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Developing a broadcast system to attract New Zealand falcons (*Falco novaseelandiae*)

JOHN HOLLAND*
ED MINOT
NAOMI MCBRIDE
JERALDINE TENG
BURGESS LANGSHAW POWER
Institute of Agriculture and Environment, Massey University, Private Bag 11-222, Palmerston North, New Zealand

Abstract It is difficult to locate and monitor populations of the New Zealand falcon (*Falco novaeseelandiae*) because the terrain they occupy is frequently inhospitable and the traditional method of walking transects lines to locate nest sites is arduous and time consuming. For this reason we developed and trialled a low-priced broadcasting system that amplifies pre-recorded vocalisations to attract falcons, which we then used to locate their nest sites. We tested the system on 20 falcons in the Kaingaroa and Pan Pac forests on the North Island. Both sexes responded but males responded more frequently. We conclude that the system can rapidly and accurately locate falcons in a large plantation forest during the summer breeding season.

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INTRODUCTION

The endemic New Zealand falcon (*Falco novaeseelandiae*) is the rarer of the 2 surviving diurnal raptors in New Zealand. The falcon has been fully protected since 1970 (Heather & Robertson 1996), and its current low population has been attributed to habitat loss, introduced predators, persecution, and pesticides. Three 'forms' of the falcon are recognised: bush falcon (North Island and north-western South Island), eastern falcon (Marlborough to southern end of South Island), and southern falcon (Fiordland to Auckland Islands). The New Zealand Department of Conservation status classification for the bush falcon is Class 3 (nationally vulnerable), for the eastern falcon it is Class 5 (gradual decline), and Class 2 for the southern falcon (Holland & McCutcheon 2007). The falcon is susceptible to disturbance and predation during nesting and it is difficult to determine whether the decline in numbers results from lower productivity or increased mortality (Fox 2001 in Hyde & Stewart 2002). Fox (1978b) estimated that there were 450-850 breeding pairs of bush falcon, nesting mostly

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*Correspondence: *J.D.Holland@massey.ac.nz*

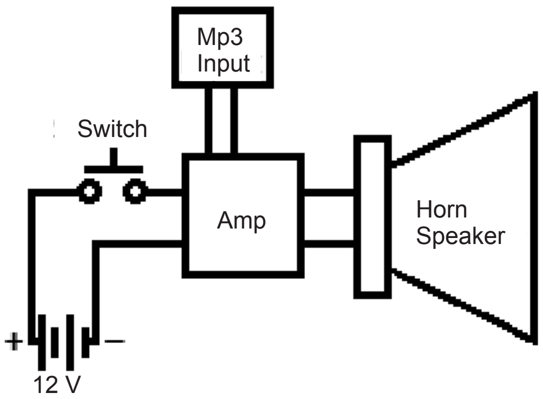

Fig. 1. Wiring diagram of the broadcast system components.

in remote hill country, in podocarp or beech forests; little was known about the population resident in exotic forests (Holland & McCutcheon 2007).

The New Zealand falcon is difficult to study due to its secluded habitats, small population numbers and defensive behaviour. Traditional study methods require researchers to traverse vast areas of inhospitable terrain and approach individuals closely for identification whilst under threat of direct attack by disturbed individuals. Various study systems have been used, including videographic recording (Gula *et al.* 2010; Kays *et al.* 2009; Kross & Nelson 2011), RFID tagging (Bonter & Bridge 2011), fixed beam radar or thermal imaging cameras (Gauthreaux & Livingston 2006), GPS tracking (Holland & McCutcheon 2007), and bal-chatris or tethered bait locations (Fuller & Christenson 1976). A technique often used in the United States to locate raptors involves broadcasting vocalisations to attract birds (Mosher *et al*. 1990; Mosher & Fuller 1996; McLeod & Anderson 1998). Broadcast vocalisation surveying increases the probability of detection, requires few volunteers and is cost effective (Kennedy & Stahlecker 1993).

The current method of locating New Zealand falcons in commercial forestry compartments (*i.e,* the fundamental unit of management in a forest plantation) relies upon researchers exploring on foot to find nests. Success in finding a nest generally depends on the behaviour of the parent birds, which changes with time of year. When the nest contains eggs, the adults usually respond to an intruder by diving at them and vocalising with a '*kekking*' call (a defensive call made during territorial disputes and while nest is being defended). When the nest contains dependent chicks, diving with direct hits is common. After the chicks fledge, however, the behaviour of the parent birds becomes variable, ranging from direct hits to no observable reaction (Addison *et al*. 2006). As a result, this method is inefficient in time, manpower and accuracy of results due to navigability of terrain and possible human error. The system we report here provides a robust and rapid surveying technique that would be beneficial to both ecologists and industry.

METHODS

Study sites

The habitat of the falcon ranges across most of New Zealand (IUCN 2010; Fox 1978; Bell & Lawrence 2009; Thomas *et al.* 2010), however, this study is limited to the bush falcon that is found across the North Island, and some sections of the west coast of the South Island (Fox 1988; Bell & Lawrence 2009). Our previous work in Kaingaroa Forest has shown that falcons typically nest on the ground within <4 year old stands of pines (Teng 2009; McBride 2008; Addison *et al*. 2006; Seaton *et al*. 2007), so we concentrated our study efforts on these stands as well as the pine plantations on the east coast of the North I in the Hawke's Bay region.

Kaingaroa Forest is one of the oldest and largest softwood plantation forests in the world and is located on the central North Island pumice plateau (Kaingaroa Timberlands Ltd 2005). The forest comprises more than 180,000 ha with *Pinus radiata* the predominant species. The forest is dissected by roads and firebreaks to form ~1,400 compartment blocks of similar sizes, averaging *c.*100 ha, but up to 363 ha (Holland & McCutcheon 2007). The forest is therefore a continuously changing mosaic of stands, ranging from clear-felled areas, newly planted areas, to sites with mature 30-year-old trees, with a diverse vegetation growing between most stands and road margins (*ibid*.). Every year ~11,000 ha of clear-felled areas are replanted (Hyde & Stewart 2002).

The second study site was the Pan Pac Forest, a 30,000 ha pine plantation that is divided into 6 forests (Addison 2006). The predominant topography of these forests consists of steep rolling hills and the compartment size is dictated by landscape and thus more variable compared to Kaingaroa (Addison 2006).

Broadcast system

The broadcast system used pre-recorded vocalisations to attract breeding pairs of falcons, a system refined for raptor use by Mosher *et al.* (1990). We used a series of falcon calls that were recorded and re-transmitted through a speaker system. During a falcon's breeding season, this sound attracts nesting pairs which investigate the possible threat to their territory (Mosher *et al.* 1990). Our apparatus consisted of a MP3 that played falcon calls (edited into a 4-minute loop) on a 12 volt-powered system. A Sony Xplod Amplifier (rated at 800 watts) was used to broadcast the calls through a cast iron 60 Watt horn tweeter loudspeaker (with a range of 0.3-20 kHz) as shown in Fig. 1.

The horn tweeter system was chosen as the speaker for a number of reasons. The first was its frequency response. The horn system was chosen to amplify the range of the tweeter speaker with the tradeoff of limiting broadcasting to a smaller dispersion angle (Kuttruff 2007; Newell & Holland 2007). Testing in favorable conditions showed the broadcast could be detected by the unaided human ear at a distance of 2500 m. There are several alternative speaker systems available but they are limited either by volume (standard speaker systems), quality (distributed mode speakers), frequency (Heil air-motion transformers) or financial constraints (compression drivers, ribbon speakers or piezoelectric drivers) (Kuttruff 2007; Newell & Holland 2007).

The amplifier increases the voltage signal thereby increasing decibel output (Kuttruff 2007; Newell & Holland 2007). An amplifier cannot improve the quality of the signal itself (with the exception of using digital signal analysis to clean up 'noise' in the original signal), however, the use of an amplifier of insufficient quality or attempting to excessively boost a signal may reduce its quality (Kuttruff 2007; Newell & Holland 2007). In such a case, distortion is created which may disrupt the reproduced call with the result that falcons are less likely to recognise and respond to the reproduction.

Our broadcast system was developed for vehicle-based use. The benefits of a vehicle-mounted system are two-fold: first, the ease of travel across large distances (as necessitated by the large territorial areas of the falcon as well as the distances between occupied territories). Second, the ability to mount the system on the roof of the vehicle reduced signal absorption by minor geographic barriers such as low vegetation. The total system weighed ~35 kg, but a smaller version could be adapted to be lighter for 'on foot' studies.

A blind test (no parties involved knew whether forestry compartments were occupied by falcon pairs or not) was carried out to gauge the efficacy of the method. We measured response rates of falcons that were known to have active nests in compartments and compared the results with broadcasted calls into compartments we thought were unoccupied. Preliminary testing suggested that using bush falcon calls to attract the other morphs is less effective (Lawrence S., *pers. comm.*, 9 November 2011).

The testing was carried out in a southeast wind, averaging 10 km/hr with gusts up to 25 km/hr. At 200 m from the vehicle, the sound level meter detected a volume of 45 dB. However, at a distance of 300-500 m from the vehicle, background noise prevented the sound level meter from detecting the broadcast. Nevertheless, at this distance human observers were still able to hear the broadcast when the wind lulled. We tested 3 different methods to detect falcons. First, we parked the vehicle in a central position of a forestry compartment (or as close as possible based on road availability), and set up the speaker system. Then a group of 'spotters' with experience in falcon identification were placed to monitor falcon movements. The repeat audio loop was broadcast, alternating a 5 second call with 5 seconds of silence. We found that falcons responded to the broadcast within the first 10 seconds of the start of the broadcast. Second, we repeated the experiment using a 10 second broadcast followed by 10 seconds of silence, repeated up to 3 times. For the third experiment, we mounted the system on the back of a vehicle that moved at ~20 km/h through the forest, utilising the previous 10-second on/off broadcast sequence. This method was determined less effective as spotters in the back of the vehicle had difficulty hearing or seeing approaching falcons.

Responses by falcons to the broadcast system were varied throughout the year (Seaton *et al.* 2009). Only during the breeding season were falcons found to react regularly to broadcasts (Seaton *et al.,* 2009; Addison *et al.* 2006). This was confirmed by other studies on similar raptor species (Crowe & Longshore 2010; McLeod & Andersen 1998; Kennedy & Stahlecker 1993; Mosher *et al.* 1990). The precise reaction to these recordings by individual falcons has been noted to depend on 3 factors: (1) distance from the nest, (2) sex of the responding individual and, (3) level of development of their young (Addison *et al.* 2006).

RESULTS

In this section we report on the performance of the equipment used, the response rates of falcons to the broadcasting and the behavioural responses of the birds to the broadcast.

Response rate

During a 3-day period 20 compartments were surveyed where there were known to be resident falcons and the broadcast system was successful 100% of the time (attracting 8 females, 9 males and 3 unidentified to sex; McBride 2008). These 20 falcons responded within 5 minutes of the broadcast. Generally, males were observed to be the first to respond to the broadcast calls. Once the birds had settled, a second broadcast was made to test whether the birds would respond again. The birds

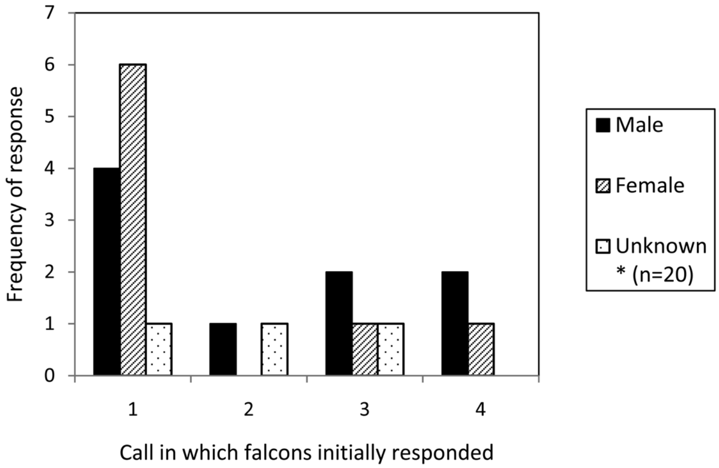

Fig. 2. Time each gender took to respond to the broadcasting. *Unknown represents birds unable to be visually identified to a particular sex.

responded within 1 minute of the broadcasted call and, again, males were consistently more responsive than the females.

In another study conducted at 49 points in Panpac Forest (Teng 2009) over 5 days, a total of 15 falcons were sighted and/or heard. All falcons responded to the broadcast within 5 minutes of the broadcast.

Response to broadcasting

The 20 falcons that responded to the broadcasting during the blind tests exhibited a range of behaviours. Eleven of the 20 falcons responded within the first 10 seconds of broadcasting; 2 falcons responded to the second 10 second broadcast and 4 falcons responded during the third broadcast. If *kekking* was heard in a compartment but no sighting was confirmed then a further broadcast was played to elicit a response. As a result, in 3 compartments, a falcon was sighted when the broadcast was played for the fourth time.

For the birds that responded during the first 10 seconds of broadcasting, the median distance between broadcast site and nest was 665 m. The birds that responded during the second 10 seconds of broadcasting did so when the median distance was 520 m. In contrast, the 2 birds that responded in the third 10 seconds did so when the distance between broadcast site and nest was 150 m and 850 m, respectively (Table 1). Therefore, broadcasting at or within 665 m of a nest should attract the attention of any parent birds before the third 10 seconds of broadcasting. However, due to the small sample size this needs further testing.

Gender

Females typically responded with a disturbed *kekking* call when they were still out of sight of the observer. This was followed by either flying from mature trees into the logged compartment while *kekking*, flying towards the vehicle while *kekking*, or flying towards and landing on a branch in the compartment while *kekking*. Males commonly responded to the broadcast by, flying from neighbouring mature trees into the compartment and *kekking*. Following this, males frequently flew towards and circled the broadcasting vehicle.

Of the 9 compartments trialled, 12 falcons responded to the broadcasting (6 female, 5 male and 1 of unknown sex). Female falcons responded when the distance between broadcast and nest site was 590 m, whereas the male falcons responded when the median distance between the 2 was 690 m. The one unidentified bird responded when the distance between the 2 sites was 770 m (Table 1).

Nesting stage

Throughout the 3 days of broadcasting, the adult falcons exhibited a range of different behaviours. Typically, parent birds with eggs or chicks less than 14 days old reacted by *kekking* whilst hidden from the observers. This was followed by *kekking* from a branch in the compartment, or flying off to a distant compartment. The behaviour of parent birds with chicks or fledglings older than 14 days, was generally *kekking* whilst hidden, or by flying into the compartment from neighbouring matures, *kekking*. This behaviour was then followed by the birds flying towards and circling the broadcast vehicle, *kekking*.

In compartments where the nest may have been reused, only 1 adult male responded to the broadcasting. He responded by flying towards the vehicle and landing in a tree near the vehicle, *kekking*, before flying towards a distant compartment. In contrast, falcons in compartments in which it was unknown if a breeding pair or nest was present, responded to the broadcasting by flying into the

Table 1. Distance between known nests and broadcast vehicle.

Compartment	Distance between nest and broadcast site (m)	Falcon response time**	Gender# of responding bird	Nesting Stage
1	740	1	F	>14 days
		1	M	
2	340	1	F	>14 days
3	630	1	F	>14 days
4	600	1	M	Possible recycle
5	520	2	M	>14 days
6	770	1	?*	>14 days
		1	F	
		1	M	
7	150	3	F	>14 days
8	910	1	F	<14 days
9	850	3	M	<14 days

?* Represents bird unable to be identified through the binoculars.
**Time measured by number of 10-sec loops.
Gender of bird was determined visually.

compartment from neighbouring mature trees or by flying towards the vehicle. These birds were then observed flying back into the neighbouring mature trees, from which they came.

When comparing the distance in which a falcon responded to broadcasting at different periods during the nesting cycle, the median distance for nests containing chicks >14 days was 525 m. The distance for chicks <14 days was 880 m; whilst the only recorded distance for possibly reused nests was 600 m (no GPS data was available for compartments where nest presence was unknown; Table 1). However, it must be noted that the sample size for these distances was small.

Time of day

Sixty percent of the different behavioural responses were noted between the hours of 10:00 – 12:00 and 15:00 – 16:00. However, since no broadcasting was carried out between 12:00 and 13:00, we could not determine if male or female falcons responded during this time, or the type of behaviour they exhibited in response to the broadcasting.

There are also insufficient data to determine whether a parent guarding eggs responded differently to a parent guarding chicks at the same time of day. This is because all unknown compartments and those containing chicks older than 14 days were visited between 10:00 and 15:00, whilst compartments containing eggs or chicks less than 14 days as well as compartments with possibly reused nests were visited between 15:00-17:00.

Broadcast distance

Only 9/16 compartments where falcons responded to broadcasting had GPS coordinates for both nest and broadcast site available. These results indicate that the greatest distance between broadcast site and nest site in which a falcon responded was 910 m. The closest broadcast distance between the 2 sites was 150 m, whilst the median distance between broadcast site and nest site that a falcon responded was 610 m (Table 1).

CONCLUSION

The broadcast system developed here for the attraction of falcons during surveys is an improvement upon older techniques for assessing habitat occupation in a selected area. Despite being able to compile more complete census data, the system we used here does have some drawbacks, including the necessity of vehicular access. However, the broadcast apparatus is promising in its utility for conducting research as well as its practical application at various industrial sites where falcon presence may be a concern (Seaton 2010). This device, while still in development, promises to be an excellent tool for forestry management, ecological monitoring and other research in that it is rapid and accurate in detecting the presence of falcons.

No formal studies have determined the impact of using broadcasts on falcons during the breeding season. The potential harm of the broadcast system may be reduced by not broadcasting during important thermoregulation periods (*e.g.*, eggs and chicks require increased parental care during the night, early morning until one hour after sunrise, peak mid-day heat, and late evening; Kennedy & Stahlecker 1993; Seaton 2007). In addition, repeatedly attracting the same individuals should be avoided, as the consequences of repeat disturbance on this species have not been fully established; similar studies with other raptor species have found decreasing responses (Mosher *et al.* 1990; Jones & Hill 2001). These decreased responses may be due to habituation or relocation of falcon pairs away from the disturbance with repeated usage (Mosher *et al.* 1990; Jones & Hill 2001).

LITERATURE CITED

Addison, N.; Holland, J.D.; Minot, E.O. 2006. New Zealand falcon (*Falco novaeseelandiae*) in pine plantations in the Hawke's Bay. *New Zealand Journal of Forestry 51*: 3-7.

Bell, D.; Lawrence, S. 2009. New Zealand falcon (*Falco novaeseelandiae*) distribution survey 2006-09. *Notornis 56:* 217-221.

Bonter, D.N.; Bridge, E.S. 2011. Applications of radio frequency identification (RFID) in ornithological research: A review. *Journal of Field Ornithology 82:* 1-10.

Cornell Lab of Ornithology: Bioacoustics Research Program. (n.d.). *Raven interactive sound analysis software*. Retrieved from: http://www.birds.cornell.edu/brp/raven.

Crowe, D.E.; Longshore, K.M. 2010. Estimates of density, detection probability, and factors influencing detection of burrowing owls in the Mojave Desert. *Journal of Raptor Research 44:* 1-11.

Fuller, M.R.; Christenson, G.S. 1976. An evaluation of techniques for capturing raptors in east-central Minnesota. *Journal of Raptor Research 10:* 9-19.

Fox, N.C. 1988. A taxonomic redescription of the New Zealand falcon *Falco-novaseelandaie* Gmelin 1788. *Notornis 35:* 270-272.

Fox, N.C. 1978. Distribution and numbers of New Zealand falcon *Falco-novaseelandaie*. *Notornis 25:* 317-331.

Fox, N.C. 1977. *The biology of the New Zealand falcon (Falco Novaeseelandlae* Gmelin 1788) Unpubl. Ph.D. thesis, University of Canterbury, Christchurch, New Zealand.

Gauthreaux, S.A. Jr.; Livingston, J.W. 2006. Monitoring bird migration with a fixed-beam radar and a thermal-imaging camera. *Journal of Field Ornithology 77:* 319-328.

Gula, R.; Theuerkauf, J.; Rouys, S.; Legault, A. 2010. An audio/video surveillance system for wildlife. *European Journal of Wildlife Research 56:* 803-807.

Holland, J.D.; McCutcheon, R.R. 2007. Satellite tracking a New Zealand falcon (*Falco novaeseelandiae*). *Notornis 54:* 20-27.

IUCN Red List of Threatened Species. 2010. *Falco novaeseelandiae*. Retrieved from: www.iucnredlist.org.

Jones, K.J.; Hill W.L. 2001. Auditory perception of hawks and owls for passerine alarm calls. *Ethology 107:* 717-726.

Kaingaroa Timberlands. 2008. *Kaingaroa Forest*. Retrieved from: http://www.kaingaroatimberlands.co.nz/forest.htm.

Kays, R.; Kraunstauber, B.; Jansen, P.; Carbone, C.; Rowcliffe, M.; Fountain, T.; Tilak, S. 2009. Camera traps as sensor networks for monitoring animal communities. *2009 IEEE 34th conference on local computer networks (LCN 2009)*, 811-818.

Kennedy, P.L.; Stahlecker, D.W. 1993. Responsiveness of nesting northern goshawks to taped broadcasts of 3 conspecific calls. *Journal of Wildlife Management 57:* 249-257.

Kross, S.M.; Nelson, X.J. 2011. A portable low-cost remote videography system for monitoring wildlife. *Methods in Ecology & Evolution 2:* 191-196.

Kuttruff, H. 2007. *Acoustics: An Introduction*. Abingdon, Oxfordshire: Taylor & Francis Group.

Lowe, L. 2011. *A broadcast vocalization-locating technique and an investigation of the calls of New Zealand bush falcons (Falco novaseelandiae)*. Unpubl. Pg.Dip. thesis, Massey University, Palmerston North, New Zealand.

McBride, N.L.E. 2008. *Effectiveness of vocalization recordings in locating New Zealand bush falcon (Falco novaeseelandia) in production forestry compartments*. Unpubl. Pg.Dip. thesis, Massey University, Palmerston North, New Zealand.

McLeod, M.A.; Andersen, D.E. 1998. Red-shouldered hawk broadcast surveys: Factors affecting detection of responses and population trends. *Journal of Wildlife Management 62:* 1385-1397.

Mosher, J.A.; Fuller, M.R.; Kopeny, M. 1990. Surveying woodland raptors by broadcast of conspecific vocalizations. *Journal of Field Ornithology 61:* 453-461.

Mosher, J.A.; Fuller, M.R. 1996. Surveying woodland hawks with broadcasts of great horned owl vocalizations. *Wildlife Society Bulletin 24:* 531-536.

Newell, P.; Holland, K. 2007. *Loudspeakers for music recording and reproduction*. Burlington, Massachusetts: Focal Press.

Seaton, R.; Holland, J.D.; Minot, E.O.; Springett, B.P. 2009. Breeding success of New Zealand falcons (*Falco novaseelandaie*) in a pine plantation. *New Zealand Journal of Ecology 33:* 32-39.

Seaton, R. 2007. *The ecological requirements of the New Zealand falcon (Falco novaseelandaie) in plantation forestry*. Unpubl. Ph.D. thesis, Massey University, Palmerston North, New Zealand.

Seaton, R.; Minot, E.O.; Holland, J.D. 2010. Nest-site selection of New Zealand falcons (*Falco novaseelandiae)* in plantation forests and the implications of this to forestry management. *Emu110:* 316-323.

Stewart, D.; Hyde, N. 2004. New Zealand falcons (*Falco novaseelandaie*) nesting in exotic plantations. *Notornis 51*: 119-121.

Teng, J. 2009. *Developing a broadcast call-back alarm system to survey New Zealand falcons (Falco novaseelandiae).* Unpubl. Pg.Dip. thesis, Massey University, Palmerston North, New Zealand.

Thomas, B.; Minot, E.O.; Holland, J.D. 2010. Home range and habitat use of the New Zealand falcon (*Falco novaeseelandiae*) within a plantation forest: A satellite tracking study. *International Journal of Ecology 2010.*