ELEMENT STEWARDSHIP ABSTRACT
for

Psidium cattleianum

Strawberry Guava

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The Nature Conservancy
Element Stewardship Abstract
For *Psidium cattleianum*

I. IDENTIFIERS

Common Name: PURPLE STRAWBERRY GUAVA Global Rank: G?

General Description:
Small tree of the myrtle family (Myrtaceae).

II. STEWARDSHIP SUMMARY

Strawberry guava is a very serious habitat-disruptive pest in many parks and preserves in Hawaii because of its tendency to form mono-specific stands. It is a potential pest at Kamakou Preserve but not at Waikamoi, unless the preserve is expanded to lower elevations. Prolific fruiting, shade tolerance, clonal regenerative strategy, tolerance of heavy litter fall, and possible allelopathic effects contribute to the success of this species. Removal of feral pigs is the sine qua non and first step of successful management of strawberry guava because pigs disperse prodigious quantities of seed. This must be followed by manual, mechanical, and chemical control measures. These have proven successful when tested on a small scale, and recruitment is low in pig-free intact forest, even with dispersal into the treated area from densely infested adjacent areas. Biological control is the long-term management solution to strawberry guava, and the prospect of locating highly specific biocontrol agents is cause for optimism about the future of biological control for this pest. Clarification of the recovery process is the single most important monitoring need.

Management and monitoring needs at Kamakou consist of feral pig control, scouting and mapping to locate all individuals, manual, mechanical, and chemical control measures, and vigilant monitoring of reinvasion and seedling recruitment.

III. NATURAL HISTORY

Habitat:
Originally introduced to Hawaii in the early nineteenth century for the edible fruit (Neal 1965), strawberry guava now occurs widely on all major islands in mesic and principally rain forest environments up to 1300 m (Smith 1985). It is most abundant below 800 m elevation (Little and Skolmen 1989, Wagner et al 1990). Single-species stand formation is, however, well on its way at 1,100 m elevation in Hawaii Volcanoes National Park. The natural range for at least one of the yellow-fruited form is coastal Brazil in shrubby vegetation or early successional forest. It is not an aggressive species in its native habitat (Hodges 1988). The red-fruited form is found at approximately 900 m elevation in eastern Brazil (Smith, pers. comm.).

Ecology:
Jacobi and Warshauer (in press) found strawberry guava from 100-1,300 m elevation gradient and over a rainfall gradient from 1,250 mm (50 in)- 7,000 mm (275 in)/year in 23 different vegetation types from dry grassland and scrub to tall native rainforest. It was most abundant in wet `ohi`a-tree fern rainforest and wet `ohi`a-koa rainforest. Strawberry guava is a highly shade-tolerant species, and seedlings and root sprouts are capable of growing in dense shade from taller canopy species and that of the parent plants. Sem (1984) found strawberry guava to be tolerant of moderately to highly acidic soils. Allelopathy may contribute to its success (Smith 1985). Brown et al. (1983) found that exudates from the roots of common guava (Psidium guajava) inhibited the growth of two plant species, and ruled out soil pH was responsible for the inhibition.

Genetic variability among taxa of Psidium cattleianum may contribute to broad environmental tolerances. Yellow fruited forms are more common at lower elevations in Hawaii Volcanoes National Park (Huennke and Vitousek 1989). Red-fruited forms dominate higher elevation sites.

The ability of strawberry guava to tolerate heavy litter fall may pre-adapt it to survival in Hawaiian rain forests. Huenneke and Vitousek (1989) found that in their study plots, when the smaller diameter strawberry guava stems were bent to the ground by the heavy litter of tree fern fronds, they invariably survived, and most sent up vigorous shoots after being bent. Native tree and shrub seedlings were typically killed by heavy tree fern litter.

Reproduction:
Broad environmental tolerances, prolific production of fruit, expansive vegetative reproduction, and dispersal by feral pigs contribute to the success of strawberry guava as a weed. Regeneration is by seed and root sprouts. Both apparently contribute to thicket formation characteristic of strawberry guava, although their relative abundance may vary considerably from site to site (Huenneke and Vitousek 1989). Generally, root suckers of clonal species tend to dominate in thicket formation because of their rapid growth and high survivorship. Consistent with this, root sprouts of strawberry guava have greater leaf area (Huenneke and Vitousek 1989). However, the dynamics of thicket formation and the contributions of sprouts and seedling require further detailed study (Huenneke and Vitousek 1989). Stem densities were high in thickets, ranging from 3-9 stems/m2.

Strawberry guava is a prolific fruiter. Diong (1983 found an average of 15 seeds/fruit in lower Kipuhulu Valley on Maui. Huenneke and Vitousek (1989) found 25-70 seeds/fruit in five different study sites on Hawaii Island. Fruiting is more abundant for stems on the edge of the thickets.

Seeds are dispersed beyond the vicinity of the parent tree by alien frugivorous birds and feral pigs (Sus scrofa) (Smith 1985), although the evidence for bird dispersal is incomplete. La Rosa et al. (1987) demonstrated that myna (Acridotheros tristis) and Japanese white eye (Zosterops japonicus) will eat strawberry guava seed in captivity and that collected scat contained seeds that germinate at similar rates to control seeds. Diong (1983) demonstrated that feral pigs are very significant dispersers. He found strawberry guava in 90% of the scats observed in sites with guava. The germination rates of seeds in pig scat were similar to that of untreated seeds, although germination was more rapid when seeds passed through the digestive tracts of pigs. From the number of seeds found in scats, he calculated that each pig in densely infested portions of Kipuhulu Valley was responsible for dispersing approximately 8,000,000 seeds per month during the peak fruiting season.

Diong (1983) perceived a mutualistic relationship between pigs and strawberry guava in Kipahulu Valley. Strawberry guava provided the main food source August-December. Pigs dispersed the plant to new areas, and these new establishments created favorable habitat for feral pigs. However, strawberry guava is not dependent on animal processing of seeds and dispersal. It germinates successfully in undisturbed forest. In fact, Huenneke and Vitousek (1989) found that seedling establishment was independent of soil disturbance, with naturally occurring seedlings found disproportionately on bryophyte mats and other undisturbed sites. Tunison et al. (in prep.) found seedling and sprout recruitment of strawberry guava in a mostly intact rainforest 10 years after removal of pigs.

Huenneke and Vitousek (1989) thought that strawberry guava does not form significant seed banks, but may rely on "seedling banks." They could find few seeds in the soil and these failed to germinate. However, Cuddihy (pers. comm.) found 50% percent germination of buried soil at nine months and 20% at 21 months.

Impacts:
Psidium cattleianum readily displaces native plant species, eventually forming single species stands. Smith (1985) characterized it as the worst pest in Hawaiian rain forests. Its most serious infestations are on Hawai`i Island when it invades forests undergoing `ohi`a dieback and in Kipuhulu Valley on Maui (Hodges 1988). It is probably not a serious threat to Waikamoi because Psidium appears to be limited by elevation, with essentially no individuals above 1,300 m. Waikamoi's boundaries are currently above this elevation. Psidium now is sparingly established in disturbed areas, principally roadsides, in Kamakou Preserve. It is intensifying in forest reserves at lower elevation, and may represent an important potential threat to Kamakou. Using Jacobi's and Warshauer's model (Jacobi and Warshauer, in press), all of Kamakou falls within the potential habitat of strawberry guava, based on current elevational and rainfall characteristics of strawberry guava habitat. However, suitable forest habitat near the ridge line lies at the extremes of the rainfall and elevational gradients and may not be optimal habitat for strawberry guava.

IV. CONDITION

Restoration Potential:
Information on recovery potential is anecdotal and limited. Tomich (pers. comm.) experimentally controlled strawberry guava in a 15 X 15 m site in an extensive dense guava stand on Hawaii Island from which essentially all native plants had been excluded.

He found that after 10 years that native ferns, especially Athyrium sandwicensium, had become abundant in the understory and that a few native trees had become established. In Hawaii Volcanoes National Park and Kalopa State Park, guava thickets were removed from the understory of native forest with an intact canopy (Tunison et al. in prep., Tomich, pers. comm.). These appeared to resist the invasion of other alien plant species, although the extent of native species recovery in unknown. Low recruitment levels of strawberry guava in sites with intact overstory and feral pigs control, even those surrounded by high densities of this weed, suggest high potential for the recovery of native vegetation.

V. MANAGEMENT/MONITORING

Management Requirements:
Active searching, distribution mapping, and control measures needed at Kamakou Preserve. Major control programs are needed in many preserves and parks in the state.

Diong (1983) demonstrated the effectiveness of feral pigs as dispersal agents. The obvious implication is that feral pig control is the first step in strawberry guava control and serves as a form of cultural control. However, it is not the only measure needed. Huenneke and Vitousek (1989) reported that soil disturbance does not encourage germination, and that most germinants were found on undisturbed sites normally supporting native plant establishment. Once strawberry guava is established, recruitment will continue without control efforts, even after pigs are removed (Tunison et al. in prep.)

Manual and mechanical control measures work reasonably well and are recommended where practical. Seedlings and saplings originating from seed can be uprooted. Stems up to two inches (basal diameter) can be uprooted with a weed wrench, although some roots may need to be cut once the plant is partly uprooted (Tomich, pers. comm.). Uprooted plants may resprout or re-root in areas with greater than 2000 mm of rain/year or drier areas after prolonged rain, especially if the plants are set on the ground. Manual and mechanical methods are less effective on root sprouts.

A number of effective chemical control measures have been developed. Strawberry guava is sensitive to picloram, dicamba, glyphosate, and triclopyr. Kageler and Eldredge (1985) found that undiluted picloram (Tordon 22K) was highly effective on strawberry guava as a cut stump treatment. Tordon 22K was used at Hawaii Volcanoes but discontinued because of unfavorable effects on non-target plants. It was replaced by Tordon RTU, which was nearly as effective, but less harmful to surrounding vegetation (Tunison et al. in prep.). Undiluted dicamba (Banvel) proved to be highly effective in a cut surface treatment (Arakaki et al. 1986). Mootoka et al. (1983) found undiluted glyphosate (Roundup) to be effective using a "hack and squirt" method. Cuddihy (pers. comm.) found undiluted triclopyr ester (Garlon 4) to be effective as a cut-stump treatment, with 80% of plants dead and 90% of treated plants without resprouts after 21 months. A frill application of undiluted triclopyr amine (Garlon 3A) was somewhat less effective, with 11 of 20 stems dead and all trees defoliated after 21 months. Fifty percent Garlon 4 and 3A were about

50% effective. A major drawback of cut-stump treatment methods in very wet areas (>5000 mm rainfall/yr) was resprouting of slash from cut stump and wood fragments from felling larger trees. Garlon is recommended because of its lack of mobility and relatively short half-life, 4-6 weeks. In addition, the research is more thorough and definitive on control methods for Garlon than other herbicides.

Biological control is the only feasible long-term management strategy for strawberry guava (Smith 1985). However, until recently, biological control has been perceived as unfeasible because common guava, grown commercially in Hawaii, is a congener of strawberry guava (Gardner and Davis 1982). Biological control is being reexamined. Hodges (1988) found several insects that defoliate strawberry guava in its natural range and felt that insect biological control agents could be found that did not attack common guava. He did not find any evidence of pathogens causing serious damage. Memoranda of agreement has been concluded between the University of Hawaii and two Brazilian Universities to locate species attacking strawberry guava and not common guava. It is thought that highly specific insect pests can be found because common guava and strawberry guava are sympatric in their natural range (Smith pers. comm.).

Management Programs:
The major control programs in Hawaii are at Hawaii Volcanoes National Park in Special Ecological Areas (500 ha) (Tunison et al. in prep.) and Kalopa State Park (40 ha) (Tomich, pers. comm.). Strawberry guava has been ranked as a high priority weed species at Kamakou Preserve and control efforts have been initiated. Some control efforts have been made at Manuka Natural Area Reserve.

Monitoring Requirements:
Monitoring is needed in Hawaii to assess management effectiveness and recovery potential for sites in Hawaii's parks and preserves heavily infested with strawberry guava. Strawberry guava is currently at insufficient densities at Kamakou Preserve to warrant such monitoring.

In heavily infested parks and preserves, monitoring should focus on specific sites from which removal is carried out to indicate the feasibility of this action, effects on non-target native plant species, and recovery of native vegetation. Monitoring at Kamakou should consist of scouting and mapping (followed by eradication).

Monitoring Programs:
Monitoring has been conducted at Hawaii Volcanoes National Park to assess changes in cover and spread in the Park and population densities in managed areas. Weed control transects in Kamakou Preserve provide similar monitoring. Tomich (pers. comm.) is monitoring the recovery of an experimental control plot on the Hamakua Coast of Hawaii Island.

VI. RESEARCH

Management Research Programs:
Huenneke and Vitousek (1989) are studying stem demography in five sites on Hawaii Island from 150-762 m elevation. Field work will be completed in 1991 after five years of study (Huenneke, pers. comm.).

Management Research Needs:
Topics important to management of the species include clarifying the contribution of sprouts and seedlings, allelopathy, dispersal by rodents and birds, seed bank characteristics, germination site requirements, sprouting response of stems buried by litter, growth rates of stems, and onset of reproductive activity. This applies to management of strawberry guava throughout the state. No research is needed specifically for Kamakou Preserve. Biological control research needs are described separately.

VII. ADDITIONAL TOPICS

VIII. INFORMATION SOURCES

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IX. DOCUMENT PREPARATION & MAINTENANCE

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