PARAKEET NESTING SUCCESS WITH AND WITHOUT PREDATOR CONTROL IN THE HURUNUI VALLEY, NORTH CANTERBURY

Marion Rhodes
Graeme Elliott
Josh Kemp

23 July 2008

INTRODUCTION

The orange fronted parakeet (*Cyanoramphus malherbi*) is one of New Zealand's rarest forest birds, with numbers on the mainland estimated to be less than 200 (van Hal and Duncan 2004). Apart from two recently established island populations they are known from only 3 inland Canterbury valleys, the South Branch of the Hurunui, the Hawdon and the Poulter, where intensive predator control is undertaken to protect them. The predator control regimes involve the poisoning and trapping of rats, stoats and possums but their effectiveness at protecting orange-fronted parakeets has yet to be tested: this test is the primary aim of this research.

Parakeet abundance is difficult to monitor using counting techniques (Elliott 1998), and counting can only be used to assess the effectiveness of predator control over long periods of time. In this study we monitor parakeet nesting success to give a quicker indication of the effect of predator control. Parakeets are particularly vulnerable to predators while nesting because they nest in holes in tree trunks. This habit prevents them seeing and escaping from approaching predators (O'Donnell 1996). Parakeet nesting success is high only when predator numbers are low either because they were naturally low or because predator control was been effective.

Because of the scarcity of orange-fronted parakeets, any nests found are protected with aluminium around the nest tree trunk (to prevent predators climbing) and extra traps around the tree to further reduce the risk of predation. The success rates of these protected orange-fronted parakeet nests give no indication of the success of unprotected nests. We therefore monitor the nesting success of yellow-crowned parakeets (*Cyanoramphus auriceps*) as a surrogate. Yellow-crowned parakeets are more abundant in the study area and their nesting habits are similar to those of orange-fronted parakeets (Kearvell, 2002). It is not clear why yellow-crowned parakeets are more abundant than orange-fronted parakeets but it is probably due to their higher productivity rather than differences in their nesting sites.

In beech forests the effect of predators on parakeets varies with the stage in the beech mast cycle. Rats reach peak densities 6-8 months after the beech seed falls in March, and they usually decline to low levels within another 6 months. Stoats reach peak densities in the summer following a beech seedfall and their abundance declines over the following two years. Although parakeets suffer high rates of predation when stoats are abundant this is offset by their prolific breeding during the beech seedfall (Elliott *et al.* 1996a). Elliott *et al.* (1996a) concluded that predation when stoats were not at peak densities might have just as great an effect on parakeets as predation at peak stoat densities. Because of this variation in

predator abundance the effectiveness of predator control in beech forests has to be assessed at every stage in the beech mast cycle.

This report covers 3 seasons of yellow-crowned parakeet nest monitoring in the Hurunui:

January – April 2006 in the South Branch
A beech (*Nothofagus* spp.) flowering in the November 2005 had yet to cause increases in the abundance of rats and stoats, and stoat and rat trapping and poisoning was keeping their numbers low.

September 2006 – January 2007 in the South Branch
Rat and stoat numbers were rising during this period due to the beech seeding but were controlled in the South Branch by ongoing ground-based poisoning and trapping and an aerial 1080 drop in October. Outside the predator controlled area rat numbers rose to moderate levels, and stoats to high levels.

November 2007 – April 2008 in both North and South branches.
Stoat numbers were low in the South Branch because of the trapping and poisoning, while in the North Branch, stoats had risen to high densities during the summer of 2006/07 and had remained high thereafter. Rat numbers in both valleys had declined to low or undetectable levels following high abundance in the summer of 2006-07.

The nest monitoring aimed to answer three questions

1. Was predator control effective during and after a beech mast in the South Branch of the Hurunui.

2. Was stoat control necessary in the summer following peak stoat abundance caused by a beech mast when stoat numbers are still elevated.

3. Were any parakeets poisoned during the 1080 drop in October 2006.

METHODS

Study areas

The South and North Branches of the Hurunui are steep-sided glaciated valleys east of the main divide and about 100km north-west of Christchurch. Both valleys are clothed with mosaics of forests dominated by red beech (*Nothofagus fusca*) on the valley floors and lower slopes and silver (*N. menziesii*) and mountain beech (*N. solandri* var. *cliffortiodes*) elsewhere. The lower reaches of both valleys are at about 700m above sea level. The North Branch is closer to the main divide than the South Branch and this results in higher rainfall and some minor vegetation differences.

Bird species assemblages are similar in the two valleys, although mohua (*Mohoua ocrocephala*) have not been recorded in the North Branch since 2002, and orange fronted parakeet sightings are rare.

Stoats and possums have been trapped and poisoned in the South Branch since 1995 and rats since 2003, but no predator control has been undertaken in the North Branch.

Finding and monitoring parakeet nests

We found nests by watching adult parakeets for "suspicious behaviour" – birds entering or exiting holes, soft chattering below the canopy or near holes, and males feeding females. When a suspect nest was located, the tree was climbed using rope and ascenders to see if eggs or chicks were present. The monitoring period was from the first check where the cavity was confirmed to be in use for nesting purposes (i.e. tree climbed and eggs or chicks seen), until the nest failed or the brood reached an estimated age of 32 days. Brood age was estimated once nestlings had hatched, using a set of reference photos of captive parakeet chicks of known age. Where a brood had a large age disparity (for example an apparent age difference of 8 to 10 days between the oldest and youngest chick in a large brood was not uncommon) the 32-day cut-off point was when the midrange of the brood reached 32 days (for example an estimated brood age of 28-36 days). After a nest was confirmed to be in use by climbing, it was sometimes checked by observation from the ground and if no activity was observed during a ground check, the tree was subsequently climbed. Nests were checked at least fortnightly, until they fledged or failed, with a check just before the 32-day cut-off. We climbed all the nests again as soon as possible after their expected fledge date to check for any obvious predation events outside of the monitoring period, and to measure and record a description of the nest.

We did not include data from nests more than 32 days after hatching in our analysis. This is because it is difficult to interpret the fate of mature broods. We could be confident that nests found empty before 32 days had failed, but after 32 days nests found empty could either have fledged or failed, since predators do not always leave sign (Brown et al, 1998), and recently fledged chicks often leave the vicinity of the nest (Elliott *et al.* 1996a).

When a nest was confirmed active a fur snag was placed around the trunk of the nest tree and any adjacent trees that might provide easy alternative access to the nest cavity. The fur snag consisted of 100mm galvanised nails placed at intervals around the trunk, with string or rubber bands encircling the tree attached to the heads of the nails. The string and nails were then painted with a thin coat of a rat and mice trapping glue (Trapper®, made by Bell Laboratories). We recoated the glue as necessary to maintain stickiness. These "sticky bands" were checked for predator hairs at every nest check. Any hairs found were collected for identification. Possum fur is easily recognised by its frizzy, wool-like appearance; other hairs were sent for DNA testing at the Landcare Research lab in East Tamaki. Sticky bands were removed at each nest's final nest check of the season.

Monitoring periods

Nests were monitored in what was probably the second half of the breeding season in early 2006. There had been a beech mast in the autumn of 2005 and parakeets had probably been breeding through the winter and spring of 2005 as well between January and April of 2006. There was another beech mast in autumn 2006 and birds nested in the winter and spring of 2006 and we monitored nests from mid August 2006 until the end of the year, after which nesting all but stopped. In our most recent season (Nov 2007 – March 2008) we looked for nests in late November and through December, with very little success – the few we found were either close to fledging, or at the pre-lay stage and didn't become active until January 2008. The nesting period monitored was therefore over the first 3 months of 2008.

Estimating nest survival

We estimated nest survival using the methods of Dinsmore *et.al.* (2002) implemented in program Mark (White & Burnham, 1999). This method removes bias caused by the fact that failed nests are invariably under-represented in nest survival studies because many nests fail before they are found. It estimates daily nest survival (essentially the number of failure events divided by the number of days over which nests were monitored) and nest survival rates are then estimated as the daily nest survival raised to the power of the number of days from laying to fledging, which is about 60.

When estimating nest survival we did not differentiate between nests that failed due to predation and nests that failed for other reasons. Often when there is no sign of predation at a failed nest we assume it has simply been abandoned by the parents for some reason, however it is possible that one or both of the parents have been caught by predators while away from the nest.

Initially we simply estimated nesting success at the five combinations of site and season for which we had data, but we also examined the possible effect of two covariates on nesting success:

1. Stage in season(Number of days since the start of the nesting season).
   During beech mast years seed runs out during the season and this might affect nesting success.

2. Nest age (Number of days since first egg was laid).
   As nests age they become smellier and nestlings become noisier, possibly increasing the likelihood of predation.

We compared models with and without combinations of the above covariates and used corrected AIC values (Burnham & Anderson, 2002) to choose the model best supported by the data.

We compared nest survival estimates from this study with those from the Eglinton Valley in the early 1990s, when there were very few rats and stoats in the forest and estimated nesting success was 71%. Survival estimates similar to, or greater than those in the Eglinton we regard as being "good" and estimates lower than in the Eglinton indicating that the predator control was probably unsuccessful.

Mortality during the 1080 drop

Any parakeet nests found before the 1080 was dropped in the South Branch of the Hurunui in October 2006 were checked immediately before the 1080 was dropped and 2 or three times in the 2 weeks following the drop. We assumed that both adults were still alive at nests that were still being incubated or still had live chicks two weeks after the 1080 drop. We spent extra time watching any nests that failed during the period of the 1080 drop in an attempt to determine whether any of the adults were still alive. The contents of any nests that failed were assayed for 1080.

Predator monitoring and control

The predator control carried out in the South Branch of the Hurunui during the 3 seasons we monitored parakeets is shown in Table 1. The main difference between the first and second seasons was the advent of the 1080 drop early in the second season. The 07/08 season had reduced predator control as there had been no beech mast and predator numbers were expected to be low.

The 2006 aerial 1080 drop in the South Branch of the Hurunui comprised a 2kg per ha drop of non toxic, 6g, pre-feed baits lured with cinnamon which was undertaken on 14 September 2006, followed by a 5kg per ha drop of 6g baits containing 0.15% 1080, lured with cinnamon.

Table 1. Predator control in South Branch Hurunui during parakeet monitoring periods.

	Trapping	Poisoning
Jan-Mar 2006	27km of stoat trap lines along the valley floor bush edge with alternating double and single set Fenn traps at 50m intervals baited with pricked eggs. A 50 × 150m grid of rat traps covering about 470 ha in the central part of the valley.	55km of rodent bait stations (yellow subs) containing brodifacoum. 50m intervals between stations with stations placed midway between stoat and rat traps.
Aug 2006 - Jan 2007	As above, but all traps baited with chocolate buttons and pricked eggs.	As above, with 1080 aerially sown over 2515ha in early October.
Nov 2007 - April 2008	27km stoat trap line and 12.8km rat trap lines run (upper lines only, 300m from the stoat line). All traps baited with pricked eggs only; traps checked monthly.	55km rodent bait stations containing brodifacoum. Poison removed from stations in January

The North Branch of the Hurunui has had neither rat nor stoat control but has had occasional localised possum control. Possum control was last undertaken at the end of 2006 when Feratox (cyanide) capsules were placed in bait stations at 100m spacing along the bush edge on both sides of the valley.

Predator monitoring is usually carried out quarterly, with tracking tunnels run in February, May, August and September. Fifteen lines of 10 tunnels in both the North and South Branch are baited overnight with peanut butter to track rodents, and then alternate tunnels on ten of these lines in each valley are baited for 3 nights with rabbit meat to track mustelids. However since the start of 2008, mustelid monitoring is run in January, February, August and November, to coincide more closely with the expected population peaks, and the number of rat monitoring lines in the South Branch treatment area has increased to twenty. From August 2006 to March 2007 rat surveys were carried out monthly in the South Branch.

RESULTS

Nesting success

Nesting successes and the causes of nest failure are summarised in Table 2 and detailed in Appendices 1-4.

Table 2. Nesting success and the causes of nest failure in the North (NB) and South Branches (SB) of the Hurunui between 2006 and 2008. Apparent nesting success is the number of nests successful divided by the number of nests observed and is a biased estimate of actual nesting success. Estimated nesting success is an unbiased estimate of nesting success calculated using the methods of Dinsmore *et.al.* (2002). *2006.5 refers to nests in the second half of 2006.

When	Where	Nests	Days observed	Estimated success	Apparent success	Failed unknown (%)	failed natural (%)	unknown predator (%)	stoat (%)	rat (%)	possum (%)
2006	SB	18	619	0.90	0.94						1 (6)
2006.5*	SB	29	806	0.70	0.83	1 (3.4)	2 (7)	1 (3)	1 (3)		
2008	SB	22	954	0.76	0.68		1 (5)	2 (9)	2 (9)	1 (5)	1 (5)
2008	NB	10	234	0.18	0.40		2 (20)	1 (10)	3 (30)		1 (10)

Of the fourteen nests that we know were depredated over the three seasons, the predator was able to be identified from fur on the sticky bands on eight occasions. Of the remaining six predation events possum DNA was identified from swabs taken from the freshly dead carcasses at one nest; both possum and stoat fur were found on the sticky bands at another nest found empty at least 12 days before it should have fledged; three nests were found empty before they should have fledged but no predation sign was found, and we found a headless female parakeet and broken eggshells but were not able to identify the predator at one nest. In 62 percent of cases where sticky bands were in use, they helped us identify the predator.

We also collected hair off the fur snags of a number of nests that were still in use; some of these were subsequently eaten, others were successful. Appendix 5 shows all nests where hairs were collected during the 2008 season (this information is not available from the previous seasons). It is interesting to note that the two nests that were still going after stoat hair was collected from the sticky bands (S313 and N113) were subsequently eaten by stoats.

Also of interest is the difference in synchronicity between the North and South Hurunui last season. In the South Branch nesting activity was highly synchronous; all except one of the twenty-five nests found there this season had their first egg laid during a nineteen day window, between 14 Jan and 2 Feb (Appendix 3). In contrast, only six of the fourteen nests found in the North Branch were laid during a twelve day period, from 3 to 15 January, with the remaining eight nests were laid between late September 2007 and mid Feb 2008 (Appendix 4).

Figure 1 shows the nesting success rates recorded in this study and compares them with those recorded in the Eglinton in the 1990s. The best model of nesting success (Table 3) grouped the nesting successes from the South Branch of the Hurunui with those from the Eglinton.

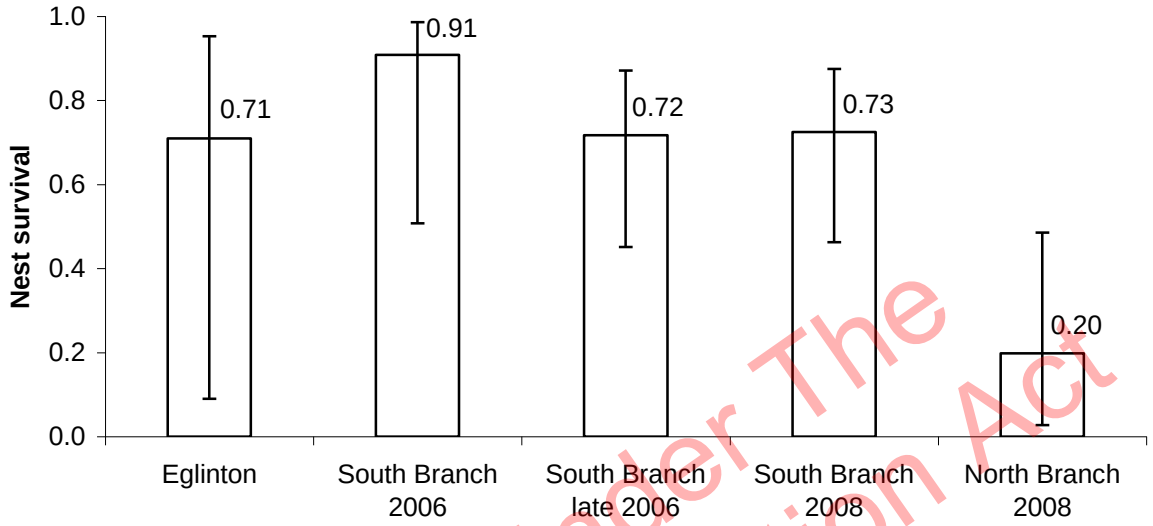

Figure 1. Nesting success of yellow-crowned parakeets in the North and South Branches of the Hurunui Valley between 2006 and 2008 and in the Eglinton in the 1990s. Error bars are 95% confidence intervals.

Table 3. Corrected AIC values for 4 different models of parakeet nesting success.

Model	AICc	Number of parameters	Deviance
Eglinton and South Branch the same - North Branch different	122.36	2	118.35
All places and seasons different	126.41	5	116.40
All places and seasons the same	130.01	1	128.01
South Branch and North Branch the same – Eglinton different	132.001	2	127.997

Mortality during the 1080 drop

Fifteen parakeet nests were monitored during the 1080 operation, and all but one continued successfully after the poison drop on 6 October 2007. Dead chicks from the failed nest were found to have traces of 1080 in their tissues and the female was not seen after the nest failed, though the male was. This suggests a mortality rate of parakeets of 3.3% with 95% confidence intervals from 0.1-17%.

At about the same time seven yellow-crowned parakeets nests were monitored during a similar 1080 drop in the Dart Valley in west Otago. The Dart operation differed only in that 3kg per ha of pre-feed and 3kg per ha of toxic bait was applied. Two yellow-crowned

parakeets were found dead with 1080 in their tissues just after the 1080 drop in the Dart Valley, but all monitored nests were successful. The combined estimate of mortality of nesting parakeets from both 1080 drops was 2.27% (95% confidence interval 0.1 - 12%).

Predator Numbers

Figures 2 and 3 show predator indices in the North and South Branch during the 3 seasons nests were monitored. Numbers of both rats and stoats were low throughout in the South Branch. In the North Branch no rats were tracked during the season that we monitored nests, but stoats were tracked at 100%.

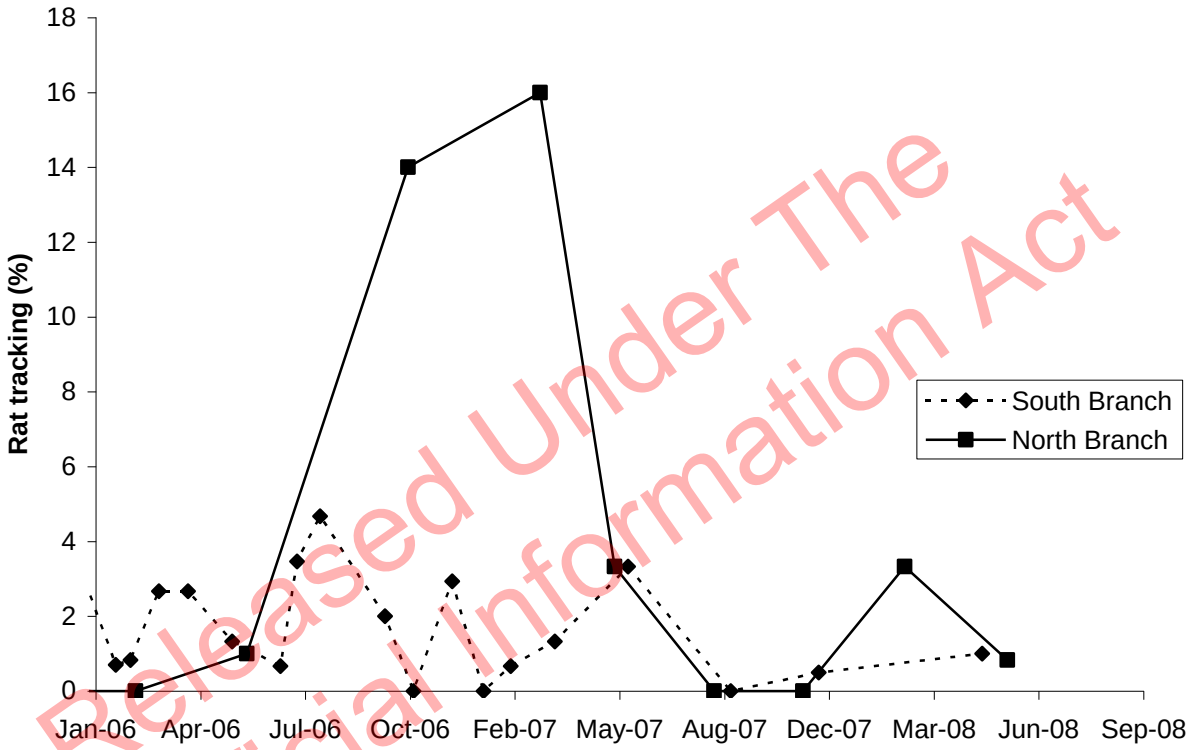

Figure 2. Rat tracking rates in the North and South Branches of the Hurunui.

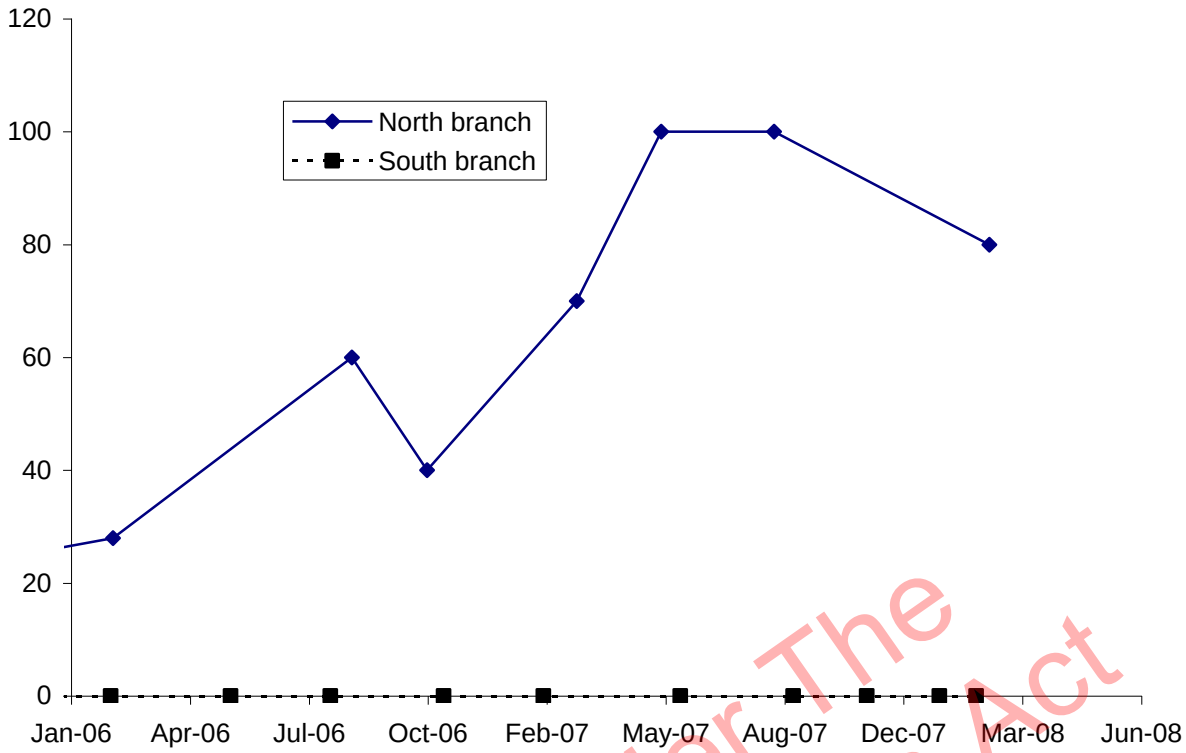

Figure 3. Stoat tracking rates in the North and South Branches of the Hurunui.

Effects of stage in season and age

The best model of nesting success included terms for both stage in season and age, and both had a negative effect on nesting success, i.e., nests late in the season were less successful than nests early in the season, and old nests (nests with near fledging chicks) were less successful than nests with eggs or small chicks.

DISCUSSION

The best model of parakeet nesting success suggests that we might reasonably regard the nesting successes that we observed in the five combinations of site and season as falling into two groups; "high" and "low". Since two of the high nesting successes occurred when rat and stoat numbers were very low, it is also reasonable to assume that "high" nesting success is sufficient to support a healthy parakeet population.

Nesting success was high in the Eglinton and the South Branch of the Hurunui in early 2006 when stoat and rat numbers were naturally low and when there was rat poison in bait stations in the South Branch. This implies either that the rat and stoat control was successful or that it was unnecessary.

Nesting success was also high in the South Branch in late 2006 when rat and stoat numbers were high in untreated areas but low in the South Branch. This suggests that the predator control (traps for stoats, poison in bait stations in combination with aerial 1080 for rats and stoats) was necessary and reduced stoat and rat densities to acceptable levels. Nesting success in the South Branch was also high in 2008 while it was very low in the North Branch. Stoat

numbers were very high in the North Branch in 2008 and would presumably have been similarly high in the South Branch if it had not been for the predator control. This suggests that the stoat control was necessary in the South Branch in 2008 and that it reduced stoat density to an acceptable level. This control was achieved using traps as well as poison (laid primarily for rats but which also kills stoats through secondary poisoning).

Although nesting success rates in predator controlled areas appear acceptable, the predator control was not perfect. Stoat, rat and possum predation was detected at nests in every season, even in those when nesting success was high (Table 2). For critically endangered species, such as the orange-fronted parakeet, such predation is undesirable, but this study provides no guide as to whether any increase in predator control effort would be cost-effective.

Some parakeets are killed by aerial 1080 poison of the type used in the Dart and Hurunui Valleys, but given the rate of nest predation observed when no predator control was carried out in the North Branch of the Hurunui, the net effect of a predator control regime that includes aerial 1080 is undoubtedly positive.

ACKNOWLEDGEMENTS

Thanks to Robyn Blyth, Jason van de Wetering, Maddie Charlton, Joris Tinnemans, and Kirsty Moran who helped with the nest monitoring, and staff from the Waimakariri Area office who undertook the predator control and monitoring and shared their huts and good times.

REFERENCES

Brown, K., Moller, H., Innes, J. & Jansen, P. 1998. Identifying predators at nests of small birds in a New Zealand forest. Ibis 140:274-279.

Burnham, K.P.; Anderson, D.R. 2002. Model selection and multimodel inference: a practical information-theoretic approach. Springer Verlag, New York.

Dinsmore, S.J.; Knopf, F.; White, G.C. 2002. Advanced techniques for modeling avian nest survival. Ecology 83:3 476-3488.

Elliott, G. 1998. Monitoring yellow-crowned parakeets. Science for Conservation: 75. Department of Conservation, Wellington.

Elliott, G., Dilks, P. & O'Donnell, C. 1996a. The ecology of yellow-crowned parakeets (*Cyanoramphus auriceps*) in *Nothofagus* forest in Fiordland, New Zealand. New Zealand Journal of Zoology 23: 249-265.

Elliott, G., Dilks, P. & O'Donnell, C. 1996b. Nest site selection by mohua and yellow-crowned parakeets in beech forest in Fiordland, New Zealand. New Zealand Journal of Zoology 23: 267-278.

Kearvell, J. 2002. Nest sites of sympatric orange-fronted (*Cyanoramphus malherbi*) and yellow-crowned parakeets (*C. auriceps*). Notornis *49*: 261-263.

O'Donnell, C.F.J. 1996. Predators and the decline of New Zealand forest birds: an introduction to the hole-nesting bird and predator programme. New Zealand Journal of Zoology 23: 213-219.

van Hal, J. and Duncan, P. 2004. Orange-fronted Parakeet (*Cyanoramphus malherbi*) Field Report 2003-2004. Internal report for the Department of Conservation CHCCO-65159.

White, G.C.; Burnham, K.P. 1999. Program MARK: survival estimation from populations of marked animals. Bird Study 46 Supplement:120-138.

APPENDIX 1: Nests found in South Branch Hurunui Jan-Feb 2006

Nest I.D.	Date found	Stage found	Lay date 1st egg (approx)	Outcome	# days exposure
58	05/01/06	Prelay	10/01/06	Assume success	58
101	06/01/06	Eggs	03/01/06	Assume success	43
102	07/01/06	Eggs	05/01/06	Assume success	41
103	07/01/06	Prelay	16/01/06	Assume success	32
104	07/01/06	Eggs	02/01/06	Assume success	40
64	09/01/06	Prelay	16/01/06	Assume success	25
105	09/01/06	Eggs	01/01/06	Assume success	45
106	10/01/06	Prelay	19/01/06	Assume success	48
107	11/01/06	Prelay	?	Unknown, too deep to see	0
108	22/01/06	Eggs	Pre14/01/06	Eaten, possum	36
110	02/02/06	Eggs	11/01/06	Assume success	36
111	02/02/06	Prelay	07/02/06	Unknown (last visit 26days)	48
113	16/02/06	10 day chicks	17/01/06	Assume success	20
114	16/02/06	Prelay	03/03/06	Unknown (last visit eggs)	19
115	16/02/06	Prelay	21/02/06	Unknown (last visit12days)	32
116	17/02/06	Prelay	21/02/06	Unknown (last visit12days)	32
117	18/02/06	Eggs	12/02/06	Unknown (last visit19days)	37
119	21/02/06	Prelay	21/01/06	Assume success	0
120	21/02/06	16 day chicks	14/01/06	Assume success	12
121	21/02/06	Eggs	15/02/06	Unknown, too deep to see	0
122	23/02/06	16 day chicks	18/01/06	Assume success	15
123	23/02/06	26 day chicks	08/01/06	Assume success	0

APPENDIX 2: Nests found in South Branch Hurunui Aug 2006-Jan 2007 (2006.5)

Nest I.D.	Date found	Stage found	Laydate 1st egg (approx)	Outcome	# days exposure
201	18/08/06	Eggs	16/08/06	Assume success	48
202	19/08/06	Prelay	29/08/06	Assume success	30
203	24/08/06	12 day chicks	20/07/06	Assume success	25
204	24/08/06	18 day chicks	14/07/06	Assume success	0
123.2	07/09/06	25 day chicks	19/07/06	Assume success	7
205	07/09/06	20 day chicks	25/07/06	Assume success	11
36a	08/09/06	Eggs	30/08/06	Success	32
216	08/09/06	14 day chicks	01/08/06	Assume success	9
206	09/09/06	Eggs	03/09/06	Eaten,unidentified predator	42
207	10/09/06	Eggs	31/08/06	Assume success	29
208	17/09/06	Laying	17/08/06	Assume success	47
209	20/09/06	Laying	19/09/06	Assume success	36
210	20/09/06	Chicks	15/08/06	Assume success	16
211	13/09/06	Prelay	29/09/06	Assume success	48
212	20/09/06	Eggs	12/09/06	Success	41
213	21/09/06	Eggs	05/09/06	Failed, non-predation	5
217	23/09/06	unknown	?	Survived 1080	0
218	12/09/06	Laying	11/09/06	Assume success	48
117.2	20/09/06	Prelay	?	Uncertain	0
49.2	25/09/06	Eggs	11/09/06	Assume success	33
215	02/10/06	Eggs	18/09/06	Assume success	41
220	07/10/06	13 day chicks	15/09/06	Assume success	0
58.3	11/10/06	Eggs	07/10/06	Failed, non-predation	37
221	11/10/06	Prelay	16/10/06	Assume success	36
222	31/10/06	Eggs	08/11/06	Assume success	19
223	31/10/06	Eggs	26/10/06	Failed, non-predation	10
224	03/11/06	Laying	01/11/06	Assume success	36
226	05/11/06	Prelay	08/11/06	Assume success	15
227	11/11/06	Eggs	08/11/06	Assume success	27
228	23/11/06	2 day chicks	27/10/06	Assume success	17
229	27/11/06	Eggs	22/11/06	Assume success	29
230	21/11/06	Eggs	01/11/06	Assume success	0
233	05/01/07	Eggs	16/12/06	Failed,cause unknown	25
234	08/01/07	14 day chicks	03/12/06	Eaten, stoat?	7

APPENDIX 3: Nests found in South Branch Hurunui Dec 2007 – Feb 2008

Nest I.D.	Date found	Stage found	Lay date 1st egg (approx)	Outcome	# days exposure
S301	09/12/07	10 day chicks	04/11/07	Failed, non-predation	0
S302	19/12/07	Prelay	17/01/08	Assume success	57
S58	19/12/07	Prelay	14/01/08	Assume success	58
S303	05/01/08	Prelay	21/01/08	Assume success	60
S301.2	09/01/08	Prelay	21/01/08	Eaten, unidentified predator	0
S305	10/01/08	Prelay	29/01/08	Failed, non-predation	0
S307	20/01/08	Laying	18/01/08	Eaten, stoat (post-obs)	56
S308	20/01/08	Laying	17/01/08	Assume success	53
S309	20/01/08	Laying	19/01/08	Eaten, ship rat	11
S310	21/01/08	Laying	20/01/08	Assume success	65
S311	21/01/08	Prelay	02/02/08	Assume success	57
S312	21/01/08	Laying	17/01/08	Success	56
S313	23/01/08	Laying	22/01/08	Eaten, stoat (post-obs)	57
S314	23/01/08	Laying	17/01/08	Assume success	54
S315	24/01/08	Laying	19/01/08	Assume success	54
S316	30/01/08	Incubating	23/01/08	Eaten, unidentified predator	38
S317	31/01/08	Laying	29/01/08	Failed, non-predation	26
S318	01/02/08	Laying	30/01/08	Assume success	54
S105	05/02/08	Incubating	17/01/08	Eaten, possum	27
S319	05/02/08	Incubating	25/01/08	Outcome unknown	42
S320	19/02/08	4 day chicks	20/01/08	Outcome unknown	23
S321	19/02/08	3 day chicks	21/01/08	Assume success	27
S322	19/02/08	1 day chicks	23/01/08	Assume success	28
S324	20/02/08	1 day chicks	22/01/08	Assume success	35
S325	29/02/08	10 day chicks	26/01/08	Failed, don't know why	16

APPENDIX 4: Nests found in the North branch of the Hurunui Nov 07-Feb 08

Nest I.D.	Date found	Stage found	Lay date 1st egg (approx)	Outcome	# days exposure
N101	25/11/07	35 day chicks	29/09/07	Assume success	0
N102	28/11/07	40 day chicks	27/09/07	Assume success	0
N103	18/01/08	36 day chicks	20/10/07	Assume success	0
N104	19/01/08	13 day chicks	14/12/07	Assume success	17
N105	20/01/08	Incubating	?	Failed, non-predation	6
N106	21/01/08	Incubating	10/01/08	Assume success	45
N107	24/01/08	Incubating	06/01/08	Eaten, stoat	30
N108	01/02/08	Laying	28/01/08	Assume success	48
N109	03/02/08	1 day chicks	08/01/08	Assume success	32
N110	02/02/08	Prelay	13/02/08	Failed, non-predation	0
N111	07/02/08	1 day chicks	15/01/08	Eaten, possum or stoat	19
N112	15/02/08	Laying	13/02/08	Eaten, unidentified predator	26
N113	19/02/08	18 day chicks	11/01/08	Eaten, stoat	7
N114	21/02/08	25 day chicks	03/01/08	Eaten, stoat	4

APPENDIX 5: Predator hairs collected from nest trees 2008, and final nest outcome.

Nest I.D.	Final check date	Nest contents at final check	Hairs found on stickies	Comments.
S307	01/04/08	Broken eggshells and lots of feathers	Stoat hair 01/04/08	Eaten (post cutoff)
S309	17/02/08	Feathers and broken eggshells	Ship rat 17/02/08	Eaten
S313	31/03/08	Lots of feathers and possible carcass	Possum fur 01/02/08; Stoat hair 03/03/08; Stoat hair 31/03/08	Nest still going 03/03/08. Eaten 31/03/08 (post cutoff)
S314	31/03/08	Nest empty	Possum fur 01/02/08	Success assumed
S317	04/03/08	2 intact eggs & 3 intact chicks of varying age and state of decay	Possum fur 14/02/08	Still going when possum fur found. Assumed abandoned 04/03/08.
S319	01/04/08	Nest empty	Stoat hair 01/04/08	Success at 32d. Final fate uncertain (last check after expected fledge date)
S320	01/04/08	Could not climb. No activity at nest in 80min	Stoat hair 01/04/08	Success at 32d. Final fate unknown. Should have fledged by 01/04/08.
S324	02/04/08	Nest empty	Possum fur 02/04/08	Hole deemed "not possumable" (too deep). Assume success
S325	26/03/08	A few feathers	Unidentified hair 26/03/08. No DNA retrieved at testing	Success at 32 days. Final fate uncertain. Chicks should have been 36-40d on 26/03/08.
N104	17/02/08	Nest empty	Stoat fur & parakeet feathers 17/02/08	2 of 3 chicks seen on the ground on 07/02/08, one heard still on nest. The two on the ground looked about 34 days – very early fledge.
N107	29/02/08	Adult parakeet body and head, dead chicks	Stoat hair 29/02/08	Eaten
N108	19/03/08	1 chick c.30 days and 7 eggs	Possum fur 15/02/08	Success to cutoff (19/03/08); not monitored past this date.
N110	19/02/08	4 cold eggs	Possum fur 19/02/08	Abandoned
N111	02/03/08	Nest empty	Possum fur and stoat hair 02/03/08	Eaten; chicks should have been 23days at this check
N113	29/02/08	Nest empty	Stoat hair 21/02/08; stoat hair 29/02/08	Nest still going 21/02/08. Eaten 29/02/08; chicks should have been 28 days at this check. Stoat seen by cavity 29/02/08
N114	28/02/08	Nest empty	Stoat hair 28/02/08	Eaten; chicks should have been 31-33 days at this check.