

NEW ZEALAND-HAWAI'I CONSERVATION EXCHANGE
PROGRAM, 2001

TRAVEL REPORT

Tristan Armstrong
Landcare Research
PO Box 92 170
Auckland
New Zealand

armstrongt@landcare.cri.nz

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INTRODUCTION

I visited Hawai'i during August 2001 as part of the Secretariat for Conservation Biology's conservation exchange program. The purpose of my visit was to attend the 15th annual Society for Conservation Biology meeting and then spend time with plant conservation researchers in Hawai'i. My aim was to discuss common issues and problems and facilitate the exchange of ideas and approaches relevant to conservation. New Zealand and Hawai'i face many of the same serious threats to indigenous flora and in my view both regions can benefit from increased bilateral communication and knowledge sharing. I certainly came away from Hawai'i with a far better understanding of rare plant conservation, and I hope that I was likewise able to provide useful advice and new ideas for some of the great people I met during my stay.

Plant Conservation in Hawai'i

Over 865 of Hawaiian vascular plant species are endemic (75% of the total flora!). This astounding level of endemism is also coupled with an alarming rate of endangerment. Hawai'i alone contains over 46% of America's endangered plant species, yet the Hawaiian Islands constitute only .001% of the total land area of the United States. Nearly half of the species of native flora in Hawai'i are considered threatened or in danger of imminent extinction. Causes of the widespread destruction of the Hawaiian endemic plant diversity are numerous: agriculture has led to the clearance of much of the fertile lowlands, grazing has caused extensive damage to lower rainfall areas. Alien plants have been either intentionally or accidentally introduced, often in order to 'improve' the native flora which was considered depauperate and worthless at various times. An incredible 6,000 plant species have been introduced to Hawai'i in the past 150 years, and naturalised species now outnumber natives by a large margin. Island biogeography theory alone suggest that this rate of immigration may have long term, profound consequences for the remaining native species.

Numerous feral animals are now well established on all the main Hawaiian Islands, including pigs, goats, deer, rats, and insects. These species continue to severely impact all native ecosystems through herbivory, direct physical disturbance, or perhaps more seriously by disrupting the natural pollination and dispersal systems of native species leading to their inexorable slide towards extinction.

Major threats to the flora continue to come in the form of direct or indirect human activities including habitat disturbance and fire. Many of Hawai'i's threatened plants are now reduced to small fragmented populations existing within a matrix of agricultural and exotic dominated land. There is little information, and widespread scientific concern about the long-term genetic and ecological viability of these species, many of which require research and active management to ensure their survival. Researchers in Hawai'i have approached these extreme conservation challenges in diverse but complementary ways, some of which I explored during my SCB exchange visit to the Archipelago.

My visit enabled me to spend time with a number of research groups addressing different aspects of the plant conservation problem, from systematics and conservation genetics to ecological management and direct conservation action. I was able to gain a broad understanding of the various essential component of effective, long-term plant conservation. My own experience as a

plant geneticist gave me a unique perspective on some of the issues discussed in Hawai'i and provided the opportunity for me to make suggestions and comments.

SCB Conference, University of Hawai'i, Hilo Campus.

This international meeting provided an unparalleled opportunity to explore the diversity of worldwide approaches being taken to the problem of bio-diversity conservation. Its location was highly appropriate; as in many ways the problems faced by Hawai'i represent a microcosm of global conservation issues. Local experts and researchers dealing with the conservation of all forms of life provided many of the most interesting and challenging discussions of conservation. As a botanist, I was disappointed by the lack of focus on plant conservation at the meeting; however, there were some botanical highlights, notably from local Hawaiian researchers. Tim Tunison (Hawai'i Volcanoes National Park) gave an informative discussion of the various ways in which the Park's plant communities are being threatened by introduced species and human activity. His discussion highlighted the fact that in many cases the only tools available to conservation researchers are the most direct – that of physically removing alien plant invaders and feral animals such as pigs and goats. These approaches can then be augmented with subsequent restoration of original communities through direct planting of key succession species in the hope of re-establishing important successional processes. He demonstrated how the park is now beginning to rehabilitate highly altered ecosystems, typically with out planting and seeding to achieve replacement native or near-native communities.

The focus of many of the plant talks was on the control of alien invaders, including case studies of Tropical Ash, (*Fraxinus spp*), *Tibouchina herbacea* and C4 grasses, now influencing the fire regimes over large areas of the archipelago. These talks highlighted a theme, which was to dominate my visit to Hawai'i – that conservation of some species is only possible through elimination of others. Flint Hughes from the USDA Forest Service's Institute of Pacific Islands Forestry gave an excellent paper on the complex relationship between various invading weeds species. Nitrogen fixing weeds, such as *Clidemia hirta* have been implicated in 'priming' areas for invasion by a suite of other introduced species that require higher N levels. The complexity of the relationship between weeds and their new habitat has yet to be fully appreciated or understood, but it seems that many surprises may still be around the corner and that initial observations of weed spread and primary effects may disguise other, more sinister implications for future management of native systems.

Other talks focussed on restorative ecology, and in particular the role of keystone species such as māmane (*Sophora*) and koa (*Acacia koa*). Paul Scowcroft from the department of Tropical Plant and Soil Sciences, University of Hawai'i discussed ways in which his group had assessed the usefulness of koa to provide suitable soil and microclimatic conditions for the reestablishment of more venerable and fragile natives.

Lloyd Loope of the U.S. Geological Survey Biological Resources Division gave a thought provoking talk, challenging the idea that science-based management can have any real and lasting influence on increasingly ubiquitous habitat disruption and mixing of species by humans. He argued that Hawai'i is a unique testing ground for ecological study, prevention, and

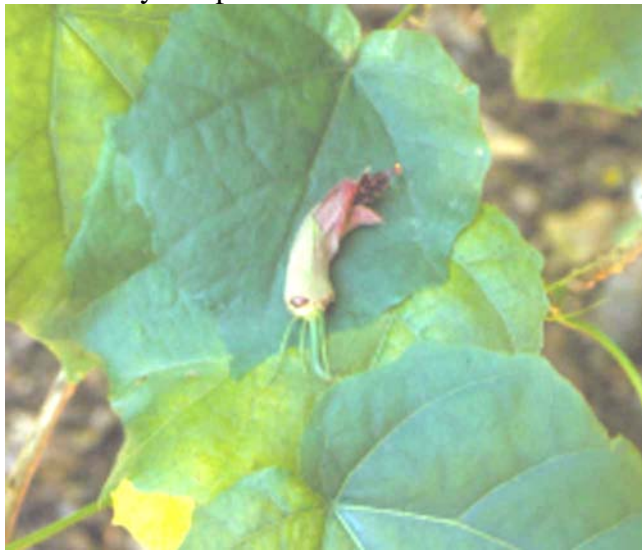
management of biological invasions but that to stem the seemingly inexorable forces of degradation clearly requires a change in the fundamental beliefs driving modern culture. I found this talk rather sobering but in many ways, Lloyd addressed a fundamental issue that tends to be ignored by the scientific community – that human values are at the basis of many of the world's environmental problems, and that in order to change the world, we need to change the way in which we conduct our everyday lives, scientists included!

RARE PLANT PROTECTION AND HABITAT RESTORATION IN HAWAI‘I VOLCANOES NATIONAL PARK

After the SCB conference, I spent two days with the dynamic and enthusiastic team at Hawai‘i Volcanoes National Park where I was introduced to some of the plant conservation and habitat restoration work being carried out there by Rhonda Loh (resource management division). It was a chance to gain insights into some of the more intensive plant management programs going on in Hawai‘i, and one that has faced and to some extent overcome some very serious conservation challenges through lateral thinking and direct action.

Interspecific hybridization

I was taken through Kīpuka Puaulu, a small remnant of a formerly more widespread forest type, surviving on older basaltic soil within a small ‘gap’ in the lava flow. These kīpuka represent a window into Hawai‘i’s botanical past and preserve many of the remaining populations of plants lost elsewhere through habitat disturbance. The conservation potential of these kīpuka has long been recognised, and as early as the 1930s plants which had been identified as being under threat of extinction in one island or another were often moved around by well meaning but perhaps (in retrospect) naive managers. One of the unforeseen consequences of this action for the kīpuka was the resultant hybridization between the local (often endangered) and relocated endangered species. Rhonda showed me some examples of lineages where this had occurred, including in one of the most endangered genus on Hawai‘i, *Hibiscadendron*. An example of one of the resultant hybrid plants is shown below:



Hibiscodendron species from Kīpuka Puaulu, HVNP.

Use of endemic plants by indigenous people

Rhonda Loh discussed situations where the interests of conservation managers and indigenous people are sometimes at odds. These included a number of herbaceous plants used in local ceremonies and for the preparation of medicinal extracts. Some of these plants are now extremely rare in the wild and require active management for their survival; so continued harvesting by indigenous people can pose a serious threat. The conflict between conservation managers and indigenous people is a theme which seems to run right through the Pacific, and certainly New Zealand is no exception, where science based approaches to management are too

often seen as culturally specific and lacking in sensitivity to indigenous concerns. Perhaps, as Rhonda suggested, education and dialogue is the only way to bridge the gap and provide outcomes that offer something for everyone whilst preserving the basic ecological and genetic integrity of the native species being conserved.

Weed invasion

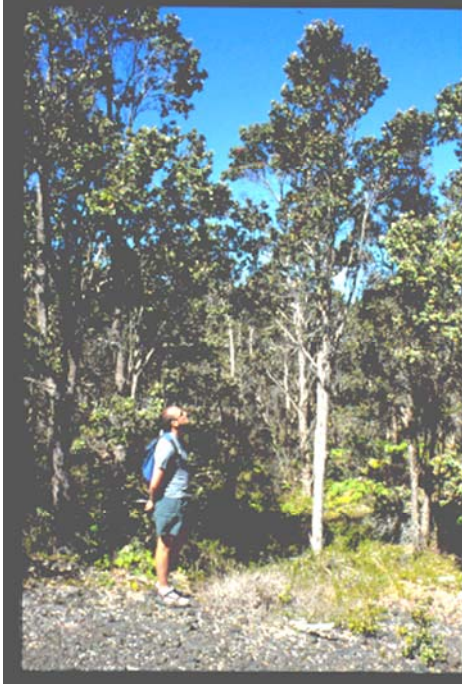
The invasion and spread of introduced plants in HVNP is a major threat to remaining native ecosystems and populations of threatened plant species. The park has made extraordinary progress in monitoring and controlling many of the most recalcitrant invaders, yet it is clear that much work needs to be done to stem the spread of many of these highly successful and competitive plants. Most conservation effort is directed at a core group of 69 species, for which up to date management and eradication protocols have been drafted. Of these species, two groups pose particularly difficult problems for managements. *Myrica faya*, an invasive tree, and introduced grasses, principally *Andropogon virginicus* and *Schizachyrium condensatum*.

Myrica faya is a small tree introduced by Portuguese speaking immigrants from the volcanic Azores islands in the Atlantic. It is an excellent coloniser of very young lava beds and skeletal lava soils, and once established, forms an almost complete canopy blocking sunlight from reaching the ground and the native species that may be in the area. Furthermore, it also lays down a thick layer of dead leaf material that other species cannot colonise. Initial attempts to control the spread of this species involved clear cutting the monospecific stands and applying herbicide to the stumps to prevent regrowth. An unforeseen consequence of this control method was the subsequent invasion of a host of other weeds that benefited from the high light levels and nutrient pulse caused by clear-cutting the *Myrica faya*. Experimental work by Rhonda has shown that ring barking the invasive tree slows down the successional cycle and gives an advantage to native ferns to colonise, this reducing the competitive advantage of the high-light requiring weeds. Techniques such as these are slowly returning the mesic 'ōhi'a forests to their former glory, and allowing the many species of native honeycreepers, still extant in HVNP to expand their habitat.

Introduced grasses and fire regime

Many species of alien grass have been introduced to the park accidentally, with increasing numbers becoming established since the 1960s. One particular species, *Andropogon virginianus*, poses a severe threat to the 'ōhi'a woodland areas of the park due to its flammability. In an environment that is not well adapted to frequent fire, introduced grasses are radically altering the composition of many communities through their effect on fire frequency and intensity, eliminating many native species and providing ideal conditions for invasion by other fire adapted weeds such as broom sedge.

Unfortunately there seems little that can be done about this problem, and now much of the park has been converted to what is effectively savannah grassland. This is also an issue in many parts of New Zealand, where grasses now dominate over indigenous herbaceous plants that are poorly adapted to competition with grasses and are killed by fire.



‘Ōhi‘a woodland, Hawai‘i Volcanoes National Park

Restoration Ecology

On a more positive note, there have been some notable successes in restoring native communities to the mesic areas of the park. Once cattle had been removed from some areas, *Acacia koa* started to regenerate strongly, providing suitable conditions for the reestablishment of many others more delicate and venerable native shrubs and herbs. The photograph below shows dramatically the effect of stock removal on forest regeneration. In the middle ground, the photograph shows a fence line between stocked areas and parkland that was fenced in 1974. Forest cover is now complete in ungrazed areas, allowing park staff to begin re-sowing other native species such as *Dodonea*, lost through cattle grazing. Initial attempts at revegetation beneath the koa canopy had failed due to the thickness of koa leaf litter. It was found that low intensity fire could be used to open areas up before seeds were planted, increasing survival rates of native seedlings.



Photo showing regrowth of *Acacia koa* woodland after fencing out stock in 1974 (right hand side)



Vegetation restoration experimental plot, Kīpuka Puaulu, Hawai'i Volcanoes National Park. Plot in foreground = *Dodonea* seedling plot, six months after a control burn in *Acacia koa* woodland

National Tropical Botanical Gardens, Lāwa‘i Valley, Kaua‘i

I spent a number of days with the staff at the National Tropical Botanical Gardens (NTBG) in Kaua‘i. This research and conservation organisation is largely privately funded and employs a highly motivated and dynamic team of scientists under the directorship of Dr. Mike Maunder, formerly of Kew gardens. The dedication and passion of the staff for threatened plant conservation, and the scope of their mandate immediately impressed me. The emphasis of the work carried out at the NTBG definitely seemed to be on direct conservation results.

The list of conservation achievements by the NTBG is very impressive. The organisation has assembled the largest collection of federally listed endangered plant species anywhere, including the largest collection of native Hawaiian flora in existence. The staff at NTBG have made or organised numerous plant exploration trips throughout the Pacific Islands, discovering more than 30 new species and also the first new genus in Hawai‘i found since the early 1900s. They have pioneered propagation techniques and established growing protocols for over forty-five percent of the existing Hawaiian flora, including 248 rare and endangered species. Furthermore they have established the world's most comprehensive collection of breadfruit cultivars, protecting this germplasm for future food crops. And developed techniques to restore tropical dry forests, one of the world's most endangered ecosystems. Their mission extends to the cultural aspects of conservation, with a commitment to public education as an essential component of effective long-term biodiversity conservation.

Ex-situ conservation

The gardens houses a large number of plant species in ex-situ cultivation, literally rescued from sites in the wild where populations were being wiped out by the activities of introduced animal herbivores or competition from invasive weeds. This facility is the culmination of years of research into effective propagation techniques and growing protocols for species with wide ranging ecological tolerances. Sadly, many of the species housed in this facility are no longer to be found in the wild, and until the political and scientific will exists to eradicate feral animals and control invasive plants, it seems unlikely that the species can be returned to the wild. The NTBG views ex-situ conservation as an essential tool to counter biodiversity loss in response to the catastrophic decline in endemic floristic diversity for Hawai‘i. After showing around the ex-situ glasshouses and plantings, Mike explained the utility of ex-situ conservation and how important it can be for maintaining taxonomic and genetic representation in cultivation. He also discussed the effectiveness of ex-situ in supporting reintroduction and habitat restoration. Mike argued that in reality, ex-situ conservation must play the fundamental role in retaining species diversity that would otherwise be destined for extinction through irreversible habitat loss and exotic species impact. I was fascinated by the range of species in cultivation, including one spectacular species of *Brighamia*, known in the wild from only one single individual, growing on a goat infested hillside on Kaua‘i.

NTBG Herbarium.

The NTBG also houses a large herbarium facility, managed by Dr. Tim Flynn. This herbarium provides a permanent record of plants collected by staff at the NTBG, and serves as a valuable resource for botanists, conservation scientists and molecular biologists, all of who make regular requests for material.

Field survey work.

A core aspect of the science carried out by the NTBG involves direct survey and botanical exploration, carried out largely by the two key field botanists, Steve Perlman and Ken Wood. These two scientists have discovered many new species in the Hawaiian Islands and elsewhere in the Pacific, and spend much of their time monitoring populations of critically threatened plants in the wild and collecting material for ex-situ propagation where necessary. I was immediately struck by the enormity of the task on the shoulders of these two individuals. Not only must they have an intimate knowledge of the rugged landscape, but also an encyclopedic knowledge of the native and introduced flora.

Steve Perlman and Ken Wood invited me to join them on field excursions to the interior of Kaua'i to monitor populations of threatened plants and obtain material for ex-situ propagation. These field excursions represent an opportunity to survey remote country in search of new species or previously unrecorded populations of rare plants that can then be monitored. The field trips were an exciting opportunity to experience work at the fore front of plant conservation, actually looking for rare plants in the field and seeing first-hand why so many of them are under threat.

We traveled to the interior of the island by helicopter, and were then dropped off in a small natural clearing before traversing steep ridges and gullies by foot to some rare plant sites. The area, just south of the Waimea canyon is known as Wailai.

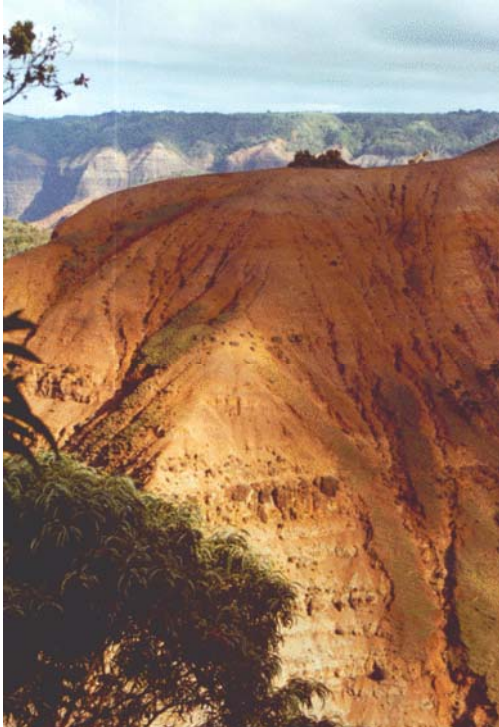


View of Wai'alae area from the helicopter

The cool mesic forest type, at 5000 ft elevation was dominated by *Acacia koa* and the ubiquitous *Metrosideros polymorpha*. From the helicopter, I noticed the pervasive effect of introduced plants across the landscape, particularly *Grevillea robusta*, *Aluerrites molluccana* and *Psidium guajava*, which in some places had completely replaced the native forest cover. I was also shocked to discover that many of these woody weeds were intentionally spread (by Airplane!) in the 1950s in an attempt to 'improve' the native forest!

I also noticed the barren and eroded hillsides denuded by the action of feral animals, goats, deer and pigs. One of the main problems faced by plant conservation organizations such as NTBG is

the strength of the local hunting lobby, who have an interest in keeping these remote areas well stocked with game. Ken and Steve explained to me that these groups have enormous political power in Hawai'i, and that the likelihood of there being any serious attempts to eradicate these serious pests is remote. The scale of damage caused by these animals is hard to imagine – they have literally eliminated whole ecosystems, as the photograph below depicts. Once we were on the ground, the effect of these ungulates was even more visible. Pigs in particular, had churned up any areas of damp ground, leaving them vulnerable to erosion and colonization by weeds such as *Lantana camera* and *Psidium*. Many of the plant populations we went to look at were directly under threat from pig damage.



Erosion damage caused by feral ungulates in central Kaua'i, Wai'alae area. No attempt is being made to eradicate these vertebrate pests and save the remaining habitat!

Steve, Ken and I walked for several hours through dense forest, across ridges and valleys, monitoring populations of rare plants, including one species that they had been very worried about, *Myrsine mezii*, pictured on the next page. We found a handful of plants, completely surrounded by pig damage. These were the last remaining specimens known. Steve and Ken were keen to collect some seed or vegetative material for ex-situ conservation, as the chance of this population surviving was slim.



***Myrsine mezii* seedling, one of four individuals remaining in the wild.**

During the fieldwork, we were lucky enough to see some spectacular native plants, unfortunately many of them threatened or vulnerable. Some highlights for me were *Pouteria sandwicensis* (Sapotaceae), a small tree; *Pipturus kauaiensis* and *Urera glabra*, two delicate shrub species in the nettle family (Urticaceae); the delightful *Dubautia knudsenii* (Asteraceae), and the most spectacular *Cyanea leptostegia* and *Cyanea spathulata* (Campanulaceae), the latter pictured below:



Ken Wood inspecting a specimen of *Cyanea leptostegia*, by far the strangest member of the family Campanulaceae that I have ever seen!

Botany Department, University of Hawai‘i at Mānoa.

I spent a couple of days discussing issues of plant conservation genetics and molecular ecology with Dr. Clifford Morden and Dr. Gerry Carr at the Botany department of UH Mānoa. The scope of the research carried out at the department is wide ranging and represents some of the most influential modern studies of plant speciation processes and population genetics.

The Morden lab has made particular use of RAPD (Randomly amplified polymorphic DNA) in their investigations of fine scale evolutionary processes and conservation genetics in the Hawaiian flora. Examples of their recent work, which was discussed, include tree ferns (*Cibotium*), *Brighamia* (Campanulaceae), *Dubautia* species *Haplostachys haplostachya* (Lamiaceae). In many cases these studies involved assessing remaining levels of genetic diversity within and between populations and then using this information to advise conservation managers about how to best conserve remaining levels of genetic diversity and prevent further losses of genetic diversity through inbreeding and stochastic effects associated with small population sizes. Much of the work deals directly or indirectly with the results of habitat fragmentation on the evolutionary potential of native species. This issue is also a serious concern in New Zealand, where many of our rarest plant species are restricted to fragmented native habitat within a matrix of agricultural land.

I was particularly interested in the research that had been carried out into the genus *Rubus*, where Cliff had shown through molecular analysis that the two endemic species of *Rubus* (*R. hawaiiensis* and *R. macraei*), always assumed to have been derived from a single transoceanic dispersal event, were in fact more closely related to other continental species than to each other, suggesting multiple dispersal events. This finding parallels some recent research of my own into the origins of *Ranunculus* in Australasia. Molecular tools often reveal hidden patterns and suggest new models to explain the origin of island floras. The conservation implications are also relevant, given that one of the species being studied was in fact found to be introgressing with its putative ancestral lineage, now an introduced weed in the Hawaiian Islands (*R. spectabilis*).

Cliff and I also discussed the work that he and fellow colleagues had been doing to set up a formal DNA library for the Hawaiian Islands since 1992. The DNA library held at the UH Mānoa campus comprises collections of over 1000 samples including material from over 200 native species as well as 71 introduced species. I was particularly interested in this idea, as New Zealand has only recently embarked on a plant genetics program and we would benefit enormously from adopting a library based approach to the preservation and archival of genomic DNA for future retrieval and usage. Such a system would facilitate speed and efficiency in projects where re-extraction could impose substantial costs. Although Herbaria are useful repositories of plant DNA (contained within the dried leaves of the herbarium samples) this DNA degrades steadily over time, often limiting the scope of DNA based approaches such as AFLP and RFLP which require relatively high quality undegraded template DNA. Since returning to New Zealand I have made some progress in implementing a similar system of collection that would require Landcare research employees and others preparing herbarium specimens to collect additional material to be used for DNA extraction and preservation. In many cases this may be the only means of preserving the genetic diversity of highly endangered species, allowing population geneticist in the future to at least track the genetic changes that may have been associated with declines and extinctions of native flora.

I was also privileged to be shown around the glasshouse containing live specimens of the extraordinary Silversword alliance, a group of plants from a handful of endemic genera that have formed the basis of one of the most influential bodies of research into plant speciation and evolution in the world. The group contains a stunning array of morphological adaptations that have arisen over a very short period of geological time, presumably in response to the availability of vacant niches on the rapidly evolving Hawaiian Islands. These species are all largely reproductively compatible, despite their gross morphological differences and ecological tolerances. The work illustrates the secondary nature of reproductive isolation in speciation, and highlights the phenomenon, common to islands such as Hawai'i and New Zealand, of rapid adaptive radiation following long distance dispersal.

Bishop Museum, Herbarium Pacificum (BISH)

I visited Dr. Chris Puttock and other staff at Honolulu's Bishop Museum Herbarium.

The Herbarium Pacificum is one of the largest in the region and plays a crucial role in the overall effort of biodiversity conservation. Sadly, many of Hawai'i's unique native plant species are now confined to herbarium specimens within this collection. The Herbarium staff has been enthusiastic in their adoption of information technology, and there is a strong program underway to place all herbarium records and vouchers on a searchable database.

The total collections of the Herbarium Pacificum consist of approximately 500,000 plant specimens, with emphasis on the Pacific Basin, particularly Hawai'i, and with representative material from other areas. The collections of Hawaiian vascular plants form the largest and most comprehensive assemblage of such specimens in the world totaling approximately 140,000 specimens, 120,000 seed plants plus 20,000 ferns. Numerous collections of major importance to Hawaiian botany are located here, including collections by H. St. John, F.R. Fosberg, O. Degener, J.F. Rock, C.N. Forbes, B.C. Stone, D.R. Herbst, W.L. Wagner, D. Nelson, U.J. Faurie, G.C. Munro, H. Mann, and W.T. Brigham.

The herbarium also serves as a valuable repository for genetic material, often from populations of plants that have long since disappeared and been replaced by agriculture or urban sprawl. In this way, the herbarium can act as a window into the history of the islands and as a record of the dramatic changes that have occurred over the past two hundred years.

Some of the current projects that I was shown included the cooperative database of Hawaiian plant specimens and the ongoing work integrating the herbarium with the Hawai'i Biological Survey. The Herbarium is also a partner in the project to develop vegetation maps from satellite imagery for Hawai'i headed by Ronald Cannarella of the State of Hawai'i Department of Land and Natural Resources. George Staples, a member of staff at the Herbarium, briefly discussed his book project entitled "A Tropical Garden Flora", detailing cultivated plant manual covering over 2,000 species plus a checklist of more than 10,000 species. Very impressive work. I was also shown the Bibliography of Hawaiian Vascular Plants; this database contains 4,225 bibliographic records for literature on the native and naturalized Hawaiian flowering plants and ferns, especially journal articles and books concerned with the taxonomy, systematics, and ecology of these taxa. Cultivated and nonvascular plants are not included at this stage. These resources are incredibly valuable, not only to those working in Hawai'i, but also to researchers in New Zealand and the Pacific in general.

Whilst at the herbarium, I was able to inspect a large number of rare and interesting native plant species. Additionally, Chris Puttock and I discussed the possibility of arranging to facilitate the exchange of plant specimens between New Zealand's Landcare Herbarium and the Herbarium Pacificum for research purposes. Because the two regions have considerable overlap at the family and generic level, there is often a need for material from close congeners, particularly for genetic work and phylogenetic studies. Understanding the colonisation of the Pacific rim by various plant groups will require considerable research and collaboration between Pacific based

Herbaria and research institutes. I am hopeful that more frequent and closer contact between our two organisations will facilitate such research.

ACKNOWLEDGEMENTS

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