

# **ALIEN PLANT CONTROL ON STATE LANDS INCLUDING NATURAL AREAS**

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## **ABSTRACT**

The priorities for weed control by the Hawaii Division of Forestry and Wildlife are clidemia (*Clidemia hirta*) and banana poka (*Passiflora mollissima*), at present (1989). A discussion of the selection system for weed control projects and the types of control actions employed is presented, along with suggestions for improving the forest pest management program. In 1978, the Natural Area Reserves System was authorized by Chapter 195 of the Hawaii Revised Statutes, to preserve and protect in perpetuity unique and representative samples of Hawai'i's natural environment. Management policy was adopted in March 1984. Efforts were initially focused on identifying and setting aside natural area sites for preservation. Greater effort is now being directed towards management of these reserves, which number 18 and encompass 108,461 acres (43,894 ha). Alien plant management programs for two Natural Area reserves on O'ahu (Mt. Ka'ala and Pahole) are described herein. Different management approaches were taken due to the differences in size and accessibility of each reserve and the differences in the severity of nonnative plant infestations. Specific management problems and solutions and research needs of the two reserves are emphasized.

## **INTRODUCTION**

Alien plant management on lands managed by the Hawaii Division of Forestry and Wildlife in the Department of Land and Natural Resources can be separated into Forest Reserve programs and Natural Area Reserves System programs. Forest reserves are managed for consumptive uses such as forestry, grazing, and hunting, while Natural Area reserves are managed for preservation of native ecosystems. Hunting of alien ungulates and birds is allowed on Natural Area reserves at present to provide recreational opportunities, as a public relations gesture, and to achieve control (of ungulates) where possible.

## FOREST RESERVES

Alien plant control on Forest reserves consists of: 1) small-area actions, such as trail and arboretum maintenance, and clearing of tree-planting areas; and 2) extensive-area treatment of widespread weeds with biological control methods. Small-area actions are accomplished routinely by Division field office personnel. Extensive-area treatments are the responsibility of the Division forest entomologist and presently emphasize control of the forest weeds clidemia (*Clidemia hirta*) and banana poka (*Passiflora mollissima*). Other weeds chosen for control by Division field offices are listed by island in Table 1. Progress for these species will be discussed in this paper only for Natural Area reserves.

### Forest Pest Management

Forest pest management became a program within the Division during the early 1970s, when the position of Forest Entomologist was created through a cooperative agreement with the U.S. Forest Service. The Agreement, executed in November 1968, provides for the prevention, detection, evaluation, and suppression of forest insect pests and plant diseases. Originally written for the implementation and management of control programs for these forest pests, the agreement now extends to control programs for other forest pests as well, including weeds. The objective of Forest Pest Management is to reduce (or prevent) damage, loss, and impacts caused by pests (insects, plant diseases, vegetation, drought, or mammals) on all state-owned forests to levels commensurate with resource management objectives (U.S. Forest Service 1981). The Forest Pest Management staff is to provide overall leadership in the Integrated Pest Management process to maximize pest management effectiveness and efficiency while minimizing adverse impacts on humans and the environment (U.S. Forest Service 1981).

The Forest Pest Management program is based in large part by the following laws and documents:

1. Chapter 344, Title 19 Health, Hawaii Revised Statutes 1976,  
The State Environmental Policy:

It shall be the policy of the State, through its programs, authorities, and resources to conserve the natural resources, so that . . . natural resources are protected by . . . preserving or augmenting natural resources, and by safeguarding the State's unique natural environmental characteristics.

2. Chapter 183, Title 12 Conservation and Resources,  
Hawaii Revised Statutes 1976:

The Department of Land and Natural Resources shall . . . have the care, custody, control, and regulation of all lands which may be set apart as forest reservations . . . [and] devise ways and means of protecting, extending, increasing, and utilizing the forests and forest reserves, more particularly for protecting and developing the springs, streams, and sources of water supply.

Table 1. Weeds listed for control by four Division of Forestry and Wildlife field offices, 1975-present.

Species	Island				
	HI	MA	MO	K	O
<i>Acacia confusa</i> (Formosan koa)		X			
<i>Acacia farnesiana</i> (klu)		X			
<i>Acacia mearnsii</i> (black wattle)		X	X		
<i>Agave sisalana</i> (sisal)				X	
<i>Ageratina adenophora</i> (Maui pāmākani)		X			
<i>Ageratina riparia</i> (Hāmākua pāmākani)	X				
<i>Andropogon virginicus</i> (broomsedge)					X
<i>Ardisia elliptica</i> (ardisia)		X			
<i>Asclepias physocarpa</i> (balloon plant)	X				
<i>Bambusa vulgaris</i> (feathery bamboo)		X			
<i>Caesalpinia decapetala</i> (cat's claw)					X
<i>Clidemia hirta</i> (clidemia, Koster's curse)	X				
<i>Dicranopteris linearis</i> (false staghorn fern)				X	
<i>Hibiscus tiliaceus</i> (hau)		X	X	X	
<i>Ipomoea</i> spp. (morning glory)					X
<i>Lantana camara</i> (lantana)	X	X		X	X
<i>Melastoma candidum</i> (Indian rhododendron)	X			X	
<i>Melastoma sanguineum</i> (fox-tongue melastoma)	X			X	
<i>Melinis minutiflora</i> (molasses grass)					
<i>Melochia umbellata</i> (melochia)	X				
<i>Myrica faya</i> (firetree)	X	X		X	X
<i>Paederia scandens</i> (maile pilau)	X				
<i>Panicum repens</i> (torpedo grass)	X				
<i>Paspalum urvillei</i> (vasey grass)				X	
<i>Passiflora mollissima</i> (banana poka)	X				
<i>Pennisetum setaceum</i> (fountain grass)	X				
<i>Pluchea symphytifolia</i> (pluchea)	X				
<i>Psidium cattleianum</i> var. <i>cattleianum</i> (strawberry guava)	X		X	X	X
<i>Psidium cattleianum</i> f. <i>lucidum</i> (waiawi)	X	X		X	X
<i>Psidium guajava</i> (common guava)	X				
<i>Pyracantha angustifolia</i> (firethorn)		X			
<i>Rhodomyrtus tomentosa</i> (downy rose myrtle)				X	
<i>Rubus argutus</i> (blackberry)	X	X	X	X	
<i>Schinus terebinthifolius</i> (Christmas berry)	X	X		X	
<i>Senecio mikanioides</i> (German ivy)	X				
<i>Setaria palmifolia</i> (palmgrass)	X				X
<i>Stachytarpheta dichotoma</i> (cayenne vervain)	X				
<i>Syzygium cumini</i> (Java plum)	X				
<i>Tibouchina urvilleana</i> (glorybush)	X				
<i>Ulex europaeus</i> (gorse)	X	X			

3. "A Multiple Use Program for the State Forest Lands of Hawaii," summarizing a change in the forestry program from an almost-exclusively watershed protection emphasis to one emphasizing sustained yields and a variety of resources (Hawaii Department of Agriculture 1962).
4. "A Program for the State Forest Lands of Hawaii," summarizing a new forest management plan that defines the objectives needed to carry out the concepts advocated in the publication "A Multiple Use Program for the State Forest Lands of Hawaii" (Hawaii Department of Land and Natural Resources 1975).

The Hawaii Department of Agriculture administers the state's weed laws, which are regulatory in function. The Division of Forestry and Wildlife is partner in four cooperative agreements that deal directly with weed control:

1. An agreement with the Hawaii Department of Agriculture in 1980, emphasizing working for the "common good [of] the flora and fauna of the State."
2. An agreement with the Hawaii Department of Agriculture in 1984, emphasizing the study of potential biological control insects of clidemia.
3. An agreement with the University of Hawaii in 1983, emphasizing the exploration for potential biological control insects and plant diseases for the control of banana poka.
4. A Memorandum of Understanding in 1983 with the U.S. Forest Service, National Park Service, University of Hawaii, and Hawaii Department of Agriculture emphasizing the biological control of forest pests on public lands in Hawai'i.

The biological control programs for clidemia and banana poka necessitate multi-agency approval. Within the context of pest control cooperation, the Forest Entomologist acts as a broker for the Division of Forestry and Wildlife, seeking funds, encouraging cooperative work, and fostering cooperation.

### **Integrated Pest Management**

Integrated Pest Management is a part of forest management that deals with regulation of pest populations to minimize their effects on resources such as water, soil, and recreation opportunities in an ecologically sound manner. Integrated Pest Management consists of a decision-making process and action alternatives based on the following considerations: 1) the ecology of the host and its pests throughout forest succession; 2) land management objectives; and 3) economic values of the subject resource. Monitoring of pest populations and environmental factors that influence them is required in order to determine when action is needed to reduce excessive losses of the resource. Action is also taken in response to chronic or catastrophic losses.

### **Improving the Forest Pest Management Program**

The Forest Pest Management Program has made good progress in the control of clidemia and banana poka in the 15 years since its inception. Although the staff has learned much about pest control in Hawai'i's forests and about program administration, improvement or refinement in some areas is necessary. Suggestions are as follows:

#### **Total program management:**

1. Review and adjust periodically the overall strategy of the Forest Pest Management Program.
2. Collect, collate, and implement all feasible suggestions and ideas that are provided (e.g., Stone and Stone 1984; Hawaii Department of Land and Natural Resources 1985; Smith 1985).
3. Improve the "Information and Education" system for disseminating information about weed problems to the public, legislators, private land managers, and other government agencies. This is important to assure funding of control programs.
4. Promote international cooperation and participation in weed control programs, especially biological control (e.g., New Zealand on the biological control of gorse, *Ulex europaeus*).
5. Implement research that would answer such questions as: Can forests be managed to increase the water supply? What effects do weeds have on each forest value? What are the economics of weed control?

#### **Prevention of alien plant introduction:**

1. Work closely with Hawaii Department of Agriculture in strengthening weed laws and rules and plant importation procedures.
2. Prepare fact sheets on plant species that are known to be pests elsewhere and that have potential for becoming pests in Hawai'i.
3. Improve the data-gathering system to detect alien plant problems.

#### **Biological evaluation:**

1. Investigate the effects of various weeds on the water supply, both in quality and quantity, and protocol to deal with space created suddenly when a biological control agent does its work swiftly.
2. Develop a system to rate weeds on the basis of their detrimental effects for comparative purposes.

#### **Control of weeds:**

1. Develop adequate technical knowledge on the control of all weeds, using all methods of control.
2. Develop ideas and methods to control seed dispersal by birds, mongooses (*Herpestes auropunctatus*), feral pigs (*Sus scrofa*), and other

agents. (See Hawaii Department of Land and Natural Resources 1984 and Hawaii Department of Land and Natural Resources 1988.)

## **NATURAL AREA RESERVES SYSTEM**

Presently (1986), 18 reserves (Table 2), totalling approximately 108,461 acres (43,894 ha), are administered by the Natural Area Reserves System. Many reserves were originally in the State Forest Reserve System discussed in the preceding section. The reserves encompass an array of diverse native ecosystems that include freshwater, marine, and coastal environments, wet, mesic, and dry forests, bogs, grasslands, and alpine scrub. The Natural Area Reserves System preserves the critical habitat of a number of rare and endangered plant and animal species.

### **Legal and Administrative Framework**

The Natural Area Reserves System was established by Hawaii Revised Statutes Chapter 195 in 1970 to "preserve in perpetuity specific land and water areas which support communities, as relatively unmodified as possible, of the natural flora and fauna, as well as geological sites, of Hawaii."

The System is managed by the Hawaii Division of Forestry and Wildlife (the Division). Any state-owned land under the jurisdiction of the Department of Land and Natural Resources (the Department) may be designated a Natural Area Reserve, subject to the approval of the Governor by executive order. New Natural Area reserves may also be established by approval of gift, device, or purchase; by eminent domain; and by setting aside of other state-owned land by the Governor. The Department is responsible for making and enforcing all rules and regulations governing the use, control, and protection of the areas included within the Reserves System.

Chapter 209 of Title 13, Administrative Rules, regulates activities within the reserves. Everything within a Natural Area Reserve is protected except game mammals and birds, which may be hunted according to Department rules. No form of plant or animal life, except hunting dogs, may be introduced to a Reserve. Use of reserves is restricted to non-destructive activities, such as hiking, nature study, photography, and camping without tents or other temporary structures. A Special-Use Permit to conduct activities otherwise prohibited within a Natural Area Reserve for research, education, and management purposes may be issued by the Department.

An 11-member Natural Area Reserves Commission recommends to the Governor and the Department areas suitable for inclusion within the System, as well as policies regarding required controls and permitted uses of areas that are part of the Reserves System. The Commission also advises the Governor and the Department on any matter relating to the preservation of Hawai'i's unique natural resources; and develops ways and means of extending and strengthening presently established preserves, sanctuaries, and refuges within the State. The Natural Area Reserves program provides administrative and technical staff assistance to the Commission. The

Table 2. Reserves in the State of Hawaii Natural Area Reserves System (as of June 1986).

Natural Area Reserve	Acres	Primary Feature
<u>Island of Hawai'i</u>		
Kipāhoehoe	5,583	Mesic forest, 'ōhi'a and koa wet forests
Laupāhoehoe	7,894	'Ōhi'a wet forest
Manukā	25,550	Dry and mesic forests, 'ōhi'a wet forest
Mauna Kea Ice Age	3,894	Geological: Ice Age and Lake Waiau
Pu'u Maka'ala	12,106	'Ōhi'a and koa wet forests
Pu'u o 'Umi	10,182	'Ōhi'a wet forest, montane bog, headwaters of six perennial streams
Waiākea 1942 Lava flow	640	Developing wet forest
Wao Kele o Puna	16,844	'Ōhi'a wet forest
<u>Island of Maui</u>		
'Ahihi-Kīna'u	1,238 (land) 807 (water)	Anchialine pools, last lava flow on Maui; marine ecosystem
Hanawī	7,500	'Ōhi'a wet forest, cloud forest, alpine grassland
West Maui:		
Kahakuloa Section	3,275	Pili grassland, mesic forest,
Honokōwai Section	750	'ōhi'a wet forests, cloud forests,
Pana'ewa Section	1,717	montane bogs, headwaters and upper reaches of four perennial streams
Lihau Section	960	
<u>Island of Moloka'i</u>		
Oloku'i	1,635 (approx.)	Mesic forest, wet shrub, 'ōhi'a wet forest
Pu'u Ali'i	1,340 (approx.)	Wet shrub and 'ōhi'a wet forest
<u>Island of O'ahu</u>		
Ka'ena Point	12	Coastal dune ecosystem
Mt. Ka'ala	1,100	Mesic and cloud forests, montane bog
Pahole	658	Dry and mesic forests
<u>Island of Kaua'i</u>		
Hono o Nā Pali	3,150	Mesic forest, 'ōhi'a wet forest
Ku'ia	1,636	Dry and mesic forests

Natural Area Reserves System program was staffed by an executive secretary, a half-time clerk-typist, and two biologists on temporary-hire status (1987). Additional positions have been created and filled since that time.

## **Management Approach**

In the initial stages of development, the Natural Area Reserves System program focused primarily on identifying and setting aside natural area sites for preservation. Having set aside a number of reserves, greater effort is now being directed towards their management. Management of the Natural Area Reserves System is guided by a Management Policy Plan, adopted in March 1984. Its purpose is to direct formulation and implementation of site-specific operational plans. Management plans have never been prepared for most reserves under contract with The Nature Conservancy of Hawaii. Two principles determine the course of management activities for the System: 1) Natural processes should control ecosystems; and 2) Native species are resources that should be conserved for esthetic, heritage, educational, and scientific values.

Management objectives for Natural Area reserves fall into three categories: managing biological disturbances, development of a database to facilitate the accomplishment of this, and managing human impacts. The major requirements in managing biological disturbances are: 1) Eliminate ungulate populations on reserves. Hunting may be used as an interim measure in accordance with Department hunting rules and policies in certain areas, but eradication of ungulates in the reserves is the goal. 2) Reduce or eliminate established alien biota in accordance with a site-specific operational plan. 3) Restrict establishment of alien biota in accordance with a site-specific operational plan.

Database and human impact information requirements are: to develop a natural resource inventory, to monitor areas of heavy human use or areas where changes are likely to occur, and to monitor the occurrence and impact of alien plant and animal species. Gathering baseline information on the resources of each reserve is the first step in management. One cannot manage an area for alien species until one knows just what species are present, their abundance and status, and their effects upon the native components.

## **Alien Plant Management**

The general approach to management of alien plant species on the reserves can be summarized in four words -- gather, evaluate, propose, and implement. Vegetation mapping, species inventory, and collecting data on phenology and population structure are necessary activities for obtaining baseline information. Data from baseline surveys are then evaluated, and alien plants that threaten, or have the potential to threaten, the continuing quality of the reserve are targeted for management. The alien plant species selected for management can usually be placed in three groups: 1) Incipient threats, which have a limited distribution and are found in small numbers. 2) Minor threats, which appear to be more or less stable in population size and distribution; they do not appear to be a threat to the native components but should be monitored. 3) Major threats, which aggressively compete with native species, occur in large numbers, and/or are widespread throughout the reserve.

The baseline information that has been gathered and evaluated is then used to propose a site-specific program for monitoring, control, and



eradication of alien plant infestations. Implementation of the proposed program is the final step in management.

Initially, the Natural Area Reserves System management program was directed towards gathering baseline data on the distribution and abundance of alien plant species and evaluating their immediate or potential threat on two O'ahu reserves. A comprehensive list of species and a map and descriptions of the major vegetation types were prepared for these reserves. Baseline surveys of this type have now been conducted on most of the 18 reserves. A summary of management accomplishments on the Ka'ala and Pahole Natural Area reserves on O'ahu follows.

**Mt. Ka'ala Natural Area Reserve -- Summit Plateau.** The Mt. Ka'ala Natural Area Reserve summit plateau remains primarily a native ecosystem, with the alien plant species confined largely to areas disturbed by humans or feral pigs. Two vegetation types are recognized there. Wet scrub forest covers most of the summit plateau and consists of a stunted native forest, roughly 6 to 10 ft (2-3 m) in height, that is closed and densely vegetated. 'Ōhi'a (*Metrosideros polymorpha*) makes up 40 - 50% of the forest cover, with a rich array of shrubs and ferns forming the remaining cover. Liverworts and mosses are also abundant. Roadside vegetation, dominated by alien species, comprises the second type. It is found along the paved access roads and the radar/communication facilities located on the summit plateau. Roadsides are periodically maintained and consist of open, grassy areas with scattered shrubs and ferns.

Of the 131 plant species inventoried during the survey, 66 (50%) are alien. Fifty of these alien species are restricted to the roadside habitat, 13 occur in both the scrub forest and roadside habitat, and three occur only in the scrub forest. Nine of the 66 alien species (13.7%) were identified as immediate or potential threats to the native scrub forest. These species can be categorized in three groups, as discussed above:

1. Incipient Group: These plants occur in small numbers and are found in or near disturbed areas that are easily accessible (e.g., along trailsides and roadsides). Species include: clidemia or Koster's curse, Hāmākua pāmakani (*Ageratina riparia*), tea tree (*Leptospermum scoparium*), koa haole (*Leucaena leucocephala*), strawberry guava (*Psidium cattleianum*), and montbretia (*Tritonia crocosmiflora*).
2. Monitor Group: Maui pāmakani (*Ageratina adenophora*) and kikuyu grass (*Pennisetum clandestinum*), the two plants in this group, are found in the roadside vegetation or in the scrub forest adjacent to the roadside where the forest had been disturbed sometime in the past. The two species appear to be more or less stable. The tephritid gall flies introduced to control Maui pāmakani seem to be effectively repressing the growth of this species on the summit.
3. Major Threat Group: Blackberry (*Rubus argutus*) is the only alien species on the plateau that is actively competing with and displacing the native plant growth. Dense thickets are found adjacent to roadsides

and other disturbed areas. Infestation becomes less dense away from these areas.

A nonnative plant eradication program for the Reserve's summit plateau has been drafted, and management efforts have begun on incipient infestations. All species in the incipient group, with the exception of montbretia, have either been uprooted and removed or severely cut to ground level. The sites where these plants occurred are being monitored at six-month intervals for new seedlings or resprouting.

Unless an effective biological control agent is found, present management plans for blackberry on the Reserve's summit will require the use of herbicides. Areas with heavy infestations are targeted for an intensive eradication program; a more selective approach will be used in light to very light infestations.

**Pahole Natural Area Reserve.** The 'ōhi'a dieback phenomenon, which began in the early 1970s on this Reserve, has had a tremendous impact on the quality and species composition of the mesic forest. This mesic forest was, at one time, considered one of the best examples of this forest type on the island of O'ahu. Approximately 187 acres (76 ha) of the reserve's 658 acres (266 ha), or 28%, contains large tracts of standing dead 'ōhi'a trees. The dieback is generally confined to the older trees, and large tracts of standing dead trees are associated with the more or less broad and gentle slopes. Smaller, scattered patches of dieback are generally confined to the upper slopes of the more narrow ridges, and there is poor regeneration of 'ōhi'a. Christmas berry (*Schinus terebinthifolius*) often quickly invades dieback areas once the canopy is opened, and the species forms dense thickets. At lower elevations, dry forest species are scattered among Java plum (*Syzygium cumini*), common guava (*Psidium guajava*), and Christmas berry. The alien species are dominant at lower elevations.

The vegetation on the Reserve is in a state of flux. Unfortunately, the prognosis is grim. The trend is towards replacement of the native elements by alien species, principally Christmas berry or a mixture of Christmas berry, common guava, strawberry guava, and lantana (*Lantana camara*) in mesic forests, and Java plum, common guava, and Christmas berry in the dry forests. Pockets of more or less undisturbed dry and mesic forest exist on the steep slopes of certain gulches and ridges. Because the terrain is so steep, these areas have sustained very little pig damage, and alien species are few and scattered. While the Mt. Ka'ala Summit Plateau Management Plan focuses on the eradication of alien species, the Pahole Reserve Plan will focus on managing those areas with remnant pockets of native forests and endangered plant species.

Pahole Gulch has been recommended as critical habitat for two candidate endangered plant species. Cyanea (*Cyanea superba*) is currently being reviewed by the U.S. Fish and Wildlife Service and is expected to be officially listed soon (D. Herbst, pers. comm.). A status packet for mehemehame (*Flueggea neowawraea*) has been completed and is currently being processed. Preservation of critical habitat calls for an active

management program eliminating pigs and controlling aggressive alien plant species.

Two hundred fifty-two plant taxa were inventoried during the survey of Pahole Natural Area Reserve. Of these, 108 (43%) are alien species. Twenty-six (24%) of the 108 species are categorized as immediate or potential threats on the Reserve, as shown in Table 3. The seven alien species in the major threat group are present in large numbers and are widespread throughout the Reserve. Control of these species on a reserve-wide basis would be cost and time ineffective. Incipient species, however, can be controlled by physical removal or by limited herbicide application for the larger trees and shrubs.

### **Natural Area Reserves Research and Management Needs**

The first steps in active management of alien species were initiated on two of the State's Natural Area reserves in 1986. Baseline surveys and site-specific management plans are now being completed for all 18 reserves within the System. The effectiveness of management will depend on applying the information gathered from baseline surveys, research, and management experience, to produce a site-specific program for each area, which, when implemented, will reduce or eliminate alien species. Four fundamental needs of the Natural Area Reserves System management program are: 1) long-term commitment and support from the State; 2) research on alien species; 3) research on the interaction between native and alien species; 4) coordination of herbicide, research, and management information.

**Long-term commitment and support from the State.** The future of the Natural Area Reserves management program depends on a long-term commitment from the State. A total commitment to the perpetual management of the reserves is necessary. Lack of support has been mentioned previously (Holt and Fox 1985; Smith 1985; Stone and Scott 1985). Unfortunately, the Natural Area Reserves program is at times a political football. An active alien plant management and research program is discouraged by a cumbersome, time-consuming bureaucracy (Smith 1985). Aggressive alien species continue to increase and spread despite budgetary constraints and lack of support; the longer alien plants are allowed to continue unmanaged, the longer and more expensive the remedy and the less likely damaged ecosystems will recover. An intensive Natural Area Reserves System management program will need the "muscle" and equipment support from the Division of Forestry and other Department divisions. The Natural Area Reserves System itself lacks a logistical support system.

**Research on alien species.** Weedy alien species are discussed in a number of weed manuals, reports on plant surveys, and flora descriptions (Hosaka and Thistle 1954; Hawaii Department of Agriculture 1962, 1979; Neal 1965; Pope 1968; Haselwood and Motter 1983). However, the literature is largely for use by agriculturists, ranchers, and gardeners. Smith (1985) provided a useful annotated list of 86 alien plant species considered pests in Hawaiian native ecosystems. For the majority of these species, there is a lack of basic background information, such as the behavior of these species in their native habitat, their ecological tolerances, mode of reproduction, and dispersal agents. The methods used for management will

Table 3. Immediate and potential alien plant threats to Pahole Natural Area Reserve.

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Incipient Group:

*Acacia mearnsii* (black wattle)  
*Cenchrus ciliaris* (buffelgrass)  
*Clidemia hirta* (Koster's curse)  
*Flindersia brayleyana* (silkwood)  
*Fraxinus uhdei* (tropical ash)  
*Melaleuca quinquenervia* (paperbark)  
*Melia azedarach* (pride of India)  
*Montanoa hibiscifolia* (montanoa)  
*Samanea saman* (monkeypod)  
*Schefflera actinophylla* (octopus tree)  
*Setaria palmifolia* (palmgrass)  
*Spathodea companulata* (African tulip tree)

## Monitor Group:

*Ageratina adenophora* (Maui pāmakani)  
*Ageratina riparia* (Hāmākua pāmakani)  
*Andropogon virginicus* (broomsedge)  
*Buddleia asiatica* (Asiatic butterfly bush)  
*Ficus microcarpa* (Chinese banyan)  
*Lantana camara* (lantana)  
*Leucaena leucocephala* (koa haole)

## Major Threat Group:

*Grevillea robusta* (silk oak)  
*Melinis minutiflora* (molasses grass)  
*Psidium cattleianum* (strawberry guava)  
*Psidium cattleianum* var. *littorale* (waiawi)  
*Psidium guajava* (common guava)  
*Schinus terebinthifolius* (Christmas berry)  
*Syzygium cumini* (Java plum)

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depend largely on knowledge of "the lifestyles of the noxious and aggressive" alien species. Knowledge of the life cycle of a species can be used to pinpoint the weakest link in that cycle.

There is also a need to be able to predict which of an ever-increasing number of new or incipient species have the potential to become a threat to native ecosystems. With the limited resources available, administrators must make hard decisions on choosing which of these species to control (Bridges, this volume; Taylor, this volume).

**Research on the interactions between native and alien species.** More management-oriented research is needed on native ecosystems and the role of alien plant species. We need to know why and how a supposedly stable

ecosystem begins to collapse. We need to know what effects, if any, alien species have on ecosystem collapse, and if and how alien species affect recovery potentials of damaged ecosystems.

Management-related research such as that by Mueller-Dombois and his students (Gerrish and Mueller-Dombois 1980; Mueller-Dombois *et al.* 1980; Jacobi *et al.* 1983) on 'ōhi'a dieback should be supported. Information from these studies helps us better understand what is presently happening to the 'ōhi'a forests on the Pahole Natural Area Reserve.

Feral pigs are the dispersal agents for the three guava species on the Pahole Reserve, while the Japanese white-eye (*Zosterops japonicus*) is primarily responsible for the spread of Christmas berry. The increasing numbers of red-vented bulbul (*Pycnonotus cafer*) on the Reserve will also hasten the dispersal of Christmas berry. Studies on the role of alien fauna on the modification of native ecosystems and the spread of alien plant species should be supported.

**Coordination of Herbicide, Research, and Management Information.** A need exists for some sort of clearing house of information on alien plant research and management programs. Information on the types of control strategies that have been tried or are currently being employed is, at times, fragmented. We need to improve communication and share data and findings. With limited resources (a characteristic of many management programs), we do not each individually have to "re-invent the wheel." Ineffective strategies that waste time and money can be avoided. Knowledge gained through considerable effort elsewhere should be used (Stone 1985).

The University of Hawaii Agricultural Extension Service provides a yearly summary of herbicide trials for pasture, range, and non-crop weed control through its Hawaii Institute of Tropical Agricultural and Human Resources publication. Observations on the responses of treated plants to different herbicides, concentrations, and application methods used, as well as data record sheets, are presented. The Extension Service has developed and standardized herbicide application methods and a rating system of weed response to herbicides. Similarly, yearly reports summarizing preliminary data by the various agencies and organizations involved in alien plant research and management would greatly improve communication and coordination of information.

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