

ALIEN PLANT MANAGEMENT IN HAWAII: CONCLUSIONS

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This volume has clearly shown the importance of the weed problem in the Hawaiian Islands. Since arrival of the first human settlers and especially with establishment of continental humans and commerce, introduced plants have colonized "Paradise" at an increasingly rapid rate (Wester, this volume). All ecosystems have been affected, including those in the remote Northwestern Hawaiian Islands of the archipelago (Herbst and Wagner, this volume).

Approximately 90 of the 861 naturalized alien plant species in Hawai'i are significant threats to native ecosystems (Smith 1985). A number of these species continue to expand occupied ranges. Among those are firetree (*Myrica faya*) (Whiteaker and Gardner, this volume); strawberry guava (*Psidium cattleianum*), fountain grass (*Pennisetum setaceum*), yellow Himalayan raspberry (*Rubus ellipticus*) (Jacobi and Warshauer, this volume); and clidemia (*Clidemia hirta*), (Smith, this volume). These species and others have not yet attained potential distributions (or, probably, densities), and species widespread on some islands are now becoming established on others. For example, *Miconia calvescens* (Melastomataceae) is established on Hawai'i Island and is now a concern on Maui (Gagné *et al.*, in press). In addition, new potentially invasive species are still being introduced to Hawai'i. Some of the most disruptive weeds are such efficient competitors that they can form monospecific stands (Smith 1985), particularly when accompanied by disturbance. Others can alter ecosystem level processes such as nutrient cycling, hydrological, and fire regimes (Vitousek, this volume; Smith and Tunison, this volume). These changes can result in widespread replacement of native vegetation by alien-dominated plant communities and the loss of native ecosystems. However, few studies have actually documented the replacement of native plants and alteration of native plant communities.

The severity of the alien plant problem and the fact that it is so widespread in the Islands make a rigorously organized approach based on relevant information especially necessary. Moreover, development of a variety of approaches to weed control to deal with different situations

(Tunison, this volume a; Stone *et al.*, this volume), use of cooperative efforts in management (Taylor, this volume; Tunison and Misaki, this volume), the implementation and enforcement of legislation and rules to control entry and spread of aliens (Higa, this volume), and emphasis on environmental education (Hawkins, this volume; Stone, this volume) are necessary components of weed management programs.

Weed management approaches in Hawai'i can be summarized in several ways, but in our opinion major emphasis must occur in three areas: 1) protecting parks and preserves from, and managing for, invasive species; 2) reducing entry and establishment of weeds in Hawai'i; and 3) developing a regional approach to accomplish 1) and 2). Minimizing disturbance that allows alien plants to establish and spread is an important part of all emphases.

EFFECTIVE WEED MANAGEMENT IN PARKS AND PRESERVES

Managers of parks and preserves in Hawai'i all have developed strategies for dealing with important introduced plants (Herbst and Wagner, this volume; Holt, this volume; Jacobi and Warshauer, this volume; Loope *et al.*, this volume; Spoehr, this volume; Stone *et al.* 1991; Tanimoto and Char, this volume; Tunison, this volume a). The weed management program in Hawaii Volcanoes National Park probably provides the most advanced model of weed management for Hawai'i's natural areas, primarily because of comparatively good support to deal with severe invasions. The ten management strategies in the Park are discussed thoroughly elsewhere (Tunison, this volume a). The following major emphases can be recommended for natural areas in Hawai'i (Fig. 1).

Removal of Artificial Disturbance

Disturbance by ungulates is one of the primary factors accounting for spread of alien plants (Loope and Scowcroft 1985; Loope and Mueller-Dombois 1989; Merlin and Juvik, this volume; Scowcroft and Conrad, this volume; Stone *et al.*, this volume). Ungulate control has traditionally been an initial and often major step in alien plant management in Hawai'i. Native vegetation often recovers well, and sometimes dramatically, once ungulates are removed (Loope and Scowcroft 1985; Merlin and Juvik, this volume; Scowcroft and Conrad, this volume; Stone *et al.*, this volume), although an introduced plant component may remain in the community. However, certain alien plants may persist and even spread in spite or because of ungulate removal or following other disturbances (Stone *et al.*, this volume). Thus, ungulate control is a necessary but not always sufficient measure in management of alien plants.

Establishment of roads and trails and transport of weed seeds by humans and their animals can also encourage establishment of invasive weeds (Tunison, this volume b; Anderson *et al.*, this volume). The widespread presence of invasive alien plant propagules now favors weed establishment and spread even after natural perturbations in many areas. Thus, physical disturbance of the land should be minimized in parks and preserves.

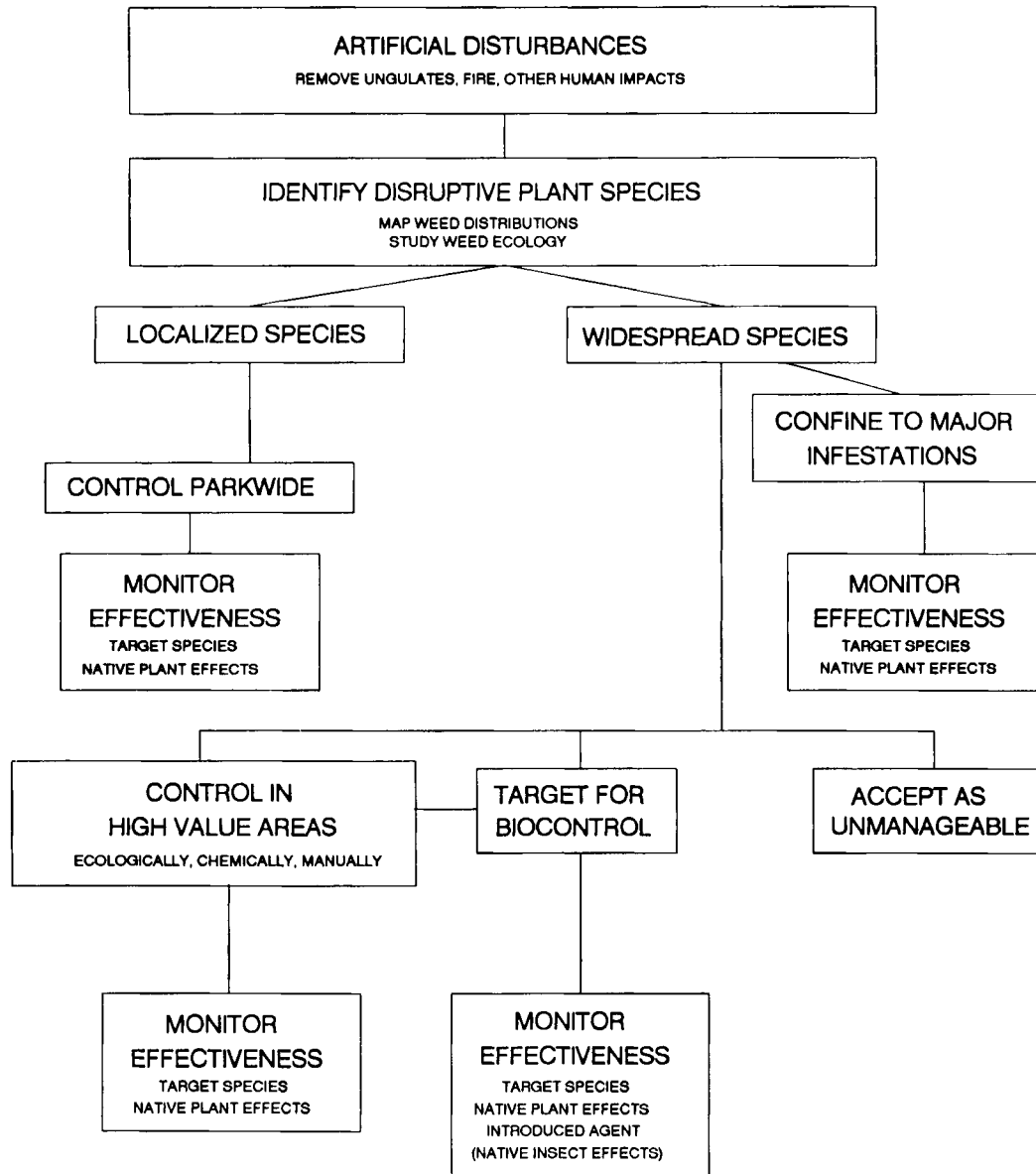


Figure 1. Alien plant control strategies or actions in the alien plant control program at Hawaii Volcanoes National Park.

Disturbance by fire often encourages introduced plants and is as important in some vegetation communities as ungulates are in others (Smith and Tunison, this volume). Uncontrolled natural fire and prescribed burning are not effective tools for managing native ecosystems in Hawai'i. Fire management policy in natural areas should mandate prevention, immediate suppression of all fires, and strategies for reducing fire starts and sizes, including fuel breaks and hazardous fuel reduction.

Biological, Chemical, Manual, and Ecological Control

Biological control is a possible strategy for control of some widespread invasive alien plants that continually reinvade parks and preserves. As with other control methods, strengths and weaknesses are inherent in this approach (Gardner and Davis 1982; Howarth 1983; Gardner, this volume; Markin *et al.*, this volume; Tunison, this volume a). However, for some widespread species no other alternative seems feasible, and economic costs and risks (in carefully managed programs) would seem to be warranted. Successes in alien plant management through biocontrol in natural areas are eagerly anticipated in the near future. It is likely that only a few major weeds will be controlled in the next decade, and perhaps only in a portion of their geographic ranges or in certain situations (moist or dry, etc.). Inadequate long-term monitoring of the results of past releases has been a weakness in the biocontrol approach, a deficiency that must be corrected in the future.

Herbicides have been successfully used to control a number of woody and non-woody plants in Hawai'i's natural areas (Santos *et al.*, this volume; Cuddihy *et al.* 1988; Santos *et al.* 1981a, b; Cuddihy *et al.* 1991). Herbicides have numerous advantages and disadvantages but despite labor requirements and some risk would appear to be a necessary component of weed management in most parks and preserves for the long term. Control of new invasions, of target species not amenable to biological control, and control to supplement biocontrol are legitimate uses for herbicides. A major disadvantage is the need for repeated treatments of widespread species that reinvade. Very little chemical is needed in careful control of selected weeds (mostly woody species) in natural areas (<16 liters in 1988 in 12,000 a (4,860 ha) in Hawaii Volcanoes National Park). As with biocontrol, little long-term monitoring of effects on vegetation recovery has been accomplished in the past to determine whether target weeds reinvade or more serious weeds establish in controlled areas in time. Native plant species diversity should also be monitored to detect changes after herbicide control. Beyond these basic questions about program benefits, more knowledge about persistence, mobility, and effects on invertebrates and other components of native species communities is desirable. Transferring knowledge about the most effective new chemicals and techniques from researchers to managers is important as new and safer chemicals are found. Adequate long-term weed control research programs are necessary to meet many of these needs.

Manual control is even more labor intensive than herbicidal control but is equally likely to be used indefinitely for some species in small areas of high ecological value in Hawai'i. Manual methods can open areas to reinvansion by the target weeds or even more invasive species, but the risk is often necessary. Manual methods are amenable to use of volunteers as a means of overcoming some of the costs of control (Tunison and Misaki, this volume). As with other control methods, long-term monitoring of results is recommended.

Ecological control, by encouraging the spread of native woody species and closed-canopy forest to shade out invasive species, has been experimentally attempted on the edges of high-value areas. Removal of alien

grass cover through herbicide treatment resulted in recruitment of native trees (G.L. Santos and L.W. Cuddihy, pers. comm.). However, direct planting of native plants to shade out alien species and prevent their establishment has not been widely used as yet. Planting may become more necessary in the future as more weed control problems are solved and management of less-intact (more highly invaded) natural areas is emphasized.

High-Value Areas

Some areas within legally protected parks and preserves in Hawai'i are less invaded and contain more native elements than others (Tunison and Stone, this volume). Such areas may contain high native biological diversity or important rare species. These areas may also be representative of widespread or rare communities, contain very few invasive alien species, or be readily manageable. Protecting such areas from alien plant invasion is a realistic strategy, especially if the areas are sizable (variously defined for the taxa and communities at risk) and can be buffered against future invasions by less intensive management of aliens in the surrounding area. Widespread as well as localized invasive species should be controlled in such areas where feasible (Tunison and Zimmer, this volume; Tunison, this volume a; Tunison and Stone, this volume). Focusing management effort on alien plants in a few important areas at a time is an incremental approach to management that has proven very successful where problems are almost overwhelming and human resources are comparatively limited. As alien plant management needs in one area are reduced, workers are freed for managing new and/or larger areas.

Confining Invasive Species to Major Sites of Infestation

Some invasive species that show great potential for invading significant parts of a protected area can be confined to major infestation sites (Tunison, this volume b), albeit with considerable effort. This strategy involves knowing enough about the species to recognize invasion corridors, major sites of concentration, and ecology to accomplish adequate confinement. Control of outlying colonization sites is more important than attacking the major infestation itself (Mack, this volume; Tunison, this volume b). A long-term monitoring program is also necessary to evaluate the effectiveness of this strategy.

Research and Monitoring

Managers and researchers need to work together in alien plant management programs in Hawai'i. The need for research in biocontrol and herbicide programs has been mentioned above, and research is also necessary to objectively evaluate long-term plant community recovery and diversity after operational management programs. Studies of alien plant ecology to determine best means and applications for control are also desirable. Monitoring of the effects of management for introduced plants on other community components, including invertebrates, birds, rare native plants, and the interactions among these, increases the level of knowledge that can be applied to accomplish effective stewardship of natural resources.

Education in Parks and Preserves

Active management of introduced plants in Hawai'i involves such controversial practices as introduction of biological control agents, use

of herbicides, and establishment of marked monitoring and research plots and transects in natural areas. The public is generally interested and supportive once it understands that the reasons for action are logical and necessary to perpetuate the native biota. Interest, concern, and action, including much-needed support for expensive programs of alien plant control, can be generated through educational programs that share knowledge and concern (Stone, this volume; Hawkins, this volume). Strategies for environmental education are an important part of alien plant management programs in natural areas, whether managers, researchers, or interpreters deliver the message.

REDUCING ALIEN PLANT ENTRY AND ESTABLISHMENT IN HAWAI'I

Among the ten actions needed in "reversing the extinction trend" in Hawai'i, according to the Hawaii Department of Land and Natural Resources, the U.S. Fish and Wildlife Service, and The Nature Conservancy of Hawaii (1991) is "Halt the flow of new foreign pest species into Hawai'i."

Congress and the state legislature must recognize Hawai'i's exceptional vulnerability to destructive, foreign plant and animal pests and enact special measures to prevent the establishment of additional problem species. Hawai'i cannot keep pace with its extinction problem if new, destructive pest species continue arriving in commercial cargo, personal baggage, or packages mailed to the islands.

Unwanted alien plants arrive accidentally in cargo, on travellers, or in their belongings. Seeds or spores are especially likely to arrive this way. Alien plants also arrive legally as feed for livestock or poultry, in seed lots for agriculture (Higa, this volume), as biological control agents, for horticulture (Yee and Gagné, this volume), and for research. Alien species will be brought in intentionally and illegally despite all efforts to intercept them. Wildflower seeds sent by mail as promotional material from the U.S. Mainland provide a good example of a deliberate entry that is difficult to counteract. Most inspection systems cannot possibly check all items, nor can thorough checks for a variety of threats be made.

Several groups in Hawai'i in addition to the regulatory agencies are now working to strengthen the process of preventing alien species entry into the State. These include The Nature Conservancy of Hawaii and the Natural Resources Defense Council, which are preparing a background study and have organized and sponsored working groups on the subject; the Alien Species Alert Program of the National Audubon Society, which is emphasizing educational materials and legislation; and the Noxious Plants Task Force of the Conservation Council of Hawaii, which is working on legislation, rulings, and education. The Office of Technology Assessment of the U.S. Congress is doing a nationwide study on the problem of introduced species, with some emphasis on Hawai'i. Increased congressional funding for introduced species programs should follow this study. The World Wide Fund for Nature

is also preparing a guide entitled "Invasive species: the threat to natural ecosystems worldwide."

Problems identified by The Nature Conservancy of Hawaii and the Natural Resources Defense Council (1992) include those under the general headings of jurisdictional gaps, overlaps, and conflicts; uncoordinated decision-making; lack of resources; and technical limitations. A number of difficulties and inefficiencies arise because: 1) Hawai'i's quarantine and inspection systems have been developed piecemeal over the past century, with each piece designed to address only part of the problem; and 2) Hawai'i has been treated the same as any other state in international traffic of biological material, despite much greater vulnerability to biological invasions. Sources of entry for alien species into Hawai'i and regulating pathways are shown in Figure 2. Five Federal agencies (the U.S. Treasury Department, the U.S. Department of the Interior, the U.S. Department of Agriculture, the U.S. Department of Defense, and the U.S. Postal Service) and two branches of State government (the Plant Industry Division and the Plant Pest Control Branch of the Hawaii Department of Agriculture) are involved in preventing alien plant entry for different programs (The Nature Conservancy of Hawaii and Natural Resources Defense Council 1992). Some current activities and concerns of the regulatory agencies are discussed by Higa (this volume).

Prevention of Establishment

Quarantine and inspection mechanisms, no matter how good, will never be able to prevent entry of all alien plants into Hawai'i. However, if detected early enough, some invasions can be stopped. A combination of awareness, expertise, monitoring, cooperation, and the capability and will to take rapid action are necessary to prevent establishment once an invasive species has arrived. Movements of introduced species from place to place on the same island and from island to island are difficult to prevent, but success is possible. The State Noxious Plant list specifies islands on which at least some plants are considered noxious. Unfortunately, unless a plant is on the noxious species list, no governmental entity is responsible for preventing establishment. A species can only become officially noxious by meeting all of several criteria. When a weed is no longer considered manageable, it is removed from the list. Currently, plant species listed on the State Noxious Plant list and the Federal Noxious Weed Seed list show little overlap.

Rapid detection of alien plant invasions is a serious problem, and action must be taken soon after discovery. The emphasis in legislation, rules, and enforcement is on threats to agriculture, forestry, and public health rather than native ecosystems. The Hawaii Department of Land and Natural Resources lacks statutory authority to list noxious plants that are problems in parks and reserves. Controlling, eradicating, or preventing the entry of noxious plant species that have not yet been listed is also a problem, since hearings must be conducted to add new species to the list, and a number of criteria must be met. An example is *Miconia calvescens*, apparently introduced by nurseries to Maui and Hawai'i islands, but not placed on the noxious list for several years because of delays in hearings required to revise the list. The Hawaii Department of Agriculture must

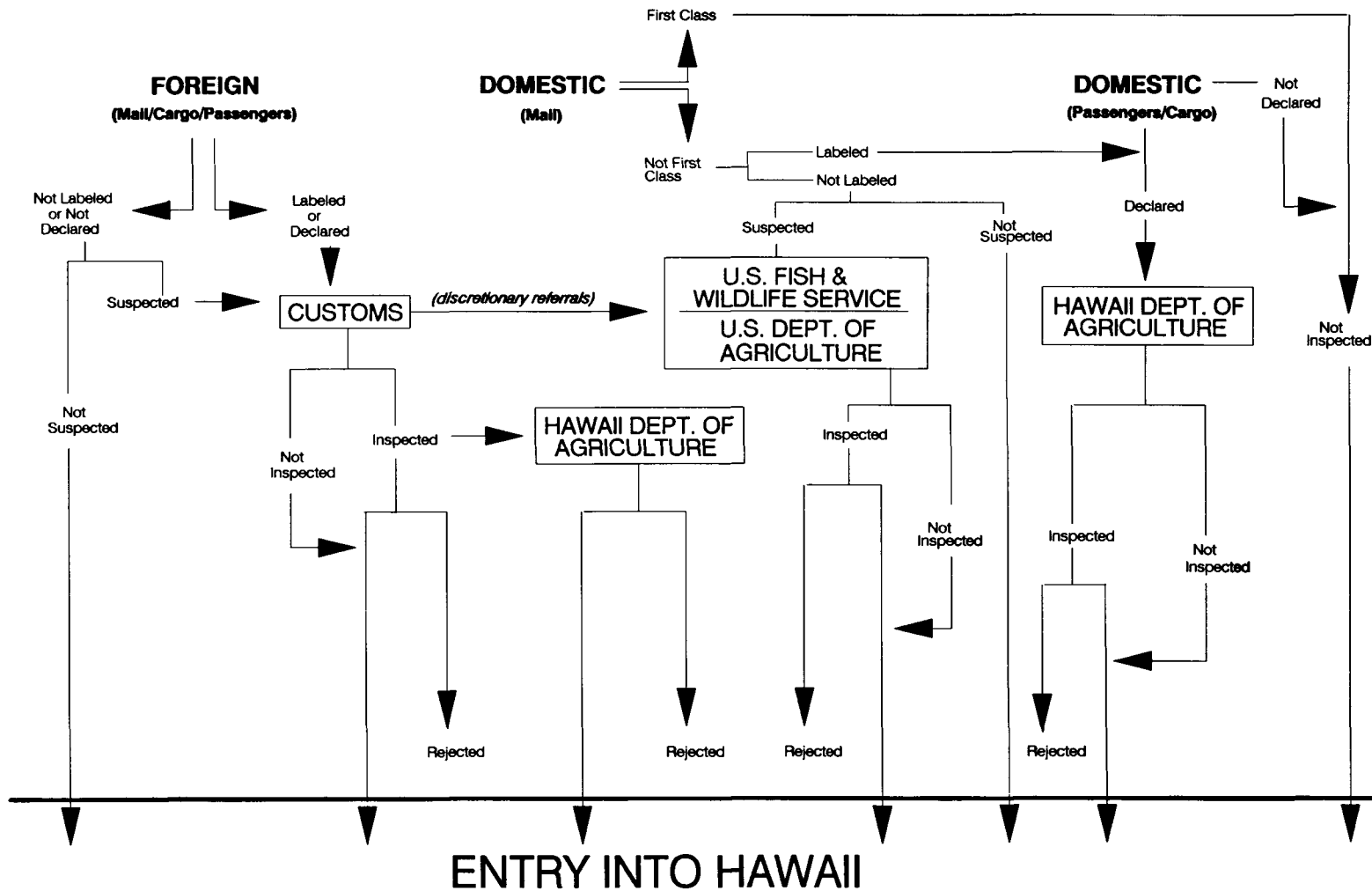


Figure 2. Prevention process for alien species entering Hawai'i. (From The Nature Conservancy of Hawaii and Natural Resources Defense Council 1992.)

remove listed noxious weeds from private property if requested but cannot enter private property to remove plants if opposed by the landowner. A rapid response to *Miconia calvescens* invasion on Maui by National Park Service, The Nature Conservancy, and Sierra Club volunteers appears to have removed 90% of the individuals in seven populations (Gagné *et al.*, in press).

Prevention of establishment of noxious plants after entry by chemical, mechanical, and biological control is a function of the Hawaii Department of Agriculture Plant Pest Control Branch. This jurisdiction extends to forest and conservation lands. The Hawaii Department of Land and Natural Resources Division of Forestry and Wildlife forestry personnel also work with private landowners to control noxious plants on private lands, as well as in state-owned conservation areas. Control programs for alien plants on lands managed by the U.S. Fish and Wildlife Service, the National Park Service, The Nature Conservancy of Hawaii, and various private landowners have already been mentioned. The U.S. Forest Service, the National Park Service, and other state and federal research entities participate in biological control programs for introduced plants (Gardner, this volume; Markin *et al.*, this volume).

REGIONAL AND STATEWIDE EDUCATION, LEGISLATION, AND COOPERATION

Public awareness and involvement are important in preventing entry of introduced plants and in detecting early establishment, as well as in supporting active management programs in natural areas. Attractive pamphlets and brochures, continual emphasis in print and electronic media, and local slide shows and talks can raise public consciousness statewide. The curriculum materials for grades K-8 produced by the 'Ōhi'a Project will do much to educate youth and their parents in public and private schools about alien species and the problems they cause in Hawai'i. A video on introduced species for use on arriving commercial airlines, prepared by the Alien Species Alert Program of the National Audubon Society, a flier on miconia prepared by the Conservation Council of Hawaii, posters on banana poka (*Passiflora mollissima*) and firetree prepared by the Hawaii Department of Land and Natural Resources, a poster/pamphlet on firetree prepared by the Big Island Resource Conservation and Development Council, and the excellent National Geographic Society video entitled "Strangers in Paradise" are but a few examples of recent educational activities related to alien plant threats. The Nature Conservancy of Hawaii, the Hawaii Department of Land and Natural Resources, the National Audubon Society, the U.S. Fish and Wildlife Service, and the Conservation Council of Hawaii have been especially active in both educational and legislative initiatives recently, often working together on these efforts. They are all to be congratulated for their success in overcoming jurisdictional and organizational barriers in a concerted effort to deal with alien species problems and the extinction crisis in Hawai'i.

Regional and statewide cooperation in weed management is difficult to address because of the number of entities and management missions

involved. Nevertheless, some examples of regional approaches such as the multi-agency biological control committee, the gorse (*Ulex europaeus*) and firetree committees, and the Hawaiian Home Lands procedures (Markin *et al.*, this volume; Tulang, this volume; Gardner, this volume; Spoehr, this volume) show promise. Information-sharing among federal and state agencies and private landowners has occurred through publications, reports, and the loan of knowledgeable personnel on occasion. However, much more could be done in regional and statewide management of alien plant problems. We think that the following statement about government and private conservation efforts could equally apply to alien plant management needs and have inserted appropriate wording in brackets (Hawaii Department of Land and Natural Resources, U.S. Fish and Wildlife Service, and The Nature Conservancy of Hawaii 1991):

A task force of federal, state, and private conservation organizations is necessary to coordinate land acquisitions, habitat management, research, enforcement, and other conservation measures in the most cost-effective manner possible. Shared databases on the status and biology of native [and alien] species need reliable funding. The existing network of environmental organizations should consider their legislative [and educational] advocacy and together prepare regular reports on progress in the fight to reduce extinction [or alien plant invasions] in the islands.

The primary difference in emphasis is that alien species are managed for reduction, whereas the native biota are managed for stability or increase. However, managers need shared databases, reliable funding, coordinated management and research, legislative advocacy, and reporting for both management efforts. It is particularly important that education, legislation, and management related to alien plant entry and invasions achieve statewide cooperation by all concerned. Not only are the resources of any one agency not equal to the task in Hawai'i, but combined efforts will be better able to reach beyond state boundaries to congressional delegations in Washington as well as to commerce and visitors from all over the world. A concerted effort will also be needed to effectively reach the local populace. Reducing alien plant ingress and establishment necessitate increasing monitoring, control, and research, and stepping up educational, enforcement, and legislative efforts all at the same time. Major enduring commitments from many quarters are necessary. It has been said that the race between developing environmental consciousness and deterioration of the environment will be decided in the next human generation. Increased effectiveness in controlling introduced plants during that period will certainly be an essential determinant of Hawai'i's future environmental quality.

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