***Bocconia frutescens* L.**
Papaveraceae

GENERAL PHYSICAL DESCRIPTION

A soft-wooded, branched shrub to small tree up to 7 m height with large lobed leaves, smooth on the upper surface and hairy underneath, up to 45 cm long and 20 cm wide, and with yellowish orange, translucent, bitter sap (Figure 1; Wagner *et al*. 1990). One common name, "Plume Poppy", is indicative of the terminal inflorescences up to 60 cm long, with up to over 2000 small, petal-less, greenish-purple flowers per panicle (Figure 2; Graf 1992). Another common name from Mexico, "Tears of Blood" refers to the bright red, pulpy aril attached to the shiny black seeds, 6-7 mm long (Pesman 1962). The Spanish common name from Puerto Rico, "Pan cimarron", may be derived from the slight resemblance of the leaves to those of breadfruit (Little *et al*. 1974). Other common names include "Tree celandine", "Grande chelidoine" in the Lesser Antilles (Howard 1988), "Parrot weed" in Puerto Rico (Liogier 1985) and "John Crow Bush" or "Celandine" in Jamaica (Adams 1972).

Figure 1. *Bocconia* tree, Kanaio, East Maui

Figure 2. *B. frutescens*, panicle with immature fruit

FEDERAL NOXIOUS WEED ACT STATUS
NONE

FEDERAL SEED ACT STATUS
NONE

STATE OF HAWAII NOXIOUS WEED STATUS
LISTED AS NOXIOUS

STATE OF HAWAII SEED ACT STATUS
LISTED AS NOXIOUS

NATIVE RANGE OF *BOCCONIA FRUTESCENS*

West Indies and Caribbean including the Greater Antilles, Lesser Antilles, Antigua, St. Kitts, Montserrat, Guadeloupe, Marie Galante, Dominica, Martinique, St. Lucia, St. Vincent, Grenada, Jamaica and Cuba (Grisebach 1864, Barker and Dardeau 1930, Adams 1972). Mexico; Central America including Belize, Costa Rica, El Salvador, Guatemala, Honduras, Nicaragua and Panama; South America including Bolivia, Colombia, Ecuador, Peru and Venezuela (Wagner *et al*. 1990).

CLIMATE OF NATIVE RANGE OF *BOCCONIA FRUTESCENS*

Bocconia occupies habitats that are sunny, and well-drained, in disturbed sites as along roadsides (Gentry 1993), in secondary thickets and woodlands at lower and middle elevations (Liogier 1985) on "the banks of rivers everywhere" in Jamaica (Hutchinson 1920), or as a weed of clearings and roadsides in damp, sheltered places (Adams 1972). Tanner (1982) states that *Bocconia* is common in disturbed areas of the tropical montane forests of the Blue Mountains of Jamaica. This habitat is "continually cloudy and often fog-shrouded forest, where winds are light and relative humidity is always high" (Tanner 1982) and with an annual precipitation that ranges from 2600-4270 mm (Tanner 1977). *Bocconia frutescens* is reported to grow in the "tierra templada" of Colombia, a region from 600 to 1300 meters elevation (1968 – 4264 feet), with a warm and temperate climate and with temperatures ranging from 17° to 22° C (Von Humboldt and Bonpland 2002). Riffle (1998) states that *Bocconia* can be grown as a shrub in USDA plant hardiness zones 9b and 10a (Cathey 1990). Zone 9b has average annual minimum temperatures ranging from 25° to 30° F (-1.2 to –3.8° C) and Zone 10a has average annual minimum temperatures ranging from 30 to 35° F (-1.1 to 1.6° C) (Cathey 1990). Riffle (1998) also states that can be grown as a tree in hardiness zones 10b and 11, with average annual minimum temperatures ranging from 35 to 40° F (1.7 to 4.4°C) and above 40° F (above 4.5° C) respectively (Cathey 1990). Zone 9 is characterized by mild winters, long growing seasons, and almost no winter freezes (Cathey 1990). Zone 10 includes subtropical regions in Hawaii and Florida and is characterized by year-round growing seasons and ocean regulated climates (Cathey 1990). Zone 11 is a tropical region that occurs in Hawaii and the lowermost Florida keys and also has mild temperatures and a year-round growing season (Cathey 1990).

In its native range, *Bocconia frutescens* occurs within the following elevational and latitudinal gradients:

- Jamaica

  Elevational gradient: 366 - 2133 meters (1200 – 7000 feet)

  Approximate latitude: 18°N - 18°30'N (Adams 1972)

- Puerto Rico

  Elevational gradient: 300 - 914 meters (1000 - 3000 feet)

  Approximate latitude: 18°N - 18°30'N (Little *et al*. 1974, New York Botanical Garden 2002).

- Mexico

  Elevational gradient: Collected from 850 - 1900 meters (2800 - 6230 feet)

  Approximate latitude: Collected from 15°N - 22°N (Missouri Botanical Garden 2002).

- Central America

  Elevational gradient: Collected from 1 - 3049 meters (0.3 - 10000 feet)

  Approximate latitude: Collected from 7.58°N – 17.06°N (Hutchinson 1920, Missouri Botanical Garden 2002)

- South America

  Elevational gradient: Collected from 600 – 3250 meters (1968 - 10660 feet)

  Approximate latitude: Collected from 22.05°S – 10.28°N (Missouri Botanical Garden 2002).

RELEVANT ASPECTS OF THE BIOLOGY AND ECOLOGY OF *BOCCONIA FRUTESCENS*

Phenology & Pollination Biology: To assess the seasonal phenology of *Bocconia* at two sites on Maui, 50 trees from Kanaio (1900-2200 feet) and 50 trees from Kula (3500-4000 feet elevation) were randomly selected, and presence of budding, flowering and fruiting (immature and mature) panicles were noted. Observations were made over a 15-month period from April 1998 to June 1999 (Figures 3 and 4).

Figure 3: *Bocconia frutescens* Phenology
Kanaio, Maui: April 98-June 99

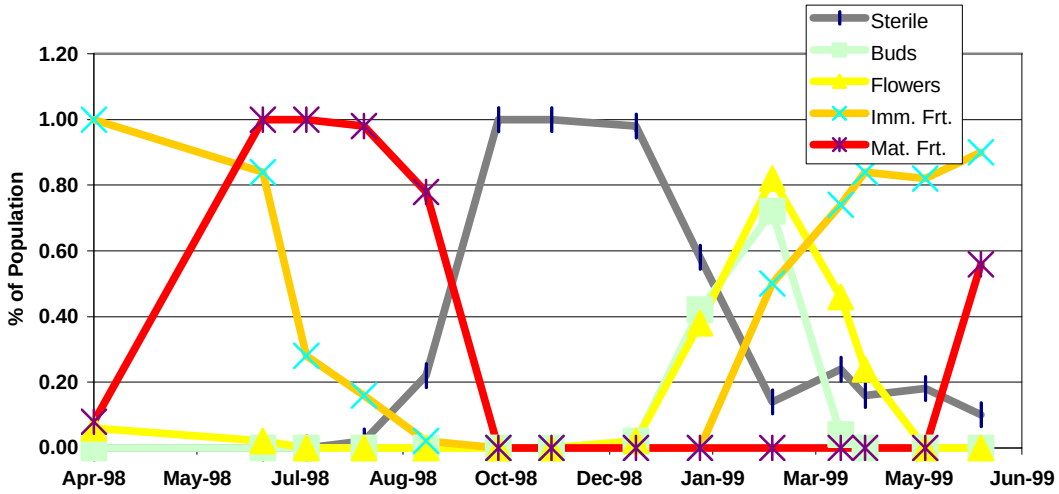
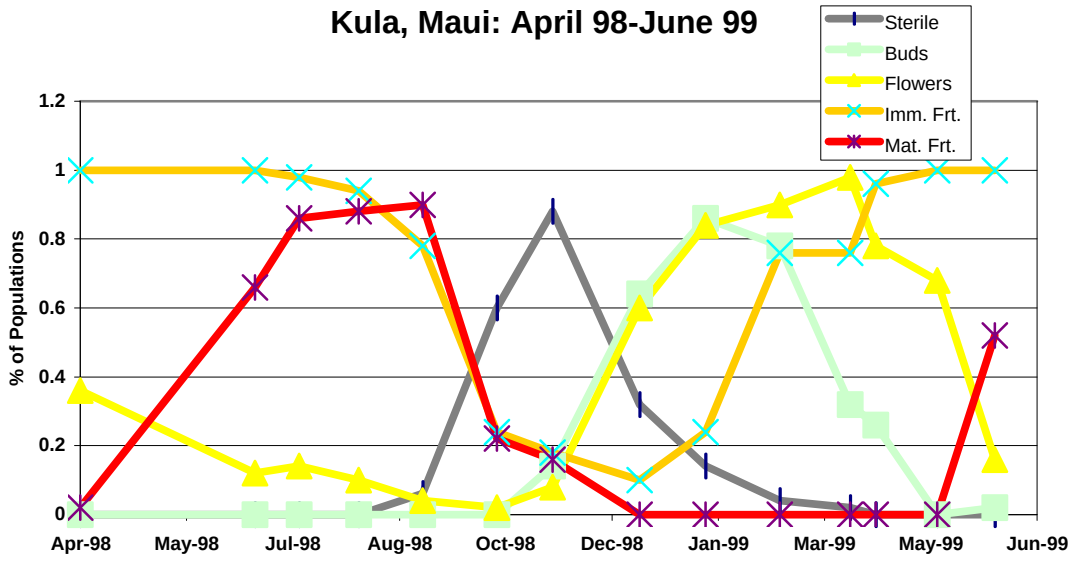


Figure 4: *Bocconia frutescens* Phenology
Kula, Maui: April 98-June 99



Bocconia frutescens will first flower and fruit with a single panicle after approximately four to six years of growth (Figure 5). Although May to July appear to be the peak fruiting period in the Hawaiian Islands, *Bocconia* possesses the capability to flower and fruit sporadically throughout the year (Adams 1972; Little *et al*. 1974).

The small, perfect, apetalous flowers are not very showy, yet are frequently visited by non-native syrphid flies and honeybees (*Apis mellifera*) within the introduced range on Maui. Tanner (1982) observed honeybees visiting the male flowers of *Bocconia* in the tropical montane rain forests of Jamaica. The structure of the flower, with anthers

dangling from pendent filaments, also suggests adaptations for wind pollination. Blattner and Kadereit (1999) showed that morphological change in the Bocconia/Macleaya clade of Papaveraceae is "related to the evolution of wind-pollination from insect-pollination in these two genera after a habitat shift." Tanner (1982) mentions that *Bocconia* is also successfully wind-pollinated.

Figure 5. Flowering panicle

As the *Bocconia* tree grows in size and increases its number of stems and branches, it has the ability to produce a significant number of panicles and ultimately seeds. On 6/12/97, a *Bocconia* tree of approximately four meters (13 feet) height, with three main trunks arising from the base (basal diameters: 34.5 cm; 14.4 cm; 9 cm), had 44 infrutescences with predominantly immature capsules and 109 infrutescences with predominantly mature capsules present. The 153 branched fruiting panicles, averaging 37.6 cm in length (n=25), had an average of 1962.8 capsules per panicle (n=11), and thus gave this tree the potential to produce up to 300,308 seeds in a single fruiting season. Nevertheless, there were also 94 old infrutescences present on the tree at the time of this survey, completely devoid of fruit, which appear to have persisted from the previous year and which could account for another 184,503 seeds produced by this tree. It is worthy of note that the tree sampled for the fruiting estimate, at four meters height, is approximately half as tall as the largest recorded individuals (Bailey and Bailey 1976). A larger tree would presumably produce a much greater number of seeds during the fruiting seasons.

Once the immature capsules, approximately 12 mm long, change from a dull, grayish-blue color to a pale yellow color, they dehisce by two caducous valves from the base to reveal the single, shiny-black seed, about 6-7 mm long, covered about ½ to 1/3 its length by a bright red to scarlet aril (Figure 6).

Figure 6. *Bocconia* seed with aril

Dispersal: The pulpy aril material is attractive to birds and aids in the dispersal of the seeds. On 6/20/97, large numbers of Japanese white-eyes (*Zosterops japonicus*) were observed feeding on the mature fruits of *Bocconia* trees at 1900 feet elevation on the south slope of Haleakala just after sunrise, beginning at about 5:42 a.m., and were, by far, the most conspicuous birds present in the area. A solitary mockingbird (*Mimus*

polyglottus) was also observed eating the ripe fruits, and a northern cardinal male (*Cardinalis cardinalis*) perched on a panicle but did not consume any seeds. Other birds recorded as present at the time but not observed to be feeding on the *Bocconia* fruits included the common mynah (*Acridotheres tristis*), the house finch (*Carpodacus mexicanus*), and several gamebirds such as the black francolin (*Francolinus francolinus*), the gray francolin (*F. pondicerianus*), and the ring-necked pheasant (*Phasianus colchicus*). On 7/9/98, mist-nets were set up in a fruiting stand of *Bocconia* in the Auwahi dry forest of Maui at an elevation of 2600 feet. Four Japanese white-eyes (*Z. japonicus*) were caught and fecal samples collected after a 20-minute holding period. Two white-eyes had one seed present in each of their fecal samples, another had two seeds present, and the fourth had remains of the aril present without the seed. On 8/12/98, several Japanese white-eyes were also observed consuming seeds of *Bocconia* growing along the road in Kula, at an elevation of approximately 4000 feet. In addition, seeds of *Bocconia* have been collected in the droppings of a larger bird, possibly a turkey or a peacock, in the dry forest of Kanaio. Fosberg and Sachet (1975) state that "the fleshy aril or caruncle of its seed probably assures its wide distribution by mynahs and other introduced frugivorous birds." Although Smith (1985) suggests that *Bocconia* seeds are wind-dispersed, this would only occur for short distances under the parent tree. It is more likely that birds play the major role in the dispersal of *Bocconia*. The pattern of seedling distribution, away from parent plants and under other trees, also suggests that birds are consuming and spreading these fruits.

Within its native range of Colombia, *Bocconia* is listed as a tree that is beneficial to native bird life (Prieto and Olarte 2002). Harvey (2000) lists *Bocconia frutescens* as a bird-dispersed tree species. "Parrot weed", a common name for *Bocconia* in Puerto Rico, may be indicative of the preference of these birds for the seeds of the tree.

Seed Longevity: In Costa Rica, Williams-Linera and Ewel (1984) claim that the seeds of *B. frutescens* have a long life in the soil but do not indicate how long the seeds persist. They also mention that the mycorrhizal status of *Bocconia* is unknown, but that no mycorrhizal fungi have been observed on root preparations they examined (Williams-Linera and Ewel 1984). This factor could contribute to the success of *B. frutescens* in colonizing disturbed areas in which the mycorrhizal flora is damaged or absent.

VALUE OF *BOCCONIA FRUTESCENS* TO HUMANS

Horticulture: *Bocconia frutescens* has been planted as an ornamental (Rzedowski 1991), especially in warmer parts of the United States for the "bold, tropical appearance" of the foliage (Everett 1992). Riffle (1998) states that *Bocconia* is "unexcelled for creating the tropical effect in sunny, well-drained sites". In Guacamayo, Costa Rica, this native *B. frutescens* is considered to be an economically important ornamental plant (Montiel 1980).

Medicine: There are also a number of medicinal properties attributed to the sap, roots and leaves of *Bocconia* from its native range (Pesman 1962; Slavik and Slavikova 1975; Caballero-George *et al*. 2001), where it has reportedly served as a dye and in home

medicines (Little *et al*. 1974). Martinez (1969) mentions that injections of an extract of *Bocconia* can produce a local anesthetic effect but with an irritant side effect. In Veracruz, Mexico, the orange sap of *Bocconia* has been used in the treatment of ulcers and skin eruptions, to alleviate bronchitis, and as a local anesthetic, whereas the leaves have been heated and applied to wounds (Martinez 1982).

The related species *Bocconia arborea* possesses strong in vitro anti-microbial agents that work against microorganisms such as *Staphylococcus aureus, Escherichia coli, Pseudomonas aeruginosa,* and *Candida albicans* (Navarro *et al*. 1996; Navarro *et al*. 1998; Navarro and Delgado 1999). Grieve (1995) reports that the orange sap of the leaf petioles of *B. cordata*, a native of China, is used to treat insect-bites, whereas the leaves of some South American species are used as " purgatives and abortifacients".

Bocconia integrifolia and *B. pearcei* were used in traditional folk medicine to treat endemic diseases such as cutaneous and mucocutaneous leishmaniasis in the humid lowlands of Bolivia. Analysis of the sap by Fournet *et al*. (1994) demonstrated in vitro activity against these endemic diseases. Oechslin *et al*. (1991) also detected alkaloids in *B. integrifolia* that possess antimicrobial, anti-inflammatory, cytotoxic, antitumor and antiviral activity.

CONTROL STRATEGIES FOR *BOCCONIA FRUTESCENS*

On June 18, 1992, the Hawai'i Department of Agriculture designated *Bocconia frutescens* as a noxious weed to be targeted for eradication and/or control. On the Big Island, *Bocconia* was one of four possible candidates proposed for eradication by the Big Island Invasive Species Committee, but later surveys discovered that the infestations were much more widespread than previously believed. These field surveys located larger infestation sites of approximately 3000-3500 acres in the Wood Valley area, and Duane Nelson of the U.S. Forest Service is aware of a few smaller populations scattered throughout other areas (pers. comm. 2001). To date, no official eradication projects have been attempted.

Some localized, small scale pulling of *Bocconia frutescens* seedlings and saplings has been carried out inside various exclosures of the Native Hawaiian Plant Society in the Auwahi dryland forest on the south slope of Haleakala (Nakagawa 1994, 1995), but no large-scale mechanical or herbicidal treatments have been performed to date. Nevertheless, Medeiros *et al*. (1993), identified *Bocconia* as one of seven alien plant species that is aggressive and a primary threat to the native ecosystems of the Kanaio Natural Area Reserve, and therefore recommended that some form of control be performed in areas of the most intact native vegetation. In an exclosure managed by the USGS-Biological Resources Division, the primary means of control involves the initial removal of all fruiting trees and the sporadic removal of the seed bank recruits. Simple mechanical control of plants involving cutting of the branches or trunks will result in the plant's regrowth (Figure 7; Chimera unpublished data). Therefore, herbicide trials involving thin line basal application of a chemical such as Garlon 4 in a diesel carrier have been suggested for *Bocconia* control. This method would probably only be practical for smaller diameter trees with single

trunks. For larger trees with multiple trunks arising from the base, a cut-stump treatment would probably be more effective.

The aerial delivery of a foliar herbicide, such as Garlon 3A, from a long-line ball sprayer attached to a helicopter has also been suggested to help reduce the ubiquitous seed source of *B. frutescens*. This strategy, similar to the method employed in *Miconia calvescens* control efforts on the windward side of Maui (Medeiros *et al*. 1998), would target the larger, fruiting trees and dense stands of plants. Motooka (pers. comm. 2002) also reports that basal bark applications of 2,4-D ester and triclopyr ester are effective methods for controlling *Bocconia*.

Figure 7. Resprouting *Bocconia frutescens*, Auwahi, East Maui

PROBLEMS CAUSED BY *BOCCONIA FRUTESCENS* OUTSIDE HAWAII

As *Bocconia frutescens* is only known to be naturalized on the Hawaiian Islands of Maui and Hawaii, very little exists in the literature regarding any problems associated with this plant, especially in its native range. Nevertheless, there are aspects of its growth characteristics and of the areas in which it grows, that are often attributed to other aggressive weed species. These attributes likely contribute to its invasiveness in the Hawaiian Islands. Species in the genus *Bocconia* are fast growing pioneers (Keane and Joyce 1997), and have been found to thrive in disturbed sites (Tanner 1982) such as those occurring along roadsides (Wagner *et al*. 1990; Gentry 1993; Young 1994), riverbanks (Hutchinson 1920), forest clearings (Adams 1972), abandoned plantations (Cavelier and Santos 1999) and secondary woodlands and thickets (Liogier 1985; Little *et al*. 1974). Goodland and Healey (1997) identify *B. frutescens* as a "gap demanding native species" in Jamaica, a characteristic that would contribute to its invasiveness in the fragmented dry forests of the Hawaiian Islands. Rozema *et al*. (1997) also describe *B. frutescens* as "weed of clearings and roadsides from 350-2200 m a.s.l." that prefers open habitats. Williams-Linera and Ewel (1984) state that *B. frutescens* can rapidly colonize both disturbed and burned areas. A South American naturalist, T. Harper Goodspeed (1941), during a botanical expedition in the Andes of Peru, commented on the aggressiveness of *Bocconia* in re-colonizing a farmer's field following clearing:

"…unfortunately, the farmer had failed to reckon with the exuberant vegetation of the forest, which almost before he had harvested his first crop began to reoccupy every square foot of his cornfield. The dominant among the invaders was a species of *Bocconia*, belonging to the Poppy family. Thousands upon thousands luxuriated in the added light and loosened soil that the farmer's clearing and cultivating had offered them."

Although he does not indicate which species of *Bocconia* is responsible for this invasion, Peru does fall within the natural distribution of *B. frutescens*.

PROBLEMS CAUSED BY *BOCCONIA FRUTESCENS* IN HAWAII

Bocconia frutescens, now naturalized in dry forests on the island of Maui and in mesic forests on Hawaii (Wagner *et al*. 1990), was first noted at a single location in Kanaio on Maui in 1920 but has spread widely since. It now occurs at elevations of at least 1600 to 4000 feet from wetter areas on the western slopes of Haleakala to the dry forests of Auwahi and Kanaio on the south slope. What are believed to be disparate populations have also been recorded as high as 5800 feet in Manawainui Gulch in Kahikinui on DHHL lands as well as at lower elevations in the Puu-o-Kali district. On the island of Hawaii, Duane Nelson of the U.S. Forest Service (pers. comm., 2001) has confirmed two specific *Bocconia* infestations: one near Manuka Natural Area Reserve (scattered plants), and the other in Wood Valley (scattered individuals or small patches of plants over nearly 3000-3500 acres). Wood Valley extends from 500 to 1500meters (152 - 457 feet) on Kilauea and receives about 60 to 80 inches of rain a year. Manuka Natural Area Reserve, which extends from about 656 to 5576 meters (200 - 1700 feet) on the leeward side of Mauna Loa, receives less than 100 inches of rain a year (Giambelluca and Schroder 1998). The Big Island Invasive Species Committee (BIISC) has produced a Hawai'i island weed card on *Bocconia frutescens*. BIISC has also recorded additional sites at Honomalino in disturbed pastures and roadsides at an elevation of about 500 – 915meters (152 - 279 feet).

Figure 8. *Bocconia frutescens* stand, Kanaio, East Maui

Because of its ability to form dense stands in dry habitats (Stone and Scott 1984, Smith (1985) listed *Bocconia frutescens* as one of the 86 worst weeds that have become serious pests of native ecosystems. The most significant infestations of *Bocconia* on Maui now occur from 1600 to 4000 feet in the dryland forests of Auwahi and Kanaio (Figure 8), and during the 1992 survey of the now Kanaio Natural Area Reserve, *Bocconia* was found to comprise the sixth highest percentage cover of alien species along five monitoring transects (Medeiros *et al*. 1993). However, of the ten most common weeds by cover, *Bocconia* was the only woody species that could achieve the stature and dimensions of a dry forest tree. With its multiple-trunked, bushy growth habit, a single *Bocconia* tree can occupy a fairly substantial amount of area close to the ground, which appears to prevent the establishment of other plants beneath it. For these reasons, *Bocconia* was identified as

one of the seven most aggressive alien plant species that are a primary threat to native ecosystems of the Kanaio Natural Area Reserve (Medeiros *et al*. 1993).

Figure 9. *Bocconia* seedlings, Auwahi, East Maui

Anecdotal evidence now strongly suggests that *Bocconia* is expanding its density and range throughout the Auwahi and Kanaio regions, with heavier concentrations of seedlings appearing with increasing frequency, especially in bare areas recently exposed by kikuyu grass (*Pennisetum clandestinum*) dieback (Figure 9). If the effects of the yellow sugarcane aphid (*Sipha flava*) and drought continue to manifest themselves, the number of suitable germination sites can be expected to significantly increase. Combined with the ever-maturing population of reproductive sized individuals, the current *Bocconia* infestation will continue to increase. In addition, the timing of the peak fruiting period for *Bocconia* provides a conspicuous food resource for birds in the area, especially during the beginning of the hot and dry summer months when other food resources become increasingly scarce. This phenomenon is aiding in the expanding range of the weed, with seedlings germinating away from parent plants and beneath both native and non-native trees. Under these trees, *Bocconia* seedlings can form dense carpets and could outcompete the rarely reproducing native dryland species (Figure 10). The U.S. Fish and Wildlife Service lists *Bocconia* as one of the major threats to the survival of *Melicope adscendens* (Anonymous 2000). This sprawling shrub is endemic to the dry forests of Kanaio and Auwahi, East Maui, areas in which *Bostonian* is proliferating. Other endangered plants occurring in the area that could also be negatively affected by competition with *Bocconia* include *Alectryon macrococcus* (Sapindaceae), *Bonamia menziesii* (Convolvulaceae), the only know Maui population of *Cenchrus agrimonioides* (Poaceae), *Fluggea neowawraea* (Euphorbiaceae), *Melicope knudsenii* (Rutaceae), and *Santalum freycinetianum* var. *lanaiense* (Santalaceae) (Anonymous 2000). The Fish and Wildlife Service also states that *Bocconia* threatens *Nothocestrum latifolium* (Solanaceae), the host plant of the endangered Blackburn's sphinx moth (*Manduca blackburni*), through displacement and shading of immature plants (Anonymous 1997).

Figure 10. *Bocconia* seedling carpet, Auwahi, East Maui

Bocconia frutescens is now demonstrating its invasive potential in the dryland forests of Maui, but it is possible that, based on rainfall data from its native range, it could prefer

wetter, more mesic habitats than those it currently occupies. The south slope of Haleakala, site of the densest *Bocconia* infestation, receives approximately 750-1200 mm (30-47 inches) of rainfall annually (Giambelluca *et al*. 1986), yet data from Jamaica indicate that *Bocconia* is also encountered in areas with 2600-4270 mm (102-170 inches) of annual rainfall (Tanner 1977). Therefore, as *Bocconia* continues to expand its range along the southern and western slopes of Haleakala, into the wetter and more mesic environments, it could become an even more aggressive and serious invader than it is now known to be. This could have serious implications for management and conservation efforts in the koa forests of Kahikinui as well as in the higher elevation, moister shrublands encircling the mountain.

As of June 18, 1992, the Hawaii Department of Agriculture has designated *Bocconia* frutescens as a noxious weed to be targeted for eradication and/or control.

HISTORY OF *BOCCONIA FRUTESCENS* IN HAWAII

Bocconia frutescens was first noted by the botanist Charles N. Forbes in the Kanaio area on the southern slopes of Haleakala on the island of Maui in 1920 (Forbes 2175.M, BISH). During an extensive collecting trip throughout leeward East Maui, Forbes reported seeing only a single eight feet tall *Bocconia* plant growing on the roadside of the old government trail in Kanaio (Medeiros *et al*. 1993). In 1961, Fosberg (1969) reported that *B. frutescens* was "very sparingly and locally naturalized, a few plants only, in East Maui, just south of Ulupalakua Ranch." On April 14, 1974, Fosberg and Sachet (1975) reported that many well-developed shrubs had spread some distance south along the road. A single seedling several decimeters tall was reported in Auwahi, in a fenced nature preserve above Ulupalakua Ranch, while a mature shrub was also reported in Kula, at about 1200 meters elevation near the junction with Upper Kula Road and Haleakala Highway. Fosberg and Sachet (1975) still believed that it was possible to eradicate the weed at the time.

In the ensuing 77 years following the collection of Forbes, *Bocconia* has spread as far to the northwest as Kula at elevations of up to 4000 feet, and as far east as Manawainui Gulch in Kahikinui on DHHL lands up to as high as 5800 feet. The heaviest concentration of plants, with the broadest elevational distribution and the largest numbers of reproductive sized individuals as well as recently germinated seedlings, occurs in the dryland forests of Kanaio and Auwahi on the south slope of Haleakala, in the vicinity of the original 1920 observation (Figure 11). Medeiros *et al*. (1986) reported that *Bocconia frutescens* was one of the characteristic introduced species of the upper dryland forest, from 3000-4800 feet (915-1464 meters), suggesting a certain ubiquity of this plant at the time, but otherwise did not comment on its current or potential invasiveness in the body of their report. In 1992, however, Medeiros *et al*. (1993) found that *Bocconia* made up the sixth most common alien plant cover for non-native species in the Kanaio Natural Area Reserve, and recommended that it be opportunistically eliminated from areas of relatively intact native vegetation. *Bocconia* now occupies an area that extends from 1600 feet to at least 4000 feet (488-1220 meters). The only other island on which *Bocconia* is naturalized

is Hawaii, where it occurs in mesic forest at elevations of 1800-3000 feet (550-920 meters) at disturbed sites such as roadsides (Wagner *et al*. 1990).

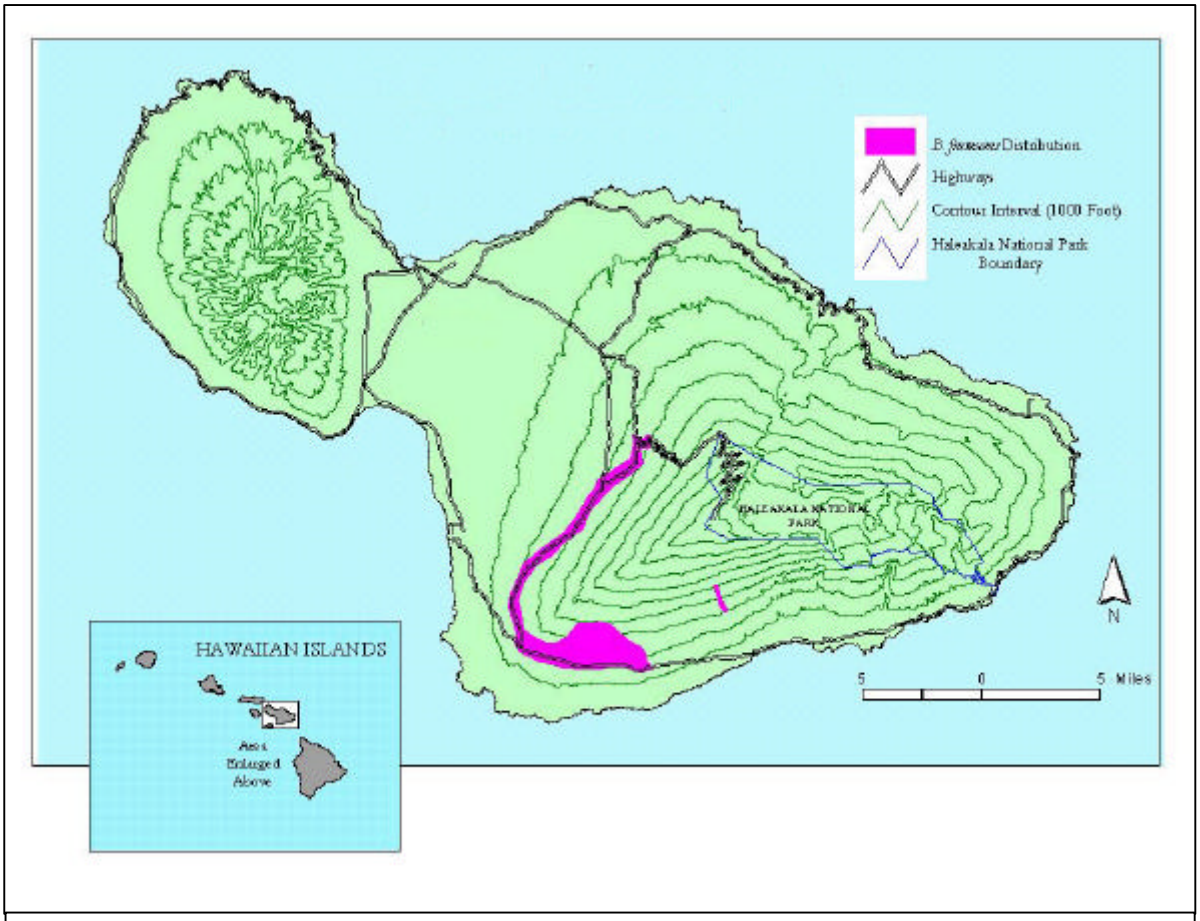


Figure 11. *Bocconia frutescens,* approximate distribution, Maui, Hawaiian Islands

INVASIVE ATTRIBUTES OF *BOCCONIA FRUTESCENS*

Because *Bocconia frutescens* can achieve the stature and canopy dimensions of a dry forest tree, it could form thick stands that exclude the establishment of rarely reproducing native species in the imperiled dryland forests of Kanaio and Auwahi on the south slopes of Haleakala. In addition, its ability to produce tremendous numbers of seeds with fleshy arils during periods of increasing scarcity on the leeward slopes greatly increases its attractiveness to birds, which in turn facilitates its increasing abundance as well as its rapid spread into moister, more mesic areas at higher elevations and further east and west along the slopes of the mountain. Finally, because of a demonstrated tolerance to a broad range of environmental conditions along a fairly large elevational gradient within its native range,

Bocconia frutescens appears to possess all the necessary qualities to further spread in area and encroach upon additional native and non-native habitats in the Hawaiian Islands.

INVADED ECOSYSTEM ATTRIBUTES

Based on data taken from Giambelluca *et al*. (1986), the mean annual rainfall occurring in *Bocconia*'s current range on Maui varies between 750-1000 mm (29-39 inches). In the most heavily invaded sites of Auwahi and Kanaio, however, the climate is rather arid and windswept with a mean annual rainfall closer to 750 mm (29 inches). On the island of Hawaii, Duane Nelson of the U.S. Forest Service (pers. comm., 2001) has confirmed two specific *Bocconia* infestations: one near Manuka Natural Area Reserve (scattered plants), and the other in Wood Valley (scattered individuals or small patches of plants over nearly 3000-3500 acres). Wood Valley extends from 500 to 1500meters (152 - 457 feet) on Kilauea and receives about 60 to 80 inches of rain a year. Manuka Natural Area Reserve, which extends from about 656 to 5576 meters (200 - 1700 feet) on the leeward side of Mauna Loa, receives less than 100 inches of rain a year (Giambelluca and Schroder1998).

Medeiros *et al.* (1986; 1993) have provided detailed descriptions of the vegetation of this area, which include a rich assortment of both common and extremely rare to endangered native plant taxa. The spread of *Bocconia frutescens* throughout the region could threaten the biological integrity of this already heavily impacted ecosystem.

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