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SURVEY OF INVASIVE OR POTENTIALLY INVASIVE CULTIVATED PLANTS IN HAWAIʻI

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Survey of invasive or potentially invasive cultivated plants in Hawai‘i

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Introduction

During the course of the past 11 years, the authors have been engaged in research and writing for a new reference manual, *A tropical garden flora* (Staples & Herbst, in press), for the garden plants of Hawai‘i. Based on the second edition of Marie C. Neal's respected reference work, *In gardens of Hawaii* (Neal, 1965), this new book focuses on the most commonly cultivated plants grown in the Hawaiian Islands, identifying, naming, and describing more than 2,100 species found in our gardens, back yards, parks, and open spaces. The text also provides information about the place of origin, history of introduction to Hawai‘i, common names, uses, and horticulture of these species.

From the early 1980s onward, there has been growing concern in the conservation community about the threat posed by invasive, non-native species of plants to Hawai‘i's environment (Smith, 1985; Cuddihy & Stone, 1990; Stone *et al*., 1992). There is a perception that the unrestricted importation of non-native plant species into the Islands has been a major source for invasive plant species that threaten natural ecosystems and habitats here. Concurrently, there has been growing awareness at the national level of the enormous costs—economic, environmental, and health—that harmful non-indigenous species of plants and animals cause in the United States (U.S. Congress, Office of Technology Assessment, 1993); Hawai‘i was singled out in this congressional report as "the worst-case example" of the national non-indigenous species problem.

To better assess the role played by introduced, cultivated plant species in Hawai‘i's alien species problem, we decided in the early 1990s to gather information about the weediness of garden plants and their potential to invade natural ecosystems as part of the research effort to prepare *A tropical garden flora.* The results are presented here in more depth than they are in the book itself. While horticultural reference books do not typically include information about the invasiveness of cultivated garden plants, there is no reason why such information should be omitted. An informed gardener is better able to make thoughtful decisions about what species to buy from local nurseries for planting in the garden, which in turn has a direct impact on what species are imported to the state. At the same time, to better focus efforts on public education, eradication, and control, conservationists and land managers need an accurate, comprehensive listing of the known and potentially invasive cultivated plant species present in the Hawaiian Islands.

Defining the scope of this paper

In this paper, we present a first approximation for a list of the garden plants present in Hawai‘i that are known or reported to be weedy and therefore could be invasive. Because of the large number of non-native plant species already present in Hawai‘i (more than 8,000), most of which have not been evaluated in terms of their invasiveness, it is quite likely that many more species will eventually prove to be capable of spreading out of cultivation. The primary focus of this paper is on *plants that do (or could) escape from garden cultivation to become weedy pests.* It addresses only tangentially other categories

of useful cultivated plants, such as forestry trees, pasture and range grasses, soil binders, and weeds already documented for the Hawaiian flora in other references. Furthermore, it does not include plant species native or naturalized in the Hawaiian Islands, unless these are also deliberately planted and cultivated by people in their gardens. Many naturalized species have already been documented in recent botanical reference books, such as the *Manual of the flowering plants of Hawai'i* (Wagner *et al.*, 1990, 1999) with updates provided in an ongoing series of technical papers, the *Records of the Hawaii Biological Survey* (Evenhuis & Miller, 1995, 1996, 1997, 1998; Evenhuis & Eldredge, 1999, 2000).

While it is highly desirable to have a single comprehensive listing of *all* invasive plant species in Hawai'i, regardless of their means of introduction (deliberate vs. accidental) or category of usefulness, it is beyond our means to provide such an encyclopedic treatise at this time. The present list is a first attempt only, focused on the particular plants grown in Hawai'i for home gardening, landscaping, ornamental, and edible purposes.

Sources for data

The primary source for the data presented here is the completed manuscript for *A tropical garden flora* (Staples & Herbst, in press); the hard copy files and electronic databases of information that support that book; the personal observations of the authors, their collaborators in the book project, and other botanists and Hawai'i residents knowledgeable about weedy and invasive plants; and published information from the literature. In particular, we have attempted to bring together all information published about weedy plants in Hawai'i by abstracting information from the articles published in the annual *Records of the Hawaii Biological Survey* for the years 1994–1999 (Evenhuis & Miller 1995, 1996, 1997, 1998; Evenhuis & Eldredge, 1999, 2000); this covers reasonably thoroughly the plants *known* to be weedy or invasive in Hawai'i. We then added such information as we had available from the published literature concerning plant species present in Hawai'i that are reported to be invasive elsewhere; this provides some information about plants *potentially* weedy or invasive in Hawai'i.

What makes plants invasive?

The characteristics that allow some plant species to escape from cultivation and invade natural areas have been described in some detail in *A tropical garden flora* (Staples & Herbst, in press). However a brief summary will be helpful to an understanding of the role dispersal plays in plant invasions. Invasive species, from the smallest herbs to the largest trees, have certain biological characteristics in common that predispose them toward invasiveness. While the detailed life histories of invasive species vary enormously, the following general characteristics apply to such species worldwide:

- adaptable to and capable of thriving in different habitats;
- tolerant of variable conditions (light, temperature, moisture);
- fast growing, thereby able to outcompete neighboring plants;
- disturbance-tolerant, preferring places disturbed by humans or natural events;
- easily dispersible to new localities by seeds, fruits, spores, or vegetative parts.

The reproductive capability of a species is critically important to its potential as a weed. Among the reproductive characteristics shared by numerous kinds of weeds are the following (Randall & Marinelli, 1996):

- able to produce many small seeds/spores and begin doing so early in life;

• able to reproduce vegetatively as well as by seeds/spores;
• have long reproductive periods;
• have seeds/spores dispersible by animals and with no special germination requirements (e.g., period of heat or cold exposure, soaking in water, desiccation).

It is important for home owners, farmers, nurserymen, foresters, conservationists, and others concerned with preventing the spread of invasive weeds to learn to recognize all these features and to evaluate plants in terms of their invasive potential. However, the most important of these features, and one about which we need to know more, is dispersal.

Dispersal: the key point in the plant life cycle

Plants, by and large stationary organisms that do not move around, can only spread to new places if some stage in their life cycle is mobile. Typically this is the seed stage, produced by sexual reproduction, although sometimes plants can spread by vegetative (non-sexual) means. In pteridophytes (ferns and fern allies) spores are often the mobile stage. In any case, dispersal of some form of propagules is the critical phase in the plant life cycle that allows a species to spread or, if dispersal fails, prevents it from moving around.

Humans have added another whole dimension to plant dispersal by their tendency to transport plant species, either deliberately or accidentally, to places where those species do not naturally occur. Once transported by human effort, plants may then spread by their own dispersal mechanisms out of the places where humans put them and into other localities.

When considering garden plants deliberately brought to the Hawaiian Islands by humans, it can be difficult to separate the role humans play in their dispersal from the inherent dispersal mechanisms of the plants themselves. Many invasive species have more than one means for spreading; indeed, this is what makes them such successful invaders. Insofar as possible, we have listed the dispersal mechanisms for all plants included in Table 2; these are summarized in the following table. The mechanisms of dispersal are explained further in the next section.

Table 1. Summary of Plant Dispersal Syndromes in Table 2

Syndrome	Spp.[1]	% of total
Individual dispersal syndromes		
Bird-dispersed taxa	193	41
Wind-dispersed taxa	95	20
Water-dispersed taxa	73	16
Mechanically-dispersed taxa	36	8
Unknown dispersal mechanism	70	15
Total number of taxa listed	469	100
Variations in dispersal syndromes		
Two or more dispersal mechanisms	75	16
Taxa with vegetative reproduction	268	57
Taxa with vegetative reproduction and two or more dispersal mechanisms	26	6

1. Counts include data in Table 2 marked with a "?" as well as information in the Comments field.

Dispersal mechanisms in Hawai‘i by which plants spread out of gardens

Plants have evolved an extraordinary diversity of mechanisms for dispersing propagules. The classic treatise on plant dispersal, *The Dispersal of Plants Throughout the World,* was published 70 years ago (Ridley, 1930). A few dispersal syndromes described by Ridley seem to us to have a greater impact on Hawai‘i’s environments than others; we focus our discussion on those most responsible for successfully moving plants out of gardens and other cultivated situations into the natural and disturbed habitats that surround them. A brief summary of these selected dispersal mechanisms follows, along with examples of plant taxa known to be spread in Hawai‘i by each of them.

Wind dispersal

Many plants have evolved fruits, seeds, or spores suited to dispersal by wind. A variety of characteristics identify wind-dispersed plant species, among them:

- large numbers of dust-fine seeds/spores;
- larger seeds bearing tufts of fine, silky hair or thin, papery wings;
- inflated, bladder-like, papery, sometimes winged fruits, containing a few smallish seeds inside.

Orchids, ferns, begonias, and some Myrtaceae (such as *Eucalyptus* and *Leptospermum*) are examples of garden plants that produce numerous, tiny, dust-fine seeds/spores. Many species of Apocynaceae, Asclepiadaceae, Asteraceae, and some Bromeliaceae have seeds with a prominent hair-tuft that serves as a parachute. A great many Bignoniaceae, Casuarinaceae, many conifers, and some legumes have seeds (or fruits) that are flattened, winged, and light in weight. Examples of bladdery, lightweight, papery fruits are found among the Sapindaceae, Polygonaceae, and some Solanaceae *(Physalis).*

In Hawai‘i, several examples of plants that spread by means of wind may be cited. Perhaps best known is the African tulip tree *(Spathodea campanulata).* At certain times of the year when the ripe capsules open, the air is densely filled with the fluttering, membranous-winged seeds, not unlike falling snow. Other less familiar examples include the giant starfish flower *(Stapelia gigantea*), which now forms a dominant understory element in the scrub vegetation of Makapu‘u Head, O‘ahu, the hair-tufted seeds having been carried by the prevailing trades across the dry promontory from the lighthouse facility where it was evidently first planted. Thirty fern taxa have now become naturalized after their spores were spread from cultivated plants into suitable wild habitats (Wilson, 1996). And a sizable number of trees, including pines (*Pinus* spp.), several other conifers, tropical ash *(Fraxinus uhdei),* several Meliaceae, silk oak *(Grevillea robusta),* and Queensland maple *(Flindersia brayleyana),* to name just a few, have lately been discovered to be widely naturalized and spreading from forestry reserves into neighboring habitats. Their wind-blown seeds, carried by prevailing trade winds, are the evident means for their spread.

Water-borne dispersal

The impact of water-borne dispersal of higher plants on the aquatic habitats in Hawai‘i warrants special consideration. Hawai‘i is remote from continental land masses and the prevailing ocean currents are not favorable for transportation of plant propagules

here over long distances, thus ocean dispersal played a small part in the evolution of the native flora. Only a few widespread, pan-Pacific coastal species succeeded in colonizing Hawai‘i’s marine shores and beaches. Likewise, thousands of miles of saltwater have been a highly effective barrier to colonization of Hawai‘i’s freshwater habitats by plants adapted to life in marshes, bogs, streams, lakes, or ponds, the only species having successfully done so seemingly having been carried here by birds. The result is that both freshwater and marine aquatic environments here are characterized by few native higher plant species and are especially vulnerable to invasion by introduced plant species. Examples are given below, grouped by freshwater and marine situations.

Human activity has had an enormous impact on plant dispersal in freshwater ecosystems in the Hawaiian Islands and it can be difficult to separate the effects of humans from water-borne dispersal independent of human activity. People brought aquatic plants to Hawai‘i for diverse purposes including farming, water gardening, wildlife habitat improvement, fish farming and other forms of aquaculture, and water purification and detoxification, among others. Once here, the deliberately introduced plant species, and weeds that inadvertently came along with them, have spread into other freshwaters. This may take place as a result of sexual or vegetative propagation; however, it bears noting that the worst aquatic weeds worldwide (e.g., water hyacinth *(Eichhornia crassipes),* hydrilla *(Hydrilla verticillata),* salvinia (*Salvinia molesta* and other species)) spread solely by vegetative propagation.

One example that recently received a great deal of publicity is floating water fern *(Salvinia molesta*), a well-known noxious weed discovered on several islands in Hawai‘i in 1999. Other examples include water hyacinth, water lilies, and an array of submerged and emergent aquatics grown as ornamentals in water gardens that have recently begun to appear outside of cultivated situations. There is considerable potential here, with the current popularity of water gardening, for more invasions by introduced freshwater plant species. Oftentimes gardeners, not wishing to “waste” excess plants from their lily pond or container, will dump them into the nearest stream, ditch, or lake, where they can quickly become established. This practice, harmless as it may seem, can have disastrous consequences. From such a locus, the plants spread on their own into other suitable habitats, can be dispersed by waterfowl, or may be further spread by human activities such as boating, fishing, or construction.

In coastal marine habitats the problem of water-borne dispersal is a little different. As noted above, very few higher plant species adapted to marine environments reached the Hawaiian Islands on their own, but some of those brought here by humans have spread very effectively inter- and intra-island by floating in seawater. Unlike the freshwater plants described above, these plants nearly all disperse by sexually propagated seeds or fruits capable of surviving immersion in salt water. Among familiar examples are ironwood trees *(Casuarina equisetifolia),* tree heliotrope *(Tournefortia argentea),* silky jack bean *(Canavalia sericea),* and several kinds of mangroves (Combretaceae, Rhizophoraceae, Sterculiaceae). Curiously, the level of public concern for invasion of coastal marine habitats by non-native higher plant species is seldom expressed with the same intensity as it is for inland terrestrial or aquatic ones.

A further dimension of water-borne dispersal is the effect of rain wash (Ridley 1930). That heavy rainfall is capable of moving fairly large fruits/seeds along with it after it collects on the ground and flows downhill is an obvious means for plant dispersal. Rain water

flowing down tree trunks, rock faces, and other near-vertical surfaces transports tiny particles, including seeds and spores. The impact of rain wash as a plant dispersal mechanism has not been investigated in Hawai‘i to our knowledge, but it would be a fascinating avenue to explore.

Mechanical dispersal

Plants have evolved numerous mechanisms for dispersing seeds and fruits. These may be passive, relying on adhesion in one form or another; or active, whereby seeds or fruits are forcibly projected away from the plant. The passive and active forms are here considered two subcategories of mechanical dispersal.

Among the passive forms of mechanical dispersal are various adaptations that cause seeds and fruits to adhere to animals, birds, humans, or other motile objects. *Adhesion* may be due to barbs, hairs, or prickles that stick to fur, feathers, leather, or clothing; sticky substances that act like glue, derived from glandular hairs, gooey pulp, or mucilaginous exudates, to name just a few; or tiny seeds that simply get stuck in muddy earth on feet, paws, footwear, or machines. Examples of adhesive dispersal mechanisms are numerous and varied; indeed, many weeds and species with worldwide distributions rely on adhesion for dispersing their propagules and are certainly highly successful. At the family level, Asteraceae, Fabaceae, and Poaceae have a goodly number of taxa that are dispersed by this means. Curiously, there are rather few cultivated plants that can be cited as examples of adhesive mechanical dispersal. Among those cultivated in Hawai‘i we can mention *Cuphea* spp. and *Plumbago auriculata,* which have sticky, glandular-hairy floral tubes that enclose the fruits/seeds and provide a carrier for them; *Ocimum basilicum,* which has dry nutlets (often mistaken for seeds) that exude a sticky mucilage when wetted; *Gomphrena globosa,* with its chaffy bract and entangling hairs on the outer fruit wall; and *Oxalis corniculata,* which has slightly sticky seeds that adhere to anything they come in contact with (after being ejected from the explosive capsule).

Some plant species have evolved active mechanical means for throwing their seeds or fruits for some distance. While this does not effect long-distance dispersal, it can be surprisingly effective for short distances. A variety of mechanisms are known, but these amount to variations on two basic themes: fruits that spring open elastically, usually as the capsule walls dry or the external humidity decreases, and fling the seeds out (many Acanthaceae, many Euphorbiaceae, *Oxalis, Viola);* and fruits that burst open due to increasing internal pressure that is abruptly relieved when something jostles the fruit, thereby squirting the seeds out (*Impatiens,* some Cucurbitaceae).

Among frequently cultivated and familiar garden plants in Hawai‘i, many Acanthaceae are able to spread aggressively from plantings to nearby areas because of the elastically dehiscent capsules that hurl the seeds for distances up to several feet. Likewise, several *Euphorbia* species have become locally abundant and weedy by means of their capsules that spring open forcibly, flinging the seeds out for some distance. Several ornamental *Pilea* species, as well as *Dorstenia contrajerva,* are well-known pests in mainland greenhouses due to their tendency to spread out of pots onto the greenhouse floor beneath the benches. This is made possible by their tiny, 1-seeded fruits that are flung out of the enclosing perianth by sterile stamens bent beneath the fruit, which eventually straighten and forcibly eject the fruit out for a surprising distance.

Among fruits that burst open due to internal pressure, the best known example in

Hawai‘i is *Impatiens.* Here the ripe, fleshy fruit dehisces suddenly, often when something touches or bumps it, and the 5 carpels roll up inwards and hurl the seeds out. This has allowed *Impatiens,* planted along roadsides, trails, and as ornamentals around buildings in parks and natural areas, to spread into surrounding areas and become naturalized.

Bird dispersal

Rather few research studies have been conducted on the dispersal of plant species by birds in Hawai‘i and these have been conducted almost exclusively in national parks. Introduced game birds (pheasants, partridge) have been found to be effective dispersal agents for a number of alien plant species (Lewin & Lewin, 1984; Cole *et al.*, 1995). Smaller birds have likewise been shown to effect dispersal for introduced (as well as several indigenous) plant species in studies conducted in Hawaii Volcanoes National Park. Two alien species of blackberries *(Rubus ellipticus, R. glaucus)* are primarily dispersed by Japanese white-eyes *(Zosterops japonica)* (Kjargaard, 1994). White-eyes were found to be the primary dispersal agents for firetree *(Myrica faya)* in one study (Woodward *et al.*, 1990) whereas house finches *(Carpodacus mexicanus)*, among other bird species, were responsible for dispersal in another (LaRosa *et al.*, 1985). These studies indicate that introduced birds, living in natural areas remote from dense human populations, are effective dispersal agents for both native and non-native plant species. However, similar studies have not come to our notice—and may not exist—documenting the interrelationships between garden plants and the small birds that live in densely populated (by humans) urban and suburban areas. For example, cardinals, mynahs, bulbuls, white-eyes, sparrows, finches, rice birds, and doves inhabit our back yards and gardens, and from there can freely disperse all manner of plant propagules into natural habitats, whether nearby or at some distance from the source.

It is our impression, based on personal observations and anecdotal evidence gathered over the past decade, that avian dispersal is a major route for invasion of Hawai‘i’s terrestrial ecosystems by non-native plants. Specifically, the worst offenders are plants cultivated by humans that produce bite-sized (for a small bird), soft-fleshy, often black, purple-blue, or red fruits containing several to many seeds. Alternatively, other bird-dispersed plants produce larger fruits that open to reveal many bite-sized seeds, each often enclosed in a bright colored aril, sarcotesta, or other coating that makes it attractive to a bird. The lining of the fruit may be contrastingly colored to provide a backdrop for the seeds, making them even more noticeable.

Among the best-known bird-dispersed plants, mostly woody perennials, are the octopus tree *(Schefflera actinophylla),* the two species of fiddlewood *(Citharexylum caudatum, C. spinosum*), Chinese banyan *(Ficus microcarpa),* fern tree *(Filicium decipiens),* miconia *(Miconia calvescens),* ivy gourd *(Coccinia grandis),* Fukien tea or Philippine tea *(Carmona retusa),* various members of the grape family (*Cissus* spp., *Tetrastigma* spp.), several species of asparagus (*Asparagus* spp.), two ardisias *(Ardisia crenata, A. elliptica),* at least three firethorns (*Pyracantha* spp.), and lantana *(Lantana camara).* It is no coincidence that some of Hawai‘i’s worst invasive plant species are included on this list. And, as may be seen from Table 2, there are a great many additional species already present in Hawai‘i that are dispersed by birds.

In addition to fleshy fruits/seeds that are eaten by birds, it has also been shown that grasses, sedges, and small herbaceous plants that produce dry seeds (or 1-seeded fruits)

are bird dispersed (Ridley, 1930). Seed-eating birds such as doves, pigeons, finches, and sparrows typically have a muscular crop that grinds food items before they pass further into the digestive tract, and experiments have shown that seeds may emerge from this process in a viable condition. Furthermore, in addition to passive dispersal by birds due to adhesion on their feet, bill, or feathers (see above), birds actively carry bits of vegetation for nesting or display, which can and does effect dispersal for a number of plants (Ridley, 1930).

All of these bird-mediated dispersal mechanisms can and probably do take place in Hawai‘i, but it is our impression that the greatest impact for plants cultivated in our gardens is caused by fruit-eating birds. The introduction of thousands of non-native plant species and several dozen non-native, fruit-eating bird species into the Hawaiian Islands over the past two centuries has set the stage for an ecological synergy that is taking place between these two groups of organisms. The impact of a single bird species (the red-vented bulbul, *Pycnonotus cafer),* has been so great on O‘ahu in recent years that it has been recognized as an “island supertramp species” (McKeown, 1996). If this is any indicator of what lies ahead, then we have not yet seen the worst environmental impacts of bird-dispersed alien plant species in Hawai‘i.

Human dispersal

Human activities are at the root of the invasive plant species problem, and gardening, in all its manifold expressions, plays a role in the dispersal of non-native plant species. Our human love of beauty, color, greenery, and fragrance leads us to move plants around the globe and rearrange our immediate environment to suit our tastes. Among the activities gardeners and homeowners engage in that have an impact are importation of plants and seeds from outside Hawai‘i, by whatever means; transporting of plants and soil inter-island; discarding of unwanted plants, trimmings, and plant waste in open landfills, dumping it along roadsides, over banks, and into streams; deliberate outplanting of non-native ornamental species into natural areas for “beautification” purposes; and even feeding of birds or wildlife at backyard feeders.

To be sure, there are a multitude of other activities people engage in that cause or contribute to the spread of non-native plant species, including construction of all kinds; agriculture (farming and ranching), commercial nurseries, and landscaping projects; reforestation and watershed protection programs; wildlife conservation and enhancement programs; soil and water conservation efforts; hiking and hunting; and (especially prevalent in Hawai‘i) military exercises and troop movements. We will not attempt to explore the impacts of these activities here, but confine ourselves to some of the more obvious impacts that derive from home gardening.

One of the byproducts of gardening is excess plant material, whether whole plants or trimmings and yard waste. To cite the most obvious example, the amount of green waste generated by trimming hedges, trees, lawns, ground covers, and other ornamental plantings is staggering. Some of this ends up burned or buried in county landfills. Increasingly, composting is an option pursued by home gardeners. Yet a disturbing number of home gardeners, lawn maintenance services, or landscape contractors dump loads of green waste onto roadsides or vacant lots, into streams, or over the edge of the nearest bank. Dispersal is effected when ripe fruits or mature seeds are included in the trimmings, or when the plant material is capable of propagating vegetatively. In fact, the combination of

the ability to propagate vegetatively and human dumping of green waste has been implicated in the spread of a number of ornamental plant species, including numerous kinds of grasses, diverse taxa of succulents *(Bryophyllum* spp., *Sansevieria trifasciata, Stapelia gigantea),* the popular ground cover *Spaghneticola trilobata* (better known as *Wedelia trilobata*), *Cissus* spp., *Coccinia grandis,* and *Dissotis rotundifolia.* It is not clear how many plant species have escaped from gardens into disturbed sites or, further, into native forests by this means. But it is a dynamic that needs to be examined carefully in light of the potential for invasiveness posed by so many cultivated plant species in Hawai‘i.

Another human gardening activity that has had an impact on the spread of invasive plants is the beautification efforts sponsored by numerous civic groups and community organizations. Planting ornamental shrubs, flowering and shade trees, ground covers, and grasses along roadside rights-of-way, in parks and other open spaces, and on private property can provide a locus for weedy species to gain a foothold. Among examples of such plants that were set out with the best of intentions but are now part of Hawai‘i’s naturalized flora are several species of ginger (*Hedychium* spp.), costus *(Costus),* bamboos (various genera), heliconias (*Heliconia* spp.), and clerodendrums (*Clerodendrum* spp.). These beautification projects are not as popular today as they were a few decades ago, and when they do take place there is a greater consciousness of the desirability for using native plants.

Recently a number of retail stores have offered bulk wildflower seed mixtures, intended to be broadcast along roadsides, in open fields, and vacant lots to add more color to our landscape. These mixtures, prepared for mainland locations, have no native Hawaiian species in them and could add many new weeds to our islands. Gardeners must think carefully about the consequences of spreading such seed mixtures around their property before they purchase the seeds.

Brief mention must be made of the contaminants found in gardening and agricultural products such as bird seed mixtures, livestock feed, mulches, soil conditioners, and home gardening products. While livestock and bird feeds are usually composed of seeds from annual grasses that do not seem to persist in Hawai‘i’s climate, there are always seeds of other weedy plant families included in the mixes, such as Polygonaceae, Amaranthaceae, and Chenopodiaceae, to name a few. Importation of feed mixes and grain from mainland producers for use in Hawai‘i has added some new weeds to our naturalized flora. Similarly, mulches, soil conditioners, potting mixes, peat moss, and other gardening products are supposed to be sterilized but it is not infrequent that weeds appear in areas where these products have been used.

A final note concerns the inter-island shipment of products harvested in Hawai‘i’s own forests. Tree fern trunks (and other forest products) harvested and moved inter-island have been observed in their new location with germinating weed seedlings previously unknown from the area, a clear indication that invasive forest weeds can be spread between islands by human gardening activities.

Unlike the other dispersal mechanisms discussed here, we make no attempt to list the human activities responsible for dispersing specific plant taxa in Table 2. Suffice it to say that humans are in some way responsible for the dispersal of every species listed in Table 2, and for that of many other introduced, non-indigenous plants as well.

Miscellaneous forms of dispersal

In compiling the information for Table 2 we came across mention of several other dispersal mechanisms that we have not found documented in Hawai‘i. These dispersal mechanisms have been acknowledged in the comments field of Table 2 but we can say little else about them except to note that published literature sources report them as a factor in plant dispersal elsewhere and that research is needed to ascertain their impact on the spread of ornamental garden plants in Hawai‘i.

A number of plant species are known to be dispersed by ants, which are attracted to arils or coatings on the seeds. The latter are carried away from the source plant toward the ant nest and either taken underground or discarded along the way once the edible portion has been removed. The plant known as sundrops *(Turnera ulmifolia)* is surely being dispersed by alien ants in Hawai‘i, though to our knowledge this has not been documented. Other examples of ant-dispersed plants present in Hawai‘i have been noted in Table 2. An ever increasing number of alien ant species are established in the Hawaiian Islands and their contribution to the dispersal of cultivated plant species needs investigation.

While large hoofed mammals (horses, cattle, pigs, goats, deer) are known to be effective dispersal agents for many plants in rural settings or uninhabited areas (Diong, 1982), these animals are seldom a factor in urban and suburban garden settings. However, small mammals such as rats and mice may be capable of carrying seeds/fruits some distance from the source plant and could be effective dispersal agents. A few examples of plant seeds/fruits known (or suspected) to be dispersed by rats have been noted in the comments section of Table 2 (Meyer, 1996, 1998). Research is needed to ascertain whether rodent dispersal has an impact on the spread of plants out of gardens into surrounding areas. Given the enormous populations of house mice and Norway rats that live in close association with humans, their impact as plant dispersal agents could be considerable. At this point we simply know nothing about this route for plant dispersal in Hawai‘i. Nor do we have an understanding of the role dogs and cats play as dispersal agents for plants. As most pet owners can attest, companion animals that are allowed outside pick up plenty of plant seeds and fruits in their fur and mud on their paws. How effective these domestic pets may be in transporting plant propagules has not, to our knowledge, been determined.

The complication of vegetative propagation

A considerable number of plants are able to propagate effectively by vegetative means that do not involve production of seeds or spores. Such asexual means of reproduction are many and varied, and include production of plantlets (offsets); adventitious bulbils on the stem; surface or below-ground spread by stolons (often referred to as runners) or rhizomes; budding of daughter corms, bulbs, or tubers from a parent unit of the same type; or simply by the ability to form new plants from broken pieces of stem, leaf, root, or rhizome that fall on the ground and take root there. And it is significant that many familiar garden plants are easy to propagate vegetatively, a factor that no doubt has contributed to their abundance in cultivation.

The dispersal agents for vegetative propagules are no different than those for seeds and spores; the act of dispersal can take any of the routes described here. Perhaps the most dangerous combination is vegetative propagation coupled with human dispersal, mentioned previously. But the fact remains that plants that can propagate by vegetative means pose a different degree of threat because they have more options for generating propag-

ules that can be dispersed and therefore a greater potential for invasiveness. And perhaps the most invasive plant species are those that combine sexual reproduction with some form of vegetative reproduction. For this reason we have included in Table 2 an indication for all species that can be dispersed by vegetative propagules.

The need for observation and documentation of plant dispersal

As the preceding discussion demonstrates, there is a lot going on in Hawai‘i that has not been well studied, documented, nor managed in terms of the dispersal of introduced, non-indigenous plants. While life history studies have been undertaken for a number of native plant taxa, similar studies for the naturalized flora are few (e.g., LaRosa *et al.*, 1985; Walker, 1990; Kjargaard, 1994). Now that management and eradication of invasive non-indigenous plant species is of growing concern to conservationists, land managers, and government agencies, the dearth of published data and observations that can guide these efforts is a critical shortcoming that must be remedied.

In the past 15 years, research projects at the Bishop Museum have produced two definitive works on the vascular flora of the Hawaiian Islands: the *Manual of the flowering plants of Hawai‘i* (Wagner *et al*., 1990, 1999), which covers the native and naturalized flowering plants of the archipelago, and *A tropical garden flora* (Staples & Herbst, in press), which identifies and describes the most commonly cultivated ferns, gymnosperms, and flowering plants grown here. These two references cover the greater portion of the native and introduced vascular flora, but they omit several groups that fall outside the scope of either reference. Specifically, there is as yet no comprehensive floristic treatment of the Hawaiian pteridophytes, and the non-indigenous trees widely planted for reforestation have not been thoroughly investigated, nor have the grasses introduced for pasturage, cover crops, and as soil binders. Also historically poorly understood and woefully under-collected are weeds of all types. It is these gaps in our knowledge that still need much work before we can fully understand the biological relationships that exist between the native and alien elements that now comprise the flora.

Crucial to gaining that understanding is a better comprehension of the dispersal mechanisms for all plant species in our Islands. While we know something about how our native plants are dispersed, the same is not true for the aliens. And there are far more alien species than natives, which is worrisome when one acknowledges how little we know about their life histories, reproductive biology, dispersal, and predators and pathogens. While the endemic biota of the Hawaiian Islands has often been described as a “laboratory of evolution,” it has not been generally acknowledged that the blend of native and introduced species brought about by human activity during the past 200+ years has created an entirely new laboratory, one which has exciting possibilities for the study of ecological and evolutionary relationships in the making.

In conclusion, we would make a plea that collectors and field biologists make an effort to observe and record the dispersal mechanisms for the plants they encounter, whether native or non-native. As Table 2 shows, there is much we don’t know about the dispersal mechanisms of plants cultivated in Hawai‘i, and much of what we do know is based on observations from other parts of the world. Very little has been recorded in the Hawaiian Islands, which now possess a unique mixture of species from all over the globe. The authors welcome corrections and additions to the information summarized in Table 2; please contact us via the address given above.

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Note: Some of the references were used in compiling Table 2 and are not cited in the text itself. Reference numbers refer to citations in Table 2, Comments column.

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Table 2. Annotated checklist of invasive or potentially invasive cultivated plants in Hawai'i with dispersal syndrome

Species	Disperal Syndrome[1]				Comments[2]
Acanthaceae					
Asystasia gangetica			M	V	
Barleria lupulina			M		
Barleria repens			M	V	
Crossandra infundibuliformis			M	V?	
Hemigraphis reptans			M	V	
Hypoestes phyllostachya			M		
Justicia betonica			M		
Odontonema cuspidatum			M?		
Ruellia brevifolia			M		
Ruellia brittoniana			M		
Ruellia devosiana			M		
Sanchezia speciosa				V	26:20
Thunbergia alata	U				
Thunbergia fragrans	U				
Thunbergia grandiflora				V	roadside plantings
Thunbergia laurifolia				V	roadside plantings; 45:11
Agavaceae					
Agave sisalana				V	fiber plant
Furcraea foetida				V	fiber plant
Phormium tenax	U				fiber plant
Sansevieria trifasciata			B?	V	22:9
Aizoaceae					
Tetragonia tetragonioides		A			
Aloeaceae					
Aloe vera				V	
Amaranthaceae					
Alternanthera spp.	U			V	
Amaranthus dubius			B?		36:362, 526–seeds spread in livestock manure, and by ants
Amaranthus tricolor			B?		36:362, 526–seeds spread in livestock manure, and by ants
Celosia argentea			M		36:696–fruit adhesive
Gomphrena globosa		W			36:98–99
Anacardiaceae					
Schinus molle			B		36:479
Schinus terebinthifolius			B		35:68–seeds also spread by animals

1. Dispersal syndrome codes: U = unknown; W = wind; A = aquatic/water; M = mechanical; B = bird; V = vegetatively propagating. See text for details.
2. Source by reference number:page–comments

Table 2. Annotated checklist of invasive or potentially invasive cultivated plants in Hawai'i with dispersal syndrome (continued)

Species	Disperal Syndrome[1]				Comments[2]
Annonaceae					
Artabotrys hexapetalus			B?		seeds carried by rats?
Apiaceae					
Cryptotaenia canadensis	U				
Eryngium foetidum	U				culinary herb; 36:650 –medicinal
Apocynaceae					
Allamanda blanchetii				V	
Alstonia macrophylla	W				
Catharanthus roseus	W?	A?			36:656; 34:6–seeds carried by ants
Aquifoliaceae					
Ilex aquifolium			B		35:57
Ilex cassine			B		
Ilex paraguariensis			B		
Araceae					
Epipremnum pinnatum				V	1:111
Pistia stratiotes		A		V	
Syngonium podophyllum			B?	V	1:115
Xanthosoma roseum	U			V	44:14–no fruits observed
Arecaceae					
Archontophoenix alexandrae			B		
Arenga pinnata			B		
Caryota mitis		A?	B		36:327, 386; 14:115 –naturalized in FL
Caryota urens			B?		36:346–monkeys; 14:115–naturalized in FL
Chamaedorea cataractarum			B		
Chamaedorea seifrizii			B		14:114–naturalized in FL
Dypsis lutescens	U				14:116–naturalized in FL; spread by rats?
Phoenix canariensis			B		14:111–naturalized in CA
Phoenix hybrids			B		14:111–naturalized in FL?, spread by raccoons
Phoenix reclinata			B		36:453, 487
Pinanga spp.			B		36:327, 416
Ptychosperma elegans			B		14:118–naturalized in FL
Ptychosperma macarthurii			B		14:118–naturalized in FL
Roystonea spp.			B		36:499; 14:117–fruits eaten by bats

1. Dispersal syndrome codes: U = unknown; W = wind; A = aquatic/water; M = mechanical; B = bird; V = vegetatively propagating. See text for details.
2. Source by reference number:page–comments

Table 2. Annotated checklist of invasive or potentially invasive cultivated plants in Hawai'i with dispersal syndrome (continued)

Species	Disperal Syndrome[1]				Comments[2]
Arecaceae (continued)					
Sabal mauritiiformis			B		36:477
Sabal palmetto			B		14:108–eagerly sought by mammals & birds
Syagrus romanzoffiana			B		14:121–naturalized in FL, seeds spread by animals?
Verschaffeltia splendida			B?		
Washingtonia filifera			B		14:118–naturalized in CA, NV
Washingtonia robusta			B		14:118–naturalized in CA, FL
Araliaceae					
Hedera helix			B	V	35:93
Schefflera actinophylla			B		35:42
Schefflera arboricola			B		
Araucariaceae					
Araucaria columnaris	W				forestry tree
Aristolochiaceae					
Aristolochia littoralis	W?				1:110
Asclepiadaceae					
Calotropis grandiflora	W			V?	
Calotropis procera	W			V?	
Cryptostegia grandiflora	W				
Cryptostegia madagascariensis	W	A			1:111
Hoya australis	W			V?	
Marsdenia floribunda	W?				abundant plumed seeds, potentially weedy
Stapelia gigantea	W			V	
Asteraceae					
Ageratum houstonianum	W				
Artemisia vulgaris	W?			V	
Bellis perennis	U				
Coreopsis lanceolata	W?				
Delairea odorata	W			V	
Dyssodia tenuiloba	W?				
Erigeron karvinskianus	W				
Kalimeris indica	W			V?	20:14
Leucanthemum vulgare	W?				
Montanoa hibiscifolia	W?				
Solidago canadensis	W?			V?	
Sphagneticola trilobata				V	1:115
Tithonia diversifolia	W?				
Tithonia rotundifolia	W?				

1. Dispersal syndrome codes: U = unknown; W = wind; A = aquatic/water; M = mechanical; B = bird; V = vegetatively propagating. See text for details.
2. Source by reference number:page–comments

Table 2. Annotated checklist of invasive or potentially invasive cultivated plants in Hawai'i with dispersal syndrome (continued)

Species	Disperal Syndrome[1]					Comments[2]
Athyriaceae						
Diplazium esculentum		W				edible fern; 53:132
Azollaceae						
Azolla filiculoides			A	B?	V	53:130
Balsaminaceae						
Impatiens sodenii				M	V?	
Impatiens walleriana				M	V?	
Basellaceae						
Anredera cordifolia					V	
Basella alba	U				V	
Begoniaceae						
Begonia cucullata		W	A?		V?	36:72, 166
Begonia foliosa		W	A?		V?	
Begonia hirtella		W	A?		V?	
Begonia vitifolia		W	A?		V?	
Berberidaceae						
Nandina domestica				B		35:63
Bignoniaceae						
Jacaranda mimosifolia		W				
Macfadyena unguis-cati		W			V	1:113
Spathodea campanulata		W				ornamental tree
Tabebuia heterophylla		W				street tree
Tabebuia rosea		W				street tree
Tecoma castanifolia		W				
Tecoma stans		W				19:9
Blechnaceae						
Blechnum occidentale		W				
Boraginaceae						
Carmona retusa				B		
Cordia dichotoma				B		17:3
Cordia sebestena	U					street tree; fruits abundantly, potentially weedy
Tournefortia argentea			A			
Brassicaceae						
Brassica rapa		W?				vegetable; 36:32, seeds carried by ants?
Eruca vesicaria		W?				vegetable, oil source

1. Dispersal syndrome codes: U = unknown; W = wind; A = aquatic/water; M = mechanical; B = bird; V = vegetatively propagating. See text for details.
2. Source by reference number:page–comments

Table 2. Annotated checklist of invasive or potentially invasive cultivated plants in Hawai'i with dispersal syndrome (continued)

Species	Disperal Syndrome[1]				Comments[2]
Brassicaceae (continued)					
Lobularia maritima			B?		36:523–seeds carried by ants
Nasturtium microphyllum		A		V	
Nasturtium officinale		A		V	36:182, 201, 546
Raphanus sativus	U				
Tropaeolum majus	U				
Bromeliaceae					
Tillandsia spp.	W			V	36:156
Buddlejaceae					
Buddleja davidii	W				36:128
Buddleja madagascariensis			B		
Cactaceae					
Cereus uruguayanus			B		36:461; seeds carried by rats?
Hylocereus costaricensis			B?	V	
Hylocereus undatus				V	
Opuntia cochenillifera			B	V	seeds spread by animals
Opuntia ficus-indica			B	V	seeds spread by animals
Selenicereus macdonaldiae			B?	V?	
Cannaceae					
Canna indica		A?	B		36:507
Caprifoliaceae					
Lonicera japonica			B	V	35:94; 1:112
Sambucus mexicana			B	V	36:407, 455–58, 470–78, 480–84
Caryophyllaceae					
Dianthus barbatus	W?				36:28
Casuarinaceae					
Casuarina cunninghamiana	W			V	forestry tree; 36:316
Casuarina equisetifolia	W	A			36:86, 316
Casuarina glauca	W			V	forestry tree; 36:316
Cecropiaceae					
Cecropia obtusifolia			B		36:499
Ceratophyllaceae					
Ceratophyllum demersum		A	B	V	36:491

1. Dispersal syndrome codes: U = unknown; W = wind; A = aquatic/water; M = mechanical; B = bird; V = vegetatively propagating. See text for details.
2. Source by reference number:page–comments

Table 2. Annotated checklist of invasive or potentially invasive cultivated plants in Hawai'i with dispersal syndrome (continued)

Species	Disperal Syndrome[1]				Comments[2]
Clusiaceae					
Calophyllum inophyllum		A			
Clusia rosea			B		
Combretaceae					
Conocarpus erecta		A			36:290
Quisqualis indica		A		V?	36:211, 290
Terminalia catappa		A			36:374–seeds spread by rats
Terminalia myriocarpa	W				forestry tree; 19:9
Commelinaceae					
Callisia fragrans				V	
Tradescantia spathacea				V	
Tradescantia zebrina				V	
Convolvulaceae					
Ipomoea aquatica		A		V	1:112
Ipomoea obscura	U				
Ipomoea ochracea		A?			
Ipomoea quamoclit	U				
Merremia tuberosa		A?			35:98; 1:113
Costaceae					
Costus pulverulentus			B	V	
Costus speciosus			B	V	
Crassulaceae					
Bryophyllum daigremontianum		A		V	40:20–plantlets catapulted by rain drops
Bryophyllum fedtschenkoi	U			V	
Bryophyllum pinnatum	U			V	
Bryophyllum tubiflorum		A		V	40:21–plantlets catapulted by rain drops
Crassula multicava				V	26:33–does it set seeds?
Crassula ovata				V	
Cucurbitaceae					
Coccinia grandis			B	V?	
Momordica charantia			B		edible vegetable
Cyatheaceae					
Cyathea cooperi	W				53:131–32
Cyperaceae					
Cyperus gracilis			B?	V	36:490
Cyperus involucratus		A?	B?	V	36:490
Cyperus prolifer		A?	B?	V	36:490; 4:277–78

1. Dispersal syndrome codes: U = unknown; W = wind; A = aquatic/water; M = mechanical; B = bird; V = vegetatively propagating. See text for details.
2. Source by reference number:page–comments

Table 2. Annotated checklist of invasive or potentially invasive cultivated plants in Hawai'i with dispersal syndrome (continued)

Species	Disperal Syndrome[1]					Comments[2]
Dilleniaceae						
Dillenia suffruticosa				B		36:425, 481
Dioscoreaceae						
Dioscorea alata	W					1:111
Dioscorea bulbifera		A			V	36:183
Dryopteridaceae						
Cyrtomium falcatum	W					53:132
Elaeagnaceae						
Elaeagnus umbellata				B	V	
Euphorbiaceae						
Bischofia javanica				B		35:28
Breynia disticha					V	26:35–root suckers
Euphorbia cotinifolia			M			
Euphorbia lactea					V	
Euphorbia leucocephala			M?			sets abundant seed, weedy in gardens
Euphorbia leuconeura			M			seeds carried by ants?
Euphorbia tirucalli					V	26:35
Jatropha curcas			M			36:502
Macaranga mappa				B?		
Macaranga tanarius				B		36:459
Phyllanthus acidus				B?		seeds spread by rats?
Ricinus communis		A?	M	B		36:315, 502, 670
Sapium sebiferum				B		35:41
Synadenium compactum			M		V?	
Fabaceae						
Acacia confusa	U					
Acacia farnesiana	U					
Acacia mearnsii	U					forestry tree
Bauhinia monandra	U					
Bauhinia purpurea	U					sets abundant seed, weedy in gardens
Bauhinia variegata	U					sets abundant seed, weedy in gardens
Caesalpinia gilliesii	U					
Cajanus cajan	U					edible seeds
Canavalia cathartica		A				36:272–73
Canavalia sericea		A				
Delonix regia	U					
Derris elliptica					V	humans use as fish poison
Falcataria moluccana	W	A?				forestry tree; 36:195
Lablab purpureus	U					vegetable

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2. Source by reference number:page–comments

Table 2. Annotated checklist of invasive or potentially invasive cultivated plants in Hawai'i with dispersal syndrome (continued)

Species	Disperal Syndrome[1]					Comments[2]
Fabaceae (continued)						
Lespedeza bicolor	U					
Leucaena leucocephala						seeds spread in livestock manure
Parkinsonia aculeata	U					
Pithecellobium dulce				B		36:487
Platymiscium stipulare		W				
Prosopis hybrid						seeds spread in animal manure
Prosopis juliflora						seeds spread in animal manure
Prosopis pallida						seeds spread in animal manure
Samanea saman	U					seeds spread in animal manure?
Senna alata		W?				36:650–medicinal plant
Senna siamea			A?			36:191, 207, 280
Senna surattensis	U					
Tephrosia purpurea			A?	M		36:370–seeds in goat manure
Vigna speciosa				M		lei flower
Flacourtiaceae						
Dovyalis hebecarpa					B	
Flacourtia indica					B	
Goodeniaceae						
Scaevola taccada			A			35:67
Grossulariaceae						
Brexia madagascariensis			A?			
Haloragaceae						
Myriophyllum aquaticum			A		B	V 36:209, 491–92, 545–47
Heliconiaceae						
Heliconia bihai					B	V
Heliconia latispatha					B	V
Heliconia metallica					B	V
Heliconia psittacorum						V
Hydrangeaceae						
Philadelphus karwinskyanus						V 26:38
Hydrocharitaceae						
Egeria densa			A			V
Hydrilla verticillata			A		B?	V weed of water gardens

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Table 2. Annotated checklist of invasive or potentially invasive cultivated plants in Hawai'i with dispersal syndrome (continued)

Species	Disperal Syndrome[1]					Comments[2]
Iridaceae						
Crocosmia ×crocosmiiflora					V	48:1446
Trimezia martinicensis	U				V	
Trimezia steyermarkii	U				V	
Watsonia borbonica	U					
Juncaceae						
Juncus effusus		A		B?	V	
Lamiaceae						
Elsholtzia ciliata	U					
Mentha pulegium					V	
Mentha spicata					V	
Mentha ×villosa					V	
Ocimum basilicum			M	B?		36:620–seeds sticky when wetted
Ocimum gratissimum				B?		
Perilla frutescens	U					
Salvia coccinea	U					36:612, 643
Salvia officinalis	U					culinary herb
Lauraceae						
Cinnamomum burmanii				B		forestry tree
Lemnaceae						
Landoltia punctata		A		B?	V	50:58–59 (as *Spirodela*)
Lemna aequinoctialis		A		B?	V	50:58
Lemna obscura		A		B?	V	50:58
Spirodela polyrhiza		A		B?	V	50:58–59
Liliaceae						
Asparagus africanus				B		
Asparagus asparagoides				B		
Asparagus densiflorus				B	V	28:4
Asparagus plumosus				B	V	
Hippeastrum striatum	U				V?	
Ornithogalum thyrsoides					V	36:520–seeds spread by ants
Zephyranthes citrina	U				V	
Zephyranthes grandiflora	U				V	
Limnocharitaceae						
Hydrocleys nymphoides		A			V	
Lythraceae						
Cuphea hyssopifolia			M?			15:236–adhesive hairs on seeds

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Table 2. Annotated checklist of invasive or potentially invasive cultivated plants in Hawai'i with dispersal syndrome (continued)

Species	Disperal Syndrome[1]					Comments[2]
Malpighiaceae						
Hiptage benghalensis	W	A?				1:111–112
Malvaceae						
Abutilon grandifolium	U					
Hibiscus mutabilis	U					
Malvaviscus arboreus	U					
Pavonia hastata	U					
Thespesia populnea		A				naturalizes readily in coastal sites
Urena lobata			M			adhesion by spines on fruit
Marantaceae						
Calathea picturata						seeds carried by ants
Marattiaceae						
Angiopteris evecta	W					53:130
Melastomataceae						
Arthrostemma ciliatum	U					
Dissotis rotundifolia					V	48:907
Heterocentron subtriplinervium	U				V?	
Medinilla cumingii				B		
Medinilla venosa				B?		
Melastoma candidum				B		
Melastoma sanguineum				B		
Miconia calvescens	W	A	M	B		30:70–rats disperse seeds in droppings
Oxyspora paniculata				B		
Tetrazygia bicolor				B?		
Tibouchina urvilleana					V	
Meliaceae						
Melia azedarach				B		36:482
Swietenia macrophylla	W					forestry tree; 36:120
Toona ciliata	W					forestry tree
Menyanthaceae						
Nymphoides aquatica		A			V	
Nymphoides peltata		A			V	
Moraceae						
Dorstenia contrajerva			M			36:673
Ficus cf. *platypoda*				B		
Ficus microcarpa				B?		forestry tree; 18:10
Ficus nota				B		forestry tree

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2. Source by reference number:page–comments

Table 2. Annotated checklist of invasive or potentially invasive cultivated plants in Hawai'i with dispersal syndrome (continued)

Species	Disperal Syndrome[1]				Comments[2]
Moringaceae					
Moringa oleifera	U				edible
Myrsinaceae					
Ardisia crenata			B		
Ardisia elliptica			B		35:46
Myrtaceae					
Eucalyptus spp.	W				forestry trees
Eugenia uniflora			B?		seeds spread by rats?
Leptospermum scoparium	W				
Melaleuca quinquenervia	W			V	forestry tree
Pimenta dioica			B		street tree
Pimenta racemosa			B		street tree
Psidium cattleianum			B		shade tree; seeds spread by animals
Psidium guajava			B		edible fruit; seeds spread by animals
Rhodomyrtus tomentosa			B		36:400, 502
Syzygium cumini			B?		seeds spread by animals
Syzygium jambos					seeds spread by animals
Syzygium malaccense					seeds spread by animals
Najadaceae					
Najas guadalupensis		A		V	weed of water gardens
Najas marina		A		V	weed of water gardens
Nelumbonaceae					
Nelumbo nucifera		A		V	rhizomes edible
Nephrolepidaceae					
Nephrolepis falcata	W			V?	
Nyctaginaceae					
Mirabilis jalapa	U			V?	
Nymphaeaceae					
Nymphaea caerulea		A	B?	V	
Nymphaea capensis		A	B?		
Nymphaea cultivars		A		V?	
Ochnaceae					
Ochna serrulata			B		
Ochna thomasiana			B	V?	

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2. Source by reference number:page–comments

Table 2. Annotated checklist of invasive or potentially invasive cultivated plants in Hawai'i with dispersal syndrome (continued)

Species	Disperal Syndrome[1]					Comments[2]
Oleaceae						
Fraxinus uhdei	W					forestry tree
Jasminum fluminense				B		35:94-95–animals spread seeds; 1:112
Ligustrum japonicum				B	V	35:58–59
Ligustrum lucidum				B		35:58–59
Ligustrum sinensis				B		35:58–59
Olea europaea (2 subspp.)				B		36:453–56, 458, 460, 474, 503
Onagraceae						
Fuchsia boliviana				B?		
Fuchsia magellanica				B?		
Fuchsia paniculata				B?		
Ludwigia repens		A		B?		
Orchidaceae						
Arundina graminifolia	W					37:81
Epidendrum ×obrienianum	W				V	37:81
Phaius tankarvilleae	W					37:81
Spathoglottis plicata	W					37:81
Oxalidaceae						
Oxalis corniculata			M	B	V?	36:664, 523–seeds spread by ants
Oxalis debilis	U				V	
Papaveraceae						
Eschscholzia californica	W?					
Parkeriaceae						
Ceratopteris thalictroides	W	A			V	36:52, 186
Passifloraceae						
Passiflora edulis				B?		seeds spread by animals
Passiflora laurifolia				B		seeds spread by animals
Passiflora ligularis				B		seeds spread by animals
Passiflora maliformis				B		seeds spread by animals
Passiflora ×violacea					V?	
Phytolaccaceae						
Rivina humilis				B		36:490
Pinaceae						
Pinus patula	W					forestry tree
Pinus radiata	W					forestry tree

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2. Source by reference number:page–comments

Table 2. Annotated checklist of invasive or potentially invasive cultivated plants in Hawai'i with dispersal syndrome (continued)

Species	Disperal Syndrome[1]					Comments[2]
Piperaceae						
Peperomia pellucida			M?			36:653–human dispersed, fruits sticky
Piper auritum	U				V	
Piper lolot					V	culinary herb
Piper methysticum					V	medicinal and ceremonial plant
Pittosporaceae						
Pittosporum pentandrum				B		street tree; 19:6
Pittosporum undulatum				B		
Pittosporum viridiflorum				B		
Plumbaginaceae						
Plumbago auriculata			M			36:612–adhesion
Poaceae						
Arundo donax			A		V	35:84
Axonopus fissifolius	U				V	pasture grass
Cortaderia jubata		W				
Cortaderia selloana		W				
Cynodon dactylon		W			V	36:694; seeds spread in livestock manure?
Oplismenus hirtellus			M			36:566–adhesion of glumes
Paspalum distichum			A?	B?	V?	
Paspalum vaginatum			A?	B?	V	36:330
Phyllostachys aurea					V	
Phyllostachys nigra					V	48:1582
Saccharum spontaneum		W				36:137, 139, 160
Schizostachyum glaucifolium					V	human dispersed
Setaria palmifolia		W?	A?	B?		
Podocarpaceae						
Podocarpus spp.				B		street trees; 36:357, 359, 459, 499
Polygonaceae						
Antigonon leptopus		W	A?			1:110
Coccoloba uvifera			A	B?		seeds carried by rats?
Polygonum capitatum				B?		36:458, 462, 496
Rumex crispus		W	A	B		36:31, 113, 224, 372, 440, 464, 522; also ants, animals

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2. Source by reference number:page–comments

Table 2. Annotated checklist of invasive or potentially invasive cultivated plants in Hawai'i with dispersal syndrome (continued)

Species	Disperal Syndrome[1]					Comments[2]
Polypodiaceae						
Microsorum scolopendrium	W				V	
Phlebodium aureum	W				V?	53:134
Platycerium bifurcatum	W					53:135
Platycerium superbum	W					53:135
Pontederiaceae						
Eichhornia crassipes		A			V	35:99
Monochoria vaginalis		A	M		V?	2:255–261
Portulacaceae						
Portulaca grandiflora				B?		
Portulaca oleracea		A		B		36:173, 455, 473, 481, 491–92
Portulaca pilosa			M	B		seeds slightly sticky when wetted
Talinum fruticosum	U					
Talinum paniculatum	U					
Proteaceae						
Grevillea banksii	W					
Grevillea robusta	W					forestry tree
Pteridaceae						
Adiantum hispidulum	W?					53:127
Adiantum raddianum	W?					53:127–28
Adiantum tenerum	W?					53:128–30
Pellaea viridis	W					
Pteris vittata	W					
Rosaceae						
Cotoneaster pannosus				B		35:49; 26:49
Duchesnea indica				B	V	16:177
Eriobotrya japonica				B		edible fruit; fruits/seeds spread by animals?
Fragaria vesca				B	V	edible fruit
Fragaria ×ananassa				B	V	36:395
Heteromeles arbutifolia				B		
Photinia davidiana				B		
Prunus spp.				B		36:351–2, 454, 457, 477 –seeds spread by animals
Pyracantha angustifolia				B		
Pyracantha crenatoserrata				B		
Pyracantha koidzumii				B		
Rosa spp.				B		36:454, 457–58, 470–72, 491

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Table 2. Annotated checklist of invasive or potentially invasive cultivated plants in Hawai'i with dispersal syndrome (continued)

Species	Disperal Syndrome[1]				Comments[2]
Rosaceae (continued)					
Rubus spp.			B	V	36:453, 457, 458, 460, 481, also by animals
Rubiaceae					
Cinchona pubescens	W?				forestry tree
Coffea arabica			B		36:485
Coffea liberica			B		36:485
Morinda citrifolia		A	B		36:295, 370–72 (animals), 507
Pentas lanceolata	U				
Serissa japonica			B?		
Rutaceae					
Flindersia brayleyana	W				forestry tree
Murraya koenigii			B?	V?	
Murraya paniculata			B?		
Triphasia trifolia			B?		
Salviniaceae					
Salvinia auriculata		A	B?	V	36:180
Salvinia molesta		A		V	
Sapindaceae					
Cupaniopsis anacardioides			B		35:31–weed tree in FL
Filicium decipiens			B		street tree
Koelreuteria elegans	W				
Sapotaceae					
Chrysophyllum cainito			B?		seeds carried by rats?
Chrysophyllum mexicanum			B		street tree
Chrysophyllum oliviforme			B		street tree
Sideroxylon persimile			B		
Saururaceae					
Houttuynia cordata				V	
Scrophulariaceae					
Hebe speciosa	U				
Lophospermum erubescens	U				
Torenia asiatica	U				
Torenia glabra	U				
Selaginellaceae					
Selaginella kraussiana	W			V	36:57
Selaginella umbrosa	W			V	36:57

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Table 2. Annotated checklist of invasive or potentially invasive cultivated plants in Hawai'i with dispersal syndrome (continued)

Species	Disperal Syndrome[1]				Comments[2]
Solanaceae					
Browallia americana	U				
Brugmansia ×candida	U	A?			21:9–spread down stream bed?
Capsicum annuum			B		
Cestrum diurnum			B		
Cestrum nocturnum			B		
Nicotiana glauca	U				
Nicotiana tabacum	U				
Solanum lycopersicon			B		36:396, 458
Solanum seaforthianum			B		
Solanum torvum			B?		edible fruit
Streptosolen jamesonii	U				
Strelitziaceae					
Ravenala madagascariensis			B?	V	36:423–25; 3:1993
Sterculiaceae					
Heritiera littoralis		A			street tree; possibly animal dispersed?
Kleinhovia hospita	W?				
Taccaceae					
Tacca chantrieri	U				
Tamaricaceae					
Tamarix aphylla				V	no seed set in HI; 35:43; 36:153
Tiliaceae					
Heliocarpus popayanensis	W				
Turneraceae					
Turnera ulmifolia					seeds carried by ants
Ulmaceae					
Trema orientalis			B		42:47
Urticaceae					
Pilea microphylla			M	V?	
Pilea serpyllacea			M	V?	
Verbenaceae					
Aloysia citriodora	U				
Callicarpa spp.			B		
Citharexylum caudatum			B		32:13
Citharexylum spinosum			B	V	street tree; 19:13

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Table 2. Annotated checklist of invasive or potentially invasive cultivated plants in Hawai'i with dispersal syndrome (continued)

Species	Disperal Syndrome[1]				Comments[2]
Verbenaceae (continued)					
Clerodendrum buchanani			B	V	
Clerodendrum macrostegium			B	V	27:12
Clerodendrum quadriloculare				V	
Duranta erecta			B		18:13–14
Lantana camara			B	V	
Lantana montevidensis			B?	V?	26:55
Phyla canescens			B	V	
Phyla nodiflora			B	V	36:491, 493
Stachytarpheta cayennensis	U				
Stachytarpheta mutabilis	U				
Verbena rigida	U				
Verbena tenuisecta	U				
Verbena ×hybrida	U				
Vitex negundo			B?		
Vitex parviflora			B		
Vitex pinnata			B		forestry tree
Vitex rotundifolia		A	B		36:309
Violaceae					
Viola odorata		M		V	36:520–seeds carried by ants; 38:15–vegetatively spread
Vitaceae					
Cissus nodosa			B	V	
Cissus quadrangularis			B	V	
Cissus rotundifolia			B	V	
Tetrastigma pubinerve			B	V	
Tetrastigma voinierianum				V	
Zingiberaceae					
Alpinia mutica			B?	V	
Alpinia purpurata				V	
Hedychium coronarium				V	lei flower
Hedychium flavescens			B	V	lei flower
Hedychium gardnerianum			B	V	
Zygophyllaceae					
Guaiacum officinale			B?		

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