

Preventing Establishment of New Alien Species in Haleakala National Park and the Island of Maui, Hawaii

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The future of Haleakala National Park and other protected natural areas as reservoirs of native biological diversity in the Hawaiian Islands may depend more than anything else on the success of efforts to stop new alien plant and animal species from becoming established. Flora and fauna of oceanic islands in general and the Hawaiian Islands in particular are well-known to be highly susceptible to displacement by invasions of non-native species (Elton 1958; Williamson 1981; Brockie *et al.* 1988; Diamond 1989), and much damage has already been done (Cuddihy and Stone 1990). Alien species could ultimately overwhelm Haleakala National Park. Many species causing serious problems are already established (Smith 1985, Stone and Loope 1987, Loope *et al.* in press). There are clearly many aggressive alien plant and animal species not yet present or established on Maui which can exploit and modify habitats not threatened by any alien species already established. Unless combatted with ingenuity and commitment, the insidious threat of alien species can be expected to proliferate and inundate all but the most resistant native ecosystems of Haleakala National Park and the larger

conservation unit (with an adjacent State Natural Area Reserve, State Forest Reserves, and a Nature Conservancy Preserve) of which it forms the core.

The U.S. National Park Service has led the way in Hawaii in the 1970s at Hawaii Volcanoes National Park and in the 1980s at both Haleakala and Hawaii Volcanoes in dealing with those alien threats already present, demonstrating that native Hawaiian biota, previously written off as hopelessly lost, can be protected through active management (e.g., Stone and Loope 1987). Although current efforts are less than adequate, recent interagency efforts are in place to more adequately address the problems (Hawaii Department of Land and Natural Resources *et al.* 1991). The primary threats to Hawaii's natural areas can be categorized as (1) threats from alien species already present; (2) threats from new alien species yet to be introduced; and (3) disruptions caused by global climate change which may tip the balance further in favor of alien species.

Diamond (1989) included the impact of introduced species among his "evil quartet" of primary causes of recent extinctions and further predicted that "it may well be that the worst is yet to come." In view of the difficulty and expense of controlling invasive species once they are permanently established, efforts to prevent establishment of new introductions may be highly cost-effective. Haleakala National Park (111 km² in area), an international Biosphere Reserve, while located on an 1864-km² oceanic island, is not in itself an island. The park's survival as a viable conservation unit depends on implementation of Biosphere Reserve-like regional management. Maui, as well as other Hawaiian islands, needs to develop and refine interagency cooperation to avoid the absurd, but probably common, situation in which aggres-

sive species become established because no agency feels that it has the mandate or responsibility to stop them.

LARGE-SCALE AND GRASSROOTS EFFORTS TO DEAL WITH THE ALIEN SPECIES PROBLEM

Efforts are in progress at the national level (by the Office of Technology Assessment) and in Hawaii (led by The Nature Conservancy and Natural Resources Defense Council) to identify gaps in the legal and quarantine systems within Hawaii and to work at top governmental levels to close the gaps. The inherent complexity of perfecting quarantine systems to stop innumerable potential invaders coming in through diverse routes is compounded by the large number of agencies having responsibilities in this field. A meeting to address the issue, called by The Nature Conservancy and the Natural Resources Defense Council in October 1991, was attended by the following agencies and organizations: Hawaii Department of Agriculture (HDOA), Plant Quarantine Branch; HDOA, Plant Pest Control Branch; HDOA Animal Industry Division, Inspection and Quarantine Branch; the Hawaii Department of Land and Natural Resources (HDLNR), Division of Forestry and Wildlife; HDLNR, Division of Aquatic Resources; the Hawaii Department of Health, Environmental Services Division, Vector Control Branch; the U.S. Customs Service; the U.S. Army, Pacific Command; the U.S. Postal Service; the U.S. Forest Service; the U.S. Fish and Wildlife Service, Enforcement Division; the U.S. National Park Service; the U.S. Department of Agriculture Animal and Plant Health Inspection Service (APHIS); and the Hawaii Sugar Planters Association. The need for coordination and cooperation among such a diverse array of players is obvious.

At Haleakala National Park, we have from necessity initiated a grassroots effort, fully complementary to, but not duplicative of, federal and state-wide efforts. State and federal interagency cooperation within Hawaii is currently at an all-time high. What is already clear is that no program will succeed without grassroots understanding and support. Experience gained by Haleakala National Park during emergency efforts to stop establishment of rabbits and several plant species suggests that the public is receptive to a campaign to really do something to stop the proliferation of alien species.

Rapid growth of the local population on Maui and ever-increasing commerce between Maui and other islands and continents are causing accelerated introduction of potential invaders. Between one and two dozen new species get established in the Hawaiian Islands every year (The Nature Conservancy of Hawaii and the Natural Resources Defense Council 1991). Fortunately, not all of them will adversely affect surviving native biota and relatively few will threaten the pristine, high-elevation native ecosystems. Which ones will adversely affect Haleakala National Park? The best source of information about potential invaders potentially comes from other areas where these species have proved to be invasive. IUCN has a project based in England nearing completion which aims at cataloguing invasive species on the islands of the world. Even before that study becomes available, we are able to make reasonable predictions of the likely invasiveness of species based simply on information on their invasiveness in other areas with comparable habitat.

PAST INADEQUATE RESPONSE : THE EXAMPLE OF BANANA POKA

There is an abundance of examples in Hawaii of how devastat-

ingly aggressive alien species became established through regrettable neglect. One example on Maui is that of the banana poka vine (*Passiflora mollissima*). The species was introduced to the Hawaiian Islands as an ornamental in the early 1900s. It is uncommon in its native habitat in the Andes where it is attacked by numerous species of co-evolved insects. Lacking natural herbivores in Hawaii, it has become established in over 500 km² of native forest on the islands of Hawaii and Kauai. In some areas, it has become so dense that the vines drape from tree to tree, smothering large tracts of native forest. It occupies elevations of 610–1,525 m and thrives where mean annual precipitation is between 500 and 5,000 mm. Feral pigs are its primary dispersal agent, but alien birds spread it as well. Widely recognized as one of the worst weeds in Hawaii, it is now the focus of a cooperative effort by federal and state agencies to screen organisms from *P. mollissima*'s native habitat in South America for introduction as biocontrol agents to Hawaii (Markin *et al.* in press). The cost of this biocontrol project is already around \$500,000 with no visible results for actually reducing the invasiveness of the weed. However, several promising organisms have been tested and released, so that there is still optimism that the program will eventually prove effective. Haleakala National Park fully supports the biocontrol efforts against banana poka since this species is a tremendous threat to park ecosystems in the long run.

Banana poka has been known to be an aggressive weed since the 1960s, and its establishment on Maui could have been readily prevented with a coordinated effort to stop it. In 1971 a group of three mature banana poka plants were reported from a farm lot in Kula, Maui. In the period since then, State Department of Agricul-

ture personnel on Maui have intermittently been involved in control efforts in that area, but the control effort was low on the priority list since the threat was not perceived as imminent and the threat to agriculture (the primary mandate for the Hawaii noxious weed program) was regarded as negligible. Access to infested private lands was a chronic problem. The problem was considered manageable until November 1984 when State Forestry crews combatting a persistent fire in the Kula Forest Reserve noted the unsuspected spread of this weedy vine throughout several hundred hectares of dense black wattle (*Acacia mearnsii*, alien) forest in upper Kula (1,070–1,220 m elevation). Prospects for control of this infestation are complicated by its occurrence on private lands. A well-organized education and eradication campaign was mounted, however, by Lorna Harrison of Makawao, Maui, beginning in 1988. This effort led directly to funding (\$60,000) by the State Legislature for banana poka mechanical control on Maui through the Hawaii Department of Land and Natural Resources in 1989-90, and hopes were high that success could be achieved. However, that amount proved inadequate to do the job and no additional funding has been allotted. The only hope now seems to be biocontrol; two moth species were released on Maui for this purpose in early 1991. The plant poses a threat to Haleakala's Kipahulu Valley koa (*Acacia koa*) forests as well as many other natural areas on Maui.

CASE STUDIES OF RECENT EFFORTS BY THE USNPS TO STOP ALIEN SPECIES ON MAUI

Many other examples of alien species establishment on Maui are horror stories in the making. Haleakala National Park, through cooperative efforts between its Research and Resource Management divisions, has been integrally in-

involved in trying to prevent such invasions from materializing over the past few years. Some of these stories are detailed below.

European rabbit (*Oryctolagus cuniculus*) Rabbits have been liberated on at least 700 islands throughout the world, and devastation resulting from their establishment has been well-documented in several areas (Atkinson 1989). Although the Hawaiian Islands are well-known to be highly vulnerable to biological invasions, the domestic European rabbit (*Oryctolagus cuniculus*) had come to be disregarded as a potential invader after more than a century without invasion on a major island. Haleakala National Park initiated rabbit removal and monitoring in July 1990 following discovery of a reproducing rabbit population covering 25 ha in high-elevation (2,075–2,135 m) native shrubland. Because of the threat of feral rabbits to native biota, rabbit eradication was placed as the highest park priority. The population is believed to have originated from as few as six unwanted cage-reared rabbits released by a pet owner in October 1989. A total of 93 rabbits were removed from the 25-ha area of the infestation during August 1990–March 1991, through snaring, shooting, and trapping. Four more rabbits were removed upslope (elevation 2,135–2,440 m), at distances of 0.6–2.4 km from the main area of infestation, the last one on May 6, 1991. Monitoring of transects (assessment of rabbit pellet presence or absence, age, and abundance), combined with scouting and follow-up of reports of rabbit sightings by visitors and other park employees, concurrently with control, allowed accurate assessment of numbers and location of remaining rabbits.

The park is still faced with the likelihood that release or escape of pet rabbits will pose a recurring problem. A snowfall on January 15, 1992, brought large numbers of local people to the park. One car brought

a pet rabbit which was running loose for a short time at park headquarters until park rangers intervened. We recently learned that during the summer of 1991, a landowner in Kahakuloa, West Maui, became concerned about a rabbit population on the edge of his land, because he was afraid that his horses would break their legs in the holes ("tunnels") the rabbits were digging. His dogs were killing the baby rabbits, but the adults could escape because of cliffs. The landowner told me that he shot about fifteen rabbits over a period of a few weeks until the population was eradicated.

It is clear that free-running dogs have served as a major factor preventing rabbit establishment up to now. There are many localities in Hawaii without free-running dogs or other significant predation pressure on adult rabbits, however. For example, a single male rabbit survived for about three years just adjacent to the Haleakala Highway at elevation 5500 ft in lands belonging to Haleakala Ranch. In our opinion, rabbit establishment on one or more of the Hawaiian Islands is just a time bomb waiting to go off.

It seems that new state legislation is needed to strengthen the law regulating rabbits and a clear mandate and responsibility needs to be given to some agency to prevent rabbits from becoming established in the Hawaiian Islands. As far as Haleakala National Park is concerned, we are just trying to maintain awareness of the problem and document any new cases of incipient rabbit establishment.

Miconia calvescens *Miconia calvescens*, "the plague of French Polynesia," is a tree, up to 18 m tall, whose large, dark-green leaves have maroon undersides. It is native from southern Mexico south to northern Argentina and Chile, where it grows at elevations of 300–1830 m and is apparently an understory species and an invader of small light

gaps. A former Harvard University physics professor, Harrison Smith, introduced *M. calvescens* to a garden at Papeari, in the south of Tahiti, in 1937. In the same year, it was also planted on the Plateau of Taravao. During the decades following the introduction of *Miconia* to Tahiti, *M. calvescens* spread but was not recognized as a problem. The first published record of its apparent invasiveness was in 1976 (Birnbaum 1991). (However, F.R. Fosberg (pers. comm. 1991) of the Smithsonian Institution saw it on the Taravao Plateau in 1971 and concluded that "this is a plant that could destroy Hawaiian forests.") Interpretation of aerial photographs from 1978 found that *Miconia* in the forest canopy was mappable only in an area of 100–200 ha on the Taravao Plateau. However, by 1989 *Miconia* dominated the canopy over a large part of the island and was present over 75% of the island (Birnbaum 1991).

Miconia apparently attained canopy dominance over such a wide expanse of Tahiti following severe forest disturbance by two hurricanes in March and April of 1983. The two hurricanes devastated Tahiti's native forests by breaking the tops of trees and detonated a demographic explosion of *Miconia*. Birds had spread seedlings of the species widely, and with the opening of the forest canopy, *Miconia* seedlings grew more quickly than anything else to reach the canopy.

Because of its perceived attractiveness as an ornamental, *M. calvescens* was introduced in the 1970s through the horticultural industry to at least three Hawaiian islands—Hawaii, Oahu, and Maui. Whereas it is said to show little evidence of invasive tendencies on Oahu, it may be locally beyond control in the vicinity of Hilo on Hawaii. The situation on Maui is such that control appears feasible if prompt and concerted action is taken. Tiny, bird-dispersed seeds

are produced after about 4-5 years of vegetative growth; each tree has the capacity to produce tens of thousands of seeds annually. It thrives best in partial shade and can establish seedlings in moderately dense shade.

Haleakala National Park learned about the threat of *Miconia* when one of the park's employees (Betsy Gagne, who was in Tahiti in 1988, and thus attuned to the threat from this plant) noticed a single tree growing in a botanical garden near Hana, on the northeast coast of Maui. Following an inquiry to the owner of the botanical garden (Alii Gardens) in January 1991, our knowledge of its status on Maui has advanced rapidly. It probably first arrived on Maui with a horticultural shipment to Helani Gardens, near Hana, in the late 1970s. Founding individuals have grown to nearly a foot in diameter and over 10 m tall and produced abundant seedlings locally.

M. calvescens appears to merit special concern on East Maui since few other plant species are highly invasive in forest situations above 1200 m elevation. Haleakala National Park is concerned that *Miconia* will not only alter landscapes in coastal areas, but will quickly spread to upland areas and disrupt natural plant succession in otherwise pristine native forests in such locations as the Park's Kipahulu Valley, State Forest Reserves, and The Nature Conservancy's Waikamoi Preserve. It can become established in such dense stands that it can change the landscape and cause massive loss of biological diversity.

It is becoming increasingly obvious that there is no effective mechanism operating in Hawaii to keep aggressive alien species such as *M. calvescens* from being brought in. Our approach has been to attempt, at least on a small scale, to publicize this problem, as we have done with

rabbits, and to raise community consciousness and concern.

Beginning in April 1991 we distributed home-made "wanted" posters illustrating *Miconia* around windward East Maui and now feel that we have a fairly good knowledge of the extent of this plant, although there are undoubtedly populations that we don't know about, since it is clear that plants have been distributed from Helani Gardens. We now know of eight populations.

Publicity in local newspapers assisted in informing the public and giving credibility to our efforts. Following a presentation in an alien-species symposium at the XVII Pacific Science Congress in May 1991, a front-page story appeared in the *Honolulu Star-Bulletin*. A concerned legislator wrote a letter to the governor complaining that although *M. calvescens* had been known as an aggressive weed for years as a result of contacts with botanists from Tahiti, the plant has still not been declared a noxious weed and is brought into the state legally. By December 1991, the Conservation Council of Hawaii, in collaboration with the Hawaii Department of Land and Natural Resources and other organizations, had printed up thousands of "wanted" posters warning of the threat to native ecosystems from *Miconia*. Still, no revision of the state noxious weed list was forthcoming, but this was promised for the coming months.

In June 1991, the park began an exploratory effort to obtain permission from landowners to eradicate *M. calvescens* from Maui. All landowners contacted to date have been highly cooperative. A major preliminary effort to eradicate *Miconia* from Maui was undertaken in Helani Gardens during four days in June and July by Haleakala National Park staff and volunteers. Helani Gardens owner Howard Cooper gave full support to the effort, and Keola Hana Maui Company gave

permission to remove *Miconia* plants on their land adjacent to Helani. A total of 9,200 *Miconia* plants were removed in the following size classes: 0-5 cm diameter—97.5%; 5-10 cm diameter—1.8%; 10-20 cm diameter—0.4%; > 20 cm diameter—0.3%. It is estimated that 95% of the *Miconia* plants in the garden (and more than 50% of the plants on Maui) were removed. Follow-up has since been implemented, with a volunteer assigned two days a week to *Miconia* during December 1991–April 1992. One negative finding is that the seed bank lasts for at least one year and probably for at least several years. Periodic follow-up for an unknown length of time will be necessary to remove seedlings from the seed bank.

Pampas grass (*Cortaderia jubata*) Two very similar South American species of pampas grass, *Cortaderia selloana* (Schult.) Asch. & Graebn. and *Cortaderia jubata* (Lem.) Stapf, have been widely planted as ornamentals, although until now only the former (*C. selloana*) has been recognized in botanical literature as occurring in Hawaii. The latter (*C. jubata*) has proved to be an aggressive weed in California and elsewhere, and would clearly be an undesirable introduction to the Hawaiian Islands. We have recently become aware that there are at least two kinds of pampas grass present in upcountry Maui and that one of them is escaping from cultivation. It turns out that there are two species—*C. selloana* and *C. jubata*, based on confirmation by Paul Peterson of the U.S. National Herbarium in Washington, D.C. (Loope and Medeiros 1991). Both species are perennial bunch grasses with coarse saw-edged leaves well over 1.5 m in length and silvery, plume-like inflorescences on stalks 2 m or more in length.

Beginning in 1987-88, seedlings of pampas grass, easily recognized by their large size and

sharp-edged leaves, became apparent along Haleakala Highway at 1,220–1,839 m elevation. In October 1989, for the first time several of these plants developed flowering stalks, which were removed. In late October 1989, a large individual of *Cortaderia* with flowering stalks over 3 m tall was sighted from a helicopter by park personnel just inside the park boundary at 2,010 m elevation on the wall of Haleakala crater in Koolau Gap. Flowering stalks were destroyed by park personnel in 1989. In July 1990, just prior to flowering, the entire plant was destroyed. The plant appeared large enough to have flowered in at least one year before 1989. In early 1991, seven seedlings were found and destroyed in the area.

Based on literature on the species in California, *C. jubata* is most likely to thrive in Hawaii in mesic, middle-elevation sites not occupied by closed vegetation. As of yet, the ability of *C. jubata* to withstand hard freezes commonly encountered during winter months above 2,000 m on East Maui remains unknown. If it can tolerate the diurnally frozen soil and harsh climate in Haleakala Crater, it could become a major invader of that area.

In January 1991, we began contacting landowners and eliminating seed sources of *C. jubata*.

Mullein (*Verbascum thapsus*) Mullein is a highly invasive weed on the Big Island of Hawaii; it grows all over Mauna Kea, up to 3,350 m elevation, in habitat very similar to that occupied by Haleakala silversword (Juvik and Juvik in press). Few other plants are known which can invade Haleakala silversword habitat. Haleakala National Park personnel found and destroyed two mullein plants growing on park roadsides in 1986 and continue to be on the alert for additional plants.

In July 1990 Haleakala National Park researcher Art Medeiros was purchasing herbs at Maui Gar-

den and Hardware in the town of Pukalani, about 20 km from the park, when he noticed mullein plants for sale. After the supplier (a small nursery named Haleakala Herbs) was tracked down, a front-page story appeared (with the endorsement of the nursery owner) in *The Maui News* publicizing the potential damage this plant could do to the national park and asking that mullein purchasers destroy their plants. The article was widely noted and may have been effective in encouraging people to destroy any mullein plants. However, a year later when park superintendent Don Reeser purchased a house in Olinda, a mullein plant was still growing in the yard. The seller apologized to Reeser, admitting that she had seen the article, but she "just didn't have the heart" to destroy her mullein plant. (She did nothing illegal; mullein is not on any prohibited list.)

Australian tree fern (*Cyathea cooperi*) *Cyathea* tree ferns have been in cultivation in the Hawaiian Islands at least since the 1960s as ornamentals at homes and botanical gardens. The widely cultivated species, *Cyathea cooperi*, is native to Queensland and New South Wales in eastern Australia. It is widely planted in Hawaii since it is a hardy, attractive species and is faster-growing than native Hawaiian tree ferns (*Cibotium* spp.).

It has been recently discovered that populations of *C. cooperi* are invasive in ohia (*Metrosideros polymorpha*) and koa (*Acacia koa*) rain forests in Kipahulu Valley of Haleakala National Park (Medeiros *et al.* in press). There are four known populations comprising over 1,000 individuals at 610-1,040 m elevation. Even in nursery and houseplant situations, *C. cooperi* has a tendency to escape, often becoming established several hundred meters from the parent populations, especially in wet areas. This species is planted and

locally naturalized at several tropical botanical nurseries near Hana, approximately 12 km from the Kipahulu Valley populations. The species is also escaping from cultivation on Kauai.

The greatest threat that *C. cooperi* poses to Hawaiian forests is its displacement of native species where the fern has achieved high densities and local dominance of communities. Unlike native *Cibotium* tree ferns, *Cyathea* does not support the dense colonies of epiphytic native species that often colonize the trunks of tree ferns (Medeiros *et al.* submitted). Where *Cyathea* forms dense stands in Kipahulu, the understory is conspicuously open and lacking many characteristic native species normally found there. This is apparently due to exclusion of other species by the thick layering of fibrous roots that forms at the soil surface surrounding a growing tree fern. On large tree ferns of this species, this dense layer of near-surface roots may extend out over a diameter of 10-15 feet, effectively excluding most other vegetation (Medeiros *et al.* in press).

Within Haleakala National Park, an attempt is being made to control this alien species before it becomes too extensively established. The known populations of *C. cooperi* are being removed, cutting the taller ferns with chainsaws and removing the growing tips. Investigation of the current stand structure and monitoring of fixed relocatable plots in the areas where *C. cooperi* is removed will allow evaluation of the feasibility of long-term control. Reconnaissance in Kipahulu Valley and surrounding forest areas will be conducted to attempt to locate additional populations of *C. cooperi*, both within and outside Haleakala National Park.

The relationship of this "wild" population of *C. cooperi* to cultivated plants on Maui remains unclear. This aspect urgently needs

investigation, as a possible prelude to efforts at stopping its continued cultivation. Bezona (1991) has recently published an article promoting the cultivation of *C. cooperi* as a substitute for the common practice of removal of native *Cibotium* tree ferns from wildland forests. Several nurseries on the island of Hawaii are already devoted primarily to growing *C. cooperi*. Although our recommendation (Medeiros *et al.* in press) is that "*Cyathea cooperi* be designated a noxious weed by the Hawaii Department of Agriculture and its horticultural trade be discontinued," we realize that this issue is a complex one that will not be easily solved.

Fountain grass (*Pennisetum setaceum*) This large bunchgrass from northern Africa has spread aggressively throughout leeward Hawaii Island during the past two decades, becoming uncontrollable in part of Hawaii Volcanoes National Park. Fountain grass creates an exceptionally large standing fuel source and promotes the spread of fires more than any other grass yet introduced to the Hawaiian Islands (with the possible exception of *Melinis minutiflora*). Fountain grass is present on Maui only in a small area of the sand hills of southeastern Wailuku. However, it poses a serious threat to rangelands of southern East Maui with young volcanic substrate as well as to the relatively intact ecosystems of upper Haleakala. Based on its occurrence as high as 2,740 m on Mauna Kea (J. Jacobi, pers. comm.), it must be regarded as a potential invader of most of Haleakala Crater. Indeed, it is one of the invasive plant species which the park must fear most.

Persistent control efforts by the Maui weed control office of the Hawaii Department of Agriculture (HDOA) since about 1976 have confined Maui's fountain grass population to a single site near a former dump, a favorable habitat on sandy

soil. In May 1986, when Haleakala National Park personnel first visited the site with the HDOA, it was pointed out that populations are controlled by hand pulling of seedlings and mature plants at 1-2 month intervals, with bagging of seeding inflorescences for disposal at a nearby landfill. An average of about 2,000 plants per year were removed in 1983-85. In 1986, population numbers were low and apparently decreasing due to a declining seed bank after several years of concerted effort at control of young plants before seed was set.

In early 1991, Richard Mack from Washington State University, who is studying fountain grass at Hawaii Volcanoes National Park and elsewhere on the Big Island, wanted to sample from the Maui population. I assured Mack that it would likely be impossible to obtain seeds of fountain grass from Maui because of an effective control program. However, when we visited the site in March 1991, Mack was able to obtain abundant seed and the population seemed to be spreading in one direction. Most of the area occupied by fountain grass burned on June 30, 1991. Fountain grass is known to thrive following fire, mobilizing released nutrients, producing abundant seed, and undergoing rapid growth in the years immediately following fire. It was clear by July that the HDOA had done no control during the past year, and was apparently putting fountain grass on the back burner since it seemed contained. In a conversation with the Maui coordinator of the noxious weed control program for HDOA, it was confirmed that fountain grass was regarded as virtually controlled and not a high priority for further effort.

In view of the importance of keeping fountain grass out of Haleakala National Park, what action should be taken? Rather than creating a major political issue, my response was to visit the site periodi-

cally, removing whatever plants I could find about once a month. After removing 135 plants, I am unable to find additional plants, but will return periodically to check for germinants from the seed bank. There is apparently another population which must be checked also.

CONCLUSIONS: COALITION BUILDING IN PREVENTING ALIEN SPECIES ESTABLISHMENT

The above case studies provide concrete examples of the types of problems with incipient alien species establishment which we have encountered at Haleakala National Park. The importance of building coalitions at all levels should be clear. The USNPS can not act legally on its own outside of its area of exclusive jurisdiction and lacks the resources to do so extensively even if it possessed the legal authority. Long-term success in such endeavors will depend on creation of an enlightened public through education, and cooperation with any agency willing to help. Significant facets of a developing coalition to this point in time are enumerated below:

- We have provided input at several points toward a study underway (1991-92) by the congressional Office of Technology Assessment on U.S. policy toward exotic species. Results of this study may provide major impetus toward federal action to tighten the system for quarantine and control in Hawaii and elsewhere.

- A study by The Nature Conservancy of Hawaii and the Natural Resources Defense Council addresses remedies for problems with alien pest invasion in Hawaii. Results of this study may provide major impetus toward federal and state action to tighten the system for quarantine and control within Hawaii.

- An educational effort by the National Audubon Society (Alien Species Awareness Program) is

reaching Hawaii citizens through various media.

- The Hawaii Department of Agriculture is in the process of soliciting public and agency review of a revised noxious weed proposal.

- An East Maui Watershed Cooperation was recently formed. An agreement was signed in November 1991 by major landowners on windward East Maui—Hawaii Department of Land and Natural Resources, Haleakala National Park, The Nature Conservancy of Hawaii, East Maui Irrigation Company, Haleakala Ranch Company, and Keola Hana Maui Company. The purpose is to work together to maintain the quality of the East Maui watershed and to preserve its biological diversity, through cooperative efforts and feral ungulate and weed control.

- A "Melastome Committee" was initiated in August 1991 by the local Soil Conservation Service and Maui Land and Pineapple Company. This committee has the goal of working through political channels to ban further importation of any plant in the Melastomataceae and to control existing problem species (especially *Miconia calvescens*, *Clidemia hirta*, and *Tibouchina herbacea*).

- The park program has had major interaction with local newspapers, almost entirely positive. This has been our major means of public education to date.

- Our program has had day-to-day interaction with employees of other local land management agencies.

- We have had interaction with the nursery industry through articles in *Hawaii Landscape Industry News* (Loope 1991, Loope and Medeiros 1991) and through informational letters and personal contacts.

- We have had interaction with the pet industry and the humane society through personal contacts.

- We have interacted with the Maui County Council through our testimony in opposition to internationalization of Maui's airport because of park concerns over alien species introduction.

- We have negotiated with the U.S. Air Force over safeguards needed (including surveillance for alien species) in the installation at Haleakala volcano's summit (outside the park) of the world's tenth largest telescope.

- We are involved in an interagency survey of the status of Maui forest birds and their habitat. This will result in a comprehensive survey of alien plant distribution on East Maui.

- We have made use of volunteers from Sierra Club and The Nature Conservancy in alien plant control.

- We have kept in touch

with local legislators. Local state representative David Morihara visited the park during the height of our rabbit invasion and attended the first meeting of the Hawaii Environmental Education Association at which we presented posters on rabbits and *Miconia*.

- This work has involved close cooperation among the Superintendent and the Research and Resource Management divisions of Haleakala National Park. The Interpretation division has helped educate the public and has provided numerous "leads" on alien species through conversations with visitors. The Visitor Protection division called the rabbit problem to our attention and assisted with emergency control efforts. The Maintenance division provided crucial information which helped lead to snaring the last rabbit.

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