Centre for Conservation Biology, University of Auckland, New Zealand.
[1] Present address: Department of Conservation, Private Bag 701, Hokitika, New Zealand.

IMPACTS OF AERIAL 1080 POISONING ON THE BIRDS OF RANGITOTO ISLAND, HAURAKI GULF, NEW ZEALAND

Summary: Bird populations were monitored for one year (October 1990-October 1991) to determine whether the 1080 poison used to eradicate possums and wallabies on Rangitoto Island had had any detrimental effects on them. There was no significant decline in bird numbers recorded immediately after poisoning, with four species increasing in abundance (*P*<0.001). Twelve months after the operation the abundance of four species had increased significantly (*P*<0.001). The poisoning does not appear to have had any negative effect on the bird populations of Rangitoto, while the removal of browsing mammals may in future prove to have beneficial effects.

Keywords: 1080 poison; five minute bird counts; habitat improvement; monitoring; brushtail possum; *Trichosurus vulpecula;* rock wallaby; *Petrogale penicillata;* eradication.

Introduction

1080 poison (sodium monofluoroacetate) has been used to control mammals, especially brushtail possums *(Trichosurus vulpecula* Kerr), in New Zealand since 1956 (Batcheler, 1978). This poison has been known to kill non-target animals during control operations, including birds (Harrison, 1978; Spurr, 1979, 1991) and dogs (Rammell and Fleming, 1978), and it may also affect invertebrates (Notman, 1989). Some species may also be affected through secondary poisoning (Eastland and Beasom, 1986; Hegdal *et al.,* 1986; Koenig and Reynolds, 1987; Pierce and Maloney, 1989).

In November 1990, the Department of Conservation (DOC) commenced an eradication operation on Rangitoto Island against possums and rock wallabies *(Petrogale penicillata* Griffith), with an aerial drop of 1080 laced pellets (11.8 kg ha-t). Assessments from recent poisoning operations carried out elsewhere in New Zealand indicated that the operation would pose little risk to the bird populations on Rangitoto (Spurr, 1991). There are no endangered or threatened species currently on the island, nor any species that are in a high-risk category of non-recovery if they were to be reduced in numbers. Only one bird, the morepork *(Ninox novaeseelandiae* Gmelin), is in a medium-risk category (Spurr, 1979).

Despite this, it was considered appropriate to monitor the bird populations during the course of poisoning. Birds have traditionally been used as indicators of environmental condition and contamination because of their conspicuousness and because they occupy most trophic levels (Morrison, 1986). This latter feature means that perturbations in any pan of the environment will influence at least one bird species. Although there is a low diversity of bird species on Rangitoto (Segedin, 1985), those present represent most trophic levels and hence allow an evaluation of most of the likely side effects of poisoning.

When looking for environmental or human-induced changes, fluctuations in the population size over time are considered to be the most appropriate response to measure (Temple and Wiens, 1989). Several New Zealand studies show the annual and seasonal fluctuations in conspicuousness that one can expect to see in some New Zealand birds (e.g., Dawson *et al.,* 1978; Gill, 1980, 1989; Clout and Gaze, 1984). These can be applied to distinguish between changes due to seasonal factors or those which may be due to poisoning.

Methods

Study area

This study was carried out on Rangitoto Island, 8 km north-east of Auckland, in the Hauraki Gulf (Fig. 1).

Between sea-level and the summit (259 m asl) vegetation types range from coastal pohutukawa *(Meterosideros excelsa*[1]*)* forest through areas of open scoria with vegetation islands dominated by pohutukawa, to low summit scrub forest, consisting mainly of mapou *(Myrsine australis),* rewarewa *(Knightia excelsa),* manuka *(Leptospermum scoparium)* and kanuka *(Kunzea ericoides)*. A full list of the vegetation is given in Segedin (1985). Although no

[1] Botanical nomenclature follows Allan (1961), Moore and Edgar (1970), and Connor and Edgar (1987).

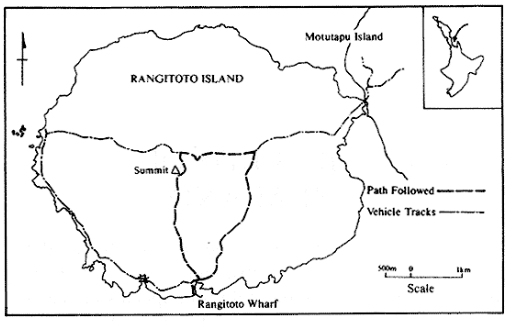

Figure 1: *Rangitoto Island. showing the path followed for bird counts.*

quantitative measurements were made of vegetation changes throughout the year, qualitative changes were observed and noted.

Bird counts

Bird populations were monitored at six-weekly intervals, for one year. Monitoring started in October 1990, just before 1080 poison was dropped on the island, and was completed in October 1991. A relative index of bird conspicuousness was obtained using five minute bird counts (after Dawson and Bull, 1975) and is expressed as the average number of individuals per five minute count. Bird counts were carried out along the walking track from Rangitoto Wharf to the summit of the island and then back along the vehicle track to the wharf. At 200 m intervals along the chosen route, all birds seen and heard within a 100 m radius of the observer were recorded.

To minimise bias, the same observer covered all sites for the entire year. Thirty counts were made between morning and afternoon, and a further ten counts were made in the two hours preceding dusk at each site. Because the timing of the poison operation was brought forward by one year and the survey was mounted at short notice it was only possible to monitor for one day (40 counts) before the poison was dropped, and this was in overcast conditions. Thereafter 80 counts were made over two days (40 counts day^{-1}) and in fine weather.

Searches for dead birds were made during daylight hours by two people searching together, for two days immediately after the poison drop. Two weeks later another search was made over three days, by one person. The areas covered were the coastal margins on the southern coast, forest and open areas for 50-75 m either side of the walking track and forested areas on the ash-cone summit.

It was not possible to establish a non-treatment area as the whole island was poisoned at once, and the unique ecological and physical characteristics of Rangitoto cannot be replicated anywhere else in New Zealand.

Analysis of bird counts

Six hundred counts from eight sample periods were made during this study. Data from each two-day count were averaged. Seabirds, and those not associated with the forest, such as the welcome swallow *(Hirundo tahitica* Gould), were not included in the analyses although their presence was noted. Counts for blackbird *(Turdus rnerula* Linnaeus) and song thrush *(T. philornelos* Hartert) were combined due to initial difficulty in distinguishing between their calls.

In the main analysis, counts for each species taken immediately before and after the poison drop were compared, to establish whether the poison had had an effect on numbers. Data from before the drop (October 1990) and from one year later (October 1991) were also compared to assess whether there had been any marked changes in species abundance that may have been attributable to changes in the habitat.

All data were subjected to a square-root transformation to stabilise variance as, in general, the numbers of birds counted per five minutes do not fall symmetrically around their means (Dawson and Bull, 1975). A Cochran's *t*-test (Sokal and Rohlf, 1981) for unbalanced sample sizes was used to examine for differences between the means. Because other factors such as weather variation cause changes in bird numbers, and because of Type I and II error associated with multiple tests, the confidence level was set at P<0.001 to avoid spuriously significant differences. Where the variances were unequal, significance was judged by non-overlap of standard errors. While this is conservative, it avoids the problem of Type I error (McArdle, 1987).

Results

No species showed any significant decreases in conspicuousness that could be attributed to 1080 poisoning, either for the comparison of pre-poison to one month post-poison, or for the comparison between October 1990 (pre-poison) and October 1991 (12 months after poison drop) (Table 1).

Silvereyes or tauhou *(Zosterops lateralis* Latham) and greenfinches *(Carduelis chloris* Linnaeus), both generalist feeders, and Australasian harrier hawks or kahu *(Circus approximans* Peale), carrion feeders and predators, all showed significant increases in conspicuousness both immediately after the poison drop

Table 1: *Numbers of birds per five minute count on Rangitoto Island. Counts were made at six weekly intervals.* * = *counts significantly different from pre-poison count (*P*<0.001.).*

	October 1990	November	January	February	April	June	August	October 1991
Silvereye	0.93 ± 0.20	2.33 ± 0.23*	1.71± 0.17	1.95 ± 0.23	2.41 ± 0.25	1.74 ± 0.28	1.99 ± 0.39	3.00 ± 0.35*
Greenfinch	0.05 ± 0.03	0.70 ± 0.14*	0.19± 0.06	0	0.08 ± 0.06	0.01 ± 0.01	0	0.56 ± 0.10*
Australasian harrier	0	0.04 ± 0.02*	0	0.01 ± 0.01	0.01 ± 0.01	0	0	0.05 ± 0.02*
Chaffinch	0.55 ± 0.17	1.44 ± 0.15*	0.75 ± 0.11	0.03 ± 0.03	0.23 ± 0.06	0.10± 0.03	0.18 ± 0.06	0.95 ± 0.12
Tui	0	0.01 ± 0.01	0.03 ± 0.02	0	0.03± 0.02	0	0.14 ± 0.04	0.31 ± 0.06*
Blackbinl/thrush	0.85± 0.24	1.09 ±0.15	0.23 ± 0.08	0.09 ±0.04	0.26 ±0.08	0.58 ±0.13	0.58 ± 0.12	0.76 ± 0.10
Grey warbler	1.80 ± 0.14	1.48 ± 0.08	0.65 ± 0.09	1.30 ± 0.12	1.20 ± 0.09	0.38 ± 0.07	1.51 ± -.10	1.45 ± 0.14
Goldfinch	0.32 ± 0.13	0.53 ± 0.12	0.28 ± 0.07	0.04 ± 0.02	0.75± 0.38	0.04 ± 0.02	0.01 ± 0.01	0.64 ± 0.17
Fantail	0.45 ± 0.13	0.48 ± 0.08	0.50 ± 0.1 0	0.63 ± 0.09	0.51 ± 0.11	0.85 ± 0.1 0	0.61 ± 0.09	0.61 ± 0.09
Hedge sparrow	0.15 ± 0.15	0.26 ± 0.14	0.16 ± 0.10	0.13 ± 0.08	0.28 ± 0.21	0.04 ± 0.03	0.13 ± 0.08	0.40 ± 0.25

and after one year from the initial count (*P*<0.001).

Chaffinches *(Fringilla coelebs* Kleinschmidt), which are granivorous feeders, also showed a significant increase immediately after the drop (*P*<0.001) but no significant increase after one year, whereas tui *(Prosthemadera novaeseelandiae* Gmelin), a feeder on nectar, fruit and insects, showed a significant increase after one year (*P*<0.001) but not immediately after the poison drop.

A number of non-significant fluctuations were also apparent. The blackbird/song thrush taxon, both terrestrial invertebrate feeders, grey warblers or riroriro *(Gerygone igata* Quoy and Gaimard), small aerial and foliage gleaning insectivores, and goldfinches *(Carduelis carduelis* Hartert), seed eaters, exhibited little change before and after but were seasonally variable. Fantails or piwakawaka *(Rhipidura fuliginosa* Sparrman), which are aerial insectivores, and hedgesparrows *(Prunella modularis* Hartert), which are also insectivorous, exhibited the least seasonal variation.

Casual observation indicated that the quality of vegetation had improved during the year following the poisoning, in contrast to the year prior to the poison drop. Extensive flowering of rewarewa was noted in September-October 1991 and pohutukawa were also observed to have more buds in spring 1991 than in previous years. Regenerating plants such as pohutukawa, poroporo *(Solanum aviculare)* and many species of orchid were noticeably more abundant than previously *(pers. obs.;* P. MacDonald, *pers. comm.).* Herbaceous plants along the tracks and roadsides were also seen to increase in abundance.

Discussion

A major concern with the use of 1080 poison is the potential impact on non-target species such as birds. It appears that the populations of bird species on Rangitoto Island were not detrimentally affected by the poison operation.

Several species on Rangitoto were thought to be at risk of poisoning because their feeding behaviour or diet may have brought them into contact with the baits. For example, it was considered possible that ground feeding birds, such as blackbirds, or granivorous species such as chaffinches or hedge sparrows could have been poisoned directly by eating the baits. This has been found to occur in earlier operations which used sliced carrot as the bait (Harrison, 1978; Spurr, 1991). The apparent absence of such deaths in this operation gives support to the efficacy of green-dyed pellet baits in minimising non-target deaths (Caithness and Williams, 1971; Spurr, 1991).

Australasian harriers were potentially at risk of secondary poisoning through feeding on possum and wallaby carcasses present after the poison drop (Pierce and Maloney, 1989). This did not appear to happen, despite a number of birds coming across from adjacent Motutapu Island to feed on the carcasses. The small population was still seen to be resident on Motutapu throughout the year following the poisoning (P. MacDonald, *pers. comm.).*

The apparent increases in some species may be attributable to improvement in the habitat, as a result of the major reduction in possums and wallabies. Both the tui and silvereye are mobile species that will seek out seasonal food sources (Bull, 1985, p. 288; Craig, Stewart and Douglas, 1981). Rewarewa flowered well on Rangitoto in September and October 1991, compared with the same time in 1990. Previously possums had severely inhibited the flowering of this tree, and most flowers were eaten or ripped off (Olds, 1987; A. Julian, *pers. comm.).* The vegetation as a whole showed a marked improvement in the 12 months following poisoning and it is likely that the increased flowering has resulted in the increase of these species.

The population trends observed for the other species are similar to the natural fluctuations recorded in other New Zealand studies. The peaks recorded for greenfinches, chaffinches and goldfinches correspond with periods of increasing vocal conspicuousness (Falla, Sibson and Turbott, 1970) and winter flocking (Bull, 1985, pp. 295-297; Gill, 1980). The significant increase in green finch numbers may be due to the increase in herbaceous weeds along the roadsides.

The insectivorous fantails and grey warblers showed no significant change either immediately after the poison drop or a year later. The slight rise in fantail numbers in August is likely to be due to winter flocking of independent juveniles, and the decline in October due to their subsequent natural mortality (McLean and Jenkins, 1980). The three peaks observed for the grey warbler correspond with those observed by Gill (1980) and are related to the changes in song intensity.

Although more observations prior to the poisoning operation would have been desirable we conclude that the poisoning operation on Rangitoto Island did not have a detrimental impact on local bird populations. We would predict that improved habitat quality, following the removal of mammalian browsers, will eventually benefit most species on the island (see e.g., Cowan, 1990; Innes and Hay, 1991). Therefore we hope that local groups, such as the New Zealand Ornithological Society, might be prepared to conduct regular seasonal counts on Rangitoto.

Acknowledgements

We wish to thank J. Craig, T. Miller, T. Lovegrove and two anonymous referees for comments which vastly improved earlier drafts. The Department of Conservation (Auckland Conservancy) allowed us to stay on Rangitoto Island. Phil MacDonald provided logistical support and advice on Rangitoto and Motutapu. Craig Miller's research was supported by a grant from the Pacific Development and Conservation Trust.

References

Allan, H.H. 1961. *Flora of New Zealand. Vol. I.* Government Printer, Wellington, New Zealand. 1085 pp.

Batcheler, C.L. 1978 (unpublished). *Compound 1080. its properties. effectiveness, dangers and use.* Report to Minister of Forests and Minister of Agriculture and Fisheries, New Zealand Forest Service and Ministry of Agriculture and Fisheries, Wellington, N.Z. 68 pp.

Bull, P.C. 1985. Silvereye; Chaffinch; Greenfinch; Goldfinch. *In: Readers Digest complete book of New Zealand birds*. Readers Digest Services Pty Ltd., Sydney, Australia. 319 pp.

Caithness, T.A.; Williams, G.R. 1971. Protecting birds from poisoned baits. *New Zealand Journal of Agriculture 122:* 38-43.

Clout, M.N.; Gaze, P.D. 1984. Effects of plantation forestry on birds in New Zealand. *Journal of Applied Ecology 21*: 795-815.

Connor, H.E.; Edgar, E. 1987. Name changes in the indigenous New Zealand flora, 1960-1986 and *nomina nova* IV, 1983-1986. *New Zealand Journal of Botany 25*: 115-170.

Cowan, P.E. 1990. Fruits, seeds, and flowers in the diet of brush tail possums, *Trichosurus vulpecula,* in lowland podocarp/mixed hardwood forest, Orongorongo Valley, New Zealand. *New Zealand Journal of Zoology 17*: 549-566.

Craig, J.L.; Stewart, A.M.; Douglas, M.E. 1981. The foraging of New Zealand honeyeaters. *New Zealand Journal of Zoology 8*: 87-91.

Dawson, D.G.; Bull, P.C. 1975. Counting birds in New Zealand forests. *Notornis 22*: 101-109.

Dawson, D.G.; Dilks, P.J.; Gaze, P.D.; McBurney, J.G.R.; Wilson, P.R. 1978. Seasonal differences in bird counts in forests near Reef ton, South Island, New Zealand. *Notornis 25*: 257-278.

Eastland, W.G.; Beasom, S.L. 1986. Potential secondary hazards of compound 1080 to three mammalian scavengers. *Wildlife Society Bulletin 14:* 232-233.

Falla, R.A.; Sibson, R.B; Turbott, E.G. 1970. *A field guide to the birds of New Zealand* (2nd ed.). Collins, London, United Kingdom. 247 pp.

Gill, B.J. 1980. Abundance, feeding, and morphology of passerine birds at Kowhai Bush, Kaikoura, New Zealand. *New Zealand Journal of Zoology 7*: 235-246.

Gill, B.J. 1989. Bird counts in regenerated urban forest at Auckland domain. *Notornis 36*: 81-87.

Harrison, M. 1978. 1080. *Wildlife - A review* 9: 48-53.

Hegdal, P.L.; Fagerstone, K.A.; Gatz, T.A.; Glahn, J.F; Matschke, G.H. 1986. Hazards to wildlife associated with 1080 baiting for California ground squirrels. *Wildlife Society Bulletin 14:* 11-21.

Innes, J.G.; Hay, J.R. 1991. The interactions of New Zealand forest birds with introduced fauna. *Acta* XX *Congressus Internationalis Ornithologici 20:* 2523- 2533.

Koenig, W.D.; Reynolds, M.D. 1987. Potential poisoning of yellow-billed magpies by compound 1080. *Wildlife Society Bulletin 15*: 274-276.

McArdle, B.H. 1987. The significance of differences between means. A simulation study. *Comparative Biochemistry and Physiology* 87: 979-982.

McLean, I.G.; Jenkins, P.F. 1980. Breeding and development of the New Zealand fantail *Rhipidura fuliginosa*. *Notornis 27*: 105-113.

Moore, L.B.; Edgar, E. 1970. *Flora of New Zealand, Vol. II*. Government Printer, Wellington, New Zealand. 354 pp.

Morrison, M.L. 1986. Bird populations as indicators of environmental change. *Current Ornithology 3*: 429-451.

Notman, P. 1989. A review of invertebrate poisoning by compound 1080. *New Zealand Entomologist 12*: 67-71.

Olds, C.B. 1987 (unpublished). *Aspects of the ecology of the brush-tail possum* (frichosurus vulpecula *Kerr) on Rangitoto Island*. M.Sc. thesis, University of Auckland, Auckland, N.Z.

Pierce, R.J.; Maloney, R.F. (1989). Responses of harriers in the MacKenzie Basin to the abundance of rabbits. *Notornis 36*: 1-12.

Rammell, E.G.; Fleming, P.A. 1978. *Compound 1080. Properties and use of sodium monofluoroacetate in New Zealand*. Animal Health Division, Ministry of Agriculture and Fisheries, Wellington, N.Z. 112 pp.

Segedin, A. 1985 (unpublished). *Rangitoto: biological assessment and natural history*. Report to Hauraki Gulf Maritime Park Board, Department of Lands and Survey, Auckland, N.Z. 28 pp.

Sokal, R.R.; Rohlf, F.J. 1981. *Biometry* (2nd ed.). W.H. Freeman and Co., San Francisco, U.S.A. 776 pp.

Spurr, E.B. 1979. A theoretical assessment of the ability of bird species to recover from an imposed reduction in numbers, with particular reference to 1080 poisoning. *New Zealand Journal of Ecology 2*: 46-63.

Spurr, E.B. 1991. Effects of brush tail possum control operations on non-target bird populations. *Acta XX Congressus Internationalis Ornithologici 20:* 2534-2545.

Temple, S.A.; Wiens, J.A. 1989. Bird populations and environmental changes: can birds be bio-indicators? *American Birds* 43: 260-270.