

ACTIVITIES AND NEEDS OF THE HORTICULTURE INDUSTRY IN RELATION TO ALIEN PLANT PROBLEMS IN HAWAI'I

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ABSTRACT

The horticulture industry in Hawai'i can be characterized by product types. They are, in order of economic importance, cut flowers, potted foliage plants, and potted ornamental-landscape material. Other products such as plant rentals are also of some importance. Most of the farms involved in growing these products are small, the majority being single-family or small-partnership operations of less than one acre. Although more than 8,000 taxa have been introduced or developed in Hawai'i, only about 15% are commonly cultivated, while the rest, seldom or rarely cultivated, are found in collections. Most plants marketed are those commonly or occasionally cultivated; however, the species composition of this group changes because plant preferences are trendy. Trends are often predicated by new introductions or newly developed cultivars that have been propagated and marketed by one source. The return from investment is often the highest for the first release and decreases almost logarithmically for each following release. The market encourages secretiveness and speed of propagation and culture, and the importation of many different taxa is required to achieve economic success. Of at least 8,000 species or cultivars introduced, about 10% have escaped and naturalized; of these, about one third were intentionally introduced by the industry. As a result, the alien plant problem when viewed from the horticulture industry's viewpoint is insignificant compared with its economic benefit. Plant material may be imported by collectors, which include professionals such as those at botanical gardens, as well as amateurs. Amateur collectors are difficult to regulate because plant material is easily shipped into Hawai'i illegally, especially if it originates on the U.S. Mainland. Many undesired pests are probably introduced in this way. The horticulture industry needs a steady influx of new plant material, some of which is collected from the wild. The industry cannot afford to screen out potential weeds. Regulation can only be minimal, since overregulation will force noncompliance because of economics. Education is necessary to promote understanding and change philosophies and may be the best long-range solution to alien plant problems. In the short term, strict enforcement is required.

INTRODUCTION

Agriculture ranks seventh in sales and income in Hawai'i's economy, behind tourism, national defense, retail and wholesale sales, construction, and manufacturing (Table 1). Within agriculture, the horticulture industry ranks fifth behind sugar, fruit and nuts, pineapple, and cattle (Table 2). Like any business, agriculture is market driven, with industry perceptions and practices reflecting the need to satisfy demand while maximizing profit.

Table 1. Sales and income of major Hawaiian industries.*

Industry	Value (\$ in millions)
Tourism	2,875
Retail sales	1,900
National defense	1,850
Wholesale sales	1,600
Manufacturing (including processing of agricultural products)	1,249
Construction	767
Agriculture	559
Fishing	10
Forestry	4

*From Schmitt *et al.* 1984.

While these perceptions and practices are similar in many respects to those outside Hawai'i, the island environment and isolation modify them. Limited land areas, increasing population sizes, small farm sizes, high land values, and high labor costs make agriculture expensive. Isolation increases the cost of marketing outside Hawai'i and, coupled with a lack of resources, requires importation of many raw materials required by industries, thereby increasing cost.

Alien plants are essential to the horticulture industry. They are introduced intentionally for sale and often dictate trends. However, some also arrive unintentionally with essential nursery products vital to the industry or with incoming plant material. Some plants introduced in this way have escaped and have become serious problems in native Hawaiian ecosystems. Plants are not only imported by commercial growers but by botanical gardens and amateur collectors. These collectors are believed to be a major source of alien plant introductions.

Table 2. Value of major Hawaiian agricultural industries.*

Industry	Value (\$ in millions)
Sugar	266
Fruits and nuts	113
Pineapple	100
Cattle	45
Horticulture	36
Milk	24
Poultry	21
Vegetables	18
Eggs	14
Hogs and pigs	9
Grains	3
Prawns	1.3
Sheep	0.8

*From U.S. Bureau of the Census 1984b.

HORTICULTURE INDUSTRY COMPONENTS

Three types of products dominate the horticulture nursery industry in Hawai'i: cut flowers, potted foliage plants, and potted ornamental plants and landscape material. Each product type is composed of various crop types, and each has its own requirement for new plant material.

Cut Flowers

Cut and lei flowers are the horticultural industry's largest segment in terms of sales and number of farms (Table 3). Major crops consist of anthuriums (*Anthurium andreanum*), dendrobium orchids (*Dendrobium* spp.), and roses (*Rosa* spp.), which collectively represent about 50% of the total. Most flowers are marketed intrastate, with some exported to Asia and the U.S. Mainland. Most are purchased by commercial users such as florists, lei-makers, and decorators affiliated with hotels, restaurants, and other public areas. Buyers are primarily concerned with availability, cost, and quality; they adapt to what flowers are available, and specific types, species, or cultivars are not important considerations. Buyers use or sell any flower that will maximize profits.

Most growers specialize in a limited number of crops, often no more than a few selected cultivars of a given species that are industry standards. Many are selected for specific characteristics desired by industry. Examples include *Anthurium andreanum* cv. 'Ozaki,' cultivated for its color, high yield, and sucker formation; *A. andreanum* cv. 'Marion Seefurth' for its color and flower form, which facilitates packing;

Dendrobium x Louis Bleriot for its availability during the winter months when other flowers are not available; and *D. x Jac-Hawaii* for its color and continual flowering. Specialization allows predictability, simplicity of culture, and steady turnover of valuable growing space, which in turn maximizes profits.

Similar crop types with similar cultural requirements allow larger farms that take advantage of economy of scale; less complexity lowers labor costs, further lowering unit costs. Since high volume and quality production are major considerations, cultivars selected for production are often restricted to those that have been carefully studied and proven.

Potted Foliage Plants

Foliage plants for indoor use rank second to cut flowers in sales (Table 3). Most are sold as potted plants for indoor decoration, with the rest grown as nursery stock and for landscaping. Like cut flowers, most foliage plants are sold intrastate, although some are exported to the U.S. Mainland. Specific species and cultivars are not primary considerations to the majority of consumers; availability and ease of cultivation in indoor situations are more important. Only a small range of plants such as aroids, palms, and ferns are commonly grown. However, unlike cut flowers, there is a demand for different species and cultivars in these groups to satisfy a wide range of situations and consumers, including many nonprofessional buyers. Single farms may cultivate plants ranging from palms and aroids such as *Dieffenbachia* for floor displays and indoor planters, *Philodendron* for totems and hanging baskets, and peperomias (*Peperomia* spp.) and ferns for table decorations. Like cut flowers, foliage plant cultivars are selected for ease of production and rapid turnover. Still, a broad market requires a wide range of crops to satisfy demand; thus, numbers of introductions of new species or cultivars of foliage plants are greater than for cut flowers.

Potted Ornamental and Landscape Plants

Businesses that sell ornamental potted plants and trees rank third in sales (Table 3). The market for these plants is broadest of all categories, ranging from designers and landscapers to homeowners and collectors, and from large estates and public plantings to small homes. The ornamental and landscape plant market also reflects changing tastes and preferences. Almost all plants in this group are sold intrastate. Unlike the market for cut flowers and potted foliage plants, there are definite demands for specific kinds of plants (often for specific cultivars), especially by hobbyists and collectors. This is particularly true for orchids, succulents, and bromeliads, in which there is a continuing interest in Hawai'i.

TRENDS AND ORIGINS OF HORTICULTURAL PLANTS

Interest in specific plants or groups of plants is trendy and often cyclic. The history of horticulture is one of waxing and waning interest in various groups of plants. In Hawai'i, interest in croton (*Codiaeum*

Table 3. Value of various components of ornamental plant industries in Hawai'i.*

Industry	Value (\$ in millions)	Number of Farms
Cut flowers and lei flowers	17.098	723
Anthuriums	7.351	205
Orchids	1.667	138
Roses	1.556	8
Chrysanthemums	0.710	415
Proteas	0.470	46
Carnations	0.219	12
Gingers	0.267	60
Birds of paradise	0.186	50
Other lei flowers	3.880	123
Other	1.052	75
Foliage plants	16.820	150
Indoor	14.050	85
Stock	1.525	20
Landscape	1.245	45
Potted ornamental plants	5.544	291
Potted orchids	2.69	155
Other flowers	1.939	94
Ornamental trees	0.915	42
Others (bedding, rental, etc.)	2.311	102
TOTAL	41.773	1,266

*From Hawaii Agriculture Reporting System 1985.

variegatum var. *pictum*) and ti (*Cordyline fruticosa*) started after World War II and continued into the 1950s, followed by bougainvillea (*Bougainvillea* spp.) in the 1960s, with ixora (*Ixora* spp.) and a resurgence of ti in the 1970s and heliconia (*Heliconia* spp.) in the 1980s (K. Wooliams, pers. comm.). As with any broad consumer market, there is a constant demand for new introductions that may or may not dictate new trends. These new introductions are acquired in a number of ways. They may be selected from mutations or sports discovered in existing stock, purposely developed from systematic breeding programs, or collected in the wild.

Many new introductions come from serendipitous discoveries in existing stock such as *Dieffenbachia amoena* cv. 'Mary Ann' from *D. amoena* cv. 'compacta' and the "double" *Bougainvillea* cv. 'Bridal Bouquet,' cv.

'Purple Prince' from single cultivars. Others, such as orchid hybrids and roses, are developed from breeding programs. Marketing such discoveries is usually financially safe and in many cases cheap, as cultural requirements are known and a ready market exists. Most "new" introductions are obtained through these methods.

Plants collected in the wild are the most sought after. New material from existing stock and breeding programs are permutations of a similar theme, but new wild-collected material has the excitement of being completely different. Growers capitalize on this excitement, which is the quickest way of turning large profits. The combination of publicity and product scarcity produce the largest return per unit cost and may start a trend that may provide an edge over the competition, a goal that many growers seek to achieve. Heliconias, gingers, and orchids are examples of ornamentals subject to such marketing.

ECONOMICS

Economic success for most ornamental farms is based on a wide range of currently popular species and cultivars, the composition of which varies as new plants are introduced and old ones are phased out. Timely introduction of newly acquired plant materials with quick propagation and release is a necessity. As a result, a large number of plants must be obtained for every one that is successfully marketed. To maximize profits, new plant materials are often imported and propagated in secrecy to avoid competition, as the amount of return per unit is highest at first release and diminishes rapidly thereafter. Many ornamental farms thus have a wide range of crop types, requiring different cultural conditions that are in some cases unknown. Operations of this kind are the most complex and are very capital- and labor-intensive; costs are further exacerbated by high land values and lack of local raw materials. These farms are also expensive to operate, and because of limited market size, many are only marginally profitable.

Most Hawaiian farms are small in size (Tables 4, 5) and generate little revenue (Table 6). Farms growing potted ornamentals are usually the smallest and are either operated by families or are one- to two-owner cooperatives (inferred from Tables 3, 4, and 7, assuming a narrow range of unit prices). Because of limited market size, high labor costs, small amounts of cash flow, and small staffs, these farms have limited resources to spend for non-production activities. This type of farm has the largest interest in the introduction of alien plants.

OTHER IMPORTATION SOURCES

Our preliminary findings indicate that professional and nonprofessional collectors may be responsible for more alien plant introductions than commercial enterprises. Preliminary examination of checklists and herbarium specimens at the B.P. Bishop Museum in Honolulu indicates large-scale importation of alien plants by Hawaiian botanical gardens. Of

Table 4. Sizes of farms by farm type.*

Type	Greenhouse**	Saran**	Natural***	Open Field***
Anthuriums	--	16,446	81	--
Dendrobiums	400	1,981	--	2
Other orchids	436	420	3	66
Potted ornamentals (including foliage)	528	5,295	1	149
Proteas	--	--	--	119
Others	1,050	2,675	7	623
TOTALS	2,414	26,817	92	959

*From Schmitt *et al.* 1984.

**Area is in 10³ square feet.

***Area is in acres.

Table 5. Number of farms by size.*

Size in acres	Number of farms
1 - 9	2,743
10 - 49	1,261
50 - 179	320
180 - 499	126
500 - 999	33
1,000 - 1,999	33
2,000 and over	79
Total farms	4,595

*From Schmitt *et al.* 1984. Data summarized from U.S. Bureau of the Census, *1982 census of agriculture*. Geogr. Area Ser., Hawaii, state and co. data, AC82-A-11, Sept. 1982, chap. 1, tables 1, 4.

Table 6. All horticultural farms in Hawai'i by value of sales.*

Value of Sales	Number of Farms
250,000 -- +	161
100,000 -- 249,999	192
40,000 -- 99,999	343
20,000 -- 39,999	469
10,000 -- 19,000	610
5,000 -- 9,999	653
0 -- 4,999	2,160
Total number of farms	4,588

* U.S. Bureau of the Census 1984b.

Table 7. Number of farms and farm size.*

Farm Type	Number of Farms	Size (Acres)
Individual - family	3,852	481,212
Partnership	351	130,761
Family-held corporation	272	507,280
Corporations other than family	80	492,941
Other -- corporations, estates, trusts, institutions	40	345,307
Total	4,595	1,957,501

*Derived from Schmitt *et al.* 1984; data from U.S. Bureau of the Census, *1982 census of agriculture*. Geogr. Area Ser., Hawaii, state and co. data, AC82-A-11, Sept. 1982, chap. 1, tables 5, 46.

more than 8,000 names of introduced plant species or cultivars found in Hawai'i, about 15% are commonly or occasionally cultivated (H. Clay, pers. comm.). The remainder are rarely cultivated or are single-specimen plants in various botanical gardens, parks, universities, or other collections. Many botanical gardens have exchange programs with other botanical gardens to increase their collections. Many of the larger botanical gardens have

propagation and distribution programs for the most promising plants. This is also one mechanism by which commercial nurseries obtain new plants.

Amateur collectors appear to be another major source of alien plant introductions. Although it is more difficult to determine conclusively, preliminary examinations of herbarium specimens collected as part of the Bishop Museum's "In Gardens of Hawaii II" project and surveys of botanical gardens, private gardens, and popular literature have indicated that a significant number of alien plants are introduced by amateur collectors. This is especially true for theme collections such as bonsai, orchids, succulents, and bromeliads. Both amateur collectors and botanical gardens have considerable motivation and, in most cases, the resources to import plant material, perhaps much more so than commercial enterprises, where profits are the overriding consideration and importation of new cultivars of known crop types is much more economical.

CONTRIBUTIONS OF THE HORTICULTURE INDUSTRY TO THE ALIEN PLANT PROBLEM

About 820 species of persisting and naturalized plants can be found in Hawai'i today (W.L. Wagner, pers. comm.) -- about 10% of the 8,000 species found in the "In Gardens of Hawaii II" project checklist. Many cultivars that can be found in Hawai'i are not included on the list of 8,000, nor are plants that did not survive to be included on checklists, nor those in private or public herbariums. Of the naturalized plants, only one-third of the 820 (3% of the 8,000 introductions) were intentionally introduced (W.L. Wagner, pers. comm.). The industry considers these consequences very small when compared with the economic benefits of introducing new plants.

In addition to intentionally introduced alien plants escaping into and persisting in the native environment, importation of related materials for the horticultural industry also may result in accidental introductions. Non-growing plant materials that are imported in large quantities, such as Christmas trees, cut flowers, and greens, may be hosts for insect pests and plant pathogens as well as alien plant propagules. Soil additives and other non-sterile organic materials are substrates for fungi and pathogenic microorganisms as well as another vehicle for the entry of alien plants.

NEEDS OF THE HORTICULTURAL INDUSTRY

The horticultural industry believes that it is necessary to continually import new species and cultivars to remain economically competitive. Although most new plants are cultivars of existing species, some importation of new alien plants of sufficient diversity is also considered necessary to maintain a successful program. Most of the members of this industry have limited incomes and small staffs and therefore have little desire to fund research and development programs related to importation impacts. Reluctance is supported by the perceptions that the number of intentionally introduced alien plants that have become established in Hawai'i is very small and that the economic benefits far exceed the problems.

POSSIBLE SOLUTIONS

The need to control indiscriminate introductions of alien plants and to produce enforceable regulations is apparent. The horticultural industry's need to import plants and raw materials vital to success is also apparent. The industry must recognize the consequences of uncontrolled importation of alien plants, and the following are suggestions to address these needs:

1. A thorough assessment of the present impact of alien plants on the environment, and the role the horticultural industry has had in inducing these changes, should be made;
2. An assessment of the threats of various alien plant groups to the native biota should be made, and regulations and mechanisms should be developed for prohibiting entry of these high-risk groups;
3. Strict enforcement of existing and formulated regulations is needed;
4. Educational programs explaining findings and regulations should be made a part of formal horticultural curricula, and participation in these programs should be a requirement for obtaining an import permit. Hawaiian natural history should be a part of school curricula to foster an appreciation of Hawaiian ecosystems.

Horticultural Industry's Contribution to Impacts

It is important to know what plants have had significant impacts on Hawai'i's environment, how they arrived, and for what reasons. This information is important for formulating necessary regulations, as well as for modifying the industry's role if necessary. The industry needs to understand both short- and long-range consequences of irresponsible alien plant importation.

Plants arriving through accidental introductions from horticulturally related goods must also be determined. Non-botanical material such as insects and diseases that arrive in conjunction with importation of alien plants or non-growing plant material such as Christmas trees and imported flowers should also be included. Only recently has the magnitude of this problem been appreciated. Many details need to be examined, and a detailed compilation as well as a summary of assessments need to be provided.

Potential Threats of Various Alien Plant Groups

A thorough assessment of threats posed by various plant groups to different Hawaiian environments is critically needed. The analysis by Smith (1985) is a good start for plants already present in Hawai'i. Assessment of threats posed by proposed introductions must be performed in a timely manner; it will not work if nurseries have to wait for results, as they need to have plants when markets are receptive. Information is vital for evaluating potentially undesirable plants and for formulating regulations for their control. Risk assessments will be difficult and expensive, and the horticultural industry alone cannot afford them. The most efficient solution may be funding by government, by pooled resources paid in the form of importation fees, or a combination of both.

A database on the present status of each cultivated taxon needs to be established. This is being accomplished in part by the B.P. Bishop Museum in the "In Gardens of Hawai'i II" project in a collection of cultivated plant specimens currently being made. The project will also make an assessment of each plant's abundance and distribution. However, the database will need periodic updating if it is to remain useful.

Assessment of risk should take place in the plant's original habitat to eliminate as many obvious undesirable plants as possible. Observations of plants in various botanical gardens can provide some information on potential naturalization, and further screening could be performed at botanical gardens located near native habitats. Using botanical gardens has significant advantages: 1) Plants can be cultivated under controlled conditions simulating horticultural environments; 2) Most botanical gardens have skilled horticultural staffs that can evaluate reproductive biology under cultivated conditions, and 3) most have extensive collections, providing a good perspective on various plant groups.

An existing *ad hoc* organization of Hawaiian botanical gardens could be used for screening. Collectively, the members represent a range of horticultural environments and have some expertise in evaluating plants. Commercial importers may accept regulation more willingly under these conditions. Botanical gardens could serve as a conduit for importation of all alien plants. However, this function should be made separate from the rest of their operations. Separate guidelines should be formulated for plant introductions initiated by industry importers that will remove the profit motive, minimize possible abuse, and prevent any shortcuts. Confidentiality between importer and competitors must be maintained, and evaluations must be made in a timely manner. Distribution should remain with the initiating agency or grower. The botanical garden should also be responsible for control of plants, and in return, gardens should be funded for this service.

A final level of assessment can be at the nursery. Importing nurseries should evaluate potential plant growth problems in addition to insect pests and diseases. Most nurseries perform these evaluations as part of their planning programs. Hopefully, by the time any plant reaches this level of evaluation, the probability of it being undesirable will not be great, the number rejected will be small, and importers will be more willing to accept controls. In general, a multi-level program would distribute the cost of evaluation among all who have interests in alien plant importation problems. It would also minimize the cost to the horticultural industry, which should encourage compliance.

Strict Enforcement

One of the major problems of enforcement is the perception that, unlike animals, plants are non-mobile, take time to spread, and are therefore easily controlled. Present plant importation regulations reflect this philosophy, allowing all plants to be imported, with only undesirables prohibited (Higa, this volume). Strict enforcement of import regulations is one of the most effective methods of regulating alien plant importation. Inspection at ports of departure is desirable but nearly impossible

because of cost and time. Routine airport and harbor inspections of all imported materials may be more feasible and would help control much noncommercial material from entering. While it may also be too expensive to inspect all incoming material, spot checks and penalties must be more frequent and consistent than at present.

Importation through the mail is more difficult to enforce. To encourage compliance with mailing import regulations, import loopholes must be closed (Higa, this volume). Inspections of wholesale and retail nurseries coupled with economic penalties such as confiscation and destruction of illegal plants seem the most efficient deterrents. Many nurseries are currently inspected for certification for export, and this mechanism could be expanded to include imports. Non-commercial sources should also be inspected. The removal of any significant economic benefit should illegally imported plants be sold, and severe penalties such as confiscation even if imported for personal use regardless of economic value, would encourage compliance.

Regulations need to be reasonable. It is very difficult to control importation even under the best of conditions. Unreasonable regulations force non-compliance, particularly smuggling, and will amplify the problem. Reasonable regulations will minimize secretiveness and facilitate control.

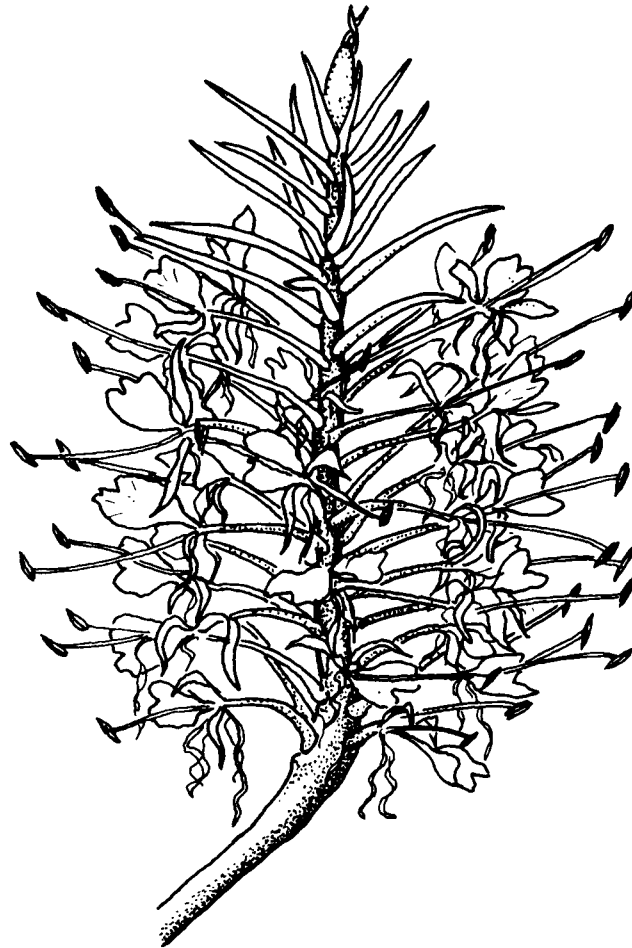
Education Programs

Educational programs may be the only way of ultimately resolving the alien plant importation problem in Hawai'i. The public perception of the values of Hawai'i's natural environments must change. As long as present opinions remain, it will be very difficult to effectively regulate alien plant introductions. Education should play a key role in providing understanding of the need for controlling introductions of alien plants, and it is probably the most effective long-term strategy in encouraging compliance.

Horticulturists rarely appreciate the magnitude of the environmental impact of their industry. It is difficult to reconcile profits with conservation of the native biota, as they are at times mutually exclusive. Because of marginal profitability, there is a strong reluctance to add to farm operations the additional burden of the cost of environmental regulations. Lack of appreciation of the problems is often reflected by disregard for conservation and, in many instances, for regulations. Programs that provide information and encourage understanding might alleviate this problem. Courses in ecology and conservation should be made part of formal agricultural curricula and short courses for non-students. Courses should also be made part of the import permitting process.

Society will have to bear the economic cost for controls. Willingness will be a function of appreciation of all facets of the alien plant problem, including an appreciation for Hawai'i's natural environment. This should start with children and continue throughout their adult lives. A curriculum needs to be developed and adopted for all of Hawai'i's schools, starting in lower grade levels and continuing through the entire

educational system. Adult education materials should also be produced. Understanding of Hawai'i's environmental problems could encourage creative solutions.



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