lyonia
a journal of ecology and application

Volume 8(1)

A Silvicultural Approach to Restoration of Native Hawaiian Rainforests

Methodos silviculturales para la restoracion de los bosques humedos nativos de Hawaii

Dieter Mueller-Dombois

Botany
Department, University of Hawai'i at Manoa, Honolulu, HI 96822, USA,
email: amdhawaii@aol.com

July 2005
Download at: http://www.lyonia.org/downloadPDF.php?pdfID=2.383.1

A Silvicultural Approach to Restoration of Native Hawaiian Rainforests

Abstract

Restoration of native Hawaiian rainforests should be based on a silvicultural rather than horticultural approach. A silvicultural approach applies knowledge from forest ecological research and focuses on simulating and enhancing natural processes for "low input management." Historically, a horticultural approach of planting alien trees was used to restore Hawaiian watersheds. This form of "high input management" was the result of insufficient understanding of how the Hawaiian rainforest perpetuates itself. It left out a major component, the change of substrate in mature rainforests. Mature rainforests usually have an abundance of decaying moss-covered nurse logs on the ground and a sufficient availability of tree fern trunks, both of which serve as the principal germination sites for native ferns and seed plants. A set of seven silvicultural tasks is suggested for application on an operational experimental basis. They begin with partially delimbing or cutting of alien trees and allowing their larger limbs and trunks to rot in situ. A special task is undermining alien forests with reintroduction of native tree ferns in kipuka-like fashion combined with out-fencing feral pigs. Other important tasks involve weed control, inoculation of moss-covered rotting logs and tree fern trunks with disseminules of robust native seed plants (wherever they are not anymore in seeding range), frequent monitoring, and for koa in particular, soil scarification. Key words: Applied forest ecology, low input management, key species, ecological properties and strategies, undermining in kipuka-like fashion.

Resumen

La restoración de los bosques húmedos nativos de Hawai debe ser basada en una metodología silvicultural y no en métodos de horticultura. La metodología silvicultural aplica conocimientos de estudios ecológicos y tiene un enfoque en la simulación y el mejoramiento de procesos naturales para un "manejo con impacto bajo". Históricamente se había usado una metodología de horticultura en manera de plantar árboles exóticos para restorar las captaciones de agua en Hawai. Esta manera de "manejo con impacto alto" estaba el resultado de entendimiento insufiente de cómo los bosques de Hawai esta regenerando naturalmente. Dejaba fuera de consideración un componente mayor - el cambio de substrato en bosques húmedos maduros. Bosques húmedos maduros normalmente tienen una abundancia de troncos en varios estados de descomposición, cubiertas de briofitos en su piso, y una cantidad elevada de troncos de helechos arbóreos, cuales ambos sirven como sitios principales para la germinación de helechos y plantas vasculares nativas. Un juego de siete métodos silviculturales esta propósito para la aplicación en base experimental operacional. Empieza de la corte parcial de las ramas de árboles exóticos o del árbol entero y bajar sus ramas grandes y troncos para descomposición en situ. Una tarea especial esta infiltrar a los bosques exóticos por la reintroducción de especias nativas de helechos arbóreos en manera de *kipuka* combinado con cercos para excluir los cerdos salvajes. Otras tareas importantes envuelven control de hierbas invasivas, inoculación de troncos decompositos y cubiertos de briofitos y troncos de helechos arbóreos con germinantes de plantas nativas robustas si no están suficientemente cerca para sembrase mismo, monitoreo frecuente, y para "koa" especialmente escarificación del suelo.
Palabras claves: Ecología forestal aplicada, manejo de impacto bajo, especies claves, propiedades y estrategias ecológicas, infiltración en manera *kipuka*

Introduction

In Webster’s dictionary, silviculture is defined as "A branch of forestry dealing with the development and care of forests." Silviculture can also be understood as the practical application of forest science or forest ecological knowledge. Silviculture always has an applied research component and may involve experiments on an operational scale. When not applied to commercial forestry, silviculture can be considered a branch of applied conservation biology. Silvicultural approaches must be based on simulating and enhancing **natural processes**. In terms of labor and materials, they should be considered "low input management." As such, silviculture can be contrasted to horticulture.

Horticulture, by definition, is garden culture, which requires "high input management." In Webster's dictionary, horticulture is defined as "The art and science of growing fruits, vegetables, or ornamental plants." When applied to conservation of plant species, horticulture can also be considered a branch of applied conservation biology. But for restructuring or restoring native rainforests, silvicultural rather than horticultural techniques should be developed. Such silvicultural techniques should be based on ecological research done in the Hawaiian rainforests.

Up to the mid-1960s, rainforest research in Hawai'i had been very limited. The most significant ecological research was that of Harold L. Lyon and a few of his contemporaries, who spent a decade researching the "Maui Forest Trouble" (Holt 1983). This phase ended with Lyon's (1918) conclusion that (quote) "Our native forests are doomed."

Lyon's conclusion was based on his implication that the native *Metrosideros* dominated rainforest was made up largely of pioneer species that could not adapt to aging soils. He thereafter postulated the idea that the missing climax species component has to be introduced from outside Hawai'i in order to save the Hawaiian watersheds. This was still the unwritten forest restoration policy in the state of Hawai'i until about the mid-1970s.

Research under the Hawai'i IBP (International Biological Program) during the 1970's focused on the biological organization of selected native Hawaiian communities (Mueller-Dombois et al 1981). Among these was an 80 ha study plot in the Kilauea rainforest on the Big Island of Hawai'i. Subsequent research on the canopy dieback syndrome in the Hawaiian rainforests was extended across the islands of Hawai'i, Maui, O'ahu, and Kaua'i and from there to the Pacific and Atlantic regions (Huettl and Mueller-Dombois 1993). A good number of dissertations and masters theses done under the advisor ship of the author dealt with questions relating to the successional dynamics of the native Hawaiian rainforest. They revealed that Lyon's conclusion was only partially correct and thus rather unfortunate. The "Maui Forest Trouble" was not simply related to soil aging but to bog formation, a fundamental process in geomorphological aging and landscape change (Mueller-Dombois 2005).

For using a silvicultural approach to restoration, one needs to know first some of the key species that either stabilize or disrupt a specific rainforest community. Second, one needs to know about their ecological properties and strategies. Such aspects will be discussed next. This will be followed by a set of silvicultural prescriptions for restoring Hawaiian rainforests.

Key species

Among plants, key species are usually the dominants or the more robust ones in the community. In particular they are those whose population dynamics has a strong effect on the other species in the community. In the mature Hawaiian rainforest such species are the 'ohi'a lehua tree (*Metrosideros polymorpha*) and the hapu'u tree fern (*Cibotium* spp.). 'Ohi'a lehua dominates the canopy and the hapu'u typically the sub-canopy. In less wet rain forests, the koa tree (*Acacia koa*) often joins the upper canopy as a second key species. Depending on habitat factors and geographic location, koa may even become an emergent tree reaching above the general canopy. Locally, other native tree, shrub, and vine species, can be added as playing key roles. Among trees they include in upper Manoa Valley for example, 'ahakea lau nui (*Bobea elatior*), hame (*Antidesma platyphyllum*), olomea (*Perrotettia sandwicensis*), lama (*Diospyros* spp.), kopiko (*Psychotria kaduana*), and 'olapa (*Cheirodendron* spp.), among shrubs they include 'ohelo kau la'au (*Vaccinium calycinum*), ha'iwale (*Cyrtandra* spp.), ho'awa (*Pittosporum glabrum*), naupaka kuahiwi (*Scaevola gaudichaudiana*), and mamaki (*Pipturus albidus*), among vines 'ie'ie (*Freycinetia arborea*) and maile (*Alyxia oliviformis*). Many other robust native rain forest plants are listed by Stone and Pratt (1994:173)

A number of alien invasives have now assumed the role of key species. Foremost among them is the feral pig (*Sus scrofa*). Pigs tend to destabilize the Hawaiian rainforest, in particular, because they seek out the native tree ferns, the hapu'u, as a favored food item. They also promote locally the spread of strawberry guava (*Psidium cattleianum*), which is a key invasive tree in pig frequented sections of the Hawaiian rainforest. A shrub in this category is Koster's curse (*Clidemia hirta*). Locally in watershed forests on 'O'ahu, a particularly disturbing invasive key species is the often very tall (>30 m), canopy emergent albizia tree (*Falcataria moluccana*). Other recently spreading and penetrating trees are the introduced secondary and fast growing shoe button ardisia (*Ardisia elliptica*) and the octopus tree (*Schefflera actinophylla*). These secondary, fast growing trees form a new life-form group with several other alien species, which never really developed among the native species.

In the Hawaiian Islands, the primary rainforest has always renewed itself through the

generational turnover of primary species without an intermediate successional phase that could be considered a secondary forest. As is well known, a secondary forest is a typical phase in disturbed continental tropical rainforests, in which recovery of primary forest is considered a very long-term process.

Ecological properties and strategies

For the purpose of this paper, only a few characteristics will be emphasized, which can be used for a silvicultural approach to forest restoration. During the IBP and canopy dieback studies, we surveyed many rainforest plots and transects. We enumerated all woody species by cover, density and size. We also studied their substrate and found that most of the native rainforest species became established on decaying wood in developed mature forests. This stands in contrast to rainforest development on lava flows, where an assortment of hardy native pioneer species establish themselves in rock fissures without or with only very little organic matter.

In mature rainforests we noted only three species that started commonly on mineral soil. These were the hapu'u tree ferns, the koa, and naio (*Myoporum sandwicense*) trees. Most others had a significant log establishment index, meaning they started as seedlings on logs above the mineral surface (Cooray 1974). That means that most Hawaiian plants have an epiphytic beginning.

Such observation can be made easily in mature native rainforests, if one knows where to look for native fern sporlings and tree seedlings. The first place to look for, are the tree fern trunks. They often are the most favorable seed beds for 'ohi'a lehua germinants and small seedlings. If left alone, eventually one of them may succeed in becoming a sapling and thereafter a mature tree by extending its roots into the mineral soil. A precondition for this to happen is a canopy opening. This may occur naturally by loss of a tree fern frond or the decline of the tree fern itself after canopy opening. Many times one can observe stilt rooted 'ohi'a lehua trees that had an epiphytic start, either on a tree fern trunk or on a moss-covered dead tree trunk. For 'alapa this seems to be the only mode of its natural establishment.

Silvicultural restoration tasks

Delimbing: Cutting off the limbs or big branches of the taller alien trees would be a useful first step in silvicultural restoration. This should not be a clear-cut logging operation, but rather a carefully selected cutting and partial delimbing of selected alien trees. Their limbs should be left on the ground, allowing them to decompose in situ. To accelerate the decomposition process, the limbs, or thick branches, and in some situations the trunks of selected trees, may be cut into meter sections and split open. In mature and senescing Hawaiian rainforests, decaying logs, particularly when moss-covered, were found to be the favored micro-habitats for native fern sporelings and woody plant seedlings to become established.

Fencing: Any section of rainforest considered for restoration needs to be fenced against pigs. Depending on financial resources one can begin with fencing of small enclosures, such as 100 m plots. Of course, anything larger would always be preferable. The purpose is to create a safe island in kipuka fashion within the larger forest infested by alien neophytes.

Reintroduction: From field research observations, it appears most efficient to begin with reintroducing the appropriate Hawaiian tree ferns into the fenced enclosures. On 'O'ahu Island this would preferably be *Cibotium chamissoi*, formerly named *C. splendens* (Palmer 2003). But *C. menziesii* may also be considered. A natural hybrid of these two species was recently discovered in the Ko'olau mountains and called *Cibotium x heleniae*. Such tree ferns are easily transplanted at any stage of their life cycle and/or raised in nurseries. Mature tree ferns are preferred. The reasons for reintroducing tree ferns are several. They can be planted directly into the mineral soil as they do not require a raised organic seedbed as do most of the other Hawaiian woody plants with exception of *Acacia koa* and *Myoporum sandwicense*. Tree ferns have a high value as watershed protectors in that they slow down the impact of heavy showers by forming a second canopy under the tree layer. They disperse the water away from their trunks in contrast to, for example, albizia trees. Albizia trees act as funnels for rain water because of their generally upward angled branch system. Because of this, they have a high rate of stem run-off, which is further accelerated due to their smooth bark. They are thus ill adapted as watershed tree cover in wet forests, where excess water is a problem. In contrast, tree ferns are expected to increase the rate of water percolation into the soil rather than contributing to run-off and erosion as do the alien albizia trees. A third major advantage is that tree fern trunks serve as epiphytic seed beds for many native ferns and woody plants. As mentioned before, many *Metrosideros* trees and almost all *Cheirodendron* trees start as seedlings epiphytically on tree fern trunks.

Weed control: In some situations, weed control may be the prerequisite prior to the introduction

of native tree ferns into the Kipuka-type enclosures. Certainly, weed control may be considered an ongoing task until the tree ferns themselves become excluders of weeds on account of having developed a closed canopy in the Kipuka-type enclosures.

Inoculation: Wherever native woody plants and ferns are too far removed from the Kipuka-type enclosures, it may become necessary to inoculate the tree fern trunks and decaying coarse woody log segments on the ground with seeds and spores of selected native plants.

Monitoring: Another silvicultural research task involves monitoring the tree fern trunks and inoculated decaying wood segments for native plant establishment, growth, and survival. Monitoring will also be necessary in the Kipuka-type enclosures to keep weeds under control and the fencing in repair.

Soil scarification: In some of ‘O‘ahu’s watershed forests, for example in the Kahana ahupua‘a, it has been found that soil scarification will encourage germination of koa seeds. An abundance of koa seedlings has been observed there by Wirawan (1978), after removal of the hala (*Pandanus tectorius*) litter associated with scarification of the surface mineral soil. Currently, there are only a few old senescing *Acacia koa* trees left in the canopy otherwise dominated by native hala trees. Soil scarification in forest gaps will increase the koa component in the inland forest (the wao nahele) of the Kahana ahupua‘a. It may also work in other ahupua‘a where koa is in decline.

Conclusions

The seven silvicultural restoration tasks for Hawaiian rainforests discussed above may be considered a first set of prescriptions. It is suggested that these are applied in kipuka-like fashion. This means that restoration should begin with fenced-in island-like nuclei of robust native plants. These comprise the ancient vegetation in usually a larger area of vegetation composed of neophytes. These native plant kipuka may be small areas such as 10 by 10 m plots to begin with. They should be protected, monitored, and studied. Such native vegetation kipuka will certainly provide a sense of Hawaiian place in our watershed forests. If they prove to have a reasonable survival value, they may eventually be expanded by silvicultural nurturing to become the vegetation matrix for reintroducing rare and endangered Hawaiian plants and animals. With further practical experiences gained from silvicultural experimentation at an operational scale, additional prescriptions will surely be developed.

References

Coorey, R.G. 1974. Stand structure of a montane rain forest on Mauna Loa. *Hawaii IBP Technical Report* No. 44. 98pp.

Holt, A.R. 1983. The Maui Forest Trouble: A literature review and proposal for research. *UH Botanical Science Paper* 42: 1-67. www.botany.hawaii.edu/pabitra (under Current and Planned Projects).

Huettl, F.R. & D. Mueller-Dombois (Eds.) 1993. *Forest Decline in the Atlantic and Pacific Regions*. Springer-Verlag. Berlin, London, N.Y. 366 pp.

Lyon, H.L. 1918. The forests of Hawaii. *Hawaii Planter’s Record* 20: 276-279.

Mueller-Dombois. D., K.W. Bridges, & H.L. Carson (Eds.) 1981. *Island Ecosystems: Biological Organization in Selected Hawaiian Communities.* US/IBP Synthesis Series 15. Hutchinson Ross Publishing Co. Stroudsburg and Woods Hole. 583 pp.

Mueller-Dombois, D. 2005. *Biodiversity limitations and landscape Change: A marginal site syndrome in the Hawaiian Islands*. Abstracts 48th IAVS Symposium July 2005, Lisbon, p40.

Palmer, D.D. 2003. *Hawai‘i’s Ferns and Fern Allies.* University of Hawai‘i Press. Honolulu. 324 pp.

Stone, C.P. & L.W. Pratt. 1994. *Hawai‘i’s Plant and Animals.* Illustrations by J. M. Yoshioka. Distributed by University of Hawai‘i Press. 399 pp.

Wirawan, N. 1978. *Vegetation and soil-water relations in a tropical rain forest valley on Oahu, Hawaiian Islands*. Ph.D. Dissertation Botany Department, University of Hawaii, Honolulu. 420 pp.