

FINAL REPORT

**Stream and Botanical Survey of an unnamed tributary flowing into Pu'u Ka 'Ele Reservoir and
Pila'a Stream, Pila'a, Kilauea, Kaua'i**

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Executive Summary

The Hawaii Biological Survey of the Bishop Museum conducted an assessment from September 27-29, 2001, of native and introduced aquatic animals and associated riparian wetland plants in association with the James Pflueger Stream Channel Alteration and Diversion permits, for an unnamed tributary flowing into Pu'u Ka 'Ele Reservoir and Pīla'a Stream, Pīla'a, Kīlauea, Kaua'i.

Four species of native birds were observed within the study area, the indigenous Black-crowned Night-Heron, the Common Moorhen, the Hawaiian Coot, and the Nēnē. Five species of native fish were common and observed immediately upstream of the ocean at the mouth of Pīla'a Stream, along with two introduced fish species, including mosquitofish (*Gambusia affinis*), and the Mexican molly (*Poecilia mexicana*). The only fish species observed at the newly excavated ponds adjacent to Kūhiō Highway (Highway 56) were the introduced tilapia, mosquitofish, and Mexican molly. The very high densities of introduced fish in these ponds, plus the unsuitability of these ponds to native fish species makes it very unlikely that native fish would survive or be currently found above the pond areas. Likewise, the native fish were not observed or found at the unnamed tributary of Pu'u Ka 'Ele Reservoir. This is because of the high densities of introduced bluegill (*Lepomis macrochirus*), largemouth bass (*Micropterus salmoides*), and tilapia would quickly consume any native 'o'opu found in the unsuitable reservoir habitat. A total of 15 species of aquatic insects were collected at the two stream areas assessed during this survey. With three native species collected, only 20% of the aquatic insect species were native, indicating the biologically degraded nature of these two stream areas.

Negative environmental impacts did not occur at Site 1 (the unnamed tributary above Pu'u Ka 'Ele Reservoir) and Site 4 (the area of Pīla'a Stream nearest the ocean), therefore no mitigative measures seem to be needed for the pond construction that was conducted in these areas. The ponds at Site 3 should remain in place because of the benefits provided to endangered Hawaiian waterbirds. These ponds could be managed and enhanced to provide additional wetland habitat for native Hawaiian waterfowl, with water levels managed appropriately for breeding birds. Additionally, nesting islands could be constructed to allow the birds to breed away from potential predators such as rats, cats, and dogs. Further downstream, at Site 4, Pīla'a Stream could be cleared of the alien grasses that have completely overgrown and obscured the

stream channel and replaced with beneficial native grasses and vegetation. The current overly thick mixture of alien grasses found at Site 4 are harmful to all native stream biota because they reduce sunlight penetration, block migratory movements, and are generally unsuitable to aquatic species that have evolved in clear, rocky stream channels lacking this thick grass layer.

Introduction

The Hawaii Biological Survey of the Bishop Museum conducted an assessment from September 27–29, 2001, of native and introduced aquatic animals and associated riparian wetland plants in association with the James Pflueger Stream Channel Alteration and Diversion permits, for an unnamed tributary flowing into Pu'u Ka 'Ele Reservoir and Pila'a Stream, Pila'a, Kilauea, Kaua'i.

This survey documented the major constituents of the flora and fauna within the proposed petition area, and located and identified sensitive native species or communities, and also assessed if Federally endangered species were found within the boundaries of the proposed project area. Areas assessed included endangered Hawaiian waterbirds, native aquatic fauna including candidate endangered damselflies, native and introduced fish, aquatic insects, crustaceans, and aquatic mollusks. Additionally, this report discusses the positive and negative impacts of pond construction on sensitive native fauna at both streams, and also discusses several potential mitigative measures.

Study Area

The two study streams are located in the northeastern corner of the island of Kaua'i near the town of Kilauea. Both the unnamed tributary flowing into Pu'u Ka 'Ele Reservoir and Pila'a Stream are quite short, low-elevation streams originating in deep, loamy soils. Study site numbers (1, 3, 4) were taken directly from Exhibit 1A and Exhibit 1B (USGS topographic maps), provided by Mr. Max Graham to the Bishop Museum, and correspond to the site numbers used on maps by the Commission on Water Resource Management. Surveys included the two stream areas where stream channel alteration permits are currently being sought.

Study Site #1 was located upstream from Pu'u Ka 'Ele Reservoir on a small tributary that enters the reservoir, and included a small excavated pond area approximately 75 m upstream of the reservoir. Study Site 1 was examined downstream to where it entered the reservoir. Study Site #3 was located just makai of

Kūhiō Highway (Highway 56), and included the small Pīla‘a Stream that flowed for a brief period of time downstream of the highway prior to the stream becoming impounded by two large dams. After the lowest impoundment, Pīla‘a Stream then cascaded over an approximate 50 ft. sheer waterfall. Study Site #4 was located close to the ocean at a very small excavation made in the grass below this waterfall. We examined Pīla‘a Stream below the waterfalls from the excavated site (marked Project Site #4 on Exhibit 1B, provided by Mr. Max Graham) to the ocean, and this entire area was our Study Site #4. A more detailed description of each study site is provided in the vegetation section.

Methods

Sampling took place during a period of sunny weather and good conditions, with light rains occurring only for a few minutes on 27 September 2002.

Avian Surveys

Surveys of avifauna were conducted in an unnamed tributary flowing into Pu‘u Ka ‘Ele Reservoir and Pīla‘a Stream from 27-29 September 2001. To assess the impacts of the pond construction on the avifauna, representative sampling stations for native birds were established at each of the three sampling sites. The total number of each species of endangered bird seen or heard at each location was tallied. Special efforts were made to search for endangered native waterbirds, including the Hawaiian Coot (*Fulica alai*), the Common Moorhen (*Gallinula chloropus sandvicensis*), the Hawaiian Stilt (*Himantopus mexicanus knudseni*), the Koloa or Hawaiian Duck (*Anas wyvilliana*), and the Nēnē (*Nesochen sandvicensis*). Introduced bird species were not recorded. Fixed plot methods were used, whereby all native species seen or heard within a 20 m radius of census stations were recorded.

Fish, Crustacean, and Mollusk Sampling

Above-water observation, hand-netting, and small seines were used to assess aquatic species composition at the various study sites. Because both the unnamed tributary flowing into Pu‘u Ka ‘Ele Reservoir and Pīla‘a Stream were very small and shallow, snorkeling was not feasible. However, the small stream size and good water clarity at both sites provided good success during netting and when conducting visual observations. Fish, crustaceans, and mollusks were collected with similar methods used to collect benthic aquatic insects; that is, mainly through benthic sampling, seining, and hand-netting. Netting allowed confirmation of visual above-water observations.

Aquatic Insect Sampling

Aquatic insect sampling was conducted according to Englund and Preston (1999). Collections of both immature and adult specimens were conducted with yellow pan traps, aerial nets, dip nets, and benthic samples. Visual observations of aquatic insects were also conducted as we traveled between sampling stations. Sampling effort was focused on habitat suitable for native insects: splash zones around riffles and cascades, and wet rock faces associated with springs and seeps, waterfalls, wetland areas, and benthic sampling of stream substrates. All aquatic habitats were sampled, however.

General collections were conducted in prime native aquatic insect habitats, with numerous aerial net sweeps taken around riffle splash-zones, cascades, seeps, and waterfall areas. Repeated benthic sampling was conducted at each sampling station by one person holding an aquatic dip net, while another person disturbed rocks upstream of the net. Benthic sampling also included collecting individual rocks and using a toothbrush to sweep off immature aquatic insects and other aquatic invertebrates from the stream rocks. All aquatic insect specimens were stored in 75% ethanol and subsequently transported to the Bishop Museum Entomology laboratory for curation and identification. Voucher specimens are currently housed in the Bishop Museum collection.

Results and Discussion

Avian Surveys Results

Four species of native birds were observed within the study area, the indigenous Black-crowned Night-Heron, the Common Moorhen, the Hawaiian Coot, and the Nēnē (Table 1). This survey did not conduct quantitative counts of native birds, but we did record all native birds observed within the study areas during our September assessments. Of these species, the latter three are listed as endangered on the Federal Register. Most of the endangered waterbirds were observed in the pond areas at Study Site 3 (the large excavated pond area next to Highway 56), while some Hawaiian Coots were also observed swimming in the Pu'u Ka 'Ele Reservoir. Study Site 3 appears to provide suitable habitat for the three endangered Hawaiian bird species observed in this study, and obviously has attracted these endangered birds in sizable numbers. For example, up to 5–6 coots and over 15 Nēnē were observed in and around the two ponds. The Nēnē left the ponds when we approached, but their return to the ponds after a short while indicated the ponds were the primary reason for their being in the area. While much more secretive and less common, at

least two Common Moorhen were observed around the fringes of the ponds at Site 3. It should be emphasized that this survey occurred in late September 2001, during a period of only a few days, and monitoring over a longer period of time and different seasons would have yielded more species of waterfowl using the ponds at Site 3. These ponds are likely also used by the endangered Koloa and other migratory waterfowl.

No native landbirds were seen at the study sites. This was expected for two reasons. First, native Hawaiian landbirds are rarely found in areas where the native habitat has been destroyed (Perkins 1903; Berger 1981). The area within and around both streams surveyed reflects over 100 years of severe human degradation.

The second reason no native landbirds were expected in this area is because this site lies within the low elevation “mosquito zone”. Since Hawaiian birds evolved in the absence of mosquitoes, they are highly susceptible to mosquito transmitted diseases such as avian malaria (Warner 1968; van Riper et al. 1986). The presence of mosquitoes below 1500 m elevation on all Hawaiian islands is believed to be a major factor limiting the abundance of lowland native forest bird populations, even in otherwise suitable habitat (van Riper et al. 1986).

Fish, Crustacean, and Mollusk Results

Five species of native fish (Table 1) were common and observed immediately upstream of the ocean at Site 4, along with two introduced fish species, including mosquitofish (*Gambusia affinis*) and the Mexican molly (*Poecilia mexicana*). Tilapia were not yet observed in the lowest portions of the stream, but will soon likely make their way to the lower stream from the impoundments located at Site 3.

Fish observation and collection was difficult in the immediate vicinity of the excavated pond at Site 4 because of the very dense grass growth at this area. Therefore, our most productive sampling for all aquatic organisms was slightly downstream of the excavated pond area at Site 4, nearer to the ocean where the stream canopy was more open. The impacts of the introduced fish on native fish in this area were apparent, with 50% of the captured native ‘o‘opu nākea (*Awaous guamensis*) at Site 4 exhibiting either fin rot or having parasitic leeches (*Myzobdella lugubris*) attached to them. In streams lacking introduced fish, native ‘o‘opu never exhibit these visible signs of parasitism and are always in much better physical condition.

Introduced fish are heavily infested with ectoparasites such as the leech *Myzobdella lugubris*, and ick or *Ichthyophthirius*, and nematode parasites such as *Camallanus cotti* (Font and Tate 1994). None of these introduced fish parasites are found in streams containing only native fish species. The impacts of these parasites upon native stream fish are likely great, as native species have not co-evolved defenses to the parasites as have the introduced poeciliids (Font and Tate 1994).

The only fish species observed above the waterfall located just below Site 3 were the introduced tilapia, mosquitofish, and Mexican molly (Table 1). Surveys above Site 3 indicated no native fish were able to pass through the two large impoundments. The very high densities of introduced fish in these ponds, plus the unsuitability of these ponds to native fish species, makes it very unlikely that native fish would survive or be currently found above the pond areas. Likewise, the no native fish were observed or found in Site #1 at the unnamed tributary of Pu‘u Ka ‘Ele Reservoir. This is because of the high densities of introduced bluegill (*Lepomis macrochirus*), largemouth bass (*Micropterus salmoides*), and tilapia would quickly consume any native ‘o‘opu found in the unsuitable reservoir habitat. Introduced fish were not found in the small excavated pond at Site #1 because of a rock barrier on this small tributary to the reservoir, but were found just below the rock barrier in the arm of Pu‘u Ka ‘Ele Reservoir that the tributary feeds. No native or introduced crustaceans were found at Site #1, but the introduced Asiatic clam (*Corbicula fluminea*) was common.

Site 4 (Pīla‘a Stream near the ocean) contained two species of crustaceans, the native *Macrobrachium grandimanus* and the introduced *Macrobrachium lar*. These crustaceans were not observed in Pu‘u Ka ‘Ele Reservoir or the unnamed tributary to the reservoir examined at Site 1, likely because both species (and the native stream fish) are amphidromous and require access to and from the ocean to complete their life cycle, which the reservoir would preclude. Although the Asiatic clam was found upstream at the two large impoundments at Site 3, it was not observed downstream at Site 4, indicating it is a relatively new introduction. The Asiatic clam will likely be found downstream of these ponds and soon be found at Site 4 near the ocean.

Currently, the only Federally listed Threatened aquatic invertebrate species found on Kaua‘i is the Newcomb’s snail (*Erinna newcombi*). The Threatened Newcomb’s snail was not observed or collected in any of the study sites sampled, and is very unlikely to be found in the small, silty, low gradient streams

examined in this study. According to the U.S. Fish & Wildlife Service (2000): “specific habitat requirements of Newcomb’s snail include fast flowing perennial streams with stable overhanging rocks, springs, rock seeps, and waterfalls”. These habitats were not found in the two streams examined.

Aquatic Insect Results

A total of 15 species of aquatic insects were collected at the two stream areas assessed during this survey. With three native species collected, only 20% of the aquatic insect species were native indicating the biologically degraded nature of these two stream areas. Because aquatic insects have more specific habitat requirements than aquatic vertebrates, they are considered a much better indicator of habitat quality than aquatic vertebrates (Englund and Preston 1999, Englund and Polhemus 2001). Thus, from the low percentage of native aquatic insect species both upstream and downstream of the impacted pond construction areas, it can be inferred that both the unnamed tributary flowing into Pu‘u Ka ‘Ele Reservoir and Pila‘a Stream are currently heavily biologically degraded and provide little habitat for native aquatic insects.

The sampling of damselflies and dragonflies (Odonata) was emphasized during aquatic insect collections, because six species of native *Megalagrion* damselflies are currently held as candidate Threatened, Endangered, or Species of Concern on the Federal Register. In addition, native Hawaiian damselflies give an indication of the relative ‘health’ of a stream system, because they do not typically occur in highly disturbed areas (Polhemus and Asquith 1996). Native damselflies were not observed or collected during these surveys, although two common introduced species were found, along with two introduced species of dragonflies (Table 1). Two common native species of dragonflies, *Anax strenuus* and *Pantala flavescens*, were observed at Sites 1 and 4, and these native species are not necessarily indicative of high-quality aquatic habitats because of their wide flight range. The only other native aquatic insect found during these surveys was a small ceratopogonid *Dasyhelea platychaeta* that was found in the outlet of the lowest large pond at Site 3. Overall, the composition of the aquatic insect species found reflected the overall disturbed nature of both study areas, and it should be emphasized that this area was ecologically degraded prior to pond construction and excavation. Evidence that this ecological degradation, in the form of alien species, was not caused by the construction or excavation of the ponds, is shown by the lack of native aquatic insect species upstream of both sets of newly created impoundments at Sites 1, 3, and 4.

Table 1. Results of Hawaii Biological Survey, Bishop Museum surveys conducted in September 2001 for aquatic species in Pu‘u Ka ‘Ele and Pila‘a Streams, Kaua‘i. See Study Area for a description of site locations.

Taxon	Site 1- Pu‘u Ka ‘Ele	Site 3	Site 4	Geographic Status
Native Birds				
Black-crowned Night-Heron	X	X		Native
Common Moorhen		X		Native – Endangered
Hawaiian Coot	X	X		Native – Endangered
Nēnē		X		Native – Endangered
Amphibians				
<i>Bufo marinus</i>	X			Introduced
<i>Rana catesbeiana</i>	X			Introduced
Fish				
<i>Awaous guamensis</i>			X	Indigenous
<i>Eleotris sandwicensis</i>			X	Endemic
<i>Stenogobius hawaiiensis</i>			X	Endemic
<i>Kuhlia xenura</i>			X	Endemic
<i>Mugil cephalus</i>			X	Indigenous
<i>Gambusia affinis</i>		X	X	Introduced
<i>Poecilia mexicana</i> (complex)		X	X	Introduced
<i>Lepomis macrochirus</i>	X			Introduced
<i>Micropterus salmoides</i>	X			Introduced
<i>Tilapia</i> prob. <i>zillii</i>	X	X		Introduced
Mollusks				
<i>Corbicula fluminea</i>		X	X	Introduced
Crustaceans				
<i>Macrobrachium grandimanus</i>			X	Endemic
<i>Macrobrachium lar</i>			X	Introduced
Hirudinea (leeches)				
<i>Myzobdella lugubris</i>			X	Introduced
Aquatic Insects				
Anisoptera (Dragonflies)				
Aeschnidae				
<i>Anax strenuus</i>	X			Endemic

Table 1 (cont). Results of Hawaii Biological Survey, Bishop Museum surveys conducted in September 2001 for aquatic species in Pu'u Ka Ele and Pīla'a Streams, Kaua'i. See Study Area for a description of site locations.

Taxon	Site 1- Pu'u Ka 'Ele	Site 3	Site 4	Geographic Status
Libellulidae				
<i>Crocothemis servilia</i>	X	X	X	Introduced
<i>Orthemis ferruginea</i>	X	X	X	Introduced
<i>Pantala flavescens</i>	X	X		Indigenous
Zygoptera (Damselflies)				
Coenagrionidae				
<i>Ischnura ramburii</i>	X		X	Introduced
<i>Ischnura posita</i>			X	Introduced
Heteroptera (True Bugs)				
Mesoveliidae				
<i>Mesovelia amoena</i>	X	X	X	Introduced
Diptera (Flies, gnats)				
Ceratopogonidae				
<i>Dasyhelea platychaeta</i>		X		Endemic
Chironomidae				
<i>Cricotopus bicinctus</i>			X	Introduced
Chloropidae				
<i>Monochaetoscinella anonyma</i>		X		Introduced
Dolichopodidae				
<i>Dolichopus exsul</i>	X			Introduced
<i>Syntormon cf. flexibilis</i>			X	Introduced
<i>Tachytrechus angustipennis</i>			X	Introduced
Ephydriidae				
<i>Scatella stagnalis</i>			X	Introduced
Tethinidae				
<i>Dasyrhicnoessa vockerothi</i>			X	Introduced

Introduction – Botanical Survey

A botanical survey of both the unnamed tributary flowing into Pu'u Ka 'Ele Reservoir and Pila'a Stream was conducted on 27–29 September 2001. The primary purpose of the survey was to determine whether any federally listed endangered or threatened plant taxa were present in the areas surveyed (with conservation recommendations, if needed); also, the vegetation was described for each site and a comprehensive list of all vascular plant species seen was compiled. Currently, 296 taxa of native Hawaiian plants, including 99 from Kaua'i, are afforded strict legal protection under the federal Endangered Species Act under the purview of the U.S. Fish and Wildlife Service (USFWS). In addition, 96 other taxa on Kaua'i are rated as Candidate endangered species or Species of Concern by USFWS, although neither category offers legal protection. (Statistics gathered from Bishop Museum Botany Department database, 2001).

Sampling Methods – Botanical Surveys

The botanical assessment was conducted using a walk-through method. The pond perimeters at all three study sites (designated as Sites 1, 3, and 4) were thoroughly surveyed, and additional surveys of adjacent areas were conducted for comparative purposes at sites 1 and 4 (designated as Sites 1b and 4b). Collections of plant specimens were made selectively. Specimens that could not be identified in the field were collected for later identification in the Bishop Museum Botany Department. Some collections of special interest (e.g., those that may be new island or state weed records) were deposited at Bishop Museum. The species recorded are to be considered a point-in-time sampling, especially for the weedy annuals, as a survey done during a different time of the year under varying environmental conditions would undoubtedly yield some variation in the species composition at each site.

Site descriptions–Riparian Vegetation

The following are capsule descriptions of the major vegetation components at each of the sites surveyed. Complete species lists can be found for each site in Appendix 1. GPS readings are in Old Hawaiian Datum to correspond with USGS topographic quads.

Site 1 – GPS 22°11.007'N 159°23.925'W

Site 1 is an excavated circular pond ranging from 40–60 ft. across, for the most part located in a depression ringed by steep slopes clothed in a variety of alien trees and shrubs on moist soils at approximately 420 ft. elevation. The pond is fed from above by a small creek, and it drains downslope into another creek. The

thick canopy layer averages 30–40 ft. in height, and is dominated by the gangly, silvery-leaved trumpet tree (*Cecropia obtusifolia*) and young Molucca albizia (*Falcataria moluccana*), with finely divided foliage and a flat-topped habit; octopus tree (*Schefflera actinophylla*) and satin-leaf (*Chrysophyllum oliviforme*) are other tree species occasionally seen. The shrub layer is thick as well, and is dominated by the aggressive strawberry guava (*Psidium cattleianum*) and shoebutton ardisia (*Ardisia elliptica*), along with sourbush (*Pluchea carolinensis*) and oī (*Stachytarpheta cayennensis*). Various weedy grasses dominate much of the ground layer, especially Glenwood grass (*Sacciolepis indica*), Hilo grass (*Paspalum conjugatum*), basketgrass (*Oplismenus hirtellus*), and California grass (*Brachiaria mutica*) on water-saturated soils. A 6 ft. tall bunchgrass called bluestem (*Andropogon glomeratus*) dominates on open flat ground on the low-sloped side of the pond. Common herbaceous plants in the understory include the prickly sensitive plant (*Mimosa pudica* var. *unijuga*) and elephant's-foot (*Pseudelephantopus spicatus*), along with thimbleberry (*Rubus rosifolius*), maile hohono (*Ageratum conyzoides*), milkwort (*Polygala paniculata*), primrose willow (*Ludwigia octovalvis*), and honohono (*Commelina diffusa*). Ferns are not a major part of the vegetation here, but those occasionally seen include pai‘i‘ihā (*Christella dentata*), *C. parasitica*, swordfern (*Nephrolepis multiflora*), *Blechnum appendiculatum*, *Deparia petersenii*, and maidenhair fern (*Adiantum raddianum*).

A telling observation on the condition of this site is that all of the above-mentioned species are introduced to Hawai‘i. Only four native species were noted, and only as rare components of the vegetation. A single hala (*Pandanus tectorius*) tree may be an indicator of former native tree cover on the site. Other natives noted included two sedges, kaluhā (*Schoenoplectus juncooides*) and *Cyperus polystachyos*, and a fern, pala‘ā (*Sphenomeris chinensis*). Overall, only 4 of 42 species noted at Site 1 were native (10%, see Table 2).

Site 1b

A plant survey was done in an area makai of Site 1 in order to compare vegetation composition between the recently disturbed Site 1 with less disturbed adjacent sites. The survey encompassed a rounded, grassy hill that extends makai from Site 1 to the large Pu‘u Ka ‘Ele Reservoir downslope, and a large portion of the mauka bank of the reservoir.

Table 2. Number of native and introduced plant species found during surveys conducted in September 2001, in Pu‘u Ka Ele and Pila‘a Streams, Kaua‘i.

Site	Number (%)	Number (%)	Total
	Native spp.	Introduced spp.	
1	4 (10%)	38 (90%)	42
1b	9 (14%)	57 (86%)	66
3	2 (3%)	75 (97%)	77
4	2 (6%)	34 (94%)	36
4b	4 (9%)	39 (91%)	43
Total	12 (9%)	124 (91%)	136

Low grasslands 1–2 ft. tall dominate the rolling hills between the forested gulches and ponds in this area. The main grass species are Glenwood grass and Hilo grass. Elephant's-foot, sensitive plant, and honohono are occasional herbaceous species in the mix, as well as swordfern. Shrubs and trees are conspicuous by their absence in these grasslands. The only native plant noted was *Cyperus polystachyos*, and it was only rarely seen.

Pu‘u Ka ‘Ele Reservoir itself is mostly ringed by low grass/sedge/herb vegetation on mucky, saturated soils; these sections are lacking tree and shrub species. In those areas where the banks are angled upwards, allowing for drier soils, there is a often dense tree/shrub thicket cover. In both vegetation types, non-native plants almost completely dominate.

The vegetation on saturated soils surrounding the reservoir is dominated by a low-growing mix of grasses, sedges, and herbs that includes the grasses Hilo grass, Glenwood grass, California grass, ricegrass (*Paspalum scrobiculatum*), vasey grass (*P. urvillei*), and narrow-leaved carpetgrass (*Axonopus fissifolius*); the sedge *Cyperus polystachyos*; the herbs sensitive plant, elephant’s-foot, and the melastome *Pterolepis glomerata*; and the ferns neke (*Cyclosorus interruptus*) and swordfern. Of these common elements, only *Cyperus polystachyos* and neke are native, and they are often noted elsewhere in the state under similar wet habitat conditions. Not as frequent but still forming a significant component along the shore are the tall bunchgrass called bluestem (*Andropogon glomeratus*), torpedo grass (*Panicum repens*), and the low-growing basketgrass; the sedges *Cyperus meyenianus*, *C. pilosus*, spikerush (*Eleocharis geniculata*), *Fimbristylis miliacea*, and kili‘o‘opu (*Kyllinga brevifolia*); the herbs primrose willow, thimbleberry,

Spanish clover (*Desmodium sandwicense*), milkwort, *Stylosanthes fruticosa*, oī, pipili (*Drymaria cordata* var. *pacifica*), and maile hohono (*Ageratum houstonianum*); and the fern pai'i'ihā (*Christella dentata*). None of these species are native.

Drier slopes are dominated by a mix of strawberry guava, shoebutton ardisia, Java plum (*Syzygium cumini*), trumpet tree, Molucca albizia, satin-leaf, common guava (*Psidium guajava*), and hau (*Hibiscus tiliaceus*). Of these, only hau is considered to be native.

Nine (14%) of 66 taxa counted at this site were native, the highest percentage at any of the sites. This probably partially reflects the larger area included in the survey (allowing for more variations in habitat to be included), and perhaps the less disturbed nature of the habitats relative to the excavated sites being surveyed. Still, none of the native taxa were especially plentiful, and there were no examples of fairly intact native habitat noted.

Site 3 – GPS 22°12.470'N 159°22.177'W

This site lies just makai of Kūhiō Highway (Hwy 56) just past mile marker 20. Fronting the highway are windbreaks of neem (*Azadirachta indica*) and rattlepod (*Crotalaria juncea*), a yellow-flowered legume. Rolling grassy slopes downslope surround two ponds apparently excavated from former hau (*Hibiscus tiliaceus*) habitat. The upper pond is fed from upslope, and the water drains from the lower pond into a gulch downslope via a small waterfall. The gulch here includes a forest of hau, black bamboo (*Phyllostachys nigra*), Java plum, kukui (*Aleurites moluccana*), and satin-leaf, and is probably indicative of the vegetation at Site 3 prior to excavation of the ponds. Of these taxa, only hau is native.

Immediately ringing the ponds is a largely non-native mix of tall/low grasses and herbs. This habitat is variously dominated by California grass up to 5 ft. tall or by the shorter Hilo grass. Other species occasionally seen include wiregrass (*Eleusine indica*); the sedges *Cyperus polystachyos* and *C. pilosus*; and the herbs primrose willow, honohono, sensitive plant, Spanish needle (*Bidens pilosa*), hairy spurge (*Chamaesyce hirta*), the legume vine *Neonotonia wightii*, Spanish clover, and *Sida rhombifolia*. Tree/shrub species seen along the banks were rare and only of juvenile age; these included trumpet tree, false kamani (*Terminalia catappa*), chinaberry (*Melia azedarach*), and koa haole (*Leucaena leucocephala*). Evidence of former cultivated plantings at the site included shrubs of *Bougainvillea*.

Some large trees in the vicinity of this site appear to have been saved from prior clearing of the landscape, and include couple of mango (*Mangifera indica*), some kukui, breadfruit (*Artocarpus altilis*), coconut (*Cocos nucifera*), and satin-leaf. A tall grove of black bamboo (*Phyllostachys nigra*) lies adjacent to the lower pond.

Overall, out of 77 plant species noted at this site, only 2 (3%) were native: *Cyperus polystachyos*, a common sedge; and *hau*, a common tree in lowland stream habitats.

Site 4 – GPS 22°12.723'N 159°22.157'W

This site consists of a small circular pool about 15 ft. in diameter excavated in a gulch bottom with a small running stream, approximately 500 yds. upstream from the coast. An overstory of 50–70 ft. tall Java plum on one slope of the stream provides almost constant shade with a bouldery understory and little in the way of groundcover. Under the Java plum is a shorter layer of strawberry guava trees. The opposite bank, on the other hand, is vegetated by a tangle of vines and shrubs with no overstory. The main vines, seen clambering on the ground, up trees, and on surrounding slopes, are moon flower (*Ipomoea alba*), maunaloa (*Canavalia cathartica*), and *Neonotonia wightii*. The stream itself is clogged with a thick growth of California grass mixed with honohono. Other common grasses in the vicinity are Hilo grass, Job's-tears (*Coix lachrym-jobi*), Glenwood grass, and basketgrass. Sourbush (*Pluchea carolinensis*) is the main shrub species, swordfern the main fern, and sensitive plant and oī (*Stachytarpheta cayennensis*) the main herbs.

Only 2 (6%) of 36 taxa noted at this site are native: the sedge *Cyperus polystachyos* and the fern neke (*Cyclosorus interruptus*), both common species in wetland sites.

Site 4b

A stream site between Site 4 and the beach was inventoried for comparison against the recently disturbed conditions at Site 4. Here, as at Site 4, tall Java plum forest covers one bank and slope, backed by black bamboo and strawberry guava. The stream is narrow and in many parts clogged with vegetation, and the opposite bank is a tangled mix of grasses, vines, and occasional shrubs. Clogging the stream is a mix of California grass, umbrella sedge (*Cyperus involucratus*), Job's-tears, Hilo grass, Glenwood grass, primrose willow, and honohono. Again, the main shrub is Indian pluchea, the main fern swordfern. Common vines

here are moon flower, maunaloa, *Neonotonia wightii*, nanea (*Vigna marina*), and koali 'awa (*Ipomoea indica*). Other grasses on the open slopes include sourgrass (*Digitaria insularis*) and palmgrass (*Setaria palmifolia*), while *Cyperus polystachyos* is an occasional sedge. Common herbs on the open slopes include wedelia (*Sphagneticola trilobata*), sensitive plant, and oī.

Only 4 (9%) of the 43 taxa noted here were native, but perhaps suggesting a lesser degree of disturbance, 3 of them were fairly common elements: the sedge *Cyperus polystachyos* and the vines nanea and koali 'awa. The fourth, 'ahu'awa (*Cyperus javanicus*), is a wetland plant only noted at this site during the survey. All of these natives commonly occur in Hawai'i.

Botanical Survey – Results

From a botanical perspective, there appears to be no impediment to further development of any of the sites surveyed. No federally listed endangered or threatened species, nor any candidate endangered species or species of concern, were noted, nor were there any significant remnants of native ecosystems, save perhaps for some areas of hau (*Hibiscus tiliaceus*) shrubland on the margin of Pu'u Ka 'Ele Reservoir and in the Pila'a Stream drainage below the waterfall at Site 3. Hau shrubland is a common coastal and lowland community adjacent to streams and ponds on windward coasts (Wagner et al. 1999). It is readily apparent that the land section that includes the survey sites has had a long history of vegetation modification. Of the 136 plant taxa noted during the survey, only 12 (9%) were native, while 124 (91%) were introduced weedy species or cultivated plantings. Furthermore, several of the native taxa were only rarely noted (e.g., *Pandanus tectorius*, hala; *Cyperus javanicus*, 'ahu'awa), and the biomass of native plants in the study area is certainly much less than 9% (see Table 2).

Impacts of Stream Channel Alteration and Pond Construction to Native Biota

Because of the long history of vegetation disturbance and near complete lack of native vegetation in the lowland areas of both the unnamed tributary flowing into Pu'u Ka 'Ele Reservoir and Pila'a Stream (Sites 1, 3, and 4), no negative impacts from pond construction to native vegetation occurred at the various study sites. Similarly, because of the complete lack of native aquatic (excluding endangered Hawaiian waterbirds) biota at Site 1, no negative impacts occurred to stream vertebrates and invertebrates. Pond construction at Site 1 above Pu'u Ka 'Ele Reservoir would have no harmful impacts to native birds, but as this pond is so small, a minimal amount of new waterbird habitat was created. Clearing of the small area at

Site 3 in Pīla‘a Stream also caused no harmful or significant impacts to the stream or stream animals, and in fact the clearing of the invasive grass that has choked the stream in the reach below the waterfalls was likely beneficial to native aquatic organisms. In summary, negative impacts to the environment from pond construction have not occurred in any way at Site 1 on the unnamed tributary flowing into Pu‘u Ka ‘Ele Reservoir, or at Site 4 (nearest the ocean) on Pīla‘a Stream.

Impacts From Construction at Site 3

It is impossible to know with certainty whether native fish, crustaceans, or mollusks were found in Pīla‘a Stream near Highway 56 (Site 3) because baseline surveys are not available prior to the construction of the two large ponds currently located in this area. The 50 ft. waterfall downstream of the lowest pond at Site 3 is certainly not a barrier for the native stream macrofauna (fish, crustaceans, mollusks). Thus, a reasonable assumption can be made that native stream species were found in this stream area, at least prior to alien fish introductions that have occurred throughout the Hawaiian Islands since the 1920’s. Reservoir habitat, such as that found at Site 3 is unsuitable and incompatible with all native fish, crustaceans, mollusks, and most native aquatic insects, because this habitat was not naturally found in Hawaii until recently and native freshwater species are unable adapt to this different habitat. Therefore, the length of the two new impoundments and areas of Pīla‘a Stream upstream of the reservoir have potentially been rendered unsuitable for native freshwater stream species (excluding waterbirds, see below), assuming alien fish species were not present in this area prior to the construction of the two impoundments.

On the other hand, the creation of the reservoir habitats has certainly increased habitat availability for at least three and possibly more species of endangered Hawaiian waterbirds. The Common Moorhen, the Hawaiian Coot, and Nēnē were all observed using the ponds at Site 3, with Nēnē showing some site fidelity to these ponds. Because of the complete predominance of alien fish upstream of the ponds at Site 3, native fish and other stream biota would not currently thrive, or perhaps even be found in this section of Pīla‘a Stream if the ponds had never been constructed. However, the current value of the reservoirs in providing habitat for endangered birds heavily outweighs the potential loss of several hundred meters of marginal, silty, disturbed aquatic habitats that comprise Pīla‘a Stream in and around, and upstream of the new impoundments.

Recommendations and Management Options

Negative environmental impacts did not occur at Sites 1 and 4, therefore no mitigative measures seem to be needed in these areas. The ponds at Site 3 should remain in place because of the benefits provided to endangered Hawaiian waterbirds. These ponds could be managed and enhanced to provide additional wetland habitat for native Hawaiian waterfowl, with water levels managed appropriately for breeding birds. Additionally, nesting islands could be constructed to allow the birds to breed away from potential predators such as rats, cats, and dogs. Further downstream, at Site 4, Pīla'a Stream could be cleared of the alien grasses that have completely overgrown and obscured the stream channel and replaced with beneficial native grasses and vegetation. The current overly thick mixture of alien grasses found at Site 4 are harmful to all native stream biota because they reduce sunlight penetration, block migratory movements, and are generally unsuitable to aquatic species that have evolved in clear, rocky stream channels lacking this thick grass layer. Remove of this thick layer of several species of exotic grasses, and replacement with native vegetation in the lowest reaches of Pīla'a Stream would improve aquatic habitats for all native species.

A number of Federal programs exist that provide incentives for private landowners to enhance their properties for fish and wildlife purposes. The landowner may be able to take advantage of some of the programs offered by the U.S. Fish & Wildlife Service and the U.S. Department of Agriculture, Natural Resources Conservation Service that provide financial incentives or assistance in enhancing wildlife and wetlands, especially endangered Hawaiian birds.

References

- Berger, A. J. 1981. Hawaiian birdlife. Second edition. University of Hawaii Press, Honolulu, Hawaii.
- Englund, R. A. and D. J. Preston. 1999. Biological assessment of the lower Hāmākua Ditch on the Hawaiian stream fly (*Sigmatineurum meaohi*) and other aquatic insects. Contribution No. 1999-003 to the Hawaii Biological Survey, Bishop Museum. 31 pp.
- Englund, R. A. and D. A. Polhemus. 2001. Evaluating the effects of introduced rainbow trout (*Oncorhynchus mykiss*) on native stream insects on Kaua'i Island, Hawai'i. *Journal of Insect Conservation* 5: 1-17.
- Font, W. F., and D. C. Tate. 1994. Helminth parasites of native Hawaiian freshwater fishes: an example of extreme ecological isolation. *Journal of Parasitology* 80: 682-688.

- Perkins, R. C. L. 1903. Vertebrata. Pages 365-466 *in* D. Sharp (ed.) Fauna Hawaiiensis. Volume 1, part IV. The University Press, Cambridge, England.
- Polhemus, D. A. and A. Asquith. 1996. Hawaiian damselflies: a field identification guide. Bishop Museum Press, Honolulu. 122 pp.
- Staples, G. W., and D. R. Herbst. In press. A tropical garden flora. Bishop Museum Press, Honolulu.
- USFWS (United States Department of the Interior Fish and Wildlife Service). 2000. Listed and Candidate Species, as designated under the U.S. Endangered Species Act. Published on November 29, 1999 at (<http://www.r1.fws.gov/pacific/wesa/ mesa /hianimals.PDF>).
- Wagner, W. L., D. R. Herbst and S. H. Sohmer. 1999. Manual of the flowering plants of Hawai'i. 2 vols. Rev. ed. Univ. Hawai'i Press & Bishop Museum Press, Honolulu.
- VanRiper, Charles III, S.G. VanRiper, M.L. Goff, and M. Laird. 1986. The epizootiology and ecological significance of malaria in Hawaiian landbirds. *Ecological Monographs* 56:327-344.
- Warner, R.E. 1968. The role of introduced diseases in the extinction of the endemic Hawaiian avifauna. *Condor* 70:101-120.

Appendix: Pu‘u Ka ‘Ele Reservoir and Pila‘a Stream Species List

The following is a list of plant taxa noted during a walk-through survey of five survey sites on the Pflueger Pu‘u Ka ‘Ele Reservoir tributary/Pila‘a Stream biological assessment of 27–29 September 2001. A total of 136 vascular plants are included. Plants are divided into 4 main groups: ferns, gymnosperms, dicots, and monocots. Within these groups, plants are arranged alphabetically by family, genus, and species. Each entry includes scientific name with author citation, biogeographic status, common name (if available), and presence or absence at each of the five sites. Taxonomy, status, and common names of the vascular plants are in accordance with Wagner et al. (1999) or Staples and Herbst (in press). A few specimens were collected and deposited in the Bishop Museum Botany Department herbarium; some unknown species were collected and compared with herbarium collections to secure correct identifications. Dr. Derral R. Herbst (vascular plants) is thanked for assistance with identifications. An explanation of abbreviations used in the list follows.

Biogeographic Status

end	Endemic: native, occurring only in the Hawaiian Archipelago; species that have evolved into something uniquely Hawaiian after arriving naturally from elsewhere.
ind	Indigenous: native, occurring naturally in the archipelago but also outside of Hawai‘i; many of these species inhabit the coastal zone, where they can be readily dispersed by water or seabirds.
nat	Naturalized: introduced to the archipelago directly or indirectly by humans since Western contact and reproducing and spreading vegetatively or from seed.
pol	Polynesian introduction: introduced by original Polynesian settlers, either intentionally or unintentionally, and now naturalized.
ind?	Questionably indigenous: probably indigenous, possibly naturalized.
nat?	Questionably naturalized: probably naturalized, possibly indigenous.
pol?	Questionably a Polynesian introduction; possibly introduced in historic times.
cult	Cultivated plant; not evidently a naturalized plant in its setting

Plant survey sites

- 1 Site 1, adjacent to Puu Ka Ele Reservoir
- 1b Margin of Puu Ka Ele Reservoir and surrounding hills
- 3 Site 3, ponds just below Kūhiō Hwy (Hwy 56)
- 4 Site 4, pond near coast
- 4b Stream approaching site 4 from coastal end

Frequency

- c common
- o occasional
- r rare

Appendix 1.

Family/Scientific name	Status	Common name	1	1b	3	4	4b
FERNS							
Athyriaceae							
<i>Deparia petersenii</i> (Kunze) M. Kato	nat		o				
Blechnaceae							
<i>Blechnum appendiculatum</i> Willd.	nat		o				
Gleicheniaceae							
<i>Dicranopteris linearis</i> (Burm f.) Underw.	ind	uluhe		r			
Lindsaeaceae							
<i>Lindsaea ensifolia</i> Sw.	nat			r			
<i>Sphenomeris chinensis</i> (L.) Maxon	ind	pala'ā	r	r			
Nephrolepidaceae							
<i>Nephrolepis multiflora</i> (Roxb.) F. M. Jarrett ex C. V. Morton	nat	swordfern	o	c	r	o	o
Polypodiaceae							
<i>Phlebodium aureum</i> (L.) J. Sm.	nat	golden polypody		r			
<i>Phymatosorus grossus</i> (Langsd. & Fisch.) Brownlie	nat	laua'e, maile-scented fern					r
Pteridaceae							
<i>Adiantum raddianum</i> C. Presl	nat	maidenhair fern	o				
<i>Pityrogramma calomelanos</i> (L.) Link	nat	silverfern	r		r		
Thelypteridaceae							
<i>Christella dentata</i> (Forssk.) Brownsey & Jermy	nat	pai'i'ihā	o	o		r	r
<i>Christella parasitica</i> (L.) Lév.	nat		o			r	
<i>Cyclosorus interruptus</i> (Willd.) H. Ito	ind	neke		c		r	
<i>Macrothelypteris torresiana</i> (Gaudich.) Ching	nat		r				
GYMNOSPERMS							
Araucariaceae							
<i>Araucaria</i> sp.	cult				r		
MONOCOTS							
Agavaceae							
<i>Cordyline fruticosa</i> (L.) A. Chev.	pol	kī, ti				r	
Araceae							
<i>Alocasia macrorrhizos</i> (L.) Schott	pol	'ape, elephant's-ear plant			r		
<i>Philodendron</i> sp.	cult				r		
<i>Xanthosoma roseum</i> Schott	nat	'ape			r		r
Arecaceae							
<i>Archontophoenix alexandrae</i> (F. Muell.) H. Wendl. & Drude	nat	king palm	r	r			
<i>Cocos nucifera</i> L.	pol	niu, coconut			r		r
Commelinaceae							
<i>Commelina diffusa</i> Burm. f.	nat	honohono	o	o	c	c	c
Cyperaceae							
<i>Cyperus haspan</i> L.	nat				r		
<i>Cyperus involucratus</i> Roxb.	nat	umbrella sedge	r				o
<i>Cyperus javanicus</i> Houtt.	ind	'ahu'awa					r

Appendix 1 (cont.)

Family/Scientific name	Status	Common name	1	1b	3	4	4b
<i>Cyperus meyenianus</i> Kunth	nat			r			
<i>Cyperus pilosus</i> Vahl	nat			o	o		
<i>Cyperus polystachyos</i> Rottb.	Ind		r	c	o	r	o
<i>Eleocharis geniculata</i> (L.) Roem. & Schult.	Nat	spikerush		o			r
<i>Fimbristylis dichotoma</i> (L.) Vahl	ind			r			
<i>Fimbristylis miliacea</i> (L.) Vahl	nat			o	r		
<i>Kyllinga brevifolia</i> Rottb.	Nat	kili'o'opu		o	r		r
<i>Rhynchospora</i> sp.	Nat			r			
<i>Schoenoplectus juncooides</i> (Roxb.) Palla	ind	kaluhā	r	r			
Heliconiaceae							
<i>Heliconia</i> spp.	Cult					r	
Orchidaceae							
<i>Spathoglottis plicata</i> Blume	nat	Philippine ground orchid		r			
Pandanaceae							
<i>Pandanus tectorius</i> Parkinson ex Z	ind	hala, screwpine	r	r			
Poaceae							
<i>Andropogon glomeratus</i> (Walter) Britton, Sterns & Poggenb.	Nat	bluestem, beardgrass	c	o			
<i>Axonopus fissifolius</i> (Raddi) Kuhlmann	Nat	narrow-leaved carpetgrass		c	r		
<i>Brachiaria mutica</i> (Forssk.) Stapf	nat	California grass	c	c	c	c	c
<i>Cenchrus echinatus</i> L.	nat	common sandbur			r		
<i>Coix lachryma-jobi</i> L.	nat	Job's-tears			r	o	o
<i>Digitaria ciliaris</i> (Retz.) Koeler	nat	Henry's crabgrass	r	r	r		
<i>Digitaria insularis</i> (L.) Mez ex Ekman	nat	sourgrass					o
<i>Eleusine indica</i> (L.) Gaertn.	Nat	wiregrass			o		
<i>Eragrostis</i> sp.	Nat				r		
<i>Oplismenus hirtellus</i> (L.) P. Beauv.	Nat	basketgrass	c	o		o	
<i>Panicum repens</i> L.	nat	torpedo grass		o			
<i>Paspalum conjugatum</i> P. J. Bergius	nat	Hilo grass	c	c	c	c	c
<i>Paspalum dilatatum</i> Poir.	Nat	dallis grass			r		
<i>Paspalum scrobiculatum</i> L.	ind?	Ricegrass		c			
<i>Paspalum urvillei</i> Steud.	Nat	vasey grass	r	c	r		r
<i>Phyllostachys nigra</i> (Lodd.) Munro	nat	black bamboo			o		o
<i>Sacciolepis indica</i> (L.) Chase	nat	Glenwood grass	c	c		o	o
<i>Setaria palmifolia</i> (J. König) Stapf	nat	palmgrass				r	o
<i>Setaria parviflora</i> (Poir.) Kerguelen	nat	yellow foxtail	r	r			
<i>Sporobolus indicus</i> (L.) R. Br.	Nat	smutgrass	r	r	r		
Pontederiaceae							
<i>Monochoria vaginalis</i> (Burm. F.) C. Presl	nat	cordate monochoria		r			
Zingiberaceae							
<i>Hedychium flavescens</i> N. Carey ex Roscoe	nat	yellow ginger			r		r
DICOTS							
Acanthaceae							
<i>Thunbergia fragrans</i> Roxb.	Nat	white thunbergia				r	r
Amaranthaceae							
<i>Amaranthus spinosus</i> L.	nat	spiny amaranth			r		

Appendix 1 (cont.)

Family/Scientific name	Status	Common name	1	1b	3	4	4b
Anacardiaceae							
<i>Mangifera indica</i> L.	nat	mango			r		
Apiaceae							
<i>Centella asiatica</i> (L.) Urb.	nat	Asiatic pennywort		r			
Araliaceae							
<i>Schefflera actinophylla</i> (Endl.) Harms	nat	octopus tree, umbrella tree	o	r			
Asteraceae							
<i>Ageratum conyzoides</i> L.	nat	maile hohono	o	r	r		o
<i>Ageratum houstonianum</i> Mill.	nat	maile hohono	r	o	r		
<i>Bidens pilosa</i> L.	nat	Spanish needle, beggartick			o		
<i>Conyza canadensis</i> (L.) Cronquist var. <i>pusilla</i> (Nutt.) Cronquist	nat	horseweed	r	r			
<i>Eclipta prostrata</i> (L.) L.	nat	false daisy				r	
<i>Emilia fosbergii</i> Nicolson	nat	pualele				r	r
<i>Emilia sonchifolia</i> (L.) DC. var. <i>javanica</i> (Burm. f.) Mattf.	nat	Flora's paintbrush				r	
<i>Erechtites valerianifolia</i> (Wolf) DC.	nat	fireweed		r		r	
<i>Pluchea carolinensis</i> (Jacq.) G. Don	nat	sourbush, marsh fleabane	o	r	r	o	o
<i>Pseudelephantopus spicatus</i> (Juss. ex Aubl.) Vahl	nat	elephant's-foot	c	c		r	r
<i>Sphagneticola trilobata</i> (L.) Pruski	nat	wedelia				r	c
<i>Synedrella nodiflora</i> (L.) Gaertn.	nat	nodeweed				r	
<i>Verbesina encelioides</i> (Cav.) Benth. & Hook.	nat	golden crown-beard				r	
Caricaceae							
<i>Carica papaya</i> L.	nat	papaya		r			
Caryophyllaceae							
<i>Drymaria cordata</i> (L.) Willd. ex Roem. & Schult. var. <i>pacifica</i> M. Mizush.	nat	pipili		o			
Casuarinaceae							
<i>Casuarina equisetifolia</i> L.	nat	common ironwood		r			
Cecropiaceae							
<i>Cecropia obtusifolia</i> Bertol.	nat	guarumo, trumpet tree	c	c	r	r	r
Combretaceae							
<i>Terminalia catappa</i> L.	nat	tropical almond, false kamani				r	r
Convolvulaceae							
<i>Ipomoea alba</i> L.	nat	moon flower, koali pehu				r	c c
<i>Ipomoea indica</i> (Burm.) Merr.	ind	koali 'awa					o
<i>Ipomoea obscura</i> (L.) Ker Gawl.	nat	morning glory				r	
<i>Ipomoea triloba</i> L.	nat	little bell				r	
Euphorbiaceae							
<i>Aleurites moluccana</i> (L.) Willd.	pol	kukui		r	r	r	r
<i>Chamaesyce hirta</i> (L.) Millsp.	nat	hairy spurge				r	
<i>Chamaesyce hypericifolia</i> (L.) Millsp.	nat	graceful spurge				r	
<i>Chamaesyce hyssopifolia</i> (L.) Small	nat	spurge				r	
<i>Phyllanthus debilis</i> Klein ex Willd.	nat	niruri				r	
<i>Ricinus communis</i> L.	nat	castor bean				r	r

Appendix 1 (cont.)

Family/Scientific name	Status	Common name	1	1b	3	4	4b
Fabaceae							
<i>Arachis</i> sp.	Nat				o		
<i>Caesalpinia decapetala</i> (Roth) Alston	nat	wait-a-bit, Mysore thorn				r	
<i>Canavalia cathartica</i> Thouars	nat	maunaloa				c	c
<i>Chamaecrista nictitans</i> (L.) Moench var. <i>glabrata</i> (Vogel) H. S. Irwin & Barneby	nat	partridge pea		r	r		
<i>Crotalaria juncea</i> L.	cult	rattlepod			o		
<i>Crotalaria</i> sp.	Nat				r		
<i>Desmanthus pernambucanus</i> (L.) Thell.	Nat	slender mimosa			r		
<i>Desmodium sandwicense</i> E. Mey.	Nat	Spanish clover, chili clover		o	o	r	
<i>Desmodium triflorum</i> (L.) DC.	Nat	tick trefoil, tick clover		r			
<i>Falcataria moluccana</i> (Miq.) Barneby & J. W. Grimes	nat	Molucca albizia	c	c			
<i>Indigofera suffruticosa</i> Mill.	Nat	indigo			r		
<i>Leucaena leucocephala</i> (Lam.) de Wit	nat	koa haole			r	r	r
<i>Mimosa pudica</i> L. var. <i>unijuga</i> (Duchass. & Walp.) Griseb.	Nat	sensitive plant, sleeping grass	c	c	o	o	c
<i>Neonotonia wightii</i> (Wight & Arn.) Lackey	nat				o	o	c
<i>Stylosanthes fruticosa</i> (Retz.) Alston	nat		r	o			
<i>Vigna marina</i> (Burm.) Merr.	Ind	nanea, beach pea					o
Lythraceae							
<i>Cuphea carthagenensis</i> (Jacq.) J. F. Macbr.	Nat	tarweed	r	r			
Malvaceae							
<i>Abutilon grandifolium</i> (Willd.) Sweet	nat	hairy abutilon			r		
<i>Hibiscus tiliaceus</i> L.	ind?	Hau		o	o		
<i>Malvastrum coromandelianum</i> (L.) Garcke ssp. <i>Coromandelianum</i>	nat	false mallow			r		
<i>Sida acuta</i> Burm. F. ssp. <i>Carpinifolia</i> (L. f.) Borss. Waalk.	Nat				r		
<i>Sida rhombifolia</i> L.	nat?				o		
Melastomataceae							
<i>Pterolepis glomerata</i> (Rottb.) Miq.	Nat			c			
Meliaceae							
<i>Azadirachta indica</i> A. Juss.	Cult	neem			o		
<i>Melia azedarach</i> L.	nat	chinaberry, pride-of-India			r	r	
Moraceae							
<i>Artocarpus altilis</i> (Parkins. Ex Z) Fosb.	Pol	'ulu, breadfruit			r		
Myrsinaceae							
<i>Ardisia elliptica</i> Thunb.	Nat	shoebuttan ardisia	o	c		r	
Myrtaceae							
<i>Melaleuca quinquenervia</i> (Cav.) S. T. Blake	nat	paperbark		r			
<i>Psidium cattleianum</i> Sabine	nat	strawberry guava	c	c		o	o
<i>Psidium guajava</i> L.	nat	common guava		o		r	
<i>Syzygium cumini</i> (L.) Skeels	nat	Java plum		c	o	c	c

Appendix 1 (cont.)

Family/Scientific name	Status	Common name	1	1b	3	4	4b
Nyctaginaceae							
<i>Bougainvillea</i> sp.	Cult	bougainvillea			r		
<i>Mirabilis jalapa</i> L.	nat	four-o'clock, marvel of Peru			r		
Nymphaeaceae							
<i>Nymphaea</i> spp.	nat			r			
Onagraceae							
<i>Ludwigia octovalvis</i> (Jacq.) P. H. Raven	pol?	primrose willow	o	o	o	r	o
Passifloraceae							
<i>Passiflora edulis</i> Sims	nat	passion fruit, liliko'i			r	r	
Polygalaceae							
<i>Polygala paniculata</i> L.	nat	milkwort	o	o	r		
Rosaceae							
<i>Rubus rosifolius</i> Sm.	nat	thimbleberry	o	o			
Rubiaceae							
<i>Morinda citrifolia</i> L.	pol	noni, Indian mulberry				r	r
<i>Spermacoce assurgens</i> Ruiz & Pav.	nat	buttonweed			r		
Sapotaceae							
<i>Chrysophyllum oliviforme</i> L.	nat	satin-leaf	o	o	r		
Verbenaceae							
<i>Lantana camara</i> L.	nat	lantana				r	r
<i>Stachytarpheta cayennensis</i> (Rich.) Vahl	nat	ōwī, oī	o	o		o	o
<i>Verbena litoralis</i> Kunth	nat	vervain			r		