Changes in density estimates and encounter rates for forest birds following a predator control operation in the lower Hollyford Valley, Fiordland

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Summary

Forest birds were monitored in the lower part of the Hollyford Valley, Fiordland to determine their response to predator control. The control programme used an aerial application of 1080, and resulted in a reduction of possums (*Trichosurus vulpecula*), rats (*Rattus rattus*), stoats (*Mustela erminea*) and mice (*Mus musculus*).

Line-transect based distance sampling was used to estimate population densities and density trends for bellbird (*Anthornis melanura*), kereru (*Hemiphaga novaeseelandiae*), South Island rifleman (*Acanthisitta chloris chloris*), South Island tomtit (*Petroica macrocephala macrocephala*) and tui (*Prosthemadera novaeseelandiae*). Encounter rate data was collected for all forest bird species seen or heard from transects to reveal gross changes in population size and composition. Initial monitoring occurred in September 2014, prior to the aerial predator control operation; the survey was repeated one year later.

A comparison of pre- and post-operational density estimates for bellbird, kereru, rifleman, tomtit and tui shows that these populations were not negatively affected by the aerial 1080 operation. Density estimates for bellbird, rifleman and tomtit increased following the 1080 operation and a season of low predator numbers. Encounter rate data also showed increased detections for brown creeper (*Mohoua novaeseelandiae*), fantail (*Rhipidura fuliginosa*) and yellow-crowned parakeet (*Cyanoramphus auriceps*). Kereru and tui density estimates did not change. Brown-creeper, yellow-crowned parakeet and rifleman became more widely distributed throughout the study site following the 1080 operation.

Introduction

The lower part of the Hollyford Valley/Whakatipu Kā Tuka, consists of a series of unique ecosystems, ranging from dune systems, wetlands to podocarp forests. The flora and fauna in the valley is threatened by introduced species such as possums (*Trichosurus vulpecula*), rats (*Rattus rattus*) and stoats (*Mustela erminea*) through predation and competition. To protect this unique area, a predator control operation was carried out in November 2014, using an aerial application of 1080.

To determine the response of forest birds to the predator control programme in the lower Hollyford and the effectiveness of the chosen management tools, a forest bird monitoring programme was initiated. To report on the response of a wide range of forest bird species, bird counts were conducted using two methods: (1) line-transect based distance sampling (Buckland et al. 2001; Buckland 2006) to estimate population densities and monitor density trends of six key forest bird species; bellbird (*Anthornis melanura*), South Island kaka

(*Nestor meridionalis meridionalis*), kereru (*Hemiphaga novaeseelandiae*), South Island rifleman (*Acanthisitta chloris chloris*), South Island tomtit (*Petroica macrocephala macrocephala*) and tui (*Prosthemadera novaeseelandiae*), and (2) encounter rates (mean number of detections per km) to monitor gross changes in population size and composition for all forest bird species.

Baseline bird counts were conducted in September 2014, prior to the application of the aerial 1080. Counts were repeated in September 2015. We report on changes in bird density trends and encounter rates following the aerial 1080 operation in the lower Hollyford Valley.

Methods

Study species

Bellbird, kaka, kereru, rifleman, tomtit and tui were monitored in detail because these species represent several important guilds for the healthy functioning of forest ecosystems and are vulnerable to predation by possums, rats and stoats. Some of the selected species such as rifleman and tomtit have high fecundity and are therefore likely to show a rapid response to predator control while others including kaka and kereru are expected to respond to management over a longer period of time once habitat improves. Other forest bird species were also monitored, although less intensively, to reveal gross changes in population size and composition resulting from management.

Study site

The study site (1,700 ha) ranges from the upper slopes of Mt Webb (840 m above sea level) to the mouth of the Hollyford River at Martins Bay (Fig. 1). The study site lies within the larger lower Hollyford predator control area (19,617 ha) which encompasses the lower half of the Hollyford Valley from the Pyke Junction to the Coast, between the Kaipo River and Big Bay. Aerially distributed 1080 was applied to the management area on November 5, 2014. Some private properties surrounding Martins Bay and Lake McKerrow/Whakatipu Waitai area were excluded from aerial control; 1080 baits were hand laid on these properties, which was completed by December 4, 2014. Post-operational monitoring showed a reduction in possums, rats, stoats and mice (*Mus musculus*) compared to pre-operational levels. The Residual Trap Catch Index (RTCI) for possums reduced from 28.7% to 1.6%, rodent tracking indexes reduced from 15% to 0%, stoat tracking indexes reduced from 10% to 0% and mouse tracking indexes reduced from 6% to 0.5%. The majority of the study site lies within a 2,500 ha area that will be intensively managed by the Hollyford Conservation Trust, through a network of bait stations and traps. This study site was chosen to utilise existing monitoring transects.

Transect establishment

Monitoring was undertaken using line-transects. Thirty transects, 450 m in length and at least 200 m apart were sampled (Fig. 1). Twenty-two transects were setup along existing tracking tunnel lines; twelve tracking tunnel lines were located on the slopes of Mt Webb at elevations

between 100 m and 840 m above sea level, and ten tracking tunnel lines were located between Jamestown and Jerusalem Creek at elevations between approximately 5 m and 120 m above sea level. To provide a better representation of the study site, five additional bird count transects were established around Jamestown at elevations between 0 m and 80 m above sea level, and three additional bird count transects were established at sea level between Jerusalem Creek and the Hollyford river mouth at Martins Bay. Transects were marked with pink flagging tape and start and end points of transects were permanently marked with a white plastic triangle.

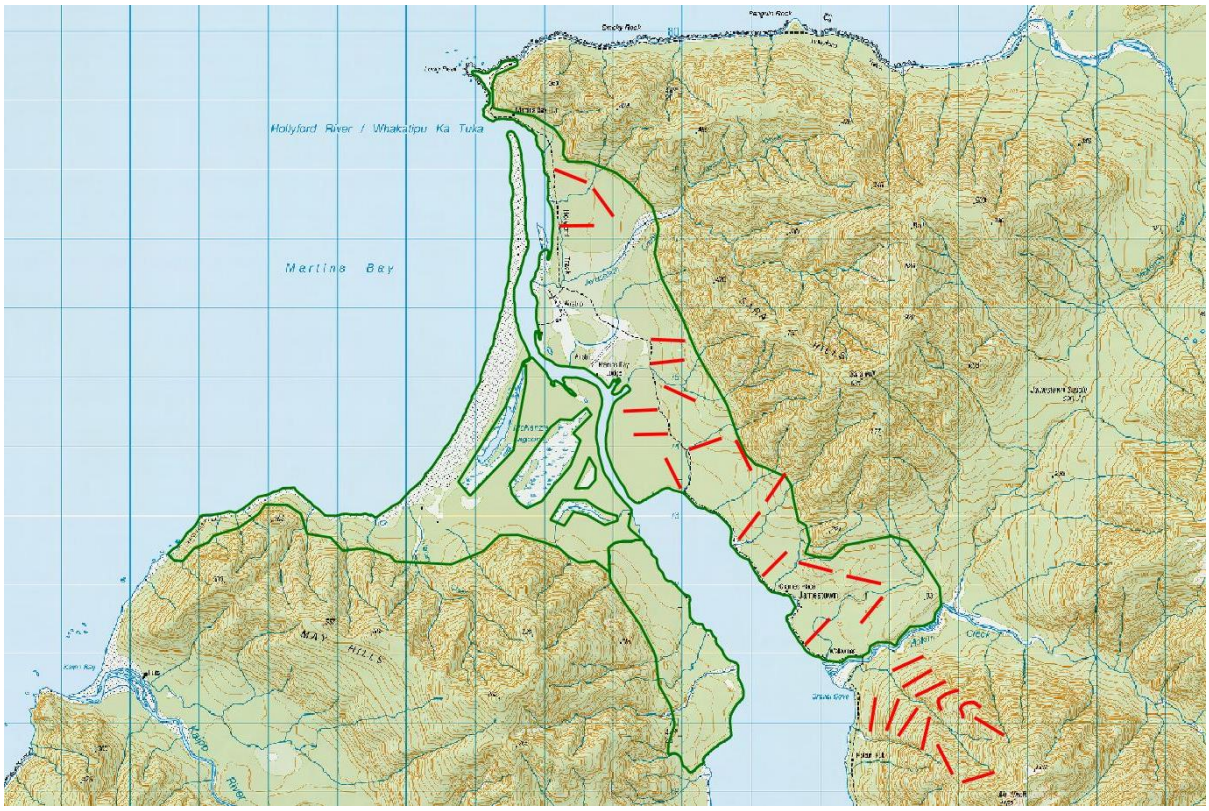

Figure 1. Distribution of bird monitoring transects in the lower Hollyford Valley between Mt Webb and Martins Bay. The area within the green boundary is managed by the Hollyford Conservation Trust.

Data collection

Pre-operational monitoring was completed over 7 days between September 21 and September 27, 2014. Post-operational monitoring was completed over 4 days between September 19 and 22, 2015. Data was collected by two observers who worked independently on different transects between 0800 hours and 1800 hours. Data for the 2014 survey was collected by observer A and B, data for the 2015 survey was collected by observer A and C. Each transect was monitored twice, once by each observer, once in the morning and once in the afternoon. Data was collected during fine weather only (no rain or strong winds). Observers approached each transect with caution to avoid flushing undetected birds at or near the transect start point. Transects were walked at a slow and constant speed. Each time a transect was walked, a selection of weather variables including temperature, rain, wind and cloud cover were recorded according to guidelines outlined in Dawson and Bull (1975).

Distance sampling

Horizontal distances perpendicular from the transect line to each bird were recorded to the nearest meter within 30 m of either side of the defined line, using a laser rangefinder with built-in inclinometer. Distances less than 5 m (minimum focal distance for a rangefinder) were estimated visually. Distances to those birds only heard, or not clearly seen, were estimated by measuring the distance to vegetation at an equivalent distance to the estimated position of the bird. Observers did not move away from the transect for more than a few meters to locate a heard bird. This was to ensure that birds on or near the transect were not missed. To prevent estimating distances to the same birds more than once, observers paid attention to the movements of the birds seen. Particular attention was paid to ensure that distance estimates were made to the position of first detection. Birds that flew into or over the transect area were ignored to avoid overestimating densities.

Encounter rates

All other forest bird species seen or heard from the transect were counted regardless of their distance from the transect. If a bellbird, kaka, kereru, rifleman, tomtit or tui was seen or heard beyond 30 m of either side of the transect, this was also recorded.

Data analysis

Distance sampling

To minimize issues surrounding the accurate identification and distance estimation of bellbird, rifleman and tomtit, data collected by observer C was removed from analysis. Pre-operational data collected by observer A and B was compared against post-operational data collected by observer A in 2015.

Limited detections make estimation of a useful detection function difficult and may bias density estimates; for this reason, data collected for kaka (2014: n=5, 2015: n=2) were not analysed. Distance sampling data collected for bellbird, kereru, rifleman, tomtit and tui was analysed in the software Distance 6.2 (Thomas et al. 2009). No distinction was made between male or female birds or birds detected by sight or their call during data analysis. Data were not truncated more than the limit set in the field (30 m) as further truncation did not improve model fit. Data were not grouped into interval classes for analysis.

To minimise potential bias in detection function between surveys, due to limited sample size, data collected for kereru and tui were analysed using Conventional Distance Sampling (CDS) with a global detection function. The global detection function was derived by pooling data from all surveys to maximise the sample size, followed by post-stratification to estimate population densities for each survey. Data collected for bellbird, rifleman and tomtit were analysed using CDS with independent detection functions for each survey. Detection probability histograms were constructed for each species and survey. Robust detection functions were fitted to the histograms based on guidelines in Buckland et al. (2001), and population density estimates were derived.

The following details were compared for each analytical approach: Akaike's Information Criterion (AIC), visual inspection of the detection probability histograms, Q-Q plots, accuracy of calculated density estimates and corresponding confidence intervals and Cramer-von Mises (CvM) GoF statistics, from which a preferred model was selected, and a density estimates were derived. Density estimates from pre- and post-operational counts were then compared for each species.

Encounter rates

Simple indices of relative abundance were estimated for all species by calculating the mean number of birds counted per km using the software R version 3.1.2 (R Core Team, 2013). To minimize issues surrounding variable detectability between surveys and provide a more accurate comparison between pre- and post-operational data, only data collected by observer A was used in a comparative analysis. Frequency of detection for all species were summarised by calculating the percentage of transects at which a given species was detected. Mean number of detections per km and frequency of detection from pre- and post-operational counts were compared for each species.

Results

Density estimates

Post-operational monitoring (2015) showed an increase in estimated densities for bellbird, rifleman and tomtit compared to pre-operational monitoring (2014, Table 1, Fig. 2). Estimated densities did not change significantly for kereru and tui (Table 1, Fig. 2).

Table 1. Population density estimates ($\hat{D}$) for bellbird, kereru, rifleman, tomtit and tui in the lower Hollyford Valley between Mt Webb and Martins Bay in September 2014 and September 2015.

Species	Year	Samples	Total transect length (km)	n	Model[1] (key+adjust)	GoF CvM (cos) P	D%CV	$\hat{D}$	$\hat{D}$ 95% CI
Bellbird	2014	30	27.0	221	Hnorm+cos	0.60	15.61	2.11	1.47-2.84
	2015	30	13.5	125	Unif+cos	0.40	18.50	2.91	2.02-4.19
Kereru	2014	30	30.6	27	Unif+cos	0.90	22.80	0.25	0.16-0.39
	2015	30	27.0	26	Unif+cos	0.90	25.89	0.27	0.16-0.46
Rifleman	2014	30	30.6	76	Hazrate+cos	0.05	29.15	0.75	0.42-1.33
	2015	30	13.5	87	Unif+cos	0.60	25.41	2.31	1.39-3.84
Tomtit	2014	30	30.6	260	Hazrate+cos	0.15	11.17	2.05	1.64-2.56
	2015	30	13.5	200	Unif+poly	0.60	9.42	3.10	2.57-3.75
Tui	2014	30	30.6	19	Hnorm+cos	0.70	48.94	0.20	0.08-0.51
	2015	30	27.0	22	Hnorm+cos	0.70	46.22	0.26	0.11-0.63

[1] Model consisting of a key function (half-normal, uniform, or hazard-rate) with a cosine or simple polynomial adjustment term.

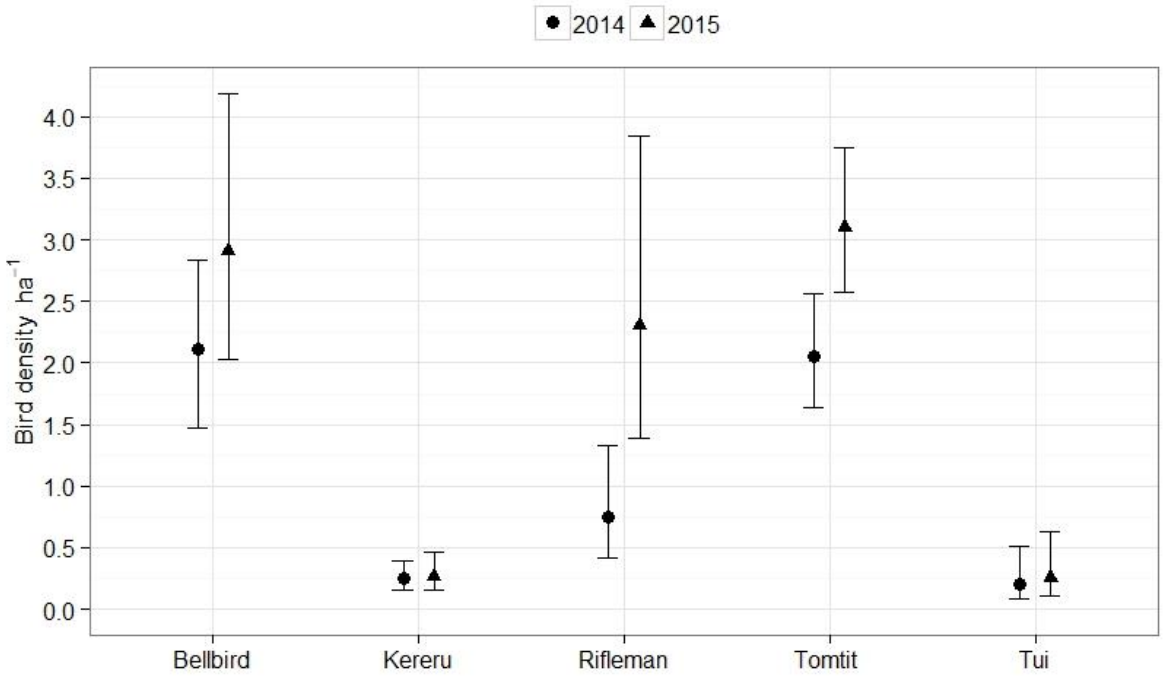

Figure 2. Population density estimates for bellbird, kereru, rifleman, tomtit and tui (birds ha^{-1} ± 95% CI) in the lower Hollyford Valley between Mt Webb and Martins Bay in September 2014 and September 2015.

Encounter rates

A comparison of pre- and post-operational encounter rate data (detections per km) showed increased detections for nine native forest bird species; bellbird, brown creeper (*Mohoua novaeseelandiae*), fantail (*Rhipidura fuliginosa*), grey warbler (*Gerygone igata*), kereru, yellow-crowned parakeet (*Cyanoramphus auriceps*), rifleman, tomtit and tui in the year following the 1080 operation (Table 2, Fig. 3). Mean encounter rates declined for kaka and silvereye (*Zosterops lateralis*), and did not change for kea (*Nestor notabilis*, Table 2, Fig. 3).

Table 2. Mean encounter rates (detections/km ± SE) and detection frequencies (%) for forest bird species in the lower Hollyford Valley between Mt Webb and Martins Bay in September 2014 and September 2015. Encounter rates are presented as the mean number of birds detected per kilometre and include all birds seen or heard regardless of their proximity from the transects. Detection frequency is presented as the percentage of transects from which one or more individuals of each species was seen or heard.

	Mean encounter rate (detections/km ± SE)		Detection frequency (%)	
Species	2014	2015	2014	2015
Bellbird	16.82 (± 1.47)	26.15 (± 1.91)	100	100
Brown_creeper	1.78 (± 0.83)	3.63 (± 1.13)	20	53
Fantail	7.48 (± 1.24)	11.93 (± 1.26)	87	90
Grey_warbler	14.37 (± 0.96)	14.89 (± 0.85)	100	100
Kaka	1.26 (± 0.38)	0.74 (± 0.25)	47	30
Kea	0.07 (± 0.07)	0.07 (± 0.07)	3	3

Kereru	0.74 (± 0.27)	1.26 (± 0.41)	50	53
YC_parakeet	0.07 (± 0.07)	1.11 (± 0.49)	3	43
Rifleman	2.89 (± 0.88)	6.00 (± 1.41)	43	63
Silvereye	12.67 (± 1.86)	2.81 (± 0.65)	90	73
Tomtit	11.63 (± 0.97)	20.82 (± 1.96)	100	100
Tui	1.63 (± 0.52)	1.78 (± 0.64)	40	33
Blackbird	1.11 (± 0.32)	1.04 (± 0.31)	43	50
Chaffinch	0.96 (± 0.45)	0.89 (± 0.43)	63	57
Greenfinch	0.07 (± 0.07)	0.00 (± 0.00)	3	0
Redpoll	0.81 (± 0.27)	2.15 (± 0.80)	27	40
Song_thrush	0.44 (± 0.27)	0.22 (± 0.16)	10	7

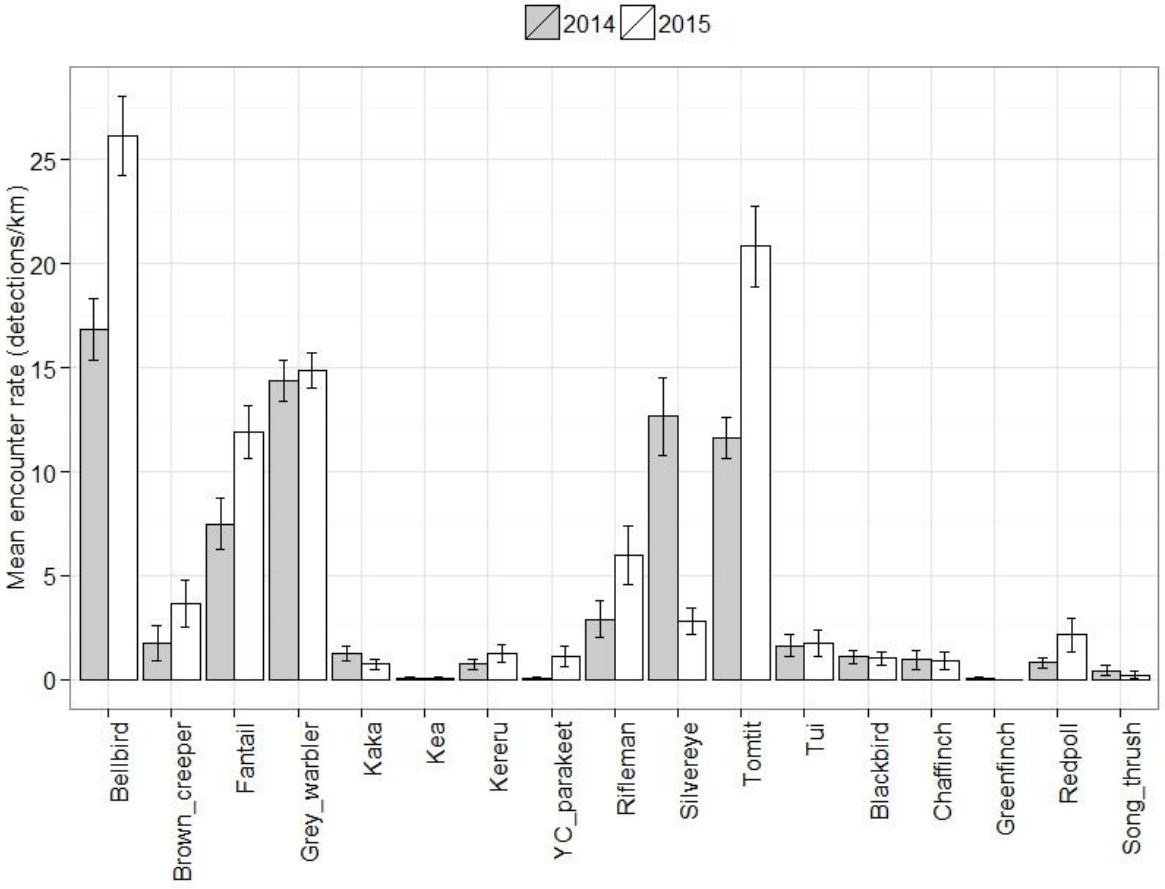

Figure 3. Mean encounter rates for forest bird species detected from transects in the lower Hollyford Valley between Mt Webb and Martins Bay in September 2014 and September 2015. Encounter rates are presented as the mean number of birds detected per kilometre and include all birds seen or heard regardless of their proximity from the transects.

Brown-creeper, yellow-crowned parakeet and rifleman became more widely distributed throughout the study site following the 1080 operation. (Table 2, Fig. 4). The number of transects from which brown-creeper were detected increased from 20 to 53%, while rifleman detection frequencies increased from 43 to 63% (Table 2). Prior to the operation, brown-creeper and rifleman were mainly found on the upper slopes of Mt Webb, after the operation,

they were also detected on the lower slopes as well as on the majority of the transects on the flat land surrounding Lake McKerrow. The biggest change was seen in yellow-crowned parakeets, previously only detected from one transect near Jamestown (3%), they were detected from the upper slopes of Mt Webb to the Hollyford River mouth at Martins Bay (43% of transects, Table 2) in the following year.

Some small changes were seen in encounter rates and detection frequencies for introduced species, the biggest change was the increase in redpoll detections (Table 2, Fig. 3 and 4).

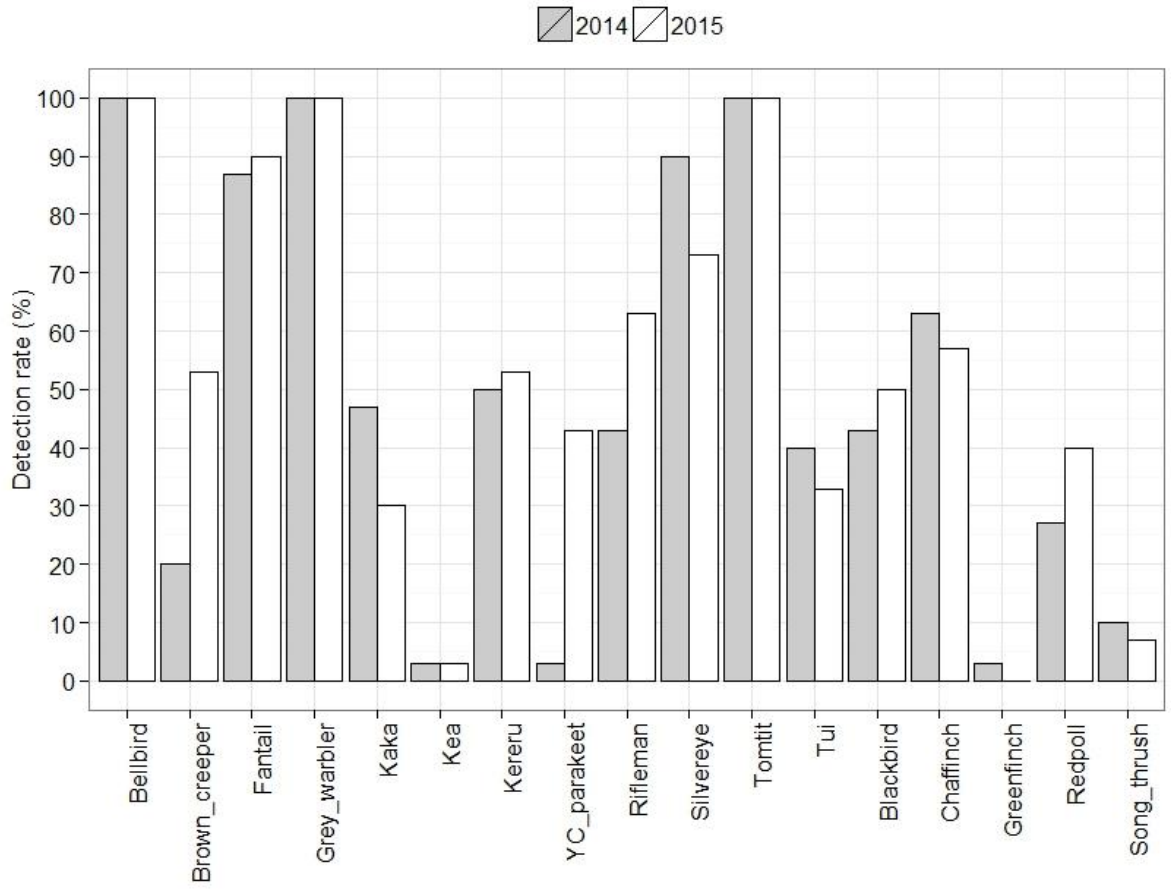

Figure 4. Detection frequencies for forest bird species seen or heard from transects in the lower Hollyford Valley between Mt Webb and Martins Bay in September 2014 and September 2015. Detection frequencies are presented as the percentage of transects from which one or more individuals of each species was seen or heard.

Other bird species detected from the transects included fernbird (*Bowdleria punctata*), paradise shelduck (*Tadorna variegata*), Canada goose (*Branta Canadensis*), New Zealand scaup (*Aythya novaeseelandiae*) and morepork (*Ninox novaeseelandiae*). These species have not been reported on here as they are either non-forest birds, or are nocturnal, and this study is not designed to accurately monitor changes in their abundance.

Discussion

Changes in density estimates and encounter rates

- A comparison of pre- and post-operational density estimates for bellbird, kereru, rifleman, tomtit and tui shows that these populations were not negatively affected by the aerial 1080 operation.
- Density estimates for bellbird, rifleman and tomtit increased following the aerial predator control operation and a season of low predator numbers. These species have high fecundity and therefore show a rapid response to predator control.
- Post-operational kereru and tui density estimates did not change compared to pre-operational levels. These larger birds are expected to respond to management over a longer period of time once habitat improves.
- A comparison of pre- and post-operational encounter rate data also showed increased detections for brown creeper, fantail and yellow-crowned parakeet.
- Brown-creeper, yellow-crowned parakeet and rifleman became more widely distributed throughout the study site following the 1080 operation.
- Post-operational detection rates for kaka and silvereye decreased compared to pre-operational levels. Both species show a considerable amount of local movement, mainly seeking fruit or nectar, and the decline in detections for these two species is more likely to be related to seasonal movements rather than effects of the aerial 1080 operation.
- No other forest bird species monitored during this study showed an obvious decline following the 1080 operation.

Recommendations for future monitoring

- Annual forest bird monitoring within the area managed by the Hollyford Conservation Trust is needed to determine long term density trends for selected forest bird species, changes to population size and composition and the effectiveness of the chosen management tools.
- Bird counts should be repeated annually in September.
- Counts should be conducted along the eighteen existing transects on the true right and the eighteen new transects on the true left. Transects on the true left were established in September 2015, and initial bird counts were conducted. Results from this survey will be discussed in a separate report.
- The twelve transects of Mt Webb are outside the area managed by the Trust and bird monitoring on these lines should be discontinued.

Acknowledgements

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