Biological Control of Introduced Weeds of Native Hawaiian Forests[1]

George P. Markin Roddy F. Nagata Donald E. Gardner[2]

Abstract: Among the many threats to the continued existence of the remaining native forests and other native ecosystems of the Hawaiian Islands, the most severe and the most difficult to control are the invasion and replacement by introduced species of plants. Because conventional methods of plant management have failed to control this invasion, a multiagency, state and federal program was initiated in 1980 to attempt control through the use of classical biological control: the introduction, release, and establishment of the natural enemies of the weeds, including both insects and pathogens. Currently, active programs are under way against six different introduced weeds: banana poka *(Passiflora mollissima)*, firetree *(Myrica faya)*, gorse *(Ulex europaeus)*, introduced blackberry *(Rubus argutus)*, Koster's curse *(Clidemia hirta)*, and strawberry guava *(Psidium cattleianum)*. Under the present program, five insects and one pathogen have been tested and released in Hawaii. Three more insects are waiting final approval, and one pathogen has been approved but not released. Ten other insects and pathogens are being tested in Hawaii, and we are supporting scientists in five foreign countries who are studying the plants in their native ecosystems to identify further agents for us. On the basis of the high rate of success of previous programs for biological control of agricultural weeds in Hawaii, we hope that this program will be a successful tool for managing forest weeds. It will also offer a relatively cheap, safe, but effective method of vegetative management in forest ecosystems on other Pacific islands.

The native forests of Hawaii are unique. Evolving over millions of years on the most isolated pieces of land in the world, most of the trees, shrubs, and ferns that compose the forest and the associated birds, arthropods, and other invertebrates are native only to the Hawaiian Islands (Carlquist 1980). This complex represents a unique ecosystem, but unfortunately one that is rapidly disappearing. The destruction of the Hawaiian forest began when the first Polynesian settlers began clearing land for farming, but accelerated greatly after contact with the rest of the world (Smith 1990).

Fortunately, some of the most pristine of our remaining forest ecosystems are now protected in state forest reserves, natural areas, parks, and wildlife refuges. Even in these protected areas, these ecosystems are not safe, because they are subjected to continual degradation, mostly from introduced species of animals, particularly cattle, goats, and pigs, as well as from replacement by introduced species of plants.

Most of our problem weeds were introduced to Hawaii as desirable plants, i.e., for their flowers and fruits or for agricultural use. But soon they escaped into the wild where, without their complex of natural enemies, they spread and multiplied unrestricted. The problems the weeds cause in these native ecosystems, and particularly in forests, are only now being recognized (Vitousek, in press) and include physical displacement of other species, competition for sunlight and moisture, competition for nutrients, interference with nutrient cycling and shading out or smothering of regenerating native species. The full impact of introduced weeds on Hawaii's native forests has not been fully studied, but it is estimated that if their invasion remains unchecked, our native forests and their complex of associated animals could be extinct within 50 to 100 years.

Invading plants can be controlled by conventional methods including grazing, herbicides, and mechanical weeding (Smith 1990). All these methods have been tried, but all were found to be expensive, often as destructive to the native forest as the weeds to be controlled, and at best, suitable for only limited areas. It was obvious that a new approach to forest weed management was necessary and in 1980 an interagency cooperative program between the State of Hawaii's Department of Land and Natural Resources, the Hawaii Department of Agriculture, the University of Hawaii, the USDA Forest Service, and the USDI National Park Service was established to attempt the use of biological control as a means to control forest weeds in Hawaii.

Biological control is based on the observation that plants, when introduced by humans to a new area, have often escaped from the constraining influence of the complex of natural enemies with which they evolved in their natural homeland (DeBach 1964). Biological control, therefore, is simply an effort to locate the original homeland of a weed, identify its natural enemies (usually insects or plant pathogens) and import and introduce these enemies into the new area, where they can once again attack their original host.

In Hawaii biological control has been tried against more than 20 species of agricultural weeds (Funasaki and others 1988), mostly found in pasture lands, and has been successful in more than half the attempts (Markin and others, in press). On a worldwide basis, this approach has been tried on more than 75 different weeds with about the same ratio of success (Julien 1987).

Exploratory work to study the weeds in their original homeland to identify their natural enemies began in 1982. An insect quarantine facility, which is the key to our insect biological control program, was constructed at Hawaii Volcanoes National Park in 1984, and the first shipment of insects from a foreign country was received in December of that year. More than 20 weeds have been identified as problems in our National Forests (Gardner and Davis 1982), and 12 cause problems serious enough to justify immediate control efforts (Smith 1990). Biological control programs are active against six of these.

[1]An abbreviated version of this paper was presented at the Session on Tropical Forestry for People of the Pacific, XVII Pacific Science Congress, May 27-28, 1991, Honolulu, Hawaii.

[2]Research Entomologist and Forestry Technician, respectively, Pacific Southwest Research Station, USDA Forest Service, Hilo, HI 96720; Plant Pathologist, USDI National Park Service, Honolulu, HI 96822.

Progress to Date

Clidemia hirta (Melastomataceae) (Clidemia)

Clidemia, or Koster's curse, is a native of low-elevation lands of the northern parts of South America. It was introduced into Hawaii probably as an ornamental plant for its veined and attractive leaves (Wester and Wood 1977). Near sea level in Hawaii, it has invaded moist areas on all major islands except Lanai. Once established, it forms dense stands 1 to 2 m high that exclude all native and most other introduced plants. Clidemia also at one time was a major problem in grazing lands in Hawaii, but programs in the 1950's introduced two insects that eliminated it in open areas (Nakahara and others, in press). Unfortunately, the insects were not effective in shade, particularly where clidemia grows as an understory in the forests. A new program has resulted in the release of a disease agent, the fungus *Colletotrichum gloeosporioides* (Trujillo and others 1988), in 1987, and the leaf mining beetle *Lius poseide*, in 1988, both of which are now well established. Many other insects have been discovered and tested in Trinidad (Nakahara and others, in press), but the expense and work necessary for releasing them is being postponed until the impact of the two new agents, in combination with the two earlier established agents, can be studied to determine whether they are capable of exerting sufficient control.

Passiflora mollissima (Passifloraceae) (Banana Poka)

Locally known as banana poka or banana passion fruit because of its elongated yellow fruit, this weed is a domestic plant grown throughout the Andes of South America. Introduced to Hawaii around 1900, it soon escaped from cultivation and found the higher-elevation (1,000 m and above) native forests of Hawaii a perfect habitat (La Rosa 1983). It is now established on three of the Hawaiian islands, where it infests 40,000 ha and is still spreading (Warshauer and others 1983). In areas where it is well established, banana poka forms mats of vegetation that can cover native trees and breaks them with their weight, or increases their chance of blowdown during storms. On the ground these mats of vegetation smother shrubs, seedlings, and even small trees. Where banana poka is well established, regeneration of Hawaii's native forests has ceased to occur (Markin and Nagata 1989).

Exploration in South America to find natural enemies of banana poka began in 1982 and although many potential biological control agents are now known (Pemberton 1989), the inaccessibility and political instability of most of the countries of the Andes make it difficult to conduct the necessary studies of this plant in its native homeland. To date, only two insects have been released. An attractive blue moth *Cyanotricha necyria* (Lepidoptera: Dioptidae), the larvae of which feed on the leaves, was released in 1988 (Markin and others 1989). A second moth, *Pyrausta perelegans* (Lepidoptera: Pyralidae), the larvae of which attack the flower buds, was released in February 1991. We hope that once *P. perelegans* is established, destruction of flower buds will reduce fruit set and slow the further spread of this weed. Four other insects are presently in quarantine undergoing evaluation, and under a new cooperative program, entomologists in Venezuela are searching for additional species. Two plant pathogens, a vascular wilt fungus *(Fusarium oxysporum)* and a powdery mildew *(Acrosporium* sp.), are also being studied. The powdery mildew has been approved for use in Hawaii, but has not actually been released in the field.

Ulex europaeus (Leguminosae) (Gorse)

Gorse is a spiny, dense-growing shrub native to western Europe that was extensively used for hedges to contain livestock before the development of barbed wire. As a beneficial plant, it was exported to many parts of the world by European settlers, but it soon escaped from cultivation (Markin and Yoshioka 1989). Around the Pacific, gorse is a problem in Australia, New Zealand, Chile, northwestern United States, as well as in Hawaii. In Hawaii, gorse is established on only two islands, usually at elevations between 1,000 and 2,000 m. It currently infests only 14,000 ha, but despite extensive efforts to contain, or eradicate it, it continues to spread (Markin and others 1988).

In recognition of gorse's role as a rangeland pest, Hawaii has had a long-standing program to find and introduce biological control agents for the weed, although the earlier programs succeeded in establishing only the seed weevil *Apion ulicis* (Coleoptera: Curculionidae) (Markin and Yoshioka 1989).

Gorse, also a forest weed, is capable of invading open forest lands, where it competes with native species, interferes with forest access and management, and competes with seedlings planted for reforestation. Because gorse is primarily a rangeland weed, the present program is still headed by the Hawaii Department of Agriculture, but receives assistance from our forest weed biological control program, as well as from cooperators in Chile, New Zealand, and Oregon. The present program has evaluated more than 10 species of insects, mainly from England and Portugal, and in 1989 released the foliage feeding moth *Agonopterix ulicetella* (Lepidoptera: Oecophoridae). This insect is now well established with an expanding population. In 1990 we also released a gall-forming weevil *(Apion scutellare* (Coleoptera: Apionidae)), and this summer we will begin releasing a small foliage feeding thrips *(Sericothrips staphylinus* (Thysanoptera: Thripoidae)). Our cooperators in New Zealand have also successfully established a gregarious web-forming mite, *Tetranychus lintearius* (Acaria: Tetranychidae), that is already killing gorse plants at some locations. We hope to introduce this mite along with several other insects still in quarantine within the next few years.

Because of the support of the agricultural community in Hawaii, cooperation from several foreign countries, and the ease of working with a plant from Europe, the gorse program is our most advanced, and we tentatively plan to discontinue the search for and testing of new insects by 1993. At that time we hope to have established a complex of at least five species of arthropods, each attacking a different part of the plant. We will then enter a phase of redistribution and monitoring for a 5- to 10-year period to allow the populations to expand and determine their impact before we decide whether further releases are necessary.

Myrica faya (Myricaceae) (Firetree)

Firetree is native to the Azores, Madeira, and Canary Islands of the eastern Atlantic and was probably introduced by Portuguese settlers from the Azores Islands who were brought to Hawaii in the 1880's as sugar cane workers. The plant readily found a new home in Hawaii and has now spread over 35,000 ha on five islands (Whiteaker and Gardner 1985). In stands of native vegetation, particularly those on new soils, lava flows or cinder fields, firetree's association with nitrogen-fixing actinomycetes in root nodules and the distribution of its seeds by birds allow this tree to rapidly outgrow and outcompete most native species (Vitousek and others 1987).

A new program was initiated against firetree in 1984. Several visits to its original islands have shown an abundance of native enemies (Hodges and Gardner 1985, Gardner and others 1988) and resulted in a cooperative program with entomologists at the University of the Azores to study them. To date, three plant pathogens have been found, two of which are undergoing testing at the USDA-ARS Plant Disease Research Laboratory, Ft. Detrick, Frederick, Maryland. The fungi are species of *Nectria* and *Cryphonectria,* which cause bark cankers in stems and branches and have the potential to kill cambial tissue and girdle the tree.

The work on insects has progressed further than that on pathogens, and the first agent was just approved for release in Hawaii. The small moth, *Phyllonorycter myricae* (Lepidoptera: Graciliaraceae), has larvae which feed in a shelter formed by rolling the tip of the leaf. Several other insects are presently being tested in quarantine in Hawaii or are being studied by cooperators in the Azores.

Rubus argutus (Rosaceae) (Blackberry)

This blackberry was introduced into Hawaii for its edible fruit, but was quickly spread by birds into the forests where, like gorse, it forms spiny, impenetrable canebrakes that replace native vegetation and interfere with forest access and management. Blackberry was originally also a pest of pasture lands, but the establishment of three insects in the 1960's resulted in its effective control in open areas. The three insects also attack it in the forest (Nagata and Markin 1986), but their impact is generally insufficient to reduce the plant to acceptable levels. Rather than introducing additional insect species that might compete with the existing complex, the present program is focusing on plant pathogens. A European rust fungus *(Phragmidium violaceum)* was introduced to Chile (Oehrens and Gonzales 1974) and later to Australia (Bruzzese and Field 1984), where it successfully attacked and suppressed related introduced species of blackberries. This pathogen was recently tested against *Rubus argutus* in a cooperative program in Chile; unfortunately, it was found incapable of attacking this blackberry species. Present efforts are continuing on finding pathogens in North America, and tests are under way on the rust *Gymnoconia nitens* in North Carolina, one of the areas that may be the original home of this particular blackberry.

Psidium cattleianum (Myrtaceae) (Strawberry Guava)

Strawberry guava is another South American plant introduced to Hawaii probably for its small, flavorful fruit (Neal 1965). It has been spread widely by birds on all of the Hawaiian islands, particularly at an elevation between 500 and 1,000 m. It is capable of becoming established in the densest forests but does best in disturbed areas where it often forms dense stands containing 50 stems per square meter.

Strawberry guava is the newest weed to be considered for biological control as part of our forest weed program. We have conducted surveys for it in South America to locate its origin, which apparently is in southern Brazil, and have a cooperative agreement with a university in Curitiba, Brazil, to survey its associated insects and diseases. It will be several years before the most promising agents have been identified, studied, and are ready for shipment to quarantine in Hawaii for further testing. Strawberry guava *(P. cattleianum)* is very closely related to the commercial guava *(P. guajava)* which is an important crop in Hawaii and is grown on approximately 400 ha, primarily for juice (Anonymous 1985). Finding an insect or pathogen that will attack only the strawberry guava and not the commercial guava will probably be difficult.

Additional Weeds Targeted for Biological Control

Rubus ellipticus (Rosaceae) (Himalayan Raspberry)

Himalayan raspberry is a native of Asia and is believed to have been introduced to Hawaii sometime in the 1950's in the area of Volcano Village on the island of Hawaii (Neal 1965). Birds feeding on its small yellow fruit have now spread it to up to 30 miles from its original site of introduction. This weed is particularly dangerous because of its ability to become established in undisturbed native forests, whereas many of our weeds at least need disturbances such as pig rooting, roads, blowdowns, or fires to get their initial foothold.

Tibouchina spp. (Melastomataceae) (Glory Bush)

Glory bush is another South American plant introduced probably as an ornamental for its attractive dark blue flowers. For many years it was thought to be only an incidental introduced plant that had become feral because it was confined to only a few small and limited areas. Recent surveys, however, indicate that for some unknown reason it has begun to expand its range and now threatens a major watershed and one of our national parks.

Pennisetum setaceum (Gramineae) (Fountain Grass)

Fountain grass is a native of North Africa, and its bushy and attractive seed heads indicate it was brought to Hawaii probably as another ornamental. The plant is unpalatable to cattle and is a pest of grazing land, so a program for its control is high on the wish list of Hawaii's ranching industry. Fountain grass also creates an extreme fire danger; wildfires carried

by this grass have recently destroyed hundreds of hectares of dryland native ecosystems and forests (Tunison, in press). Biological control has never been tried against any species of grass because of the potential danger that an introduced agent might also attack some related agriculturally important species (Pemberton 1980). The experience and techniques developed in biological control over the past 90 years have now reached the level that crossover by an introduced agent from its target weed to another plant is no longer a danger. Fountain grass would be an ideal species on which to attempt the first effort at biological control of a grass species.

Conclusions

Our program in Hawaii, we believe, is the first to attempt specifically to control introduced weeds of forests and other native ecosystems using biological control, although a similar program is currently under development for the Everglades of Florida. Although our program is only 10 years old, we already have released six agents and are ready to release four more. Several of the released agents are well established, increasing in numbers, and spreading through the range of their target weeds. It is still too early to tell which of these agents will be successful, since establishment and population buildup to sufficient levels to damage the plant usually require 5 to 10 years or more. On the basis of the success of earlier programs against agricultural weeds in Hawaii, we are confident that most of our programs will eventually be successful.

Our experience in Hawaii has shown us that biological control has several disadvantages. It is neither fast, nor cheap, and occasionally conflicts of interest arise with groups opposed to such a program, because to them the target weed may be beneficial (Markin 1989, Markin and Yoshioka, in press). However, we have also learned that in many instances biological control is the only tool available to us for managing weeds in forest ecosystems and when successful will give a permanent solution.

As we have watched our program progress and now see insects and pathogens that we introduced attack the weeds, we believe the program is showing the first sign of success and that biological control will eventually become a key method for weed management in forest areas and other natural ecosystems here in Hawaii and probably on other Pacific islands.

References

Anonymous. 1985. Statistics of Hawaiian agriculture 1984. Prepared by Hawaii Agricultural Representative Service, Honolulu, HI. 100 p.

Bruzzese, Eligio; Field, Ross P. 1984. Occurrence and spread of *Phragmidium violaceum* on blackberry *(Rubus fruticosus)* in Victoria, Australia. In: Delfosse, E. S., ed. Proceedings of the VI International Symposium on Biological Control of Weeds, 19-25 August 1984, Vancouver, Canada. Agric. Can.; 609-612.

Carlquist, S. 1980. Hawaii: a natural history. Lihue, Kauai, Hawaii. Pacific Tropical Botanical Garden.

DeBach, Paul Ed. 1964. Biological control of insects pests and weeds. New York: Reinhold Publishing Corp; 844 p.

Funasaki, George Y.; Lai, Po-Yung; Nakahara, Larry M.; Beardsley, John W.; Ota, Aster K. 1988. A review of biological control introductions in Hawaii: 1890 to 1985. Proceedings of the Hawaiian Entomological Society 28: 105-160.

Gardner, Donald E.; Davis, Clifton J. 1982. The prospects for biological control of nonnative plants in Hawaiian National Parks. Technical Report 45, Honolulu, Hawaii. Cooperative National Park Studies Unit, Dep. of Botany, Univ. of Hawaii at Manoa; 55 p.

Gardner, Donald E.; Markin, George P.; Hodges, Charles S., Jr. 1988. Survey for potential biological control agents for *Myrica faya* in the Azores and Madeira. Technical Report 63. Honolulu, Hawaii. Cooperative National Park Studies Unit, Dep. of Botany, Univ. of Hawaii at Manoa;

Hodges, Charles S., Jr.; Gardner, Donald E. 1985. *Myrica faya:* Potential biological control agents. Technical Report 54. Honolulu, Hawaii. Cooperative National Park Studies Unit, Dep. of Botany, Univ. of Hawaii at Manoa; 42 p.

Julien, M. H. 1987. Biological control of weeds, a world catalogue of agents and their target weeds. 2nd ed. Wallingford, UK: CAB International; 145 p.

La Rosa, Anne M. 1983. The biology and ecology of *Passiflora mollissima* in Hawaii. Technical Report 50. Honolulu, Hawaii. Cooperative National Park Studies Unit, Dep. of Botany, Univ. of Hawaii at Manoa; 168 p.

Markin, George P. 1989. Alien plant management by biological control. In: Stone, Charles P.; Stone, Danielle B., eds. Honolulu, Hawaii. Conservation biology in Hawai'i, Stone, Univ. Hawaii Press, Univ. Hawaii Cooperative National Park Resources Studies Unit; 70-73.

Markin, George P.; Dekker, Laurel A.; Lapp, Joyce A.; Nagata, Roddy F. 1988. Distribution of the weed gorse *(Ulex europaeus* L.) in Hawaii. Bulletin of the Hawaiian Botanical Society 27:110-117.

Markin, George P.; Nagata, Roddy F. 1989. Host preference of *Cyanotricha necyria* Felder (Lepidoptera: Dioptidae), a potential biocontrol agent of the weed, *Passiflora mollissima* (H.B.K.) Bailey in Hawai'i forests. Technical Report 67. Honolulu, Hawaii. Cooperative National Park Resources Studies Unit, Univ. of Hawaii at Manoa; 35 p.

Markin, George P.; Nagata, Roddy F.; Taniguchi, Glenn. 1989. Biological and behavior of the South American moth, *Cyanotricha necyria* Felder (Lepidoptera: Dioptidae), a potential biocontrol agent in Hawaii of the forest weed, *Passiflora mollissima* (HBK) Bailey. Proceedings of the Hawaiian Entomological Society 29:115-123.

Markin, George P.; Yoshioka, Ernert R. 1989. Present status of biological control of the weed gorse *(Ulex europaeus* L.) in Hawaii. In: Delfosse, E. S., ed. Proceedings of the VII International Symposium of Biological Control of Weeds, Rome, Italy. Instituto Seprimentale per la Patologia Vegetale Ministero dell'Agrocoltura e delle Foreste; 357-362.

Markin, George P.; Yoshioka, Ernest R. Evaluating proposed biological control programs for introduced plants. In: Stone, C.P.; Smith, C. W.; Tunison, J. T., eds. Alien plant invasions in native ecosystems of Hawai'i: management and research. Honolulu, Hawaii. Univ. Hawaii Cooperative National Park Resources Studies Unit [In press].

Markin, George P.; Lai, Po-Yung; Funasaki, George Y. Status of biological control of weeds in Hawaii and implications for managing native ecosystems. In: Stone, C.P.; Smith, C. W.; Tunison, J. T., eds. Alien plant invasions in native ecosystems of Hawai'i: management and research. Honolulu, Hawaii. Univ. Hawaii Cooperative National Park Resources Studies Unit [In press].

Nagata, Roddy F.; Markin, George P. 1986. Status of insects introduced into Hawai'i for the biological control of the wild blackberry *Rubus argutus* Link. Proceedings of the Sixth Conference of Natural Science, Hawaii Volcanoes National Park; 541-547.

Nakahara, Larry M.; Burkhart, Robert M.; Funasaki, George Y. Review and status of insects for biological control of *Clidemia hirta* in Hawaii. In: Stone, C.P.; Smith, C. W.; Tunison, J. T., eds. Alien plant invasions in native ecosystems of Hawai'i: management and research. Honolulu, Hawaii. Univ. Hawaii Cooperative National Park Resources Studies Unit [In press].

Neal, Marie C. 1965. In gardens of Hawaii. Bernice P. Bishop Museum, Special Pub. 50. Honolulu, Hawaii. Bishop Museum Press; 924 p.

Oehrens, Edgardo; Gonzales, Susana. 1974. Introduccion de *Phragmidium violaceum* (Schultz) Winter como factor de control biologico de zarzamora *(Rubus constrictus* Lef. et M. y. *R. ulmifolius* Schott.). Agro. Sur.; 2:30-33.

Pemberton, Robert W. 1989. Insects attacking *Passiflora mollissima* and other *Passiflora* species; field survey in the Andes. Proceedings of the Hawaiian Entomological Society 29:71-84.

Pemberton, Robert W. 1980. International activity in biological control of weeds: patterns, limitations and needs. Proceedings of the V. International Symposium of Biological Control of Weeds, Brisbane, Australia; Commonwealth Scientific and Industrial Research Organization, Australia; 57-71.

Smith, Clifford W. 1990. Weed management in Hawaii's National Parks. Monogram, Systemic Botany, Missouri Botanical Gardens 32:223-234.

Trujillo, Eduardo E.; Latterell, F.M.; Rossi, A. E.. 1988. *Colletotrichum gloeosporioides*, a possible biological control agent for *Clidemia hirta* in Hawaiian forests. Plant Disease 70:974-976.

Tunison, J. T. Fountain grass *(Pennisetum setaceum)* control in Hawai'i Volcanoes National Park: effort, economics, and feasibility. In: Stone, C.P.; Smith, C. W.; Tunison, J. T., eds. Alien plant invasions in native ecosystems of Hawai'i: management and research. Honolulu, Hawaii. Univ. Hawaii Cooperative National Park Resources Studies Unit [In press].

Vitousek, Peter M. Effect of alien plants on native ecosystems. In: Stone, C.P.; Smith, C. W.; Tunison, J. T., eds. Alien plant invasions in native ecosystems of Hawai'i: management and research. Honolulu, Hawaii. Univ. Hawaii Cooperative National Park Resources Studies Unit [In press].

Vitousek, Peter M.; Walker, Lawrence R.; Whiteaker, Louis D.; Mueller-Dombois, Dieter; Matson, Pamela A. 1987. Biological invasion by *Myrica faya* alters ecosystem development in Hawaii. Science 238:802-804.

Warshauer, Frederick R.; Jacobi, James D.; La Rosa, Anne M.; Scott, J. Michael; Smith, Clifford W. 1983. The distribution, impact and potential management of the introduced vine, *Passiflora mollissima* (Passifloraceae) in Hawaii. Technical Report 48. Honolulu, Hawaii: Cooperative National Park Resources Studies Unit, Dep. of Botany, Univ. of Hawaii at Manoa; 39 p.

Wester, L. L.; Wood, Hulton B. 1977. Koster's curse *(Clidemia hirta)*, a weed pest in Hawaiian forests. Environmental Conservation 4:35-41.

Whiteaker, Louis D.; Gardner, Donald E. 1985. The distribution of *Myrica faya* Ait. in the state of Hawai'i. Technical Report 55. Honolulu, Hawaii: Cooperative National Park Resources Studies Unit, Dept. of Botany, Univ. of Hawaii at Manoa; 36 p.

United States
Department
of Agriculture

**Pacific Southwest
Research Station**

General
Technical Report
PSW–GTR–129

Proceedings of the Session on Tropical Forestry for People of the Pacific, XVII Pacific Science Congress, May 27–28, 1991, Honolulu, Hawaii