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SHORT NOTE

Unmanned Aerial Vehicle (UAV) activity elicits little to no response from New Zealand forest birds during wildlife monitoring

ZOË L. STONE*
Zoology and Ecology Group, School of Natural Sciences, Massey University, Palmerston North, New Zealand

KEVIN A. PARKER
Parker Conservation Ltd. PO Box 130, Warkworth, New Zealand

Drones, or UAVs (unmanned aerial vehicles) are increasingly popular for wildlife monitoring because they offer a relatively cheap and fast means to monitor wildlife (Chabot & Bird 2015; Gallego & Sarasola 2021). However, there is concern about how UAVs influence wildlife behaviour. Most studies investigating bird responses to UAVs have focused on open habitats (e.g. Weston *et al.* 2020) where these bird assemblages, including raptor species, have demonstrated sensitivity to UAV activity (Lyons *et al.* 2017), but few studies have examined how forest species respond. In Aotearoa New Zealand, wildlife monitoring within forest landscapes is often challenging, and UAVs have been touted as a means for improving monitoring in these complex habitats. However, forest bird responses to UAVs are largely unknown. Here we outline observations of forest bird responses from sustained UAV use within rich and diverse forest sites during recent monitoring.

Turitea reserve is the main water catchment for Palmerston North and consists of broadleaf/podocarp forest at lower elevation (80–300 m a.s.l.) dominated by a tawa (*Beilschmiedia tawa*)/rewarewa (*Knightia excelsa*) canopy with emergent rimu (*Dacrydium cupressinum*)/miro (*Pectinopitys ferruginea*), transitioning into regenerating submontane horopito (*Pseuduowintera colorata*) scrub. The site has a diverse bird assemblage typical of New Zealand broadleaf forests (Table 1) and includes large populations of uncommon species such as pōpokotea (whitehead, *Mohoua albicilla*), tītitipounamu (rifleman, *Acanthisitta chloris*), miromiro (North Island tomtit, *Petroica macrocephala*), korimako (bellbird, *Anthornis melanura*), and kārearea (New Zealand falcon, *Falco novaeseelandiae*). The two reservoirs also provide habitat for a range of aquatic birds, including tētē-moroiti (grey teal, *Anas gracilis*).

We conducted 48 flights (*c.* 15 hours) using a large (4 kg) UAV (DJI Matrice 200) to track the dispersal of 40 toutouwai (North Island robin, *Petroica longipes*) reintroduced to Turitea reserve (Fig. 1). A commercial-sized UAV capable of carrying a custom receiver was required for toutouwai monitoring. These larger UAVs are louder than smaller recreational drones which are commonly used for

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*Corresponding author: *Z.Stone@massey.ac.nz*

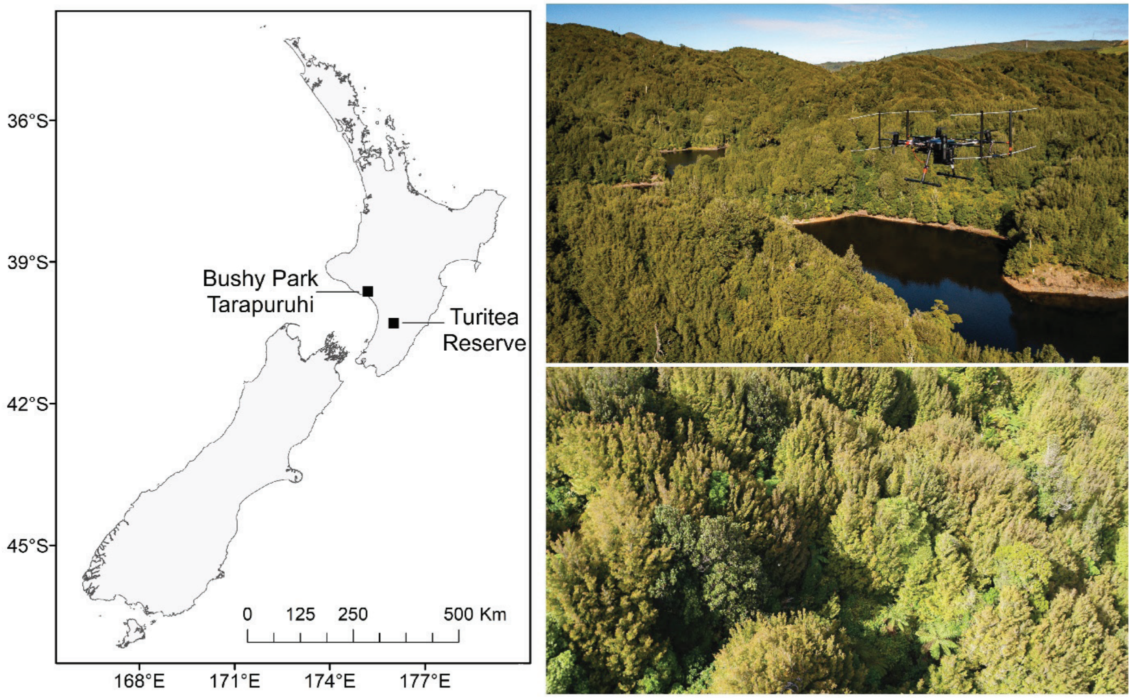

Figure 1. Location of observation sites in New Zealand, with aerial views of the landscape where UAV monitoring was conducted (upper image – UAV above Turitea reserve; lower image – Close up image of canopy from UAV camera used for helping identify bird responses).

wildlife surveys. For instance, similar commercial UAVs produce noise emissions ranging from 80–90 dB compared to smaller recreational UAVs, which produce 50–80 dB of noise (Schäffer *et al*. 2021). This noise level is comparable to heavy traffic and far above the ambient noise level of typical rural/forest environments (Torija *et al*. 2020). As a result, we expected our observations to reflect the higher end of potential forest bird responses to UAVs.

Monitoring was conducted by a Part 101 licensed operator (ZLS) which meant the UAV was always within line of sight and bird responses to the UAV could be observed. Noise emissions were generally heard at all times by the operator except at the furthest distances (e.g. >1 km). Volunteers undertaking toutouwai ground monitoring were also occasionally below the UAV during flights and could clearly hear it from beneath the canopy (D. Armstrong & K. Macdermid *pers. comm.*).

In addition to the sound and flight associated disturbance from the UAV, we attached additional navigation strobe lighting to the unit to assist with visibility during monitoring. These strobe lights (Firehouse Technology Arc "V" Drone Strobe Navigation Light – in red and white) produce 1,000 lumens of output which may also disturb birds. UAV flights followed a lawnmower pattern with gridlines 60 m apart and lasted on average 12 minutes and covering 2.2 km per flight. The UAV was flown at speeds of 14–16 km/h (3.8–4.4 m/s) at an altitude of 70 m a.g.l. (above ground level). Prior to monitoring calibration flights were also flown at 45 m a.g.l. – the lowest possible altitude that allowed canopy clearance, 50, 60, 75, and 100 m a.g.l. While this speed and altitude were specific to toutouwai monitoring, it likely reflects a higher potential disturbance to forest species as the transmitters used (Lotek Picopip Ag376) are small and require the UAV to be flown close to the canopy for best detection. Take-off was generally 100 m from the forest edge but sometimes occurred within 10–20 m.

During monitoring almost all of the observed 33 species (Table 1) showed no discernible response to the UAV (April – July 2021) based on approximately 2,259 anecdotal observations. Observations were taken from the ground by the pilot and observers, and from video footage retrieved from the UAV. Of the few species that did display an identified response (8), these appeared to be relatively minor or very brief.

Table 1. List of all bird species recorded in Turitea reserve (Manawatu, New Zealand) during annual bird monitoring by Palmerston North City Council (ordered according to Gill *et al.* 2010; E = Exotic). UAV response column indicates whether a response was observed (Y = 8), not observed (N = 21), if observed response was not clearly UAV triggered (? = 4) or if species was never directly observed during flights (- = 10). Number of observations for each species that were clearly identifiable has been estimated based on visual observations per flight (e.g. average of five tūī observed per flight = 240 observations).

Common name	Scientific name	Number of observations	UAV response	Response type
PHASIANIDAE				
Peafowl (E)	*Pavo cristatus*	0	-	-
ANATIDAE				
Black swan (E)	*Cygnus atratus*	5	N	-
Canada goose (E)	*Branta canadensis*	5	N	-
Tētē moroiti/Grey teal	*Anas gracilis*	10	Y	Minor displacement
Mallard (E)	*Anas platyrhynchos*	300	N	-
Pūtangitangi/Paradise shelduck	*Tadorna variegata*	120	Y	Take-off, circling & displacement
PHALACROCORACIDAE				
Kawau/Black shag	*Phalacrocorax carbo*	15	?	Possible take-off/displacement
Kāruhiruhi/Pied shag	*Phalacrocorax varius*	48	?	Possible take-off /displacement
ACCIPITRIDAE				
Kahu/Swamp harrier	*Circus approximans*	70	N	-
FALCONIDAE				
Kārearea/New Zealand falcon	*Falco novaeseelandiae*	15	N	-
RALLIDAE				
Pukeko	*Porphyrio melanotus*	0	-	-
CHARADRIIDAE				
Spurwinged plover	*Vanellus miles*	15	Y	Take-off & displacement (only when UAV very close)
LARIDAE				
Black-backed gull	*Larus dominicanus*	0	-	-
COLUMBIDAE				
Kererū	*Hemiphaga novaeseelandiae*	240	N	-
STRIGOPIDAE				
Kaka	*Nestor meridionalis*	0	-	-
CACATUIDAE				
Sulphur crested cockatoo (E)	*Cacatua galerita*	20	Y	Take-off/displacement, circling (Bushy Park)

Table 1. *continued*

Common name	Scientific name	Number of observations	UAV response	Response type
PSITTACIDAE				
Eastern rosella (E)	*Platycercus eximius*	3	Y	Stopped singing (UAV directly overhead)
CUCULIDAE				
Koekoeā/Longtailed cuckoo	*Eudynamys taitensis*	0	-	-
Pīpīwharauroa/Shining cuckoo	*Chrysococcyx lucidus*	5	N	-
STRIGIDAE				
Ruru/Morepork	*Ninox novaeseelandiae*	0	-	-
HALCYONIDAE				
Kotare/Sacred kingfisher	*Todiramphus sanctus*	0	-	-
ACANTHISITTIDAE				
Tītitipounamu/Rifleman	*Acanthisitta chloris*	15	N	-
ACANTHIZIDAE				
Riroriro/Grey warbler	*Gerygone igata*	90	Y	Stopped singing, possible take-off/displacement (UAV directly overhead)
MELIPHAGIDAE				
Korimako/Bellbird	*Anthornis melanura*	380	N	-
Tūī	*Prosthemadera novaeseelandiae*	240	N	-
PACHYCEPHALIDAE				
Pōpokatea/Whitehead	*Mohoua albicilla*	90	Y	Stopped singing (UAV directly overhead)
ARTAMIDAE				
Australian magpie (E)	*Gymnorhina tibicen*	3	N	(Bushy Park)
RHIPIDURIDAE				
Piwakawaka/New Zealand fantail	*Rhipidura fuliginosa*	150	N	-
PETROICIDAE				
Toutouwai/North Island robin*	*Petroica longipes*	15	N	-
Miromiro/North Island tomtit	*Petroica macrocephala toitoi*	40	N	-
ALAUDIDAE				
Skylark (E)	*Alauda arvensis*	10	N	-
ZOSTEROPIDAE				
Tauhou/Silvereye	*Zosterops lateralis*	60	?	Possible take-off/displacement (UAV directly overhead)

Table 1. *continued*

Common name	**Scientific name**	**Number of observations**	**UAV response**	**Response type**
HIRUNDINIDAE				
Warou/Welcome swallow	*Hirundo neoxena*	30	Y	Changed course (only when UAV very close)
TURDIDAE				
Eurasian blackbird (E)	*Turdus merula*	80	N	-
Song thrush (E)	*Turdus philomelos*	15	N	-
STURNIDAE				
Common starling (E)	*Sturnus vulgaris*	20	N	-
MOTACILLIDAE				
Pihoihoi/New Zealand pipit	*Anthus novaeseelandiae*	0	-	-
PRUNELLIDAE				
Dunnock (E)	*Prunella modularis*	0	-	-
FRINGILLIDAE				
Chaffinch (E)	*Fringilla coelebs*	20	?	Possible take-off/displacement
European goldfinch (E)	*Carduelis carduelis*	60	N	-
European greenfinch (E)	*Carduelis chloris*	50	N	-
Common redpoll (E)	*Carduelis flammea*	0	-	-
EMBERIZIDAE				
Yellowhammer (E)	*Emberiza citrinella*	20	N	-
TOTAL		**2,259**		

In general, native forest birds showed little or no reaction to the UAV, with some minor responses observed such as brief pauses in singing by smaller species (K. Macdermid *pers. comm.*) or possible displacement from perches when the UAV was directly overhead. The UAV often flew directly over perching kererū (New Zealand pigeon, *Hemiphaga novaeseelandiae*) which could be seen in the canopy from both ground and UAV camera footage, and no individuals were observed moving or being alarmed when the UAV flew or hovered above. Kererū can be sensitive to ground disturbance, e.g. from hikers and walkers (Mander *et al.* 1998). However, it was reassuring that kererū did not appear to respond to UAV activity and seemed to move naturally below it (including performing breeding displays). Tūī (*Prosthemadera novaeseelandiae*) and korimako were also often seen undertaking general movements and foraging activities, and singing and being territorial within the canopy prior to UAV take-off. As the UAV approached during monitoring (*c.* 40 m), individuals appeared to maintain these behaviours and did not appear to alter their movement patterns.

Predatory birds can respond aggressively to UAVs (e.g. Junda *et al.* 2016); however, we noted no response by kārearea and kahu (swamp harrier, *Circus approximans*) which often flew past or directly above the UAV without changing behaviour.

All other forest bird species showed no response to UAV activity directly above. This included the recently released toutouwai; a pair observed at a nest when the UAV passed directly above did not alter their behaviour and the nestlings remained vocal while being fed (K. Macdermid *pers. comm.*). This nest was located in a tall tawa (20–30 m), so the UAV would have been within 40 m at the time.

The main responses observed were from aquatic birds found at the reservoirs. Pūtangitangi (paradise shelduck, *Tadorna variegata*) reacted to UAV take-off and fly-bys, with individuals responding almost every time to take-off. When the UAV was in flight and crossed a reservoir, responses could be observed at a distance. For example, pūtangitangi disturbed from the water (or a perch) circled the UAV a few times and then left the reservoir while alarm calling. In some instances, individuals would return to their original location before being disturbed, but most were displaced, settling out of range of the UAV. Various shags were also seen flying during UAV flights; however, these individuals were only observed from a distance, and it is unclear whether the displacement was in response to the UAV or not. On the few occasions where tētē-moroiti were close to a UAV take-off, they did move away from the dam edge but did not take flight. These responses were consistent with observed responses to general human presence.

During preliminary testing at Bushy Park Tarapuruhi – a fenced sanctuary 20 km north-east of Whanganui which has a similar bird assemblage to Turitea but with the addition of tīeke (North Island saddleback *Philesturnus carunculatus*) and hihi (*Notiomystis cincta*) – we also witnessed no notable responses to the UAV by native species. Hihi continued to use the supplementary feeders when the UAV was directly above, and no change in tīeke behaviour occurred. However, during these flights, we did witness our only major response by a forest bird – sulphur crested cockatoos (*Cacatua galerita*). Soon after UAV take-off, a small flock (*c.* 10 birds) of this non-native species rose from the canopy and flew towards the UAV, calling loudly. This response happened on two occasions with the flock circling the UAV a few times before returning to their original perches. This reaction was provoked from over 100 m away. Native parrots (Strigopidae & Psittaculidae) were not observed at our sites (although kaka *Nestor meridionalis* has been recorded rarely in Turitea reserve) so we are unable to evaluate their response. Based on the cockatoo response, we recommend testing prior to the use of UAVs within sites where they occur.

Our UAV flew at consistent flight speeds on autopilot, occasionally pausing briefly at waypoints to change direction or adjust altitude. Bird responses to UAVs may vary depending on whether the UAV is stationary or mobile, so different responses to those identified here could be possible for different flight patterns. During their research, Muller *et al.* (2019) filmed nesting penguins and found that sudden changes in UAV acceleration triggered more head tilts than smooth flight patterns. We never witnessed this during our monitoring, where the use of autopilot software meant flight paths were smooth and continuous. We therefore suggest the use of autopilot software, for future monitoring, to reduce bird disturbance by UAVs.

A benefit of the receiver system we used during monitoring (Muller *et al.* 2019) was that the aerial array was custom-designed to sit as a box protruding wider and higher than the rotors. We believe this may provide a solid barrier that birds are able to see compared to bare spinning rotors which could be difficult to see. This meant that in the few instances when birds did get close to the UAV, they were kept away from potential harm. During our monitoring, we only observed one incident where a pūtangitangi had to change course to avoid a collision. This occurred during preliminary test flights during the breeding season (November), and it was suspected a nest may have been nearby, prompting the pair to display more defensive behaviour. We suggest utilising a similar barrier/guard to our aerial array that sits outside the rotors or using propellor guards that are available for some UAV models to avoid harm to individuals.

Our observations at sites with a wide assemblage of New Zealand forest bird species present a scenario where UAV disturbance can be assessed. While these observations are anecdotal, they provide evidence that many of New Zealand's forest dwelling birds are unlikely to be negatively affected by UAVs during wildlife monitoring research. Our monitoring used automated piloting software for smooth and consistent, and predictable flight paths, which may provide less disturbance to birds. However, aquatic birds, particularly ducks responded to the UAV take-off, flybys, and hovering in a similar way as to human presence. UAVs for tracking wildlife, therefore, likely provide low disturbance to birds in forest settings. However, additional testing of specific species responses during breeding, and for particular groups (e.g. native parrots) would be beneficial to identify and minimise any potential negative responses.

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