EXOTIC PLANTS IN KĪPAHULU VALLEY: 1945-1980

Alvin Y. Yoshinaga
Department of Botany
University of Hawaii at Manoa
Honolulu, Hawaii 96822

The Kīpahulu Valley District of Haleakala National Park is known for the exceptional quality of its native montane rain forest vegetation. In recent years there has been concern about damage to native plant communities from feral pig (Sus scrofa L.) activities and invasion by exotic plant species. The number of exotic plant species noted by scientific parties between the Haleakalā Crater rim and the lower edge of the forest has increased steadily. In 1945, the first such party reported five species between the upper tree line and Palikea (Fagerlund 1945). In 1967, Lamoureux (1967) reported 22 species within that zone. During the present study (1978-1980), we have recorded 55 species of exotics and new weedy natives. Each succeeding party surveyed a wider area more intensively than the previous party. If the 1945 party had retraced its route on the same schedule, it might have noted about 13 exotic species in 1967 and 18 today. In 1945, only *Maui pā'makani (Eupatorium adenophorum) was com-com. At present, 20 species are either widespread or abundant. Exotics are most abundant in the koa (Acacia koa Gray) forest below 1200 m (3940 ft). Some exotics occur within the 'ōhi'a (Metrosideros) forest above 1200 m (3940 ft) but none are common beneath the canopy.

Appendix I lists exotic and weedy native plant species reported from Kīpahulu Valley between 610 m (2000 ft) and the Haleakalā Crater rim. Grasses, sedges, and composites make up a particularly large part of the list. Characteristics shared by many species on this list are: Small size, light propagules, herbaceous growth form, and tropical origin. Most are ruderal species which readily colonize disturbed habitats. Species which are now especially abundant or appear to be spreading include the following:

Ageratum conyzoides	Maile honohono
Cuphea carthagenensis	Puakamoli
Cyperus brevifolis	Kyllinga
C. haspan	
C. kyllinga	Kyllinga
Eupatorium adenophorum	Maui pā'makani
Hydrocotyle verticillata	Pohepohe

* Exotic species.

Ludwigia octivalvis	Kāmole
Paspalum conjugatum	Hilo grass
P. orbiculare	Ricegrass
Psidium cattleianum	Strawberry guava
Rhynchospora lavarum	Kuolohia
Rubus rosaefolius	Thimbleberry
Sacciolepis indica	Glenwoodgrass
Stachytarpheta jamaicensis	Oi
Youngia japonica	Oriental hawksbeard

The two agents most commonly accused of spreading exotics into Kīpahulu Valley are man and feral pigs. The argument for wholesale man-caused vegetation change is not strong. Most of the spread of exotics occurred during periods of very little human activity, frequently in areas far from any activity. Comparison of the most heavily used trail for the present project with an otherwise similar trail used only for light downhill traffic (counter to the direction of spread of most exotics) suggests some small-scale dispersal from human activity, but no large-scale mass movement. Many of the exotics have propagules which are readily dispersable independently.

Feral pigs are known to disperse some exotics, such as *strawberry guava, and to attack certain natives, such as lobeliads and hāpu'u (Cibotium sp.). Probably more important is their role in habitat modification, particularly by rooting. Most of the widespread exotics are ruderal species, well-adapted to disturbed habitats. By contrast, few of the natives are; the few which have increased or become established since 1967 are mostly weedy sedges.

A series of exclosures have been established at 670 m (2200 ft), 960 m (3150 ft), and 1430 m (4700 ft) to study the effects of pig exclusion on vegetation. The lower two are in koa forest heavily invaded by exotics, the uppermost is in relatively uninvaded 'ōhi'a forest. The exclosures range from 0.04 ha (0.1 acre) to 0.12 ha (0.3 acre). Frequencies of plants in 1 m^2 quadrats along fixed transects both inside and outside the exclosures are recorded.

So far there have been few changes in vegetation. In the longest established exclosure, at 670 m (2200 ft), the average number of plant species per 1 m^2 quadrat in September 1978 was 2.9 inside the exclosure and 2.6 outside. In February, the average was 3.0 inside, and 2.8 outside. The most noticeable difference between the inside and the outside in 1980 was the more continuous leaf litter layer inside.

There is special concern about *strawberry guava, which has spread rapidly since 1967. In Kīpahulu Valley, the red variety predominates, although the yellow spherical variety occurs also. Unlike most of the other exotics, *strawberry guava is a tree which is relatively long-lived and shade-tolerant. It forms dense stands from which natives may be excluded.

To study its establishment mechanism, all *strawberry guava was cleared from 20 m X 20 m sites at 640 m (2090 ft), in an area with ca. 2900 trees of 2 cm or greater diameter at breast height (dbh) per ha; at 820 m (2700 ft), near the current upper edge of heavy infestation; and at 950 m (3120 ft), where *strawberry guava is currently scattered and uncommon. A 10 m X 10 m gridded plot was laid out in the center of each site so that records could be kept of individual seedlings as they emerged. Pig rootings and droppings were also recorded.

The average rate of seedling appearance at the 640 m (2090 ft) site has been 0.4 seedling/m^2/year. Seedling density 14.5 months after initial clearing was 0.2 seedling/m^2; this implies a new seedling has a 20% chance of surviving one year.[1] At the 820 m (2700 ft) site, appearance rate has been 0.6 seedling/m^2/year; density 13.5 months after clearing was 0.2 seedling/m^2, implying a survivorship rate of 8% per year. No seedlings have appeared within the 950 m (3120 ft) site, which had no mature trees to begin with. The latter observation suggests that the seedlings arise from dormant seeds rather than from seeds brought in by animals. No seedlings have arisen within the plots from pig droppings, although they are known to do so elsewhere. Most have arisen on undisturbed moss or leaf litter.

Observations of other marked *strawberry guava seedlings show low mortality once the seedlings reach around 10 cm height. Of 27 such seedlings marked in February 1979, 23 were still alive in July 1980, for an 89% annual survivorship rate. Seedlings are common beneath mature plants below about 900 m (2950 ft). Above that elevation, they are practically absent beneath mature plants, and occur elsewhere mainly in scattered clumps. This suggests that at these elevations it becomes established mainly through animal dispersal.

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[1] Assuming that: (1) All seedlings have been counted; (2) seedlings appear at a constant rate; and (3) the death rate is uniform for seedlings of all ages throughout the year, the survivorship rate for one year can be found by solving for "a" in the following equation:

$$\int_0^t a^t dt = x \qquad \text{where} \qquad t = \text{total elapsed time}$$

$$x = \frac{\text{(seedling density at t)}}{\text{(annual appearance rate)}}$$

This gives $\frac{a^t - 1}{LNa}$, which is readily determined numerically.

LITERATURE CITED

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APPENDIX I

List of Exotic and Weedy Native Plant Species Reported from Kīpahulu Valley

SPECIES REPORTED UP TO 1945 (Fagerlund 1945; Lamoureux 1967):

Coix lachryma-jobi L.	Job's tears
Eupatorium adenophorum Spreng.	Maui pā'makani
Musa sp.	Banana
Polygonum glabrum Willd.	Kāmole
Rubus rosaefolius Sm.	Thimbleberry
Setaria palmaefolia (Koen.) Stapf	Palmgrass ?

ADDITIONAL SPECIES REPORTED IN 1967 (Lamoureux 1967):

Adiantum cuneatum Langs. & Fisch.	Maidenhair fern
Cordyline terminalis (L.) Kunth	Ti
Cuphea carthagenensis (Jacq.) MacBride	Puakamoli
Cyperus brevifolius (Rottb.) Hassk.	Kyllinga
Drymaria cordata (L.) Willd.	Pipili
****Eleocharis obtusa* (Willd.) Schult.	Pīpī wai
Erechtites valerianaefolia (Wolf) DC.	Hino hana
Geranium carolinianum L. var. *australe* (Benth.) Fosb.	Carolina crane's bill
Holcus lanatus L.	Velvetgrass
Hydrocotyle verticillata Thunb.	Pohepohe
Hypochaeris radicata L.	Gosmore
Ludwigia octivalvis (Jacq.) Raven	Kāmole
Oplismenus hirtellus (L.) Beauv.	Honohono-kukui
Paspalum conjugatum Berg.	Hilo grass
Prunella vulgaris L.	Self-heal
Psidium cattleianum Sabine	Strawberry guava
P. guajava L.	Guava
Rumex acetosella L.	Sheep sorrel
Sacciolepis indica (L.) Chase	Glenwoodgrass
****Solanum nigrum* L.	Pōpolo
Youngia japonica (L.) DC.	Oriental hawksbeard

ADDITIONAL SPECIES REPORTED BY 1980 (Becking 1970; Yoshinaga 1980):

Ageratum conyzoides L.	Maile honohono
Axonopus compressus (Sw.) Beauv.	Broad-leaved carpetgrass
Castilleja arvensis Schlecht.	Field Indian paintbrush
Commelina diffusa Burm. f.	Honohono
Cyperus haspan L.	
C. kyllinga Endl.	Kyllinga
Digitaria sanguinalis (L.) Heist. in Scop.	Kūkaipua'a ?
Erigeron canadensis (L.) Cronq.	Ilioha
Eugenia jambos L.	Rose apple
Eupatorium riparium Regel	Hāmākua pamakani
Festuca sp.	Fescue
Fimbristylis dichotoma (L.) Vahl	Tall fringe rush
Melinis minutiflora Beauv.	Molassesgrass ?
Paspalum dilatatum Poir.	Dallis grass
P. orbiculare Forst. f.	Ricegrass
P. urvillei Steud.	Vaseygrass
**Rhynchospora lavarum* Gaud.	Kuolohia ?
Senecio vulgaris L.	Common groundsel
Setaria geniculata (Poir.) Beauv.	Perennial foxtail
Spathodea campanulata Beauv.	African tulip tree
Spathoglottis plicata Bl.	Malayan ground orchid
Stachytarpheta jamaicensis (L.) Vahl	Oi

And several species not yet identified.

** Native or possibly native.

? Questionable identification.