

FIRETREE (*MYRICA FAYA*) DISTRIBUTION IN HAWAI'I

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ABSTRACT

The primary objective of this study was to map the distribution and abundance of firetree (*Myrica faya*) in the state of Hawai'i. Reconnaissance data were used to map 85,912 a (34,365 ha) of infestation throughout the State. Infestations of 72,265 a (28,906 ha) occur on the island of Hawai'i, 4,770 a (1,908 ha) on Maui, 2,518 a (1,007 ha) on Lāna'i, 435 a (174 ha) on O'ahu, and 5,925 a (2,370 ha) on Kaua'i. Distribution ranges in elevation from as low as 1,400 ft (425 m) on Lāna'i to as high as 6,400 ft (1,940 m) on the slopes of Haleakalā on Maui. Firetree occurs on recent, thin ash over pāhoehoe lava as well as on deep, well-developed silty clay loam soil. It is found in montane rain forest habitats and in dry scrub (marginal through submontane seasonal) forest. The distribution patterns of firetree suggest that this species has not yet reached the limits of its potential distribution in Hawai'i. Observations on the phenology of firetree were made at two-week intervals from March 1983 through March 1985. Data were taken at three sites and were related to the data from nearby weather stations. Information on flowering, fruiting (mature and immature), leaf flushing, leaf fall, and fruit drop was collected. Analysis of the phenologic patterns observed showed flowering, fruiting, and fruit drop to be endogenously controlled, while leaf flushing and leaf fall were influenced by environmental variables.

INTRODUCTION

Fire or faya tree (*Myrica faya*, Myricaceae) is a native of the Azores, Madeira, and the Canary Islands in the Atlantic Ocean. It was introduced to Hawai'i in the late 1800s by Portuguese immigrants, presumably as an ornamental (Fosberg 1937). Because it forms multiple branches near the base of the main stem (Smathers and Gardner 1979), firetree has often been described as a shrub or small tree reaching heights of only 13 to 20 ft (4-6 m) (Fosberg 1937; Neal 1965; Hasselwood and Motter 1983). However, in the Hāmākua region of the island of Hawai'i, firetree

grows to over 50 ft (16 m) high, forming dense canopies with an understory devoid of other plant life (Smathers and Gardner 1979).

Firetree has narrow, pointed, smooth, shiny, dark green leaves with entire or toothed margins (Neal 1965; Hasselwood and Motter 1983). Although firetree has a strong tendency toward dioecism, a few staminate flowers are found on pistillate plants and a few pistillate flowers are found on staminate plants (Gardner 1985). Staminate flowers with four stamens each are borne on small catkins. Three pistillate flowers that may be joined and accompanied by one bract are also grouped in small catkins. Fruits are small, edible drupes that form dense clusters changing from green through red to purple when ripe (Fosberg 1937; Lawrence 1951; Neal 1965).

The purpose of this study was to map the distribution and abundance of firetree and to observe the phenological cycles of this species in the state of Hawai'i. Distribution studies will provide a database for location of all infestations, both for implementation of a biological control program, should an appropriate agent be found, and for future studies of the spread of this species in Hawai'i. The phenology data will help to determine the timing of control programs.

HISTORY OF SPREAD AND CONTROL EFFORTS

The Hawaiian Sugar Planters' Association obtained seeds of firetree from a Portuguese farmer on the island of Hawai'i for use in reforestation attempts (Fosberg 1937). Plantings were made on the islands of Kaua'i, O'ahu, and Hawai'i (Skolmen 1979), most of them in the 1920s. The aggressive, noxious character of this species was soon noted, along with its spread to Maui (Fosberg 1937). The continued spread of firetree led the Territorial Board of Agriculture and Forestry to begin attempts to eradicate it in 1944 (Neal 1965). Managers of Shipman Estate observed firetree spreading in the Volcano area on the island of Hawai'i in the mid-1940s. In the mid-1960s, Shipman attempted to control the species there (T. Lindsey, pers. comm.). It was declared noxious for state land leases because it spreads rapidly and forms a dense cover that crowds out desirable species (Hosaka 1945; Haselwood and Motter 1983). Firetree has continued to spread despite efforts by the State and the National Park Service, and it now occurs on all major Hawaiian Islands except Kaho'olawe, Moloka'i, and Ni'ihau. Estimates of the total infested area have increased over the years: 8,200 a (3,280 ha) (Yamayoshi 1954), 21,375 a (8,550 ha) (Anonymous 1962), 40,000 a (16,000 ha) (Walters and Null 1970), and the most recent estimate, showed 53,938 a (21,575 ha) to be supporting firetree populations of various densities (Watanabe 1982). Hawai'i contained 50,000 a (20,000 ha); Maui, 3,000 a (1,200 ha); O'ahu, 100 a (40 ha); Kaua'i, 325 a (130 ha); and Lāna'i, 512 a (205 ha).

Firetree was thought to occur where average annual rainfall is 35 in. (900 mm) or more in mesic low-elevation forest and wet low- and high-elevation forest [vegetation zones C₁, C₂, D₁, and D₂ of Ripperton and Hosaka (1942)] (Hosaka and Thistle 1954; Anonymous 1962).

Within these broad limits, however, the tree can adapt to a wide range of habitats. Clarke (1978) described the distribution of firetree in Hawaii Volcanoes National Park as a horizontal band between 2,200 and 4,000 ft (665-1,210 m) elevation, including 11 soil types and 15 of the vegetation units described by Mueller-Dombois and Fosberg (1974). Average annual rainfall within this distribution is from 50 in. (1,270 mm) to over 100 in. (2,540 mm), and average annual temperature ranges from 60 to 72 F (22 C) (Clarke 1978). The wide range of habitats where firetree has been found suggests that it has not yet occupied its full potential range.

An estimated 15,000 a (6,000 ha) of infestation along the Hāmākua coast on the island of Hawai'i has been classified as "heavy" (Watanabe 1982). In this region firetree grows over 50 ft (16 m) tall and forms dense, interlocking canopies with no understory (Smathers and Gardner 1979). The absence of other plant species under the canopy may be due partially to shading. However, allelopathic activity has been reported for a closely related species (*M. cerifera*) from the southeastern United States (Dunevitz and Ewel 1981). Thus, the lack of understory in firetree stands may be due not only to canopy shading, but also to allelopathic activity (Smith 1985).

Current evidence suggests that the seeds of firetree are dispersed primarily by birds (Smathers and Gardner 1979; LaRosa *et al.* 1985). The extensive, uniform distribution of the tree in remote areas and the close spatial association of this species with other tree species, especially 'ōhi'a (*Metrosideros polymorpha*), suggest dispersal of seeds by birds. Birds commonly associated with dispersal include the Japanese white-eye (*Zosterops japonica*), the common myna (*Acridotheres tristis*), the red-billed leiothrix (*Leiothrix lutea*), and the 'ōma'o (*Phaeornis obscurus*) (Clarke 1978; Smathers and Gardner 1979; Gardner and Davis 1982; LaRosa *et al.* 1985). Low germination rates of firetree seeds collected in the field, contrasted with copious seed production and rapid dispersal of the species, has led to the hypothesis that scarification from bird ingestion greatly improves germination rates (Clarke 1978). This idea was supported by experiments that showed increased amounts and rates of germination due to mechanical or chemical scarification of seeds of *M. cerifera* (Ewel *et al.* 1982). However, germination tests of firetree in Hawai'i showed no significant difference in amounts or rates of germination between seeds that passed through captive birds and apparently mature, viable seeds collected in the field from trees (LaRosa *et al.* 1985). Feral pigs (*Sus scrofa*) have also been identified as possible dispersal agents for seeds of firetree. Firetree seedlings have been observed growing directly from pig-rooted areas in Hawaii Volcanoes National Park (Clarke 1978). Stomach content analyses of feral pigs in the Park have shown significant percentages of firetree seeds during certain times of the year (Stone and Taylor 1984).

Firetree control efforts have been implemented primarily by the state of Hawai'i and the National Park Service. The effort by the State has been conducted over the last 25 years, but variations in availability of funding and manpower have resulted in fluctuations in intensity of this effort. Herbicides are the primary control agents. Of the various herbicides used

by the State, Tordon 22K (picloram) has been the most effective, producing a complete canopy kill and a 99% control of resprouting (Walters and Null 1970; Smathers and Gardner 1979; R. Kami, pers. comm.). In Hawaii Volcanoes National Park, basal bark application of a 4% solution of KURON (silvex) in diesel oil was effective, and a method to introduce ROUNDUP (glyphosate) directly into the vascular tissue of firetree through a cut branch was suggested for remote areas and less-than-ideal weather conditions (Gardner and Kageler 1982). In some areas, pasturelands have been cleared of invading firetree with bulldozers by private landowners. However, follow-up monitoring and/or herbicide treatment of stumps and brush piles are needed with mechanical methods to control resprouting (R. Kami, pers. comm.).

F. Bianchi, an exploratory entomologist from Hawai'i, was sent by Hawaiian Sugar Planters' Association to the native habitats of firetree in 1955 to search for potential biological control agents. A fungus disease caused by *Dothiorella berengeriana* initially appeared promising but was later rejected because tests conducted in Portugal showed a lack of host specificity (Gardner and Davis 1982; Gardner 1984). Other disease-causing organisms were observed on this trip, but none have been sufficiently tested for use as control agents. Krauss (1964) summarized his and others' previous observations of insects associated with firetree and related species. However, insects collected during exploratory efforts either proved ineffective in tests of control or failed to propagate. Krauss (1964) also discussed other apparently pathogenic organisms on *Myrica* spp., but no attempt has been made to test these as control agents in Hawai'i (Gardner and Davis 1982). Observations from another exploratory trip indicated that firetree is generally abundant and healthy in its native range and that biological agents in these areas are not important factors in limiting the growth, reproduction, or distribution of this species. However, at least two diseases and two insects were found to merit further investigation; these should be the subjects of current research in a biological control program for firetree in Hawai'i (Gardner 1984; Hodges and Gardner 1985).

DATA COLLECTION

Maps of the distribution of firetree in Hawai'i presented herein (Figs. 1-5) are based on reconnaissance data. Reconnaissance was done in or near areas where firetree was reported by knowledgeable individuals. Final drafts of the distribution maps were plotted on U.S. Geological Survey topographic maps (Whiteaker and Gardner 1985). Phenology data (flowering, immature fruiting, mature fruiting, leaf flushing, leaf fall, and fruit drop) were collected at three sites on the island of Hawai'i (Whiteaker and Gardner 1987).

RESULTS

Distribution

Island of Hawai'i. Firetree was found between Laupāhoehoe and Honoka'a (Hāmākua District) from 2,000 to 4,400 ft (600-1,335 m) elevation, with 29,390 a (11,755 ha) infested (Whiteaker and Gardner 1985). Much of this area is ranchland where firetree has been cleared from pasture areas, but extensive areas are still covered with heavy or moderate density stands of large (65 ft or 20 m tall) trees.

Another major infestation on Hawai'i Island is in the vicinity of Volcano Village, including a large portion of Hawaii Volcanoes National Park. The distribution ranges between 1,800 and 4,000 ft (545-1,210 m) elevation and covers 41,500 a (16,600 ha). The Volcano area has a wide variety of habitats, including montane 'ōhi'a rain forest near Volcano Village and the Kīlauea summit area, submontane seasonal forest near 'Āinahou Ranch and Hilina Pali Road, montane seasonal forest converted to pasture on Keauhou Ranch adjacent to the Mauna Loa Strip Road area of the Park, and dry scrubland with scattered trees in the Ka'ū Desert. The vegetation, climate, and substrates of the wide variety of habitats in which firetree is found within the Park have been described in detail by Doty and Mueller-Dombois (1966) and Mueller-Dombois and Fosberg (1974).

An infestation of firetree occurs on the Kapāpala Ranch (Ka'ū District) adjacent to the Ainapō Cabin between 3,500 and 3,760 ft (1,060-1,140 m) elevation. The infestation occupies 80 a (32 ha). This ranchland consists of pasture mixed with stands of alien shrubs and trees on steeper slopes. Firetree has also been reported in the Kiolaka'a-Kea'a Homesteads Addition portion of the Ka'ū Forest Reserve at 2,300 ft (720 m) elevation. A single plant was recorded on a Hawaii State Division of Forestry survey of this area (L.W. Cuddihy and S.J. Anderson, pers. comm.).

Firetree occurs on the slopes of Hualālai (North Kona District) between 4,850 and 6,040 ft (1,470-1,830 m) elevation. The infestation covers 1,300 a (520 ha). This population is in a remote area on privately owned ranchland (R. Kami, pers. comm.).

The total area of firetree distribution on the island of Hawai'i is 72,265 a (28,906 ha) (Fig. 1), including 30,500 a (12,200 ha) within Hawaii Volcanoes National Park.

Island of Maui. Firetree is found in the Kula area on the western slopes of Haleakalā between 3,200 and 6,400 ft (970-1,940 m) elevation (Fig. 2). The area consists of ranchland and small, private residential parcels of land. Total area of firetree distribution is 4,770 a (1,908 ha). The distribution may be limited by the efforts of Haleakalā Ranch, which controls weed species. Only one individual firetree along the Haleakalā Highway, at 4,250 ft (1,290 m) elevation, and a small stand in Hāpapa Gulch were noted within the boundaries of Haleakalā Ranch (Fig. 2). However, these individuals indicate that the ranch is suitable habitat for an infestation of this species. The Hawaii Department of Agriculture attempted to control firetree on Maui in the mid-1970s, but logistical

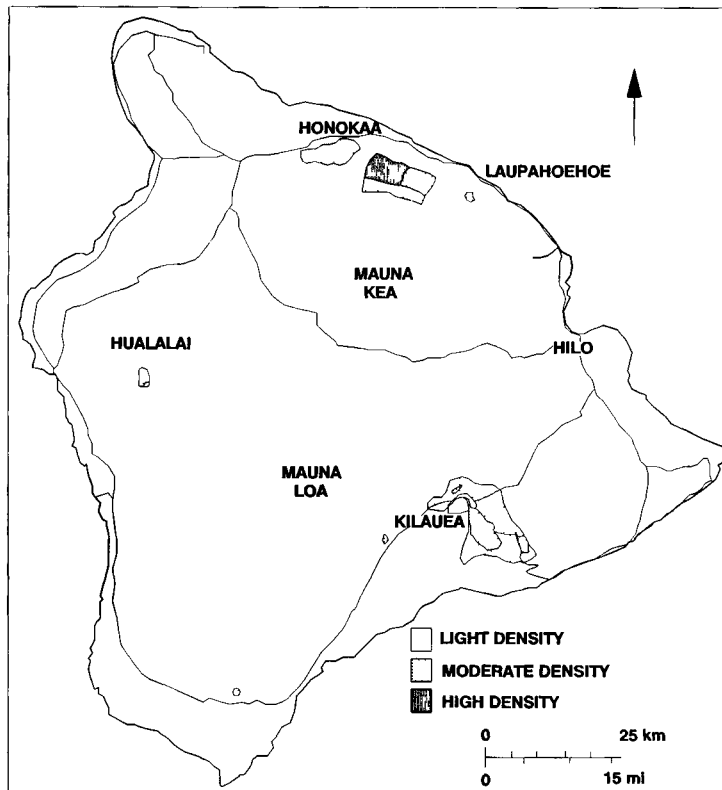


Figure 1. Distribution of firetree on the island of Hawai'i.

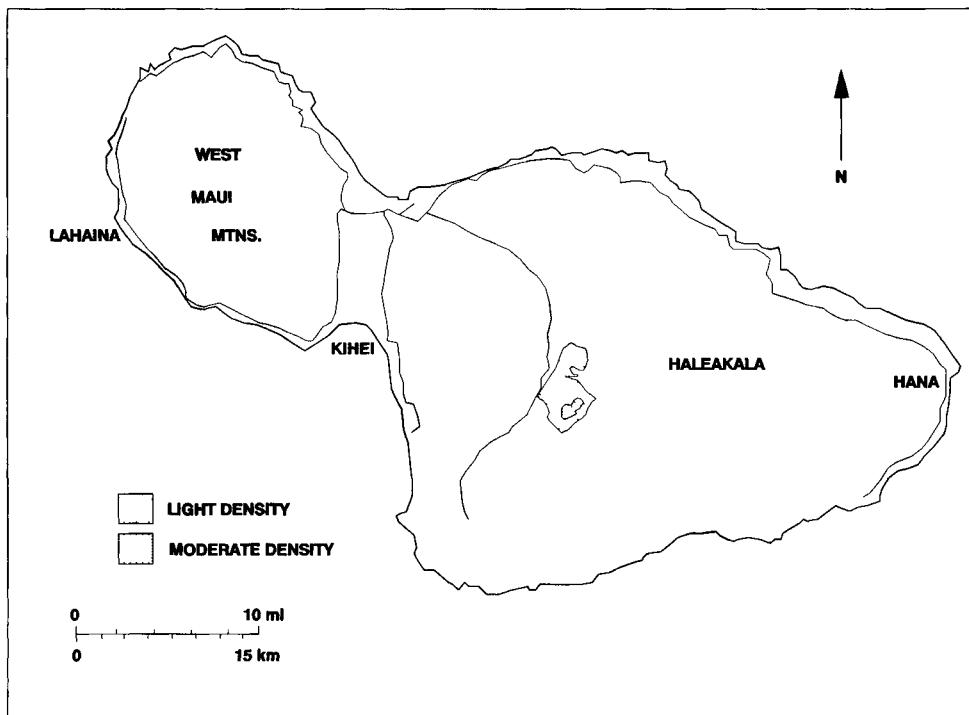


Figure 2. Distribution of firetree on the island of Maui.

difficulties related to the large number of small, privately owned parcels of land led to abandonment of the effort (E. Tamura, pers. comm.).

Island of Lāna'i. Firetree occurs in the mountainous portion, or Lāna'i Hale area, of the Island (Fig. 3). The distribution ranges from 1,400 ft (425 m) elevation in protected gullies to the summit of the Island at 3,370 ft (1,020 m). The total area occupied is 2,518 a (1,020 ha). This range of firetree on Lāna'i is rough, mountainous terrain consisting of narrow ridges and steep slopes.

Island of O'ahu. Firetree is found in the Wai'anae mountains between 2,000 and 3,127 ft (610-948 m) elevation (Fig. 4). The center of distribution is at the southern end of the Wai'anae mountains between Mauna Kapu and Pu'ukaua in the Honouliuli Forest Reserve, where it was planted by the Territory of Hawaii for reforestation (Skolmen 1979). A smaller, noncontiguous population occurs to the northwest at Pu'u Kawiwi, and to the north at Pu'u Hāpapa (Fig. 4). The total area occupied is 435 a (174 ha). As on the island of Lāna'i, the range is rough, mountainous terrain with narrow ridges and steep slopes.

Firetree was planted in several other areas on O'ahu, including sites in the Ko'olau mountains (Skolmen 1979). However, populations in these locations have not been observed by persons familiar with these areas (J. Obata, pers. comm.), and it is assumed that plantings were at elevations not suited for reproduction.

Island of Kaua'i. The major infestation of firetree is found just west and north of Waimea Canyon, mostly within Waimea Canyon and Kōke'e State Parks. A separate population just east of Waimea Canyon is centered around Wai'alaie Cabin on Wai'alaie Stream in the Nā Pali-Kona Forest Reserve and is partially within the Alaka'i Wilderness Preserve. Firetree is also found on the northwestern slopes of the Island below the mesic native forest and/or forestry plantings (Fig. 5). These populations occur between 1,800 ft (545 m) on the northwestern slopes and 4,200 ft (1,270 m) within Kōke'e State Park. The total area occupied is 5,925 a (2,370 ha). On Kaua'i, firetree occurs in a variety of habitats, from montane rain forest with little topographic relief to sparsely vegetated, dry, eroded, steep slopes.

All Islands. Total area of firetree distribution in Hawai'i is 85,912 a (34,365 ha). More detailed maps and descriptions of the distribution of firetree in Hawai'i are presented in a separate report (Whiteaker and Gardner 1985).

Phenology

Krauss (1964) reported that firetree in its native habitat showed abundant male flowers and a few small fruits in June; in July, most male flowers were dry, and many green (and a few purple) fruits were seen. Krauss observed all stages of fruiting in September, and by November many ripe and fallen fruits were reported. Gardner (1985) reported various

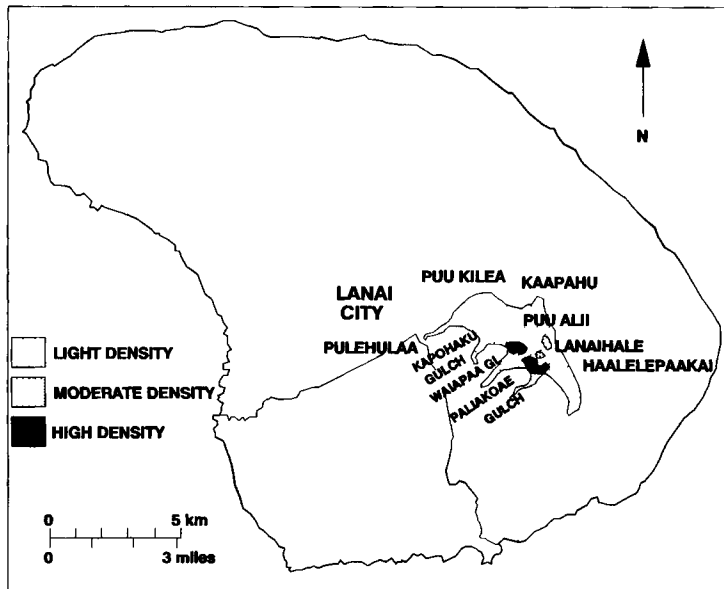


Figure 3. Distribution of firetree on the island of Lāna'i.

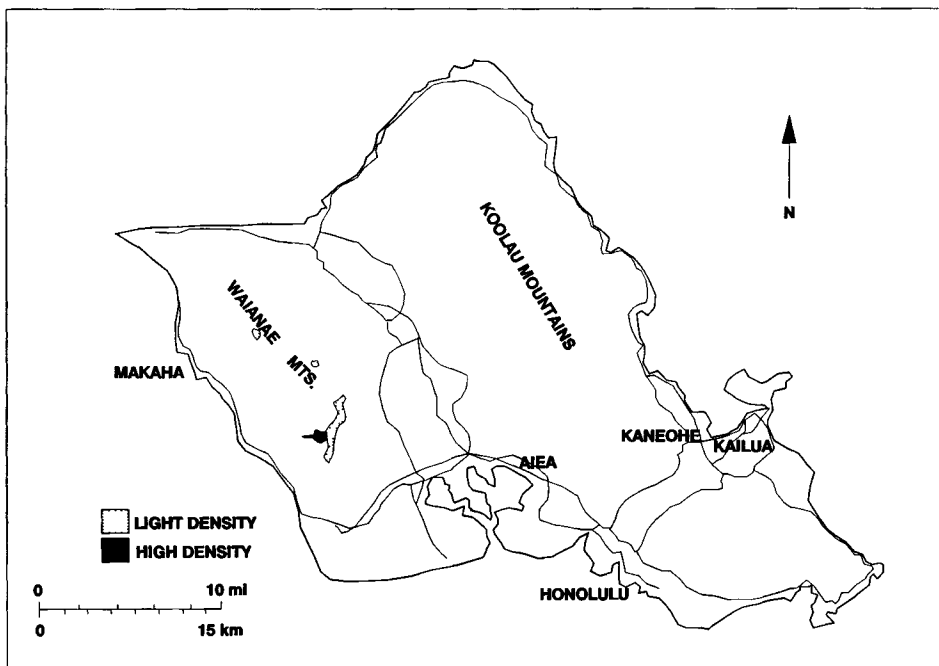


Figure 4. Distribution of firetree on the island of O'ahu.

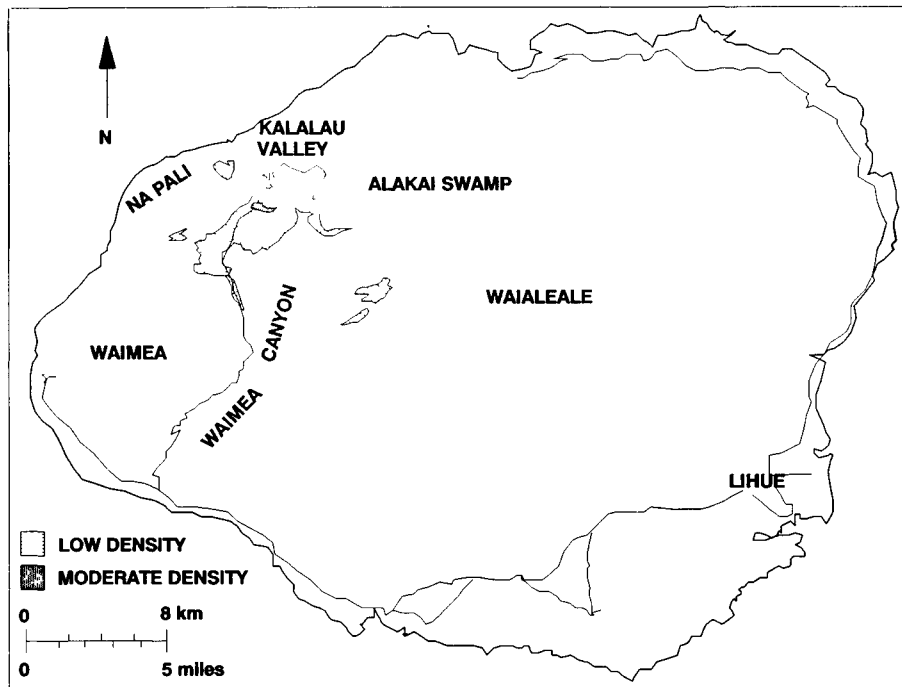


Figure 5. Distribution of firetree on the island of Kaua'i.

stages of flowering with some immature fruit development during a visit to the native habitats of firetree in April and May.

In this study, flowering, immature fruiting, mature fruiting, and fruit drop showed similar patterns at all three study sites on Hawai'i Island (Hilina Pali and Byron Ledge in Hawaii Volcanoes National Park, and the Eldon English property in Volcano). Flowering showed maximum activity in June and minimum activity in December and January in the two years observed. Peaks of immature fruiting followed in August and September, with minimum activity in February and March. Maximum mature fruiting was observed in November, and minimum mature fruiting was seen in May. Fruit drop followed a similar pattern to mature fruiting in the one year observed. Leaf flushing showed similar patterns at two of the sites, with maximum activity in June. At the third site, leaf flushing also had peaks in June, but the pattern over the entire observation period differed somewhat from the other two sites. Two sites also had similar patterns in the amounts of leaf fall, but the amounts of leaf fall at the third site showed a different pattern. A more extensive presentation and discussion of these data, including graphs, appears in a separate report (Whiteaker and Gardner 1987).

DISCUSSION

Distribution

The distribution of firetree described here indicates that this alien species is adapted to a wide variety of habitats in Hawai'i. It occurs on recent, thin ash over pāhoehoe lava on Hawai'i Island and on soil classified by Foote *et al.* (1972) as deep, well-developed silty clay loam on Kaua'i and Hawai'i. It occurs in montane rain forest habitats on Hawai'i and Kaua'i islands and in dry scrub marginal to submontane seasonal forest on Kaua'i and Hawai'i. It grows as low as 1,400 ft (425 m) elevation on Lāna'i and as high as 6,400 ft (1,940 m) on Maui. It is found on nearly vertical slopes on Lāna'i, in volcanic craters in Hawaii Volcanoes National Park, and on nearly level terrain or gentle slopes in Kōke'e State Park, Kaua'i. These extremes of several habitat factors in areas where firetree occurs suggest that the species may be able to occupy sites that are intermediate along these habitat factor gradients where it does not now occur. Competition from other plants may also be a factor on some sites, and some small, outlying populations may have been missed during the survey. The distribution of firetree has likely not reached its potential extent in Hawai'i.

Firetree infestations in leeward areas such as Kula on Maui and North Kona, Hawai'i, extend up to 6,400 ft (1,940 m) and 6,040 ft (1,830 m) elevation. These records imply that infestations on Kapāpala and Keauhou ranches and Hawaii Volcanoes National Park (in Ka'u District), with upper limits of 3,760 ft (1,140 m) and 4,000 ft (1,210 m), have not yet reached their potential upper elevational extent. Similarly, firetree is found down to 2,000 ft (600 m) and lower in protected sites in Hāmākua and Hawaii Volcanoes National Park on Hawai'i Island, on Lāna'i, and on Kaua'i. Infestations along Highway 11 near Volcano Village and on Kapāpala Ranch may not have reached their potential lower elevation extent.

The rate at which firetree can spread into suitable habitats appears to be very rapid. A single individual was noted in Hawaii Volcanoes National Park between Kilauea Military Camp and Hawaiian Volcano Observatory by F.R. Fosberg in 1961 (Doty and Mueller-Dombois 1966). By 1978, 1,304 a (609 ha) in the Park were mapped as supporting firetree infestations of various densities (Clarke 1978). Data from the present study show 30,134 a (12,200 ha) infested with firetree in the Park, including a 704-a (285-ha) increase during the two-year course of the study. These records indicate a 20-fold increase in infested area within Hawaii Volcanoes in approximately eight years. Firetree has since spread into suitable habitats that were not occupied at the time of this distribution survey (1983-1985).

The distribution of firetree on Kaua'i (Fig. 5) includes infestations on the northwestern slopes of the Island that are noncontiguous with the center of distribution in the Kōke'e/Waimea Canyon area. Separating these areas of firetree invasion is an area of closed-canopy mesic native forest. This pattern of invasion may indicate that the tree is limited in its ability to invade intact closed-canopy native forests. If so, it is possible that firetree is somewhat shade intolerant, and that its spread may be partially controlled by excluding disturbances, such as feral

animals and forest fragmentation, in areas that support a closed canopy forest.

More generally, the distribution of firetree throughout the State seems associated with disturbance. Major areas of infestation are pastures, roadsides, trails, secondary forest, and steep, unstable slopes. In fact, the aggressive nature of the species was first noted in pasturelands. Even the areas of its distribution that are within Hawaii Volcanoes National Park have been subjected to fire, volcanic activity, and foraging by feral goats (*Capra hircus*), pigs, and cattle (*Bos taurus*). Additionally, firetree has been identified as an actinorrhizal nitrogen-fixing species (Miguel and Rodriguez-Barrueco 1974; Turner and Vitousek 1988). Thus, the widespread invasions observed in Hawai'i may be due to a competitive advantage gained through nitrogen fixation on sites undergoing primary or secondary plant succession, especially on nitrogen-poor substrates such as those occurring in Hawaii Volcanoes National Park. This advantage may be lost on sites that have not been recently disturbed. However, in a landscape that is predominately influenced directly and/or indirectly by human activities, the further spread of firetree seems inevitable.

The complex of environmental factors in a particular area may affect the potential elevational range of firetree, even on a single island. In leeward areas such as North Kona, Hawai'i, and Kula, Maui, the distribution is between 3,200 and 6,400 ft (970-1,940 m). However, in windward areas such as Hāmākua, Hawai'i, the distribution is between 2,000 and 4,400 ft (600-1,335 m) elevation. This implies that the species may be adapted to a lower elevational range in windward (wetter) areas than in leeward (drier) areas in Hawai'i. In regions that are intermediate along rainfall gradients, firetree may have an intermediate potential elevational range.

Phenology

Flowering, immature fruiting, mature fruiting, and fruit drop seem to follow an annual cycle that is endogenously controlled and/or initiated by consistent annual environmental cycles, such as day length. The timing of these phases in Hawai'i seems to be similar to that observed in the native habitat of the species (Krauss 1964; Gardner 1984). Fruiting was heaviest at the warmest and driest site and lightest at the coolest and wettest site. This suggests that firetree may not be well adapted to reproducing in cold and/or extremely wet habitats. Also, our data (Whiteaker and Gardner 1987) show that while these phenophases have definite maximum and minimum activity periods, at no time during the course of this study were any of these phenophases completely absent.

Leaf flushing may also have a generally consistent annual cycle, as illustrated by the similar patterns at two of the study sites, and by the peak of activity occurring in June of each year at all three sites. However, when the slightly different overall pattern of leaf flushing at the driest site is compared with precipitation, maximum flushing seems to follow periods of high precipitation; minimum flushing seems to follow periods of low precipitation (Whiteaker and Gardner 1987). Thus, flushing of firetree may be sensitive to variations in precipitation where total

annual precipitation is relatively low. Flushing was only absent at one site for one observation. Thus, although the amount of flushing may vary, this phenophase of firetree is also almost never absent.

The variation among sites in the pattern of the amount of leaf fall is shown by large peaks of leaf fall occurring at different times of the year at one study site relative to the other two sites. This may be due to the geographical position of the sites relative to the volcanically active Pu'u 'Ō'ō vent and the corresponding incidence of high sulfur dioxide levels in the atmosphere. Thus, the large peaks in the amount of leaf fall may reflect the response of firetree to high sulfur dioxide concentrations superimposed on the otherwise steady rate of leaf fall of an evergreen species.

MANAGEMENT CONSIDERATIONS

Most ecologists familiar with the problem think that, if no action is taken, the present trend of rapid spread of firetree into native habitats will continue, resulting eventually in formation of dense, closed-canopy stands, beneath which native plant life will be excluded. This, in turn, will result in the destruction of habitats for native birds, including endangered species. However, sufficient funds and manpower are not available, nor is it anticipated that they will be provided in the future, for large-scale control of firetree through the labor-intensive chemical or mechanical removal approaches used in the past. Such continued efforts would serve only to divert limited funding and manpower away from efforts to control other alien plant species for which these approaches may still be feasible.

Although chemical and/or mechanical control over large areas would be impractical, these approaches may be within the manpower and funding capability of management on comparatively small areas that contain particularly valuable resources, such as rare and endangered endemic species and the native plant communities that support them. In conjunction with this more focused approach to chemical and/or mechanical control, biological control is the only long-term hope for widespread control.

By promoting awareness of the threat of firetree to native ecosystems and ranchlands, the support of public land managers and ranchers adjacent to conservation areas can be obtained. This would aid in preventing firetree from being continually reintroduced into protected areas. It would also enable managers to consider direct control in larger areas with increased possibility of success.

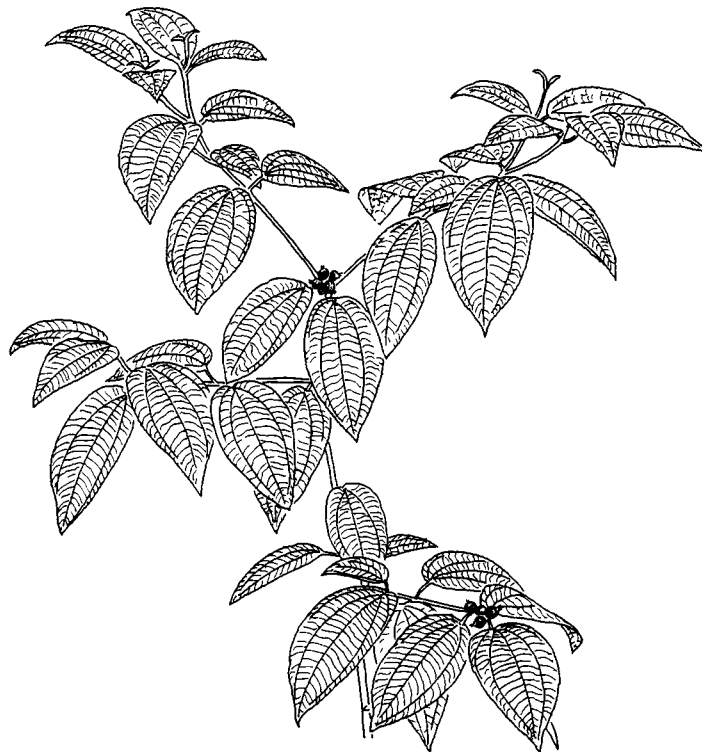
The Hawaii Department of Agriculture and the Department of Land and Natural Resources should again declare firetree a noxious weed and increase efforts toward its control on a statewide basis on State as well as privately owned land. Support for biocontrol research for firetree should be encouraged by providing funds for foreign exploration and related work. Federal agencies should cooperate in any State-supported control program and could provide biological control quarantine facilities as well as

services of federally funded personnel. A cooperative Statewide control program would enhance the ability of management to control firetree and to prevent this species from becoming established in protected areas such as Haleakala National Park. Public awareness would then be much more widespread than at present, and public attitudes toward permitting the occurrence of apparently innocuous infestations of firetree on private land could be altered, with increased understanding of the need for control. The public should be less tolerant of firetree infestations on State and federal public lands than it is.

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