Propagating Native and Introduced Plants for Hawaii[1]

Jeanine Lum[2]

Abstract.--Hawaii Division of Forestry and Wildlife nurseries propagate both native and introduced plants for conservation plantings. Propagation and re-establishment of native Hawaiian species is proving to be as challenging as managing the threats to the Hawaiian plant communities. A summary of the history and threats to native plant communities is included in this paper.

INTRODUCTION

Most people view Hawaii as a tropical paradise consisting of sandy beaches, warm blue skies, and coconut trees. However there is much more that makes the islands so special. Hawaii's flora and fauna is known for its natural diversity and high level of endemism. To appreciate the challenges of plant conservation in Hawaii, one must have a general understanding of its history, uniqueness, and current threats to the native plant communities. This paper includes a brief summary of Hawaii's past.

The Hawaiian archipelago extends from Kure atoll in the west to the island of Hawaii in the east, a distance of 1,200 miles. It contains eight main islands and a number of smaller ones. The island of Hawaii is about the size of Connecticut and is approximately the same land mass of the other main islands combined. The oldest island is an atoll and is 27 million years old. The youngest island is about one-half million years old and still volcanically active (Carlquist 1980). A new island is forming on the ocean floor south of the island of Hawaii.

Hawaii has a diverse range of native plant communities that vary greatly over short distances. This is attributed to the great differences in rainfall, topography, elevation, soils, and exposure. Rainfall varies from less than 10 inches in coastal areas to over 460 inches on Kauai's Mt. Waialeale. Midelevation rainforests receive fog and rain throughout the year while leeward areas often receive moisture seasonally. Plant communities begin along the coast and span up to alpine conditions found at 10,000 feet on the 13,796 foot Mauna Kea mountain.

The Hawaiian Islands are the most isolated land mass in the world, located 2,500 miles away from the closest continent. Plants seeds were carried by birds, ocean currents and winds from neighboring continents. Many Hawaiian plants evolved are endemic, being found nowhere else in the world. One example is the native Silverswords which evolved from California Tarweeds. Some plants are endemic to a particular island. For example, the Iliau (Wilkesia gvmnoxiphium), found only on the Island of Kauai.

1Paper presented at the Combined Meeting of the Western Forest Nursery Council and Intermountain Conservation Nursery Association, Fallen Leaf Lake, CA, September 14-18, 1992.

[2]Jeanine Lum, Nursery Forester, State of Hawaii, Hawaii Division of Forestry and Wildlife, Kamuela, Hawaii.

Hawaii has the highest level of endemism in the world. Of the 216 native Hawaiian genera, 32 (15%) are endemic (table 1) (Wagner et al. 1990). Endemic species account for 89 percent of all native plants.

HISTORY AND THREATS

Hawaiian forests have been greatly altered since the arrival of man. Polynesians arrived in Hawaii about 1,500 years ago. They brought pigs, chickens, and dogs for food and inadvertently introduced Polynesian rats and other pests. The lowland forests were slashed and burned to make way for cultivated crops such as taro, sweet potatoes, and bananas. White man arrived in 1778 and the forest alteration accelerated. Large scale agricultural crops were introduced such as sugarcane and pineapple. As the word spread about this paradise called Hawaii, urbanization and development rapidly progressed thus displacing native forests.

Hawaii has no native terrestrial mammals except the Hawaiian bat. Goats, cattle, and sheep were introduced in the 1790's and a taboo was placed on them to protected and conserve them. These animals became established in the wild and destructive to the forests. In the early 1820's cattle were captured and domesticated for ranching.

Today cattle graze as high as the 6,000 foot elevation and ranching comprises 25% of the land area (Hugh et al. 1986). The feral pig with its opportunistic feeding habits and prolific reproduction capability, penetrates into some of the most remote and sensitive Hawaiian forests. Even rodents are a problem as they devour native seed, strip bark off trees and consume plant pollinators (Cuddihy and Stone 1990). Hawaiian plants evolved in the absence of mammals, therefore, they have no natural defense mechanisms. Browsing, trampling, and erosion by feral animals are a key factor in the reduction and extinction of many native plant species.

Other changes include wildfires that threaten the dry lowlands ecosystems. Although some plants may recover from the wildfire, the setback gives the competitive advantage to non-native fire adapted species such as fountain grass (Pennisetum setaceum). Fountain grass is aggressive, and virtually eliminates regeneration of native plants.

Introduced plants flourished in Hawaii's mild climate. They compete and displace native plants, especially in disturbed areas. Forty-seven percent of the plant species found in Hawaii are introduced (table 2) (Wagner et al. 1990). Some of the introduced plants such as Banana Poka vine (Passiflora mollissima) have become pests and are smothering trees in forest reserves. Eighty-six plants have been recognized as serious problems in native ecosystems (Smith 1985).

With Hawaii's high endemism of flora and the many threats to the native plant communities there is no wonder many of the native plants are threatened or endangered. Approximately one-third of the plants on the U.S. Threatened and Endangered Federal Register are Hawaiian species. In 1991, only 19 of Hawaii's plants were listed. A law suit between U.S. Fish and Wildlife Service and Sierra Club Legal Defense Fund was settled out of court and the judge ruled there will be approximately 209 species listed on the federal register over the next two years (table 3) (pers. comm., U.S.F.W.S.).

Table 1.--Summary of native flowering plants in Hawaii.

	TOTAL
Families	87
Total genera	216
Endemic genera	32
Total species	956
Endemic species	850
Indigenous species	106
Total taxa	1,094
Total endemic taxa	995
Total indigenous taxa	99

[1]Data from Wagner et al. (1990).

Table 2.--Number of native and non-native flowering plants in Hawaii.

Total species	1,817
Native species	956
Naturalized species	861

[1]Data from Wagner et al. (1990).

Table 3.--Federal status of threatened and endangered plants in Hawaii as of August 1992.

	Number of Species
Listed as endangered	88
Proposed endangered	40
Proposed to be listed Nov. 1992	65
Proposed to be listed Nov. 1992 (Category 3a)	16
Total	209

[1]Data from (pers. comm., U.S.F.W.S.).

KAMUELA STATE TREE NURSERY

The degradation of Hawaii's watershed became evident and in 1903 an agency now known as the Division of Forestry and Wildlife was formed to set aside forest reserves and take care of what remained of the forests. Its goals included eradicating the thousands of animals running wild and planting many tree species in denuded areas. Many planting trials were also conducted in forest reserves to determine best species for reforestation. State nurseries were created to meet these goals.

The State Tree Nursery is situated in Kamuela on the island of Hawaii. It was formed in 1960 to provide trees for statewide reforestation projects and offer affordable seedlings to the public. The nursery began as a bareroot operation and in 1978 converted completely to a container nursery growing timber, windbreak, and Christmas trees. Some introduced timber species grown at the nursery are Queensland Maple (Flindersia bravleyana), Australian Red Cedar (Toona ciliata), Japanese Sugi (Cryptomeria iaponica), and various pines (Pinus.spp.). The only native timber species grown at the nursery is the Hawaiian Koa (Acacia koa). It is a valuable hardwood similar to Black Walnut (Juglans niara). Windbreak trees propagated include rapid growing introduced species such as the Casuarina spp., Cypresses (Cupressus spp.), Paperbark (Melaleuca quinauenervia), Wild Olive (Olea europea), various Eucalyptus and Pines (Pinus). Trees such as Monterey Pine (Pinus radiata) and Norfolk Island Pine (Araucaria excelsa) are commonly propagated for Christmas trees. The nursery grows over 70 species of plants of which 22 are available for sale to the public. The nursery has the capacity to produce one million seedlings per year but currently producing approximately 500,000 seedlings a year.

The Division of Forestry and Wildlife (DOFAW) also has four district nurseries on the other islands propagating plants for each district's specific needs. Facilities usually consists of mist houses, and more advanced propagation techniques such as cuttings and air layering. Plants are grown for Arbor Day, threatened and endangered reforestation and other special projects. In addition, tissue culture techniques using threatened and endangered plant material are being developed at Lyon Arboretum affiliated with the University of Hawaii.

NURSERY TECHNIQUES

Field planting in Hawaii occurs year-round because of the favorable climate and many microclimates statewide. Therefore the nursery sows year-round and has the challenge of managing multiple crops at multiple ages. A computer program is being customized to assist in processing tree orders, production scheduling, and monitoring of the crops.

Most nursery seedlings are grown in a 3.4 cubic inch dibble tubes while others are grown in black plastic bags for special projects. Native plants are experimentally propagated in various container size since many do not grow well in the smaller dibble tubes.

The nursery sows a variety of seed sizes and shapes. Eucalyptus deglupta (.25 mm) produces the smallest seed and the native Soapberry (Sapindus saponaria) (3 cm) produces the largest seed. Most seeds are sown directly into container using the Old Mill Seeder which can manage a wide range of seed sizes, weights, and shapes.

One of the challenges that all the nurseries face is the recalcitrant seeds of the native plants. It appears that seeds of native plants have a critical moisture content and a limited viability time. In general, seeds experimentally collected at different stages of maturity show that the fresh, recently matured seeds have a faster and higher germination rate.

Many seeds from native plants exhibit erratic germination rates. Seeds of species not previously propagated are treated using various methods including water soaks, chipping, sanding, and acid

[3]Old Mill Seeder is a tradename for a electronically controlled optical seeder manufactured in Savage, Maryland.

soak. In general, water soaks and direct sowing seem to yield the best results. Many seeds such as Sandalwood (Santalum spp.) are slow to germinate. Sandalwood seeds germinate as early as three months and continue for two years. Some native seeds such as Ohia (Metrosideros polymorpha) germinate readily but grow slowly. It is not unusual for a one year old Ohia seedling to be only five inches tall.

Collecting seed from rare native trees is sometimes difficult because they are growing in lava tube openings, cliffs, or the seeds are out of reach. The Hawaii Plant Conservation Center is contracted by DOFAW to collect seed, especially the rare, threatened and endangered species. Approximately 97 species have been collected and 7,000 plants propagated since the contract began in 1990. Some plants that were thought to be extinct are being found and more plant populations are being found thus increasing the gene pool. Through this cooperative effort the collected seed is made available to DOFAW, arboretums, gardens, and nurseries in return for feedback on propagation success. Propagation information is compiled and made available to anyone.

Another method of propagation besides direct sowing is to lift seedlings from the wild and transplant them such as Wild Olive. A planting table technique is used for seeds that are too large to direct sow in a dibble tube, for seeds that have poor or erratic germination, and for species that require a selection of the strongest seedlings. The planting table technique consists of a six foot by four foot table with one inch wire mesh on the bottom, a layer of plastic, well drained soiless mix, and seeds which are lightly rolled into media and covered with cinder. Holes are poked into the plastic to allow drainage. The table is placed on hollow tiles at a comfortable working level and may be covered with shade cloth if seed requires shade or protection from birds. Germinating seedlings are gently lifted from the table and transplanted into containers with a chopstick. The stronger germinating seedlings are selected as a means of genetic improvement. This method works well with the native Koa since seedling quality diminishes with progressive peaks of germination.

Many native plants experience sensitivity to pesticides. Insecticidal soaps or chili pepper water is commonly used to reduce insect infestations. The chili pepper recipe consists of one cup of crushed peppers added to three gallons of water. In field planting, ants are the greatest culprit since they bring in aphids and scales. Although the ants and other insects don't kill the seedlings it sets the plants back in an already harsh conditions.

FIELD PLANTINGS

Pohakuloa Nursery is an acclimation holding area on the island of Hawaii at the 6,000 feet elevation on the slopes of Mauna Kea. Plants such as Mamanae (Sophora chrvsophvlla) and Silverswords (Arcryroxiphium sandwicense) are grown at the Kamuela State Tree Nursery (2,800 feet) or Hawaii district nursery in Hilo (sea level) and sent up to Pohakuloa to acclimate for 6 months or longer before field planting at 10,000 feet. Plants sent up to Pohakuloa last February were exposed to a late frost in March and died. The plants that were there from the previous summer were not affected.

A real challenge continues to be protecting and reforesting montane dry forests on State land where cattle have grazed for a century. Plants from Kamuela State Tree Nursery and Hawaii District Nursery are planted in exclosures set up to protect the remaining trees from grazing animals and fire. Competition with non-native plants, insects, fire, drought stress, and grazing animals are a constant threat. Sometimes the field planted seedlings are especially palatable to animals because they are the only green plant material available.

THREATENED AND ENDANGERED PLANTS

Hawaii's State Law, Section 195D-4, addressing the Threatened and Endangered List is more stringent than its Federal Act counterpart. It prohibits the collection, possession, propagation, cultivation, export or selling of any listed threatened and endangered plant or plant parts thereof without a permit. With an expected 180 Hawaiian plants proposed there is currently no provision for a grandfather clause. A task force has been set up to amend the law but progress has been slow as there are very differing opinions. Ideally the task force wants to create a list of threatened and endangered plants that are suitable for propagation, such as the State flower (Hibiscus brakenridgei). In this case, propagation material is readily available in cultivation, it is a good candidate for landscaping, and it would not risk hybridization of any wild populations.

The current State Law prohibits the planting of a threatened and endangered species in ones backyard. If not for the backyard planting of a Kokio (Kokia cookei) tree on Molokai years ago this species would be extinct today. This species was discovered on Molokai in the late 1860's and in 1910 only two specimens were surviving. Molokai rancher George Cooke took concern and planted seeds in his yard. By 1933, about 30 trees were growing strong. Fortunately successful grafting took place before a wildfire in 1978 claimed the remaining trees. All other plantings in gardens worldwide had failed.

NATIVES IN THE LANDSCAPE

Landscaping with native plants in Hawaii is drawing interest as the awareness of the crisis in species extinction has focused attention on Hawaii's native plants and the need for their conservation and their usefulness in the landscape. The passing of Hawaii State Act 73 which requires all government projects to be landscaped with indigenous plant materials is one step closer in the encouragement in use of native plants.

Using natives in the landscape involves a shared risk between the landscape architect, landscape contractor, and the nurseryman. Frequently expressed is the complaint that native plants are not specified because the nurseries don't grow them. The nurseryman sees a lack of interest in growing native plants because landscape architects don't specify them in contracts and propagation techniques are not established. Landscape architects sometimes feel that the use of native plants is too risky fearing financial loss and a damaging reputation. Demonstration projects or pilot projects are needed and previous successful plantings should be identified. Proper species selection and maintenance tips need to be shared. DOFAW views themselves as protectors of the wild plant populations and hopes the private industry would be leaders in the propagation of more common native plants.

The State Threatened and Endangered species law would need modification to promote such use of these natives in landscape. Certification of cultivated stock would help protect wild populations, keep track of germplasm, limit distribution of plants between islands, and reduce hybridization. The interest and commitment is obvious by the number of cooperating agencies and groups, however, the process needs to be made easier.

LITERATURE CITED

Carlquist, S. 1980. Hawaii: a natural history: geology, climate, native flora and fauna above the shoreline. 468 p. Pac. Trop. Bot. Gdn., Lawai, Kauai, Hawaii.

Cuddihy, Linda W., and Charles P. Stone. 1990. Alteration of native Hawaiian vegetation: effects of humans, their activities and introductions. 138 p. Univ. Hawaii Press, Honolulu.

Hugh, W.I., T. Tanaka, J.C. Nolan, Jr., and L.K. Fox. 1986. The livestock industry in Hawaii. 31 p. Hawaii Inst. Trop. Agric. and Human Resour., Coll. Trop. Agric. and Human Resour., Univ. Hawaii. Information Text Series 025. Honolulu.

Smith, C.W. 1985. Impacts of alien plants on Hawaii's native biota. p. 180-250. In C.P. Stone and J.M. Scott (eds.), Hawaii's terrestrial ecosytems: preservation and management. Univ. Hawaii Coop. Natl. Park Resour. Stud. Unit. Univ. Hawaii Press, Honolulu.

Wagner, W.L., D.R. Herbst, and S.H. Sohmer. 1990. Manaual of the flowering plants of Hawaii. 1853 p. Bishop Museum and Univ. Hawaii Presses, Honolulu.