Banana poka
(*Passiflora mollissima*)

An Alien Plant Report

Prepared by:
Forest Starr, Kim Martz and Lloyd Loope
United States Geological Survey Biological Resources Division

In cooperation with:
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Maui County Board of Water Supply

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What is Banana poka? Why is it bad?

Banana poka is a climbing, semi-woody vine with three lobed leaves, pink flowers, and yellow fruit. Banana poka forms a dense canopy, and smothers vegetation, fences, forests, pastures, and farm land.

Banana poka covers thousands of acres of forest on the Big Island and Kaua'i. On Maui, banana poka is currently restricted to the Kula Forest Reserve, but is expanding its range.

What should you do if you see this plant outside of Kula?

1. Call the Hawai'i Ecosystems at Risk (HEAR) project at 572-4418, or the State Department of Agriculture at 873-3555.
2. Dig out the root of the vine, if possible. Otherwise, cut the vine near the root of the plant, and treat with an herbicide.
3. For more information or additional copies of this flyer, call 572-4418, 873-3555, or websurf to www.hear.org.

You can help keep Maui no ka oi.

USGS
United States Geological Survey
Biological Resources Division

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Board of Water Supply

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Overview: Banana poka, a native of central America, is a climbing, semi-woody vine with three lobed leaves, pink flowers, and yellow fruit that forms a dense canopy, and smothers vegetation, fences, forests, pastures, and farm land. Initially introduced for ornament and fruit, banana poka has become one of the worst forest destroying weeds in the Hawaiian islands, covering thousands of acres of forest on the Big Island and Kaua'i. On Maui, banana poka is currently restricted to a few square miles in the Kula Forest Reserve, but is expanding its range, and its potential range could be quite large. Many control methods are used, but control is difficult, and all methods require subsequent follow up. Using ranch land as a buffer zone to prevent spread seems to be a promising ecosystem management approach. Future physical and chemical control efforts should focus on outliers, the mauka leading edge of the invasion, and roadsides.

Public Involvement: There are many opportunities for the public of Maui to help prevent the spread of banana poka. Na ala hele trail crews, mountain bikers, hikers, and hunters, have found new banana poka locations in the past. Those familiar with banana poka can keep an eye out for it in the future, especially in the watershed. New locations should be forwarded to USGS/BRD. Along with new locations of banana poka, any information on biology, ecology, control, or potential public involvement can also be forwarded to USGS/BRD. Information such as this report, flyers, web pages, and videos can be duplicated and distributed. The Native Hawaiian Plant Society and other groups often have speakers who talk about banana poka and other alien threats to the watershed. There have been many efforts at controlling banana poka in the past. Current efforts are focused on outlier populations, the mauka leading edge, and roadsides. Groups involved with banana poka control efforts include the Sierra Club of Maui, the State Department of Land and Natural Resources, and the State Department of Agriculture.

Common Name: Banana poka (Hawai'i), banana passion fruit (Australia and New Zealand), curuba, tintin, tumbo, trompos (South America), granadilla cimarrona (Mexico).

Latin Name: *Passiflora mollissima* (Kunth) L.H. Bailey (Wagner et al. 1990).

Synonyms: [*Passiflora tomentosa* Lam., *Murucuju mollissima* Spreng., *Tacsonia mollissima* Kunth] (Wagner et al. 1990).

Taxonomy: In the Passifloraceae (Passion flower) family, a family comprising two tribes, 22 genera, and about 600 species. Represented in Hawai'i by 11 naturalized species and one persisting hybrid of *Passiflora* (Wagner et al. 1990). *Passiflora mollissima* (as now recognized) is a morphologically variable species and may be a hybrid between certain original, less variable species, (such as *P. mollissima* in a

restricted taxonomic sense and another, unknown species of *Passiflora*) (LaRosa 1984,1987).

Description: Lianas. Leaves with blades 6-16 cm long, 7-20 cm wide, deeply 3-lobed, softly pubescent on lower or both surfaces, petioles with 4-6 scattered, minute, subsessile nectaries, stipules obliquely ovate, ca. 6 mm long, apex setaceous, deciduous. Flowers pendent, salverform, 6-9 cm in diameter, peduncles solitary, 3.8-10 cm long, bracts ovate, coherent at base, forming an ampliate tube over base of hypanthium; hypanthium green, tubular, 5-7 cm long; sepals and petals pink, lanceolate to oblong, 4-5 cm long; corona purple or white, tuberculate to dentate. Fruit yellow at maturity, pericarp softly coriaceous, obovate to oblong, 6-8 cm long, 2.5-4 cm wide, pubescent, 50-200 seeds per fruit, aril orange (Wagner et. al. 1990).

Noxious weed acts: *Passiflora mollissima* is a Plant Species Designated as Noxious Weed for Eradication or Control Purposes by the Hawaii Department of Agriculture chapter 68 noxious weed rules. The weed list database created for this study has five references that list banana poka as a weed.

Native Range: Banana poka is native to the Andes of South America, including eastern Cordillera of the Andes of Colombia, southeastern Andean slopes of Peru and western slopes of the Bolivian and Venezuelan Andes (Killip 1938).

Native Climate: Banana poka grows wild in the Andean upper montane forest (known as ‘ceja de la montana’) above 2000 m (6,562 ft), a forest type composed of evergreen woody vegetation with abundant epiphytic ferns, orchids, mosses and bromeliads, and with a cool, moist, foggy climate (LaRosa 1984). The climate can be described as cool-warm, temperate, moist-wet, 500-2000 mm (20-79 in) precip., 6-18 degrees C (43-64 degrees F (Cronk and Fuller 1995).

Global range of invasion: Banana poka can be found invading South Africa where it is naturalized (Macdonald 1987); banana poka can also be found invading New Zealand. (Webb, Sykes, and Garnock-Jones 1988). In South Africa it was only noticed in the wild as recently as 1987; it is available for sale in nurseries (Warshauer et al. 1983). It appears to have naturalized in some forests in South Africa, but is not yet widespread. It has been seen in Knysna Forest of the southeast Cape Province as well as in other areas. In New Zealand it occurs mainly in forest plantations, margins and on isolated trees and is sometimes a serious weed (Webb, Sykes, and Garnock-Jones 1988)

Range of invasion in the State of Hawaii: In Hawai'i, banana poka is a serious pest in mesic forest, 850-2,225 m (2,789-7,300 ft), on Kaua'i, Maui, and Hawai'i (Wagner et al. 1990), where it can be found in a variety of habitats including both open and closed forests of black wattle (*Acacia koa*) and 'Ohia (*Metrosideros polymorpha*), mixed native species associations and hapu'u tree fern (*Cibotium*) forests (LaRosa 1984).

Range of invasion on the island of Maui: Banana poka is currently restricted to the Kula area of Maui, where it is invading residential, agricultural, and natural areas. Most

of the area is a tangle of black wattle forest. Recently, however, plants have been found invading the sub-alpine shrubland. The upper leading edge of the banana poka invasion is located on the Waiakoa loop trail in the Kula Forest Reserve at an elevation of over 6000 ft (1829 m). There are currently three known possible populations of banana poka outside of the Kula population; 1) One plant was found at the top of Olinda road in a person's yard and identified by Fern Duvall. The plant was pulled. It is not known whether any other plants are near by. A survey should be done around the area to see if there are any more plants in the area; 2) Apparently, the agricultural extension office in Piiholo used to have a few different types of *Passiflora* spp. growing here until Wes Wong and Ed Tamura asked them to stop. They said they killed all of them. It is not known whether any seed could have dispersed nearby. A survey should be done around the location to see if there are any other plants in the area; 3) Somewhere in the Makawao Forest Reserve, about five years ago, Fern Duvall found what he thought was *Passiflora mollissima*. He went back with Glenn Shishido, Anne Marie LaRosa, and Bob Hobdy, but was unable to relocate it. At this time, it is not known where the plant was. Another search attempt with Fern Duvall and persons from DLNR, DOA, and USGS/BRD would be prudent.

Climate where invading: Hawai'i: Cool-warm temperate moist-wet, 500-2000 mm (20-79 in) precipitation, 6-18 degrees C (54-64 degrees F) (LaRosa 1984). South Africa: Warm temperate dry, 500-1000 mm precipitation, 12-18 degrees C. Knysna Forest, where it is found in South Africa, has a climate which is fairly humid all year round with little in the way of a dry period and no frost.

Value to Humans: Widely cultivated for its fruit (Escobar 1980), and its showy flowers.

Problems: *Passiflora mollissima* is at first sight an innocuous gardener's plant, spread for ornament and fruit and apparently modified by hybridization. However, in Hawai'i it has become a destroyer of forests. It was first reported in Hawai'i in 1921, probably planted in gardens from which it then spread. According to Degener, Degener, and Gunn 1973, banana poka was introduced to hide an outhouse on Hawai'i earlier this century. It is now proliferating in mid to high elevation forests, both disturbed and undisturbed, on the islands of Hawai'i, Kaua'i, and Maui.

The total area covered by a continuous distribution of *Passiflora mollissima* was over 190 square kilometers (19,000 ha) in 1983 (Warshauer et al. 1983) and it has successfully invaded areas of diverse climate and vegetation. The area cover by banana poka has doubled since 1983, and today it now occupies over 400 square kilometers (40,000 ha) of Hawaiian forests, where it spreads through the canopy killing trees (Luken and Thieret 1997).

On the island of Hawai'i it can be found in habitats ranging from dry lava flows with sparse open scrub to montane rainforests and pastures (LaRosa 1984). Banana poka is a serious pest in mesic forest, 850-2,225 m (2,789-9,842 ft), where it overgrows native trees and is distributed by feral pigs and other animals (Waage, Smiley & Gilbert 1981).

Banana poka is a vine that smothers even the largest trees. Humans were responsible for its spread over long distances, but feral pigs and kalij pheasants (*Lophura leucomelana*) intensify infestations once established. The weed is too widespread to be effectively controlled except in small areas, but natural enemies (for example insects, diseases) from its native Colombian forests are being evaluated in Hawai'i, and one potential biological control agent, a moth, has been released (Stone and Stone 1989).

The dispersal of the large fleshy fruits of *Passiflora mollissima* by birds and feral pigs (LaRosa 1984) has confounded all attempts to control it. Many isolated infestations, some in inaccessible areas, have presumably been established originally by long distance bird dispersal, while local infestations from these foci is promoted by pigs (Quentin 1995).

Biology and Ecology: In its native habitat of the moist Andes from 2000 to 3600 m (Martin and Nakasone 1970), populations of *Passiflora mollissima* are sparse, with only about two or three plants per hectare; its flower and fruits are heavily predated by numerous insects (Warshauer et al. 1983). In Hawai'i, it is found at densities far in excess of this. *Passiflora mollissima* grows best in cold regions and can tolerate occasional frosts to -2 degrees C (LaRosa 1984), although it occurs in Hawai'i under a broad range of environmental conditions and on several types of soils, from ash to weathered basalt (Warshauer et al. 1983).

In Hawaii, dense curtains of the vine extend to the ground from canopy branches, sometimes causing branches to break and toppling trees during storms. Where the canopy has been opened, dense mats of vines also mantle the understory trees and shrubs and inhibit regeneration of the native trees (Mueller-Dombois et al. 1980). Endangered endemic forest birds are affected by the increase of *Passiflora mollissima*, which alters the structure and composition of the forest (Warshauer et al. 1983). On Kaua'i, the populations are centered in Koke'e and are found in both open and closed Acacia forests from 850 to 1300 m elevation.

Passiflora mollissima is a self-compatible woody climber which takes advantage of both self-fertilization and cross-fertilization. This characteristic, along with its adaptation for long-distance dispersal, has allowed it to spread into isolated areas, away from the main focus of invasion, where it is invading evergreen rainforest (Cronk and Fuller 1995). Seeds can remain dormant for some time (Cronk and Fuller 1995).

The relatively shade-tolerant seedlings (there is usually a large seedling bank resulting from the continuous and prolific seed rain) grow rapidly in full sun. *Passiflora mollissima* can invade closed forests through gap-phase replacement involving its rapid growth in gaps caused by fallen trees; it forms a dense tangle of vegetation which smothers the undergrowth. Individuals reach reproductive maturity at an early age and mortality is low after establishment: the life span may exceed 20 years (LaRosa 1984).

Flowers can be found all months of the year and fruit is copiously produced. The abundant fruit set observed in Hawai'i seems to be due to a mixture of spontaneous self-

pollination and pollination by alien insects. The newly opened flowers have exposed stamens, favorable to cross-pollination by insects; if cross-pollination does not occur, each flower later pollinates itself through movement of the stigmas to touch the stamens. Where native, it is thought to be pollinated by hummingbirds and large bees. *Passiflora mollissima* exhibits continuous growth and reproduction, but peak flowering occurs in the dry season in both Hawai'i and South America (LaRosa 1984). The seeds are dispersed by frugivorous animals, in Hawai'i principally by feral pigs (Sus scrofa L.). Birds aid in long distance dispersal to uninfested areas, providing new foci for invasion. Pigs provide a fertile medium for seedling growth in the early stages of establishment (LaRosa 1984) and their rooting activities create an environment with low competition, favorable for *Passiflora*.

The following ecological characteristics of *Passiflora mollissima* may be suggested as reasons for its success as an invasive species. Prolific, continuous seed production; effective dispersal by feral pigs in Hawai'i; long-range dispersal by birds; facilitation by the 'rooting' activities of pigs; disturbing the soil and providing suitable areas for seedlings to establish and a fertile medium of pig dung in which the seedlings initially grow; ability to tolerate low light levels and exploit gaps; combination of auto- and allogamy; and relatively fast growth rates leading to early reproductive maturity (Cronk and Fuller 1995).

Physical and chemical control: When deciding whether to use mechanical or chemical control methods, managers must weigh the success of control efforts against the possible disturbance to the surrounding environment. Herbicide effects on nontarget species and possible drift or leaching of herbicides are especially important. Chemical control can be relatively safe when herbicides are applied carefully, correctly (according to label specification), and directly to individual target plants. Because stems of banana poka do not readily sprout, mechanical means of control may suffice in selected areas. Some sprouting has occurred on the abaxial cut surface, however (J. T. Tunison, pers. comm. 1986). Careful use of these techniques may be effective for control of small populations in the immediate future (LaRosa 1992).

In the early 1970's, several small scale chemical control projects, using picloram (Tordon), 2,4-D (Tordon 22K), a mixture of picloram and 2,4-D (Tordon 212), and Paraquat, were conducted on the island of Hawai'i by the Hawai'i Division of Forestry. All herbicides proved effective against banana poka but were nonselective and resulted in undesirable effects on nontarget species (Landgraf 1971; Cusset 1975).

Since the 1970's, several attempts by the State of Hawai'i and the National Park Service at control by physical and chemical means have met with little success (Warshauer et al. 1983). The extent and density of infestations make these methods uneconomical as well as ineffective. However, one exception was noted where forests of the endemic Acacia koa are being re-established on degraded montane forest land infested by *Passiflora mollissima*. The application of a high dose of glyphosate (6kg/ha) prior to planting Acacia significantly reduced to mortality of Acacia by *Passiflora mollissima* after 10

years; in contrast, all Acacia trees were killed on untreated plots (Scowcroft and Adee 1991).

Two herbicides in three different concentrations were tested for use against banana poka in ‘Ola’a Tract. Treatments were Garlon 3A (triclopyr) and Roundup (glyphosate), each undiluted and at 50% and 5% dilutions in water. Herbicides were applied to the cut surfaces of banana poka stems near the point of rooting. Water applied to cut-stem bases served as a control and a test of the effectiveness of cutting alone. Sample size for each treatment was 10 vines. All treatments, including the control, killed 100% of banana poka stumps. However, the aerial portions of the vines survived and rooted in 40% of the water control plants and 10% of vines treated with 5% Garlon 3A. In the other five treatments, all vines were killed. Ten common, widespread native plant species and many others of sporadic occurrence were monitored in plots surrounding treated banana poka. Three woody plant species, four fern, and two herbs generally remained constant or increased in numbers over the year in plots of most treatments. Only one fern species (ho’io-kula or *Pneumatotopteris sandwicensis*) showed a significant decline in numbers; this occurred in the undiluted Garlon 3A, undiluted Roundup, and 50% Roundup treatments. The 5% dilution of Roundup is recommended as an effective cut-stump treatment for banana poka, with no observed negative impacts on surrounding vegetation (Santos et al. 1991).

Early results on the efficacy of herbicide control concur with previous findings: herbicides, and in this case, mechanical means, appear effective in controlling banana poka. More data are needed on nontarget effects, resprouting of vines, and long-term control efficacy.

Biological control: Because of its widespread distribution and dense populations in many areas, overall control of banana poka in Hawai’i can only be achieved by using biological control. (Warshauer et al. 1983) But biological control is not a panacea (Howarth 1983), and the potential impacts of introduced control organisms on other native vegetation and the native arthropod fauna must be carefully considered. Follow-up studies will be necessary to monitor the long term efficacy and effects on the ecosystem (LaRosa 1992).

In the early 1970s, an alien passion vine butterfly, *Agraulis vanillae,* was introduced to Koke’e (Kaua’i Island) to control banana poka. Individuals did not readily establish on banana poka and were therefore unsuccessful in its control (Murai 1977; Nakahara 1977; Bianchi 1979). The Division of Forestry then looked for biological control agents present in Hawai’i. Several species of the fungus *Alternaria* and a scale insect (*Ceroplastes cerripidiformis*) were identified as potential control agents, but work on these projects was inconclusive (Laemmlen 1971). Serious attempts at biological control began in 1981, when the Hawai’i State Legislature appropriated funds to begin control work on forest pest plants.

Passiflora mollissima is attacked by many pests and diseases in its native range (LaRosa 1984) but at present only one candidate, a moth, *Cyanotricha necyrina*, has been cleared

by officials for release (Markin 1989). Studies on the potential of *Fusarium oxysporum f. sp. passiflorae* are in progress (Smith 1989). High host specificity is needed due to the large commercial passion fruit (*Passiflora edulis* Sims) industry on Hawai'i and the potential damage which might be caused to this by more generalist control agents.

CASE STUDIES

'Ola'a Tract: The most recent and rapidly expanding population of banana poka on Hawai'i is in the Ola'a Tract of Hawai'i Volcanoes National Park; this infestation originated from a transplant from Keanakolu (Mauna Kea) to Volcano in 1958 (Pung 1971). Density was generally low (on the order of 2,025 individuals/a or 5,000 individuals/ha) (LaRosa 1984), as are foliage cover values (generally less than 5%) (Warshauer et al. 1983). However, cover was much greater locally along forest margins and in forest openings. Habitats occupied by banana poka include closed-canopy, wet 'ohi'a-tree fern forests, and more open-canopy, wet 'ohi'a forests (lacking a dense tree fern subcanopy). A small, relict stand of wet koa-'ohi'a forest is heavily infested with banana poka (Warshauer et al. 1983).

The 'Ola'a Tract population has grown explosively in the last 10 years. The infested area increased 17-fold (1,700%; from 350 to 5,775 a or 142 to 2,338 ha) from 1971 to 1981 (Warshauer et al. 1983). Most of this increase can be attributed to the severe windstorm of January 1980 (Warshauer et al. 1983; LaRosa 1984). Prior to the storm, small seedlings were numerous in the understory, but mature canopy vines were rare. Following the storm, banana poka increased visibly in the many canopy gaps created by the loss of tree fern fronds and canopy trees. Feral pigs played an important role by dispersing seeds throughout the area before and after the disturbance (LaRosa 1984).

Mauna Kea, Hawai'i: Banana poka was introduced to the Keanakolu area of the Laupahoehoe district in 1928 and spread rapidly. The highest density and cover values (>202,000 individuals/a or 500,000/ha; 75 to 100% cover) of banana poka occur in the Laupahoehoe-Keanakolu area of Mauna Kea (Warshauer et al. 1983; LaRosa 1984). The heavy infestation may be largely a consequence of historical grazing and subsequent logging. Cattle used the area heavily prior to the introduction of banana poka in 1928 but were removed in the 1940s (Pung 1971). Following removal, banana poka spread rapidly through the heavily disturbed forest. Areas with less than 30% cover are often grazed by cattle, which reduces most species, including banana poka. Optimal habitats on Mauna Kea include mesic and wet koa-'ohi'a forests. Rainfall in excess of 175 to 220 in. (4,500-5,100 mm) appears to limit population expansion into wet 'ohi'a forests of Mauna Kea (Warshauer et al. 1983).

Feral pigs, which reach their highest density on Hawai'i on Mauna Kea (Giffin 1972), are now largely responsible for the intensive dispersal of seeds. Other dispersal agents include cattle (feral and escaped livestock), turkeys, gallinaceous birds, and horses (*Equus caballus*).

The Mauna Kea population of banana poka is stable (Warshauer et al. 1983): the total area infested by banana poka on Mauna Kea declined 3% between 1971 and 1983.

Localized changes in distribution and abundance, however, indicate that population expansion is still occurring within limited areas, but that some population losses have also occurred. Fore example, the area in the highest cover class declined from 2,970 to 803 a (1,202 to 325 ha). Cattle grazing and the disturbance accompanying koa logging may account for some of the banana poka cover loss.

North Kona, Hawai'i: This infestation is the result of the merging of two populations from separate introductions – the original introduction to the Hawaiian Islands a Pu'uwa'awa'a in 1921, and a later introduction to Honua'ula in 1928 (Pung 1971). Banana poka is still spreading into favorable habitats in North Kona. The area of continuous distribution increased 51% from 1971 to 197; 20% of this increase was in the high cover class (30% - 70% cover). In 1981, a 15,565 a (6,300 ha) core area of continuously distributed individuals surrounding a sparsely populated (3-16 individuals/a or 8-40/1,000 ha), 15,565 a (6,300 ha) area with low banana poka cover (Warshauer et al. 1983).

While banana poka populations in Kona are as old or older than the Mauna Kea population, the degree of infestation is less. The rate of spread has been slower in Kona, and cover values are less (Warshauer et al. 1983). Several factors may explain lower success in Kona, particularly on Hualalai volcano. Growth of Banana poka shoots from Hualalai was slower than for those from 'Ola'a Tract and Mauna Kea (LaRosa 1984), likely a function of the lower annual rainfall on Hualalai. Other site factors may also be limiting. Hualalai is a composite of geological and plant successional stages, and much of the area is geologically young, with little soil development and early successional vegetation (Warshauer et al. 1983). Areas of low-stature 'ohi'a forest support lower densities and cover of most plants, including banana poka (LaRosa 1984). Areas with banana poka cover in excess of 30% are restricted to more mature forest, such as mesic koa-'ohi'a or koa-mamane (*Sophora chrysophylla*) (Warshauer et al. 1983).

In addition, disturbance factors, including cattle grazing, logging, and forest clearing, have generally been less in Kona than at many areas on Mauna Kea, although disturbance is rapidly increasing. Feral pigs and cattle, Kalij pheasants, and the 'alala are known to disperse seeds in the Kona area, but dispersal may be less intensive than elsewhere. Coarse lava flows isolate some animal populations, reducing home ranges and resulting in fewer potential sites colonized (Warshauer et al. 1983). Also, the density of feral pigs is much lower on Hualalai than on Mauna Kea (Giffin 1972).

Koke'e, Kaua'i: Banana poka was introduced to the Koke'e area in 1923 (Wenkham 1967). The infestation currently extends from 2,790 to 4,265 ft (850-1,300 m) elevation (Daehler 1975; Warshauer et al. 1983). Principal habitats invaded include mesic koa-'ohi'a forests and, to a lesser extent, wet 'ohi'a forests (Warshauer et al. 1983). Alien feral pigs and red jungle foul (*Gallus gallus*) range throughout the area and, along with passive dispersal of the plant via streams, are largely responsible for its widespread occurrence.

Little quantitative information is available on the distribution and population dynamics of banana poka on Kaua'i. In 1981, approximately one-third of the infested area had high cover values (>30% banana poka foliage cover). Highest cover values occurred in mesic areas such as gulches, while surrounding drier ridges had lower cover values (Warshauer et al. 1983). Banana poka is excluded from the wettest habitats (*e.g.*, Alaka'i Swamp). Comparison of a 1975 population estimate (Daehler 1975) with a 1981 aerial survey (Warshauer et al. 1983) suggests that the population declined 30% in six years, although the estimates may not be comparable due to differences in estimation techniques.

In 1982, Hurricane Iwa severely disturbed the vegetation in the Koke'e area and damaged many canopy trees. While its effects on the banana poka infestation have not been quantitatively assessed, a cursory examination of the area suggests a proliferation of banana poka in the ground layer. This likely resulted from extensive canopy disturbance, which allowed more light to reach the forest floor. Vines that were in the canopy prior to the storm were displaced to the ground along with supporting trees (and branches). As the forest recovers, banana poka will be carried into the canopy, increasing its cover in the upper strata. A recent study (LaRosa and Floyd 1988) suggested that banana poka may be interfering with the post-hurricane reproduction of the endemic understory species mokihana (*Pelea anisata*) in a heavily disturbed area of Koke'e.

Kula, Maui: Prior to the early 1970's, the only known specimens of banana poka on Maui were part of a cultural planting at the Hawai'i Agricultural Experiment Station (Wong 1973). However, the most recently documented infestation began presumably as an ornamental planting on private property and when "discovered," in 1971, by Hawai'i Division of Forestry personnel, consisted of one adult and approximately 250 seedlings (less than 2 a (0.8 ha) in extent) in the Waiakoa (Kula) area. The potential invasiveness and dominance of banana poka was known to the Division of Forestry officials at that time, and they immediately alerted the Hawai'i Department of Agriculture, which promptly eradicated the population (Wong 1973). They presumed this was so until 1978, when it was again noted in the same area (Tamura 1978a, 1978b). Little attention was paid to the periodic appearance of seedlings until the early 1980s, when banana poka was noticed spreading through a forest of black wattle (*Acacia mearnsii*).

In 1988, the Waiakoa population was mapped, using aerial and ground surveys, by the Hawai'i Division of Forestry.(Hobdy 1988). Their data represent the most comprehensive information available on this infestation. In 1989, banana poka continuously covered 9 a (3.6 ha) within a 200 acre (80.9 ha) radius, largely on privately owned agricultural parcels and homesteads in the Waiakoa area. Fifteen different invasion centers have been mapped. Cover ranges from light (<10%) to heavy (>50%), with 77% of infestation in the heavy class. Outside of developed areas (agriculture, landscaping), vegetation in the area is primarily a mixture of black wattle and Eucalyptus sp. Heaviest densities and cover occur in the gulches (LaRosa 1992).

Comparison of the 1971 and 1988 population estimates indicates an explosive population increase. Most of this increase appears to be local population enhancement rather than expansion beyond the 200 acre radius and may be largely a result of banana poka

invasion following large scale vegetation disturbance in the area during the January 1980 windstorm. Additionally, some population expansion is occurring downslope, presumably via expansion of this population will be held in check by rapid development and utilization of the area, but State owned lands in the Kula Forest Reserve, located at higher elevation than the infestation, are threatened (LaRosa 1992).

The most encouraging note to date has been the continued support and efforts of the local community, particularly the local chapter of the Sierra Club, to eradicate this pest from the area. Consequently, in 1988, Senate Bill 599 was passed, appropriating State monies for control of this population (LaRosa 1992). Currently, the Hawai'i Department of Agriculture is battling banana poka on Maui in conjunction with the Forestry Division of the State Land and Natural Resources Department. The distribution of banana poka on Maui is increasing. Currently there are between 300-500 acres infested with banana poka. The makai extent of the population is Lower Kula Rd. The mauka extent is below the hunter check in station. Current thinking is that control efforts will focus on stopping spread laterally and mauka. Makai spread of banana poka is not being addressed (Tamura pers. comm. 1997). Chemical control by aerial application of both Garlon 3A and 4 kills the mature plants, but does not kill the seeds in the ground. A fungus has been released by the Forestry Division, and some of the larger parcels of residential land may be fenced, and cattle introduced to control the spread of banana poka (Tamura pers. comm. 1997).

Management recommendations: Banana poka has invaded, and is expanding in, a wide range of habitats in Hawai'i. Mechanical, biological, and chemical means of control have all been attempted for banana poka, but to date, no comprehensive management strategy exists. Future control efforts should be concentrated on outlying populations, as they are the easiest to control and have the greatest potential for spread. The leading edge and roadsides should also be focused on. Following the principles of weed population expansion set for by Mack and Woodall (1981), we may predict several things. For a dense, mature population such as that at Mauna Kea, there would be little additional consequence in waiting for a successful biological control program to become established. Some population expansion might occur on the perimeter of this population, but this would take place at a relatively slow rate (LaRosa 1992).

There are currently no known satellite populations on Maui that still have living individuals. If/when a new population it brought to light, it is imperative that is be jumped on right away. Each new location is a unique scenario, but the same major players will usually be involved. Those players and their roles are: USGS/BRD (Mapping and distribution of information), DLNR (Physical and chemical control), DOA (Physical and chemical control), LANDOWNER (Initial location, mapping, and control).

Because biological control is a long-range goal, if in fact a successful agent (or agents) can be found, it is necessary to weigh the short-term consequences and costs of no action. For populations of limited extent, efforts should be directed toward timely mechanical and/or chemical control. Delaying control measures will be costly. With the potential for rapid rates of banana poka population growth under favorable conditions, the possibility

of later control by these means may be quickly lost forever. Several such populations on the island of Hawaii were identified by Warshauer et al. (1983), including one each in Kohala, Manuka, and Pohakuloa. A more recent discovery of banana poka in Olinda, Maui is another small population that if not jumped on now will become another opportunity missed.

In the absence of a worldwide database of invasive plants, species that are a serious problem in one area may be unwittingly introduced to another by those unaware of the potential threat. For example, *Passiflora mollissima*, one of the most serious invasive plants of the Hawaiian forests, was noticed recently spreading in native forest in South Africa (Macdonald 1987). Fortunately, the forestry board in South Africa was quickly alerted to the danger. It had apparently been introduced by an enthusiastic gardener and was being sold in plant nurseries. This is a good example of how Maui and the state of Hawai'i can act as an early warning system for others around the world.

Efforts to predict potential habitat (Jacobi and Warshauer 1992) are quite helpful in determining future management strategies, and more work should be put into refining the preliminary model. Banana poka can be considered an "attractive nuisance;" increase in public awareness of the problem and proposed solutions are necessary and would decrease chances of intentional introductions to new areas (LaRosa 1992). Successful biological control programs seldom completely eliminate a pest, but elimination of banana poka from selected areas, such as control efforts in the Special Ecological Areas within Hawai'i Volcanoes National Park (Tunison and Stone 1992), remains a viable management alternative. Control of banana poka is a long-term problem requiring continued involvement and commitment by government agencies. Coordination is necessary to develop an effective statewide control program, but a single agency needs to take the lead in compiling and updating distribution information and formulating statewide priorities for control of populations (LaRosa 1992).

KEY CONTACTS
MAUI:
United States Geological Survey – Biological Resources Division
Forest Starr & Kim Martz, Chuck Chimera and Lloyd Loope
PO Box 369
Makawao, HI 96768
(808) 572-4472

Native Hawaiian Plant Society – Board Member
Lorna Harrison
Makawao, HI 96768
(808) 572-6338

Hawai'i State Department of Land and Natural Resources
Division of Forestry and Wildlife
Fern Duvall, Bob Hobdy and Glenn Shishido
54 S. High St. Rm. 101

Wailuku, HI 96793
(808) 984-8100

Hawai'i State Department of Agriculture -- Plant Quarantine Branch
Edward Tamura
635 Mua St.
Kahului, 96732
(808) 873-3555

KAUA'I:
Hawai'i State Department of Agriculture
Guy Nagai
4398A Pualoke St.
Lihue, HI 96766-1673
(808) 274-3069

HAWAI'I (Big Island):
Hawai'i State Department of Land and Natural Resources
Division of Forestry and Wildlife
Bryon Stevens
P.O. Box 4849
Hilo, HI 96720
(808) 974-4221

Hawaii Volcanoes National Park
Tim Tunison
P.O. Box 754
HI National Park, HI 96718
(808) 967-8226

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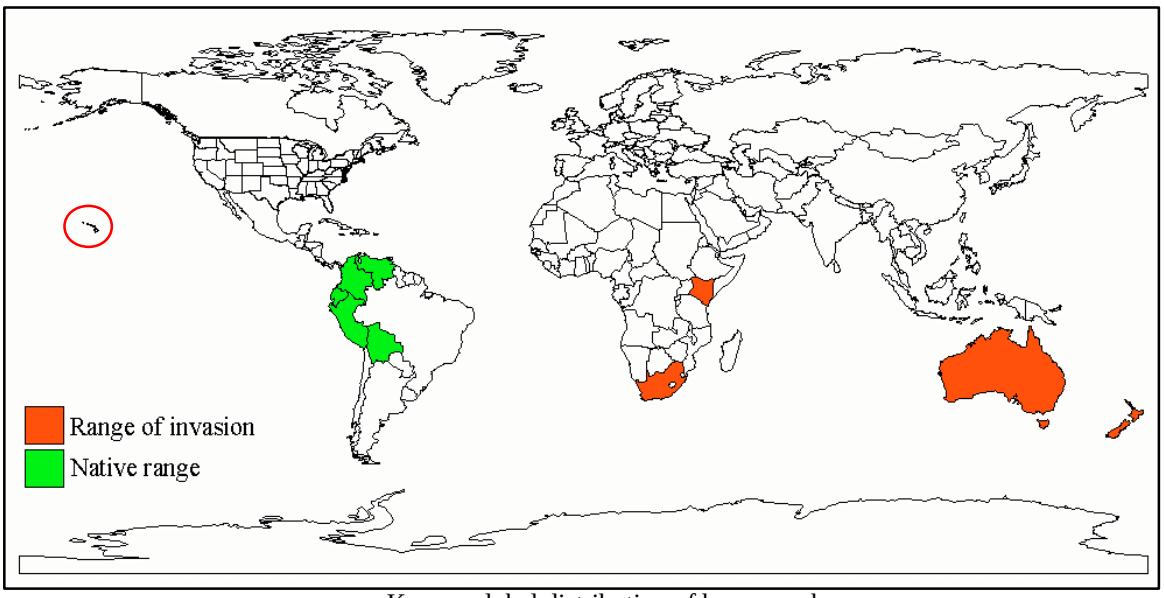
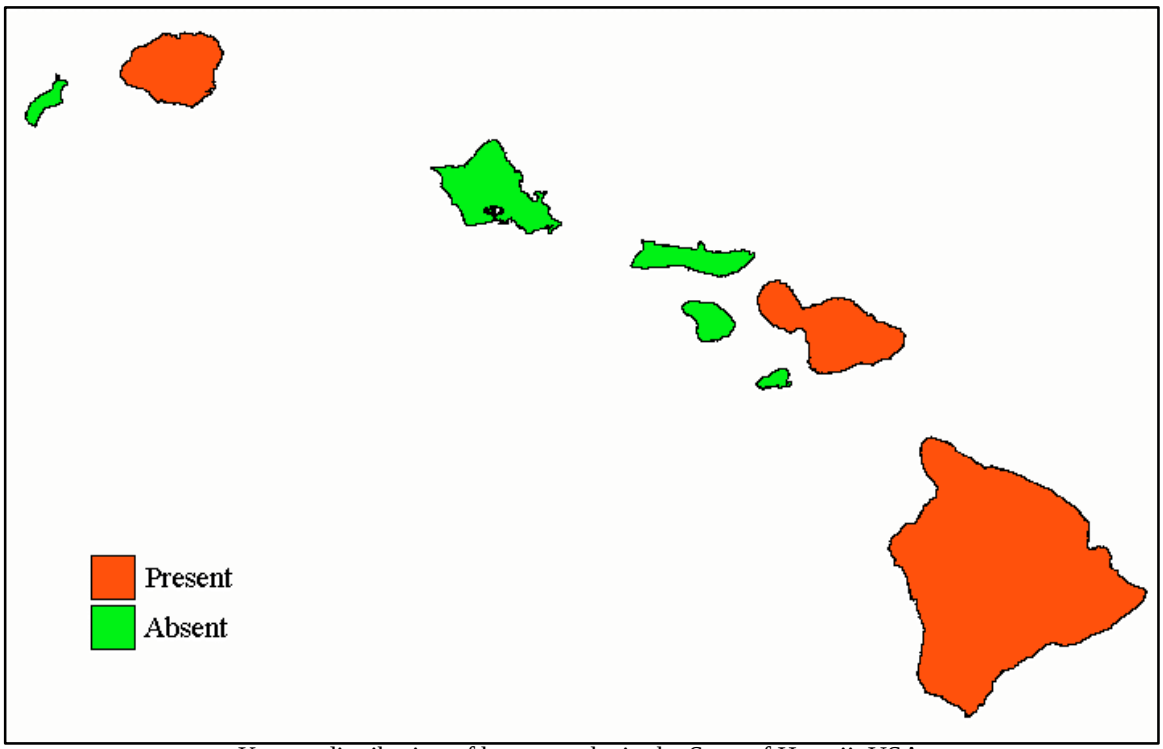
Volunteers hiking through typical sub-alpine habitat of leading edge of banana poka invasion - Polipoli, Maui

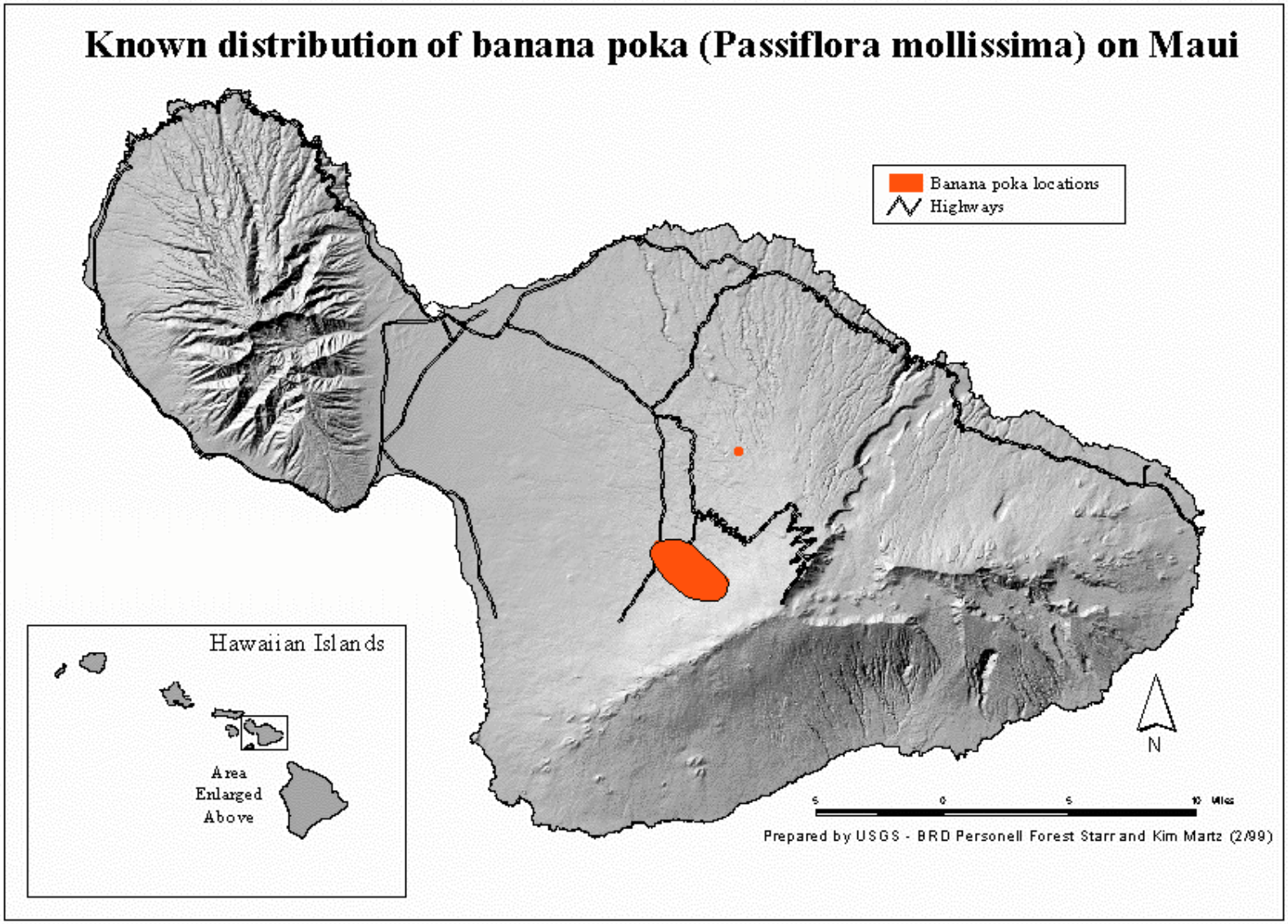
Joy Tamayose and Peter Kafka pulling banana poka - Polipoli, Maui



Known global distribution of banana poka



Known distribution of banana poka in the State of Hawaii, USA


Known distribution of banana poka (Passiflora mollissima) on Maui
Banana poka locations
Highways
Hawaiian Islands
Area
Enlarged
Above
N
Prepared by USGS - BRD Personell Forest Starr and Kim Martz (2/99)