New Zealand – Hawai‘i Conservation Exchange Program, 2001

Grant Norbury
Landcare Research
PO Box 282
Alexandra
New Zealand
norburyg@landcare.cri.nz

Landcare Research Travel Report

DATE: September 2001

1. Introduction

I visited Hawai‘i for 13 days in July–August 2001 with support from Landcare Research, New Zealand, and the Secretariat for Conservation Biology, Hawai‘i, under the New Zealand – Hawai‘i Conservation Exchange Program. The Secretariat for Conservation Biology promotes conservation of Hawai‘i’s native ecosystems through collaborative research and training among land managers, scientists, and educators. The purpose of my visit was to meet Hawaiian scientists to discuss approaches to protecting native species from alien predators, and to attend the Society for Conservation Biology’s annual conference in Hilo.

There is much to learn from this fascinating archipelago, but one can experience only so much in a 2-week visit to just part of the Hawaiian Islands. Most of my time was spent absorbing the ecology, and any inaccuracies or naive interpretations of how to manage these ecosystems should be considered in light of the brevity of my visit.

2. First Impressions

My arrival at customs in Honolulu was notable for its friendliness and lack of border restrictions. I stated my occupation as a biologist, but the Customs Officer’s only query was did I work with Steve Irwin, the crocodile hunter? We had a laugh and I was allowed straight through with no further questions. I suppose I have grown used to recently-tightened border controls in New Zealand where questioning and bag-checking are more strict.

I based myself on the Big Island (Island of Hawai‘i) to attend the annual conference of the Society for Conservation Biology. The day I arrived, I visited the Pacific Tsunami Museum in the main town, Hilo. The geography of Hilo Bay exposes the town to tsunami, and you can watch a live video of Hilo Bay taken from the rooftop of this interesting museum at http://www.tsunami.org/hilobaycam.htm.

3. Ecological Degradation in Hawai‘i

An amazing 75% of documented floral and faunal extinctions in the USA have occurred in Hawai‘i alone. About half of Hawai‘i’s 140 historically recorded native bird species are now extinct, including all of the flightless species (rails, geese, and ibis). Most of the extinctions occurred during the Polynesian occupation beginning 1600 years ago, when most of the lowland forest was destroyed, birds were hunted, and pigs and the Pacific rat were introduced. European occupation exacerbated the problems by destroying more habitat, and by introducing other ungulate species, ship rats, Norway rats, cats, and Indian mongoose (the mongoose was introduced to control the rats!). Europeans also

introduced a species of mosquito in 1832 that carries avian malaria and pox – diseases now considered by many to be the main limiting factor for many susceptible Hawaiian bird species below about 4000 feet above sea level. A vast number of other invertebrate and plant species have also been introduced (e.g., wasps, Argentine ants, gorse and Cape ivy to name a few).

4. Palila Restoration Project – Island of Hawai‘i

I attended an excellent pre-conference tour of the Palila Restoration Project run by the Biological Resources Division of the US Geological Survey. This is a Federal organisation that conducts government and contract research on conservation problems. The palila is an endangered species of Hawaiian honeycreeper that specialises on the seeds of māmane, a species of *Sophora*. Incidentally, Hawai‘i also has a species of *Metrosideros*, called ‘ōhia – an amazing species that not only colonises lava flows, but which is also a climax forest species and an important food source for honeyeaters. The stronghold for palila is now confined to critical mesic habitat on upland Mauna Kea Volcano, where about 95% of the birds remain (Mauna Kea is inactive and last erupted 4000 years ago).

The area has been proclaimed a Natural Area Reserve and is managed by the State of Hawai‘i Department of Land and Natural Resources. Paul Banko runs a multi-disciplinary team of ornithologists, entomologists, botanists, and predator ecologists who are restoring native ecosystems at this site. The area was once part of a pastoral station, and has an induced understorey dominated by fire-prone exotic grasses and herbs. Although there is a legal mandate to remove feral sheep and goats from the reserve, there are socio-political constraints enforced by hunters. Less grazing has resulted in exotic grasses and herbs smothering recruitment of māmane. Judicious use of grazing to allow regeneration is considered too difficult and risky, and so the team is planting māmane seedlings to regenerate the forest.

Predation by cats is one of the many threats to palila. Cats are very mobile, and will climb māmane trees and eat the chicks. Cats also prey on mice and rodents. Predation of chicks is erratic and varies from year to year, regardless of cat control. Managers are constrained in their ability to control cats in Hawai‘i because some of the public does not want them killed. Members of the Humane Society catch feral cats, desex them and put them in free-ranging “cat colonies” where they are fed. National Park trappers have to transport cats to the towns where people are supposed to look after them, or they release them back into the wild. People even feed feral cats at permanent feeding stations (which I witnessed). Apparently, a woman and her dog were recently attacked by one of these cats in Honolulu! Luckily for us in New Zealand, contentious cat issues are restricted to urban pets damaging local wildlife. Most New Zealanders accept that feral cats are destructive and that their numbers should be controlled. Hopefully we won’t have to confront the bizarre situation that Hawaiian wildlife managers have to face.

Paul is trying to inject some rationale into the cat control debate by measuring improvements in recruitment of palila with and without cat control. However, predation rates of nests at the reserve are only 8–12% (minimum estimates), and it appears the palila population here may be stabilising. Apparently palila are declining in sub-optimal habitats elsewhere, where presumably predation rates are a lot higher. If this were the case, it would suggest that palila may be able to sustain cat predation in productive habitats such as in the reserve, and that they may be prone to cat-induced extinction in less productive habitats. This scenario of a high stable state and a low unstable state is predicted by density-dependent predation theory involving generalist predators, like cats.

There is political urgency for Paul's team to demonstrate the benefits of controlling cats, but I'm not sure whether the productive habitat will deliver the benefits they need. Paul and I discussed options for doing the cat removal experiment in less productive habitat, where the benefits are more likely to be apparent. However, Paul is politically constrained in doing so. He thought there might be an opportunity in a less productive reserve that will soon be purchased by the US Army as compensation for realigning a road through critical palila habitat. The scientists are also limited in their ability to use experimental controls and to replicate treatments. Paul thinks the more common forest bird, the 'amakihi, may be a more suitable species to test these principles. Paul and I will continue our liaison on this important predation issue.

We also discussed the spatial scale of cat control and the protection it affords young palila that disperse away from productive habitat. Paul thinks that because cats in the area are so mobile, the effects of *in situ* cat control in the reserve are spread widely. The costs and benefits of different spatial scales and intensities of predator control is something predator scientists need to examine more closely. By analysing the ability of a predator species to reinvade control areas, the extent to which juvenile prey disperse from protected areas, and the relationship between predator density and their impact on prey. Non-linear relationships between predator density and impacts on prey have important implications for benefit:cost analyses of predator management.

5. Society for Conservation Biology Conference – Hilo

The conference was attended by about 1100 people. Sir Robert May (President of the Royal Society) gave an excellent plenary speech on the state of global conservation (latecomers had to view the talk on monitors outside the packed theatre). He described the rate of extinction of species during the last century as the fastest rate so far, compared with the big five extinction events evident from the fossil record. The extinction rate next century is expected to be 10,000 times the rate from the fossil record. Last century saw a 12% decline in forest species, a 35% decline in marine species, and a whopping 50% decline in freshwater species. A World Wildlife Fund study suggests that humans exceeded the earth's carrying capacity in 1975. Sir Robert considers that priorities for species conservation should be based on evolutionary distinctiveness (e.g., tuatara) and ecosystem services. He split ecosystem services into three components: (1) the genetic diversity that provides humans with undiscovered foods and drugs. (He downplayed this

argument by saying it is unlikely to stand the test of time); (2) that ecosystems services probably provide humans with 1–2 times the value of the world's gross domestic product, and that the first rule of intelligent tinkering is to keep all the pieces. (He questioned this and wondered whether it may be possible for humans to live in an ecologically simpler world); (3) an ethical/aesthetic argument that we do not want to live in an ecologically degraded world (which is an argument afforded only by the developed world). He found none of these arguments compelling on their own. Regarding conservation science, he noted that the number of scientific publications on a given taxon is broadly inversely proportional to their taxonomic diversity. He advocated far greater research, firstly, on soil microorganisms; secondly, invertebrates; and thirdly, plants. He thinks there is too much duplication of conservation research and not enough coordination. Integration is the imperative because of limited resources. He argued that science's role to advise on what is and what is not possible is of little use without the socio-political will to achieve a world we want. He therefore urged scientists to engage more with the public and to enter socio-political debates more often. Scientists have to accept that they have a minor role compared with people's values. He said we must be explicit about what we do and don't know, despite our culture saying that science knows all.

Peter Vitousek (Stanford University) talked about the unique opportunities Hawaiian volcanoes offer for environmental research because of their sharp altitudinal and rainfall gradients, and the wide range of soil ages (fresh or weathered lava) found over very small areas. Allen Allison (Bishop Museum, Honolulu) and Jim Jacobi (USGS, Kīlauea Field Station) noted Hawai'i's lack of native mammals (apart from one seal and one bat species), and complete absence of native reptiles, amphibians, social insects, mosquitoes, cockroaches, migratory land birds, and conifers. The lack of herbivores and predators has meant the native mint plant has lost its "mintiness", the native raspberry has lost its spines, and many birds are flightless. Hawai'i has very high rates of endemism of vascular plants, insects, spiders, snails, and forest birds. Explanations include Hawai'i's extreme isolation, its large range of habitats (huge rainfall and altitudinal gradients), and long evolutionary time. Hawai'i also has a very high rate of invasive species, which Allen hypothesised could result from its ecosystems being isolated and therefore "unsaturated". Despite habitat loss, invasive species are Hawai'i's number one environmental problem. About 6,000 plant species have been introduced in the past 150 years.

Earl Campbell (US Dept of Agriculture, Hilo) talked about the threat of brown tree snakes invading Hawai'i. This snake species, originally from New Guinea and northern Australia, invaded Guam 55 years ago and has decimated their native wildlife. There, the snake population is driven largely by two species of highly fecund, introduced lizards, resulting in hyperpredation of native species (see Fritts, T.H. and Rodda G.H. 1998: The role of introduced species in the degradation of island ecosystems: a case history of Guam. *Ann. Rev. Ecol. Syst. 29*: 113–140). The Hawaiians are worried that if these snakes enter Hawai'i, their wildlife will suffer a similar fate because the habitat is suitable for brown tree snakes, and there are two species of highly fecund, introduced frogs in Hawai'i upon which snakes could thrive. There are few methods for controlling frog numbers, but concentrated caffeine is being considered. These examples of predator-mediated hyperpredation (or apparent competition) resulting from abundant exotic

primary prey are common throughout the world. New Zealand's examples are exotic rodents driving abundant stoats, and exotic rabbits driving abundant ferrets and cats. These can have serious flow-on effects on native prey.

I attended a meeting during the conference to discuss the possibility of creating a South Pacific Chapter of the Society for Conservation Biology. While Australia and New Zealand have their own version of conservation societies, it was agreed that exposure to the international society would be beneficial. There was a suggestion that some Hawaiians may prefer to be part of the South Pacific Chapter rather than the North American Chapter. If this were so, it would greatly benefit New Zealand's already-close relationship with Hawai'i.

6. Habitat Restoration in Hawai'i Volcanoes National Park

I attended a post-conference tour of habitat restoration in Hawai'i Volcanoes National Park. Tim Tunison, the Park's resource manager, showed us regenerating rainforest following removal of feral pigs. Pigs knock over smaller ferns and eat out the pith, which creates hollows for water to pool and for mosquitoes to breed, thereby worsening avian diseases. Fewer ferns also allow weeds to invade. Pigs also eat introduced earthworms. Unlike State Natural Area Reserves, the goal of pig management in National Parks is straightforward – they are eliminated where possible. Tim was adamant that trying to conserve biota while allowing hunting can not be done effectively. Many hunters think pigs are native to Hawai'i and that they are good for the forest.

As far as predators are concerned, rats prey on native birds in the Park, as they do in most Hawaiian forests. Generally within Hawai'i, ship rats are considered a greater threat than Pacific rats because ship rats are more arboreal and are able to access nests more readily. Rats are most abundant in rainforest, less common in mesic environments, and uncommon in lowland areas. This seems the opposite of mongoose abundance (is there a mongoose predation effect here?). Cats concentrate mostly in drier habitats and in coastal areas.

Eric Spurr (Landcare Research) told us about the aerial diphacinone poisoning trials he is doing in Hawai'i to gather the necessary data on kill rates of target and non-target species to allow registration of the toxin for aerial use. Eric is also studying the efficacy of fipronil to control wasp numbers, which were introduced from California, perhaps on imported Christmas trees.

We then visited a more mesic environment of koa (*Acacia* spp.) forest that was once grazed by livestock. The understorey is dominated by exotic grasses, which increase the frequency of fire. The soils are depleted of seeds of native plants. National Parks staff are planting an impressive 2.5 million seeds in 850 plots where they will be ready to germinate after the next fire. They expect these native species will ultimately out-compete the exotic grasses.

7. Waikamoi Preserve – Island of Maui

I visited the nearby Island of Maui for four days. The strong, warm north-east trade winds were howling when I arrived, as they do most days. I met up with Eric Nishibayashi (The Nature Conservancy – an international non-profit conservation organisation) at Makawao, and we talked about predator management issues in the Waikamoi Preserve – an area managed for watershed conservation and biological conservation. Preserves are normally owned jointly by private landholders and state and federal agencies. Funding put up by private individuals is generally matched 2:1 by the State. Because of the emphasis on watersheds, it is relatively easy to gain consensus on how they should be managed. Access to preserves is only by arrangement. Eric gave me a key to enter the Waikamoi Preserve and was very attentive to ensuring that I did not accidentally transfer seeds of exotic plants into the area.

Rats are the most abundant predator in this forest system. Mice are few, and there are some cats and mongooses. Eric is interested in understanding some of the unintentional effects of predator control, such as the effects of cat and mongoose removals on rat populations, and whether rat control induces prey-switching by cats and mongooses. He is a little frustrated at the lack of basic ecological research that has been done in the preserve, such as finding out what predator species are doing the damage. Eric is trying to initiate a small fund for student research, but is having trouble getting it off the ground.

I visited a team of researchers at the Maui Forest Bird Conservation Center in Olinda: Jim Groombridge, Trent Malcolm, Bill Sparklin, and three interns, Sarah, Bobby, and Jessica. They are trying to save the forest bird, the po‘ouli, of which there are only three individuals left (one male and two females). To make matters worse, they occur in separate home ranges, they remain in difficult, remote terrain, and rats prey on them. Other scientists and managers have decided that bringing them into captivity is likely to be more risky than trying to get them to mate in the wild. So the team are planning to move one of the females into the range of the male. They are also applying ground-based rat control using diphacinone and measuring its impact on rat abundance. This appears to work well for ship rats, but less so for Pacific rats. I was impressed by the team’s dedication, and equally impressed by the daunting task ahead of them.

8. Haleakalā National Park

Cathleen Hodges (National Park Service wildlife ecologist) showed me around the 10,000-foot-high extinct crater of Haleakalā Volcano – a spectacular, deep crater full of cinder cones and wide barren landscapes (the volcano last erupted 750 years ago). This was the last place I expected to see nesting and roosting sites for petrels, the dark-rumped petrel, or ‘ua‘u. The once rare Hawaiian goose, or nēnē (the state bird of Hawai‘i), also occurs in the crater. During the 1960s and 1970s about 500 nēnē were introduced into the crater, but their numbers declined to 150. Predator trapping has increased nēnē numbers

to 250, and they have remained at that number since the mid-1980s. Petrels and nēnē are preyed on by cats and rats. Predator trappers use mostly cage traps (collapsible Tomahawk and non-collapsible Havahart) and sometimes leg-hold traps, baited with a combination of commercial cat and dog food. (Preliminary work we recently completed in New Zealand looking at what bait types attracted most wild ferrets to traps revealed the best bait type appeared to be the most locally abundant food.) The range of active petrel burrows also appears to be expanding since trapping began. Although rats are readily caught, it is unclear what impact trapping has on the population. Cats are rarely caught in the crater because it is sub-optimal habitat for cats, and only a few stray into the area. However, because there appears to be increasing numbers of rats, chukar, and pheasants in the crater, Cathleen is worried that more cats may be attracted into the area. Given that only a few individual cats appear to be occupying the crater, and that cats are not easy to trap, we discussed the use of trained dogs to locate occupied cat dens to target control. There are many examples in Hawai‘i of very high rates of predation (sometimes 100%) of petrel colonies that are close to high concentrations of cats, and very low rates where they are further away. Clearly, cats are a critical threat to some fauna.

We walked around the crater with Karl Campbell, an Australian working on ungulate control in the Galapagos Islands. Karl was experimenting with Judas goats. The problem with using nannies as Judas goats is that, when they give birth, they tend to separate from the herd, defeating the purpose of the Judas approach. Karl is testing whether surgically sterilising Judas nannies and implanting a hormone pellet will prevent pregnancy but maintain them on heat. This apparently keeps the herd intact.

I gave a talk on predator–prey research and management in New Zealand at the Maui Forest Bird Conservation Center, where a number of endangered bird species are being bred in captivity. The facility is funded by the San Diego Zoo. Afterwards, a group of us walked into the Waikamoi Preserve to do some bird watching. We found a cat scat that was full of fur, presumably rodent fur. The next day I toured around east Maui along the ocean road at the base of Haleakalā Volcano. The coastal scenery was spectacular from the wet, windward, northern side to the incredibly dry and barren slopes of the leeward south side.

9. Hakalau Forest National Wildlife Refuge – Island of Hawai‘i

Donna Ball from the US Fish and Wildlife Service took Barbara Spurr (Eric’s wife) and myself out for a day to the Hakalau Wildlife Refuge. This 33,000-acre area is surrounded by 44 miles of ungulate fencing. As for many reserves in Hawai‘i, it was once grazed by livestock. This has depleted the native vegetation and left few viable seeds in the soil. Again, managers are faced with planting seedlings to restore the forest.

Donna explained an interesting situation with the plight of the Hawaiian crow, or ‘alalā, of which only two remain in the wild on the drier, southern side of the island. ‘Alalā are bred in captivity and released, but one of the main sources of mortality is predation by the endangered Hawaiian hawk, the ‘io. Because the forests have been opened up and

fragmented by grazing, ‘alalā now have less refuge from predators and so appear to be more vulnerable to ‘io predation. ‘Io have increased in number in recent years to about 1400, presumably because of more abundant primary prey (rodents and game birds) and more open habitat in which to hunt them. This is another example of how the numerical response (more ‘io because there are more alternative prey) and the functional response (easier for ‘io to find prey and, therefore, consume more of them) of a predator can result in hyperpredation of a native prey species. To make matters worse, captive ‘alalā have lost their anti-predator skills, and some individuals also suffer from toxoplasmosis. The Fish and Wildlife Service consider that poisoning the exotic primary prey is risky to native species in the reserves, and reducing the native hawk is ruled out. This leaves restoring habitat refuge for ‘alalā as the most sustainable solution to the predation problem. Some of the political implications of ‘alalā conservation can be found at http://www.planet-hawaii.com/environment/200cov.htm. The effects of habitat structure on the vulnerability of prey populations to predators is attracting increasing attention by scientists.

10. Pacific Island Ecosystems Research Center - Kīlauea Field Station

I spent the next few days at the Kīlauea Field Station, located on the edge of the Kīlauea caldera. The field station is part of the Pacific Island Ecosystems Research Center. I talked with Thane Pratt, an ornithologist with the Biological Resources Division of the US Geological Survey, who told me about a state-wide bird monitoring programme that started in 1988. Surveys are repeated every 4–5 years (some sites every 1–2 years). These data provide rates of change in bird abundance, density estimates, and distribution maps. I also chatted with Jim Jacobi, and he told me why Hawaiian insectivorous forest birds are in more trouble than nectivorous species. The nectivores are more fecund and more mobile, and so are able to make greater use of a range of resources. Insectivores are very territorial and are thus more vulnerable to disturbance. Jim also talked about some of the broader issues that hamper Hawai‘i’s ability to conserve their fauna. One of the main problems is a general lack of awareness and support for conservation from the Hawaiian public. For example, the public’s fear of brown tree snakes arriving in Hawai‘i are more to do with fear of snakes and disruption to power supplies (by shorting out lines) than the snakes’ potentially devastating impacts on wildlife (see recent media release on $1.6 million to continue and expand use of existing techniques to control brown tree snakes and prevent their introduction to Hawai‘i http://www.senate.gov/~inouye/97pr/97pr66.html).

The weed *Miconia* is one of few exotic species issues that attract significant public support. Surprisingly, ecotourism is almost non-existent in Hawai‘i. Tourists are confined to coastal resorts where all the lush, tropical vegetation is exotic. Their knowledge of Hawai‘i’s natural ecosystems is almost non-existent. One of the great advantages of the Hawaiian conservation scene Jim spoke about was the cooperation between the multitude of agencies.

Bethany Woodworth told me about some bird predation work she did with Steve Fancy at Hakalau Forest several years ago, where they tested the effects of ground-application of diphacinone to control rats and to increase bird populations. Ground baiting reduced numbers of ship rats, but not of Pacific rats. Pacific rats (plus cats and mongooses) were reduced in number by trapping. Although birds' nests are certainly subject to predation, the team could not detect any significant change in forest bird dynamics with predator control. Bethany thinks the treatment and control blocks (no replication) were too close to allow independence, and the variable-circular-plot method of assessing bird abundance was too imprecise. Another interpretation is strong density-dependent effects, where the positive effects of reducing predation were compensated by negative, density-dependent declines in some form of prey productivity. The evidence for predator impacts on forest birds in Hawai'i comes from sign left in the nest, from video evidence of artificial nests, from high rates of nest failure measured in the Hakalau experiment, and from improved recruitment of some birds where predator control is applied. The effect of variation in food abundance on bird dynamics is poorly known, but is likely to interact significantly with predator impacts.

I was able to see first-hand some of the volcanic features of this island. In the afternoon I walked over the raw lava flows (20–40 years old) inside the massive caldera at the summit of Kīlauea Volcano. A caldera is formed when the magma reservoir inside the mountain shrinks and the top caves in, leaving a basin at the summit. That evening, Eric Spurr and I watched raw lava pour into the ocean, sending a massive plume of hydrochloric acid and steam into the air. While most of us watched this fiery spectacle from 200 m away, some unthinking people watched it from an unstable ledge only meters away. They are lucky to be alive because half of the ledge fell into the sea only minutes after they departed.

The next day, I gave a talk at the Kīlauea Field Station on predator–prey research and management in New Zealand.

11. Dark-rumped Petrels on Mauna Loa Volcano

I met with Darcy Hu and Roberta Swift (National Parks Service), who work on predators in Volcanoes National Park. Predation of petrels and nēnē are the main predator issues in the park. As in Haleakalā National Park, petrels nest on the inhospitable lava flows of upland Mauna Loa. Petrels used to be one of the most common Hawaiian birds right down to sea level. Petrels and nēnē were probably originally forced higher by Polynesian hunting and by their dogs. Lowland threats now include habitat loss, cats, and pigs. Active petrel burrows have been monitored since the early 1990s. In 1995, there were estimated to be about 45 breeding pairs in the Park; this is now down to about 25. Two colonies exist in the Park – the one most accessible to cats (and to people) is declining and only one active nest remains there. Darcy and Roberta suspect the second colony is to some extent protected by rough lava (or 'a'ā) that cats prefer not to use. We discussed the worth of investigating the way cats use habitats in order to help target cat control. Cat predation is uncommon, as is a cat capture by one of the staff. Rather than radio-collaring

a cat and releasing it to monitor its use of habitat, the staff feel compelled to remove any cats they are fortunate enough to catch. I can understand this, but there may be longer-term rewards by foregoing a few removals and understanding cat behaviour better in this environment.

The next day, Roberta took Barbara Spurr and I to the most accessible petrel colony. Besides trapping, the team has considered fencing the colonies, but the problem is that petrels sometimes kill themselves on the fence. The burrows I saw were holes in mantles of lava. We discussed alternative predator-control methods. I wondered whether the few active burrows in the colony could be protected by an artificial entrance large enough for petrels only (other holes would have to be blocked off). However, even if this worked, it would still leave adults vulnerable when outside the nest. It is also possible that intensive ring-trapping around the few nests would improve protection. This approach may seem risky as everything depends on the last (and only) line of defense, but it at least targets the effort where the action takes place and targets individuals that cause the problems. Another option is to move traps around on a regular basis. My experience in New Zealand is that some sites never catch predators, yet other sites nearby consistently do so. On our return, we came across a cache of petrel egg shells between a small shrub and rock shelf that looked like the work of a rat. Unfortunately, some of the traps used to catch cats leak rats.

That night we joined the USGS staff at their annual dinner by the sea – a very pleasant way to spend my last evening in Hawai‘i.

12. An Overview

A recurring theme in Hawai‘i (and indeed elsewhere in the world) is that predation by exotic species on its own is not always sufficient to drive prey populations to peril, but has the potential to do so when combined with some other form of mortality (e.g., disease or adverse climatic conditions), loss of prey productivity (e.g., overgrazing of a food source), or more pervasive factors such as abundance of alternative food for predators or depletion of habitat and subsequent loss of refugia for prey. For example, many Hawaiian scientists believe that clearing of lowland habitat has pushed many forest bird species into higher, sub-optimal habitat, where presumably their populations are more vulnerable to the effects of predation. As the Hawaiians are attempting to do, it is important to understand these effects because they can often be the primary threat that exacerbates predation. In a sense, excessive predation could sometimes be viewed as a symptom of other more insidious forms of disturbance. In some circumstances, there are likely to be far greater and more sustainable gains from managing these other threats than having to continuously apply predator control.

More specifically, many questions about predator–prey ecology remain unanswered in Hawai‘i, as they do in New Zealand:

- What predator species pose the most critical threat for a given prey species in a given habitat?

- How strong are the trophic or competitive interactions between predator species?
- What drives predator population dynamics?
- What level of predator control will allow prey populations to persist?
- Are there conditions that will allow some prey species to sustain predation, and if so, what are those conditions?

Needless to say, these are difficult questions to answer. New Zealand and Hawai‘i desperately need more cost-effective tools to reduce predator abundance over large areas. But there will always be financial, technical and socio-political limitations to any control method, and there will sometimes be unexpected and undesirable side effects. That is why it is increasingly necessary to target predator control when and where it matters the most, and to recognise that attempting to control only one part of the system is likely to exacerbate another part (e.g., putative rat increases after cat or mongoose control). I would also advocate a wider approach to predator problems that is premised on a greater understanding of predation processes. This at least allows a broader, and sometimes less intuitive, range of management options to be considered.

13. Acknowledgements

Special thanks to Andy Pearce (CEO, Landcare Research) and to the late Nancy Glover (Hawaiian Secretariat for Conservation Biology) for supporting my visit. Thank you also to Moani Pai from the Secretariat, to Trent Malcolm, Bill Sparklin, Jim Groombridge, Cathleen Hodges, Donna Ball, and Roberta Swift for hosting me and showing me around in the field, and to Eric and Barbara Spurr for their generous hospitality during my last few days in Hawai‘i.

14. Contacts

Claudia Hamblin-Katnik
Secretariat for Conservation Biology
1601 East West Rd
Honolulu, HI 96848
Tel: (808) 944 7133
Fax: (808) 944-7298
Email: katnik@hawaii.edu

Paul Banko
PIERC Kīlauea Field Station
Bldg. 344
P.O. Box 44,
Hawai'i National Park, HI 96718
Tel:(808) 967-7396, ext. 235
FAX:(808) 967-8568
Email: Paul_Banko@usgs.gov

Jim Jacobi
PIERC Kīlauea Field Station
Bldg. 344
P.O. Box 44,
Hawai'i National Park, HI 96718
Tel:(808) 967-7396, ext. 229
FAX:(808) 967-8568
Email: Jim_Jacobi@usgs.gov

Thane Pratt
PIERC Kīlauea Field Station
Bldg. 344
P.O. Box 44,
Hawai'i National Park, HI 96718
Tel:(808) 967-7396, ext. 234
FAX:(808) 967-8568
Email: Thane_Pratt@usgs.gov

Bethany Woodworth
PIERC Kīlauea Field Station
Bldg. 344
P.O. Box 44,
Hawai'i National Park, HI 96718
Tel:(808) 967-7396, ext. 235
FAX:(808) 967-8568
Email: Bethany_Woodworth@usgs.gov

Tim Tunison
Hawai‘i Volcanoes National Park
PO Box 52
Hawai‘i National Park, HI 96718
Email: Tim_Tunison@nps..gov

Darcy Hu
Hawai‘i Volcanoes National Park
PO Box 52
Hawai‘i National Park, HI 96718
Tel: (808) 985-6092
Email: Darcy_Hu@nps.gov

Roberta Swift
Hawai‘i Volcanoes National Park
PO Box 52
Hawai‘i National Park, HI 96718
Email: Roberta_Swift@nps.gov

Eric Nishibayashi
The Nature Conservancy
PO Box 1716
Makawao, HI 96768
Tel: 808 572 7849 ext 23
Email: enishibayashi@tnc.org

Trent Malcom, Jim Groombridge, Bill Sparklin

Maui Forest Bird Recovery Project
Olinda Field Station
2465 Olinda Road
Makawao, HI 96768
Tel: 808 573 0280
Fax: 808 573 0519
poouli@maui.net

Cathleen Hodges
Haleakalā National Park
PO Box 369
Makawao, HI 96768
Tel: 808 572 4491
Fax: 808 572 4498
Email: Cathleen_hodges@nps.gov

Karl Campbell
Fundacion Charles Darwin Para Las Islas Galapagos
Email: karl@fcdarwin.org.ec

Donna Ball
US Fish and Wildlife Service
C/O Big Island NWR Complex
32 Kino'ole Street, Suite 101
Hilo, HI 96720-2469
Tel: 808-933-6915
FAX: 808-933-6917
Email: Donna_L_Ball@r1.fws.gov