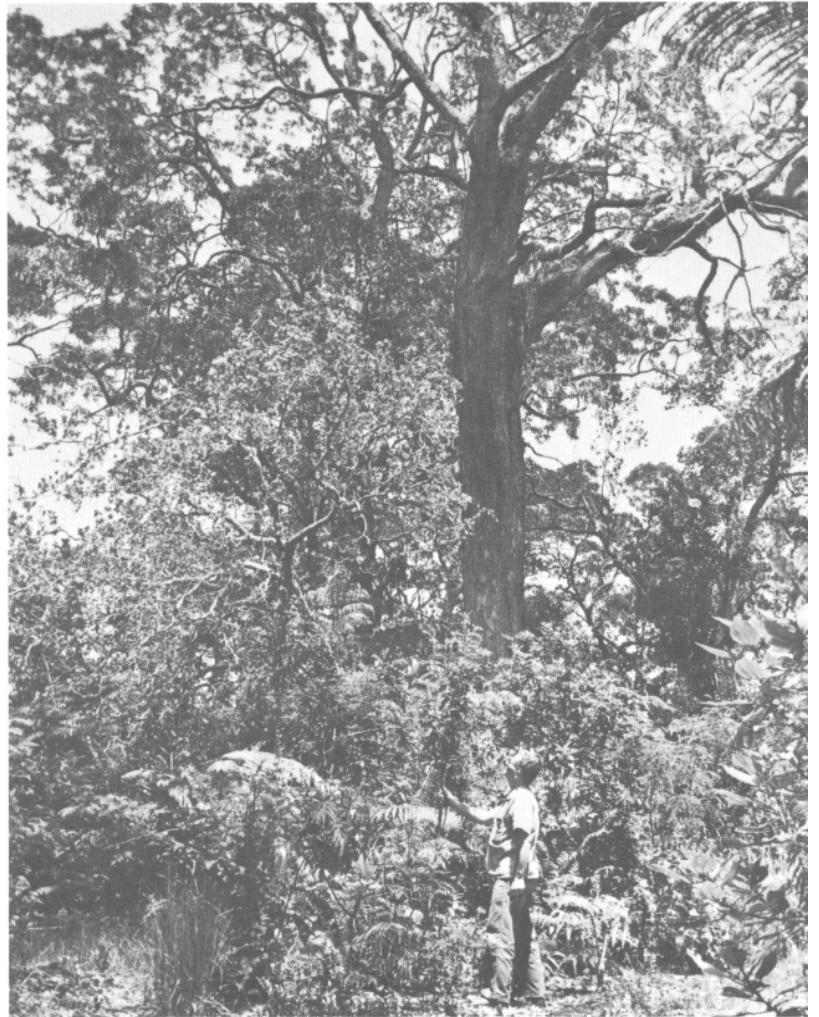


Silvical Characteristics of Koa

(*Acacia Koa* Gray)

Craig D. Whitesell



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ERRATA

Page 5: Left-hand column, lines 31-32 as reads:

"Evidence of natural layering has been observed."

Should read:

"Evidence of natural layering has not been observed."

Page 10: Left-hand column, lines 17-10 as reads:

"...Hillebrand's A. koa- β var. and ..."

Should read:

"...Hillebrand's A. koa- β var.) and ..."

Koa (*Acacia koa* Gray) is considered the most valuable common native timber species in Hawaii (21, 38).¹ From the time of the early Hawaiians, this tree has been prized for its exceptionally fine wood. Koa has curly grain, striking coloration, and takes a high polish (9, 26). It grows on each of the six main islands, but the only extensive forests remaining are on the island of Hawaii. It occurs in nearly pure stands, or in admixtures with ohia (*Metrosideros polymorpha* Guad.). Other tree species are of limited occurrence in these forests. A large evergreen hard-

wood tree endemic to the State, koa belongs to the thornless, phyllodinous group of the genus *Acacia*, subfamily Mimosaceae of the Leguminosae.

Koa forests must have been much more extensive in the past than they are today. Land clearing, poor cutting practices, and destruction by animals, insects (33), and fire (18, 25) have all taken a toll. Koa forest land in the State now totals about 50,000 acres, ohia-koa forests about 150,000 acres. Volume of koa sawtimber totals about 121 million board feet (35).

Habitat Conditions

Climatic

Koa grows in a widely diverse tropical climate. The northeasterly trade winds dominate, although seasonal storms also influence the islands (6). Mountains, especially massive Mauna Loa and Mauna Kea on Hawaii and Haleakala on Maui, strongly modify the marine effect.

Snow seldom falls at elevations below 8,500 feet (6). Below 10,000 feet snow seldom persists on the ground. Frost is not uncommon during the winter months on the upper slopes where koa grows.

"Kona" storms from the south or west during winter, and occasional tropical storms throughout the year often bring high winds and heavy rains to the islands: Rainfall varies greatly within short distances. Monthly amounts recorded over a period of years at weather stations in the koa belts show a phenomenal range. Most stations -- even many of those where the annual normal is 100 inches or more -- occasionally have dry periods when rainfall totals less than an inch a month. Conversely, some of the driest points -- where

the annual average is 20 to 30 inches -- may have an amount approaching or surpassing this annual average in just a few days (15).

Koa grows best in the higher rainfall areas of from 75 to more than 200 inches annually. Cloud cover and fog commonly shroud the middle forest zone where koa is concentrated: Koa also occurs in semi-arid and moderately wet areas that receive from 25 to 75 inches of rain annually.

The annual temperature range is relatively small, as may be seen from data for the island of Hawaii (table 1).

Edaphic

Koa is found on volcanic soils of all degrees of development -- from the oldest on Kauai to some of the relatively young "aa" rocky soils on the island of Hawaii. Insufficient work has been done to evaluate the tolerance of koa to different soil conditions. The tree grows on both well-drained (27) and poorly-drained soils, the latter including the Hydrol Humic Latosols. Most koa forests occur upon the Yellowish-Brown -and Reddish-Brown. Laterite soils described (45) as rain forest soils -- occurring between 1,500 and 5,000 feet. Physically these soils are characterized by their permeability

¹ Italic numbers in parentheses refer to Literature Cited, p. 11.

to moisture and air, their granular structure, friability, high percentage of colloids, and high moisture equivalents. Chemically, they have a high content of organic matter, hydrous oxides of iron and aluminum, manganese and titanium. Low in silica, calcium, potassium, and sodium, they generally have a marked degree of phosphorus fixation, although this and other features are variable within the group. Soil reaction is distinctly acid in most areas. Mottling is an occasional feature. Soil texture ranges from a silty clay loam to a very fine sandy loam, and structure is variable. Koa is also found on Lithosols and shallow soils (humid), and on rough broken land.

Physiographic

The range of koa extends from longitude 154° to 160° west; its latitude ranges from 19° to 22° north. It grows at elevations from 600 (39) to 7,000 feet (26), on both flat lands and slopes. MacCaughy. (33) listed koa as a component of the forests occupying gulch and ravine walls sloping 40° to 80°.

Biotic

Hillebrand (21) divided the flora of Hawaii into groups occupying different zones of elevation:

The lowland zone. -- Open country, with isolated trees or clumps of trees. Koa rarely grows here.

The lower forest zone. -- An upper limit between, 1,000 and 2,000 feet. Tropical in character, woods are rather open. Koa occurs in scattered stands, in admixture with ohia.

The middle forest zone. -- An upper limit of 5,000 to 6,000 feet. This zone lies within the region of clouds, and develops the greatest luxuriance in trees and jungle. Here koa reaches its greatest development in size and number.

The upper forest zone. -- Extending as high as 8,000 or 9,000 feet. Koa reaches into this zone, but seldom above 7,000 feet.

Trees associated with koa (18, 21, 22, 39) ² include

- ahakea (*Bobea* spp. Gaud.)
- 'ala'a (*Sideroxylon sandwicensis* (Gray) Benth.)
- kalia (*Eleaocarpus bifidus* Hook & Arm.)
- kauila (*Alphitonia ponderosa* Hbd.)
- kolea (*Myrsine lessertiana* D.C.)
- kopiko (*Straussia* ssp. Gray)
- loulou palm (*Pritchardia* ssp. Seem. & H. Wendl.)
- mamani (*Sophora chrysophylla* Seem.)
- naio (*Myoporum sandwicense* (D.C.) Gray)
- 'ohē'ohē (*Tetraplasandra hawaiiensis* (Gray))
- ohia (*Metrosideros polymorpha* Gaud.)
- olapa (*Cheirodendron gaudichaudii* (D.C.) Seem.)
- olopua (*Osmanthus sandwicensis* (Gray) Knobl.)
- pilo (*Coprosma* spp. Forst.)
- sandalwood (*Santalum* spp. L.)

Botanists and foresters have listed more than 80 trees, shrubs, vines, herbs,, ferns, club mosses, grasses, and sedges associated with koa.

Relatively few species of birds are now associated with koa. Their numbers have been reduced largely by land clearing and the introduction of mammals and plants that have helped destroy the specialized habitats required by endemic birds (2, 14). Several exotic birds, including the white-eye (*Zosterops palpibrosus japonicus* Temminck &

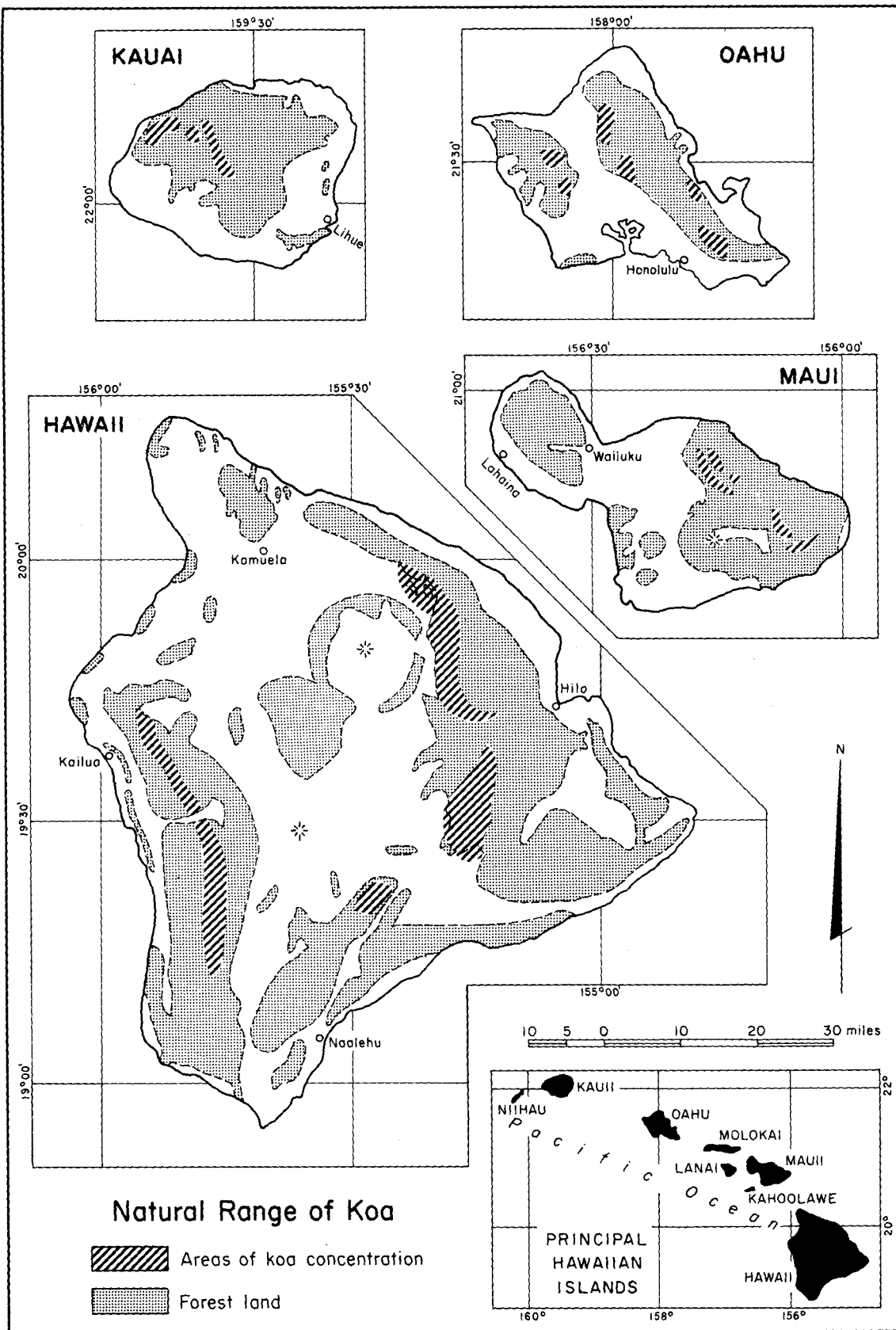
²Personal correspondence with M. F. Landgraf, Hawaii: Forestry Division, Hilo, Hawaii, Dec. 6, 1963.

Table 1. Mean temperatures for six stations, island of Hawaii ¹

Station	Elevation above sea-level	Mean January temperature	Mean August temperature
	<i>Feet</i>	<i>° F.</i>	<i>° F.</i>
Hilo	40	71	76
Olaa	280	70	75
Mountain View	≈/1,530	65	70
Hawaii National Park	≈/3,971	58	64
Kulani Camp	≈/5,190	53	58
Mauna Loa Observatory	11,150	39	47

¹Source: Blumenstock (6).

²Elevations at which koa occurs.





Flowers and phyllodes of koa.

Schlegel), have successfully competed with the native birds for food; others have introduced diseases and parasites (2, 14). Munro (34) mentioned several species of the Hawaiian honey-creeper family (Drepanididae) and the small

Kauai thrush (*Phaeornis palmeri* Rothschild) as residents of the koa forests. These species feed on insect enemies of koa and are now believed to be uncommon, rare, or extinct (2, 34). The parrot-billed koa finch (*Pseudonestor zanthophrys* Rothschild), a bird confined to the higher koa forests on Mount Haleakala, Maui is a good example of the close association of a honey-creeper and koa forests. Henshaw, in 1902, observed:

... the bird appears never to wander far from the koa, and obtains the principal part of its food, the larvae of longicorn beetles (cerambycids) by tearing open the small terminal dead twigs of this tree in which the larvae burrow, secure from all bird enemies less formidably equipped. . . . The koa upon Maui has suffered much of late years from the ravages of the insect pests above alluded to, and thousands of mature trees have been killed. The life of *Pseudonestor* is so inseparably connected with the koa tree that the destruction of the latter will be almost certainly followed by the extinction of the former, and it is to be feared that this interesting and valuable bird, confined as it is to one island, has before it no very long term of existence" (20).

By 1950, Amadon (2) considered this bird "perhaps extinct."

Life History

Seeding Habits

Flowering and Fruiting

Other than Rock's (40), few observations on the flowering and fruiting periods of koa have been published. Trees at the lower elevations flower at different times than those at higher elevation. Flowers have been observed during February at 1,800 feet, and during June³ and December at about 4,200 feet, but the number of flowering periods per year is not known. A 2-year-old specimen has been observed in fruit and flower (3). A pollinating insect found on koa flowers was an unidentified species of bee. The extent to which other insects, birds, and the wind affect pollination is being studied.

The inflorescence of koa is an axillary raceme of pale yellow heads composed of many flowers. Each flower has an indefinite number of free stamens and a single elongated style.

³Field observations by G. B. Richmond, July 10, 1963. Data on file at Hilo, Hawaii, office of Pacific SW. Forest and Range Expt. Sta., U.S. Forest Serv.

The fruit is a tardily dehiscent legume about 6 inches long and 1 to 1½ inches wide. It contains about 12 ovules. The seeds vary from dark brown to black. They mature at different times throughout the summer -- depending upon the location.

Seed Production

Koa bears seeds often and abundantly. The actual quantities of seeds produced per tree, or per acre, however, is not known. No records of the frequency of exceptionally good or poor seed years are available. Mature trees probably produce the most seed, but the quantity of sound seed has not been estimated.

In three samples, the number of clean seeds per pound ranged from a low of 2,400 to a high of 7,400.

Many koa seeds are destroyed by the larvae of four different species of Tortricid moths (42). These seed moths may destroy as much as 99 percent of any given seed crop in the pods (44).

Seed Dissemination

Koa seed pods dehisce while on the tree, or fall to the ground unopened, where they either dehisce

or disintegrate. Judd (26) reported that "the horny seed often remains on the tree for a year after it ripens, and when lying on the ground is known to have retained, for a period of 25 years, its ability to germinate." Koa seeds are seldom dispersed very far beyond the crown. Occasionally, the wind may carry unopened pods some distance. Seeds from koa growing in gulches possibly are carried downstream to lower elevations, especially during torrential rains.

Vegetative Reproduction

An intensive study of koa reproduction was conducted by Baldwin and Fagerlund (5) on an area of the Volcano National Park having an annual rainfall of about 40 inches. Koa stands appeared to regenerate almost entirely by means of root suckers on this once heavily grazed site. These authors reported that "many vigorous suckers arise from the buried and exposed roots of a single tree. . . . In three cases, suckers were seen 50, 90 and 95 feet away from the base of isolated koa trees. Suckers develop into healthy trees three to six inches in diameter at breast height in five or six years [and were] estimated to be 12 feet in height."

Koa root sprouts have also been observed in rain forests. The extent to which koa will root sprout, in the absence of fire or grazing animals, has not been established. Stump sprouts have rarely been observed. Propagation of koa by grafting or cuttings has been reported in the literature. Evidence of natural layering has not been observed.⁴

Seedling Development

Establishment

Under favorable conditions--that is, bare mineral soil and exposure to sunlight -- koa seeds will germinate readily. Seedlings are commonly observed soon after land is cleared for pasture or roads, or after fires. Judd (30) reported that as many as 143,537 koa seedlings per acre were counted in the vicinity of old koa trees in burned-over areas. Possibly seeds escaping the flames are induced to germinate by the heat. Rarely do koa seedlings survive in the dense rain forests unless openings have been created, such as those in a

⁴Field observations by R. M. Lanner, Aug. 4, 1963. Data on file at Hilo, Hawaii, office of Pacific SW. Forest and Range Expt. Sta., U.S. Forest Serv.

commercial cutting operation. Kraebel (31) reported that "where cattle have been excluded for a number of years, koa groves are developing with surprising speed on exposed and barren ridges."

Although no specific germination tests have been reported, nurserymen indicate that obtaining "good" germination is no problem. The customary presowing treatment is to place the seeds in hot water, and let them soak.

Direct seeding of koa on prepared seed spots has been moderately successful (7, 10).

Judd (23, 26, 28) recommended koa for watershed planting on well-drained areas: "The one native tree which can be easily handled in nursery and planting operations.... suitable for the larger portion of areas in need of reforestation and particularly for the drier edges and slopes" (24). In Judd's time, the standard nursery practice was to start the seeds in wooden flats and to transplant seedlings to tin cans (24).

Other investigators, less enthusiastic about planting koa, do not recommend it (10, 11). Crosby and Hosaka (11) reported that "Results on older soil formations have been uniformly disappointing. Frequently the trees die out after 15 or 20 years." Plantations established on Maui during the late 1930's contain scattered large trees, but they are of exceptionally poor form and are being removed.⁵

Early Growth

Koa seedlings grow rapidly. Judd (30) determined that one month after a burn koa seedlings were an inch high; after three months they ranged from 4 to 11 inches tall, averaging about 5 inches. On a cleared area at 1,700 feet elevation, 1-year-old seedlings varied from 2 to 13 feet in height, and averaged 6 feet. In favorable localities seedlings will attain 30 feet in 5 years (26).

Sapling Stage to Maturity Root

Development

Little is known of the root development of koa. It grows on the deeper Hawaiian soils, but also reaches impressive size on the shallow as lava flows. "The root system of the mature koa," according to Baldwin and Fagerlund (5), "is shallow and extensive, spreading out radially from the base of the tree up to 100 feet or more." Judd

⁵Personal correspondence with K. H. Korte, Hawaii Forestry Division, Kahului, Maui August 23, 1963.

(26) agrees that "the tree has a shallow rooted system, a flat plane of roots spreading out in all directions just beneath the surface of the ground. For this reason the larger top-heavy trees are easily overturned by severe wind storms. . . ." In describing the root systems of lava-flow plants, MacCaughy (32) classified koa as one of the comparatively deep-rooted woody species.,

Growth and Yield

We have no way of determining the maximum age reached by koa. The species does not appear to produce annual rings. Old relic forests still in existence were probably present at the time Captain James Cook discovered the Hawaiian Islands in 1778.

A permanent growth plot established in a 12-year-old plantation (10-foot by 10-foot spacing) had a survival of 85 percent, with 28 vigorous trees and 12 suppressed trees. The average diameter breast height of the 28 larger trees was 4.3 inches, and their average height was 25 feet. The tallest individual was 40 feet.⁶

The form of koa varies greatly. Most mature trees have large, open, scraggly crowns, and limby, fluted boles. In the rain forests on deep, rich soil, an occasional koa tree may reach 110 feet; but few possess clean, straight boles. On drier sites the form of koa is even poorer, and trees are often stunted and misshapen.

Precise yield figures are not available.

Reaction to Competition

Koa is rated as intolerant--both in the dry forests (19) and in the rain forest. Hall (18) rated the species "intolerant of shade at all ages, and will not germinate or grow without a large amount of light." Under favorable light and soil conditions koa can compete aggressively with other vegetation.

Hathaway (19) classified koa as a pioneer species on the grassy slopes of dry forest sites, whereas Forbes (16) considered it a climax species. Judd (26) considered koa the ultimate forest type, following the ohia forest on the ancient as lava flows. Russ observed that "at maturity a grove [of koa] casts a shade in which its own seedlings have difficulty in growing, and unless they fill

⁶Pickford, G. D. (Unpublished data on file, Hawaii Forestry Division, Hilo, Hawaii, 1961.)

a vacancy in the parental ranks, they must seek the outer limits of the stand" (41). Available evidence indicates that koa is a sub-climax type.

Condition and Quality

Missing from the koa and ohia-koa forests in many areas are the koa size classes that normally form the recently mature, vigorous stands. Rock (39), in 1913, graphically described the condition of large tracts of koa forest:

Above Kealakekua, in South Kona, of the once beautiful koa forest 90 percent of the trees are now dead, and the remaining 10 percent in a dying condition. Their huge trunks and limbs cover the ground so thickly that it is difficult to ride through the forest, if such it can be called.... It is sad, however, to see these gigantic trees succumb to the ravages of cattle and insects.

The forest survey of 1959-1961 clearly indicates the present condition of much of the saw-timber-size koa (trees over 10.9 inches d.b.h.). Of the 103 trees classified according to merchantability based on form and defect, 36 percent were considered merchantable, 15 percent sound cull (with such defects as crook, excessive limbs, or poor form), and 49 percent rotten [sic] cull (excessive rot). The "average" tree was 35 inches d.b.h. (basis : 103 trees), 72 feet high (basis : 31 trees), and had a crown diameter of 58 feet (basis: 31 trees). Log grades were determined for logs in 103 koa trees. Less than two-fifths of all butt logs (first 16 feet) met the specifications for either factory lumber logs or tie and timber logs. More than three-fifths were considered cull logs. Only 35 percent of the 103 trees sampled had an upper log of 8 feet or more, and more than half of these logs were graded cull.⁷

Principal Enemies

Hawaiian forestry literature is full of references to the disastrous effects of cattle, sheep, and goats on koa and other native species (for example: 1, 4, 5, 11, 18, 24, 27, 39). Cattle, especially, are particularly fond of koa root sprouts, seedlings, pods, and leaves. They straddle and trample large saplings to devour the foliage.

⁷Hawaii forest survey, 1959-1961. (Unpublished data on file at Honolulu, Hawaii, office, Pacific SW. Forest and Range Expt. Sta., U.S. Forest Serv.) Log grade specifications were from U.S. Forest Serv. Forest Products Lab Rpt. 1737 (46).



A

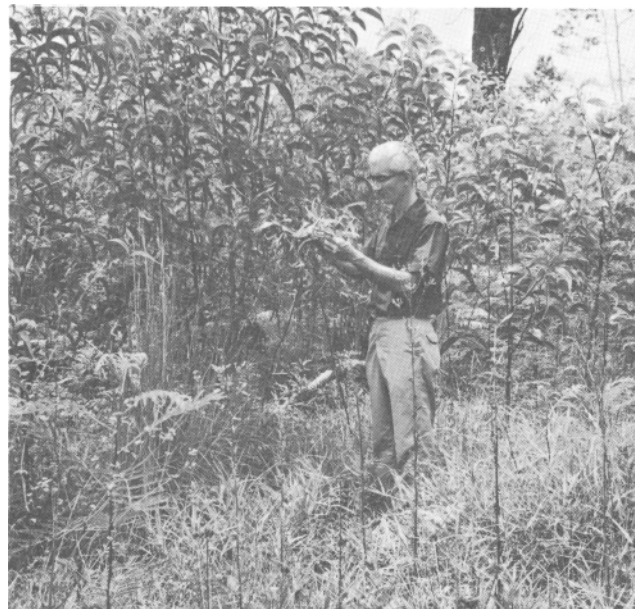
A Decadent, dry forest koa stand in a rangeland lacking in koa reproduction. Area was heavily grazed for many years.

B Decadent old koa, surrounded by root sprout regeneration, on land once heavily grazed and now in a national park in Hawaii.

C Koa seedlings nine months after removal of overstory.



B



C

Hawaii Forestry Division records show that more than 250,000 pigs, goats, and sheep were destroyed from 1921-1946 in the forests on the island of Hawaii (8), where an active exclosure program was conducted. Such efforts did much to reduce the amount of browsing by these animals on koa forests.

Koa attracts other kinds of animals. Black-tailed deer (*Odocoileus hemionus* Richardson), recently introduced from California to the island of Kauai, eat koa reproduction. There is evidence that the tree rat (*Rattus rattus* L.), during a heavy population buildup, will girdle koa saplings 1 to 2 inches in diameter by stripping off bark as high up as 4 feet.⁸

More than 40 species of native insects are considered enemies of koa (43). Insect damage to koa is well documented (12, 17, 36, 37, 42). Swezey (44) has compiled an excellent checklist. This recognized authority believes "there are more endemic insect species attached to this koa complex (*Acacia koa* and related Hawaiian members) than to any other genus in the Hawaiian Islands." C. J. Davis, State entomologist for Hawaii has evaluated the most important of these insects:⁹

- The most destructive insects of koa are lepidopterous defoliators of the genus *Scotorythra*. Fortunately, they appear to be under good control biologically and seldom build up to damaging levels.

- The koa seed worm (*Cryptophlebia illepidia* Butler) is very destructive to the seed and will be a factor to contend with if seed is harvested for reforestation purposes.

- At the higher elevations, koa terminals are sometimes heavily attacked by *Pantomorus godmani* Crotch, (Fullers rose weevil), but this ap-

pears to be highly seasonal and of no serious consequence.

- Koa rust (*Uromyces* sp.) persists on young trees at the higher elevations (5,000-7,000 ft.) and the [infected] malformed trunks [and] branches are attractive to [the moth] *Enarmonia walsinghami* (Butler).

Little information on diseases of koa is available. Dieback is common in the crowns of older trees. It was observed in more than half of the sawtimber-size koa measured during the 1959-1961 forest survey. The root rot *Armillaria mellea* (Fr.) Quel. is probably the cause of this disease.¹⁰ Stands possibly weakened by old age, extended droughts, and grazing have succumbed to attack by this root rot. Other diseases of koa include sooty molds, such as *Meliola koae* Stevens, which cover the leaves and restrict growth. The rust *Uromyces koae* Arthur, an obligate parasite on young koa, causes bud proliferations which attract destructive insects. The Hawaiian mistletoe (*Korthalsella complanata* [v Tiegh.] Engl.) has been observed in some decadent koa stands.¹¹ It also deforms young koa.¹² More than half the large koa measured in the 1959-1961 forest survey were classified as unmerchantable because of excessive rot, including the heart rot *Ganoderma* sp.

Pole-size trees and the smaller sawtimber-size koa have relatively thin bark. Fires can damage the bark, or kill the tree.

Weed species are serious problems in certain areas. The banana poka (*Passiflora mollissima* (HBK) Bailey) smothers both koa reproduction and mature trees by laying a curtain of vines over them. The German-ivy (*Senecio makanioides* Otto)¹² is also difficult to control.

Special Features

The true leaf of koa consists of 12 to 15 paired, bipinnate leaflets. They are most commonly found on the younger plants, although one may find both the true leaves and phyllodes (dilated petioles) on

the same seedling. The older trees usually bear only the laurel green, sickleshaped phyllodes, but sometimes true leaves also grow on lower branches.

The most important use of koa timber by Ha-

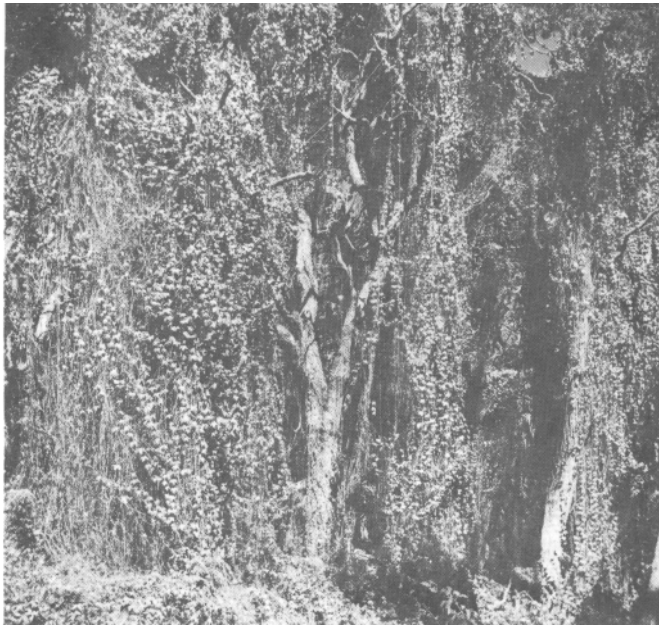
⁸Korte, K. H., Rodent damage in koa reproduction. 1963. (Unpublished report to State Forester, Hawaii Forestry Division, Kahului, Maui.)

⁹Davis, C. J., in personal correspondence with R. E. Nelson, Pacific SW. Forest and Range Expt. Sta., U.S. Forest Serv. Honolulu, Hawaii. Jan. 9, 1963.

¹⁰Personal correspondence with R. D. Raabe, University of Hawaii, Hilo, Dec. 4, 1963.

¹¹Bega, R. V. Forest disease research. 1962. (Unpublished report on file at Pacific SW. Forest and Range Expt. Sta., U.S. Forest Serv., Berkeley, Calif.)

¹²Personal correspondence with R. E. Daehler, Hawaii Forestry Division, Honolulu, Hawaii. Oct. 10, 1963.

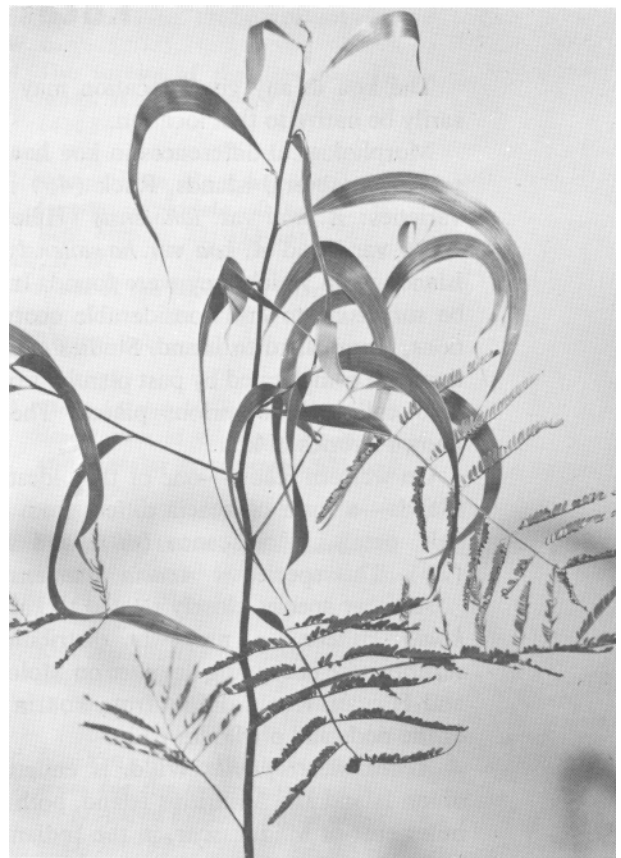


Ralph Daehler, Hawaii Forestry Division

A

A Curtain of banana poka vines (*Passiflora mollissima*) hangs over a koa tree.

B Koa seedlings, showing true leaves (*lower*) and phyllodes (*upper*).



B

C Koa logs piled in a cleared koa rain forest area.



waiians was to build canoes. The largest of the giant war-canoes extended 70 feet; their hulls were made of single giant koa logs (9). Koa was also used for surf boards, some 18 feet or longer (9), for paddles, and for framing grass-houses (13). The bark provided dye for kapa, a light cloth made from the bark of *wauke* (*Broussonetia papyrifera* (L.) Vent.) (13).

Koa wood is now used primarily for furniture, cabinet work, and face veneers. It is widely used in woodcraft. Cabinet makers recognize a dozen or

more types of koa wood, including curly or "fiddle back" koa, red koa, and yellow koa (9). One local use is for making ukuleles. At one time koa was sold on the world market as Hawaiian mahogany (39).

Large logs have a narrow, creamy white band of sapwood. The heartwood may vary through many rich shades of dark red, golden brown, or brown. The heartwood seasons well without serious degrade from warping, checking, splitting, or stain.¹³

Races and Related Species

The koa in any given location may not necessarily be native to that location.

Morphological differences in koa have been observed on several islands. Rock (40) named two varieties: *A. koa* var. *lanaiensis* (Hillebrand's *A. koa*- β var.) and *A. koa* var. *hawaiiensis*, after the islands upon which they were found. It would not be surprising to find considerable ecotypic variations, from island to island. Studies of such variations, are complicated by past plantings of koa from seed collected at various places. There are no known hybrids of koa.

On western Kauai--one of the oldest Hawaiian islands--a form of acacia differs from koa in se-pals, petals, inflorescence (40), and seed shape (26). This species is *Acacia kauaiensis* Hillebr.

Another species closely related to koa is *Acacia koaia* Hillebr., a narrowly distributed, small, shrubby tree occupying dry sites on Molokai, Maui, and Hawaii. *Koaia* differs from koa in the shape of the pods and phyllodes (40).

Acacia heterophylla Willd. is endemic to Reunion Island and Mauritius Island, both about 450 miles east of Madagascar, in the Indian Ocean. It

is so similar to koa that Gaudichaud identified them as the same species. Asa Gray identified the two as separate species entirely on the basis of distance and isolation (40).

Tasmanian blackwood (*Acacia melanoxylon* R. Br.), native to Australia and Tasmania, resembles koa. But it has straighter and shorter phyllodes, a narrower curved pod, and a more pointed crown (40). Another closely related species, *Acacia simplicifolia* (L. f. Druce), grows in Samoa and Fiji (39).

Koa is a tetraploid with $2n=52$; all other phyllodinous acacias studied have the diploid chromosome complement (3). The chromosome complements of *A. kauaiensis*, *A. koaia*, *A. heterophylla*, and *A. laurifolia* have not been reported. Atchison (3) reasoned "that polyploidy in *A. koa* occurred after the initiation of phyllody. This is supported by its distribution as an endemic island extension of the Australian flora."

¹³Personal correspondence with R. G. Skolmen, Pacific SW. Forest and Range Expt. Sta., U.S. Forest Serv., Honolulu, Hawaii, Aug. 28, 1963.

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