

Inter situ conservation: Opening a “third front” in the battle to save rare Hawaiian plants

Anyone who has taken a course in conservation biology, or even read a book on the subject, knows that there are fundamentally two kinds of conservation: *in situ* and *ex situ*. The former, aimed at preserving species where they presently occur naturally, will perhaps always rightly be the front line of conservation. The latter, however, has become increasingly important as botanical gardens, zoos, and other cultural institutions strive to save the rarest species by growing them under intensive care in living collections and backing this effort with seed banks, tissue culture, and other relatively expensive high-tech methods.

Each strategy has its advantages and disadvantages (Table 1). In places like Hawaii, where approximately half the native flora is considered at risk of extinction in the next few decades, scientists and conservationists have begun asking themselves how they can do more for these roughly 500 species, through innovative and more cost-effective strategies that aim to bridge the gap between these two methodologies. Although the term has been around for over a decade, the concept of “*inter situ*” conservation first came to the attention of the public in Hawaii through a radical experimental plan that was hatched by

paleoecological researchers whose focus was originally on the past, not the future, of rare plants and animals.

Listening to the fossils

Since 1992, our group has been excavating a remarkable fossil site, at Makauwahi Cave on Kaua'i's south shore. It is generally acknowledged as the richest in the Hawaiian Islands. This ancient limestone feature, a large cave system complete with stalactites and highly endangered blind cave organisms that live their entire lives in complete darkness, contains a large open sinkhole in the center that was actually a lake inside the cave for thousands of years. Soft sediments there are filled with splendidly preserved seeds, pollen, bird bones, snail shells – even fossil DNA and a thousand-year record of human activity. From artifacts of not just stone but wood, gourd shell, and plant fibers we have been able to learn how Hawaiians used plant resources for many centuries. The site provides a continuous record of all that happened on the landscape for 10,000 years or more.

Like most lowland areas of the state, the surrounding acreage has been dominated by a handful of invasive plant species introduced to the island since the arrival of Europeans in the late 18th century. A few years ago, our group decided to enlist the aid of the large contingent of community volunteers that had helped us with the fossil dig to attempt to recreate, to the

Right:
Hibiscus waimaeae is a favourite among the over 100 native species used in the *inter situ* restorations on Kaua'i (Alec Burney)





Left: View of the rare native plants growing in the sinkhole at Makauwahi Cave, as seen from the darkness of the large cave on the south end (Alec Burney)

extent possible, the plant communities that the fossils showed us grew there for thousands of years before the recent human transformation of the landscape through deforestation and the introduction of a host of invasive animals and plants.

By this time we had obtained a lease on the cave and surrounding property from the owners, Grove Farm Company. In addition to an array of limestone sea cliffs, rolling dunes, and the largest limestone cave in Hawaii, the property also contained some abandoned farmland covered in a tangle of thorny non-native bush. That was in 2004. By now, thanks to the efforts of nearly everybody on the island from school classes, Boy Scouts, and native Hawaiian groups, to the numerous retirees and tourists on Kaua'i, much of the land surrounding the site features the native plants that we have inferred, from the fossil record, to be the ones that existed there before.

This was no easy process. Techniques were developed to use heavy equipment, such as mowers, tractors, and rotary tillers, to convert the weedy farmland back to bare soil and start over, planting native species, including many quite rare ones, where we knew they once had grown. We soon found that, in this dry leeward habitat, native plants could best outstrip the

aggressive invader plants if we put them on an automated drip irrigation system, similar to the ones used for maize and other crops by our farmer neighbours nearby, until they were thoroughly established – generally through two of the long, intensely dry summers. After that, many natives had gained a sufficient head start on the weeds to hold their own.

Because the site is on top of and adjacent to the habitat of three species of endangered blind cave invertebrates and a potential breeding and foraging site for endangered birds and invertebrates, we have developed techniques for controlling the weeds and insect pests that avoid the use of herbicides and pesticides. The challenges have been great, but the Makauwahi Cave Reserve, as we have come to call it, now hosts nearly 100 native plant species and provides habitat for rare Hawaiian animals. For several extremely rare plant species, we can now say that the largest “wild” populations in existence are thriving there, planted by thousands of willing hands.

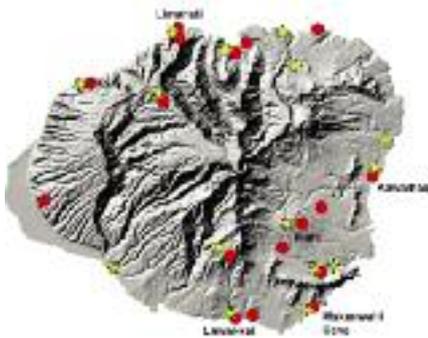
So what kind of conservation is it?

So what is it, *in situ* or *ex situ* conservation? Well, both, and neither. As this idea has caught on and spread to other sites on Kaua'i and elsewhere

here in the islands, we have come to refer to this as *inter situ* to signify its intermediate status. The basic idea is to conserve rare species by reintroducing them to sites where they once grew, but have been eliminated in recent decades or centuries by human agencies such as, here in Hawaii, the highly destructive impact of introduced goats, pigs, and rats.

One of the first places that this idea has caught on is on the properties of the National Tropical Botanical Garden (NTBG) and those of collaborating landowners. At Lāwa'i-kai, the uniquely beautiful coastal property managed by NTBG as part of the historic Allerton Gardens on Kaua'i's south shore, just a few kilometers from Makauwahi Cave, invasive vegetation has been removed from the beach strand and coastal forest and replaced with not just the three hardy native plant species that had persisted there, but dozens of other natives that cores collected from the adjacent marsh as well as the detailed record from other sites along the south shore such as Makauwahi shows were there when the Polynesians arrived a little more than a millennium ago.

Other natives have been reintroduced to the restoration sites NTBG maintains along nearby Lawai Stream, on the cliffside in Lawai Valley, and on the upper edge of McBryde Garden.



Above: Map of Kaua'i showing location of Makauwahi Cave and other sites mentioned in text. Asterisk symbol shows sites that have yielded useful paleoecological information, and dots show restoration sites that have been able to use this information

The Lawai Forest Restoration is near NTBG's *ex situ* collection of native plants from throughout the state of Hawaii, the largest living collections of this flora found anywhere. To supply all the plants needed for these and other restoration efforts, NTBG's Conservation and Horticulture Center has stepped up production in its state-of-the-art micropropagation, greenhouse, shadehouse, and sunny nursery facilities to the point that the organization has planted out nearly 12,000 specimens in the past year, and currently has over 18,000 plants in pots awaiting their "turn."

One of the most spectacular conservation projects of NTBG is the beautiful Limahuli Garden and Preserve on Kaua'i's north shore. The nearly 1000-acre property contains a massive archaeological site and cultural restoration, featuring centuries-old stone terraces and pondfields for growing taro (*Colocasia esculenta*) and other traditional Polynesian crops. A key effort here, as well as at NTBG's Kahanu Gardens near Hana, Maui, is to grow not only native plants in contexts that span the full range of *in situ*, *ex situ*, and now, *inter situ* techniques, but also to collect and propagate the rapidly disappearing old Hawaiian varieties of Polynesian crops such as breadfruit, banana, coconut, kava, and – of course – for the mainstay of Polynesian diet, more than 50 varieties of taro.

Watch out, it's spreading!

The *inter situ* approach has spread rapidly to other properties throughout Kaua'i, notably Grove Farm's Iliahi project, near our Kilohana Crater coring site, where the fossil pollen record reaches back all the way to the late Pleistocene, more than 27,000 years ago. Another is Kawaihau Wetland, a

collaboration between NTBG, Ducks Unlimited, the US Fish and Wildlife Service, and the USDA Natural Resources Conservation Service that has been creating new habitat for endangered endemic waterfowl and native wetland plants on property owned by singer/actress Bette Midler. Plant choices there were guided by the results of a sediment core from the wetland containing a 7,000-year record of fossil pollen and spores.

With only 0.2% of the land area of the United States, and 43% of the endangered plant species, the challenges to conservation in Hawaii continue to be daunting. Classic *in situ* and *ex situ* methods of conservation will continue to be major "fronts" in the eleventh-hour battle to stem the tide of extinction. They need all the support they can get from government and private sources, far more than they are getting now. But opening a "third front" in the struggle makes a lot of sense, to fill the many gaps in coverage of our conservation efforts, particularly in reclaiming the abundant lands available for conservation but not currently being used because of their state of degradation and commitment to other purposes. By blending advanced agricultural techniques such as conservation tillage, mulching, integrated pest management, and drip irrigation with large-scale conservation efforts on marginal lands – using the records from sedimentary fossils, archaeological sites, historical

evidence, oral traditions, and old herbarium sheets as a guide to what was growing there just moments ago in evolutionary and ecological time – we can bring resources and people into the fray that can never reach the last *in situ* stand of a rare plant, and extend the reach of *ex situ* botanical gardens to larger land areas, more diverse habitats, more people, and a longer list of species. As our meticulous record-keeping has shown, this approach is cheap and efficient, with a low per-plant cost and high survival rate.

Conserving more than we thought

One realization that has emerged from this expanded *inter situ* effort is that, by preserving these plants, we are also helping preserve native Hawaiian culture. Many native plants and rare Hawaiian cultivars are integral to local culture, but the lore is slipping away because the plants are otherwise just too rare and inaccessible — perhaps even illegal — for cultural practitioners to use them, and most young people will never even see them. At Makauwahi Cave and at Limahuli, McBryde, and Kahanu Gardens of NTBG, young and elderly Hawaiians, as well as persons of other backgrounds with an interest in preserving traditional cultures, frequently come together to grow and use these nearly-forgotten plants in ways they could never do in an *in situ* context. In *inter situ* projects, subsequent generations of these

Right: Girl Scouts from Kaua'i plant natives at Iliahi, the Grove Farm Ecological Restoration Project. Over 1000 young people from the island have assisted in planting several thousand native plants at this site, not far from Kilohana Crater (David Burney)



restored plants, now reproducing on their own in places where they were once abundant, then extirpated, and now re-established, hold out the possibility that subsequent generations of people will still know about these plants, their lore, and uses both past and future. With this increased accessibility, even the most endangered plants can potentially be studied and understood, so that precious *in situ* populations are not impacted, but better management can potentially be applied through research focused on rare species' biology, ecology, and ethnobotany.

One of the most heartening triumphs of our *inter situ* experiments is that, for the first time, some rare plants are now being made available for restoration on a larger scale. A current NTBG project in collaboration with the State Department of Forestry and Wildlife and the US Fish and Wildlife Service is a good case in point. We are reintroducing native plants to the remote uninhabited Lehua Islet just

Table 1. Comparison of three "fronts" in conservation.



north of Kaua'i's neighbour island of Niihau, guided by fossil pollen and charcoal identified from deposits there – since rabbits and rats now being eradicated had driven most native plants to extinction years ago. Producing enough seeds to restore a 300-acre (122 ha) island is a tall order. Recently NTBG interns and volunteers have been able to gather, under the guidance of NTBG field botanist Natalia Tangalin, huge quantities of fully accessioned weed-free native plant seeds for the restoration effort. So, in the space of a few years of *inter situ* efforts, we can now say that our restoration sites are restoring other sites!

Key references:

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- ➔ Burney, D.A., and Kikuchi, W.K.P. 2006. *A millennium of human activity at Makauwahi Cave, Maha'ulepu, Kaua'i*. *Human Ecology* 34:219-247.
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Left: Aerial view of an *inter-situ* restoration site at Makauwahi Cave, where rare native plants are being grown on abandoned farm land (Matthew Bell)

DEFINITION	ADVANTAGES	DISADVANTAGES
<i>In situ</i> : Conservation efforts applied to species in a pre-existing wild condition in their current range.	Species is presumably adapted to the site already. Co-evolution with other species in the community may be critical to survival and ecological function.	Site may be remote, expensive to maintain, and undergoing degradation. Problems leading to rarity may be unabated. Stochastic events such as storms, disease outbreaks, and human over-utilization are difficult to factor into planning
<i>Ex situ</i> : Efforts based on intensively human-controlled environments such as botanical gardens, zoos, genebanks, and propagation facilities.	Provides a second line of security for rare species by allowing specimens to be grown in the absence of challenges faced in nature. Gives people a chance to see biodiversity up close and near home.	Stops or even diverts evolution. Species may become "domesticated" and no longer suitable for reintroduction. Per unit cost may limit number of species and/or individuals that can be managed with this intensity.
<i>Inter situ</i> : The establishment of a species by reintroduction to locations outside the current range but within the recent past range of the species.	In effect bridges the gaps between <i>in situ</i> and <i>ex situ</i> . Species can be more accessible and better protected than former, and produced at much lower unit cost than latter. Evolutionary processes can be retained to varying degrees. New populations can be controlled or manipulated to enhance or preserve genetic diversity	Insufficient knowledge of community and ecosystem function limits our ability to reconstruct complex biotic webs. Some follow-up care is required to effect most successful reintroductions. Legal obstacles may inhibit innovative conservation efforts for rarest species. Long-term persistence of reconstructed communities needs evaluation through long-term monitoring.