ALIEN PLANTS AND THEIR MANAGEMENT IN HAWAII VOLCANOES NATIONAL PARK

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Abstract: Hawaii Volcanoes National Park (HAVO) contains a large number of alien plant species, of which nearly 30 are capable of disrupting intact plant communities. The National Park Service mandate is to preserve the Park in its natural state. Because of the severity of HAVO's alien plant and animal problems, this goal is not possible to achieve parkwide at the present time. The HAVO Resources Management Division has prioritized alien plant problems and developed a three-part strategy to make the most of limited funding. Objectives include: (1) controlling potentially disruptive but currently localized alien plant species, (2) confining the extremely disruptive, fire-adapted fountaingrass (*Pennisetum setaceum*) to the already-disturbed HAVO lowlands, and (3) controlling widespread disruptive alien plant species in 21 proposed Special Ecological Areas (SEAs) - the most intact, unique, and species-rich sites in HAVO. Within seven managed SEAs, alien plant control and research activities are focused on disruptive species such as firetree or faya tree (*Myrica faya*), strawberry guava (*Psidium cattleianum*), kahili ginger (*Hedychium gardnerianum*), nasturtium (*Tropaeolum majus*), banana poka (*Passiflora mollissima*), and yellow Himalayan raspberry (*Rubus ellipticus*). Current management and research on these alien plants in HAVO are detailed.

The flora of the Hawaiian Islands contains approximately 1,100 native vascular plant taxa, more than 90 percent of them endemic (Wagner et al. in press). More than 4,600 species of alien plants also occur in the State (Smith 1985), and about 900 of these are naturalized (Wagner et al. in press).

The introduction of alien plants into Hawai'i began with the Polynesians about 1,500 years ago (Kirch 1985). The Hawaiians introduced at least 32 plants, most of them for food or other uses (Nagata 1985). Several unintentional Polynesian introductions have become minor weeds. A few tree and shrub species introduced by Hawaiians have become community dominants in some wet lowland areas, for example: kukui (*Aleurites moluccana*) and mountain apple (*Syzygium malaccensis*).

Since 1778 and the arrival of continental human, the rate of plant introduction has greatly increased. Most introductions have been of cultivated plants, but at least 86 established alien plant species are invaders of native plant communities in the Hawaiian Islands (Smith 1985).

ALIEN PLANTS IN HAWAII VOLCANOES NATIONAL PARK

Hawaii Volcanoes National Park (HAVO) contains approximately 900 vascular plant species. Of this number about 600 are aliens (Higashino et al. in press). Many of these are ornamental plants in housing areas, while others are restricted to roadsides or are relatively innocuous. At least 29 of the alien plants found in HAVO are disruptive species capable of invading native ecosystems, and 24 of these are already too widespread to be controlled parkwide by any conventional methods (Tunison in prep). Some of these are the subject of biocontrol research being carried out by U.S. Forest Service and National Park Service scientists in cooperation with the State of Hawaii.

Hawaii Volcanoes National Park is approximately 230,000 ac in size and extends from the coast to the summit of Mauna Loa volcano (13,796 ft). The coastal lowlands of HAVO support vegetation that is for the most part dominated by alien grasses, with only a few areas still covered by native shrublands and forests. These alien grasses are often fire adapted and have increased both the intensity and frequency of fires in HAVO (NPS 1986). By contrast, the higher elevation zone in the Mauna Loa Strip of HAVO above 4,500 ft supports primarily native vegetation such as koa (*Acacia koa*) parkland and subalpine shrublands. Feral pigs (*Sus scrofa*) and goats (*Capra hircus*) have been removed from much of this section, which has relatively few alien plant problems, although several extremely disruptive species found elsewhere in HAVO could invade this zone. It is the middle elevations of HAVO between 2,000 and 4,500 feet elevation where alien plant problems receive the most attention. This region contains HAVO's greatest diversity of vegetation types: native shrublands, open woodland, rain forests and mesic forests, as well as successional communities on lava flows.

ALIEN PLANT MANAGEMENT STRATEGY IN HAVO

Because of the number of invasive alien plant species present in HAVO and the large areas already invaded, it is not possible to control problem plants parkwide. Over the last five years, the Resources Management Division has developed an alien plant control program with three major objectives (Tunison in prep.): (1) control of localized alien plants, (2) confining foun-

taingrass (*Pennisetum setaceum*) to the lowlands, and (3) control of widespread alien plant species in Special Ecological Areas (SEAs).

Support of the ongoing cooperative biocontrol research program is also recognized as important. While biocontrol is not the subject of this paper, a few biocontrol efforts will be briefly treated in this overview of HAVO alien plant management activities.

Localized Alien Plant Populations

Control of localized alien plants involves recognizing potentially disruptive alien plant species while they have a restricted distribution, and preventing their establishment in HAVO. Plants that are known to be aggressive elsewhere in Hawai'i and those taxonomically related to other problem plants are targeted for control. Roadsides and trails are periodically scouted for such plants. More than 40 such plant species have been identified and treated and 75 percent of these have been eradicated or effectively controlled. Mechanical treatment is preferred, but herbicides are used where necessary. For one localized alien, prickly pear cactus (*Opuntia ficus-indica*), two known effective biocontrol agents (Fullaway 1954) were introduced to the infested area from cactus stands near Waimea. These were the cochineal insect *Dactylopius opuntiae* and larvae of the moth *Cactoblastis cactorum*. Other examples of localized alien plants being controlled are sisal (*Agave sisalana*) near Waha'ula, maile pilau (*Paedaria scandens*) and melochia (*Melochia umbellata*) on the Chain of Craters roadside, and princess flower (*Tibouchina urvilleana*) near roads in the Kilauea area. While this approach has been largely successful, treated plant stands must be monitored for regrowth and often retreated, and the search for new plant invaders is continuous.

Fountaingrass

Fountaingrass (*Pennisetum setaceum*), native to Africa, was introduced to Hawai'i as an ornamental in the early 1900's. The grass is a serious threat to dry and mesic ecosystems from the coast to the subalpine zone, where it may completely dominate ground cover, interfere with native plant reproduction, invade bare lava flows, and increase the likelihood of damaging fires. It spread to HAVO from the leeward side of the island, possibly via four-wheel drive vehicles. About 21,000 ac of the park lowlands are infested with this species. Over most of its HAVO range, fountaingrass occurs as scattered plants in non-native grassland, where its seeds are spread by wind over relatively short distances (Tunison in press). At present, funds are inadequate to treat the entire infested area of HAVO. Instead, fountaingrass is being controlled mechanically in a band (approximately 0.6 mi wide) on the upper edge of the lowland infestation in an attempt to prevent its spread to higher elevations. In addition, roads and trails are periodically surveyed and newly discovered fountaingrass plants are pulled. Other known outlying populations away from trails are also treated. If funding increases, we will be able to treat a greater proportion of the infested area. Research is planned to test several pre-emergent herbicides (as yet unselected) at the site of densest cover.

Special Ecological Areas

SEAs (Fig. 1) are the major focus of alien plant managemet and research efforts in HAVO (Tunison et al. 1986, Tunison and Stone in press). At present, widespread invasive alien plants are being controlled in seven of HAVO's most intact and species-rich SEAs, totalling 10,000 ac. Fourteen additional SEAs are proposed for future management or monitoring. All 21 SEAs are located within units where feral animals have been eliminated or an animal control program is in progress. Criteria for selection of SEAs include intactness, species richness, presence of rare species, manageability, potential for interpretation and research, and uniqueness. An attempt has been made to select potential areas from all ecological zones of HAVO. With this approach, degradation by alien plant species may be prevented or even reversed in some of HAVO's most intact systems.

Firetree, Faya Tree (Myrica faya).—This tree, intentionally introduced in the late 1800's and planted on several islands, is native to the Azores and Canary Islands. The species has infested more than 41,000 ac in HAVO and adjacent lands and is rapidly spreading between 2,000 and 4,500 ft elevation (Whiteaker and Gardner 1985). The fruits of firetree are spread by birds, particularly the Japanese white-eye (*Zosterops japonica*). Firetree has invaded rain forest, mesic forest, and open woodland, and in some areas has formed monotypic stands. Capable of fixing nitrogen, firetree grows rapidly and may be able to eventually replace native trees such as the 'ohi'a (*Metrosideros polymorpha*). The altered nutrient balance in invaded areas may encourage the invasion of other alien plant species.

At present, firetree is being controlled in more than 9,500 ac in HAVO, including five SEAs (Ainahou North and South, Keamoku, Keanakako'i, Kipuka Kahali'i, Thurston) and a buffer zone around Kipuka Puaulu. Young trees are uprooted. Established trees in dry open areas are cut down at the base and treated with the herbicide Tordon 22K[1] (Santos et al. 1986). Larger trees, particularly in closed forest, are left standing and are treated with the same herbicide applied in a continuous

[1] Reference to a company or product name does not imply approval or recommendation of that product by the National Park Service.

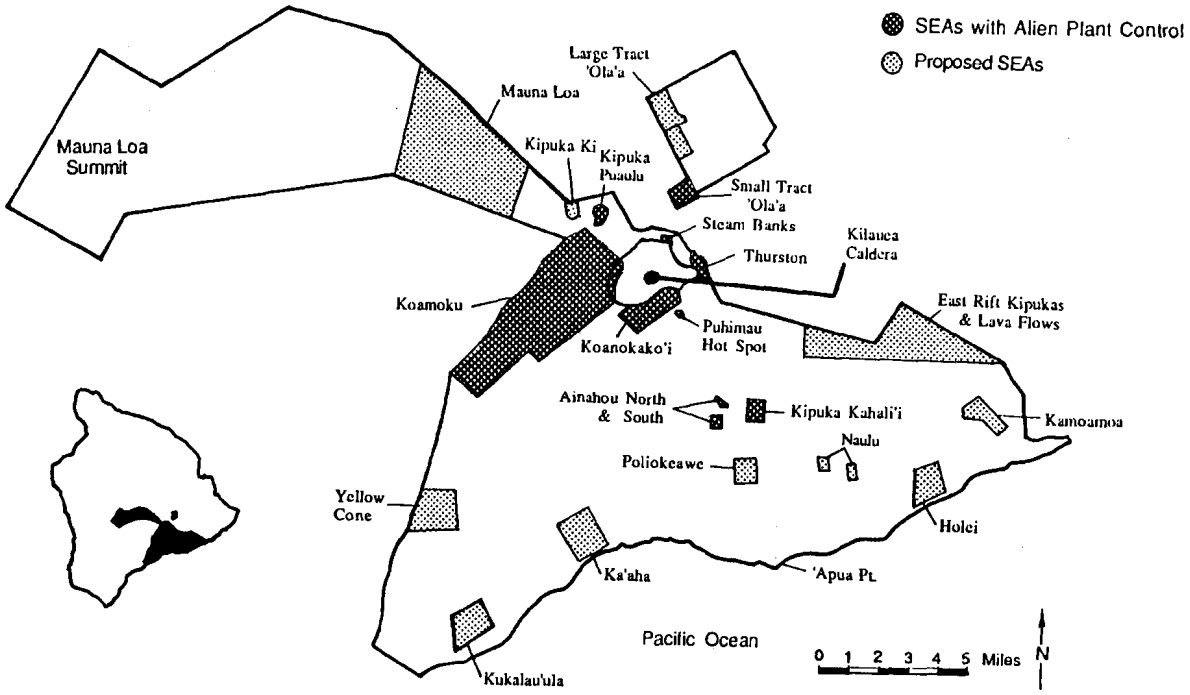

Fig. 1. Hawaii Volcanoes National Park, showing Special Ecological Areas (SEAs) with alien plant control programs, and proposed SEAs.

frill cut on the trunk. Other herbicides and application techniques have been used in the past (Gardner and Kageler 1982), but were abandoned because of costly materials and application difficulties.

Research is under way in HAVO to find other herbicides effective on firetree, because problems with Tordon 22K persistence and water table contamination on the U.S. mainland may cause the Environmental Protection Agency to withdraw it from use. Tests of the effectiveness of four additional herbicides (Chopper, Escort, Garlon 3A, Roundup) are being conducted at two sites, a rain forest (Thurston) and a drier open woodland (Kipuka Kahali'i), adjacent to SEAs in which firetree is currently being controlled. At both sites, native plants are monitored in plots surrounding each treated tree. HAVO management personnel recognize firetree as an important subject for biocontrol research, and the species is one of the subjects of the biocontrol program currently under way.

Strawberry Guava (Psidium cattleianum).—A small tree native to South America, strawberry guava was introduced to Hawai'i before 1825 (Nagata 1985). This species has invaded many wet lowland forests of Hawai'i, where it is capable of forming a dense understory which excludes other species. In HAVO, strawberry guava has invaded wet and mesic forests from 300 to 4,000 ft elevation, and it is scattered in the understory of several proposed SEAs.

Currently strawberry guava is being uprooted or treated with a cut stump application of the herbicide Tordon RTU in Ainahou North and South, Kipuka Puaulu, and Thurston SEAs (about 330 ac).

Past research has indicated that several other herbicides may be effective against strawberry guava (Gardner 1980). Current research efforts are directed at finding another effective herbicide, particularly one that will work in extremely high rainfall areas, such as Kipahulu Valley in Haleakala National Park on Maui, where strawberry guava is a serious threat to native rain forest. Several concentrations of two herbicides (Garlon 4 and Garlon 3A) are being tested on cut stumps of strawberry guava, and potential effects on adjacent native plants are being examined.

Kahili Ginger (Hedychium gardnerianum).—This species was planted as an ornamental in Volcano Village and in the HAVO housing area, probably in the 1940's (Fagerlund 1947). Unlike most ginger species in Hawai'i which seed sparingly or not at all, kahili ginger prolifically produces seeds which are spread by birds. The species has become established in the rain forests near Kilauea Crater and is invading sections of 'Ola'a Tract. Kahili ginger is a problem because it can completely dominate the understory of forests and prevent the reproduction of native plants.

Kahili ginger has been removed from two SEAs totalling about 220 ac in the mesic forest of Kipuka Puaulu and a rain forest near Thurston Lava Tube. Both areas had relatively light infestations of ginger, and most plants were small. Resources Management personnel and volunteers searched these two areas, dug up ginger rhizomes and hauled them away. This treatment is effective, but very labor intensive.

In another SEA, the small section of 'Ola'a Tract, a dense rain forest with scattered ginger plants, ginger was mechanically removed from approximately 50 of 350 ac. Treated and untreated areas are being monitored to determine if the treatment is effective and if alien plant invasion and intensification in this pig-free area are rapid enough to require immediate action.

Research is in progress to find an effective herbicide to apply to the rhizome mass that will not also adversely affect surrounding native plants. Four different herbicides (Amitrol, Arsenal, Crossbow, Escort) are being tested in an area adjacent to Thurston SEA. If such an herbicide is found, it may be possible to treat ginger in more remote forests and expand the area currently managed.

Nasturtium (*Tropaeolum majus*).—An ornamental vine from South America, nasturtium has escaped cultivation and become established in and near the mesic forest of Kipuka Puaulu SEA. Before treatment more than 30 populations occurred in an area of about 100 ac. The vines can quickly produce very dense foliage, completely cover the ground, and climb high into native trees.

Management personnel first mapped the distribution of nasturtium and found an effective herbicide to treat it. Since 1984, nasturtium in Kipuka Puaulu has been treated three times a year with a very dilute solution (less than 1 percent) of the herbicide Garlon 4 applied as a foliar spray. Nearly 30 plots were established to monitor effects on native plants and reduction in nasturtium cover. With treatment, cover of nasturtium in plots has decreased from 71 to 16 percent.

Research to determine if a pre-emergent herbicide can be used to reduce recruitment from the seed bank is in progress. Two different herbicides (Surflan and Oust) have been tested, and one (Oust) appears promising. Further tests will be concerned with application method, lowest effective rate, and effects on native plant seedlings.

Banana Poka (*Passiflora mollissima*).—Poka is a large vine native to South America, which was introduced into Hawai'i as an ornamental. This species has invaded more than half of the 10,000-ac 'Ola'a Tract (Warshauer et al. 1983), which contains most of the montane rain forest found in HAVO. Banana poka can completely smother forests. Its fruit provide food for feral pigs, which disrupt the forest ground cover and destroy the tree fern layer.

Banana poka is present in relatively low numbers in the two 'Ola'a SEAs (350 and 1,000 ac). Both have been fenced, and feral pigs have been removed or reduced to low numbers. Management of banana poka has not been initiated in the two SEAs because a control method is not known. Even though biocontrol research is being carried out by the U.S. Forest Service and its cooperators, and one potential biocontrol agent, the pyralid moth *Cyanotricha necyria*, has just recently been released at several infested sites on the island of Hawai'i, it would be desirable to have a conventional control method to use now in small, fence-enclosed, lightly infested areas of HAVO. Research is in progress to determine if the vines can be killed by cutting alone, and two herbicides (Garlon 3A and Roundup) are being tested as a stump treatment. Banana poka frequencies and densities in pig-infested and nearly pig-free adjacent areas are being followed through time to help determine the need for immediate control of this plant.

Yellow Himalayan Raspberry (*Rubus ellipticus*).—This species was introduced to Hawai'i relatively recently as a potential food plant. It apparently spread into HAVO from a nearby experimental farm (Smith, in press). Yellow raspberry is spread by birds and is invading the rain forests of 'Ola'a Tract and the Kilauea Crater area. The full potential of the plant is not known, but it is capable of forming huge, dense thickets in wet forests. At present, the only SEAs affected by the yellow raspberry invasion are Thurston and the two SEAs in 'Ola'a Tract, but other wet and mesic forests within HAVO are threatened.

Because no control method is currently known, management has not been initiated. We are monitoring yellow raspberry density and population structure in one infested SEA, the small section of 'Ola'a Tract. Research is under way to test six different herbicides (Arsenal, Crossbow, Escort, Garlon 3A, Garlon 4, Tordon 22K) on the cut stumps of yellow raspberry in the 'Ola'a rain forest adjacent to the small section.

FUTURE ALIEN PLANT MANAGEMENT AND RESEARCH IN HAVO

As the most invasive alien plants are controlled in the seven managed SEAs and management workloads decrease, alien plant control will be initiated in additional designated areas.

Research in HAVO will continue on the eight alien plant species discussed above and will begin on additional invasive plants found in other SEAs or on localized alien plants which prove intractable to management efforts. Monitoring will continue in managed SEAs to help us understand alien and native plant relationships over time. In unmanaged SEAs, research will follow densities

and population structures of selected alien and native plant species to allow us to determine if and when management is needed.

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