

DISTRIBUTION, STATUS, PHENOLOGY, RATE OF SPREAD, AND MANAGEMENT OF CLIDEMIA IN HAWAI'I

Clifford W. Smith

ABSTRACT

Clidemia (*Clidemia hirta*, Melastomataceae) is a significant disruptive weed in many ecosystems in Oceania and the Southeast Asian and Indian subcontinents. In Hawai'i, it forms dense monotypic stands in mesic to wet environments between 33 and 4,920 ft (10-1,500 m) elevation. First reported in the Hawaiian Islands on O'ahu in 1941, it has since spread to Hawai'i Island (1972), Moloka'i (1973), Maui (1976), Kaua'i (1982) and Lāna'i (1988). Humans are long-distance dispersal agents, whereas short-distance dispersal is effected by birds, feral pigs (*Sus scrofa*), mongooses (*Herpestes auropunctatus*), humans, and other organisms. Wildfires, landslides, and windstorms accelerate dominance of this weed. All efforts to eradicate newly established populations failed when they were not initiated before first fruit set. The impacts of this weed on native species and ecosystems are devastating. *Clidemia* has the potential of driving a number of species to extinction. However, impacts on the water balance of entire ecosystems may be more devastating in the long run.

INTRODUCTION

Clidemia hirta (Melastomataceae), commonly known as clidemia or "Koster's curse," is a serious weed in many ecosystems in Oceania as well as on the Southeast Asia and Indian subcontinents. First reported in the Hawaiian Islands on O'ahu in 1941 (Anonymous 1954) and included by Hosaka and Thistle (1954) in their list of noxious plants because of its history in Fiji, it remained a relatively uncommon plant in the Islands into the early 1960s. *Clidemia* was declared noxious by the Hawaii Department of Agriculture in 1957 (Regulation 10). However, Plucknett and Stone (1961) stated that it was not common and "at present cannot be classed as dangerous." It was still confined to O'ahu at that time, but in the early 1970s it was spread to the other Islands. In 1975, the State Senate, in response to pressure from agriculturists, foresters, and conservationists and concerned about further spread to islands other than O'ahu, passed a

resolution recommending action; in the past 10 years considerable management of, and research on, this weed has been conducted.

This paper documents the ecology, phenology, distribution and dissemination of *C. hirta* in the Islands. Its spread, potential range and probable impact are also considered. Biological control is discussed in Nakahara *et al.*, this volume.

ECOLOGY

Clidemia is found in secondary-succession tropical rain forests in Central and South America and the Caribbean Islands, where it is not a common plant (Cook 1929; Wester and Wood 1977). In its native habitat in the West Indies and Central America, it is an early colonizer of cleared ground, rapidly becoming dominant before being smothered by gap-replacement vines (Burkhart, pers. comm.). It is constantly present in open forested areas, plantations, and along roads and trails, but only as an occasional plant (Wester and Wood 1977). All plants show signs of heavy predation by insects and other organisms. Burkhart (pers. comm.) has noted that it also faces strong competition from other melastomes in its native habitat.

Clidemia invades undisturbed areas in Hawai'i, but population levels remain low. However, once an area is disturbed, colonization proceeds rapidly. Wester and Wood (1977) recorded the domination of an area on O'ahu by *clidemia* within two years after a fire. Similar responses have been seen elsewhere on O'ahu after fire. Hurricane Iwa, in 1981, disturbed much of the area along the Contour Trail in the Wai'anae Mountains on O'ahu. Two years later there was an almost impenetrable thicket of *clidemia* 10 ft (3 m) or more tall. Feral pigs (*Sus scrofa*) play a significant role in the intensification of infestations of this weed. Along the Aiea Loop Trail in Honolulu, areas dug up by pigs showed large numbers of seedlings within two months of disturbance. These later grew into dense thickets within six months. Pigs not only bring seeds into an area, but disturb the ground sufficiently to provide an excellent environment for germination and establishment.

In Hawai'i, *clidemia* is free of competition from other melastomes and gap succession vines. The only significant insect pest is a thrips, *Liothrips urichi* (Thysanoptera: Phlaeothripidae), an introduced biocontrol agent. Plants are now found in forested areas and open situations where rainfall is high and cloud cover frequent. In open areas with high insolation, *Liothrips* debilitates the weed sufficiently to effectively control it. In shaded areas, however, *Liothrips* is not as effective.

Clidemia occurs in dense, monotypic stands in mesic to wet environments from 36 ft (11 m) above sea level (never directly exposed to salt spray) to at least 4,000 ft (1,220 m) elevation. In exposed windy areas, it remains a scrambling shrub not more than 30 in. (75 cm) tall. In moist, shaded environments, the bush reaches 16 ft (5 m) into the subcanopy. Pendant

plants up to 50 ft (15 m) long have been observed along precipitous streams in Wailau Valley, Moloka'i (A.C. Medeiros, pers. comm.).

The impact of heavy infestations of clidemia on associated vegetation is devastating. Most plants below the clidemia canopy disappear, including even mosses and liverworts, which are normally able to survive in shaded habitats. A few tussock mosses remain as spindly strands, but the soil-binding, mat-forming species, such as *Leucobryum gracile* and *Rhizogonium spiniforme*, disappear. Rare subcanopy species cannot compete against this weed and are rapidly displaced. Even common species are unable to reproduce. Their survival, dependent on their seed banks, declines as the infestation continues.

PHENOLOGY

Growth, flowering, and fruiting of clidemia have been observed throughout the year in areas where the rainfall exceeds 98 in./yr (2,500 mm/yr) with no dry season. However, in areas where rainfall is as low as 39 in./yr (1,000 mm/yr), and particularly where there is a dry season, the plant does not flower or fruit much after the dry season has begun. Leaves fall off, growth ceases, and some death of shoot tips occurs. As long as drought does not last more than about six months, plants recover and resume reproduction within a very short period.

DISTRIBUTION

Considerable inconsistency in estimates of the distribution of clidemia in the Islands exists. Some estimates refer only to known populations, which tends to minimize estimated area of occupation because of inadequate field surveys. Other estimates join isolated populations together and consider the whole area infested unless there is reasonable explanation for the disjunction. I have followed the latter approach because the ease of dispersal, rapid growth and maturation, and the abundance and diversity of dispersal agents indicate that on O'ahu, in particular, clidemia has saturated the environment.

O'ahu

How and when *Clidemia hirta* first arrived in the Islands is not known. However, Whitten (1977) reported that H.L. Lyon (who thought that it "was very promising because it won't be spread by birds"), grew it in the Wahiawa Botanic Garden. Clidemia was first reported from Pōamoho in 1941 (Hawaii Department of Agriculture 1975). Otto Degener, on a B.P. Bishop Museum herbarium label dated 1949, noted that clidemia was "escaping." In 1952, State foresters estimated that it was growing vigorously in an area of less than 250 a (100 ha) in the Ko'olau Mountains (Hawaii Department of Agriculture 1975). In retrospect, we can be almost certain that the plant occurred at low densities in an area three times the size of this estimate. By the early 1960s, clidemia had spread as far south as Mt. Tantalus and as far north as Kawailoa (Thistle 1962). In 1975, State Forester J. Pelly (1975) estimated that approximately 96,000 a

(38,400 ha) were infested, 77,000 a (30,800 ha) in the Ko'olau Range and 19,000 a (7,600 ha) in the Wai'anae Range. However, in 1977 Wester and Wood (1977) estimated that it occupied only 77,455 a (31,350 ha). Today, the infestation ranges as far south as Mariner's Ridge above Hawai'i Kai, and to Pūpūkea in the Ko'olau Range (Fig. 1).

Clidemia spread to the Wai'anae Range before 1970. The initial infestation was probably in the Schofield Barracks military reservation, transported there from the Kawaihoa and Kahuku military training area. In 1973, it had reached the contour trail below Pu'u Hāpapa. The weed is now present throughout the Honouliuli Forest Reserve, and in the north it almost reaches the tracking station above Ka'ena Point. The rapid spread and increase in cover of *clidemia* in the Wai'anae Range was particularly evident after Hurricane Iwa in 1981. The only area in this mountain range that remains free of infestation is 'Ōhikilolo; this is probably due to the very dry conditions there, even in the forest, and the inability of pigs to climb the cliffs.

On O'ahu, *clidemia* is found from 35 ft (11 m) above sea level at Pōamoho Gulch, Waialua, to the summit of Mt. Ka'ala at 4,025 ft (1340 m) elevation, where several plants were removed from the Mt. Ka'ala Natural Area Reserve in 1986. However, its abundance on O'ahu is quite erratic. Some gullies are almost filled by this weed, whereas adjacent areas may be little affected. The heavy cover in most gullies and other protected areas is effected by a few large individuals. In contrast, in more open situations, such as on the windward summit slopes of the Ko'olau Range, there are solid stands of many short, stunted plants.

I estimate that the plant is now present in over 252,000 a (100,000 ha) on O'ahu. This figure is tentative because I have assumed that all areas somewhere between the 40-50 in. (1,016-1,270 mm) isohyet are habitat, and that if it is present in the bottom of a gulch it is on the adjacent ridge, and vice versa. The range extension from 1972 (estimated 77,435 a or 31,350 ha by Wester and Wood 1977) is dramatic, but it appears that this weed has now invaded all the territory on O'ahu that it can. It is reported as an occasional weed in gardens in Aiea Heights, Tantalus, Mānoa, and Pālolo.

Kaua'i

By 1982, *clidemia* was established on Kaua'i. The largest infestation is now in Limahuli and Wai'oli valleys, where it is fairly common (Fig. 2). The plant has also been seen where the Nā Pali trail crosses Hanakoa Stream and along the trail on the Kalalau side just beyond Hanakāpī'ai. The Hawaii Division of Forestry has been sending crews to eradicate *clidemia* on Mt. Kāhili, where it is fairly common, and a small population, recently found along the Nounou Forest Reserve tree plantation trail, with little success so far. There are also unconfirmed reports of the plant in the back of some of the valleys along the Nā Pali Coast and along Highway 581 between Wailua and Kapa'a.

The current infestation, consisting of five separate confirmed populations and a number of other unconfirmed locations, suggests that

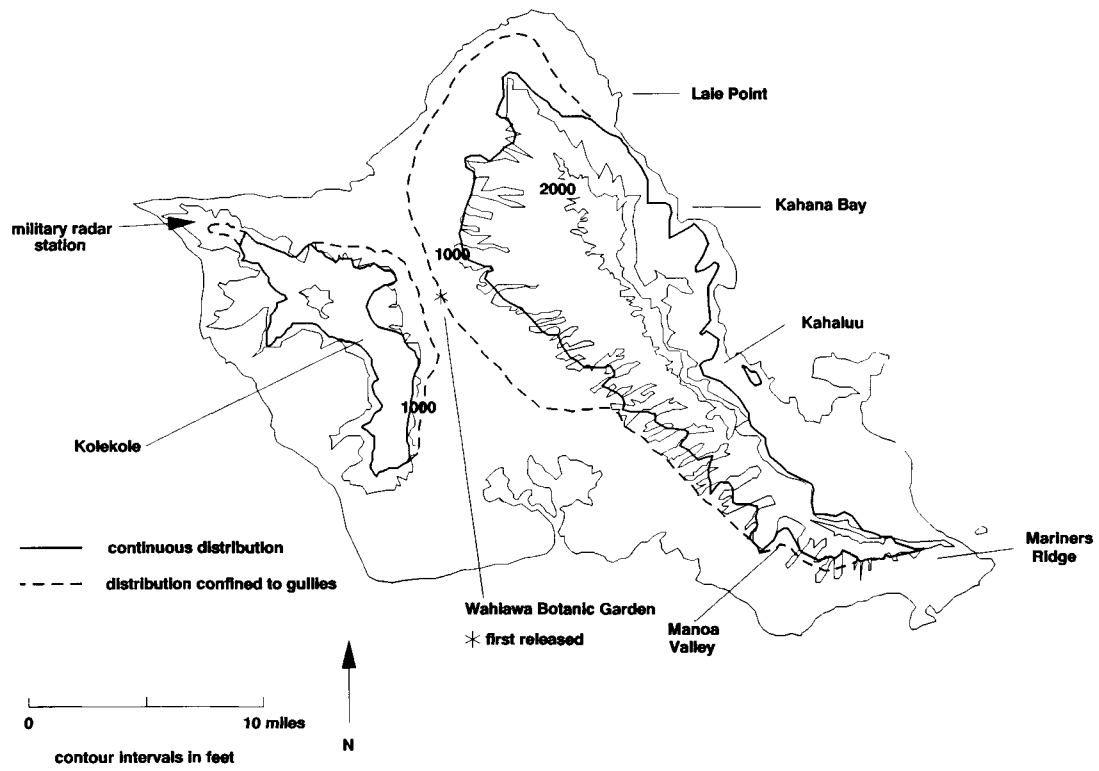


Figure 1. Distribution of *Clidemia hirta* on O'ahu, Hawaiian Islands.

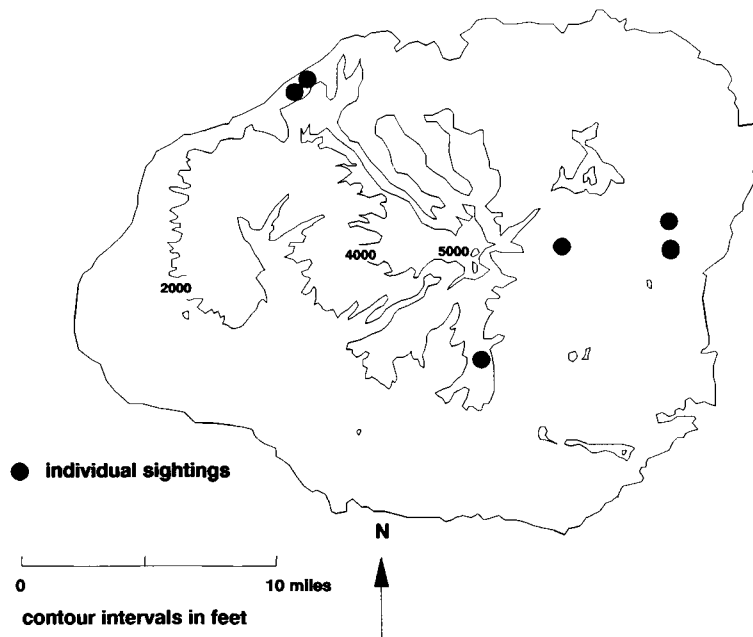


Figure 2. Distribution of *Clidemia hirta* on Kaua'i, Hawaiian Islands.

clidemia has become well established on Kaua'i. The fact that less than 99 a (40 ha) are occupied is no comfort. The prognosis is that these populations will expand very rapidly.

Maui

Clidemia was first reported on East Maui in 1976, along Makapipi Stream just below Pogues Tunnel. One and one-half years later it was quite common above Kailua as far as O'opuola Stream, where it was growing in deep shade under uluhe (*Dicranopteris linearis*) and even epiphytically. It has since spread to many of the adjacent ridges and along the Ko'olau Ditch banks and associated roads. *Clidemia* is now seen fairly frequently along the Hāna highway in the Kailua area (Fig. 3). Approximately 4,940 a (2,000 ha) are infested. *Clidemia* was first seen in Kipahulu Valley in 1988.

On West Maui, it was first reported in 1983-1984 in the Kahakuloa area in Po'elua Gulch and the adjacent ridge by R. Hobdy (pers. comm.). It is now present in 124 a (50 ha). L.T. Gill (pers. comm.) uprooted one plant about 0.25 mi up the Pu'u Kukui trail in the same year, but no other plants have been found in the area.

Moloka'i

Clidemia was first seen on Moloka'i in January 1973 along the *pali* trail in Wailau Valley between 3,000 and 3,500 ft (1,000-1,150 m) (Wester and Wood 1977). Participants of Sierra Club service trips began removing the plants along the trail in the spring of 1974. In 1978, the plant was reported on Pu'u Ali'i but was not seen the following year. The first report from Pelekunu Valley was the collection of a mature plant along the Manuahi ridge trail below 'Ohi'alele, at 1,600 ft (530 m) elevation. The population is expanding but not very rapidly. It has also been seen along the Wailau trail on the leeward side of the Island as low as 1,970 ft (600 m) elevation.

A fruiting plant was discovered in The Nature Conservancy of Hawaii Preserve at Kamakou Flats in 1981 and was uprooted immediately. Since then, seedlings have been destroyed, suggesting that the seed bank from the initial invasion is still present. No other populations have been found in the Kamakou Flats area.

I estimate that in 1974, clidemia occupied about 12 a (5 ha) (>1% of the land area of Moloka'i). By 1979, the infestation had spread to 6,175 a (2,500 ha) (<4%), and it now covers 15,560 a (6,300 ha) (9%) of Moloka'i (Fig. 4). In the next few years clidemia will invade most of the available habitat on Moloka'i.

Hawai'i

Hawai'i was the first island other than O'ahu on which clidemia was recorded, yet, until recently, it has not spread as rapidly as on Maui or Moloka'i (Fig. 5). It was first seen in the Waiākea Forest Reserve in 1972 (Davis 1974) and is now firmly established. From there, it spread to other areas in Puna, where it was first recorded below Pu'u Kauka in 1976. Since then the plant has been seen throughout lower Puna, generally in small

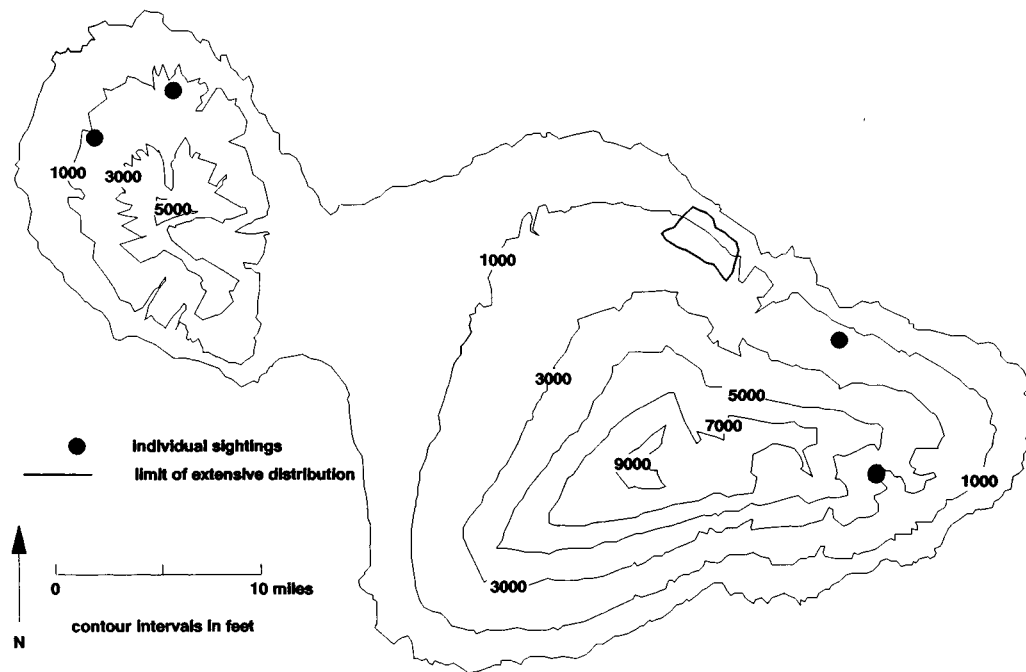


Figure 3. Distribution of *Clidemia hirta* on Maui, Hawaiian Islands.

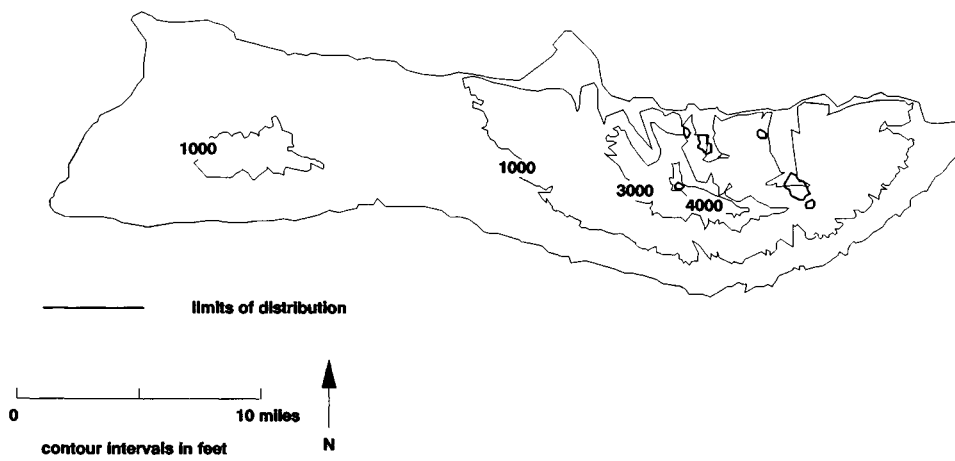


Figure 4. Distribution of *Clidemia hirta* on Moloka'i, Hawaiian Islands.

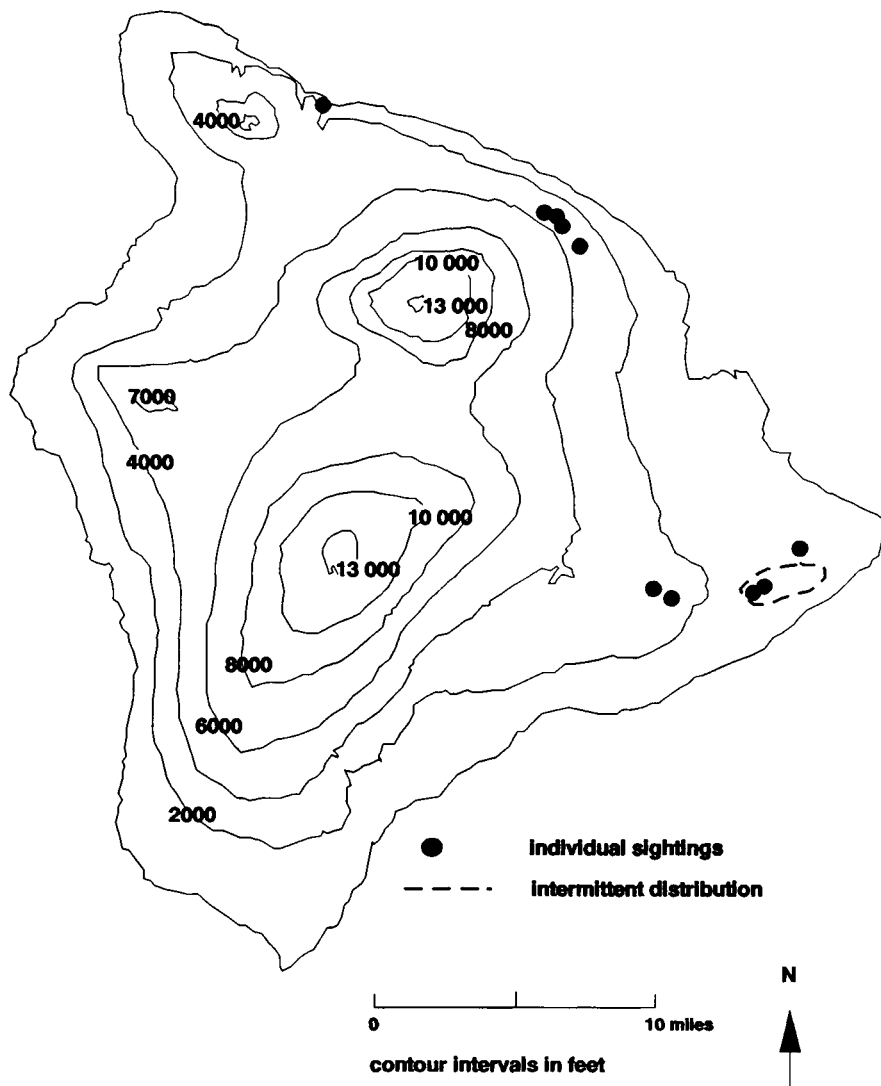


Figure 5. Distribution of *Clidemia hirta* on Hawai'i, Hawaiian Islands.

isolated populations. The latest report, from the area of Pu'u Kia'i, places it three miles from the boundary of Hawaii Volcanoes National Park. In 1983, a separate population was found along the Waimanu trail in the Kohala mountains. It was not there in 1981-1982. Sierra Club trips to control this weed have been unsuccessful to date. Three separate populations above Laupāhoehoe (Kilau Stream, Humu'ula Trail, and the South Fork of Pāhale Stream) indicate that *clidemia* is established in that area also.

Lāna'i

Clidemia was reported from Lāna'i in October 1988 by Holt and Connally (Holt 1988). Two plants were found at the beginning of the Hauola Gulch north trailhead, within 20 feet of the Munro jeep trail. The plants were removed.

Kaho'olawe and Ni'ihau

Clidemia has not been recorded from these two islands. Public access to Kaho'olawe and Ni'ihau is severely restricted, which significantly reduces the chance of introduction. Both islands are quite arid, which would also probably prevent establishment.

DISSEMINATION

Long-distance dispersal of *clidemia* is effected by people who work in or use the forests. No one group is entirely responsible for spread. For example, reasonable circumstantial evidence suggests that the West Maui infestation was introduced by marijuana (*Cannabis sativa*) growers, as the center of the infestation is in some abandoned clearings previously used for that purpose. The first wild population on O'ahu, the Moloka'i infestation, the Nounou and Nā Pali Coast invasions on Kaua'i, and the Waimanu population on Hawai'i were first observed along trails, suggesting that hikers were responsible. Elsewhere, e.g., Kilauea East Rift zone on Hawai'i Island and the initial infestation in the Wai'anae mountains on O'ahu, it is fairly obvious that the seeds were transported by vehicles. The abundance of *clidemia* in the Kawailoa and Kahuku military training areas and the Schofield Barracks Military Reservation may have been the result of transportation by soldiers and military vehicles (Anonymous 1976). The remaining infestations, e.g., the Laupāhoehoe populations, are probably the result of pig hunters. It is extremely unlikely that the introduction of *clidemia* is deliberate, as is the case with banana poka (*Passiflora mollissima*), because this weed is despised by all for its dense, rank growth.

Local dispersal is caused by a variety of organisms. Wester and Wood (1977) stated that frugivorous birds, humans, and perhaps mongooses (*Herpestes auropunctatus*), the latter since confirmed by Burkhart (pers. comm.), are important local disseminators. Seeds are viable after passage through mongooses (Burkhart, pers. comm.). Feral pigs must be added to this list, as they are attracted to the fruit during the peak fruiting season. Seedlings are often seen in dense clusters of several square inches, strongly suggesting that they are growing in the remnants of pig droppings. Pigs also carry seeds on their pelage.

DISCUSSION

Disturbance is a key element in the establishment and invasion of *clidemia*. In its native environment, plants are confined to open areas and only become dominant about twelve months after disturbance, e.g., in slash-and-burn agricultural areas (Burkhart, pers. comm.). All new range extensions in Hawai'i begin along the open edges of trails or other disturbed areas. Pigs, fires, landslides, and major windstorms all result in the opening of the subcanopy, and if *clidemia* seeds are present they germinate rapidly. Within two years, a disturbed area can become smothered (Wester and Wood 1977). In order to keep this weed out of an area, the

primary management objective should be to minimize if not prevent any disturbance.

There have been many well-meaning attempts by volunteer groups to control the spread of clidemia through pulling it by hand. Unfortunately, unless the invasion is caught in the earliest stage -- that is, before it has set seed -- the effort is likely to fail. The seed bank produced by these plants is colossal over a very short period of time. Each fruit contains well over 100 seeds, and a mature plant produces in excess of 500 fruits each season. Field observations demonstrate that the seeds can remain dormant for up to four years in the soil. These observations suggest that in order to effect control of an infested area by mechanical means, the eradication efforts must be conducted at least once a year and continued rigorously for up to 10 years. Merely uprooting the plants is insufficient, because even the leaves of clidemia form roots in suitable situations, *e.g.*, on the ground in rain forest (A.C. Medeiros, pers. comm.). Only two instances of successful control, Kamakou (Moloka'i) and Pu'u Kukui trail (Maui), are known.

Clidemia is susceptible to a number of herbicides, *e.g.*, 2,4,5-T, 2,4-D, Trichlopyr (Teoh *et al.* 1982). The first two chemicals are banned in most areas of the U.S., and the population soon regenerates from seedlings unless further applications are made. Chemical treatment of clidemia does not appear practical in Hawai'i's native ecosystems, especially those that are difficult of access.

No control effort has been effective in the Islands to date, other than the action of the thrips on ranchlands (Reimer 1985) and the mycoherbicidal action of the fungus *Colletotrichum gloeosporoides* (Trujillo *et al.* 1986). Although thrips are effective only in open areas (Reimer 1985), they are also present in open forested areas heavily infested with clidemia. Perhaps thrips are not able to flourish in these areas due to other environmental constraints, or the plants under shady conditions are sufficiently healthy to resist infection.

The introduction of an effective biological control agent, should one be found, will require very careful evaluation prior to release, particularly on O'ahu. The infestations of clidemia are so complete in some areas that the sudden loss of this plant could result in more serious consequences than currently exist. Two scenarios are possible. The loss of ground cover could be so severe that erosion would become a very serious problem. In contrast, if erosion is not a major problem, the exposure of so much bare ground would provide a good seed bed for a number of other weeds. Of particular concern are the grasses (*e.g.*, Hilo grass, *Paspalum conjugatum*, and broomsedge, *Andropogon virginicus*) and strawberry guava (*Psidium cattleianum*). Grasses would significantly increase fuel loadings in many areas, which could result in further degradation of the native vegetation by fire. Strawberry guava would form impenetrable thickets, which would prevent the reestablishment of native species.

One of the greatest difficulties in documenting the spread of weeds in the Islands is the failure of many field botanists to record their

observations for later analysis. Part of the problem is that most people focus on the rarer native and endemic species and just grumble about the weeds. They might lament that a particular alien species is now in a particular locality, but never document it. Herbaria are, understandably, reluctant to accumulate large numbers of verification specimens of new localities of weeds. There is, however, a perfectly good place to deposit information on alien species distribution: newsletters of local botanical, agricultural, or horticultural groups. Misidentifications may be reported, but, if actively pursued, the process can be self correcting.

The rate at which clidemia has spread through the Islands is cause for alarm. Many new infestations occurred even after the considerable publicity in the press between 1975 and 1977. It was almost inevitable, given the mobility of our human population, that this dispersal would happen. What is disquieting is that public discussion on this weed did not result in greater care by the users of our forests. Ignorance is probably not the cause, and laziness about taking the necessary precautions may be only a small component. The major problem is the "couldn't care less" attitude. Our hedonistic society places little value on the quality of natural resources: it is not that society does not understand the general ecological messages of recent years; the public simply does not understand the value of some plants and the harm that can be caused by others. The attitude can best be paraphrased by "Look, the Islands have lots of vegetation -- what more do you want?!" The goal of education should be a reawakening of pride in things Hawaiian, both cultural and biological.

RECOMMENDATIONS

1. The State of Hawaii should intensify its public awareness campaign to prevent the dissemination of clidemia and other weeds to areas where they are absent.
2. Conservationists need to coordinate their programs with one another and reach out to other organizations trying to reinstall a pride in things Hawaiian, improve the quality of life in the Islands, and counteract the dominance of economic considerations as the only criterion in development and politics.
3. Conservationists, scientists, and hikers should record all alien species observed during excursions and report them in the newsletters and other publications of local environmental interest groups.

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