Records of the Hawaii Biological Survey for 1996. Bishop Museum Occasional Papers 48: 23-36. (1997)

Status, Ecology, and Management of the Invasive Plant, *Miconia calvescens* DC (Melastomataceae) in the Hawaiian Islands[1]

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Abstract

Miconia calvescens (Melastomataceae), native to montane forests of the neotropics, has now invaded wet forests of both the Society and Hawaiian Islands. This tree, which grows up to 15 m tall, is potentially the most invasive and damaging weed of rainforests of Pacific islands. In moist conditions, it grows rapidly, tolerates shade, and produces abundant seed that is effectively dispersed by birds and accumulates in a large, persistent soil seed-bank. Introduced to the Hawaiian Islands in 1961, *M. calvescens* appears to threaten much of the biological diversity in native forests receiving 1800–2000 mm or more annual precipitation. Currently, *M. calvescens* is found on 4 Hawaiian islands—Hawaii, Maui, Oahu, and Kauai. Widespread awareness of this invader began in the early 1990s. Although biological control is being pursued, conventional control techniques (mechanical and chemical) to contain and eradicate it locally are underway.

Introduction

The effects of biological invasions are increasingly being recognized for their role in degradation of biological diversity worldwide (Usher *et al*., 1988; D'Antonio & Vitousek, 1992). Native ecosystems of oceanic islands are known to be especially subject to invasion and displacement by non-native species (Loope & Mueller-Dombois, 1989; others). The Hawaiian Islands now have nearly 100 invasive plant species that threaten to seriously alter native ecosystems (Smith, 1985; Stone *et al.*, 1992).

The Melastomataceae is one of the most damaging and invasive families of weeds in Hawaii. Of the 15 melastome species naturalized in the Hawaiian Islands (Almeda, 1990), 9 have been declared Noxious Weeds, the worst being *Clidemia hirta*, *Tibouchina herbacea*, *Oxyspora paniculata*, and *Miconia calvescens*.

With approximately 1,000 species, *Miconia* is easily the largest genus in the tropical family Melastomataceae (Cronquist, 1981). *Miconia calvescens* DC is a small tree 4–15 m tall with large (to 80 cm), strongly trinerved leaves. It is native to Central and South America from southern Mexico to northern Argentina and Chile, where it is an early successional tree species of wet thickets and dense mixed forest, colonizing small light gaps (R. Burkhart, Hawaii Department of Agriculture (HDOA); F. Almeda, pers. comm.). It occupies middle elevation sites in Ecuador at 300–1830 m (Wurdach, 1980). Specimens of the bicolorous form with purple leaf undersides have been collected only from southern Mexico to Costa Rica; farther south, leaf undersides are greenish (Meyer, 1996). The bicolorous form of *M. calvescens*, known to horticulturists as "velvet tree", is valued for its attractive large leaves, velvety dark green above and purple on the underside. This bicolorous form of the species has been cultivated in greenhouses in Europe and botanical gardens in Asia since the mid-1800s (Birnbaum, 1991) and is the form established and

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invasive in the Hawaiian Islands and in French Polynesia.

Introduced to Tahiti at the Papeari Botanical Garden in 1937, it now dominates the forest over 65% of the 1045 km^2 island (Meyer, 1996). Many sites, formerly dominated by native vegetation, have become completely transformed as *M. calvescens* gained dominance, due to the creation of deep shade which few native species can tolerate (Meyer, 1994). In Tahiti, 70–100 native plant species, including 35–45 species endemic to French Polynesia, are directly threatened by invasion of *M. calvescens* into native forests (Meyer & Florence, unpublished ms.). This invader has now spread to 3 other islands of French Polynesia (Moorea, Raiatea, Tahaa). After the late Pacific botanist F.R. Fosberg saw the developing infestation of *M. calvescens* in Tahiti in 1971, he warned Hawaiian authorities that "it is the one plant that could really destroy native the Hawaiian forests" (Altonn, 1991).

Miconia calvescens was introduced to Hawaii as an ornamental in 1961. Currently found on four islands (Hawaii, Maui, Oahu, Kauai), it is generally recognized as a threat to native habitats receiving 1800–2000 mm or more of annual precipitation. This paper presents the history of *M. calvescens* in the Hawaiian Islands, its status, ecology, and prospects for management.

History and status of *Miconia calvescens* in the Hawaiian Islands

Until 1991, awareness of the threat from *M. calvescens* was not widespread in Hawaii. It was not listed as naturalized in Hawaiian plant literature of the 1960s and 1970s (e.g., Neal, 1965; St. John, 1973). The authoritative *Manual of the flowering plants of Hawai'i* (Wagner *et al*., 1990) did not include *M. calvescens* as one of the 861 naturalized species receiving treatment. The introduction to the Melastomataceae (Almeda, 1990) did mention that "In addition to the species treated here, *M. calvescens*... is sometimes cultivated, and volunteer seedlings have reportedly appeared at the Lyon Arboretum, Oahu, and on private estates near Hilo, Hawaii. It is now apparently becoming naturalized. Establishment of this species on Sri Lanka and Tahiti suggests that it will spread in our area unless cultivation is discouraged." In the 1980s, a few conservationists expressed alarm at a burgeoning population at Onomea, north of Hilo, island of Hawaii, and volunteer efforts to remove plants were mounted. This effort did not receive widespread support.

In 1991, conservation agencies on Maui became aware that *M. calvescens* was present on that island. An alarm was raised in the press (Hurley, 1991; Altonn, 1991) and by scientists (Gagné *et al*., 1992, Medeiros & Loope, 1992). By late 1991, a colorful and factual "wanted" poster on *M. calvescens* was produced in large numbers and distributed widely, especially on windward Maui, with the aim of education and soliciting reports of *M. calvescens* locations. As of 1996, serious removal/eradication programs are progressing on Maui, Oahu, and Kauai, and the problem is being fully assessed and control efforts started on Hawaii.

Miconia calvescens on Oahu Island

Miconia calvescens was first introduced to the Hawaiian Islands in 1961 by the noted botanist and horticulturist Joseph F. Rock at Wahiawa Botanical Garden (planting records, Wahiawa), a site in central Oahu with suboptimal, seasonally dry habitat—about 1500 mm of annual rainfall. A report from a homeowner of a single sapling growing in her yard

across the street from the garden entrance led to the destruction of the original parent tree by the garden staff (W. Kobayashi, HDOA, pers. comm.) in May of 1995. A door-to-door canvassing effort in May 1996 resulted in location of only one other plant (Whitmore Village).

At Waimea Botanical Garden, northwest Oahu, *M. calvescens* was grown (1975–1983) but did not thrive in the seasonally dry climate (1500–1650 mm mean annual rainfall), before being destroyed because of its potential to spread (K. Woolliams, Waimea Botanical Garden, pers. comm.).

In 1964, a single individual of *M. calvescens* was planted at Harold L. Lyon Arboretum in Manoa Valley on the outskirts of Honolulu in the southeastern Koolau Range (planting records, Lyon Arboretum). Naturalized seedlings were first noted in 1975 and continue to be reported to the present (R. Hirano, pers. comm.). Recognizing the threat, the garden destroyed the original plant in the early 1990s (C. Lamoureux, Lyon Arboretum, pers. comm.). Although all new seedlings are promptly removed upon discovery, 5 fertile *M. calvescens* trees and numerous associated seedlings and saplings were discovered and destroyed by Sierra Club volunteers in steep, thickly vegetated, unmaintained portions of the arboretum in 1995.

Another single specimen of *M. calvescens* was planted, probably in the late 1970s or early 1980s (W. Wong, pers. comm.), at the entrance to Paradise Park, in Manoa Valley near Lyon Arboretum; the tree had produced numerous seedlings around its base, none of which had reached reproductive age by 1991 when management removed all known plants on the recommendation of conservationists (B. Gagné, pers. comm.). However, an adjacent infestation on an upland 14 ha parcel was discovered and plant removal started by HDOA and the Department of Land and Natural Resources (DLNR) in 1995. Five fertile trees and numerous saplings have been removed so far. Also, probable progeny (4 non-reproductive plants) of the original planted specimen were found on the west slope of Puu Pia in central Manoa Valley.

Miconia calvescens is now known to have naturalized at 3 locations in the southeastern Koolau Range, including Manoa, Kalihi, and Nuuanu valleys (Conant, 1996). Finally, on windward Oahu (Kahaluu), *M. calvescens* is known (A.C. Medeiros, pers. observ.) to have been grown by at least one private horticulturist (who obtained a single plant from a mainland nursery in the early 1980s) until it was destroyed in the early 1990s.

Known sites of *M. calvescens* on Oahu are mapped in Figure 1, and populations are summarized in Table 1.

Miconia calvescens *on Hawaii Island*

Miconia calvescens was first noted in the early 1960s on Hawaii island near Hilo at the Herbert Shipman estate (R. Blackshear, pers. comm.). By 1971, the species was clearly naturalized at the Hilo estate (K. Wooliams, pers. comm.). At an early date, *M. calvescens* was also introduced to Onomea, where it is now extensively naturalized and has locally developed nearly monospecific stands. Due to its sale prior to 1992, *M. calvescens* has become naturalized from numerous loci on the windward side of the island in North Hilo (Hakalau), South Hilo (Onomea, Papaikou, Hilo, Panaewa, Waiakea-uka), and Puna (Keaau, Kurtistown, Paradise Park subdivision, Orchid Land subdivision, Nanawale, Pahoa, Leilani Estates subdivision) districts. *M. calvescens* is also present less extensively in the North Kona district (Keauhou and Holualoa) and South Kona district

Table 1. Known populations of *Miconia calvescens* on Oahu, Maui, and Kauai:

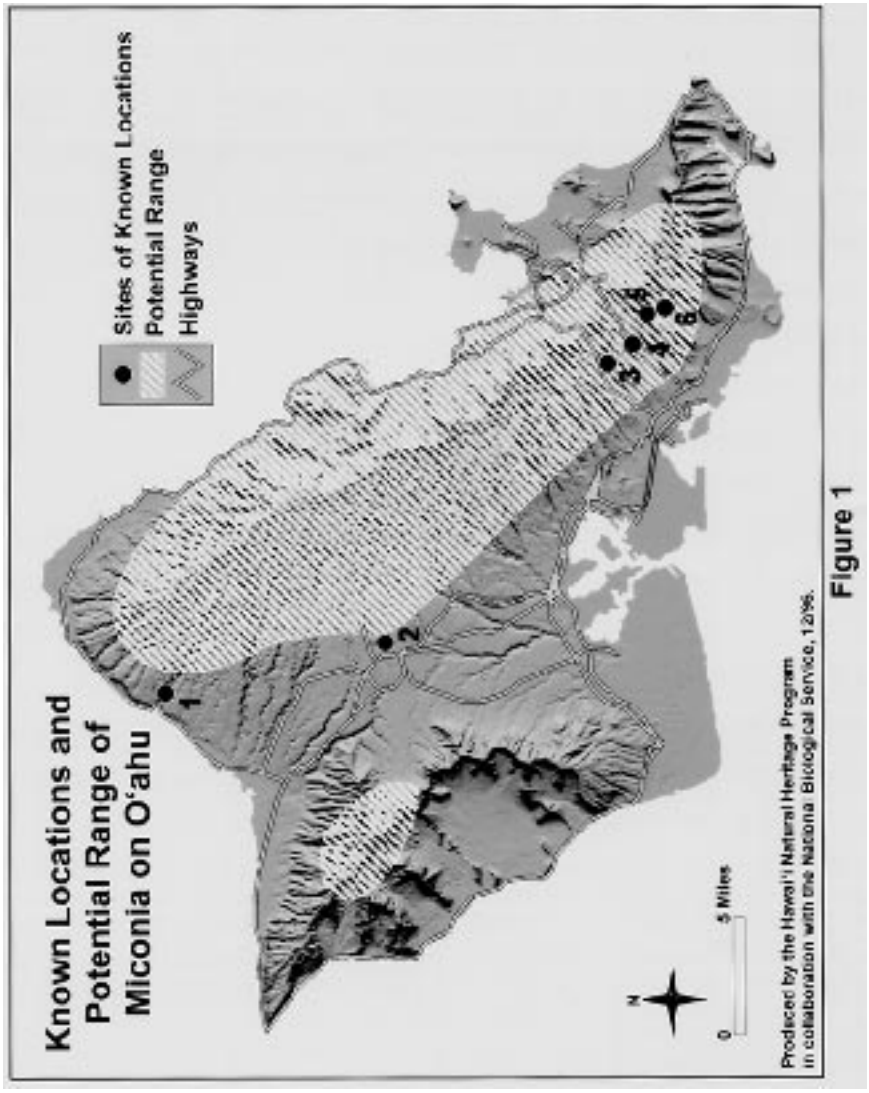
Location	Year "Discovered"	Elevation (meters)	Extent
OAHU			
Wahiawa Bot. Garden	1961	292	2 plants
Lyon Arboretum	1964	120-395	61 ha
Waimea Bot. Garden	1976	15	1 plant
Paradise Park	1978/1991	150-245	7 ha
Kalihi Valley	1994	207	6 ha
Nu‘uanu Valley	1995	200	4 ha
MAUI			
Upper Nahiku	1990	120-300	ca.80 ha
Hana/Olopawa	1991	60-370	300 ha+
Lower Nahiku	1991	20-160	ca.50 ha
Keanae	1991	50-60	ca.40 ha
Hoalua	1991	360	1 sapling
Huelo 1	1992	110	ca.7 ha
Huelo 2	1995	120	2 trees++
Peahi	1995	150	1 tree+
Upper Keanae	1995	430	1 sapling
Kaupo	1995	490	1 tree
KAUAI			
Wailua Homesteads	1995/1996	40-140	35-40 plants
Kapa‘a Homesteads 1	1995	97	1 plant
Kapa‘a Homesteads 2	1995	134	1 plant
Wailua Reservoir	1996	146	1 plant

(Hookena), western Hawaii island (W. Shishido, HDOA, pers. comm.).

The *M. calvescens* infestation on Hawaii island is more extensive than the second largest one on Maui island. Known sites are mapped as polygons based on available information in Fig. 2, but we have not attempted to summarize populations in Table 1. Detailed mapping of invaded areas is a huge task that has only recently begun (R. Warshauer, USGS/BRD, pers. comm.). A special concern involves the existence of large tracts of fallow land resulting from recent abandonment of sugar cane cultivation. The cleared lands, lacking tree and shrub cover, may facilitate the inland spread of *M. calvescens* to extensive upland forest reserves nearby.

Miconia calvescens *on Maui Island*

On Maui, *M. calvescens* was first introduced in the early 1970s at the private nursery and botanical garden, Helani Gardens, not far from the coast at Hana on northeastern East Maui (H. Cooper, pers. comm.). By the time the potential threat was realized in 1991 (Gagné *et al.*, 1992), *M. calvescens* was naturalized and abundant throughout the 16.5 ha garden. When removed in 1991, the largest *M. calvescens* trees in the garden were over 10 m tall with basal diameters to 30 cm. Nevertheless, concerted removal effort within Helani Gardens has resulted in a manageable situation where local eradication is feasible.


Known Locations and
Potential Range of
Miconia on O'ahu
Sites of Known Locations
Potential Range
Highways
1
2
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4
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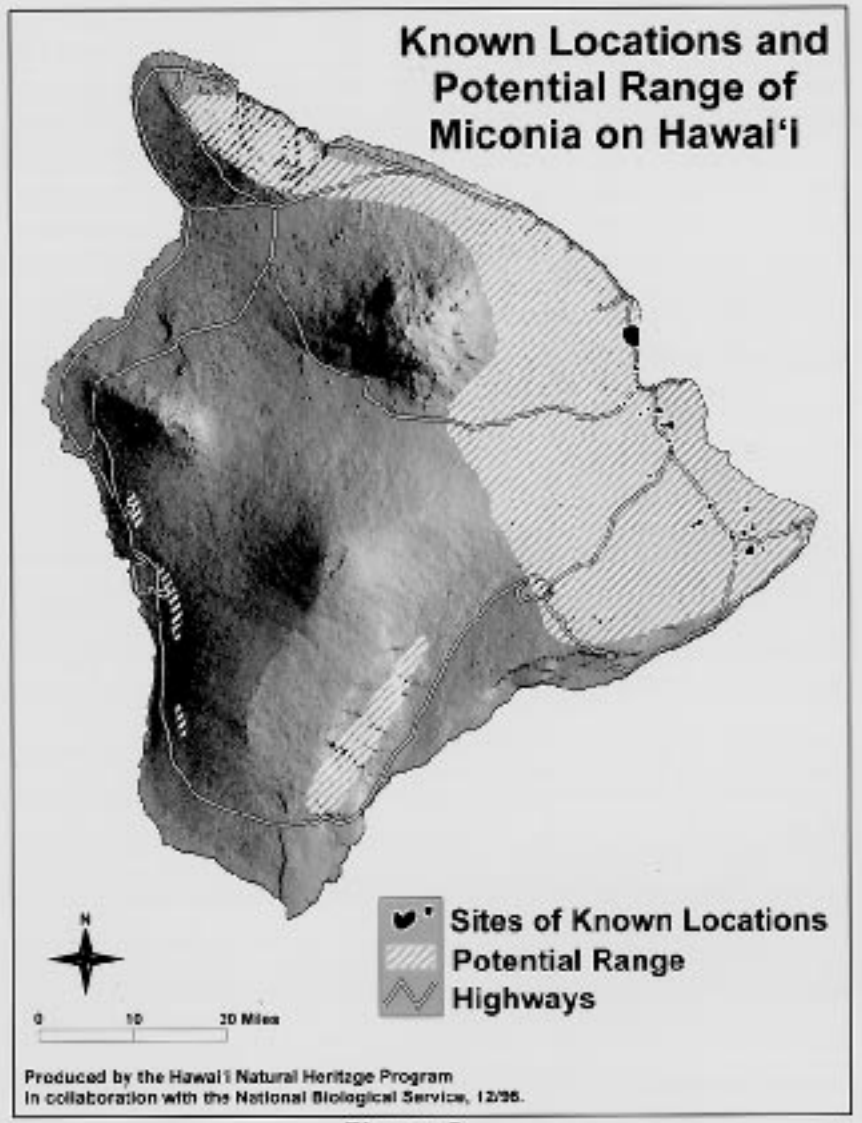
Produced by the Hawai'i Natural Heritage Program
in collaboration with the National Biological Service, 12/96.

Figure 1


Known Locations and Potential Range of Miconia on Hawai'i
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Sites of Known Locations
Potential Range
Highways
Produced by the Hawai'i Natural Heritage Program
In collaboration with the National Biological Service, 12/96.

Figure 2

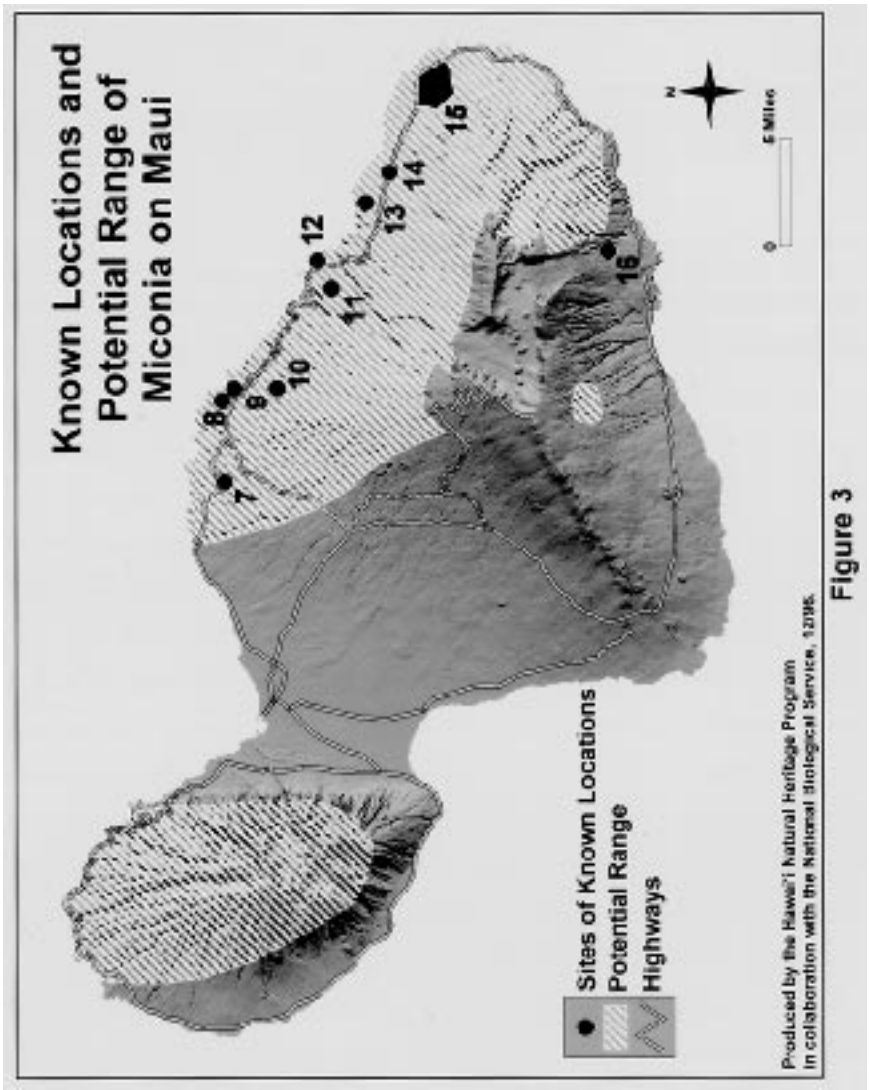
Known Locations and Potential Range of Miconia on Maui
Sites of Known Locations
Potential Range
Highways
7
8
9
10
11
12
13
14
15
16
N
0
5 Miles
Produced by the Hawai'i Natural Heritage Program
in collaboration with the National Biological Service, 1996.

Figure 3

Five additional populations were found in 1991–93 on windward East Maui and over 20,000 plants were removed. However, in September 1993, a much larger concentration of *M. calvescens* was discovered upslope above Helani Gardens and Hana, up to 370 m in elevation, stretching as far as Olopawa cinder cone. This Hana/Olopawa population is by far the largest on Maui. Four discrete dense stands of canopy-sized *M. calvescens* trees occur on a 500-year old lava flow (Crandell, 1983) in predominantly non-native forest, dominated by the introduced tree *Spathodea campanulata*, with pockets of lowland native wet forest. Numerous outliers occur within an area of over 300 ha. The original source of the dense stands may have been planted or seeds may have been dispersed from nearby (<1 km) Helani Gardens by birds.

Currently, 10 populations of *M. calvescens* are known on Maui (Fig. 3; Table 1). With the exception of a single tree in leeward Kaupo district, all other populations are located on the northern and northeastern flanks of Haleakala volcano (East Maui) from near sea level to 430 m elevation. Known populations on Maui are currently the focus of aggressive management.

Miconia calvescens *on Kauai Island*

Miconia calvescens was discovered on Kauai in October 1995 in Wailua Homesteads by an HDOA employee following up a report by a local resident, who was alerted to the threat of Miconia by a public service announcement on television. The source of plants in the area was apparently a large tree (30 cm basal diameter), destroyed in 1993, grown from a seedling from Oahu given to a nursery by a friend (Conant, 1996). In 1995, approximately 20 plants were removed, and monitoring continues in an area within 0.5 km of the nursery. In December 1995, a large (7 m tall) flowering *M. calvescens* plant was found 2 km distant from the nursery with the remnants of a plastic pot attached to its roots (G. Nagai, HDOA, pers. comm.). Soon afterwards, a second large plant, also with remnants of a plastic pot, was found even further distant (4 km) from the infested nursery. An additional 15–20 plants were near the banks of the Wailua River (40 m elevation) near the infested nursery in 1996 and can probably be considered a range extension of the nursery infestation. Most recently in 1996, a single spontaneous plant has been removed adjacent to Wailua Reservoir. This is the only known "wild" plant disjunct from the nursery infestations on Kauai.

Known sites of *M. calvescens* on Kauai are mapped in Fig. 4, and populations are summarized in Table 1.

Aspects of the invasion and ecology of *Miconia calvescens*

The invasion of native ecosystems on Tahiti island has been the most important factor in the recognition in the Hawaiian Islands of *M. calvescens* as one of the most invasive and damaging of wet forest weeds. With similar volcanic origins, ages, and distance from the equator and from continents, the Society (16°40'–18°00' S lat.) and Hawaiian (19°00'–22°20' N lat.) Archipelagos have highly comparable climate, topography, and biota. Both the Society and Hawaiian Islands have relatively high endemism, rich pteridophyte, and depauperate monocot floras with many native genera in common (Florence, 1987, Wagner *et al.*, 1990, Wagner, 1992).

Native forests of the Society and Hawaiian Islands are relatively low statured, have naturally higher solar radiation levels, and fewer tree species than many other rainforests.

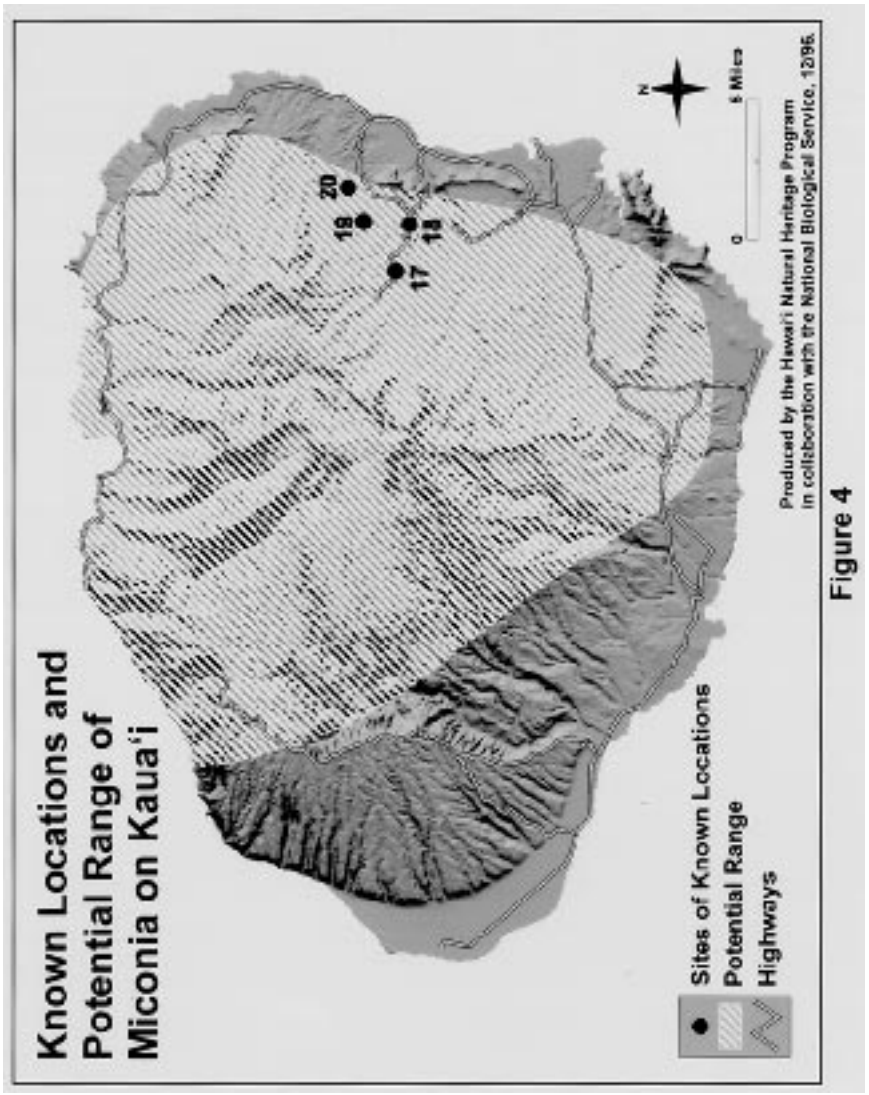
Known Locations and Potential Range of Miconia on Kaua'i
Sites of Known Locations
Potential Range
Highways
20
19
18
17
N
0
5 Miles
Produced by the Hawai'i Natural Heritage Program
in collaboration with the National Biological Service, 12/96.

Figure 4

These factors may act in making these forests especially vulnerable to invasion by *M. calvescens* because solar radiation levels at the forest floor are not dark enough to preclude germination and establishment of its seedlings. Relatively high intensity of solar radiation has been suggested as a factor in the vulnerability of native forests in the Seychelles to the melastome, *Clidemia hirta* (Gerlach, 1993).

Naturalized populations of *M. calvescens* in the Hawaiian and Society Islands characteristically have leaves with purple undersides. *Miconia calvescens* from the southern part of its range, South America, have older leaves that are entirely green (Wurdack, 1971). *Miconia calvescens* plants with all leaves having red to purple undersides typically originate in the northern part of the range of the species in Mexico, Guatemala, and Costa Rica (Wurdack, 1971). The original source of the *M. calvescens* introduced to Tahiti is known to be Mexico via Peradeniya Botanical Garden, Sri Lanka (Meyer, 1994). The red-purple lower leaf surface of *M. calvescens* and the fact that botanist J.F. Rock spent much time in Asia suggests that the *M. calvescens* introduced to Hawaii by Rock had a similar origin.

Phenology

Flowering and fruiting of mature trees in *M. calvescens* populations in Hawaii can occur nearly anytime of year. A single tree can flower/fruit 2–3 times in a year with flowers, mature and immature fruits often seen on the same tree. *Miconia calvescens* trees begin to flower at 4–5 years old at about 3–4 m in height. Full-sized (> 8 m) trees produce 50–200+ inflorescences, increasing with tree size and sun exposure. Each inflorescence is comprised of 1000–3000 perfect flowers with exserted styles. When fully open, the short-lived (ca. 12–24 hours) flowers, white with pink tint, are strongly sweet-scented. At Hana, Maui, nonindigenous syrphid and other unidentified small flies have been observed visiting flowers.

Ripe fruits are dark purple, average 5.9 mm (n = 250) in diameter and have a sweet taste; each fruit contains 50–200 seeds. Seeds of *M. calvescens* are tiny, about 0.5 mm in diameter. A single 10 m tree with 100 inflorescences, 300 fruits/inflorescence, and 100 seeds per fruit, will produce 3 million seeds 2 or 3 times a year.

Seed Dispersal

In the Society and Hawaiian Islands, *M. calvescens* seeds are effectively dispersed by non-native frugivorous birds. In the Society Islands, *M. calvescens* seeds are dispersed by the abundant white-eye *Zosterops lateralis* (Gaubert, 1992), and the red-vented bulbul (*Pycnonotus cafer*) (Meyer, 1994). In Hawaii, dispersal is probably by Japanese white-eye (*Zosterops japonicus*), red-billed leiothrix (*Leiothrix lutea*), and common mynah (*Acridotheres tristis*). In Hawaii, the Japanese white-eye is abundant from low elevations up to high elevation native rainforests (Scott *et al.*, 1986). The red-vented bulbul, an important disperser of *M. calvescens* seeds in the Society Islands, while established on Oahu since the 1960s (Pratt *et al.*, 1987), is not (at least not yet) established on Hawaii, Maui, or Kauai.

Seed Banks

Substantial stored seed banks can accumulate beneath dense naturalized stands of *M. calvescens*. In greenhouse trials in Tahiti, a square meter of the uppermost 2 cm of soil

from a dense *M. calvescens* stand, periodically disturbed, produced 17,808 *M. calvescens* seedlings in six months (Gaubert, 1992).

Seed banks lie largely dormant under normal shaded conditions but are stimulated by an opening in the canopy. After herbicidal defoliation of Maui's main population, *M. calvescens* seedlings appeared in great numbers, especially on preferred microsites of mineral soil, dead tree boles, and dead *Sadleria* tree fern trunks. Under normal conditions, *M. calvescens* seedlings are characteristically found clustered or scattered near, or less often at some distance from, fruiting-sized *M. calvescens* trees, sometimes in deep shade.

Meyer (1994) has verified *M. calvescens* seed life in soil samples of more than 2 years. Three years after acquisition, Maui horticulturists have found *M. calvescens* germinants in pots of *Heliconia* from *M. calvescens*-infested Helani Gardens. Indirect evidence from a long-term plot on Raiatea, Society Islands, suggests seed life of at least four years (J.-Y. Meyer, unpubl.).

Natural enemies

Herbivory by the Chinese rose beetle (*Adoretus sinicus*) on *M. calvescens* leaves is frequently observed in both the Hawaiian and Society Islands. Though this herbivory can cause up to 50% defoliation on individual leaves, it has never been widespread and has never been observed to cause mortality.

Management of the *M. calvescens* invasion

Despite many invasive plant control projects in Hawaii, *M. calvescens* is regarded as a very high priority because 1) its potential impacts on watershed lands and biological diversity appear to be much greater than those of other invasive plants, and 2) containment and/or eradication is still feasible, at least on some islands and parts of other islands, at this time.

Miconia calvescens was listed on 22 August 1992 as a Noxious Weed under Chapter 68 of the Hawaii Revised Statutes by the HDOA. This authorized (but did not fund) the HDOA to conduct control on private land. An interagency Melastome Action Committee (MAC), formed on Maui in 1991, began to convene regularly to plan strategy and solicit funding. The Melastome Action Committee (MAC) has had broad interagency representation, with at least 5 government agencies and private entities involved in control efforts on Maui. Increased awareness of the threat from *M. calvescens* on Maui has led to important efforts on other islands (Conant *et al.* in press). By 1995–96, MAC, working in cooperation with the East Maui Watershed Partnership, had developed a comprehensive plan for control of *M. calvescens* on Maui, obtained meaningful funding, and initiated aggressive control. Beginning in 1995, a Melastome Action Committee was set up on the island of Hawaii and quickly became effective in organizing mapping and control efforts and lobbying for funding. Efforts on Oahu and Kauai, where *M. calvescens* is less widespread, are being handled successfully by the combined efforts of State agencies (HDOA and the Oahu District DLNR) and volunteers.

It is clear that the relatively early stage of detection and control on Oahu and Kauai should result in substantial savings in the cost of control. Low level helicopter reconnaissance is an important tool for locating remote populations. Public education (wanted posters, newspaper stories, public service announcements) has been important in locating new *M. calvescens* populations, aided by the distinctive appearance of the plant. "Operation Miconia", a state-wide interagency public education and involvement effort in

April 1996, used hotlines, reporting forms, and agency followup for surveillance (Tanji, 1996).

Infestations of *M. calvescens* are controlled using mechanical and chemical means. Ground crews uproot smaller plants entirely or cut down larger plants and chemically treat the stumps. Herbicidal control (Garlon® 4, DowElanco, Indianapolis, Indiana) of canopy trees with a helicopter is an innovative and effective technique (Medeiros & Loope, unpubl. data). Control efforts involving volunteers must be balanced with the appreciable risk of spreading *M. calvescens* seeds in mud on boots, by equipment, etc. Because of persistent seed banks, all areas where *M. calvescens* has been found and removed must be rechecked periodically for newly germinated individuals.

Worldwide success of biological control of invasive plants has had mixed results; assessments suggest that success occurs in 20–40% of cases (Julien, 1982; Hobbs & Humphries, 1995). Despite this, initial exploration of the native range of *M. calvescens* has yielded numerous potential biocontrol agents (R. Burkhart, HDOA, pers. comm.). Of these, fungal pathogens currently appear most promising. At the end of 1996, a proposal for release of *Colletotrichum gloeosporoides* f. sp. *miconiae* was submitted to the Hawaii Department of Agriculture.

If biological control is developed successfully, substantial effects on the growth and reproduction of *M. calvescens* are at least a decade away. Pending further developments, mechanical and chemical control are the most promising methods of containing and potentially eradicating invasive populations of *M. calvescens* in the Hawaiian Islands.

Acknowledgments

Many individuals, too numerous to name, contributed to the information presented here. We single out the following for special thanks: Sherry Amundson, Patrick Bily, Charles Chimera, Robert Hobdy, Sandy Margriter, Jean-Yves Meyer, Guy Nagai, and Robert Teytaud.

Hillshade maps were produced using the 7 1/2' DEMs (Digital Elevation Models) from the U.S. Geological Survey using the grid module in ArchInfo®.

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