Monitoring forest birds using acoustic recorders in the Abel Tasman National Park 2019-2022

Update of the report from 2020

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Prepared for Project Janszoon

PROJECT JANSZOON

Together restoring the Abel Tasman

Note

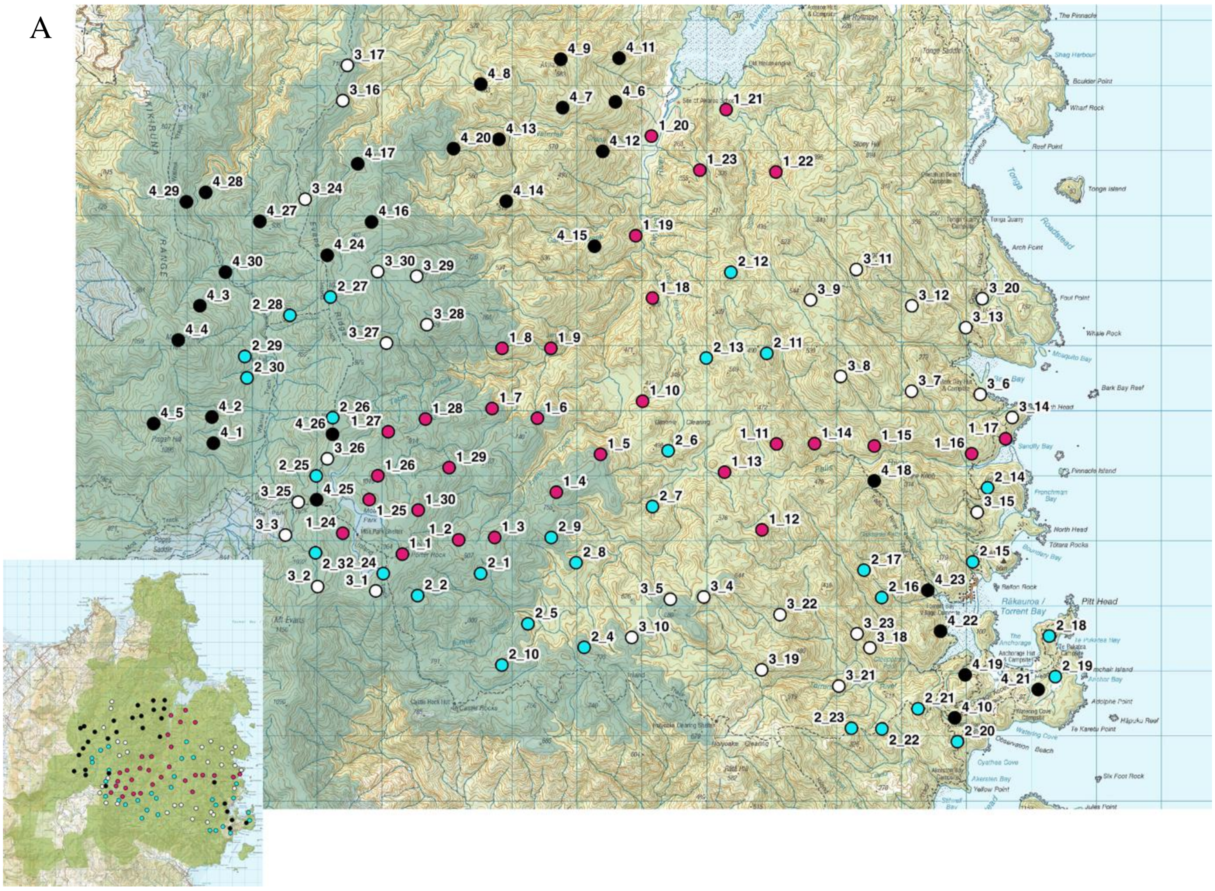
This is an update of the report "Monitoring forest bird occupancy using acoustic recorders in the Abel Tasman National Park" (R. Bollongino 2022). It includes the results of the 2022 monitoring season and updated tables, maps, and graphs. It is not meant to be a standalone report, please refer to the previous report for details on objectives, study design, methods, and discussion.

Background

In brief, passive acoustic recorders were deployed at 120 locations within the aerial rat control area in the park (Fig. 1). Thirty recorders were available, therefore four monitoring cycles in total were performed in order to achieve 120 sampling points. The distribution and density of rat-sensitive bird species like robin, rifleman, and brown creeper is correlated to elevation, with more birds being present at higher elevations where rat numbers are lower. Thus, a stratified approach was chosen, with six elevation bands covering 1-1200m ASL (Tab.1).

Recorders were deployed for two weeks at each location, recording 2.5 h in the morning and late afternoon, respectively. Manual bird annotations were carried out for 90s sub-samples per day and location. The presented results summarise presence/absence (or more precisely, minimum occupancy) of each bird species within the study area as well as the ratio of 15s-annotation frames where a certain bird species was detected. This is referred to as the acoustic detection rate (ADR) or call rate.

A



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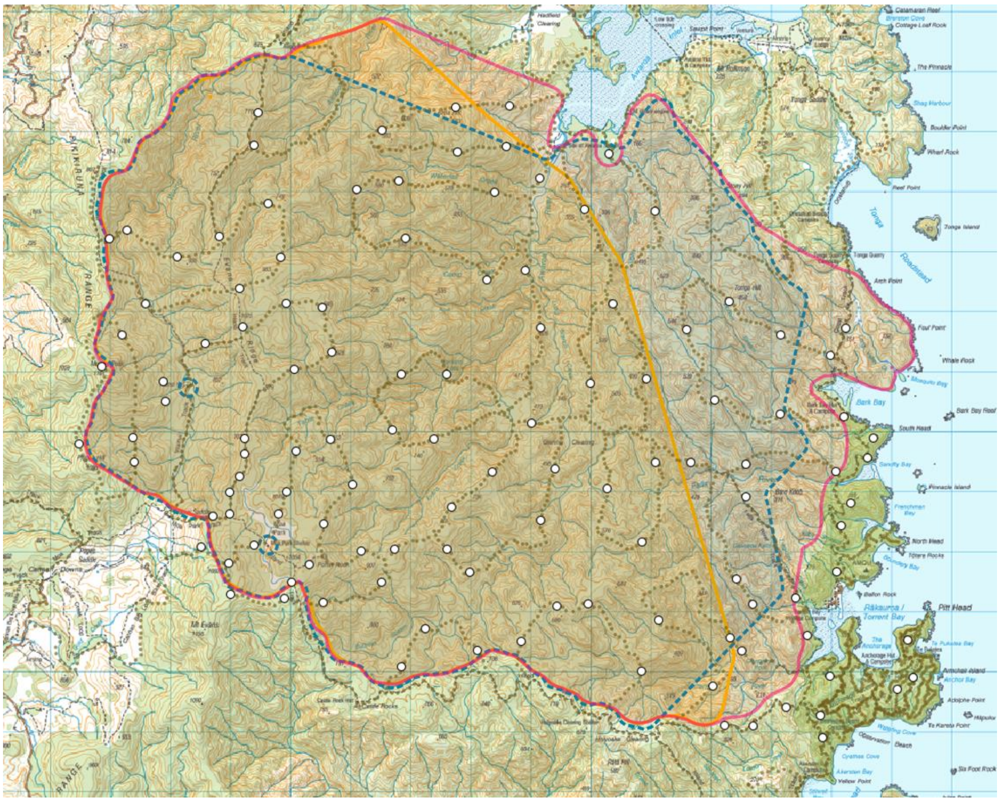


Figure 1: Study area. A) Recorder locations. IDs read as “Cycle_location number”. Cycles: 1=pink, 2=turquoise, 3=white, 4=black. Please note that some location IDs changed since the last report. Blue highlight: area above 600m ASL. Insert: Recorder locations in relation to park area (green). B) Relevant treatment areas: aerial control June 2019 (pink shape), August 2017 (blue) and September 2020 (yellow). Green highlight: A24 rat-trap area.

Table 1: Elevation strata applied in this study.

Stratum	Elevation (m ASL)
1	1-200
2	200-400
3	400-600
4	600-800
5	800-1000
6	1000-1200

Results

All 120 recording sites were monitored successfully. A list of the most common native forest birds and the minimum number of occupied sites is shown in table 2 and figure 2 (see table 4 & 5 for occupancy per stratum). Robins, riflemen, tomtits, weka warbler and shining cuckoo showed constant increase of occupancy over survey seasons. Fantails and silvereyes decreased significantly since the previous season. Robins expanded remarkably within strata 2-3 (200-600m ASL, Tabs. 4 & 5), riflemen expanded slightly within the two highest strata. Tomtits expanded constantly over the four years of monitoring, mainly along the coast. In contrast, silvereye and fantail are found in less locations at the top of the park.

Average acoustic detection rates are presented in table 3 and figure 2 (see table 5 for call rates below and above 600m). Trends are generally following those of occupancy but show more fluctuation.

Table 2: Minimum number of occupied sites (maximum 120).

	2019	2020	2022
Robin	65	68	83
Creeper	16	11	16
Rifleman	37	42	45
Kākā	30	27	47
Kea	27	27	24
Kākāriki	40	12	14
Tomtit	106	108	119
Weka	96	108	116
Fantail	96	108	84
Warbler	110	114	117
Silvereye	115	117	106
Bellbird/Tui	117	119	120
Kingfisher	15	7	12
Shining Cuckoo	10	18	24

Table 3: Average acoustic detection rates

	2019	2020	2022
Robin	7.33	8.43	12.99
Creeper	0.32	0.15	0.31
Rifleman	8.23	4.69	10.06
Kākā	1.06	0.84	1.42
Kea	0.39	0.49	0.30
Kākāriki	0.85	0.20	0.26
Tomtit	19.35	25.61	27.66
Weka	2.92	3.54	4.78
Fantail	8.03	8.98	4.80
Warbler	11.65	17.14	16.68
Silvereye	40.96	38.50	20.10
Bellbird/Tui	46.42	54.65	53.38
Kingfisher	0.27	0.18	0.19
Shining Cuckoo	0.15	0.23	0.74

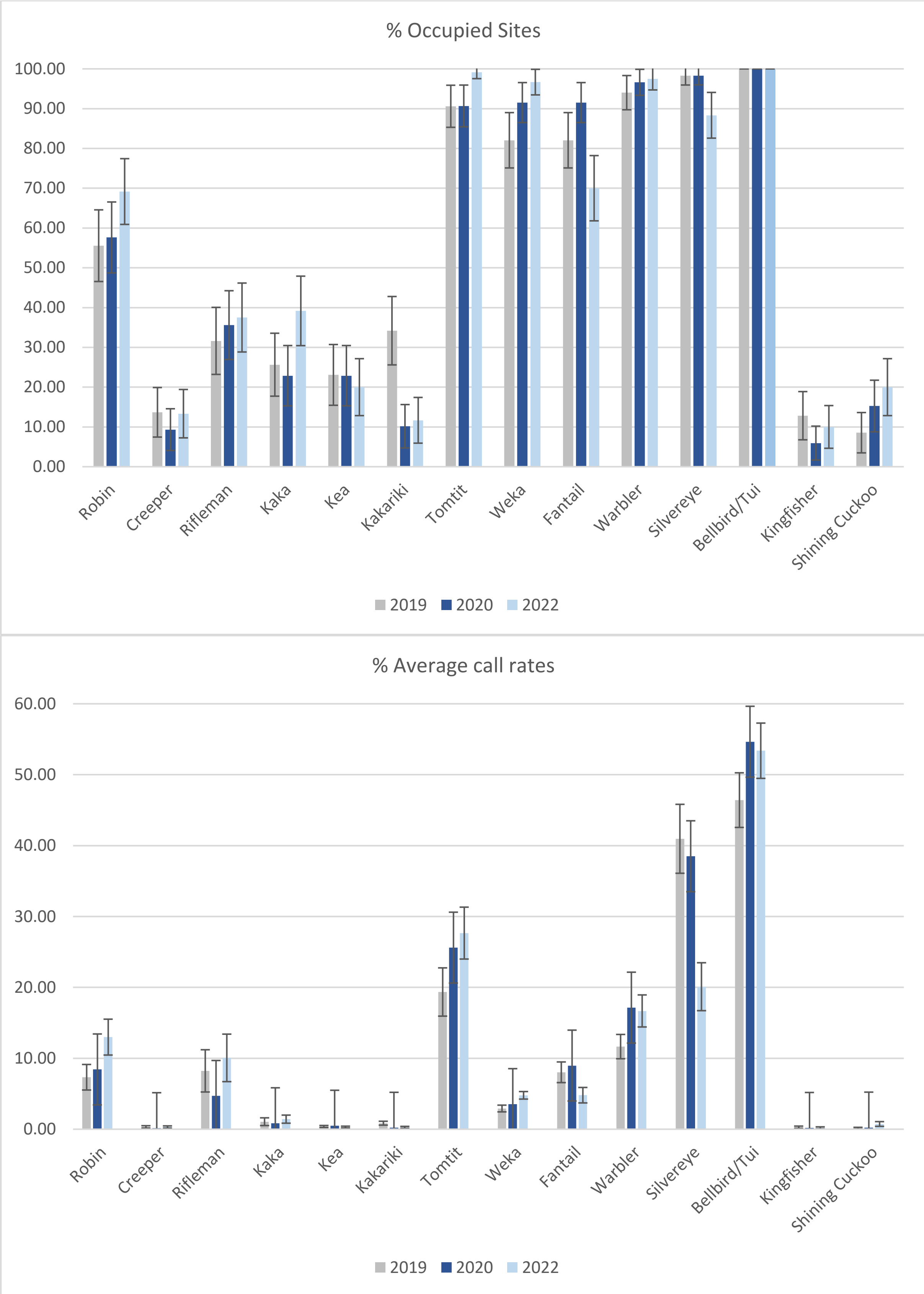


Figure 2: Average percentage of occupied sites (top) and acoustic detection rates (ADR, bottom), bars indicate 95% binomial confidence intervals.

Table 4: Number of occupied sites per stratum (maximum 20 per stratum). Elevation strata see Tab. 1.

Stratum	Year	Robin	Creeper	Rifleman	Kākā	Kākāriki	Kea	Tomtit	Weka	Fantail	Warbler	Silvereye	Bellbird/Tui	Kingfisher	Sh. Cuckoo
1	2019	0	0	0	2	0	2	15	15	17	17	20	20	9	1
	2020	1	0	0	4	0	2	16	15	15	19	20	20	4	3
	2022	0	0	0	9	0	0	19	19	19	18	19	20	3	5
2	2019	1	0	0	1	4	7	14	15	18	19	19	19	5	2
	2020	3	0	2	1	0	6	15	19	19	20	20	20	2	2
	2022	7	0	0	4	1	5	20	20	16	20	20	20	4	6
3	2019	10	0	0	4	4	6	18	17	19	19	19	19	1	1
	2020	10	0	2	4	2	12	18	16	16	19	19	19	0	4
	2022	18	1	2	1	1	9	20	20	15	20	20	20	5	5
4	2019	17	4	5	12	13	7	20	13	17	20	20	20	0	6
	2020	15	2	9	7	5	4	20	19	19	19	20	20	0	6
	2022	19	2	6	13	7	8	20	18	14	20	19	20	0	5
5	2019	20	4	13	10	9	3	20	20	14	19	20	20	0	0
	2020	20	2	14	10	3	2	20	20	20	19	18	20	0	3
	2022	20	4	17	13	3	2	20	19	11	20	16	20	0	3
6	2019	17	8	19	1	10	2	19	16	11	16	17	19	0	0
	2020	19	7	15	1	2	1	19	19	19	18	20	20	1	0
	2022	19	9	20	7	2	0	20	20	9	19	12	20	0	0

Table 5: Average number of occupied sites and average ADRs below and above 600m ASL. See table A1 in the appendix for details on binomial confidence intervals. Green/orange highlight= significant increase/decrease since 2019, green/red bold letters= significant increase/decrease since previous survey.

		Robin	Creeper	Rifleman	Kākā	Kākāriki	Kea	Tomtit	Weka	Fantail	Warbler	Silvereye	Bellbird/ Tui	Kingfisher	Sh. Cuckoo
Occupied sites															
below 600m	2019	19.0	0.0	0.0	12.1	13.8	25.9	81.0	81.0	93.1	94.8	100	100	25.9	6.9
	2020	23.7	0.0	**6.8**	15.3	3.4	33.9	83.1	84.7	84.7	98.3	100	100	10.2	15.3
	2022	41.7	1.7	3.3	23.3	3.3	23.3	**98.3**	**98.3**	83.3	96.7	98.3	100	20.0	26.7
above 600m	2019	91.5	27.1	62.7	39.0	54.2	20.3	100	83.1	71.2	93.2	96.6	100	0.0	10.2
	2020	91.5	18.6	64.4	30.5	**16.9**	11.9	98.3	**98.3**	**98.3**	94.9	96.6	100	1.7	15.3
	2022	96.7	25.0	71.7	55.0	20.0	16.7	100	95.0	**56.7**	98.3	**78.3**	100	0.0	13.3
Average call rate															
below 600m	2019	1.59	0.00	0.00	0.88	0.19	0.41	8.72	2.64	11.5	14.3	60.9	49.3	0.62	0.17
	2020	2.06	0.00	**0.63**	0.93	0.05	0.68	**10.5**	2.69	10.6	22.9	58.5	**62.2**	0.50	0.20
	2022	**6.39**	0.04	**0.24**	1.33	0.11	0.41	**16.3**	**4.13**	**5.79**	19.6	**32.5**	**58.9**	0.39	**1.12**
above 600m	2019	12.9	0.60	17.0	1.25	1.52	0.38	30.7	3.21	4.61	9.86	22.2	42.5	0.00	0.15
	2020	16.7	0.27	**6.95**	0.75	**0.42**	0.20	**40.9**	**4.38**	**6.33**	11.1	22.9	**53.1**	0.07	0.35
	2022	**19.8**	0.56	**19.5**	1.45	0.39	0.20	38.3	5.57	**3.75**	14.0	**7.47**	**48.2**	0.00	0.45

Most rat-sensitive bird species showed an increase in both occupancy and ADRs, whereas rat-tolerating species like fantail and silvereye decreased. Minimum occupancy and call rates of rat-sensitive bird species (robin, rifleman, creeper, tomtit, kākāriki) increased constantly over the last four years (Figs. 3 & 4). Non-sensitive species (bellbird & tui, warbler, fantail, silvereye) occupied most of the study area over time, but call rates started to decrease over the last two years.

Spatial mapping of the number of species per location revealed fewer locations with all five rat-sensitive species present, but an increase of diversity within the mid-range elevation strata (Fig. 5). In contrast, the number of locations with all non-sensitive species present is decreasing (Fig. 6 bottom map). ADRs for rat-sensitive birds increased by 24 % (Fig. 4), whereas call rates of non-sensitive birds decreased by 20 %. The increase of ADRs of rat-sensitive birds can mainly be observed in the highlands (Fig. 7), while the decrease in ADRs for non-sensitive birds is predominantly seen in the mid- and lowlands (Fig. 8).

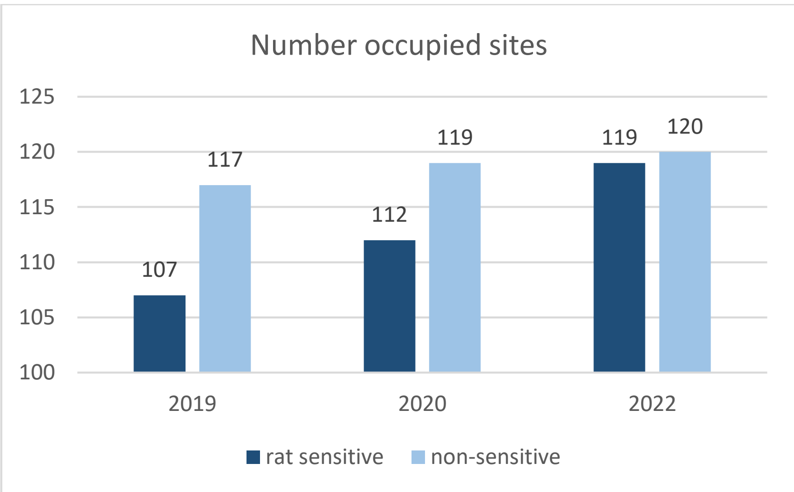


Figure 3: Number of occupied sites of rat sensitive bird species vs. non-sensitive species.

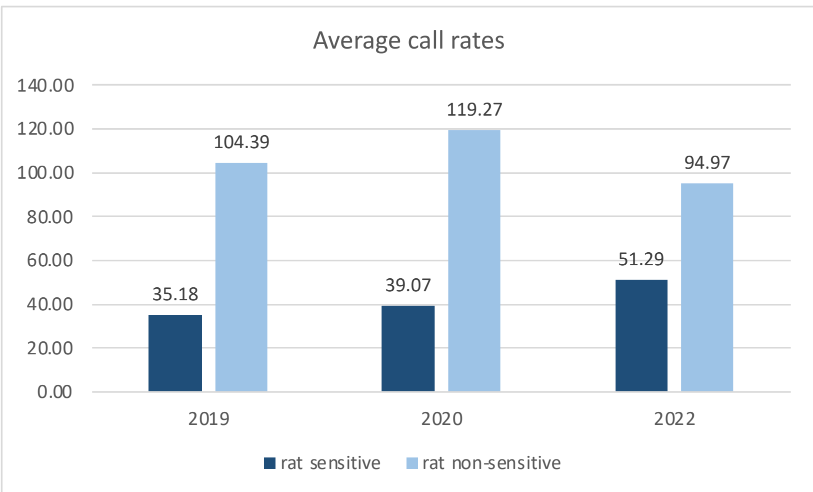


Figure 4: Average ADRs of rat sensitive bird species vs. non-sensitive species.

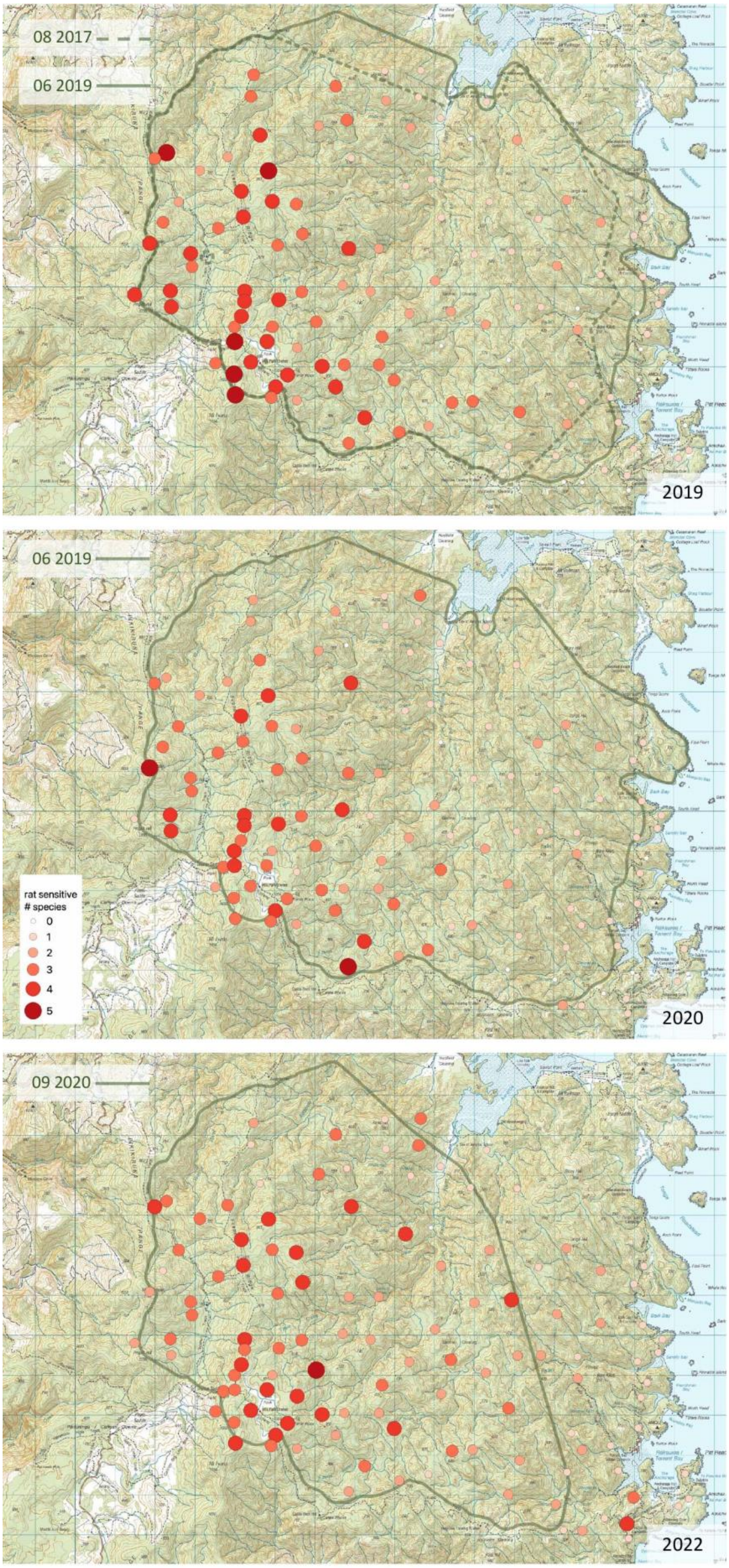


Figure 5: Number of rat sensitive bird species (robin, rifleman, creeper, tomtit, kākāriki) per location. Dark green shapes= latest relevant aerial treatment, dates of operation see top left corner of the maps.

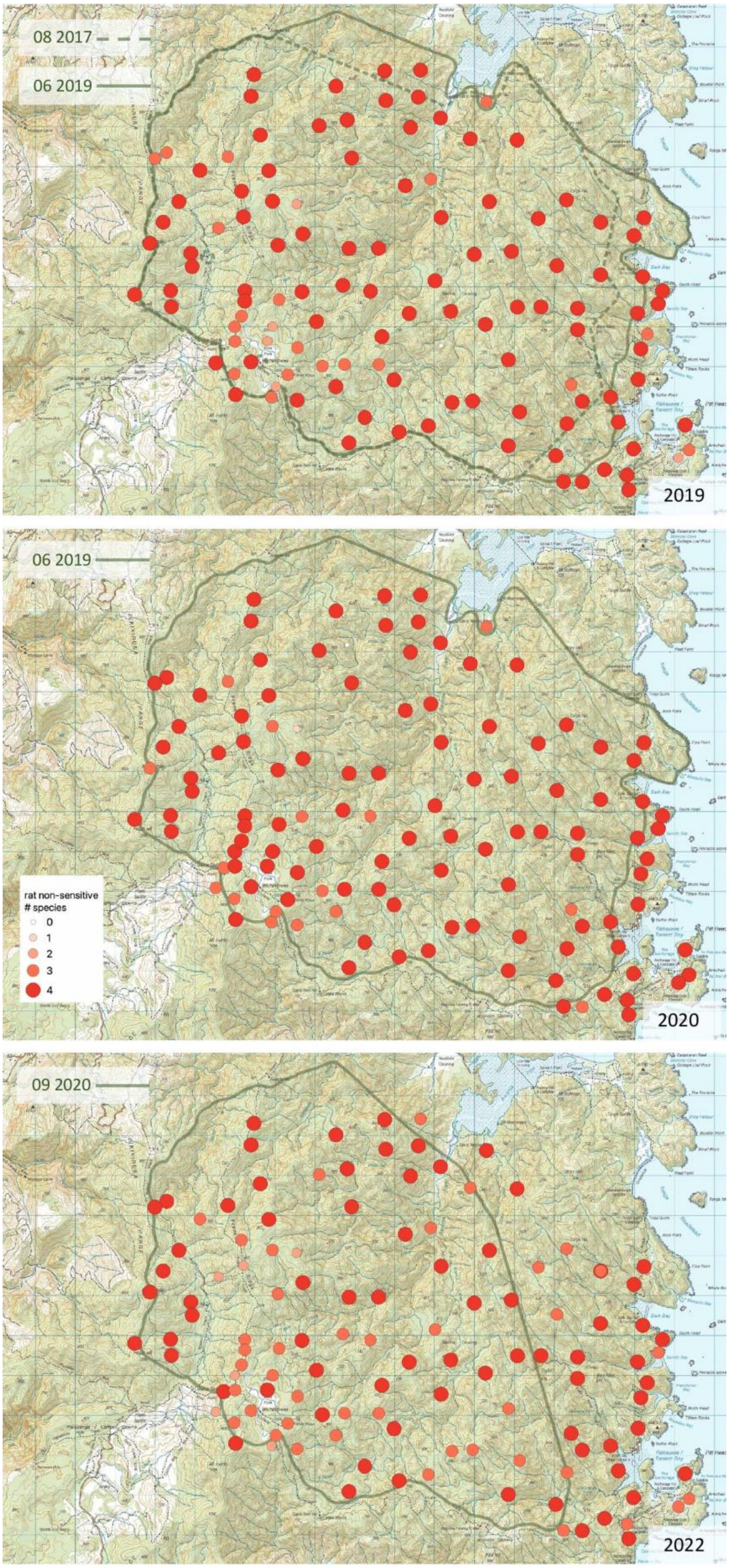


Figure 6: Number of rat non-sensitive birds (bellbird/tui, fantail, warbler, silvereye) per location. Dark green shapes= latest relevant aerial treatment, dates of operation see top left corner of the maps.

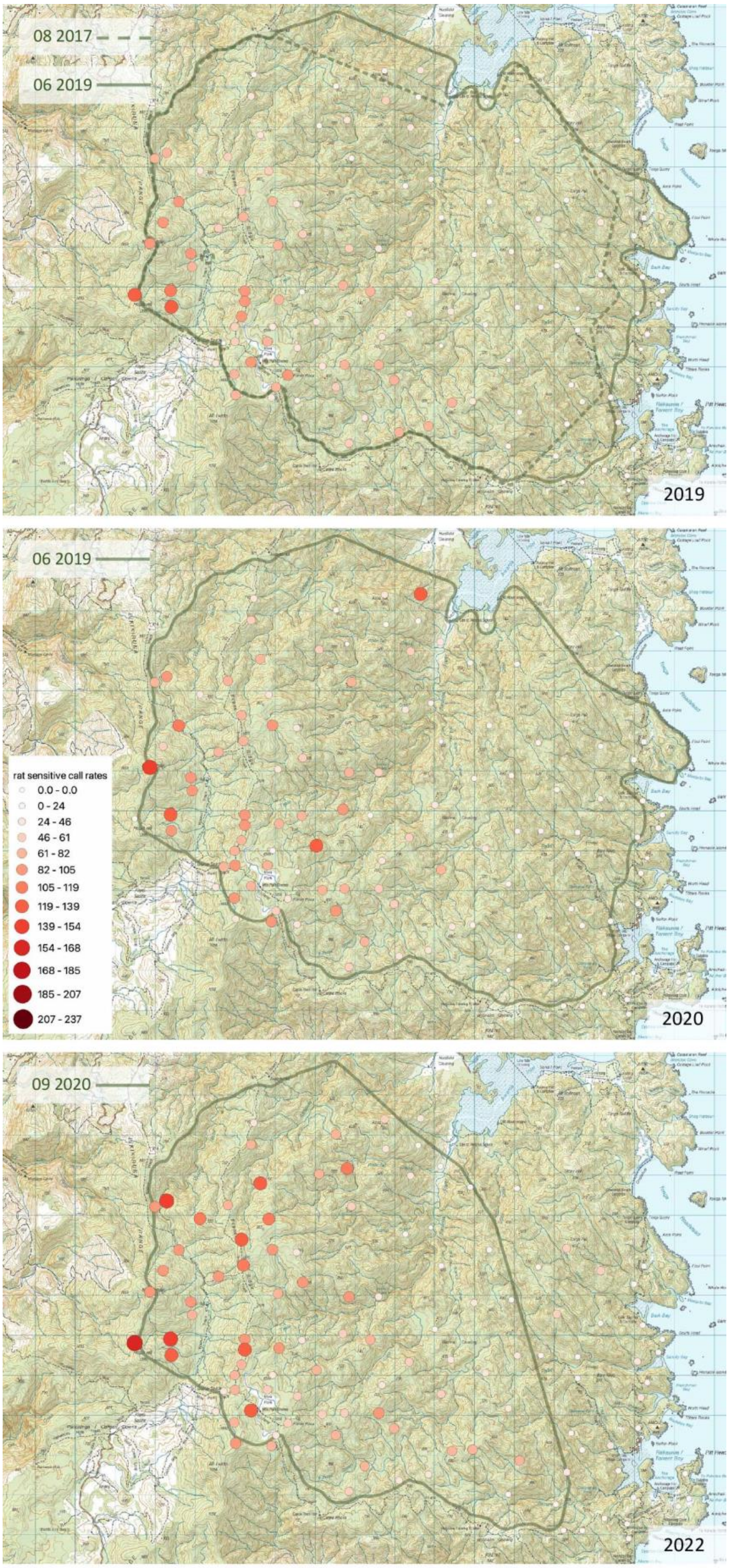


Figure 7: Call rates of rat sensitive bird species (robin, rifleman, creeper, tomtit, kākāriki) per location. Dark green shapes= latest relevant aerial treatment, dates of operation see top left corner of the maps.

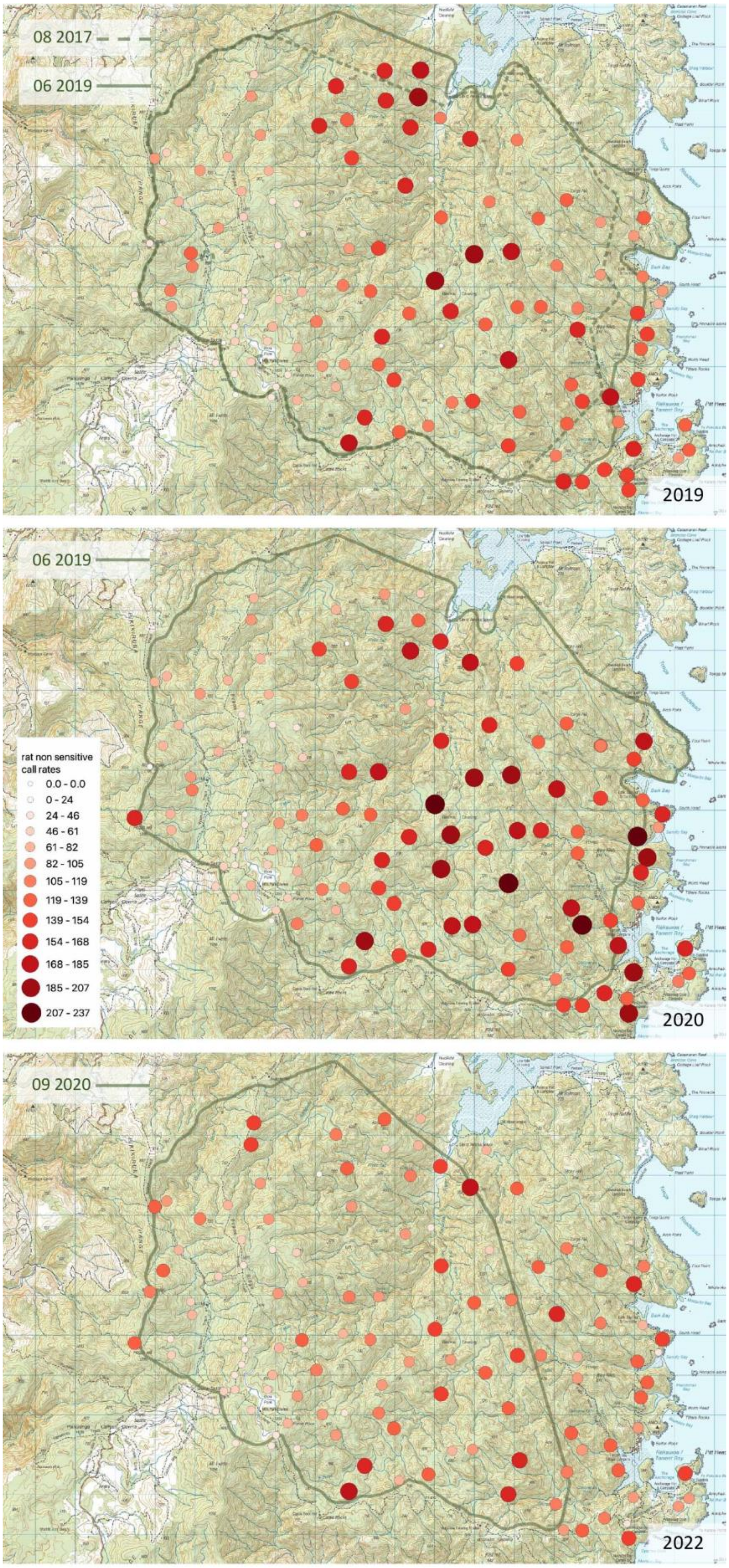


Figure 8: Number of rat non-sensitive birds (bellbird/tui, fantail, warbler, silvereye) per location. Dark green shapes= latest relevant aerial treatment, dates of operation see top left corner of the maps.

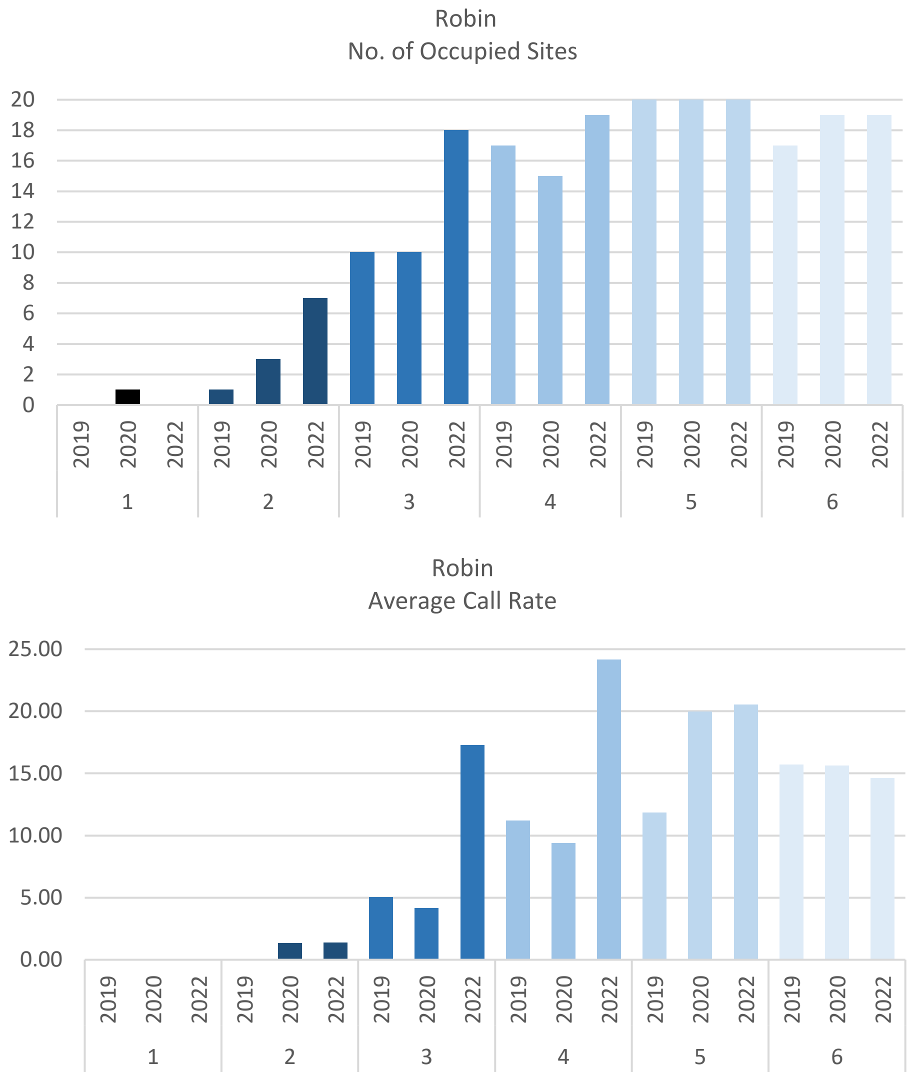


Figure 9: Robin minimum number of occupied sites (top) and average acoustic detection rates (bottom) per stratum. See Tab.1 for elevation strata.

Robin: Robin occupancy increased by 18 % over all within the last two years, 57 % and 44 % in stratum 2 and 3, respectively (Tab.2, Figs. 2 & 9). No changes in occupancy were observed in the top two strata (Tab.4), although increased call rates for stratum 5 indicate a raise in abundance even after occupancy reached 100 %. On average, acoustic detections rates increased by 35 % (Tab. 3) over the last two years.

Robins were not detected under 200 m ASL, however robin sightings along the coast have been reported occasionally, especially in the Anchorage area.

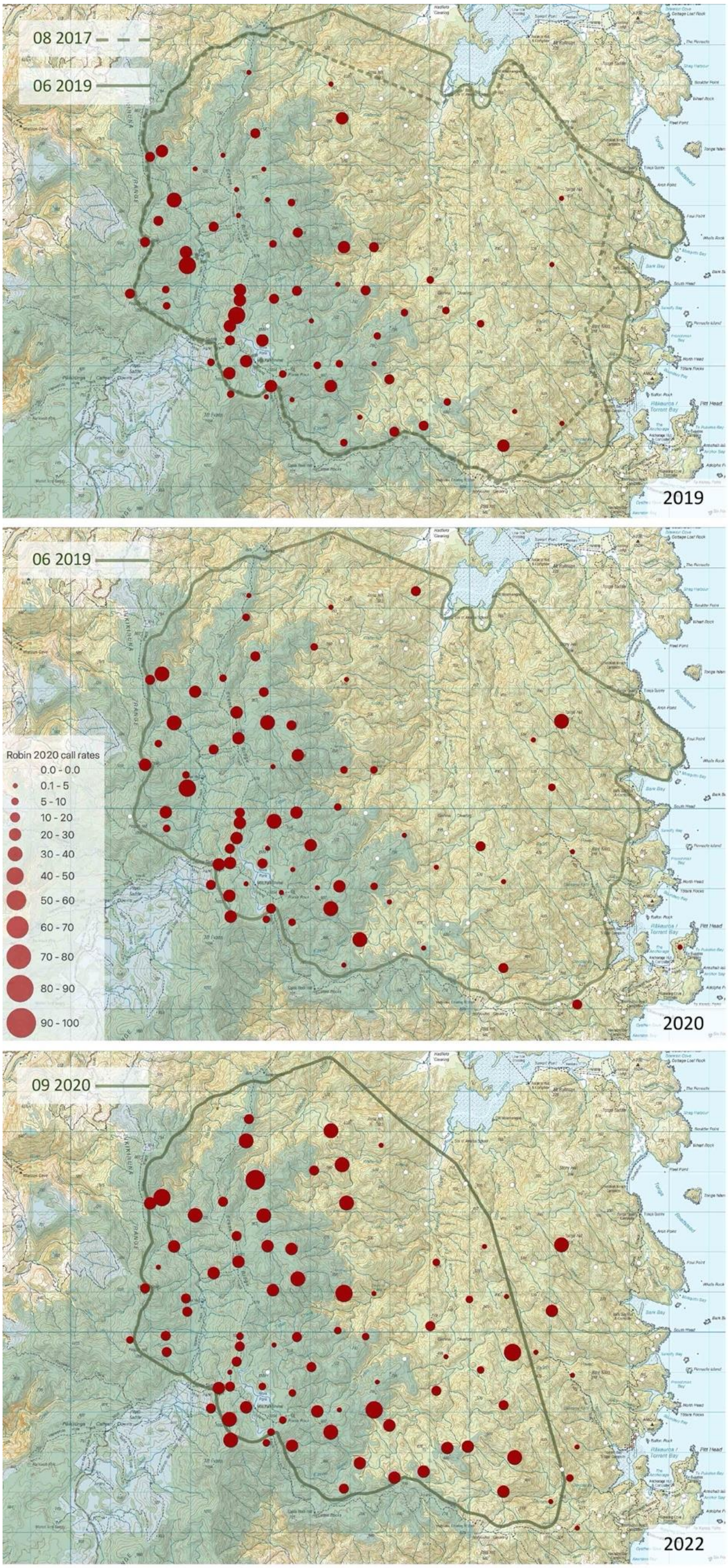
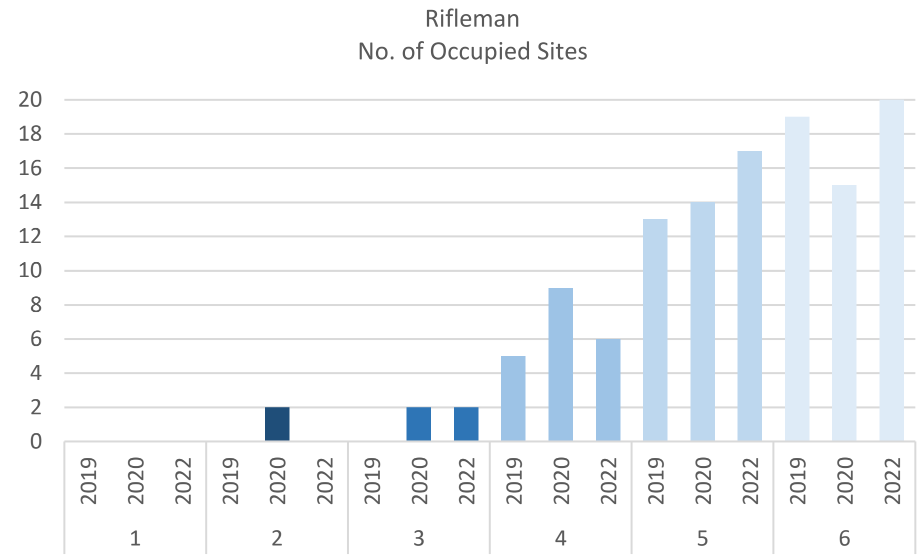


Figure 10: Robin acoustic detection rates and minimum occupancy. Dark green shapes= latest relevant aerial treatment, dates of operation see top left corner of the maps. Blue highlight: > 600m ASL.



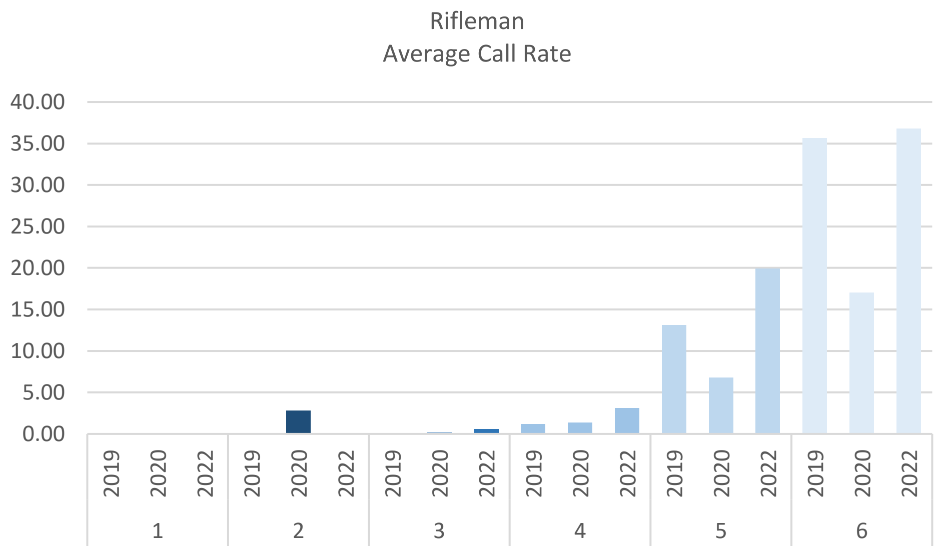


Figure 11: Rifleman minimum number of occupied sites (top) and average acoustic detection rates (bottom) per stratum. See Tab.1 for elevation strata.

Rifleman: The uplands are still the stronghold for riflemen, but occupancy is slowly but steadily rising (Tab. 2, Fig. 11). Spatial distribution of occupied sites along the distribution edges is fluctuating, especially where call rates are low (Fig. 12). ADRs are generally increasing but revealed a setback in 2020 (Fig. 11). ADRs are following the trend of occupancy, with call rates being highest in the upland and decreasing steeply towards the lowland.

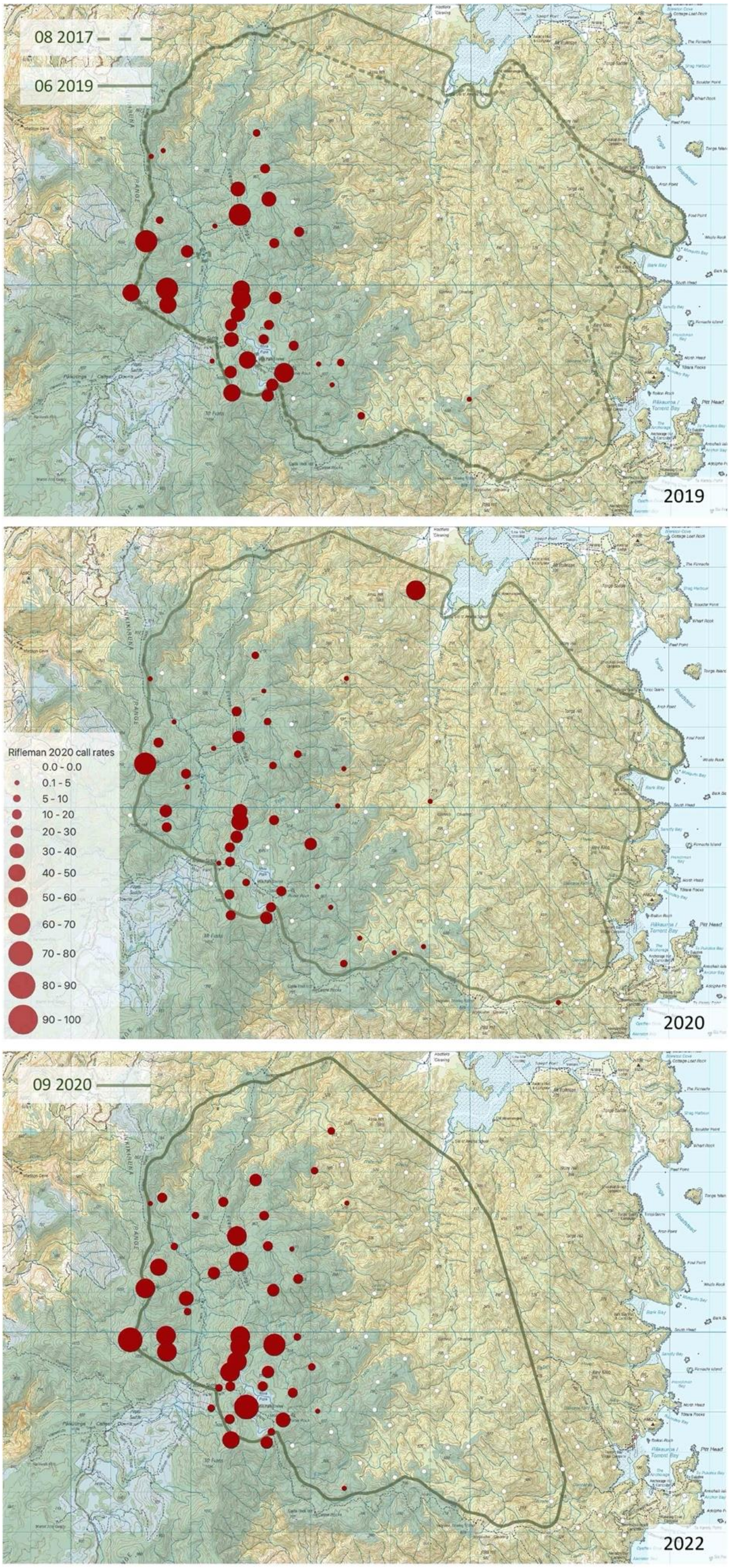
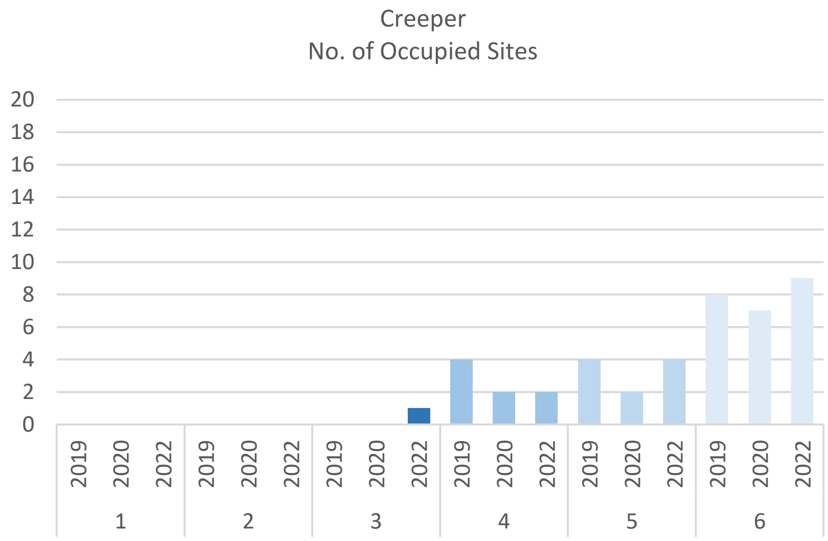


Figure 12: Rifleman acoustic detection rates and minimum occupancy. Dark green shapes= latest aerial treatment, dates of operation see top left corner of the maps. Blue highlight: > 600m ASL.



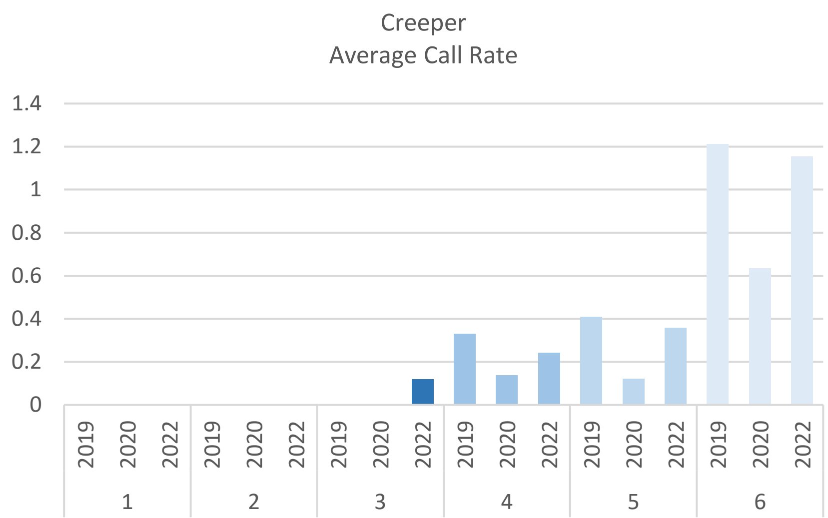


Figure 13: Brown creeper minimum number of occupied sites (top) and average acoustic detection rates (bottom) per stratum. See Tab.1 for elevation strata.

Brown creeper: reveal a similar pattern and development as rifleman, but on a smaller scale and with no significant increase of occupancy or ADR over time (Tabs. 2 & 3, Figs. 13 &14).

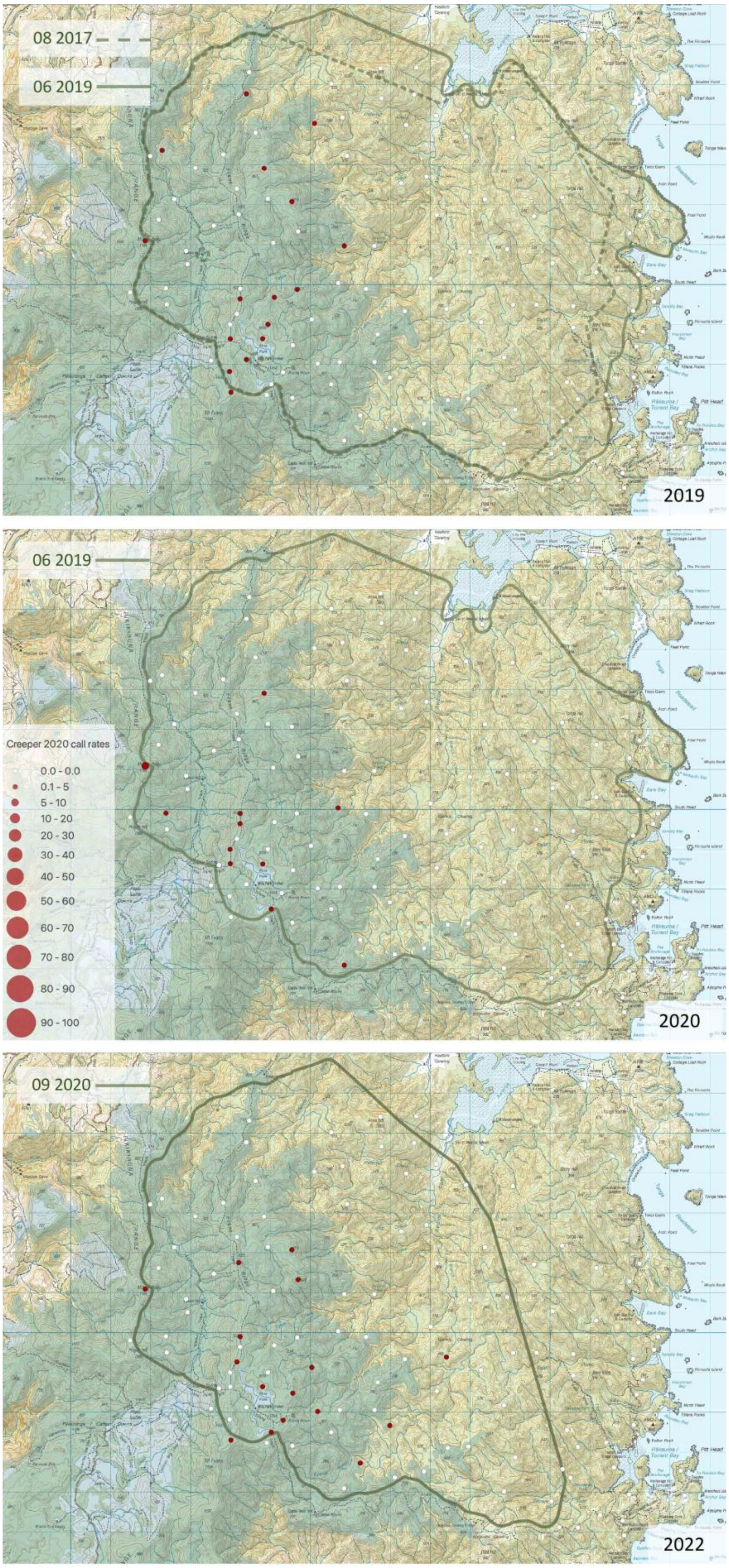


Figure 14: Brown creeper acoustic detection rates and minimum occupancy. Dark green shapes= latest aerial treatment, dates of operation see top left corner of the maps. Blue highlight: > 600m ASL.

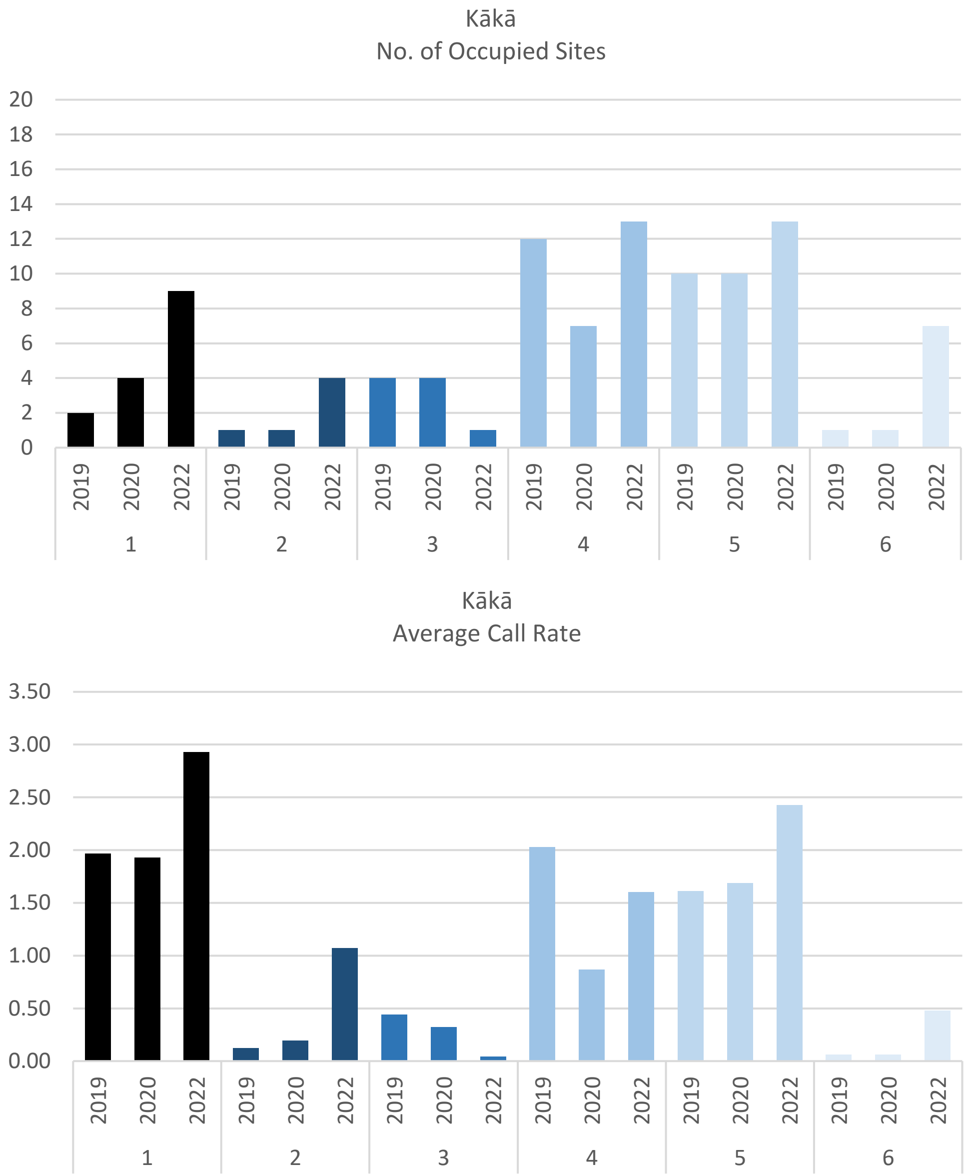


Figure 15: Kākā minimum number of occupied sites (top) and average acoustic detection rates (bottom) per stratum. See Tab.1 for elevation strata.

Kākā: increased in occupancy by 43 % and ADRs raised by 40 % over between the last two monitoring seasons (Tabs.2 & 3). This increase was observed across all elevation strata (except for stratum 3, Tab. 4, Fig. 15). Spatial mapping of results identifies Anchorage/Torrent Bay and Buttress Stream as the main expansion areas in addition to the traditional strongholds in the Upper Wainui and around the translocation site at Bark Bay (Fig. 16).

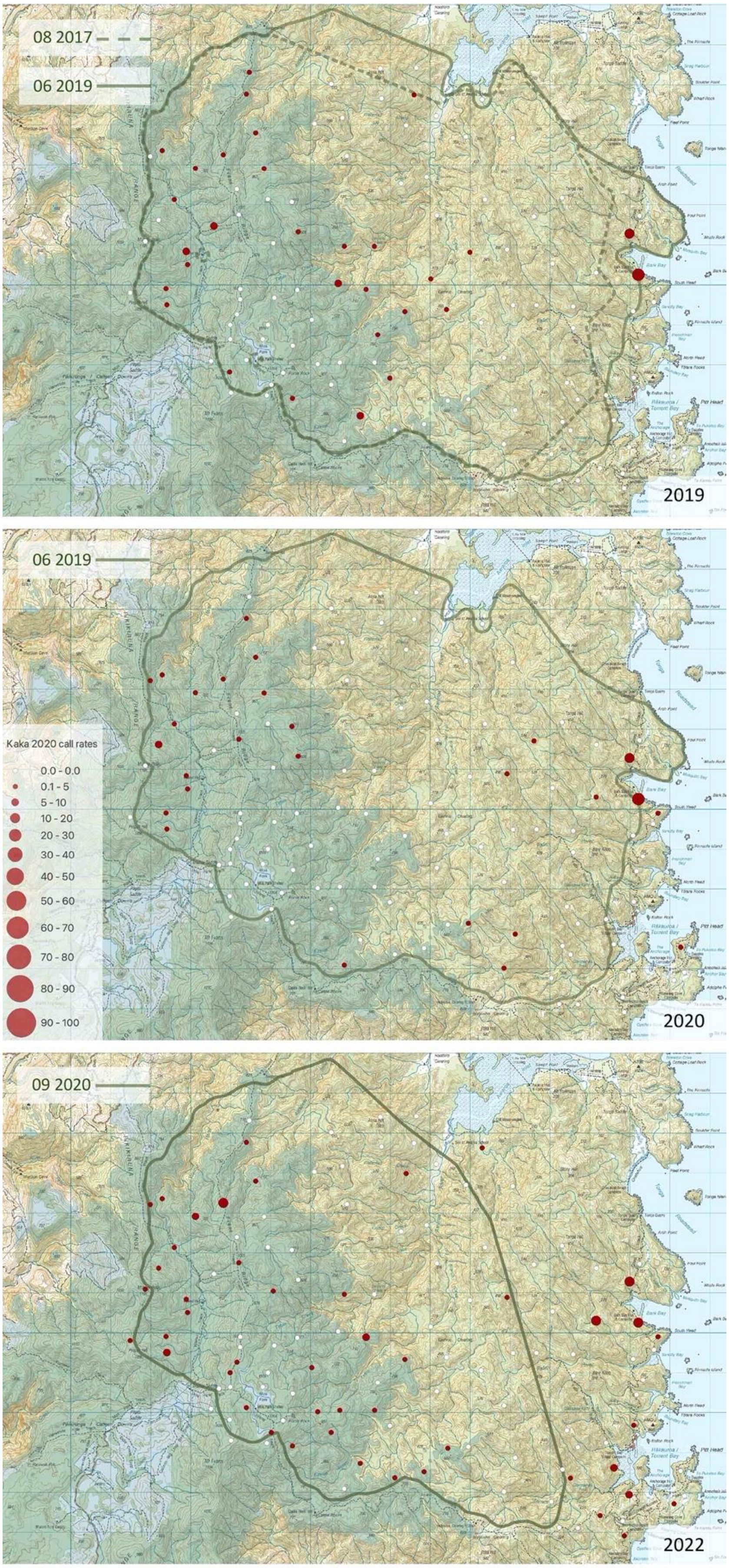


Figure 16: Kākā acoustic detection rates and minimum occupancy. Dark green shapes= latest relevant aerial treatment, dates of operation see top left corner of the maps. Blue highlight: > 600m ASL.

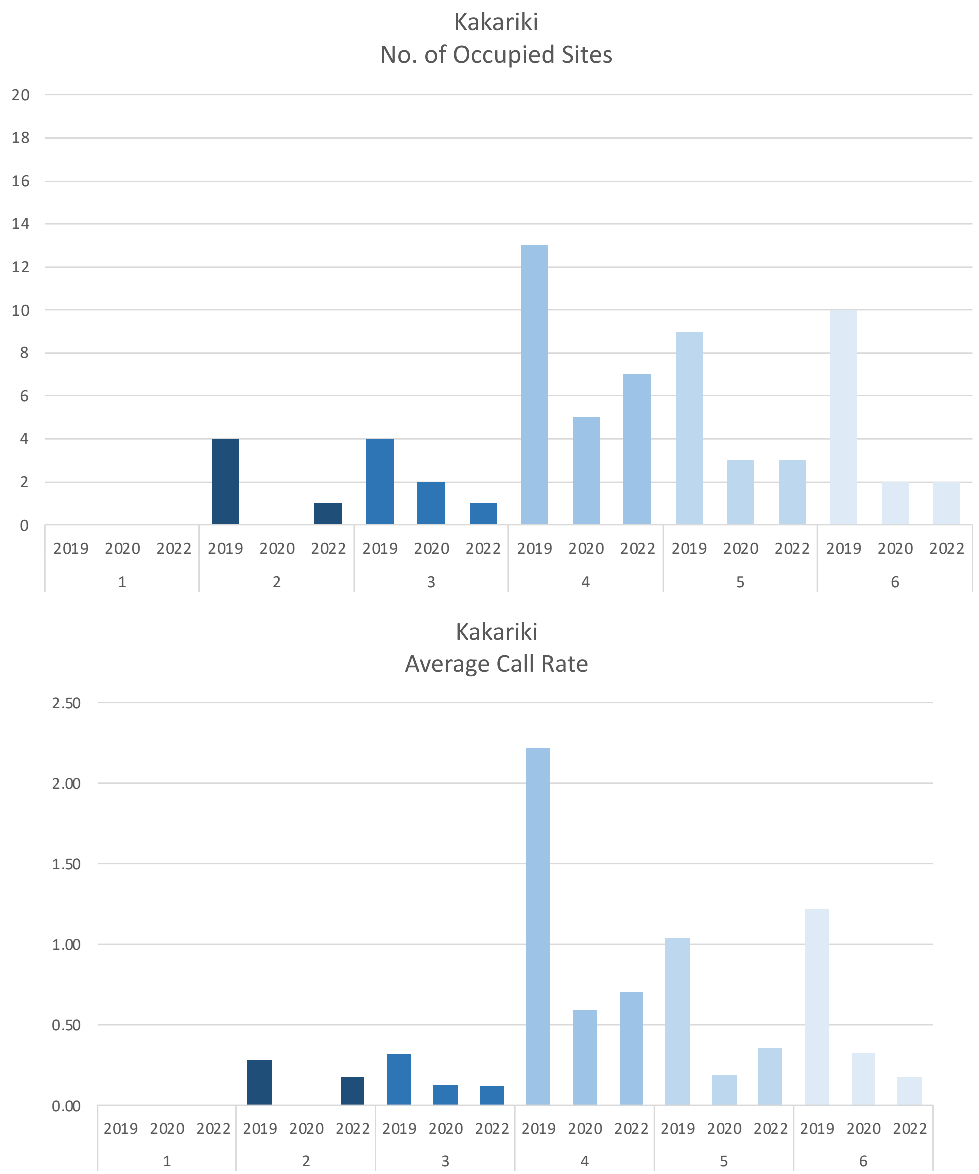


Figure 17: Kākāriki minimum number of occupied sites (top) and average acoustic detection rates (bottom) per stratum. See Tab.1 for elevation strata.

Kākāriki: did not reveal a noticeable recovery from the decrease in occupancy or ADR in 2020 (Tabs. 2 & 3, Fig. 17). The decrease occurred across all elevation strata (Tab. 4). Figure 18 shows a patchy and irregular distribution of parakeets across the study.

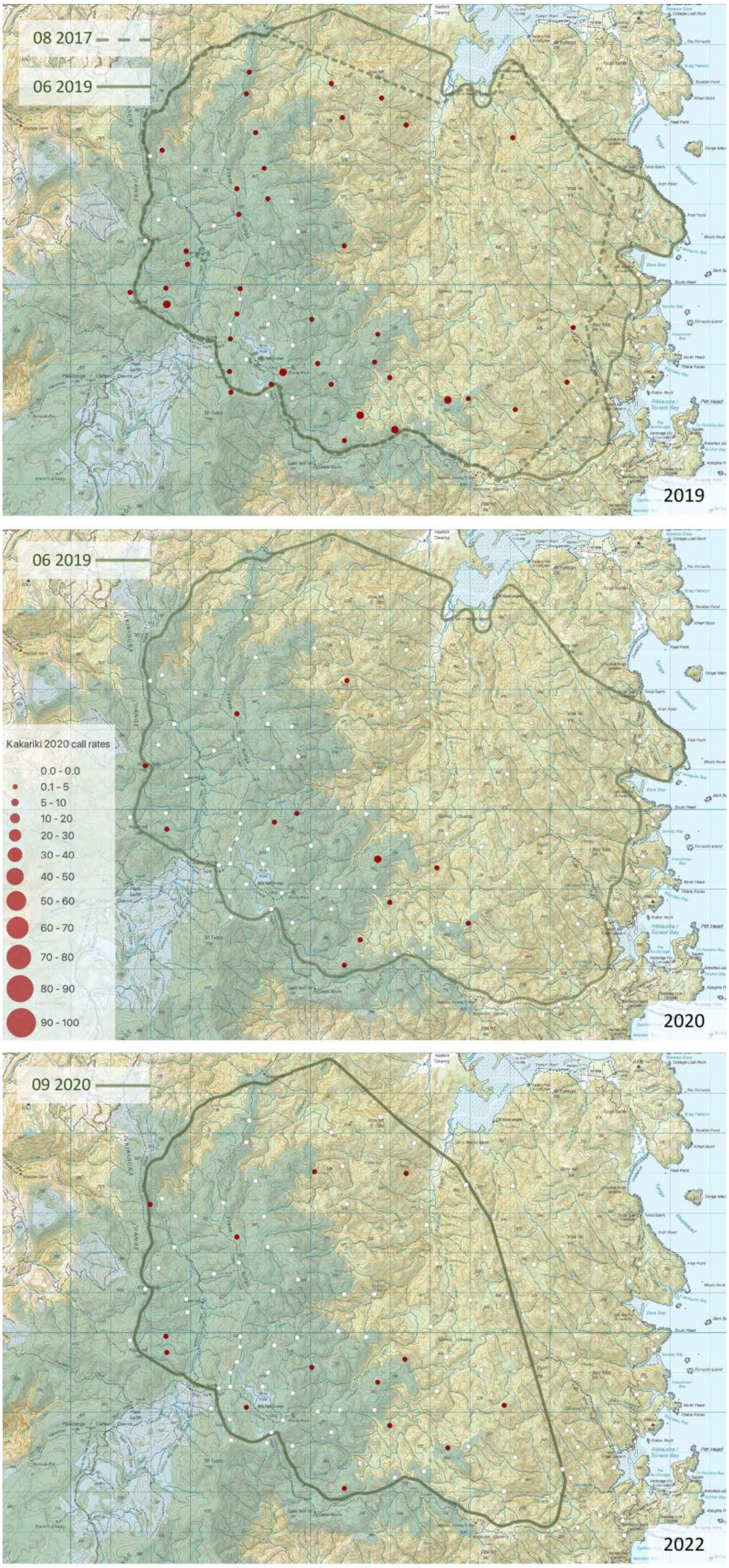
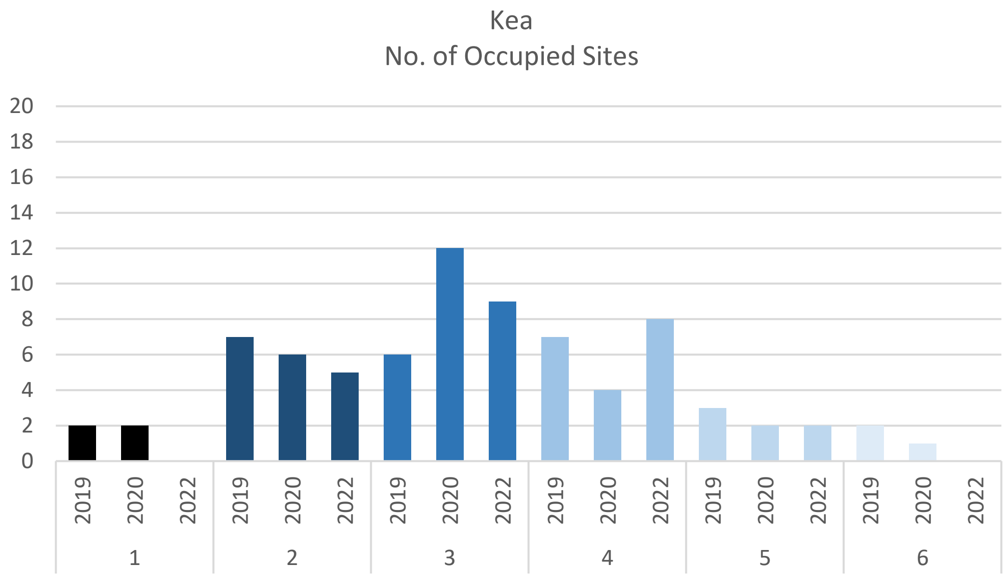


Figure 18: Kākāriki acoustic detection rates and minimum occupancy. Dark green shapes= latest aerial treatment, dates of operation see top left corner of the maps. Blue highlight: > 600m ASL.



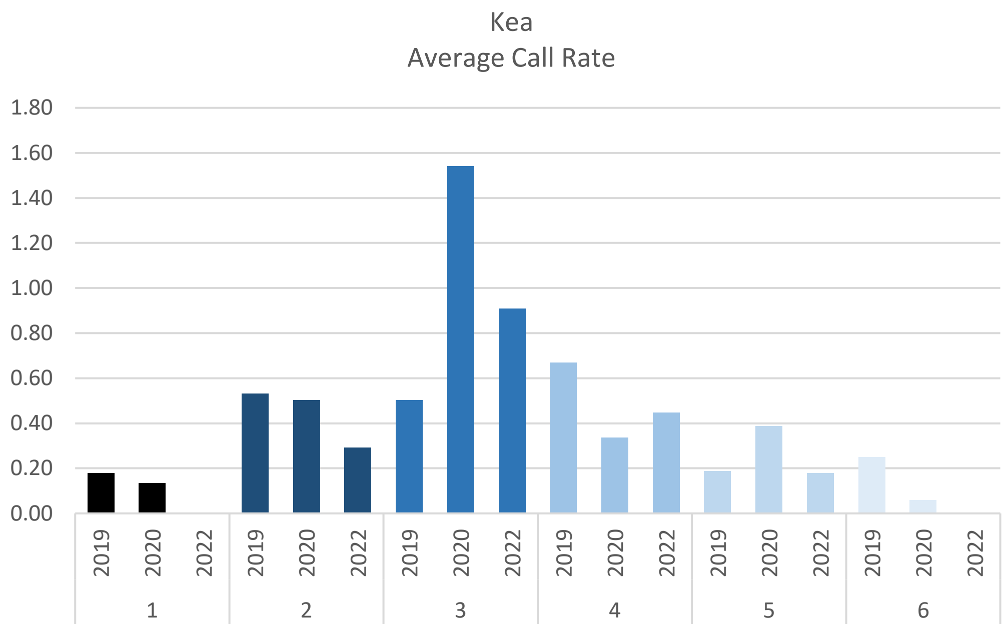


Figure 19: Kea minimum number of occupied sites (top) and average acoustic detection rates (bottom) per stratum. See Tab.1 for elevation strata.

Kea: The distribution of kea varies within the study area (Figs. 19 & 20), but overall occupancy over time remains similar (Tab. 2). Average ADRs are very low (Tab. 3, Fig. 19), but kea appear across all elevation strata, mainly across the midlands.

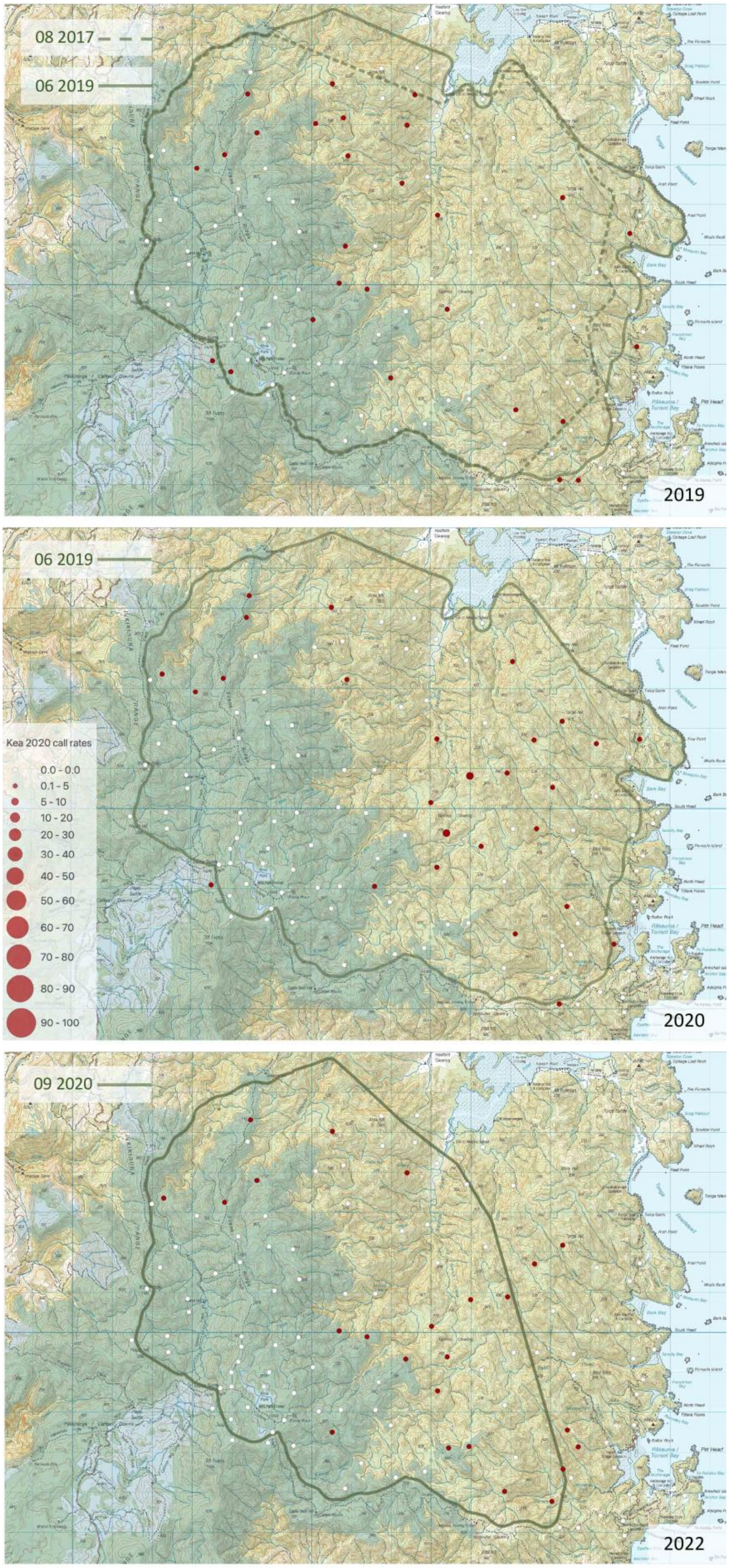


Figure 20: Kea annual detection rates and minimum occupancy. Dark green shapes= latest relevant aerial treatment, dates of operation see top left corner of the maps. Blue highlight: > 600m ASL.

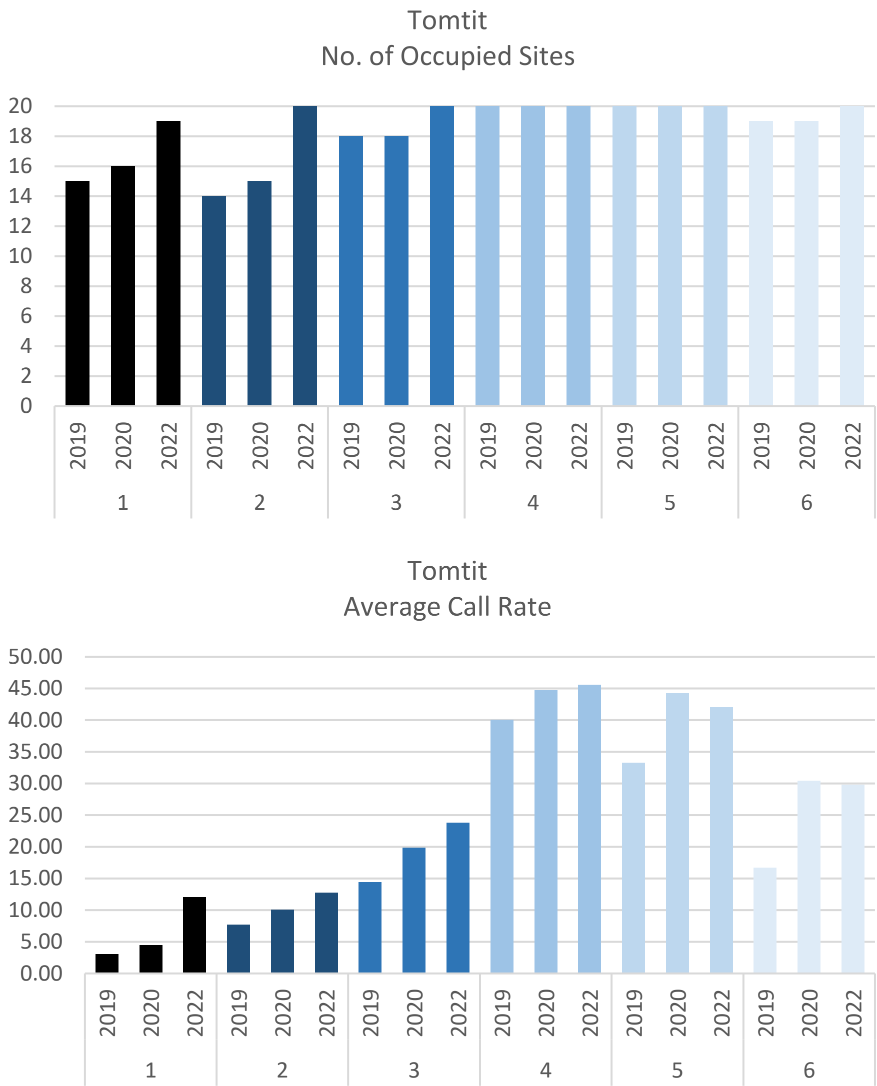


Figure 21: Tomtit minimum number of occupied sites (top) and average acoustic detection rates (bottom) per stratum. See Tab.1 for elevation strata.

Tomtit: Tomtits constantly increased in both occupancy (Tab.2, Fig. 21) and ADRs (Tab.3, Fig. 21). Over the last four years, occupancy and ADR rose by 11 % and 30 %, respectively. Tomtits are most common above 600m elevation (Tab. 4, Fig. 22) but the increase in occupancy and ADR was mainly observed below 600m elevation. ADRs kept increasing across all strata (Fig. 21), even in the top three strata where occupancy has been close to 100 % over the last four years.

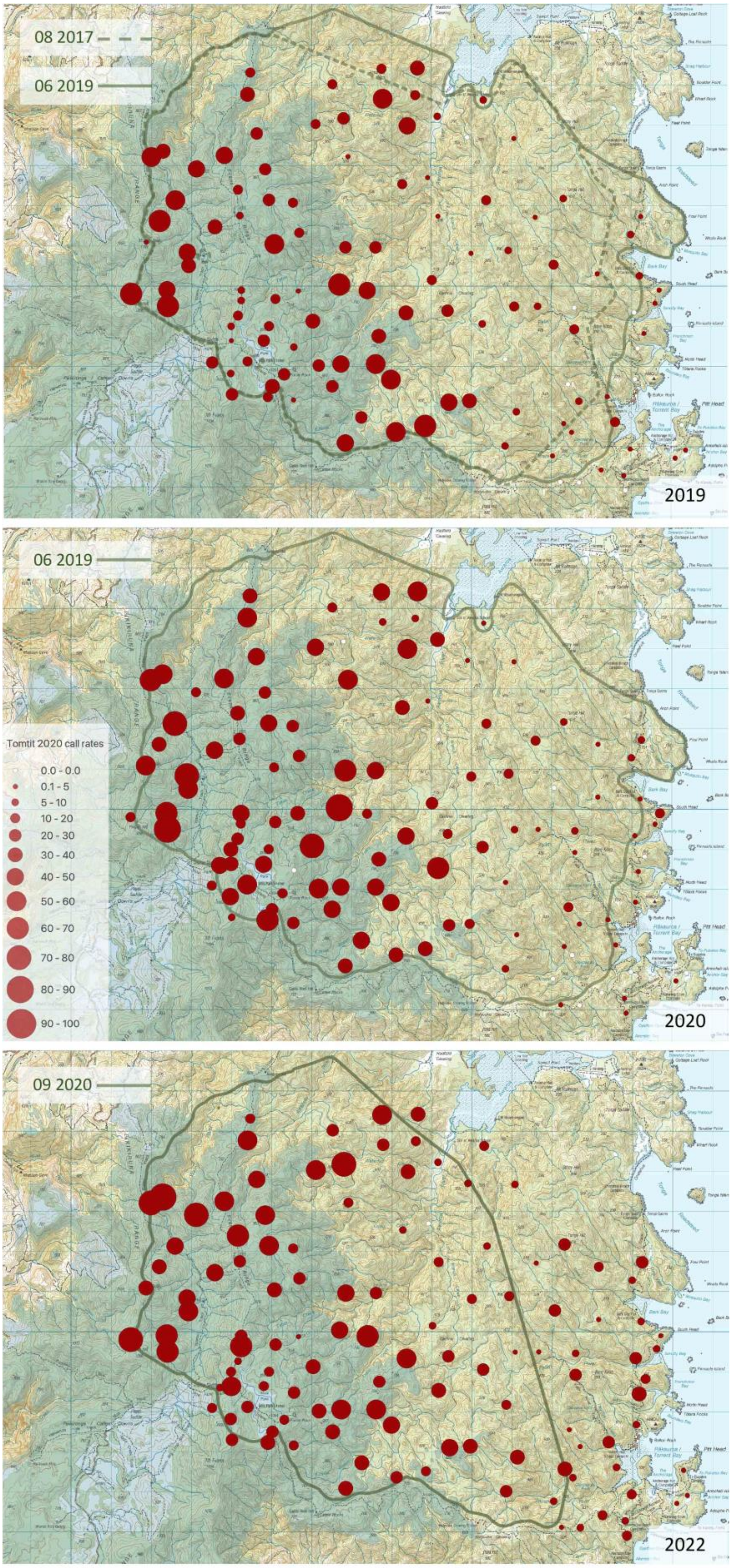


Figure 22: Tomtit acoustic detection rates and minimum occupancy. Dark green shapes= latest aerial treatment, dates of operation see top left corner of the maps. Blue highlight: > 600m ASL.

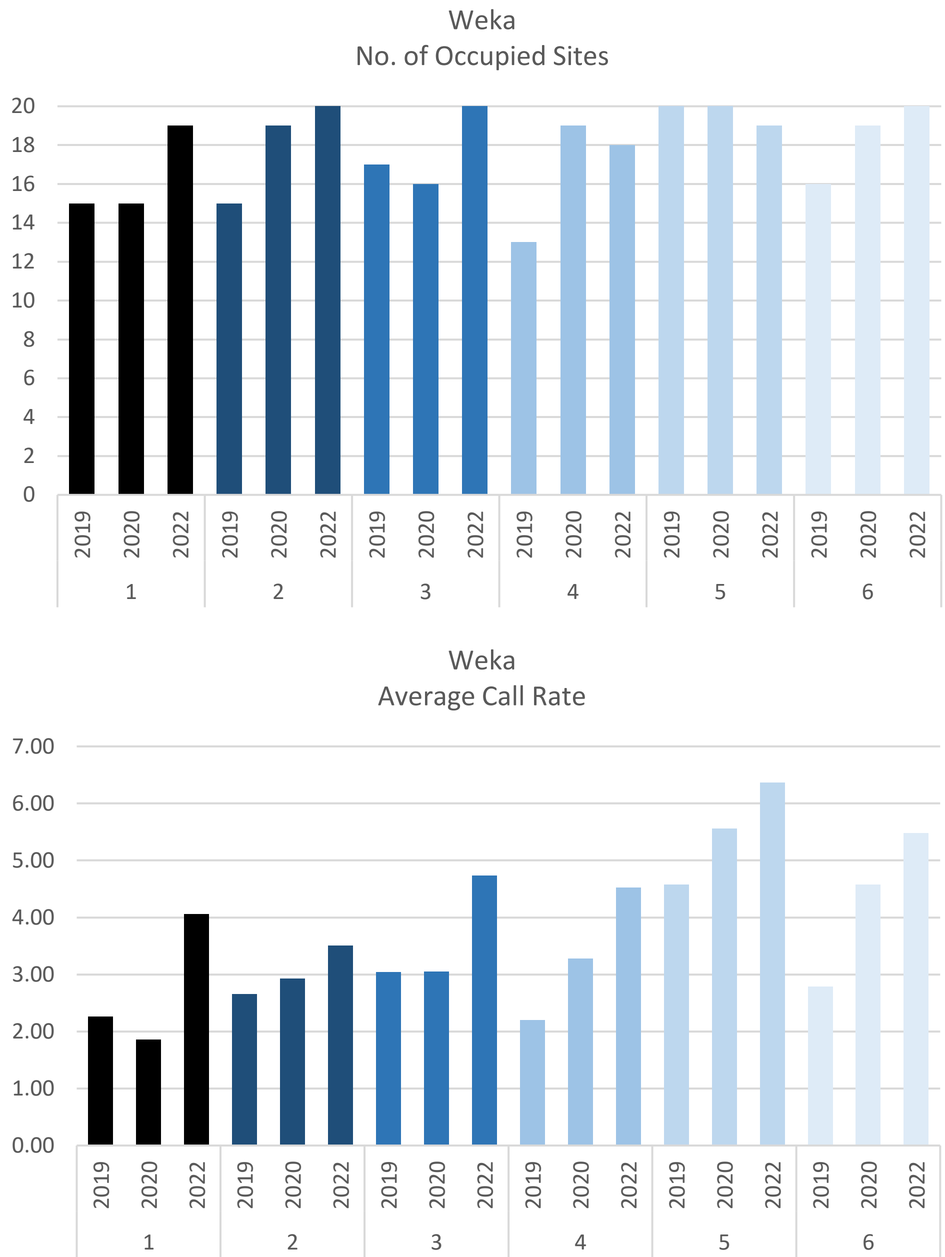


Figure 23: Weka minimum number of occupied sites (top) and average acoustic detection rates (bottom) per stratum. See Tab.1 for elevation strata.

Weka: Weka are close to reaching 100 % occupancy in the study area (Tab. 2, Figs. 23 & 24). Like tomtits, ADRs keep increasing even when occupancy is at or close to 100 %. Calls rates are low, but calls are only counted once per 15s-annotation frame, even when multiple birds are calling simultaneously.

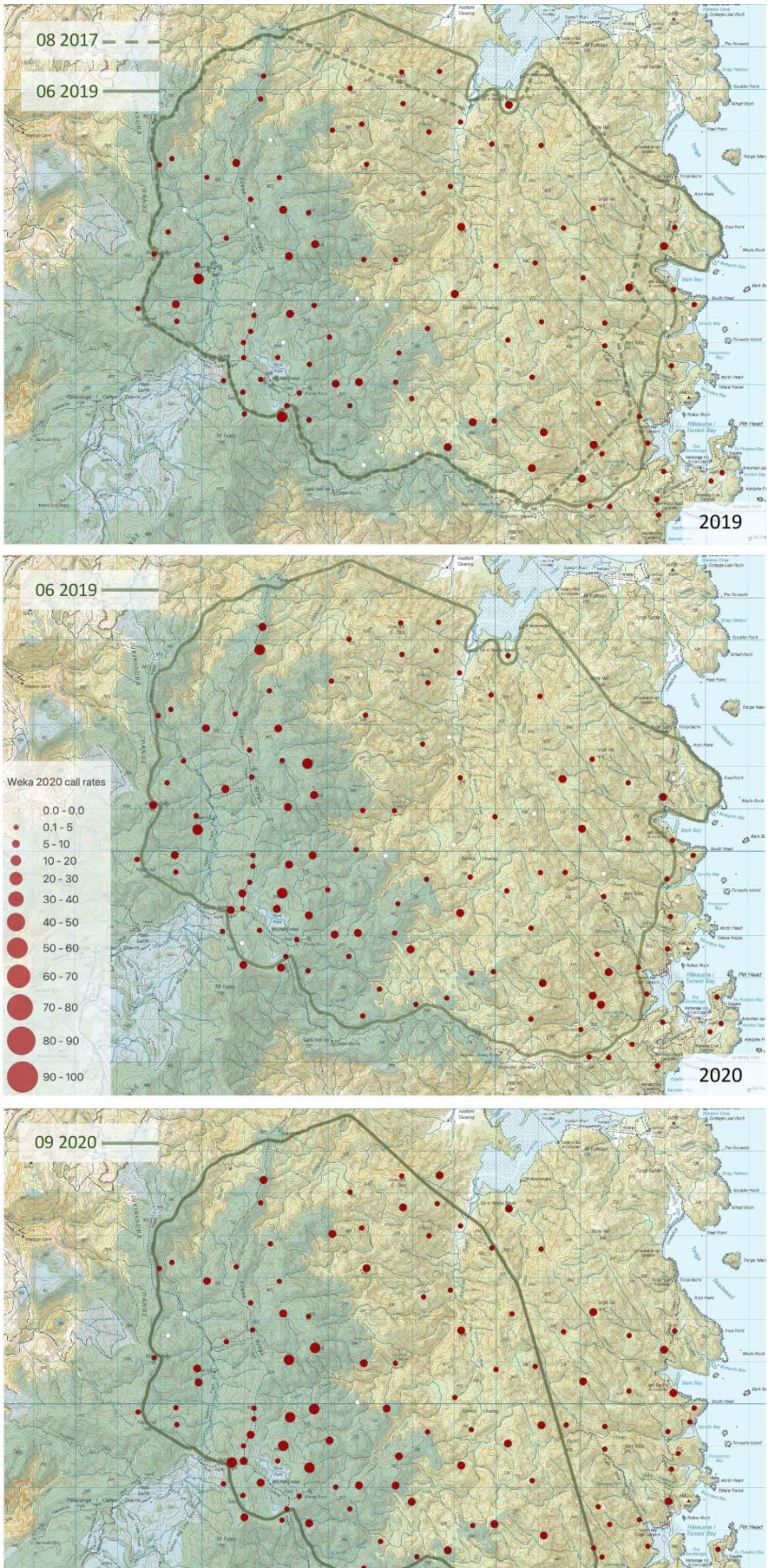
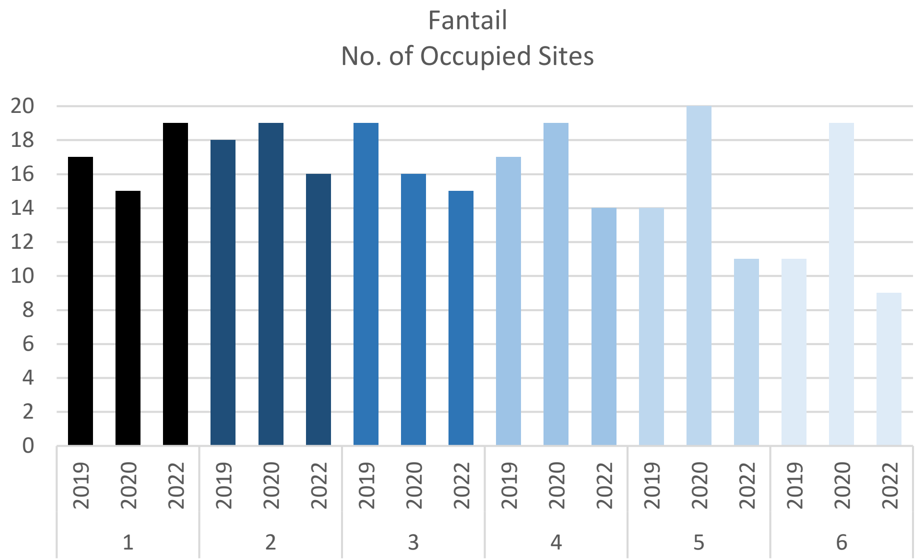


Figure 24: Weka acoustic detection rates and minimum occupancy. Dark green shapes= latest relevant aerial treatment, dates of operation see top left corner of the maps. Blue highlight: > 600m ASL.



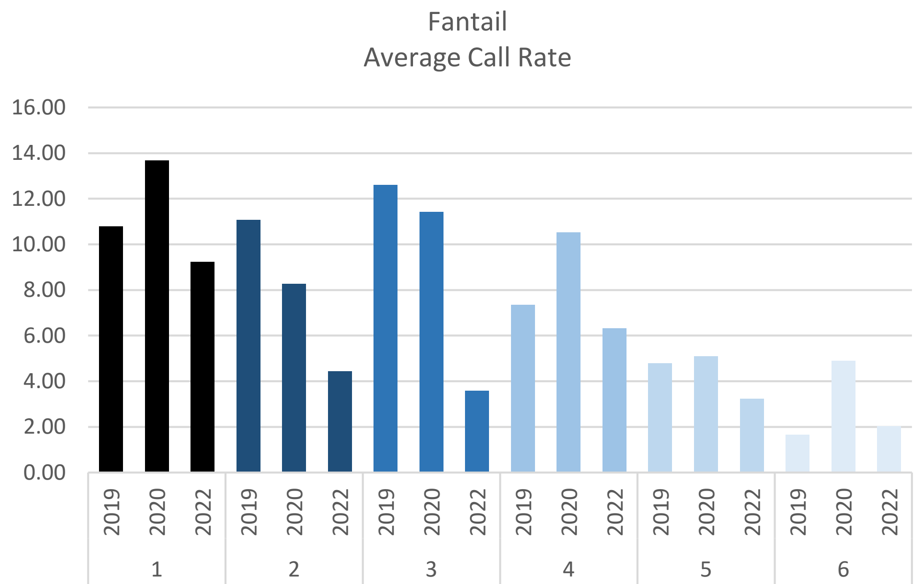


Figure 25: Fantail minimum number of occupied sites (top) and average acoustic detection rates (bottom) per stratum. See Tab.1 for elevation strata.

Fantail: Stratum 1is the only area where fantails increased in occupancy (Tab. 4), although ADRs decreased. Over the last two years, occupancy mainly decreased in the uplands (Tab. 4, Figs. 25 & 26).

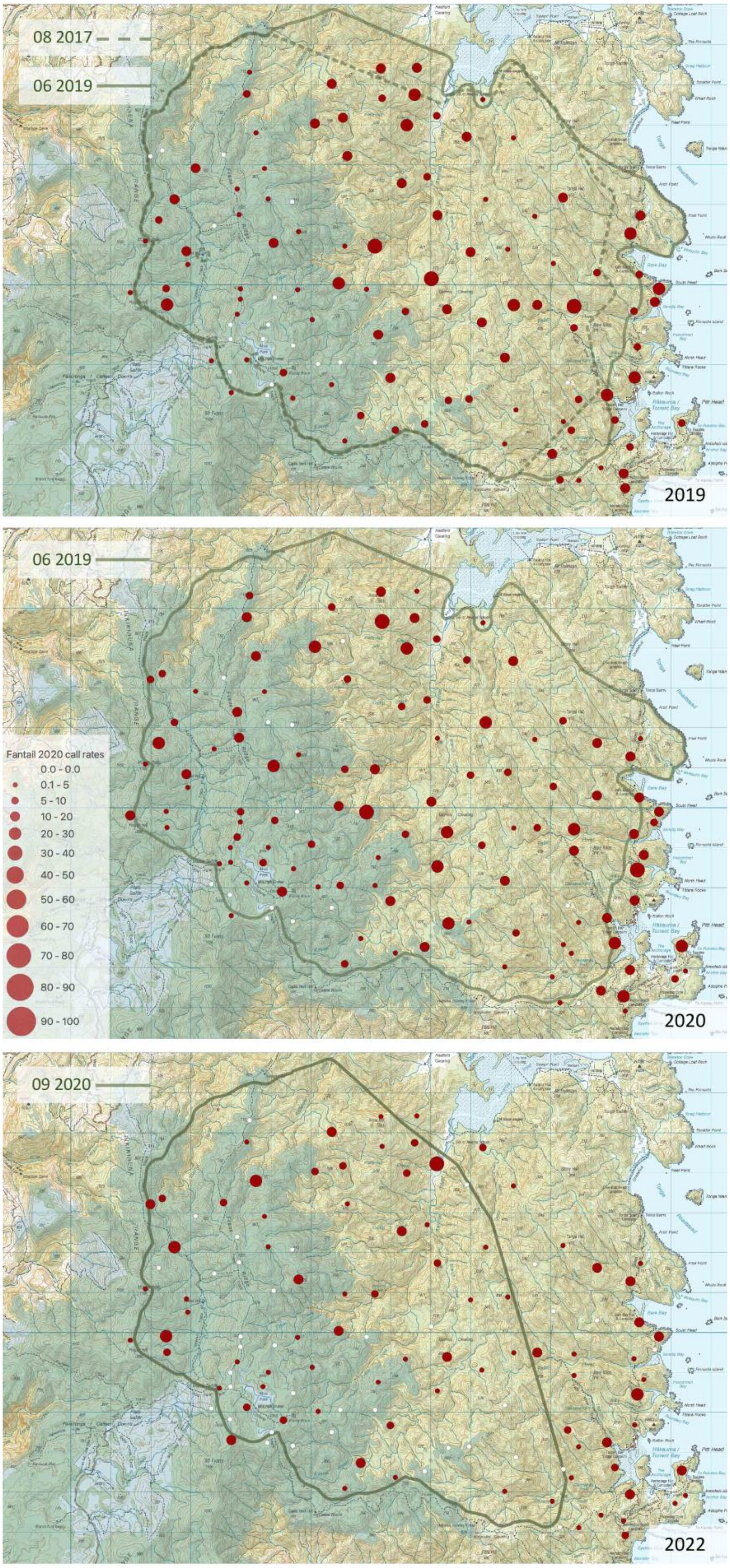
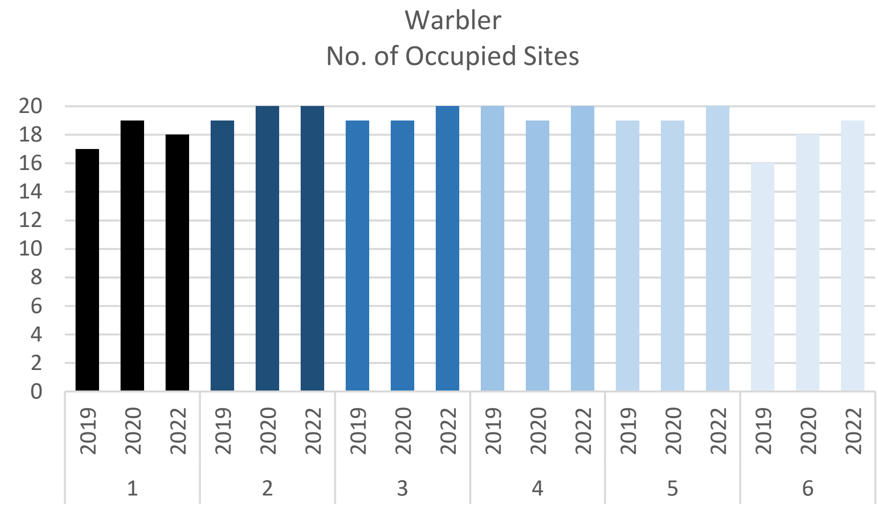


Figure 26: Fantail acoustic detection rates and minimum occupancy. Dark green shapes= latest aerial treatment, dates of operation see top left corner of the maps. Blue highlight: > 600m ASL.



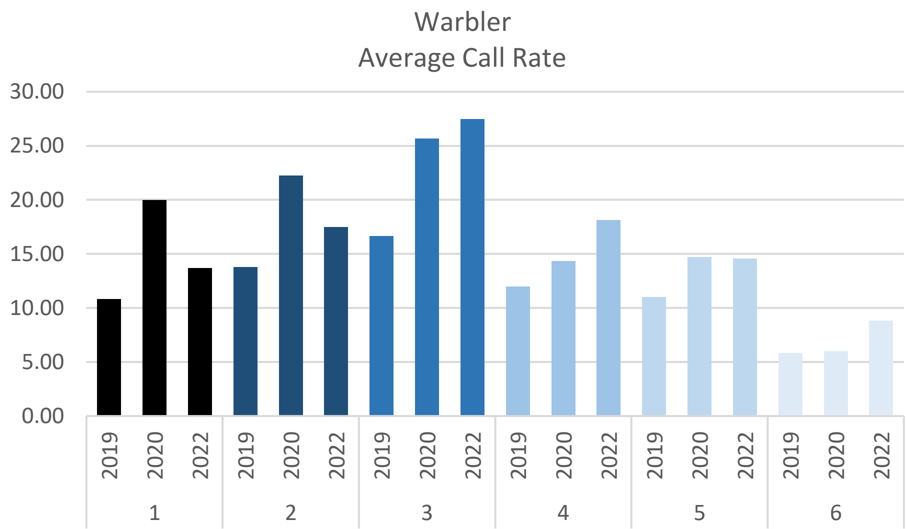


Figure 27: Grey warbler minimum number of occupied sites (top) and average acoustic detection rates (bottom) per stratum. See Tab.1 for elevation strata.

Grey warbler: Warbler have been present across the monitoring area from the beginning with an increase in occupancy over the last four years (Tab. 2). ADRs are on the rise, as well, except for the lowlands (Fig. 27).

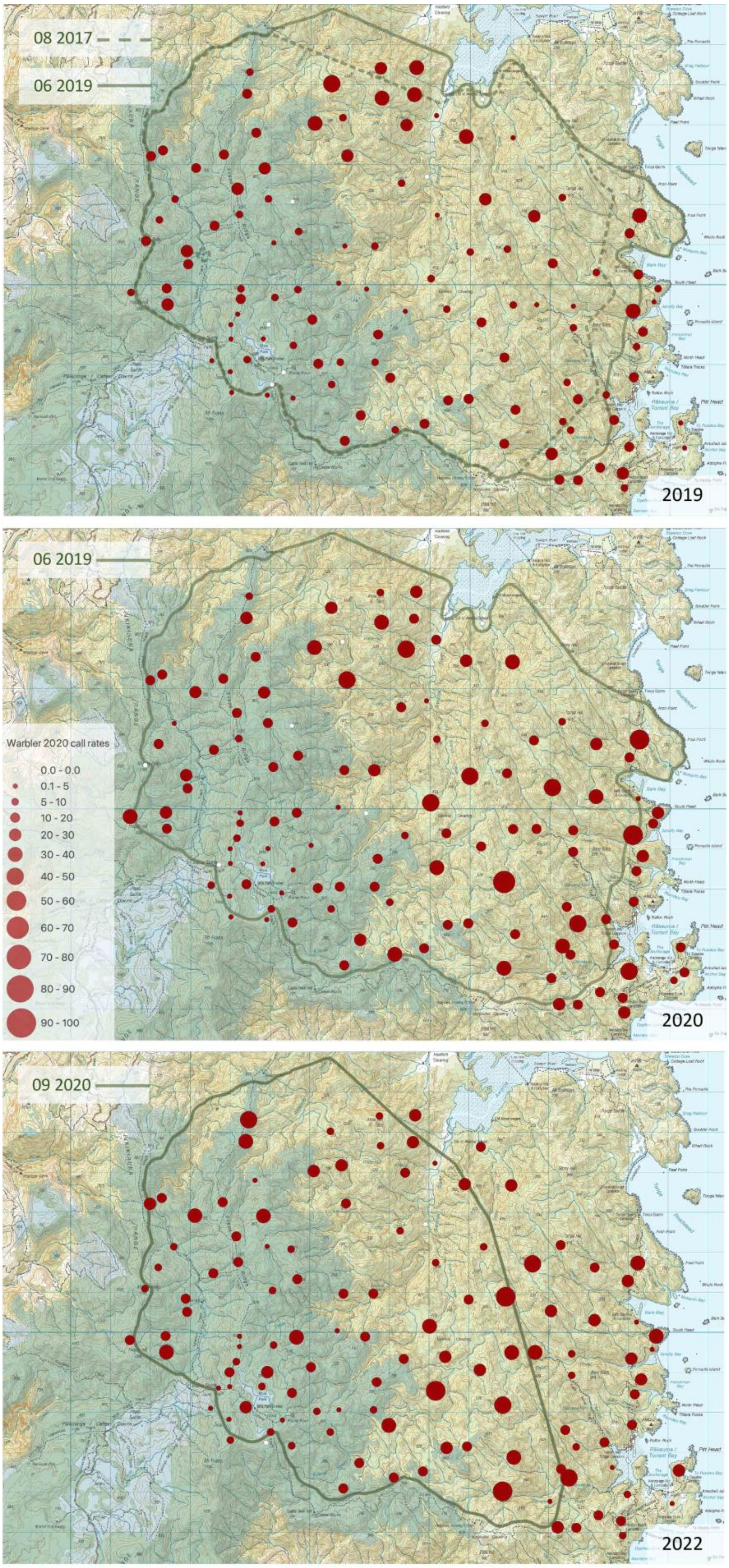


Figure 28: Grey warbler acoustic detection rates and minimum occupancy. Dark green shapes= latest aerial treatment, dates of operation see top left corner of the maps. Blue highlight: > 600m ASL.

Figure 29: Silvereye minimum number of occupied sites (top) and average acoustic detection rates (bottom) per stratum. See Tab.1 for elevation strata.

Silvereye: Silvereye occupancy decreased slightly (Tab. 2, Fig. 29), with most of the losses being observed in the uplands (Tab. 4, Figs. 20 & 30). The decrease is more prominent within ADRs (Tab. 3, Figs. 29 &30), with an average loss of almost 50 % over the last four years across all elevation strata.

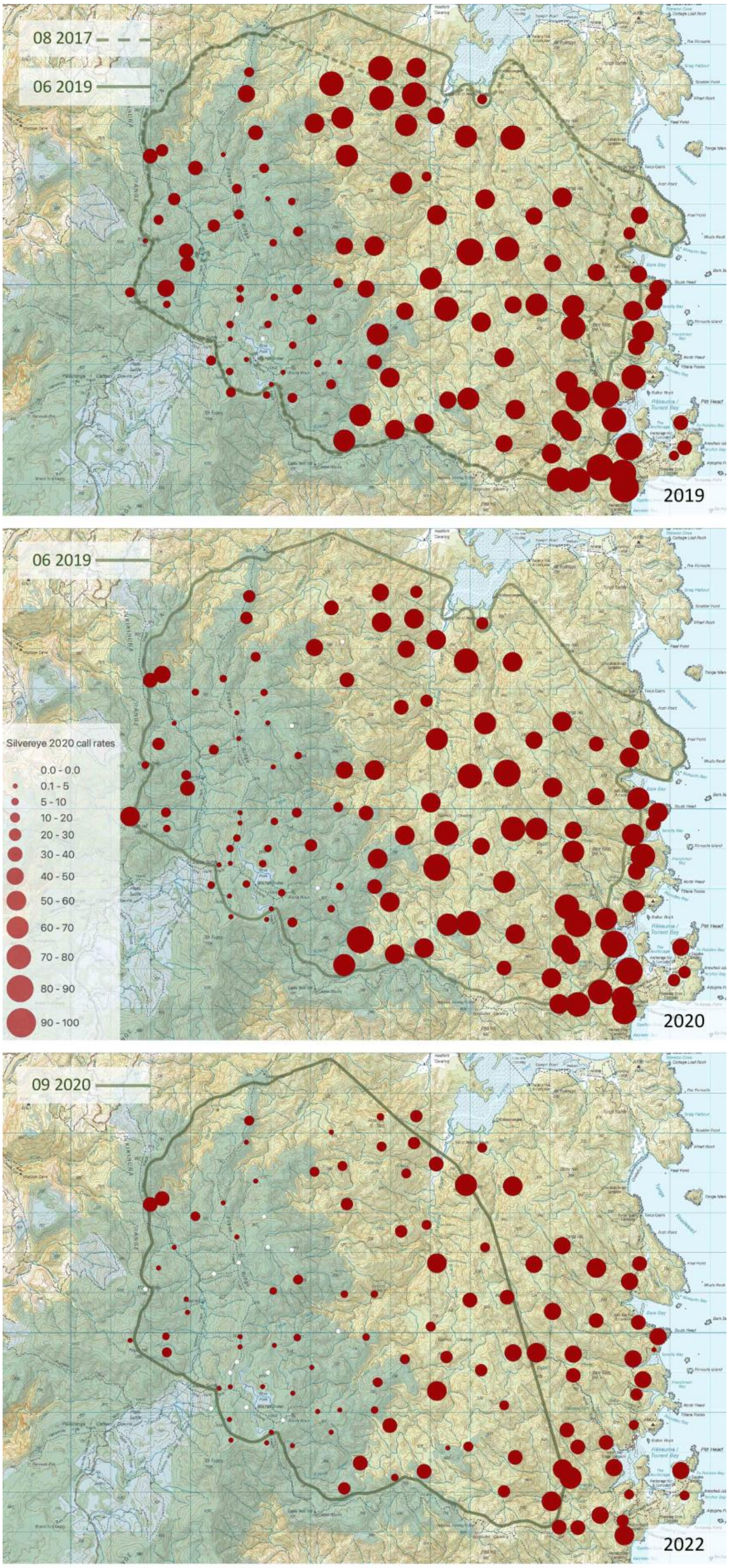


Figure 30: Silvereye acoustic detection rates and minimum occupancy. Dark green shapes= latest aerial treatment, dates of operation see top left corner of the maps. Blue highlight: > 600m ASL.

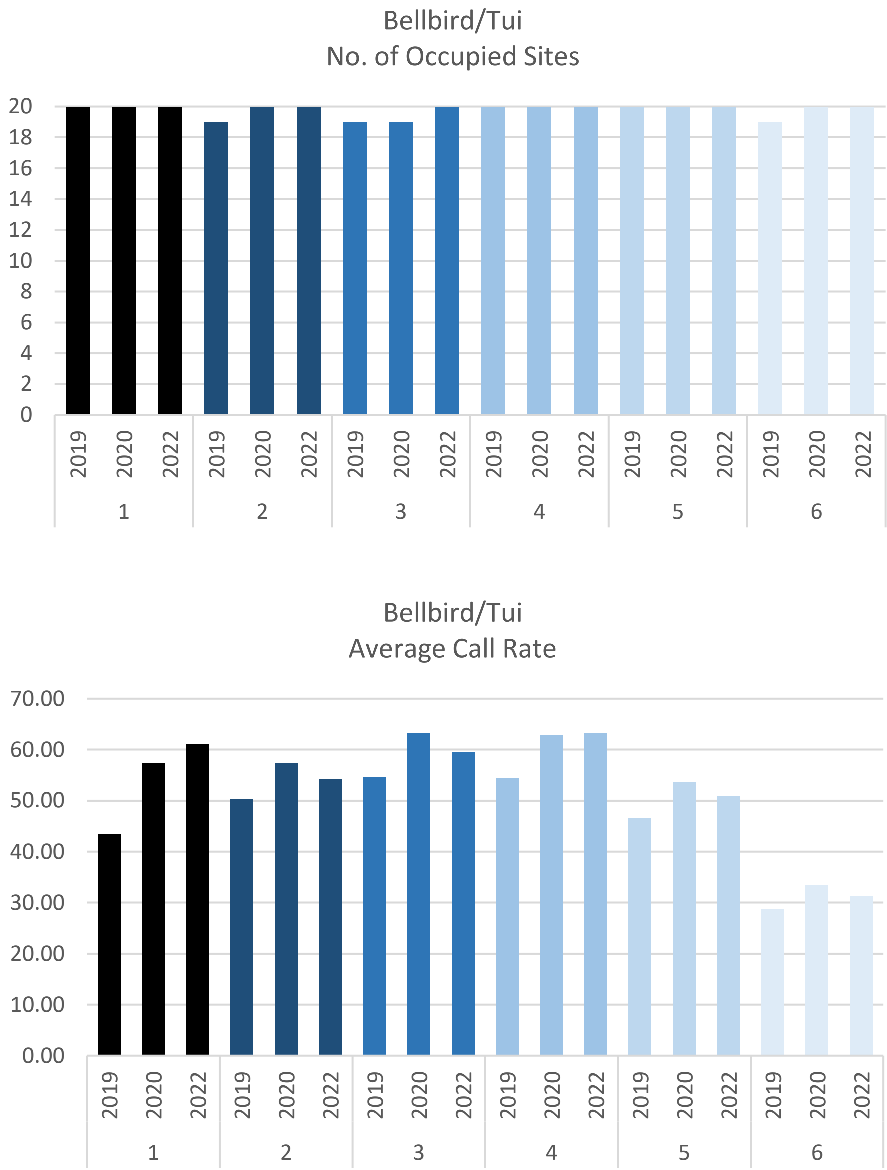


Figure 31: Bellbird/Tui minimum number of occupied sites (top) and average acoustic detection rates (bottom) per stratum. See Tab.1 for elevation strata.

Bellbird/Tui: Bellbird and tui counts were pooled as both species mimic each other and are hard to discriminate based on auditory clues alone. Occupancy first reached 100 % in 2022 (Tab. 2, Fig. 31). ADRs increased initially but remained stable over between the last two monitoring seasons (Tab. 3). Call rates tend to be higher in the lowlands (Fig. 31).

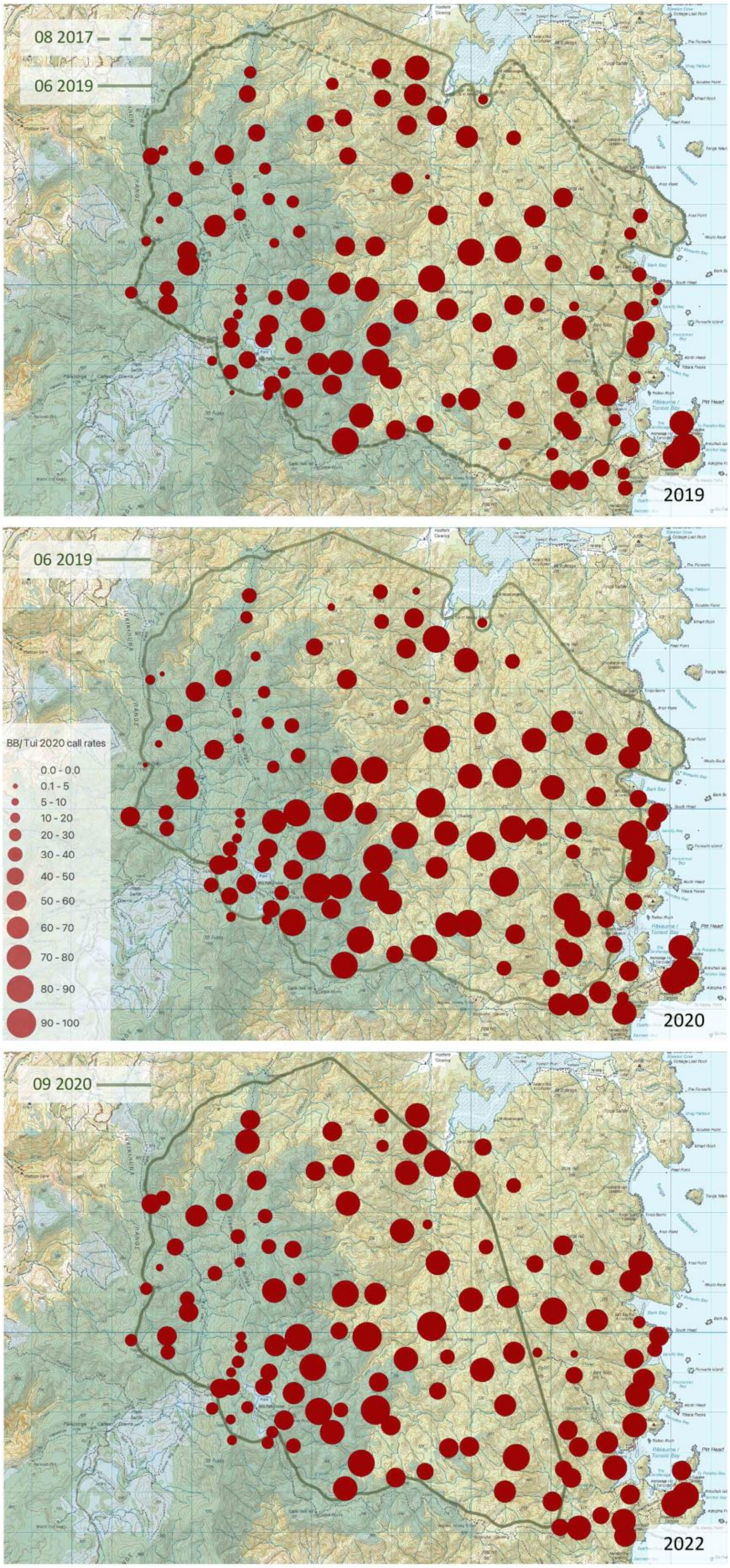
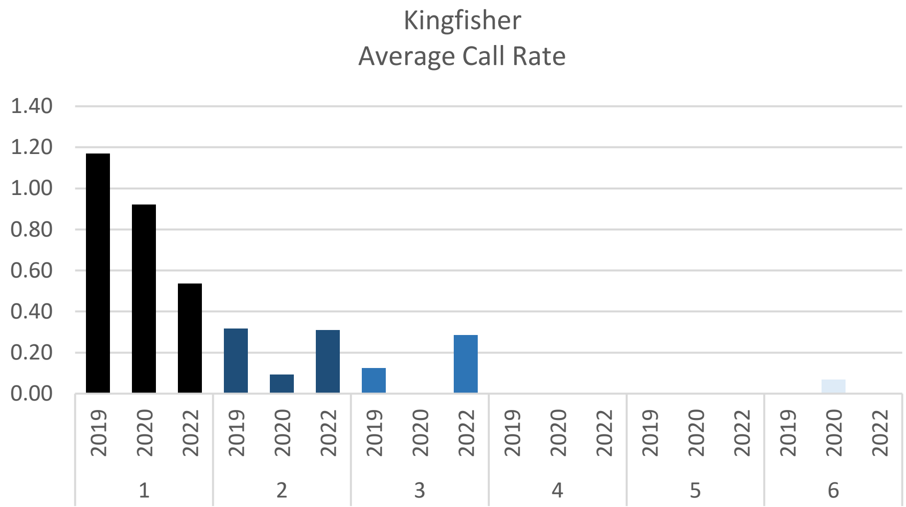


Figure 32: Bellbird/Tui acoustic detection rates and minimum occupancy. Dark green shapes= latest aerial treatment, dates of operation see top left corner of the maps. Blue highlight: > 600m ASL.



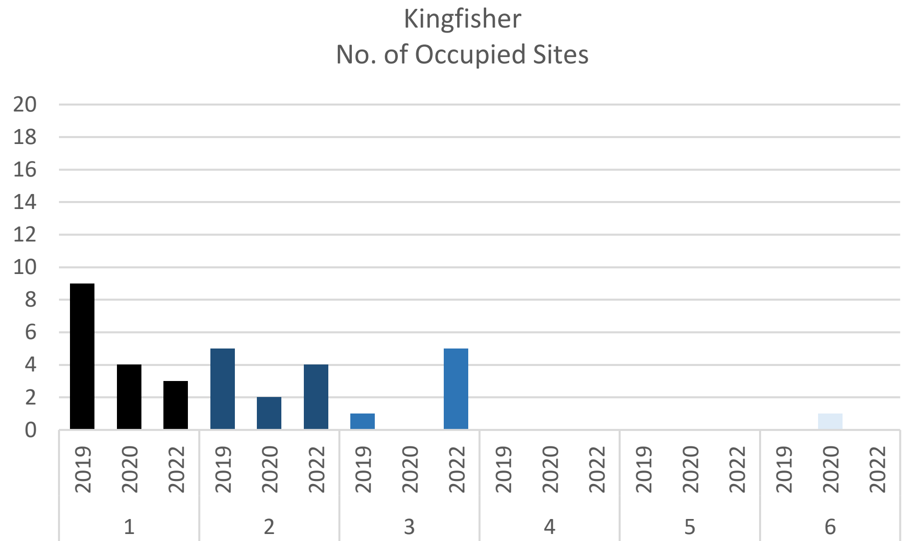


Figure 33: Kingfisher minimum number of occupied sites (top) and average acoustic detection rates (bottom) per stratum. See Tab.1 for elevation strata.

Kingfisher: Occupancy and ADRs are lowest of all species reported in this study. Kingfisher are mainly detected in lowlands and along the coast. There is no clear trend.

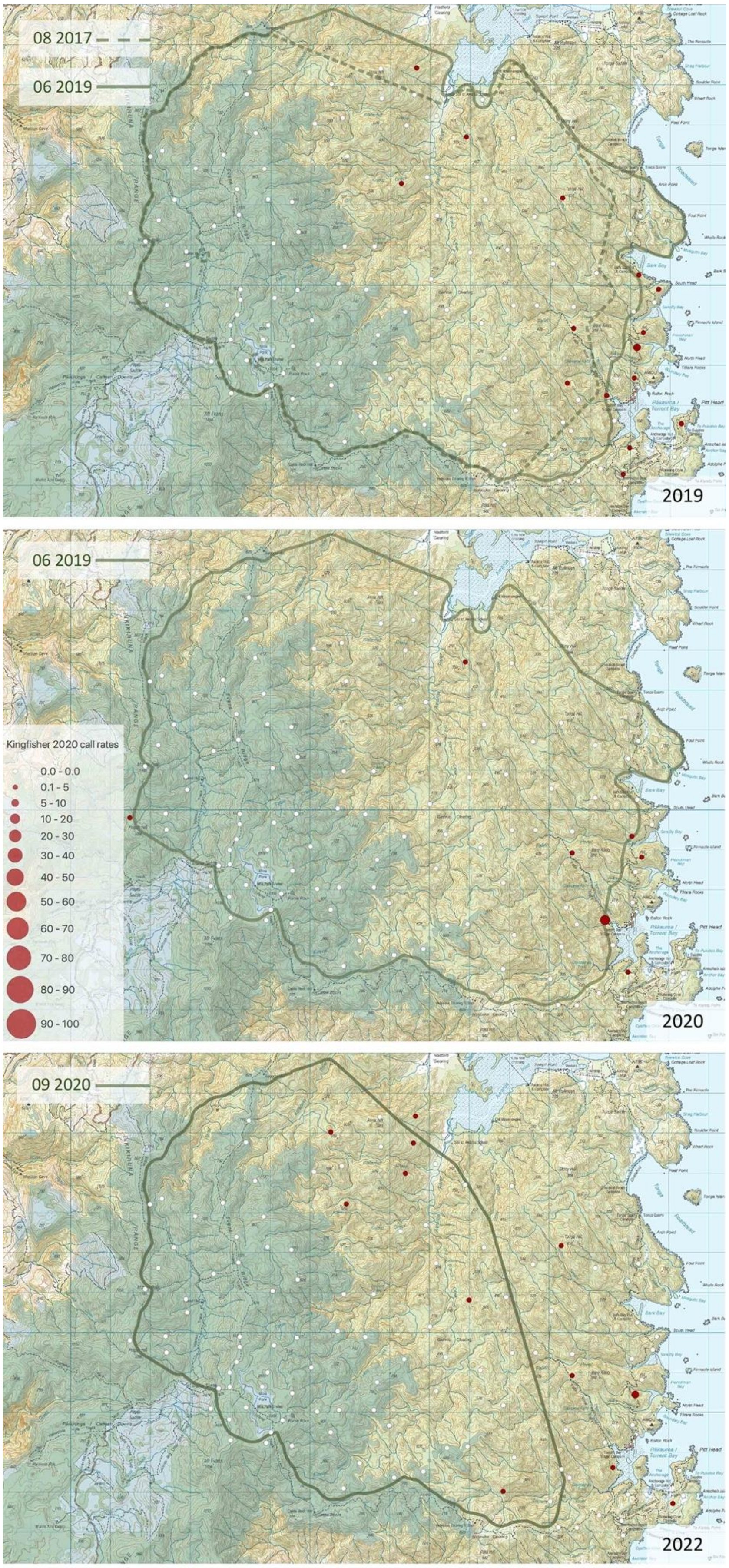
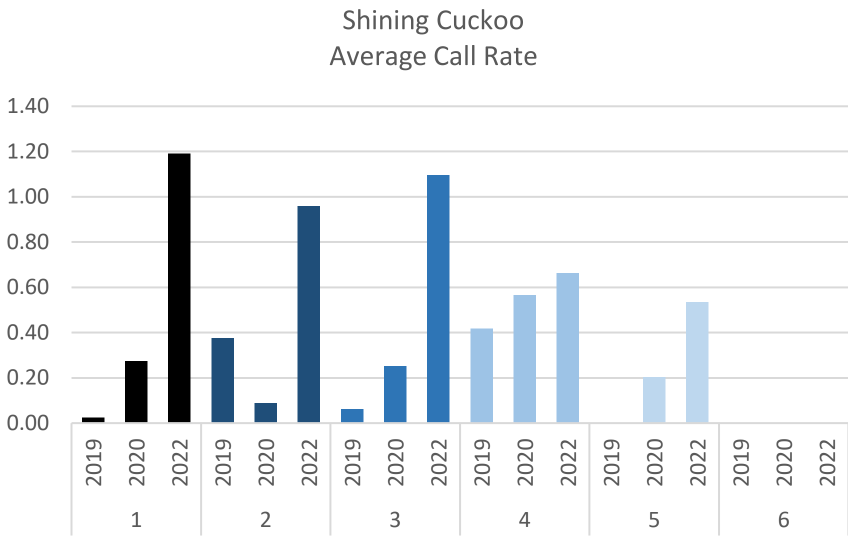


Figure 34: Kingfisher acoustic detection rates and minimum occupancy. Dark green shapes= latest aerial treatment, dates of operation see top left corner of the maps. Blue highlight: > 600m ASL.



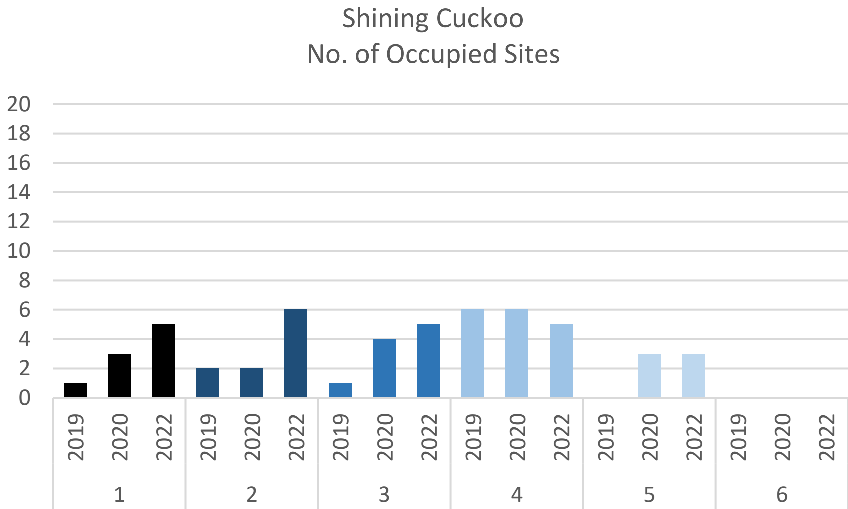


Figure 35: Shining Cuckoo minimum number of occupied sites (top) and average acoustic detection rates (bottom) per stratum. See Tab.1 for elevation strata.

Shining Cuckoo: This species shows a constant increase in both occupancy and ADRs (Tabs. 2 & 3, Fig. 35), especially in the area below 600m elevation. High ADRs coincide with high ADRs of grey warbler (Figs. 36 & 28), the host of shining cuckoos.

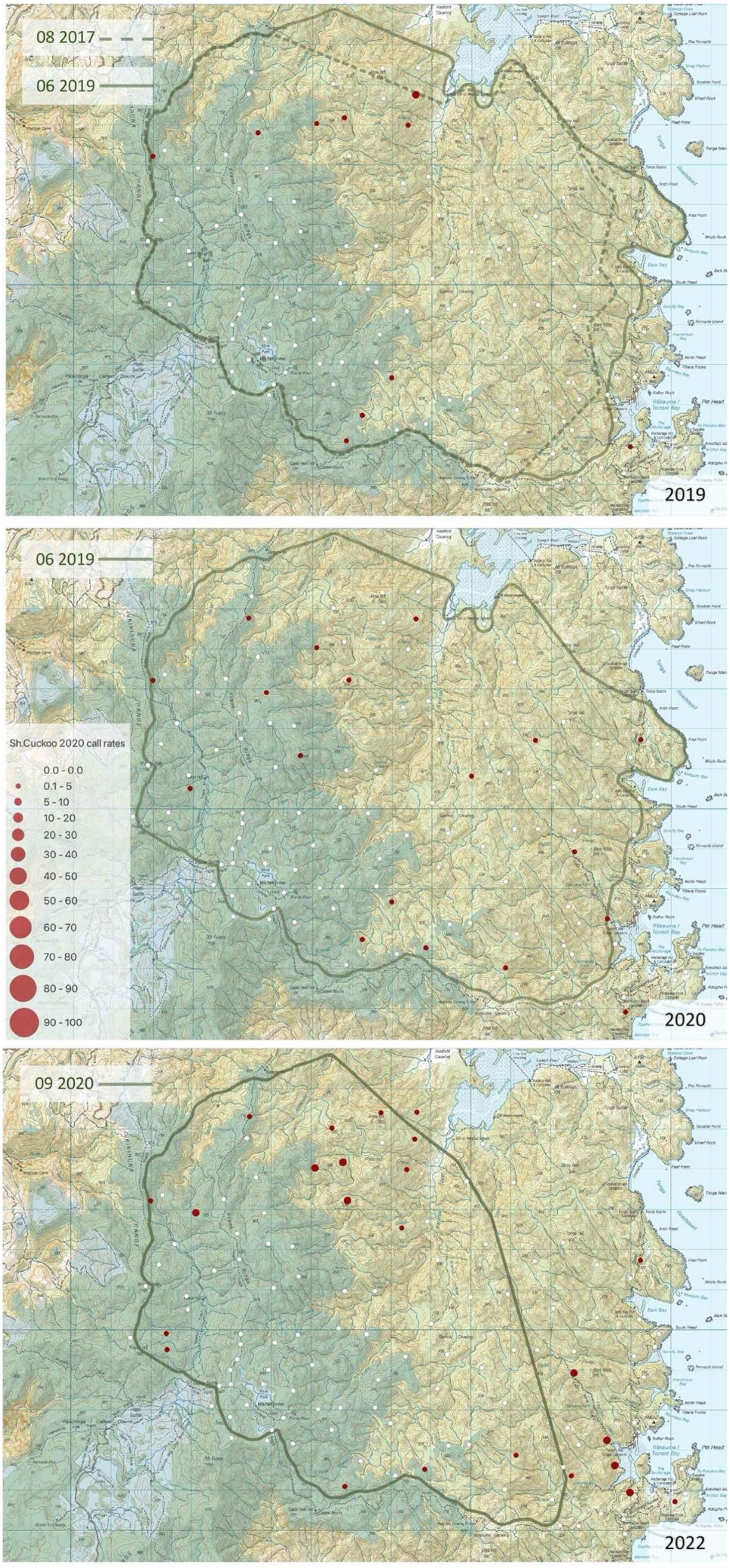


Figure 36: Shining cuckoo acoustic detection rates and minimum occupancy. Dark green shapes= latest aerial treatment, dates of operation see top left corner of the maps. Blue highlight: > 600m ASL.

Standard sampling versus deep sampling

The standard sub-sampling strategy was 45s sampling in the morning and late afternoon, respectively, applying intermittent sampling of 15s-intervalls every 5 minutes. A previous sampling sensitivity study revealed that birds are likely to be missed under the standard sampling strategy if call ADRs are below 1-2 % (see previous report). Simulations based on eight locations with full annotations showed that the most efficient sampling strategy is to sample 10s every 2.5 minutes, resulted in 84 % detection probability for any species present in the recordings. This deep sub-sampling strategy was applied to eight selected sites from the mid-range elevation strata (Tab. 6, Fig. 37) during the morning recording hours. Results confirm that birds with low call rates, e.g. kākāriki, kea and robin in low population density areas, are likely to be missed. For birds with high call rates ADRs were similar for both sampling strategies, but variance increased as call rates decreased. On average, ADRs varied 3.5 percentage points between standard and deep sub-sampling (Tab.6).

Table 6: Comparison of ADRs for selected locations (ID) with standard sub-sampling (S) and deep sub-sampling (D). Cases where a bird was only detected with deep sampling are highlighted in green. Note that data are based on morning recordings only, thus underrepresenting species like weka that predominantly call in the evening.

	Robin		**Silvereye**		**Fantail**		**Bellbird/Tui**		**Tomtit**		**Weka**		**Kea**		**Parakeet**	
ID	**S**	**D**	**S**	**D**	**S**	**D**	**S**	**D**	**S**	**D**	**S**	**D**	**S**	**D**	**S**	**D**
1_10	25.6	18.6	25.6	26.0	0.0	0.7	87.2	72.9	5.1	7.0	0.0	2.1	7.7	0.8	0.0	1.0
1_11	81.0	64.2	50.0	41.2	4.8	3.7	54.8	40.1	2.4	5.6	2.4	2.6	0.0	0.0	0.0	0.0
1_14	4.76	2.7	83.3	69.9	9.5	7.9	9.5	8.9	4.8	2.6	4.8	0.3	0.0	0.0	0.0	0.3
1_15	0.00	0.0	64.3	60.1	7.1	7.2	9.5	14.5	9.5	9.6	0.0	1.1	0.0	0.0	0.0	0.0
1_4	7.7	5.7	25.6	10.1	2.6	8.9	61.5	50.8	25.6	28.4	0.0	1.2	5.1	0.6	5.1	2.4
1_5	0.00	0.9	14.3	9.8	4.8	0.3	69.0	63.0	54.8	47.7	2.4	2.3	0.0	0.3	0.0	2.1
3_18	0.00	3.8	59.0	58.7	7.7	3.7	51.3	48.4	10.3	11.6	2.6	1.2	0.0	0.1	0.0	0.0
3_9	0.00	0.0	48.7	44.2	7.8	1.6	53.9	46.5	20.5	15.6	0.0	1.0	0.0	0.8	0.0	0.0

Percentage points difference:

	Robin	Silvereye	Fantail	Bellbird/Tui	Tomtit	Weka	Kea	Parakeet
1_10	7.0	0.3	0.7	14.3	1.9	2.1	6.9	1.0
1_11	16.8	8.8	1.1	14.6	3.2	0.2	0.0	0.0
1_14	2.04	13.5	1.6	0.6	2.2	4.5	0.0	0.3
1_15	0.0	4.2	0.1	5.0	0.1	1.1	0.0	0.0
1_4	2.0	15.6	6.3	10.7	2.8	1.2	4.5	2.7
1_5	0.9	4.5	4.5	6.1	7.1	0.1	0.3	2.1
3_18	3.8	0.3	4.0	2.9	1.0	1.3	0.1	0.0
3_9	0.0	4.5	6.1	7.4	4.9	1.0	0.8	0.0
Ø	4.1	6.5	3.0	7.7	2.9	1.4	1.6	0.8

Total average: 3.5 percentage points (0.1 – 16.8)

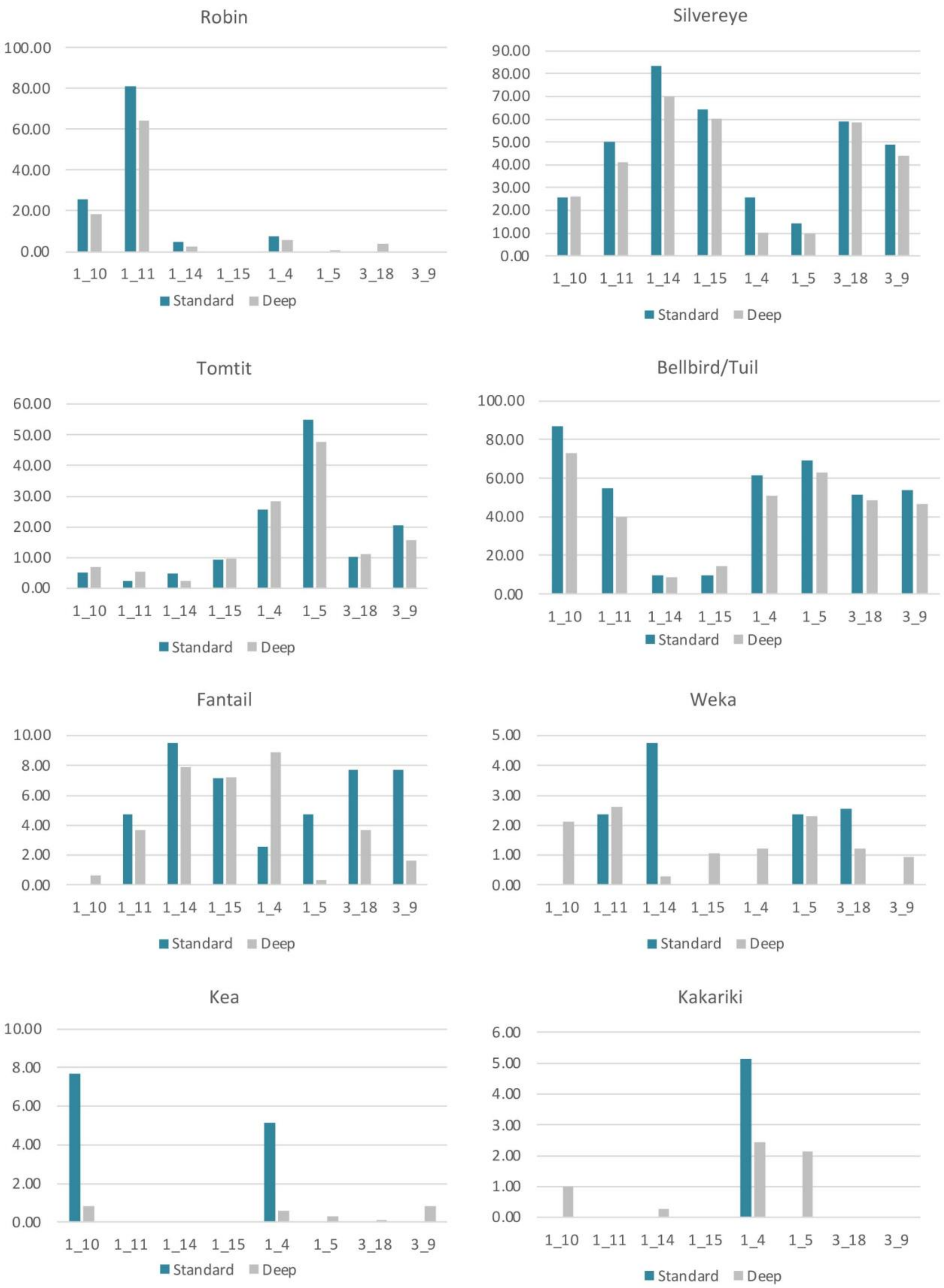


Figure 37: Comparison of ADRs for selected locations (x-axis) with standard sub-sampling (blue) and deep sub-sampling (grey). ADRs of both sampling strategies are similar for bird species with high call rates (top half). Species with low call rates (bottom half) have a higher variance of ADRs between standard and deep sampling.

Discussion

The third season of acoustic monitoring in the Abel Tasman National Park replicated the overall results of the previous seasons and thus corroborates the value and applicability of the method. The first two seasons were carried out within two consecutive years, whereas the current survey was conducted after a break in 2021. The monitoring results of the 2022 season reflect the outcomes of approximately two breeding seasons (about 4 months after the monitoring season 2020 ended in October of the same year, a full season in 2020/21 and the first 2-3 months of breeding season in 2022 as monitoring took place in September and October). A 1080 operation in June 2019 during a mega-mast event did not achieve to control rats efficiently (Fig. 38), and numbers increased rapidly in the following months. A second treatment in Spring 2020 resulted in low rat tracking rates for about two years.

Within those two years, a clear trend towards a recovery of rat sensitive bird species like robin, rifleman and tomtit could be observed (Figs. 3 & 4). Robins and tomtits predominantly increased in occupancy below 600m elevation (Tab.5), riflemen above 600m. Robins doubled the number of occupied sites below 600m. This remarkable recovery is most likely a response to intensive aerial rat control in the study area, which successfully kept rat FTT rates under 30 % during breeding seasons (Fig. 38).

During the last two years, robins expanded beyond the aerial treatment zone from 2020 (Fig. 10). Several reason are conceivable for this: 1) rat numbers remained low during breeding season 2) robin populations increased to an abundance that conceded them to a higher resilience against rats 3) birds kept moving in from the nearby treatment zone.

Robin ADRs also increased considerably (Tab. 3). High call rates are not necessarily an indicator for an increase in abundance, male robin for example show elevated vocal activity after the loss of the female (Powlesland 1983). However, it is plausible that an increase in call rates does reflect an increase in abundance when it is correlated with spatial expansion of the bird's occupancy.

Robin sightings have been reported from Anchorage, Torrent Bay, Tregidga Track, and Waiharakeke/Awaroa. Robins were not detected on any of the recordings from the coast. Call rates are probably below 2 % and thus likely to be missed under the standard sampling regime. It is likely that robin abundance along the coast is very low, and it remains unclear if these are established, pioneer or scouting birds. If they are establishing and breeding successfully, robins should be detected during future surveys.

Brown creeper, who are also sensitive to rat predation, remained stable over time and increased slightly over the last two years (Tab. 2 & 3). Due to their low ADR, the current sub-sampling regime is not effectively monitoring these birds (see discussion below). Assuming the data reflect the true situation, the lack of a stronger recovery signal would indicate that brown creeper might not thrive under rat tracking rates of 15-20 %. The situation might be similar for riflemen who show an increase in occupancy and especially in ADRs in the upland, but not in the lowland where rat tracking reached 30 % within a year after the last treatment (Fig. 38).

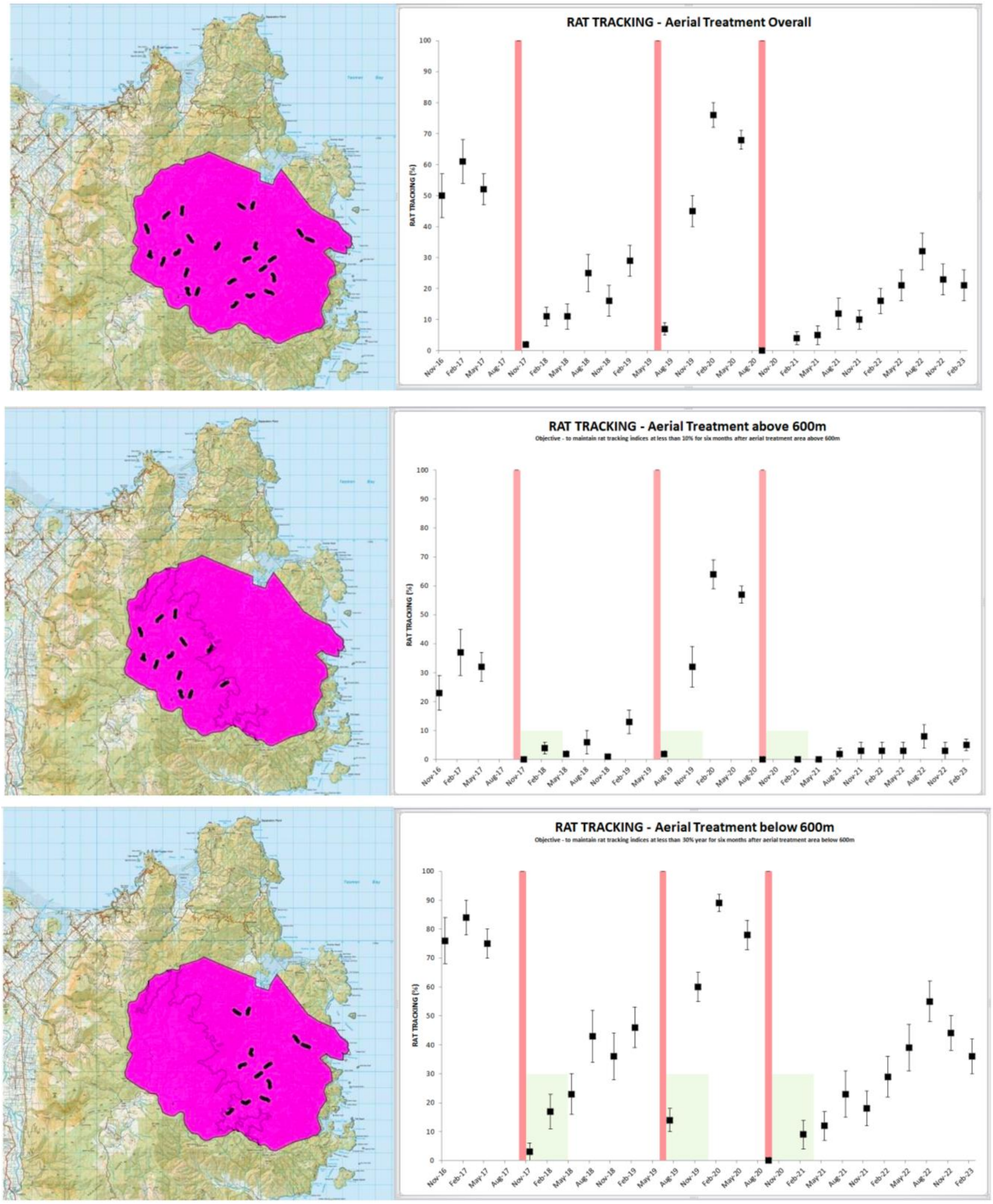


Figure 38: Rat FTT (foot tracking tunnel) results. Pink shade: aerial rat control zone. Black lines within pink shade: location of FTT tunnel lines represented in the respective graph. Pink bars: time of aerial treatment. Green shade: target maximum FTT rate. (Graphs provided by Andrew Macalister)

Both creeper and rifleman revealed a temporary low in occupancy and ADR in 2020 (Tabs. 2 & 3, Figs. 11 & 13), which is converse to the FTT rate, i.e. bird populations were on a low when rat numbers were highest.

Both riflemen and robins re-occupied a site at the bottom of Alma Hill near the Awaroa Inlet in 2020 but could not be observed there during the 2022 survey. This area was not covered by the 2020 aerial operation, suggesting that re-invading rats caused the birds to disappear again.

The decrease of rifleman and creeper during the strong mast year indicates that rat FTT in the upland should be kept below 30 % (a precise threshold cannot be derived from the current data) to protect these species from decline.

Tomtits reached an occupancy of almost 100 % (Tab. 2). Their ADRs keep increasing even in areas with full occupancy, suggesting that the population keeps growing, especially in the lowland (Figs. 21 & 22).

In contrast to rat-sensitive bird species, non-sensitive species like fantail and silvereye are showing signs of decline (Tab. 5, Figs. 3 & 4). Below 600m, the decline is yet only visible in ADRs, above 600m, both occupancy and ADRs lessened. Fantails are vulnerable to increased competition as rat-sensitive species recover (Innes et al. 2010). Silvereyes have been decreasing in gardens for more than a decade (Hayman et al. 2022), due to unknown causes. The results of this report suggest that increased competition by recovering native species might have an impact in silvereyes, as well.

Kākāriki are threatened by rats but did not indicate a significant recovery over the last two years while rat numbers were low (Tabs. 2 & 3, Fig. 17). Parakeet breeding intensity is depending on food (seed) availability and driven by mast events (Elliott et al. 1996), it is therefore conceivable that food levels were too low to allow for a population boom. This is corroborated by persistent low rat tracking rates over the last two years, in case of high seed/food availability, rats would be expected to regain high densities within less than a year.

Kākā recovery is a main objective of Project Janszoon, and translocations to Wainui hut and Bark Bay boosted the rudimentary population in the park. During the last two years, forest parrots spread into the Anchorage and Torrent Bay area as well as into the central areas between Buttress steam and Table creek (Fig. 16).

Kea call rates are low and detectability therefore likely to be underrepresented. Over the three monitoring periods kea tend to occur in the areas of Awapoto, Evans/Jenkins, Glennies and upper Huffams and Cleopatras Pool (Fig. 20). Kea are highly mobile birds and many calls are recorded while birds are flying over, however regular observations in a certain area can indicate the presence of a nearby nest.

Weka reached close to full occupancy in the study area (Tab. 2). ADRs can be expected to be biased by the fact that weka tend to call simultaneously, however, if increased weka densities trigger higher call rates, the increase in ADRs (Tab. 3) reflects an elevation in weka abundance across the monitoring region.

Bellbird/Tui reached 100 % occupancy this season, and ADRs remained high (Tabs. 2 & 3). Due to the pooling of bellbird and tui, results and trends should be considered with caution, as both species may have opposite trends that level each other out when being pooled. However, both species are known to occur in the presence of exotic predators, although they reach higher densities in areas with pest control (Robertson 2013, Sagar 2013). It can therefore be considered that both species should respond in a similar way to successful pest control and that trends are unlikely to be conflictive.

Kingfisher distribution (Fig. 34) is probably mostly determined by habitat. They are rarely found in land above 700m elevation and prefer lowland, coastal habitats (McKinlay 2013). Shining cuckoo are relying on grey warbler as their hosts, as expected cuckoo distribution and trends are in congruence with grey warbler (Figs. 28 & 36).

Acoustic detection rates

ADRs mirror the trend of occupancy for all studied bird species. The only exception are species which reached full occupancy within the study area. Once occupancy reached 100 %, no further information on populations trends can be derived from this measure, whereas abundance can still de- or increase without having an impact on occupancy. Tomtit, robin and warbler for example showed a raised ADR in some strata with full occupancy, suggesting that population densities are still increasing. In contrast, less calls for fantail and silvereye were detected below 600m, although the occupancy remained stable. ADRs are likely to be more biased in birds with low call rates. Comparing standard and deep sub-sampling, ADRs have a greater variance when call rates are low (Fig. 37) which can be explained by a greater sampling bias when birds call rarely. Caution should be taken when using ADRs as a proxy for abundance for birds with low call rates.

ADRs have the potential to be a more sensitive measure for population trends than occupancy. The relationship between ADRs and abundance should be investigated in more depth. One major drawback of acoustic monitoring is that it is thought to deliver data on presence/absence only. The ability to derive a proxy for abundance from acoustic data would open a much broader field of application and present an alternative to often biased 5MBC.

Sampling strategy

The average ADR of brown creeper, kea, kingfisher, shining cuckoo and kākāriki are under 1 %, the current sampling strategy is most likely failing to paint a representative picture of their occupancy and distribution trends. A more thorough sub-sampling strategy is recommended if more detailed information on these species is required.

The current sampling regime is sufficient to detect considerable changes in occupancy patterns across the landscape for robins. It is likely that robins are missed in areas of low abundance, but the objective is to achieve an expansion of established robin populations across the park, and individual or scouting birds are not targeted. ADRs below 1 % represent birds that were detected merely one or two times per location, i.e. they were detected at one day only within the 14-day deployment period.

However, the advantages of deep sub-sampling are: 1) more sensitive, accurate and precise data on robin and rifleman occupancy, especially along the distribution fringes, where current data are most likely underestimating the true occupancy 2) the standard method is not adequate to detect brown creeper or kākāriki, deep sampling would considerably improve the results on these two indicator species.

Synopsis

- Overall patterns of bird distribution in the study area were successfully replicated by acoustic monitoring over three monitoring seasons
- In comparison to occupancy, acoustic detection rates show a steeper trend, indicating that they are a more sensitive measure for population trends
- Acoustic detection rates remain comparable across sub-sampling regimes for birds with call rates above 5-10 %, however, variance increases when call rates fall below that threshold
- Rat-sensitive bird species increased in both occupancy and call rates
- Rat non-sensitive birds remained stable or showed signs of decline (fantail and silvereye, possibly due to increased competition)
- Robins almost doubled their occupancy and average call rates below 600m elevation
- Riflemen, and to a lesser degree creeper, increased in abundance and call rates above 600m ASL, but not below, suggesting that populations decrease when FTT rates rise above 20-30 %. Both species also decreased during the mast in 2020, providing good indication for aerial treatment thresholds for these species.
- Kākā increased their occupancy by 47 % and are spreading beyond the original release sites
- Kākāriki populations did not experience a boost over the last two years, probably due to a lack of mast events and low seed availability

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Appendix Tab. A1: Call rates and % occupancy. CI=95% binomial confidence interval. Green/orange highlight= significant increase/decrease since 2019, green/red bold letters= significant increase/decrease since previous survey.

		Year	Average call rate %	CI	Lower CI	Upper CI	% Occupied	binary CI	Lower CI	Upper CI
Robin	below 600m	2019	1.59	0.36	1.23	1.95	18.97	10.19	8.77	29.16
		2020	2.06	0.42	1.64	2.48	23.73	10.97	12.76	34.70
		2022	**6.39**	0.66	5.73	7.04	41.67	12.60	29.06	54.27
	above 600m	2019	12.98	0.95	12.03	13.94	91.53	7.18	84.35	98.70
		2020	**16.74**	1.16	15.59	17.90	91.53	7.18	84.35	98.70
		2022	**19.84**	1.07	18.77	20.91	96.67	4.59	92.08	101.26
Creeper	below 600m	2019	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
		2020	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
		2022	0.04	0.05	-0.01	0.09	1.67	3.27	-1.61	4.94
	above 600m	2019	0.60	0.22	0.39	0.82	27.12	11.46	15.66	38.58
		2020	0.27	0.16	0.11	0.44	18.64	10.04	8.60	28.68
		2022	0.56	0.20	0.36	0.76	25.00	11.07	13.93	36.07
Rifleman	below 600m	2019	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
		2020	**0.63**	0.23	0.40	0.87	**6.78**	6.48	0.30	13.26
		2022	**0.24**	0.13	0.11	0.37	3.33	4.59	-1.26	7.92
	above 600m	2019	17.03	1.06	15.96	18.09	62.71	12.47	50.25	75.18
		2020	**6.95**	0.79	6.16	7.74	64.41	12.34	52.06	76.75
		2022	**19.45**	1.06	18.39	20.51	71.67	11.52	60.15	83.19
Kaka	below 600m	2019	0.88	0.27	0.61	1.15	12.07	8.47	3.60	20.54
		2020	0.93	0.28	0.64	1.21	15.25	9.27	5.99	24.52
		2022	1.33	0.31	1.02	1.63	23.33	10.81	12.52	34.14
	above 600m	2019	1.25	0.31	0.94	1.57	38.98	12.57	26.41	51.55
		2020	0.75	0.27	0.48	1.01	30.51	11.87	18.64	42.38
		2022	**1.45**	0.32	1.13	1.77	55.00	12.72	42.28	67.72
Kea	below 600m	2019	0.41	0.18	0.22	0.59	25.86	11.38	14.48	37.25
		2020	0.68	0.24	0.44	0.92	33.90	12.20	21.70	46.10
		2022	0.41	0.17	0.24	0.58	23.33	10.81	12.52	34.14
	above 600m	2019	0.38	0.17	0.20	0.55	20.34	10.38	9.96	30.71
		2020	0.20	0.14	0.06	0.34	11.86	8.34	3.53	20.20
		2022	0.20	0.12	0.08	0.33	16.67	9.53	7.14	26.19
Kakariki	below 600m	2019	0.19	0.13	0.07	0.32	13.79	8.97	4.83	22.76
		2020	0.05	0.06	-0.02	0.11	3.39	4.66	-1.28	8.05
		2022	0.11	0.09	0.02	0.20	3.33	4.59	-1.26	7.92
	above 600m	2019	1.52	0.35	1.18	1.87	54.24	12.84	41.39	67.08
		2020	**0.42**	0.20	0.22	0.62	**16.95**	9.67	7.28	26.62
		2022	0.39	0.17	0.22	0.56	20.00	10.22	9.78	30.22
Tomtit	below 600m	2019	8.72	0.81	7.91	9.53	81.03	10.19	70.84	91.23
		2020	**10.45**	0.90	9.55	11.35	83.05	9.67	73.38	92.72
		2022	**16.29**	0.99	15.30	17.28	**98.33**	3.27	95.06	101.61
	above 600m	2019	30.70	1.31	29.39	32.01	100.00	0.00	100.00	100.00
		2020	**40.96**	1.52	39.43	42.48	98.31	3.33	94.98	101.63
		2022	38.27	1.30	36.97	39.57	100.00	0.00	100.00	100.00

		Year	Average call rate %	CI	Lower CI95	Upper CI95	% Occupied	binary CI	Lower CI 95	Upper CI95
Weka	below 600m	2019	2.64	0.46	2.18	3.10	81.03	10.19	70.84	91.23
		2020	2.69	0.48	2.21	3.17	84.75	9.27	75.48	94.01
		2022	**4.13**	0.53	3.59	4.66	**98.33**	3.27	95.06	101.61
	above 600m	2019	3.21	0.50	2.71	3.71	83.05	9.67	73.38	92.72
		2020	**4.38**	0.63	3.75	5.02	**98.31**	3.33	94.98	101.63
		2022	5.57	0.61	4.96	6.19	95.00	5.57	89.43	100.57
Fantail	Below 600m	2019	11.51	0.92	10.59	12.42	93.10	6.59	86.52	99.69
		2020	10.56	0.91	9.66	11.47	84.75	3.33	81.42	88.07
		2022	**5.79**	0.63	5.16	6.42	83.33	9.53	73.81	92.86
	above 600m	2019	4.61	0.59	4.01	5.20	71.19	11.67	59.51	82.86
		2020	**6.33**	0.75	5.57	7.08	**98.31**	3.33	94.98	101.63
		2022	**3.75**	0.51	3.24	4.26	**56.67**	12.67	44.00	69.33
Warbler	below 600m	2019	14.28	1.00	13.27	15.28	94.83	5.76	89.07	100.59
		2020	**22.94**	1.24	21.70	24.18	98.31	3.33	94.98	101.63
		2022	**19.61**	1.06	18.55	20.68	96.67	4.59	92.08	101.26
	above 600m	2019	9.86	0.84	9.01	10.70	93.22	6.48	86.74	99.70
		2020	11.09	0.97	10.11	12.06	94.92	5.66	89.25	100.58
		2022	**14.04**	0.93	13.12	14.97	98.33	3.27	95.06	101.61
Silvereye	below 600m	2019	60.86	1.40	59.46	62.26	100.00	0.00	100.00	100.00
		2020	58.52	1.45	57.06	59.97	100.00	0.00	100.00	100.00
		2022	**32.52**	1.26	31.26	33.77	98.33	3.27	95.06	101.61
	above 600m	2019	22.16	1.18	20.98	23.33	96.61	4.66	91.95	101.28
		2020	22.89	1.30	21.59	24.20	96.61	4.66	91.95	101.28
		2022	**7.47**	0.70	6.77	8.17	**78.33**	10.53	67.80	88.86
Bellbird/Tui	below 600m	2019	49.27	1.44	47.83	50.71	100.00	0.00	100.00	100.00
		2020	**62.23**	1.43	60.80	63.66	100.00	0.00	100.00	100.00
		2022	**58.87**	1.32	57.55	60.19	100.00	0.00	100.00	100.00
	above 600m	2019	42.52	1.40	41.12	43.92	100.00	0.00	100.00	100.00
		2020	**53.09**	1.54	51.54	54.63	100.00	0.00	100.00	100.00
		2022	**48.15**	1.34	46.82	49.49	100.00	0.00	100.00	100.00
Kingfisher	below 600m	2019	0.62	0.23	0.40	0.85	25.86	11.38	14.48	37.25
		2020	0.50	0.21	0.29	0.71	10.17	7.79	2.38	17.96
		2022	0.39	0.17	0.22	0.56	20.00	10.22	9.78	30.22
	above 600m	2019	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
		2020	0.07	0.08	-0.01	0.16	1.69	3.33	-1.63	5.02
		2022	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Sh. Cuckoo	below 600m	2019	0.17	0.12	0.05	0.29	6.90	6.59	0.31	13.48
		2020	0.20	0.13	0.07	0.34	15.25	9.27	5.99	24.52
		2022	**1.12**	0.28	0.84	1.40	26.67	11.30	15.36	37.97
	above 600m	2019	0.15	0.11	0.04	0.25	10.17	7.79	2.38	17.96
		2020	0.35	0.18	0.17	0.53	15.25	9.27	5.99	24.52
		2022	0.45	0.18	0.27	0.62	13.33	8.69	4.64	22.02