SUCCESS IN CONTROLLING LOCALIZED ALIEN PLANTS IN HAWAII VOLCANOES NATIONAL PARK

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ABSTRACT

Alien plant management at Hawaii Volcanoes National Park emphasizes control of localized alien plant species on a parkwide basis and control of widespread alien species in Special Ecological Areas. The purpose of the localized alien plant control program is to prevent the spread of potentially disruptive nonnative species while populations are still manageable. The program has intensified in the last five years, with control efforts currently directed at 41 species. Some of the more significant target species are black wattle (*Acacia mearnsii*), castor bean (*Ricinus communis*), nasturtium (*Trapaeolum majus*), New Zealand flax (*Phormium tenax*), and Formosan koa (*Acacia confusa*). Target species were identified by weediness in other areas, expansions of range or densities in the Park, affinities to known invasive taxa in Hawaii, viney habit, and/or readily dispersed dissemules. Target species were mapped by surveys from 1983 to 1986 along roadsides, trails, developed areas, and in approximately 39,500 a (16,000 ha) of backcountry incidental to other management tasks. Effective treatment methods, developed mostly from trial and error practice, are described. Target populations were monitored to determine the effectiveness of control practices by counting individuals surviving treatments or estimating aerial cover following treatment. Control efforts have been effective on 21 of 41 species under management. Reproduction has been curtailed, and populations have been markedly reduced. Eleven of these species were not observed for over one year, but it is premature to conclude that they have been eradicated. Nine other species were reduced to a population of seedlings (or a few sprouts). Population size and/or reproduction were reduced in 17 other species, suggesting partial control. Work loads are declining on all species partially or completely controlled. Reproduction or population size were not affected on three species. The ability of managers to correctly identify potentially disruptive species, together with restriction of reconnaissance for new introductions to a fraction of the total area in the Park, may result in preventing establishment and spread of new alien plants in the Park.

INTRODUCTION

Localized Alien Plant Control Program

Alien plant management at Hawaii Volcanoes National Park emphasizes control of localized plant species on a parkwide basis, control of some widespread species in localized areas called Special Ecological Areas (Tunison and Stone, this volume), and biological control for suitable widespread species. Only localized alien plant species with the potential to disrupt native vegetation or prevent the recovery of native plant communities are targeted for control in the program described in this paper.

Localized alien plant species to be managed are selected on the basis of plant aggressiveness in Hawai'i and elsewhere, affinites with aggressive taxa, possession of readily dispersed dissemules, and/or viney habit. The advice of local botanists is sought. Some localized alien plant species are threats to a number of native plant communities; others affect limited areas or vegetation types (Table 1). A few are targeted for control because they became established recently in the Park and appear to be easily eradicable.

The localized alien plant control program started in 1982 with two target species and expanded rapidly; 12 species were added in 1983, 10 in 1984, 15 in 1985, and only one in 1986. The reason for the program expansion was not the recent establishment of target species, but a growing emphasis on control of potentially disruptive introduced plant species with currently limited ranges. Although Park collection records are incomplete, they suggest that most target species have occurred in the Park for 10 to 60 years (Fosberg 1975; Division of Resources Management, Hawaii Volcanoes National Park, unpub. data).

Surveys for new weeds along roadsides are now made every three months incidental to fountain grass (*Pennisetum setaceum*) control, annually in Special Ecological Areas in conjunction with other weed control efforts, and twice yearly in developed areas and along trails.

Target species

Approximately 405 nonnative plant species grow in the Park (Higashino *et. al.* 1988). Many naturalized plant species are localized and are comprised of a few to a few hundred individuals distributed over a few to several hundred hectares, or as many as 100,000 individuals over a few hectares (*e.g.*, wire vine (*Muehlenbeckia axillaris*) -- three individual vines in two locations; Formosan koa (*Acacia confusa*) -- approximately 370 individuals scattered over 1,235 a (500 ha); and sisal (*Agave sisalana*) -- over 100,000 individuals concentrated in 12 a or 5 ha).

Twenty-seven of the 40 target species are probably deliberate introductions to the Park, most planted as ornamentals in the Kīlauea Crater Rim area or as reforestation, shade, or forage species at 'Āinahou Ranch, a former inholding now included as National Park Service land. Six species are unintentional introductions along roads, apparently from fill (Table 1).

Table 1. Characteristics of localized alien plant species currently managed in Hawaii Volcanoes National Park.

Target Species	Family	Origin	Fruit	Habit	Introduction to Park	Reason for Controlling
Acacia confusa (Formosan koa)	Legum.	Philippines, Taiwan	Dry pod	Tree	Intentional: shade	Spreading in Park
Acacia mearnsii (black wattle)	Legum.	Australia	Dry pod	Tree	Intentional: reforestation	Invasive in Hawai'i; spreading in Park
Acacia melanoxylon (blackwood acacia)	Legum.	Australia	Dry pod	Tree	Intentional: reforestation	Invasive in Hawai'i; spreading in Park
Agave americana (century plant)	Amary.	Trop. Amer.	Capsule	Per. herb	Intentional: ornamental	Spreading in Park
Agave sisalana (sisal)	Amary.	Trop. Amer.	Bulbils	Per. herb	Intentional: ornamental	Invasive in Hawai'i; spreading in Park
Albizia sp. (albizia)	Legum.		Dry pod	Tree	Accidental: road fill	Invasive in Puna
Ardisia crenata (Hilo holly)	Mryta.	S. Asia	Red berry	Low	Intentional: ornamental	Invasive in lowlands; manageable
Arthrostema ciliatum (arthrostema)	Melas.	S. Amer.	Many-seeded capsule	Herb	Accidental	Invasive in Hawai'i; invasive family; manageable

Target Species	Family	Origin	Fruit	Habit	Introduction to Park	Reason for Controlling
Benicasa hispida (Chinese melon)	Cucur.	Trop. Asia	Large berry	Vine	Intentional: food	Spreading in Park
Casuarina equisetifolia (ironwood)	Casua.	Trop. Pacif.	Winged seeds	Tree	Intentional: reforestation	Invasive in Hawai'i
Desmodium cajanifolium	Legum.	Trop. Amer.	Dry pod	Perenn. herb	Accidental: road fill	Invasive in Hawai'i
Eleagnus umbellata	Elea.		Red berry	Low shrub	Intentional: ornamental	Invasive in Volcano Village; manageable
Eriobotrya japonica (loquat)	Rosac.	China/Japan	Pome	Small tree	Intentional: food	Spreading in Park
Eucalyptus spp. (eucalyptus)	Myrta.	Australia	Many-seeded capsule	Tree	Intentional	Spreading in Park
Feijoa sellowiana (guavasteen)	Myrta.	S. Amer.	Berry	Small tree	Intentional: food	Spreading in Park; manageable
Ficus pumila (climbing fig)	Morac.	Japan/China	Drupe	Vine	Intentional: ornamental	Viney habit; manageable
Fraxinus americana (white ash)	Oleac.	N. Amer.	Winged seeds	Tree	Intentional: reforestation	Spreading in Park

Table 1, continued.

Table 1, continued.

Target Species	Family	Origin	Fruit	Habit	Introduction to Park	Reason for Controlling
Fraxinus uhdei (tropical ash)	Oleac.	Mexico	Winged seeds	Tree	Intentional: reforestation	Invasive in Hawai'i
Fuchsia paniculata (fuchsia)	Onagr.	Mexico	Fleshy black berry	Shrub	Intentional: ornamental	Fruit dispersable by birds; manageable
Hedera helix (English ivy)	Arali.	Eurasia	Black berries	Vine	Intentional: ornamental	Fruiting in Park; fruits attractive to birds; spreading in Park
Heterocentron subtriplinervium (pearl flower)	Melas.	Mexico	Many-seeded capsule	Shrub	Intentional? ornamental	Invasive family; population spreading from roadside
Luculia gratissima	Rubia.	S. Asia	Winged	Small Tree	Intentional: ornamental	Seeds readily dispersed
Lupinus sp. (lupine)	Legum.		Dry pod	Herb	Accidental: road fill?	Manageable
Melaleuca quinquenervia (paperbark)	Myrta.	Australia	Many-seeded capsule	Tree	Intentional: reforestation	Invasive in Hawai'i
Melochia umbellata (melochia)	Sterc.	India	Winged seeds in capsules	Tree	Accidental: road fill	Invasive in lowlands; manageable

Target Species	Family	Origin	Fruit	Habit	Introduction to Park	Reason for Controlling
Muehlenbeckia axillaris (wire vine)	Polyg.	New Zealand	Nut	Vine	Intentional: ornamental	Viney habit
Opuntia ficus-indica (prickly pear)	Cacta.	Mexico	Fleshy berry	Stem succulent	Intentional: forage	Invasive in Hawai'i
Paederia scandens (maile pilau)	Rubia.	S. Asia	Berry	Vine	Accidental: road fill	Spreads in lowlands; Viney habit; manageable
Phoenix dactylifera (date palm)	Palma.	N. Africa	Drupe	Tree	Intentional?	Manageable
Phormium tenax (New Zealand flax)	Lilia.	New Zealand	Capsule	Herb	Intentional	Invasive in Hawai'i
Phyllostachys sp. (bamboo) (possibly two spp.)	Grami.			Woody grass	Intentional: ornamental	Invasive in Hawai'i
Pinus sp. (pine)	Pinac.		Winged seeds	Tree	Intentional: wood, shade	Spreading in Park
Pittosporum undulatum	Pitto.	Australia	Orange capsule; red seeds	Small tree	Intentional: ornamental	Spreading in Park

Table 1, continued.

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Target Species	Family	Origin	Fruit	Habit	Introduction to Park	Reason for Controlling
Prosopis pallida (kiawe)	Legum.	S. Amer.	Dry pod	Tree	Accidental	Invasive in Hawai'i; spreading in Park
Pueraria lobata (kudzu)	Legum.	Asia	Dry pod	Vine	Intentional: livestock forage	Invasive on Mainland
Ricinus communis (castor bean)	Eupho.		Capsule	Shrub	Accidental	Invasive in Hawai'i; spreading in Park
Soliva sessilis	Compo.	N. Amer.	Achene	Herb	Accidental	Forms dense ground cover in Calif; manageable
Syzygium jambos (rose apple)	Myrta.	Trop. Asia	Berry	Tree	Accidental	Invasive in Hawai'i; manageable
Tibouchina urvilleana (glorybush)	Melas.	Brazil	Capsule(no seeds seen)	Tall shrub	Intentional: ornamental	Invasive in Hawai'i
Trema orientalis (gunpowder Tree)	Ulmac.	Malaysia	Drupe	Tree	Accidental; in roadside fill	Invasive in lowlands
Tropaeolum majus (Nasturtium)	Tropae.	S. Amer.	Capsule	Vine	Intentional: ornamental	Monospecific stands in montane seasonal

METHODS

Distributions of localized alien plant species were delineated by systematic mapping. Surveys were made along roads, developed areas, trails, and neighboring subdivisions (L. Stemmermann, unpub. data), in seven Special Ecological Areas (6,670 a or 2,700 ha), and in ʻAinahou Ranch (3,705 a or 1,500 ha). Park staff examined pig activity transects in approximately 1,360 a (550 ha) of ʻŌlaʻa Tract (S.J. Anderson, unpub. data) and 8,645 a (3,500 ha) of the Mauna Loa Strip (L.K. Katahira, unpub. data). About 29,840 a (12,000 ha) of coastal lowlands and submontane seasonal environment are also surveyed incidental to fountain grass control work.

Treatment methods developed by Park Resources Management staff were applied to 36 target species (Table 2). Park researchers developed methods for one species, and control methods for another were available from the literature. Introduction of known effective biocontrol agents was attempted for a third species (Davis *et al.*, this volume). Uprooting was used exclusively for three herbaceous species and for seedlings of most species. Herbicides were used to control at least one life stage of 36 species and were applied by foliar spray, cut stump, or frill (notching the bole of a standing tree) techniques (Table 2).

Effectiveness of treatments was monitored at three- to six-month intervals, and retreatments were applied as needed. The retreatments required were determined by counting numbers of target individuals, or estimating the aerial cover of target species prior to, and at intervals after, treatments were applied. Effects on nontarget (native) species were not consistently determined.

RESULTS

Eleven treated plant species were not observed over one year after treatment: albizia (*Albizia* sp.), Chinese melon (*Benicasa hispida*), eleagnus (*Eleagnus umbellata*), guavasteen (*Feijoa sellowiana*), tropical ash (*Fraxinus uhdei*), fuchsia (*Fuchsia paniculata*), *Luculia gratissima*, paperbark (*Melaleuca quinquenervia*), maile pilau (*Paederia scandens*), New Zealand flax (*Phormium tenax*), and rose apple (*Syzygium jambos*) (Table 2). One other species, *Desmodium cajanifolium*, was not observed six months after treatment.

Populations of nine species were reduced to seedling stages (or sprouts) with significantly reduced population numbers: black wattle (*Acacia mearnsii*), from 240 to 30 seedlings (when last monitored); blackwood acacia (*Acacia melanoxylon*), from 20 plants to 8 seedlings; ironwood (*Casuarina equisetifolia*), from 20 plants to 4 sprouts; loquat (*Eriobotrya japonica*), from 6,750 plants to 42 seedlings; white ash (*Fraxinus americana*), from 76 plants to 2 seedlings; date palm (*Phoenix dactylifera*), from 16 plants to 2 seedlings; *Pittosporum undulatum*, from 25 plants to one seedling; kiawe (*Prosopis pallida*),

Table 2. Changes in target alien plant populations with treatment; most effective treatments used in Hawaii Volcanoes National Park.

Species	Population Changes		Most Effective Treatment Used		Comments
	Status/Start	Current Status	Appl. Technique	Herbicide	
Acacia confusa (Formosan koa)	370 plants (12/84)	50 plants (11/86)	Basal bark (sapl.) Cut stump (mature) Uproot (seedlings)	5% Garlon 4/ diesel; Tordon RTU	Remainder to be removed by contractor.
Acacia mearnsii (black wattle)	240 plants (1/81)	30 plants (4/87)	Basal bark (mature) Uproot (seedlings)	5% Garlon 4/ diesel	Population reduced to seedling stage.
Acacia melanoxylon (blackwood acacia)	20 plants (2/85)	8 plants (11/86)	Cut stump (mature) Uproot (seedlings)	Tordon RTU	Population reduced to seedling stage.
Agave americana (century plant)	25 plants (1/85)	5 plants (4/87)	Foliar (mature) Uproot (seedlings)	5% Garlon 4	Some plants in hard to reach area on wall of Kīlauea Caldera.
Agave sisalana (sisal)	>100,000 plants	<25,000 plants	Foliar	5% Garlon 4	Effective treatment found 2/87; method only partially effective on small plants.
Albizia sp. (albizia)	1 plant (12/85)	0 plants (4/87)	Cut Stump	2% Garlon 4/ diesel	One plant found along roadside killed.
Ardisia crenata (Hilo holly)	2 plants (1/86)	2 plants (4/87)			No effective treatment found to date.

Species	Population Changes Status/Start	Current Status	Most Effective Treatment Used Appl. Technique	Herbicide	Comments
Arthrostema ciliatum (arthrostema)	>100 plants (6/84)	<25 plants (11/85)	Uproot		
Benicasa hispida (Chinese melon)	1 ha colony (7/83)	No plants (4/87)	Uproot		Apparently eradicated; no plants found since 10/84.
Casuarina equisetifolia (ironwood)	20 plants (3/83)	4 plants (12/86)	Basal bark	2-5% Garlon 4/ diesel	Reproduction curtailed; retreating persistent sprouts.
Desmodium cajanifolium	1 plant (11/86)	0 plants (4/87)	Uproot		One plant found along roadside.
Eleagnus umbellata	1 plant (10/84)	0 plants 11/86)	Cut stump	Tordon RTU	One plant at Volcano House killed.
Eriobotrya japonica (loquat)	6,750 plants (7/84)	42 plants (4/87)	Cut stump Uproot (seedlings)	2% Garlon 4	Population mostly seedlings and saplings; small numbers of seedlings recruited.

Table 2, continued.

Table 2, **continued.**

Species	Population Changes: Status/Start	Population Changes: Current Status	Most Effective Treatment Used: Appl. Technique	Most Effective Treatment Used: Herbicide	Comments
Eucalyptus spp. (eucalyptus)	30 plants (5/83)	3 plants (1/87)	Cut stump	2% Garlon 4 Tordon RTU	Retreating persistent sprouts; effectiveness of treatments increasing as methods refined; both Garlon and Tordon RTU only partially effective.
Feijoa sellowiana (guavasteen)	20 plants (11/85)	0 plants (4/87)	Cut stump (mature) Uproot (seedlings)	**Tordon RTU**	This species apparently eliminated from Park.
Ficus pumila (climbing fig)	3 plants ($900\ m^2$) (1/85)	3 plants ($90\ m^2$) (5/86)	Foliar	**5% Garlon**	Possibly eradicated.
Fraxinus americana (white ash)	76 plants (1/83)	2 plants (4/87)	Frill (mature) Foliar (saplings) Uproot (seedlings)	5% Garlon 4 5% Garlon 4	Population reduced to seedling stages.
Fraxinus uhdei (tropical ash)	1 plant (9/84)	0 plants (3/87)	Cut stump	Tordon RTU	Probably eradicated.
Fuchsia paniculata (fuchsia)	3 plants (12/85)	0 plants (12/86)	Cut stump (mature) Uproot (small)	Tordon RTU	Population probably eradicated.

Species	Population Changes Status/Start	Current Status	Most Effective Treatment Used Appl. Technique	Herbicide	Comments
Hedera helix (English ivy)	8 plants (6/85)	7 plants (4/87)	Foliar (mature) Uproot (seedlings)	2% Garlon 4	Large population at ʻĀinahou Ranch not yet treated; seedling found in Thurston; treatment results inconsistent.
Heterocentron subtriplinervium (pearl flower)					Control efforts not started.
Luculia gratissima	2 plants	0 plants	Cut stump	Tordon RTU	Probably eradicated.
Lupinus sp. (lupine)	35 plants (3/84)	4 plants (4/87)	Uproot		Population reduced to flowering stages.
Melaleuca quinquenervia (paperbark)	6 plants (6/83)	0 plants 4/87)	Cut stump (mature) Uproot (seedlings)	Tordon RTU	Probably eradicated.
Melochia umbellata (melochia)	9 plants (10/83)	5 plants (4/87)	Cut stump (mature) Uproot (seedlings/ saplings)	Tordon RTU	Continues to be introduced along Park boundary.
Muehlenbeckia axillaris (wire vine)	3 plants (2/83)	1 plant (11/86)	Foliar	2% Garlon 4	Two of three plants probably eradicated.

Table 2, continued.

Table 2, continued.

Species	Population Changes Status/Start	Current Status	Most Effective Treatment Used Appl. Technique	Herbicide	Comments
Opuntia ficus-indica (pānini cactus)	100 plants/ 30 populations	100 plants/ 30 populations			Two biological control agents, *Cactoblastis cactorum* and *Dactylopius opuntiae*, introduced to local populations; some plants declining.
Paederia scandens (maile pilau)	1 colony (3/85)	0 plants (4/87)	**Foliar**	**5% Tordon 22K**	Probably eradicated.
Phoenix dactylifera (date palm)	16 plants (3/85)	2 plants (4/87)	**Cut stump**	**100% Banvel**	Reduced to seedling stages.
Phormium tenax (New Zealand flax)	3 colonies (12/82)	0 plants (4/87)	Foliar (mature) Uproot (sprouts)	**2% Roundup**	Probably eradicated from **Park.**
Phyllostachys sp. (bamboo)	2 colonies (12/83)	1 colony (4/87)	Foliar	**5% Garlon 4**	One colony eradicated; the other resistent to all treatments tried; possibly two species.
Pinus sp. (pine)	110 plants (4/83)	5 plants (5/86)	Cut (mature) Uproot (seedlings)		Reproduction away from main population treated; main population not treated.

Species	Population Changes Status/Start	Current Status	Most Effective Treatment Used Appl. Technique	Herbicide	Comments
Pittosporum undulatum	25 plants (12/85)	0 plants (11/86)	Cut stump (uproot) Uproot (seedlings)	Tordon RTU	Premature to consider eradicated.
Prosopis pallida (kiawe)	105 plants (3/85)	3 plants (4/87)	Cut stump (mature) Uproot (seedlings)	100% Roundup 5% Garlon 4/ diesel	5% Garlon 4/diesel partially effective.
Pueraria lobata (kudzu)	210 shoots (9/84)	42 shoots (4/87)	Dig up root		Recommended method (2% Roundup) only partially effective.
Ricinus communis (castor bean)	600 plants (3/85)	200 plants (3/87)	Cut stump (mature) Uproot (seedlings)	100% Banvel	Population reduced to seedling stages; Banvel nearly 100% effective.
Soliva sessilis	125 plants (4/85)	5 plants (4/87)	Uproot		Reduced to seedling stages.
Syzygium jambos (rose apple)	2 plants (12/85)	0 plants (5/86)	Cut stump	Tordon RTU	Two plants in Kilauea Caldera below Volcano House apparently killed.
Tibouchina urvilleana (glorybush)					Some populations not treated to date.

Table 2, continued.

Table 2, continued.

Species	Population Changes: Status/Start	Population Changes: Current Status	Most Effective Treatment Used: Appl. Technique	Most Effective Treatment Used: Herbicide	Comments
Trema orientalis (gunpowder tree)	200 (3/83)	25 (3/87)	Basal Bark	5% Garlon 4/ diesel	Plants invade roadsides.
Tropaeolum majus (nasturtium)	67% cover in monitoring plots (6/84)	2% cover (6/87)	Foliar	0.4% Garlon 4	Mapped 9/83; new populations found since then; no populations eradicated but cover reduced in populations by 23%.

from 76 plants to 2 sprouts; and castor bean (*Ricinus communis*), from 600 to 200 seedlings (Table 2).

Reproduction and/or population size were reduced in 18 of the 20 other taxa: Formosan koa (*Acacia confusa*), century plant (*Agave americana*), sisal (*A. sisalana*), *Arthrostema ciliatum*, eucalyptus (*Eucalyptus* sp.), climbing fig (*Ficus pumila*), English ivy (*Hedera helix*), lupine (*Lupinus* sp.), melochia (*Melochia umbellata*), wire vine (*Muehlenbeckia axillaris*), pānini cactus (*Opuntia ficus-indica*), pine (*Pinus* sp.), bamboo (*Phyllostachys* sp.), kudzu (*Pueraria lobata*), *Soliva sessilis*, gunpowder tree (*Trema orientalis*), glorybush (*Tibouchina urvilleana*), and nasturtium (*Tropaeolum majus*) (Table 2). Reproduction was curtailed but population size was not affected in Hilo holly (*Ardisia crenata*). Reproduction and population size were not reduced in pearl flower (*Heterocentron subtriplinervium*).

The number of worker days allocated to localized alien plant control projects increased significantly from 1983 through 1985 as the number of target species increased. Forty-seven worker days were expended in 1983, and 299 in 1985. The work load decreased sharply thereafter as the time required to treat each species declined. Seventy-five worker days were expended in 1987. Surveys to locate target plants, labor-intensive initial treatments of mature individuals, and larger populations required relatively greater time in the first stages of control of most weed species than in later stages.

DISCUSSION

Eradication

The 11 target species not observed more than one year after treatment may be eradicated. However, seed banks may be present, and resprouting may occur. Populations of 21 target species were very small. Two of these were trees or shrubs consisting of one individual each. Populations of six other species were comprised of less than seven individuals. One tree population was 20 individuals. Another species was an herbaceous vine, possibly consisting of one individual colonizing a 5-a (2-ha) area (Table 2).

More species of localized alien plants were not eradicated for the following reasons:

1. Control work had begun only recently at the time. Treatments of most species were started between 1983 and 1985 (Table 2). Most treatment methods were discovered by trial and error procedures, and typically 6 to 12 months were required to determine the effectiveness of the methods. Only a few populations of six target species have been treated (Formosan koa, century plant, sisal, eucalyptus, English ivy, pine, and glorybush). Control efforts were not started for one species, pearl flower.

2. Effective treatment methods were not known at the outset of control efforts, and effective methods are still not available for pearl flower and pānini cactus (Table 2).

3. Soil seed banks or extensive underground root systems may require a number of years to deplete.

4. Some species continue to be reintroduced along roadsides, *e.g.*, gunpowder tree and melochia.

Rationale for Control Program

The main rationale for the localized alien plant control program is the cost effectiveness of controlling alien plant species prior to expansion. Expensive management programs on species following range expansions are thus avoided. Moreover, controlling localized species reduces further degradation of native plant communities and Special Ecological Areas by alien species.

Localized alien plant control may not seem worthwhile when disruptive, widespread alien plants continue to spread throughout most of the Park (except in Special Ecological Areas). For example, the value of controlling castor bean in the lowlands may be questioned if fountain grass cannot be controlled. However, we believe that control of localized species is justified because the potential range and ecological impact of many widespread species cannot be predicted with great certainty. Moreover, biological control may eventually become available for some widespread species.

Limitations of Control Program

Effective management of localized alien plant species on a parkwide basis is limited by factors that make it impossible to prevent the successful introduction of all new weed species in the Park:

1. Reconnaissance to detect new introductions is restricted to a small percentage of the Park. Systematic and regular scouting for new introductions has focused on ruderal habitats such as roadsides, trails, and developments, areas known to support many weed species (*e.g.*, ʻĀinahou Ranch), and designated Special Ecological Areas. Some weeds become established in areas not regularly reconnoitered for new weeds. In many cases, botanists are not available for survey work. Consequently, most areas of the Park are not being adequately surveyed for the establishment of new weeds.

2. Managers are not able to correctly predict with certainty the invasiveness of localized alien plants, so potential threats may not be correctly identified. Most localized alien plant species are not currently managed. Additional species can be anticipated to invade the Park, and it is likely that some of these will become disruptive. Compounding the problem of correctly identifying alien plant threats is the fact that disruptive species may occur at low population levels for many years before spreading. For example, Christmas berry (*Schinus terebinthifolius*) is known from collections in Florida in the 1850s,

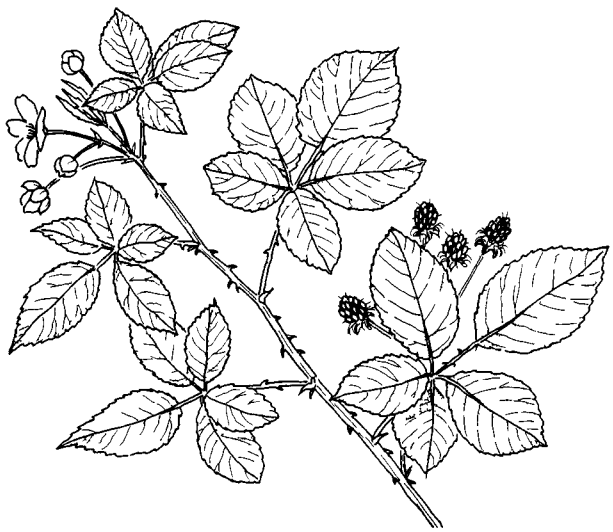
yet it did not become a significant problem until the 1950s (Ewell *et al.* 1982). Moreover, it is not possible to predict with great certainty the behavior of alien plants from other parts of Hawai'i. For example, olive (*Olea europaea* subsp. *africana*) has spread rapidly over several thousand hectares in the 'Āinahou Ranch area of the Park, but it is not normally invasive in Hawai'i.

3. There is high potential for invasions from adjacent areas. This results from increasing introduction of species due to ineffective control and quarantine (Smith 1985) and encroachment of development on Park boundaries. To date, reinvasion appears to be a problem only with a few species along roadsides.

CONCLUSIONS

Effective treatment methods and parkwide control were implemented for 21 of 40 target species. Control was effected by markedly reducing populations and curtailing reproduction; work loads decreased. It is premature to conclude that any species have been eradicated because of the presence of seed banks or the potential for resprouting. Seventeen additional target species are partially controlled in that populations and reproduction are reduced. Three species have not been controlled at all. Success of the first five years of the program suggests that uncontrolled species will be controlled once effective treatment methods become available and control efforts are extended to all populations in the Park.

One of the most significant findings of the localized plant control program is that successful control requires a regime of consistent and timely followup treatments. Moreover, alien plant species, even when comprised of only one to several plants, may require a number of years for successful control, and probably much longer for eradication.



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