

INVESTIGATING CAUSES OF POPULATION DECLINE IN NEW ZEALAND PLANTS AND ANIMALS: INTRODUCTION TO SYMPOSIUM

The first step - natural history matters

The four steps we must take to identify why a species is declining and what can be done about it begin with a natural history study to select correct hypotheses about the likely causal agent (Caughley, 1994). For most readers, this will seem so immediately obvious as not to need page space, but the implication that there are incorrect hypotheses we might erect has been a painfully learned lesson in conservation biology in general (e.g., Black *et al.*, 1991), and in New Zealand in particular.

The "Parable of the Takahe" (*Porphyrio mantelli* A.B. Meyer) is taking on cult status with each retelling (Gray and Craig, 1991; Clout and Craig, 1994; Bunin and Jamieson, 1995). It is instructive firstly because it reminds us that the reason why takahe persisted in Fiordland may have been that the area was unfavourable for the agents of decline, like human hunters, ungulate competitors and carnivorous predators. A downward trend in takahe numbers during the 1960s pointed to a change in the system, and it was the observable correlation between increases in deer abundance and reduction in forage that received most attention (Mills and Mark, 1977; Mills *et al.*, 1989). A possible confound with changes in predator abundance was not identified at the time (Clout and Craig, 1994). With hindsight, we might hypothesise that more deer meant more carcasses and therefore more stoats (*Mustela erminea* L.), or that beech mast events drove increases in mouse numbers that benefited stoat populations in a habitat substantially altered by browsing, but data gathered at the time did not include measurements targeted at these scenarios. More recently, reviewers of the Kakapo Recovery Programme found difficulty interpreting effects of supplementary feeding because there was insufficient background on the nutritional requirements of kakapo (*Strigops habroptilus* Gray) and their natural patterns of diet selection (Imboden, Jones and Atkinson, *unpubl. report*; Department of

Conservation, Wellington, N.Z.). The moral must be that initial investigations of a species' natural history require the broadest possible objectives.

Steps two and three - short-listing likely agents of decline

The next two steps in a declining-population investigation are to list all likely agents of decline and then to compare their occurrence in areas where the species persists with that in areas where the species recently disappeared (Caughley, 1994). This systematic procedure would let us rank potential causes of population decline in terms of likelihood, as long as we could find enough places with sufficient variation in their set of agents. In practise, case studies usually develop from serial rather than parallel lines of enquiry and explicit rankings are not obtained. For example, Savidge (1987) associated the introduction and spread of a snake with bird extinctions on Guam, and Savidge, Sileo and Seigfried (1992) went on to rule out avian pathogens as causal agents of bird extinctions. Populations of kaka (*Nestor meridionalis* Gmelin) have declined as possum (*Trichosurus vulpecula* Kerr) numbers rose, as wasps (*Vespula vulgaris* L.) spread, and in the presence of stoats and rats (Beggs and Wilson, 1991). The process of ranking these threats will not be easy, but at least it is underway (O'Donnell and Rasch, *unpubl. report*; Department of Conservation, Wellington, N.Z.).

In New Zealand, we have tentatively identified some causes of decline from observations of translocated or natural populations on islands that lack predators or competitors. High survival rates of kakapo translocated to Codfish and Little Barrier Islands were associated with the absence of cats (*Felis eatus* L.) (Lloyd and Powlesland, 1994). Data on reproduction by tuatara (*Sphenodon punctatus* Gray) on islands with and without rats provides circumstantial evidence that kiore (*Rattus exulans* Peale) somehow lower tuatara recruitment rates

(Cree, Daugherty and Hay, 1995). Given the successful effort to remove Norway rats (*Rattus norvegicus* Berkenhout) from Breaksea Island (Taylor and Thomas, 1993), kiore from the Mercury Islands (Towns, 1991) and ship rats (*Rattus rattus* L.) from forest patches in the North Island (Innes *et al.*, 1995), kiore eradication from tuatara islands is both logical and practicable. A decline in numbers of a bird, the kakerori (*Pomarea dimidiata* Hartlaub and Finsch), on Rarotonga in the Cook Islands was halted by trapping ship rats, but how much of this was due to associated effects on cats could not be assessed (Robertson *et al.*, 1994). Similar management to benefit tuatara may well work, but would we know why it had?

In some cases, the imminent risk of losing a species may be so high that it seems to outweigh the risk of wrong action, and conservation has to proceed on the best guess. Cree *et al.* (1995) recommended an approach which accepts that "demands for scientific proof are usually impossible to fulfill". This is firefighting talk, which would find many sympathetic listeners amongst ecologists and conservation managers in New Zealand. Despite the fact that some of the time the best guess will even turn out to have been the correct one, the approach is still seriously flawed. I was struck by eerie echoes of the takahe experience, and of Caughley (1994) who wrote that many declining-population studies were short on scientific rigour and a high proportion of mistaken diagnoses could be traced to faulty scientific method. The vaccine against mistaken diagnosis is an experiment, in which kiore are removed from some islands but not others and to this end I was encouraged that Cree *et al.* (1995) suggested leaving Hen Island as a control for kiore eradication from the Three Chickens Islands.

The fourth step - hypothesis testing

Declining-population research in New Zealand is increasingly focused on experimental manipulations of hypothesised causal agents like predators, competitors and pathogens. This fourth and final step crystallises the management problem for us - either we proceed to reduce the abundance of the causal agent (to zero on some offshore islands) or translocate organisms to places where the threat is absent, or we change our focus and research the yet-untested ideas. Whatever the route by which we stumbled towards the hypothesis, the way forward is clear once the experiment has been done. This is the point in my review when, like a magician, I should snatch the cover off some well executed, reputedly published, local, examples - bases for conservation action.

Experiments are being done (C. O'Donnell, *pers. comm.*; Department of Conservation, Christchurch) but finding out what they are and what they achieved can be difficult. It was to meet this problem, and to flesh out the first three steps in declining-population research in New Zealand, that papers appearing in this issue of the Journal were solicited for a symposium on Competition, Predation and Disease as Agents of Decline in the New Zealand Biota at the 1995 Annual Conference of the New Zealand Ecological Society. Word-of-mouth, itself a biased sampling system, was used to identify researchers working on declining populations or theorizing about the problem. A real effort was made to spread coverage wider than birds, and beyond terrestrial ecosystems. Ten groups accepted an invitation to speak at the Symposium, and eight of them submitted papers for this issue. A ninth conference paper and a paper subsequently submitted to the Journal complemented the Symposium theme and are published in this issue.

Investigations in New Zealand of agents of population decline

Not surprisingly, the best-studied New Zealand organisms are those with economic value. Populations of oysters are harvested from Foveaux Strait for human consumption, and declines in oyster abundance in late 1985 that were associated with a parasitic protozoan called *Bonamia* were the impetus for a sampling programme to determine occurrence and spread of the parasite and its effects on oyster populations. As Hine (1996) reports, *Bonamia* outbreaks have a cyclical character that may result from temporal variations in host resistance and human-induced increases in oyster densities. A picture of the natural history thus emerges, even if - as Hine points out - it lacks much understanding-of the benthic community that the oysters inhabit. A contentious hypothesis also suggests itself; a reduction in oyster densities achieved through harvesting could reduce risk of a *Bonamia* outbreak. Paradoxically, oyster conservation might be managed by oyster harvesting.

Some native insects have profited from anthropogenic changes in the New Zealand landscape (Yeates, 1991). The grass grub beetle (*Costelytra zealandica* White) and porina moth (*Wiseana cervinata* Viette) are now serious pests of pasture, and strategies for pest control that exploit pathogenic organisms are being pursued, reviewed here by Bourner *et al.* (1996). Population collapses of both grass grub and porina have been associated with disease outbreaks (Bourner *et al.*, 1996, Table 2), and can be caused in grass grub by applications

of the bacteria *Serratia entomophila*. This suggests Caughley (1994) was premature in judging that declining-population research has contributed little theory on population extinctions. Surely we are beginning to understand decline processes, if we can disturb a community enough to produce population declines on demand?

The debated hypothesis that disturbance of the grassland community by ploughing precedes virus outbreaks in porina populations (Bourner *et al.*, 1996) deserves highlighting, since community and ecosystem resilience in the face of disturbances may be an important protection for some populations (Walker, 1995). The question of whether community sensitivity to disturbance could be a predictor of extinction risk for populations is addressed by Death (1996), using data from invertebrate communities in tributaries of the Waimakariri River. A surprising result is that the stream communities studied by Death (1996) were inherently unstable on objective criteria, yet they persisted unaltered through several real disturbances. Experience has taught us that many population declines of New Zealand organisms can be traced back to community disturbances (Atkinson and Cameron, 1993). The plant community patterns in North Island areas affected by volcanic disturbance can be related to the scale and intensity of the eruptions, and to the changes in substrate wrought by vulcanism (Clarkson, 1990). For conservation on an ecosystem scale to be successful (Towns and Ballantine, 1993), we are going to need an understanding of the population-level effects of community disturbance.

One symposium paper provides a textbook example of how putative agents of decline may be investigated in parallel and ranked in terms of the likelihood that they are the cause of the problem. Cabbage trees (*Cordyline australis* (Forst.f.) Endl.) were ubiquitous in urban and rural landscapes in New Zealand until quite recently, but skeletons of dead trees starkly mark a population decline. Beever *et al.* (1996) describe how they systematically ruled out aging, changes in vigour or flowering patterns and abiotic influences as causes of cabbage trees decline. They hypothesized that a pathogen was involved in cases of sudden decline, and after researching likely possibilities, could not rule out phytoplasmas as disease agents (Beever *et al.*, 1996). The final, experimental test of their hypothesis may have to wait until phytoplasmas can be cultured.

Mistletoes (Loranthaceae) are also declining in abundance. Ladley and Kelly (1996) investigated the role of birds as seed dispersers, and show that seed passage through a bird gut sets germination processes in motion. Their finding raises the possibility that mistletoe declines might be related in

some way to changes in bird abundance in New Zealand forests since last century (Ladley and Kelly, 1996), and reminds us that extinct birds might have been important seed dispersers (Clout and Hay, 1989).

Completion of an experimental test of the hypothesis that predation on young kiwi (*Apteryx* spp.) by stoats and cats impedes recruitment and causes population declines (McLennan *et al.*, 1996) cannot be far away. This hypothesis emerges from the analysis by McLennan and co-workers of all available records of predation on eggs, chicks and adults, and is as compelling as the tuatara study (Cree *et al.*, 1995). We thus return to the issue of whether levels of scientific proof are too demanding for situations where populations are rapidly declining, and therefore whether predator-removal experiments can be done in any meaningful way. This problem formed the brief for McArdle (1996), who dealt with it by evaluating the usefulness of evidence obtained at different levels of reliability. Weak data might have to be used, as long as conclusions based on them are suitably qualified. Better still are hard data that allow us to distinguish between competing hypotheses, and obtaining such information is not so constrained by considerations of independence as fieldworkers sometimes think (McArdle, 1996).

The two predator-removal experiments reported here were both failures, in the sense that results were rendered uninterpretable by events outside experimenter control. What we can rescue from each of them are lessons for designing better experiments in future. The majority of New Zealand pigeon (*Hemiphaga novaeseelandiae* Gmelin) nests monitored by Clout *et al.* (1995a) failed because of predation of eggs, chicks or nesting adults. A poisoning operation that lowered rat numbers in one breeding season at Wenderholm Regional Park was associated with improved breeding success by pigeons when compared with the previous year (Clout *et al.*, 1995b). Against this background an experiment was designed to formally test the hypothesis that ship rats hold down pigeon abundance via nest predation (James and Clout, 1996). Nest predation was indeed reduced, but a reduction in possum numbers in the treated area during the experiment may have had a contributory effect. It was discovered in the course of the experiment that possums visit pigeon nests and may take eggs (James and Clout, 1996). It is much better for reliable knowledge that the possibility of a confound was identified, but a salutary lesson nevertheless.

The paradox of having fewer remnant populations than blocks required for good experimental design calls

for creative approaches. Bramley (1996) describes single subject experimental designs of the sort developed in medicine and the social sciences, and argues for their use in experiments involving small populations. Such designs risk carry-over of treatment effects, but they liberate workers from the lack of power inherent in small sample sizes, and might have generated a more convincing test of his hypothesis that predation is the agent of decline in North Island weka (*Gallirallus australis greyi* Buller) using the population of less than 50 individuals at Rakauroa (Bramley, 1996).

It is very encouraging to see the growing number of New Zealand studies of agents of decline that have now been published. Good research is as unhelpful as poor research if we cannot find it, hardly a new point but often a sore point for people outside of recovery groups or the social networks and in-groups that store knowledge. Authors of all the papers published here hope, as I do, that compilation of studies into one volume will provide a valuable source of material to guide future research on how agents of decline affect plant and animal populations

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