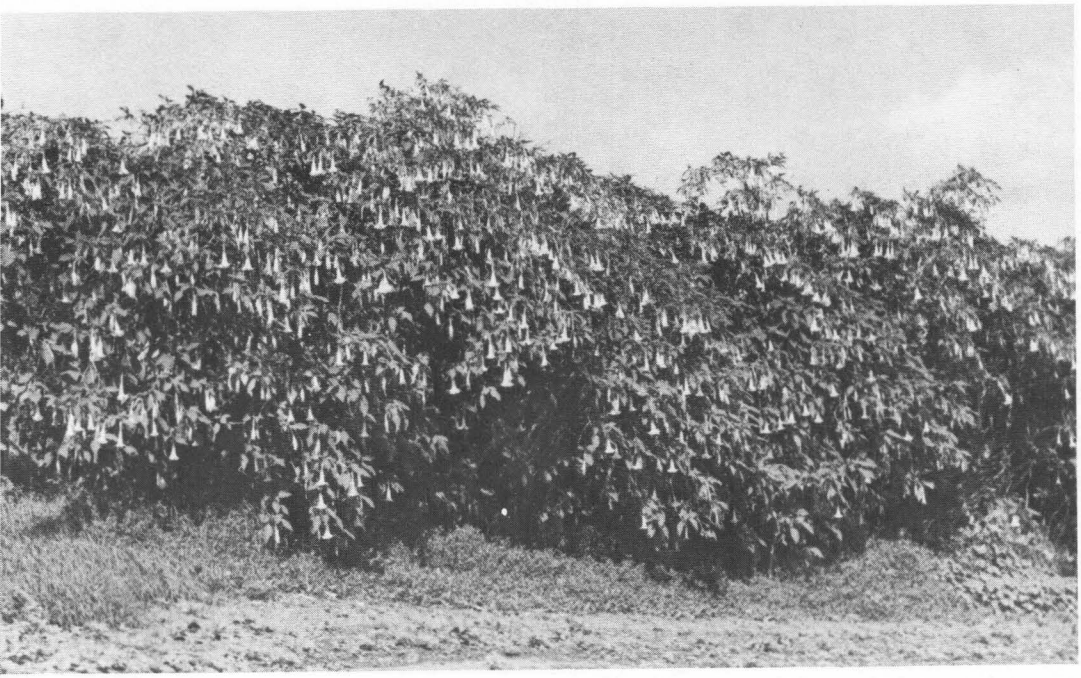

Figure 55. Angel's trumpet, *Datura candida,* used as a wind barrier in Kamuela, Hawaii.

Figure 56. Castor bean, *Ricinus communis,* used as a wind barrier in Kamuela, Hawaii.

Figure 57. A tall avocado, *Persea americana*, used in a dual capacity of giving protection to papaya trees and of providing marketable fruits.

Figure 58. Sorghum, *Sorghum vulgaris,* used as a wind barrier for tomatoes.

SITE SELECTION FOR WINDBREAK PLANTINGS

After the species has been selected it is necessary to select the site and prepare it for planting. When choosing the site, many general factors must be considered. These should be considered in conjunction with the special requirements of the various species you have chosen to use as a windbreak. Some of these factors are climate, soil texture, soil structure, soil depth, soil reaction (pH), soil fertility, soil-water relationships, topography, and erosion hazard.

Local climatic data for the site chosen can be obtained from the U.S. Weather Bureau, from airports, and from people who have lived in the area for a long time. Temperature, both day and night as well as seasonal, should be considered, and only those species that are acclimated to the conditions of the area should be used. Rainfall is important, although lack of rainfall may be overcome by irrigation. The nature and velocity of the wind and the subject of the protection must be considered before finally selecting the type of wind barrier to use. Depending on the nature and velocity of the wind, further protection may be needed for the windbreak plants themselves until they become established.

Generally speaking, soils with medium to fine texture and with granular or blocky structure are best suited for plant growth. These soils allow easier root penetration and provide adequate aeration for good root growth. In addition, they allow good water infiltration and have good water retention capacity so that plants may obtain adequate moisture and air for growth. These soils also have the power to retain added plant nutrients and to release the supply when needed for plant use. The soil reaction (pH) should be within the proper range for the optimum growth of the species chosen. The pH may be adjusted by the use of lime if found lacking or unfavorable for plant growth. A laboratory soil test should be made to determine what is needed and the recommendations followed. Soil depth is also important, as compact layers, high water tables, or impenetrable rocky formation may limit the growth of roots. Deep-rooted species may grow with difficulty in soils 20 inches or less in depth. In such areas, further preparation may be desirable.

Topography is important, as microclimate and soil characteristics often depend upon slope. To establish the planting on steep slopes, contour planting, terracing, or other special practices are needed.

The type of area to be protected is an important consideration—its size, its shape, and the crop to be grown. These must be considered to select windbreak species that will fit the area and its needs.

Preparation of the site

Site preparation should be done with as much care, effort, and thought as needed for establishing and growing an income-producing crop. If contour furrows, terraces, leveling, or grading is required, this should be one of the first

things done to prepare the site. Weeds, undesirable brushes, and grasses should also be destroyed by cultivation, with chemicals, or by other special practices. These plants are major competitors for nutrients, moisture, and space. Weed control also reduces the sources of infection by diseases, insects, and rodents, and it reduces the probable danger of fire and browsing animals attracted to the windbreak. If necessary, a windbreak planting should be fenced to protect it from grazing animals.

The area should be staked and laid out so that each line of the windbreak and the location of each plant is established before planting. All site preparation should be accomplished and in readiness when plants arrive from the nurseries so that the plants do not deteriorate in quality as they wait to be planted.

Planting

When planting a windbreak only healthy plants should be chosen. Those that are weak, diseased, or show effects of insect damage should be discarded or used only as a last resort. Windbreak plants should be well-established nursery stock with sturdy stems and branches. When container-grown plants are used, make sure that the roots are not bound. Bound roots should be loosened and properly placed, or they should be clipped to induce development of a better root system. Seedlings should be at least 8 to 12 inches high since smaller seedlings are more susceptible to weed competitions and other hazards.

The distance between rows and within rows should be appropriate to the species chosen. Plants should be properly "settled" in holes of adequate shape and depth so that roots are not crowded and air pockets are not formed in the planting process. Fertilizers should not be placed in holes in direct contact with the roots; this may damage the plant. The use of slowly soluble fertilizers results in less damage to the roots; also, frequency of application is reduced.

Constructed windbreaks, such as saran cloth, bags, woven coconut leaves, or similar materials, may be used, where necessary, to protect the young windbreak plants until they become established.

Maintenance of established plantings

Once the planting is done, the plants should receive adequate care to promote rapid growth. The soil moisture levels should be maintained, with irrigation when necessary, so that plants are not subjected to severe stress. The use of tensiometers or other devices as an indication of need is a satisfactory means of maintaining adequate moisture in the soil. Fertilization to maintain adequate growth should be done on schedule. Soil may be tested every 3 to 5 years for recommendations on plant nutrient needs.

Weed control should be maintained until the windbreak plants are beyond suffering from weed competition. This may be done by cultivation, mulching, or with the use of herbicides. However, mulches of organic residues may harbor mice or other rodents which may damage the plants by feeding on the bark or other parts of the plant. The organic mulches may also serve as sources of

insects and diseases harmful to the plants. When herbicides or cultivation is employed in weed control, care should be taken not to damage the plants.

Windbreaks should be adequately protected from fire, livestock (see Figure 59), and rodents. Keeping out undesirable vegetation and leaving a clean cultivated strip on either side of the windbreak is an excellent way of preventing fires and rodent build-up. Removal of dead limbs, trash, etc., provides further protection from fire. Browsing livestock may uproot or destroy younger plants during feeding. By eating all the lower vegetation to form "browse lines," they reduce the effectiveness of the windbreak.

Vehicular traffic in the windbreak area results not only in damaging the trees but also brings about soil compaction, causing poor aeration and poor root growth that greatly reduces tree growth. Where it is necessary to provide roadways through windbreaks, efforts should be made to keep damage to the plants at a minimum.

All dead plants should be removed and replanted as soon as possible so that bad gaps in the windbreak are avoided. When necessary, trees should be pruned to remove all unnecessary branches and leaves and to shape the trees to provide maximum growth.

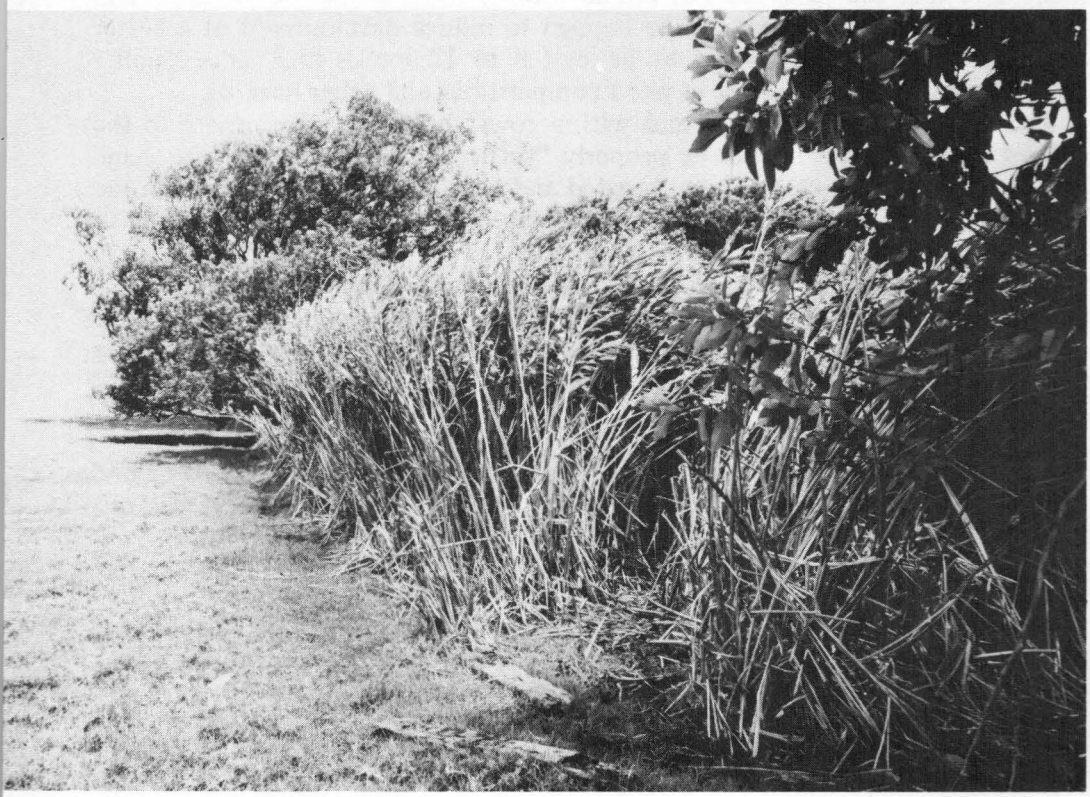

Figure 59. Shell ginger used as a wind barrier next to the open range in Kamuela, Hawaii. Note extreme damage due to foraging cattle.

The care in growing the windbreak trees should be no less intensive than the care going into the production of the cash crop. Growth space set aside for the windbreak area should be ample and should provide enough space for normal growth of the windbreak species used. However, when desired, management practice can be altered to equate the pros and cons of space allocation. One method that can be used very advantageously is pruning of undesirable limbs or severing of the roots of the windbreak tree when they begin to compete with the cash crop. When necessary, root severing can begin at 4 to 6 years on permanent plantings and at 6 months to 1 year for temporary plantings. Root severing should be done when soil conditions are favorable to prevent unnecessary damage to the windbreak and crop plants and to minimize regrowth from the severed roots of the windbreak plant.

Where to obtain help

Planting materials may be obtained from the State Tree Nursery, P. O. Box 457, Kamuela, Hawaii 96743, and from commercial nurseries located in each county.

For further information and help in establishing windbreaks in your area, contact your County Extension Agent, the local U. S. Department of Agriculture Soil Conservation Service Technician, or the State Forester. They can help you obtain good quality seedlings, plan your windbreak layout, and obtain soil samples for testing. They may also assist in obtaining materials and equipment needed for site preparation. The County Agricultural Stabilization Committee will advise you of any financial help that is available on a cost-sharing basis.

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