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Plant Pest Control in Hawai‘i

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Abstract—About 15-20 new insects become established in Hawai‘i each year, of which one or two become serious pests. The Hawai‘i Department of Agriculture uses four primary strategies based on three methods to control alien plant pests (i.e., pathogens, weeds, mollusks, insects, and other invertebrates). Chemical and mechanical control methods have been used in eradication strategies against incipient pests with limited success. Both methods have also been used with some degree of success in containment strategies against localized pests to slow down their spread or to gain time for development of other solutions. Biological control has been the most successful method applied in Hawai‘i to control pests throughout the State. Integrated control strategies, utilizing all three methods, have also been successful in protecting specific crops while promoting the biological control method. Examples of each strategy are provided.

Introduction

Many alien species find refuge in the Hawaiian Islands because of Hawai‘i’s mild climate, a wide variety of plants introduced from many parts of the world, many climatic habitats from sea level to 4,205 meters in elevation, and the absence of natural enemies of new introductions. Beardsley (1979) believed that there are many unexploited or underexploited ecological niches in Hawai‘i, particularly within man-altered urban, suburban, agricultural, and disturbed (exotic) forest ecosystems, and that throughout the tropics and subtropics, there exists a vast array of insects and related arthropods that have the potential to exploit these niches if and when man provides the opportunity for them to do so. Alien species enter the Hawaiian Islands on or in plants and produce, or as hitch-hikers on aircraft, ships, and cargo. Hawai‘i is vulnerable to alien invasions because it is an island community that is dependent on the importation of food and goods, and is subject to heavy international and domestic traffic from its primary industry, tourism.

Beardsley (1962) calculated that the average rate of accidental introduction and establishment of alien terrestrial arthropods in Hawai‘i from 1937 to 1961 was 16 species per year. Later, after reviewing establishment records from 1962 to 1976, he determined that the number had increased slightly to 19 species per year (Beardsley 1979). His review of the seven years from 1970 to 1976 showed that the number had increased to 22.6 new alien species per year. It is unclear what the present rate of introduction and establishment of alien species is today. Air and sea traffic to Hawai‘i, quarantine inspections, and public education on alien species have increased since 1976, but efforts to find and report newly established alien species have been on the decline in recent years due to shrinking resources for this activity. Today, about 15-20 new alien molluscs, insects, and related arthropods are reported in Hawai‘i each year (unpublished data). Alien species arrive in Hawai‘i from both domestic and international sources. A review of the possible origin of new pests found in 1985 showed that 24% probably originated from the continental United States, 24% from Southeast Asia, 16% from the Southwest Pacific, 16% from Tropical America, and 20% from other areas (Anon. 1985). Noteworthy was the 16% from Tropical America since there were no direct flights or shipping from this area. Since some of the insects from Tropical America were those that required a plant host for survival, it was believed that these pests had entered Hawai‘i on infested plants that transited through the continental U.S.

Not all alien species become pests in Hawai‘i. In a review of those that became established in Hawai‘i from 1977 to 1986, 57% were considered pests (Anon. 1986). Seven percent (1-2 species) were considered serious pests, 44% were moderate to minor pests, and 6% were pests because they were predators, parasites, or hyperparasites of beneficial organisms. Another 11% were general predators or parasites, while 32% were of unknown importance.

Plant Pest Control Strategies

In order to focus on the more serious pests, the Plant Pest Control (PPC) Branch of the Hawai‘i Department of Agriculture periodically updates priority lists of noxious weeds, insects and other invertebrates, and plant pathogens and nematodes (Tables 1-3). The priority lists are not limited to pests of agriculture, as they include forest weeds as well as nuisance pests. Pests are first ranked by their importance in each of the four counties in the state. Each county is weighted equally to provide a state-wide priority list of problem pests. Since noxious weeds are, by legal definition, pests that are not widely distributed in the islands, the priority list of noxious weeds usually targets pests for eradication or containment.

Four strategies are used to control pests in Hawai‘i. Eradication is often desired by many because it fulfills the need to do something quickly with the expectation of definitive results. Containment is used to prevent the pest from moving to other islands, or to slow down its spread until other control measures can be developed. Biological control is used on pests that are, or have the potential of becoming, widespread and are too costly to control by other means. Integrated control has been used to allow introduced biocontrol agents to become established and to control the pest in otherwise inhospitable crop environments.

Table 1. Priority list of noxious weeds found in Hawai‘i (by islands).

Priority Noxious Weeds	Hawai‘i	Maui	Molokai	Lanai	O‘ahu	Kauai
1. *Pennisetum setaceum* (Forssk.) Chiov. (fountaingrass)	W	I*	I	I	I	I
2. *Miconia calvescens* DC (miconia)	W	I	—	—	I	I
3. *Coccinia grandis* (L.) Voigt (ivy gourd)	I	I	—	—	W	I
4. *Senecio madagascariensis* Poiret (fireweed)	W	I	—	—	—	I
5. *Melastoma septemnervium* Lour. (Indian rhododendron)	W	—	—	—	I	W
6. *Prosopis juliflora* (Sw.) DC (thorny kiawe)	—	—	—	—	I	I**
7. *Myrica faya* Aiton (firebush)	W	W	—	W	I	W
8. *Andropogon virginicus* L. (broomsedge)	W	W	W	W	W	—
9. *Ulex europaeus* L. (gorse)	W	W	—	—	—	—
10. *Passiflora mollissima* (Kunth) L.H. Bailey (banana poka)	W	I	—	—	—	W
11. E*lephantopus mollis* Kunth (elephantfoot)	I	I	I	—	I	I
12. *Acacia mearnsii* De Wild. (black wattle)	I	W	—	W	I	I
13. R*hodomyrtus tomentosa* (Aiton) Hassk. (downy rosemyrtle)	W	I	I	I	I	I
14. *Solanum torvum* Sw. (turkeyberry)	—	W	—	—	W	—
15. *Clidemia hirta* (L.) D. Don (clidemia)	W	I	I	—	W	W

— Not known to occur.
I Incipient populations.
W Widespread occurrence.

* also on Kahoolawe
** also on Niihau

Eradication

Between 1959 and 2001, the PPC Branch conducted 56 eradication projects against 28 pests, including 13 weeds, 10 insects, 2 snails, 2 plant diseases, and a vertebrate animal, a black-tailed prairie dog (Table 4). If “success” is defined as the elimination of the target species while fulfilling the intent of the eradication, 18% or 10 projects can be considered a success. By this measure, the 1963 eradication of the giant African snail from Hakalau is considered a success even though the pest is established on the island of Hawai‘i due to other infestations. Conversely, the 1997-1998 eradication of banana bunchytop virus (BBTV) from the island of Kauai is not considered a success because new infestations of the virus can be linked to the original infestation even though the treatment area is

Table 2. Priority list of insects and other invertebrate pests found in Hawai‘i. *

Priority	Scientific Name	Common Name
1.	*Coptotermes formosanus* Shiraki and	Formosan subterranean termite
	Cryptotermes brevis (Walker)	West Indian dry wood termite
2.	*Bactrocera cucurbitae* (Coquillett)	melon fly
	Bactrocera dorsalis (Hendel)	Oriental fruit fly
3.	*Pentalonia nigronervosa* Coquerel	banana aphid
4.	*Frankliniella occidentalis* (Pergande)	western flower thrips
5.	*Myzus persicae* (Sulzer)	green peach aphid
	Aphis gossypii Glover	melon aphid
6.	*Trialeurodes vaporariorum* (Westwood)	greenhouse whitefly
7.	*Plutella xylostella* (Linnaeus)	diamondback moth
8.	*Aleurocanthus woglumi* Ashby	citrus blackfly
9.	*Thrips palmi* Karny	melon thrips
10.	*Coccus viridis* (Green)	green scale
11.	*Tetranychus urticae* Koch	two spotted spider mite
12.	*Veronicella cubensis* (Pfeiffer)	two-striped slug
	Vaginulus plebius Fischer	brown slug
13.	*Helicoverpa zea* (Boddie)	corn earworm
14.	*Pomacea canaliculata* (Lamark)	golden apple snail
15.	*Wasmannia auropunctata* (Roger)	little fire ant

* Mosquitoes and other vectors of human diseases are controlled by the Hawai‘i Department of Health and are not included on this list.

free of the virus. The nine successful projects included three on the giant African snail, *Achatina fulica* Bowdich (Molusca: Acatinidae) (subsequent establishments of this species on Hawai‘i and Kauai were due to re-infestations in other parts of both islands); three on papaya ringspot virus or PRV (Kauai still remains free of the

Table 3. Priority list of plant pathogens and nematodes found in Hawai‘i.

Priority	Name of Pathogens and Nematodes
1.	banana bunchytop virus
2.	papaya ringspot virus
3.	burrowing nematode, *Rodopholus similis* and reniform nematode, *Rotylenchulus reniformis*
4.	taro leaf blight fungus, *Phytophthora colocasia*
5.	ginger wilt bacterium, *Ralstonia solanacearum*
6.	Panama wilt fungus of banana, *Fusarium oxysporum* f. sp. *cubense*
7.	coconut heart rot fungus, *Phytophthora* sp.
8.	pineapple mealybug wilt virus
9.	powdery mildew caused by various fungi
10.	tomato spotted wilt virus
11.	citrus tristeza virus
12.	soybean rust fungus, *Phakopsora pachyrhizi*
13.	anthurium blight bacteria, *Xanthomonas campestris* pv. *dieffenbachiae*
14.	cymbidium mosaic virus
15.	*Odontoglossum* ringspot virus

Table 4. Eradication projects carried out by the Plant Pest Control Branch from 1959-2001.

Status	Number	Per Cent
Successful Projects *	9	16
Monitoring Continues	5	9
Eradication Continues	2	3
Failed Projects	4	7
Evolved to Containment	25	45
Evolved to Biocontrol	11	20
Total	56	100

* Only 1 project (2%) successful in eradicating pests from the State; 3 projects (5%) successful in eradicating pests from an island.

disease); two on fountaingrass, *Pennisetum setaceum* (Forssk.) Chiov. (Poaceae) (both were of first generation seedlings on Kauai and Maui); and one on the tumeric scale, *Aspidiella hartii* (Cockerell) (Homoptera: Diaspididae) infestations were confined to a 1/4 acre commercial planting on Hawai'i). In most cases, the pests were limited in distribution at the time of the eradication and are considered eradicated because they had not been detected in the area for several generations following eradication. A single colony of 3-12 black-tailed prairie dogs, *Cynomys ludovicianus* (Rodentia: Sciuridae) was also eliminated from Waikapu, Kauai, but due to reasons other than the eradication effort (Anon. 1981). Two live animals were captured near the treatment area after the eradication attempt.

There are other ways of defining a successful eradication. If "success" were to be defined as the total elimination of the pest from the entire Hawaiian Islands, only the turmeric scale project would meet that criterion, a success rate of only 2%. If total elimination from one or more islands were to be used as the basis, however, the eradication of PRV from Maui and Kauai would increase that success rate to 5%, or 3 of 56 projects. In contrast, 56%, or 36 eradication projects, eventually evolved into ongoing containment projects or have resulted in successful biological control projects.

Decisions to eradicate must be carefully weighed because of the commitment of often large resources. The discovery of BBTV on Kauai in April 2000 illustrates how a decision was made *not* to initiate an eradication project. Early reports of BBTV indicated that the disease was confined to a couple of farms and several surrounding backyard plantings of banana in Kapahi, near Kapaa. After several weeks of surveys, it was concluded that the earlier eradication of BBTV from Kilauea in 1997-1998 had not been successful and that the disease had spread in the Kilauea and Kapaa areas. By comparing information from the Kilauea eradication with information from the new surveys, it was determined that the perimeter of the original Kilauea infestation had been at least three times the distance from the furthest known infestations when the project was initiated. The eradication had failed because the perimeter of the eradication zone was drawn at only twice the distance from the furthest known infestations to take into account infected plants that were not showing visible symptoms at the time. Based on this new information, an eradication zone of 65,000 ha, covering half the island of Kauai, was drawn to represent the natural movement of the banana aphid vector, *Pentalonia nigronervosa* Coquerel (Homoptera: Aphididae). Knowing that the BBTV had been on Kauai for almost four years strongly suggested that diseased plants could also have been moved to other locations on the island by individuals moving planting materials. This information was evaluated with the economic viability of bananas on Kauai in mind, and an eradication was not initiated. Two months later, the BBTV was found on the southern boundary of the proposed eradication zone.

On the island of Hawaiʻi, the Kona BBTV Eradication Project was completed on March 30, 2001. The intent was to eradicate the virus from Kona in West Hawaiʻi to prevent its spread to the major banana production area in East Hawaiʻi. BBTV was first found in Kona in 1995. After several years of roguing only diseased banana plants followed by roguing diseased plants and those within a 40-meter radius, an eradication project was initiated in January 1999. All *Musa* species (Musaceae), including edible and ornamental banana plants, were destroyed in the designated eradication zone composed of 2,600 ha of small farms and residences. The 27-month project required manpower and funding support from several agencies. Over 5,500 property owners had to be notified for the eradication crew to enter property and get permission to destroy their banana plants by injection with glyphosate (Roundup Ultra®). Court Orders were needed to allow crew members to enter and destroy banana plants on 23 properties. Banana plants in adjacent communities are being monitored to determine if the BBTV has been successfully eradicated from Kona.

Containment

Containment strategies have primarily been used against weeds because weeds tend to disperse more slowly and are often more difficult to control biologically. Herbicides or physically removing weedy plants are usually the methods of choice for controlling fountaingrass, *P. setaceum.* While it is well-established in West Hawaiʻi, attempts are being made to contain its spread on the island of Oʻahu and other islands. A designated state noxious weed, fountaingrass encroaches on pasture areas and native dry-land forests and shrub lands. Cattle do not eat the fountaingrass, and it provides fuel for fire during dry periods. Roadside fountaingrass or that found along airport runways is treated with herbicides, while seed heads are removed and plants are grubbed from residential or other sensitive areas to prevent their spread.

Thorny kiawe, *Prosopis juliflora* (Swartz) DC (Fabaceae) is a priority state noxious weed in Hawaiʻi. It was described as a pest in the 1970s. It produces two-inch-long spines on its branches, much longer than those of the established common kiawe, *P. pallida*, (Humb. and Bonpl. ex Willd.) Kunth (Fabaceae) the needles of which are 1/2 inch long. It is found along coastal areas of West Oʻahu and West Kauai. Efforts are being made to document its spread since the 1970s and to coordinate military, government and community efforts to control this pest with herbicides and by removing trees.

Chemical or mechanical measures are rarely used to contain insect pests because most insects spread very rapidly in the islands. The little fire ant, *Wasmannia auropunctata* (Roger) (Hymenoptera: Formicidae), is an exception. This tiny (< 2 mm), pale orange ant has a powerful sting that leaves welts on people who are sensitive or allergic (Heu et al. 1999). It is otherwise innocuous and disperses slowly on its own . While it is attracted to peanut butter bait sticks, it is difficult to survey for in large areas because it does not forage very far from its colony nor does it produce any visible signs that would be useful in surveys, such as dirt mounds or erratic behavior. Almost all infestations are known from reports by those who have been stung in the past or by tracing infested potted plants back to sellers. The little fire ant is currently known from several localities in East Hawaiʻi, and new colonies are treated with Amdro® bait-toxicant in non-food crop situations to slow their spread on the island as biocontrol is being explored. No eradication project was initiated against this pest primarily because of the PPC Branch's inability to detect new colonies, both for control purposes as well as to evaluate success or failure.

Biological Control

The use of classical biological control measures to reduce pest populations and reduce damages associated with the pest have been very effective in Hawaiʻi. The PPC Branch has used this as the primary means for controlling pests for over 100 years. Whenever a new pest is discovered in the islands, biocontrol is frequently reviewed as an option. Not all pests can or should be controlled using this method, however. In some cases, the biocontrol measure may be more problematic than the pest. Classical biocontrol is conducted in several phases: literature review, explorations, quarantine testing, technical review of data, approval for release by state and federal agencies, mass rearing and release, and evaluations. Several projects may be undertaken at any one time with each operating at a different phase from the others. In 2000, the department worked on the biocontrol of the yellow sugarcane aphid, *Sipha flava* (Forbes) (Homoptera: Aphididae); citrus blackfly, *Aleurocanthus woglumi* Ashby (Homoptera: Aleyrodidae); Koster's curse, *Clidemia hirta* (L.) (Melastomataceae); gorse, *Ulex europaeus* L. (Fabaceae); ivy gourd, *Coccinia grandis* (L.) Voigt (Cucurbitaceae); miconia, *Miconia calvescens* DC (Melastomataceae); and fireweed, *Senecio madagascariensis* Poiret (Asteraceae) (Anon. 2000). Three are highlighted.

The discovery of the citrus blackfly in 1996 prompted staff to search for biocontrol agents against this pest even before problems were evident on farms and backyard citrus (Heu & Nagamine 2000). Two parasitoids, *Encarsia opulenta*

(Silvestri) (Hymenoptera: Aphelinidae) and *Amitus hesperidum* Silvestri (Hymenoptera: Platygasteridae), were collected from Guatemala during explorations for biocontrol agents of another pest (Anon. 2000). Approvals for the release of both parasitoids from quarantine were received in March 1999, and by June 2000, citrus blackfly populations were becoming scarce on Oʻahu. Currently, parasitoids are being re-distributed from earlier release sites on Oʻahu and other islands to areas where citrus blackfly populations are just starting and parasitoids are still in low numbers.

Ivy gourd is a designated state noxious weed, the vines of which cover fences, trees, and telephone poles in coastal and lowland areas. The ivy gourd vine borer, *Mellitia oedipus* Oberthür (Lepidoptera: Sesiidae), was imported into quarantine in 1992 during explorations in Kenya, Africa (Chun 2001). It was released in 1996 after receiving state and federal approvals, and the first recovery of this moth was made in 1999 (Anon. 1999). Two weevils that had also been collected during explorations in Kenya were held in quarantine until they could be named. The ivy gourd gall weevil, *Acythopeus burkhartorum* O'Brien and Pakaluk (Coleoptera: Curculionidae), and the ivy gourd leafmining weevil, *A. cocciniae* O'Brien and Pakaluk (Coleoptera: Curculionidae), were approved for release from quarantine in 1999. All three biocontrol agents are being released in ivy gourd infestations throughout the State (Anon. 2000). The moth and the leaf mining weevil are well-established on Oʻahu and exerting control on this weedy plant. The gall former has been recovered in primarily shady areas on Oʻahu.

Miconia is an invasive plant that threatens to destroy native forests occupying and completely shading out the understory. In 1996, a fungal pathogen, *Colletotrichum gloesporiodes* f. sp. *miconiae* Killgore, Sugiyama, Barreto & Gardner, was received from Brazil for host-specificity testing (Anon. 1998). It was approved for release in 1997 and has been inoculated in miconia infestations on Hawaiʻi and Maui where it has caused some premature leaf drop. Studies and field releases are continuing in cooperation with the U.S. Forest Service and other agencies. Under a cooperative agreement with the Government of French Polynesia, it was also released in Tahiti.

Integrated Control

Sometimes, it is difficult to get a new biocontrol agent to become established in the field because its host (the pest) is under heavy insecticide pressure. This was the case when the PPC Branch tried to establish two parasitoids to control leafminers and a parasitoid to control the diamondback moth on lowland truck crops. An integrated control approach was needed to address all of the pests on the crop so that pesticides need not be used against the parasitoid's host.

After monitoring tremendous losses by leafminers to watermelon, green onion, tomato, string bean, and cucumber during 1976-1978, an extensive survey was conducted in 1979 on watermelon grown in Kahuku on Oʻahu. It was determined that heavy insecticide pressure not only kept leafminer parasitoids from building to control levels, but also caused the more insecticide resistant chrysanthemum leafminer, *Liriomyza trifolii* (Burgess) (Diptera: Agromyzidae), to gain dominance over the otherwise predominant vegetable leafminer, *L. sativae* Blanchard (Diptera: Agromyzidae) (unpublished data). Besides the leafminers, four other key pests were identified on watermelon: melon fly, *Bactrocera cucurbitae* (Coquillet) (Diptera: Tephritidae); melon aphid, *Aphis gossypii* Glovern (Homoptera: Aphididae); carmine spider mite, *Tetranychus cinnabarinus* (Boisduval) (Acari: Tetranychidae); and greenhouse whitefly, *Trialeurodes vaporariorum* (Westwood) (Homoptera: Aleyrodidae). In 1980-1981, the PPC Branch, university researchers and extension personnel, and the Kahuku farmers'association developed a demonstration project for growing watermelon without the use of any pesticides to control leafminers. Overhead irrigation was converted to drip irrigation so that plastic mulches could be used to reduce aphid migration into watermelon fields. Watermelon mosaic was controlled by roguing diseased plants rather than spraying for the aphids. Melon flies were controlled by spraying bait sprays on corn borders instead of directly on the crop. This protected the watermelon seedlings as well as the young fruits. Planting corn borders before planting the watermelon also allowed parasitoids of the corn leafminer, *Pseudonapomyza spicata* (Malloch) (Diptera: Agromyzidae), to become established in the planting. These parasitoids also attacked both *Liriomyza* species. Predators of the tumid spider mite, *Tetranychus tumidus* Banks (Acari: Tetranychidae), found on the corn, were known to prey on *T. cinnabarinus* on watermelon and existing parasitoids or chemical treatments were to control the greenhouse whitefly. However, both pests did not surface as problems. The project was a huge success as yields almost quadrupled. Kahuku farmers quickly adopted the techniques the following season because the project was conducted on farm land donated by one of the farmers where everyone was able to monitor the project's progress on a daily basis. Two parasites, *Chrysonotomyia punctiventris* (Crawford) (Hymenoptera: Eulophidae) and *Ganaspidium hunteri* Crawford (Hymenoptera: Eucoilidae), which had been released by the department in 1976-1977, kept both leafminers under excellent control, demonstrating the successful use of biocontrol agents to control pests on truck crops in Hawai‘i for the first time. The techniques developed for watermelon also carried over to other truck crops, resulting in a greater reliance on biocontrol agents soon thereafter in the 1980s.

In 1982, the diamondback moth, *Plutella xylostella* (L.) (Lepidoptera: Plutellidae), caused extensive damage to watercress on O‘ahu in spite of heavy applications of pesticides. At the time, the PPC Branch was also having problems getting the diamondback moth larval parasitoid, *Cotesia plutellae* Kurdjumov (Hymenoptera: Braconidae), established in lowland vegetable crops infested by the moth. To find a suitable site for releasing the parasitoid, this author agreed to monitor a farmer's overhead irrigation system for controlling the diamondback moth in exchange for the use of a watercress bed where no insecticides would be used and where the parasitoid would be released. The farmer had observed that diamondback moth damage was less on watercress being cooled by the overhead irrigation. The overhead irrigation was effective in controlling the moth in the 3.84-ha commercial watercress farm at Aiea by disrupting the mating and ovipositional activities of the moth once the sprinklers were left on in the evening hours (Nakahara 1986). The parasitoid quickly became established in watercress and other lowland vegetable crops on the island. It was especially effective in controlling the moth in watercress beds that were being prepared for replanting, where the sprinkler could not be used for a period of time. However, the overhead irrigation also caused outbreaks of the grass sharpshooter, *Draeculacephala minerva* Ball (Homoptera: Cicadellidae), which apparently thrived in the new environment, possibly because its parasitoids did not. With the monitoring in place, the pest was easily controlled with timely applications of diazinon to control the adults and newly hatched nymphs. In 1983, the overhead irrigation and few applications of diazinon reduced chemical control costs by 89%, while production increased by 93%.

The rediscovery of BBTV on Kauai has resulted in the development of an integrated approach to controlling this disease that will require quarantines, public education, and grower support. It may even require changing the way bananas are grown in Hawai‘i. To support this approach, the department will be trying to reduce banana aphid populations on farms and wayside bananas using a coccinellid predator. In December 2000, with the help of the National Biological Control Research Center at Kasetsart University in Thailand, 247 *Scymnus* sp. (Coleoptera: Coccinellidae) beetles were collected from banana plants infested with banana aphids in that country and hand-carried back to Hawai‘i. Unlike other predators or parasitoids in Hawai‘i that attack exposed aphids, these beetles search for and attack their aphid prey under the banana leaf sheaths. The beetles are currently being studied in quarantine for host and site preferences. If approvals for release are obtained and if the beetles are effective in controlling the aphid, then the rate of spread by the virus may be reduced to an extent whereby other strategies, such as early detection and roguing, and the use of tissue-cultured plantlets can become more cost-effective in controlling BBTV in Hawai‘i.

Conclusion

Over the years, Hawai‘i's Department of Agriculture has relied on four primary strategies to control plant pests in Hawai‘i. Based on the past, eradication has not been a viable option in Hawai‘i, except for a few pests. However, interest in eradicating weeds and other pests in Hawai‘i by other agencies and community-based groups has been increasing. Containment programs using chemical or mechanical means can be very effective, especially when coupled with future biocontrol solutions. Unfortunately, they require long-term commitment and are not as exciting or promising of definitive results as eradication programs are, so continued funding is always a problem. Biological control has been the primary strategy for controlling many, but not all, pests in Hawai‘i. While this strategy also requires long-term commitment and funding, it is absolute, long-lasting, and takes only a few successes to illustrate its cost-effectiveness. Integrated control measures have not been used as frequently, but when used, have been especially effective in demonstrating the effectiveness of biocontrol agents in what would otherwise have been considered failed attempts in Hawai‘i.

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