ESTIMATING QUAIL AND PIGEON POPULATIONS IN NSW FOR USE IN 2017 NATIVE GAME BIRD HARVEST QUOTA DETERMINATION

FINAL REPORT

(MAY 2017)

Prepared for: The Game Licensing Unit, Department of Primary Industry

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SUMMARY

- ALL REQUIRED PERMITS AND AUTHORITIES TO UNDERTAKE THE RESEARCH WERE OBTAINED.

- SITE IDENTIFICATION OBJECTIVE: COMPLETED AS TASKED. FOUR SURVEY SITES, CORRESPONDING TO ADMINISTRATIVE BOUNDARY ZONES IDENTIFIED BY THE GAME LICENSING UNIT (GLU), WERE SURVEYED. PRECISE SAMPLING AREAS WITHIN THESE WERE CHOSEN BASED ON SATELLITE DATA, ON-GROUND ASSESSMENTS AND THE USE OF LOCAL CONTACTS.

- CONDUCT TRADITIONAL SAMPLING OBJECTIVE: PROTOCOLS WERE DEVELOPED FOR ALL SITES, WITH DATA COLLECTION COMPLETED AT EACH BY THE END OF MARCH 2017.

- NON-TRADITIONAL SURVEY TECHNIQUE EFFICACY OBJECTIVE: CAMERA TRAPPING APPROACH TRIALED AND SUCCESS QUANTIFIED, HOWEVER THIS APPROACH IS NOT RECOMMENDED FOR FURTHER DEPLOYMENT. ACOUSTIC CENSUS GROUND TRUTHING COMPLETED AND SHOWS HIGH PROMISE. ASSESSMENT IN OTHER HABITATS NOW A PRIORITY, HOWEVER TECHNIQUE IS RECOMMENDED FOR FURTHER SURVEY WORK ON BOTH QUAIL SPECIES SURVEYED HEREIN.

- SUSTAINABLE HARVEST OBJECTIVE: DENSITY ESTIMATES IN EACH OF THE FOUR ZONES HAVE BEEN COMPLETED FOR EACH OF THE TARGET SPECIES TO ENABLE THE GLU TO MAKE INFORMED DECISIONS CONCERNING POTENTIAL HARVEST LIMITS.

OVERVIEW

STAFFING AND CAPACITY:

In addition to M^{c}Donald and Hall, to ensure an appropriate WHS environment in the field, and to maximise data collection and analysis efficiency, Ms Sigrid Mackenzie was appointed to the project in the capacity of a Research Assistant. Sigrid has a first class Honours degree focusing on the natural sciences, specialising in zoology. This staff person assisted in carrying out fieldwork, collecting survey data, and preliminary analysis of sonograms.

To further augment the project, a current PhD student at UNE, Ms Ionie-Lee Smallwood and a final year Bachelor of Zoology student, Ms Alison Cash, also assisted in data collection. Ms Cash has several years experience acting in a research assistant capacity with avian field research projects, and assisted in deploying field equipment. Ms Smallwood is currently in her first year of a PhD that will investigate the behaviour, movement and molecular population substructure of both Stubble (*Coturnix pectoralis*) and Brown Quail (*C. ypsilophora*) across several sites in NSW. Given this focus and obvious overlap with the objectives of this project, Ms Smallwood's experience was used to assist in deploying field equipment and visually surveying quail during the acoustic census assessment trials conducted at Inverell.

Together, this staffing portfolio provided expertise and sufficient labour in all areas required to complete the project, whilst also keeping to budgetary constraints and reporting timelines. Higher than expected rainfall in early 2017 led to slight delays in preparing this report, as field sites were inaccessible to vehicles for several weeks, and therefore recording equipment and their onboard data could not be collected for assessment. By delaying the release of this final report, we have ensured that all collected data has been incorporated and analysed to provide the most robust population size estimates possible.

OBJECTIVE **1**: IDENTIFY THE FOUR GLU ZONES MOST LIKELY TO HOLD SIGNIFICANT POPULATIONS OF THE FOUR TARGET SPECIES

RESULTS:

We identified the four sites that were monitored under this project to gain an index of abundance, and thus sustainable harvest levels, for the four target species (Fig. 1). These sites were distributed so that they covered four of the Game Licensing Unit (GLU) administrative zones, namely:

- Site 1: Armidale/Inverell region: Northern Tablelands GLU Zone
- Site 2: Plains southwest of Dubbo: Western GLU Zone
- Site 3: Jerilderie and Hay: South West Riverina GLU Zone
- Site 4: Coffs Harbour region: North Coast GLU Zone

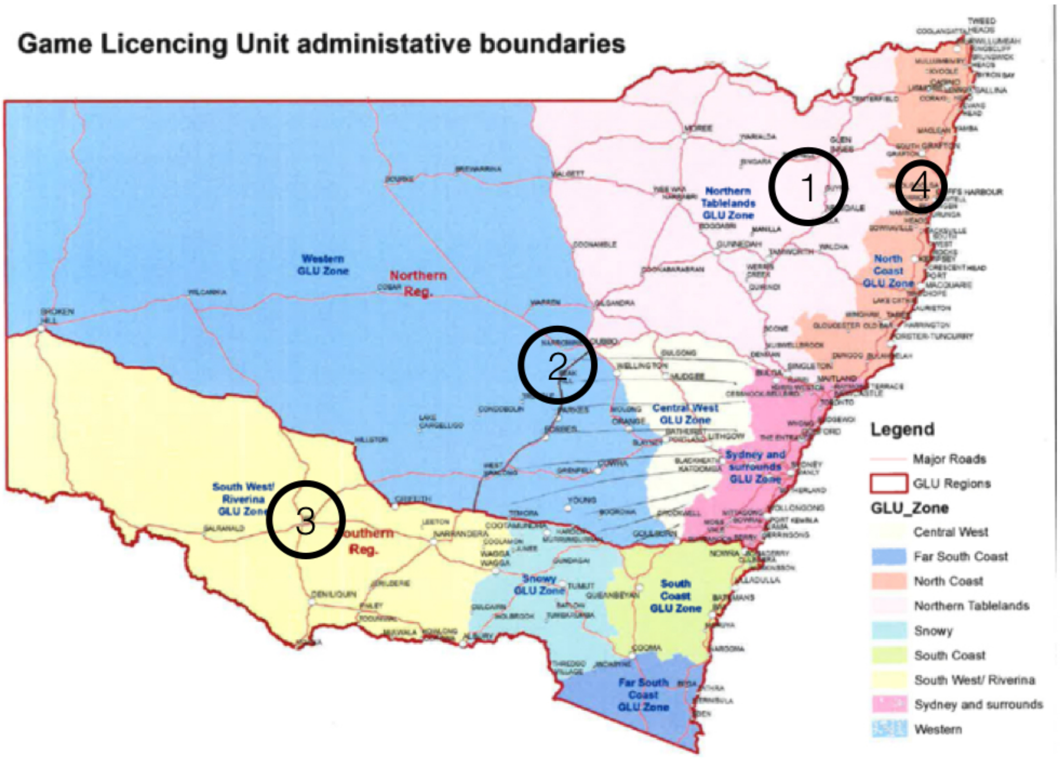

Figure 1: The GLU administrative boundaries and four identified regions of research as mentioned throughout the proposal.

These regions were identified through a combination of assessment of past site occupancy data in the literature and relevant databases (e.g., Birdlife Atlas and Atlas of Living Australia data), as well as assessment of current conditions using remote sensing data. The latter was possible thanks to a system previously developed by our team (McDonald et al. 2015) that identified the amount of standing water present at a resolution of 250 x 250 m pixels across NSW. We both visited and carried out on-ground assessments of potential specific survey sites within all of these regions in late 2016 to visually confirm the presence of most target species. We augmented our own personal observations with information from local GLU staff and landowners about bird distribution and abundance in their area to assist in determining the final survey and monitoring sites within each of the four GLU administrative zones.

Objective 1 is therefore complete. Details of the final areas surveyed within each are presented below. Pigeon surveys targeting Crested Pigeons (*Ocyphaps lophotes*) and Common Bronzewings (*Phaps chalcoptera*) consisted of a minimum of 4 x 50km survey routes, as outlined and detailed below under Objective 2, within each zone. Survey work targeting the two quail species utilised spotlighting and acoustic sensor deployment focusing on key properties containing likely habitat in each of the zones. The location of each is outlined below. Both Stubble and Brown Quail were either observed in these areas directly by members of the research team or had been reported as being present by landholders within a month of the survey beginning.

SITE 1: NORTHERN TABLELANDS GLU ZONE

Location 1: Armidale, 'Points View', 30.43700S, 151.98386E.

Habitat: Irrigated improved pasture with tree-lined creek nearby (Fig. 2).

Location 2: Inverell, 'Cayuga', 29.58377S, 150.96936E.

Habitat: Both barley and chickpea crops in paddocks, often interspersed with improved pasture. Sparse primarily Eucalypt tree overstorey in some areas (Fig. 3).

SITE 2: WESTERN GLU ZONE

Location: Forbes, 'Lawson Grains', 33.49490S, 147.96259E.

Habitat: Large wheat stubble paddock with distant, sparse Eucalypt tree borders (Fig. 4).

SITE 3: SOUTH WEST RIVERINA GLU ZONE

Location 1: Jerilderie, ‘Old Corrie’, 35.34127S, 145.54840E.

Habitat: Large wheat stubble paddocks, with sparse Eucalypt tree lines around cropped area (Fig. 5).

Location 2: Hay, ‘Mungadal’, 34.54256S, 144.81169E.

Habitat: Large native grassland paddocks with no emergent trees (Fig. 6).

SITE 4: NORTH COAST GLU ZONE

Location 1: Bellingen, 30.47472S, 152.88185E.

Habitat: Dense Eucalypt forest with native grassland in cleared zones throughout (Fig. 7).

Location: Nana Glen, 30.11796S , 152.98561E.

Habitat: Dense Eucalypt forest with native grassland in cleared zones throughout (Fig. 8).

Figure 2. Aerial picture of Armidale survey site 'Points View', with location of bioacoustic recorders deployed during surveys as part of the Northern Tablelands GLU Zone Quail Survey indicated.

Figure 3. Aerial picture of Inverell survey site 'Cayuga', with location of different crop types surveyed as part of the Northern Tablelands GLU Zone Quail Survey indicated.

Figure 4. Aerial picture of Forbes survey site 'Lawson Grains', with location of bioacoustic recorders used during surveys as part of the Western GLU Zone Quail Survey also indicated.

Figure 5. Aerial picture of Jerilderie survey site 'Old Corrie', with location of bioacoustic recorders used during surveys as part of the South West Riverina GLU Zone Quail Survey also indicated.

Figure 6. Aerial picture of Hay survey site 'Mungadal', with location of bioacoustic recorders used during surveys as part of the South West Riverina GLU Zone Quail Survey also indicated.

Figure 7. Aerial picture of Bellingen survey site, with location of bioacoustic recorders used during surveys as part of the North Coast GLU Zone Quail Survey also indicated.

Figure 8. Aerial picture of Nana Glen survey site, with location of bioacoustic recorders used during surveys as part of the North Coast GLU Zone Quail Survey also indicated.

OBJECTIVE 2: CONDUCT TRADITIONAL LINE TRANSECT AND POINT COUNT SURVEYS IN REPRESENTATIVE AREAS OF THE IDENTIFIED GLU REGIONS TO BUILD ROBUST ESTIMATES OF FOCAL SPECIES POPULATION SIZES.

RESULTS:

Initial survey activity focused on the first site in the New England region. This approach enabled a direct comparison between established traditional survey sourced data and information gathered in the non-traditional approaches outlined in Objective 3. Our aim was to establish an appropriate protocol in this region that could then be utilised with confidence across the other three regions to enable a robust estimation of population sizes throughout representative regions of NSW.

PIGEON SURVEYS:

The different survey targets require a different approach to effectively census. For the two pigeon species of interest, namely Crested Pigeons and Common Bronzewings, a vehicular-based transect survey was developed to identify individuals present in the study area. These species both regularly congregate near roads and are relatively easily identified by an observer travelling in a slow moving vehicle. An advantage of these vehicular based surveys is that a larger area is able to be surveyed than otherwise possible on foot, an important consideration given the widely dispersed, clumped nature of the populations of both species in the surveyed areas.

During each survey, a transect of at least 50km was covered whilst driving at less than 40km/hr. The driver counted each species to the right of the road out to a distance of 50 meters from the roadside edge, while the passenger counted individuals present from the road to 50 meters to their left. This effectively enabled a 100 meter wide transect to be continuously surveyed, therefore for every kilometre travelled, survey area was 0.10km^2. Binoculars were used for clarification of species identity where needed due to vegetative obstruction, and the vehicle was stopped to ensure larger flocks (>5 individuals) were accurately assayed.

Transect routes were repeated 4 times per site, with survey effort spread equally over the morning and evening periods to account any diurnal variance in pigeon numbers. Morning surveys were completed within two hours of sunrise, while evening surveys were initiated no more than two hours prior to sunset. Transects were also conducted in an alternating direction (e.g., if a given survey initially was driven in a clockwise loop, the second survey would be driven in the opposite direction, i.e., an anti-clockwise loop). In this way, each transect was driven at least once in each direction for each temporal period.

Before commencing each transect, potential confounds such as cloud cover and climatic variables such as wind speed, precipitation and ambient temperature were recorded. These did not meaningfully impact results, so are not presented herein for brevity.

The route taken for each transect was mapped beforehand using satellite imagery. An odometer reading was taken at each encounter of the focal species, enabling locations of birds to be mapped along transect routes for identifying potential clusters or habitats of greater than typical abundance.

A total of 28 surveys were completed, covering a total area of 155.08 km^2 (Table 1). In all, 1128 Crested Pigeons and 67 Common Bronzewings were detected during the survey. It should be noted that the Northern Tablelands GLU Zone and surveyed regions of the South West Riverina GLU Zone are considered marginal habitat for Common Bronzewings, following perusal of past atlas records of the species. However, Crested Pigeons are considered common to abundant in these regions with a lower reliance on wooded areas, leading to us surveying these zones.

Perusal of Table 1 quickly highlights that both species were encountered in relatively low numbers throughout many surveys. Further, when the location of each observation was mapped, many records of both species were tightly clustered near feedlots or other anthropogenic structures on survey routes. In all, 55% of the 67 Bronzewing individuals and 18% of the 1128 Crested Pigeon records were detected within 2km of a feedlot or town centre on surveys. Further, when flocks were considered (flock here defined as groups of >1 bird), this increased to 56% of the 9 Common Bronzewing flocks and 38% of the 69 Crested Pigeon flocks. A clear conclusion from these data is that both species are tightly clustered around townships in the current landscape, presumably to access the anthropogenic resources that these provide, such as food and water.

To further reinforce these differences between rural surveys and town areas in the survey zones, we undertook a single survey of 50 km through the streets of Armidale on 14 February 2017 where we counted a total of 182 Crested Pigeons. Survey routes of the same distance encompassing rural landscapes in the Northern tablelands GLU Administrative Zone averaged just 20.3 ± 12SD birds for comparison. Together, these data highlight the clustered nature of both species around these anthropogenic resources.

Overleaf: Table 1. Location of pigeon surveys and numbers of Common Bronzewing (BWP) and Crested Pigeon (CP) recorded on each survey conducted in each of the four GLU administrative zones surveyed. Region numbers correspond to Site numbers presented under Objective 1.

GLU Zone	Location	Date	Distance (km)	Area (km²)	Time	#BWP	#CP	#BWP /km²	#CP /km²
1	Inverell	13.09.16	52.4	5.24	am	5	40	0.95	7.63
1	Inverell	13.09.16	52.4	5.24	pm	6	44	1.15	8.40
1	Inverell	14.09.16	71.6	7.16	am	9	50	0.13	7.00
1	Inverell	12.10.16	71.6	7.16	pm	5	53	0.07	7.40
1	Inverell	13.10.16	71.6	7.16	am	3	51	0.04	7.12
1	Inverell	13.10.16	71.6	7.16	pm	5	78	0.07	10.89
1	Inverell	14.10.16	71.6	7.16	am	6	58	0.08	8.10
1	Armidale	25.10.16	45.5	4.55	am	0	9	0	1.98
1	Armidale	25.10.16	45.5	4.55	pm	0	50	0	11.00
1	Armidale	26.10.16	45.5	4.55	am	0	20	0	4.40
1	Armidale	26.10.16	45.5	4.55	pm	0	17	0	3.74
1	Armidale	1.11.16	54.5	5.45	am	0	18	0	3.30
1	Armidale	1.11.16	54.5	5.45	pm	0	15	0	2.75
1	Armidale	2.11.16	54.5	5.45	am	0	25	0	4.59
1	Armidale	2.11.16	54.5	5.45	pm	0	14	0	2.57
1	Armidale City	14.02.17	49.6	4.96	am	0	182	0	36.69
2	Forbes	6.03.17	57	5.7	pm	4	9	0.7	1.58
2	Forbes	7.03.17	57	5.7	am	1	15	0.18	2.63
2	Forbes	7.03.17	57	5.7	pm	1	3	0.18	0.53
2	Forbes	22.03.17	57	5.7	am	0	24	0	4.21
3	Jerilderie	22.03.17	46.6	4.66	pm	0	76	0	16.31
3	Jerilderie	23.03.17	46.6	4.66	am	0	64	0	13.73
3	Jerilderie	23.03.17	46.6	4.66	pm	0	62	0	13.30

Table 1. (continued)

GLU Zone	Location	Date	Distance (km)	Area (km²)	Time	#BWP	#CP	#BWP /km²	#CP /km²
3	Jerilderie	24.03.17	46.6	4.66	am	0	111	0	23.82
4	Coffs Harbour	12.01.17	56	5.6	pm	1	10	0.18	1.79
4	Coffs Harbour	13.01.17	56	5.6	am	0	4	0	0.71
4	Coffs Harbour	20.01.17	56	5.56	pm	0	4	0	0.71
4	Coffs Harbour	30.01.17	56	5.6	am	21	22	3.75	3.93

QUAIL SURVEYS

The two focal quail species, the Stubble and Brown Quail were also monitored using methods established for other *Coturnix* and similar ground bird species internationally (Hall 2013). Given the cryptic nature of these two target species, smaller, foot-based transects being walked through likely habitat to detect their presence was considered, analogous to the techniques used to monitor pigeons. However, time and labour constraints meant that this approach would have been unviable, covering an in sufficient area of interest to satisfy our objectives (Fig. 9).

Instead, nocturnal spotlight transects of recently harvested paddocks were traversed using a combination of vehicular and foot transport according to access restrictions. Despite this, it rapidly became apparent that the low density of birds would prevent an adequate survey being conducted given the logistical parameters of this project. We therefore choose to use the manual survey technique of spotlighting to identify areas with known quail populations, and then ground truth the suitability of a more efficient acoustic-based survey approach for wider deployment.

Figure 9: Female Stubble Quail detected and photographed during a transect walked during daylight hours. Note the low to ground posture that makes detection of this species difficult in thicker vegetation.

VISUAL SURVEYS: NORTHERN TABLELANDS GLU ADMINISTRATIVE ZONE

We took advantage of the crop harvest activities being undertaken on the Inverell property 'Cayuga' (Fig. 3) to ground-truth the acoustic-survey data. At the time of these activities, October through to the end of December 2016, two crop types were actively being harvested: chickpea and barley. The landholders kindly allowed researchers to sit in the cabin of the harvester as it traversed each paddock, enabling the number of quail of each species flushed out of the crop to be recorded (Fig. 10).

The Harvester first moved around the perimeter of each focal paddock and then in increasingly smaller concentric, approximately circular, shapes so that the paddocks were harvested 'from the outside in'. This approach was used to help ensure that birds present in a given paddock at the start of harvest were flushed and recorded, rather than simply leaving the paddock undetected through thick crop areas given the aversion of both quail species to move over open ground. Observers identified the species (Brown or Stubble Quail) and age (adult or juvenile) flushed from each paddock. Individual birds that flushed back into the unharvested crop area were not recounted.

Figure 10. The harvester used to identify number of birds present in surveyed paddocks, here harvesting the outer limits of the crop. Observers sat in the cabin and counted the number of birds flushed from the crop as it transversed the paddock.

This approach facilitated a means by which we could exhaustively sample a known area of habitat to generate per hectare occupancy for each paddock, with paddock area calculated using satellite imagery. This then provided the comparison data used to generate population estimates from the call rate data gathered from bioacoustic recorders deployed as outlined in Objective 3 below.

The different crop types yielded different numbers of flushed individuals, with barley crops (n=10) and chickpea crops (n=11) differing in their relative attractiveness to each species, although Stubble Quail were more common in both crops (Fig. 11). As barley crops were naturally harvested earlier in the year (late October-early November) than chickpea crops (late December) these differences may be due to crop-specific microhabitat differences, seasonal shifts in the relative abundance of the different species, and/or differences in physical habitat structure - barley crops at the time of harvest were 60-70cm above ground and relatively uniform in distribution, whereas chickpea crops varied between 60-100cm and sometimes also contained weedy species of varying density within the crop. Further elucidation of the fine scale impact of these microhabitat differences on quail distribution is beyond the scope of this report, as annual monitoring across an entire year would be required, however this is an area that will be pursued by Ms Smallwood's project for future verification. For the purposes of this report, crop type should be taken as a proxy variable that is potentially indicative of all of the above.

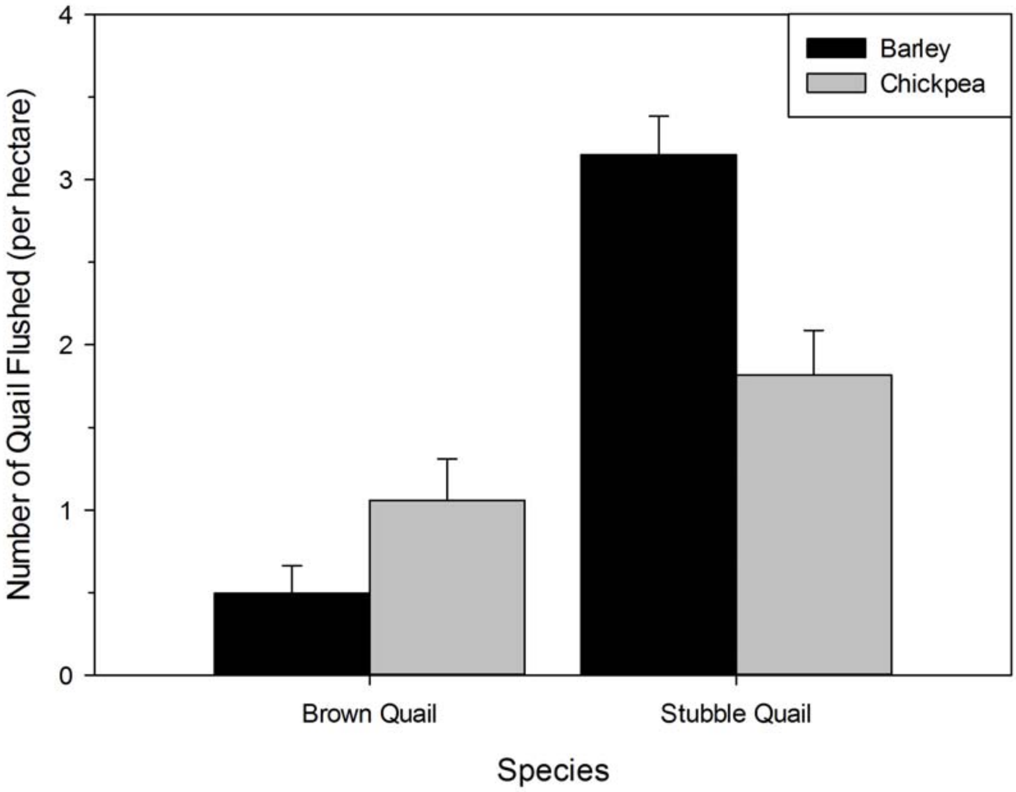

Figure 11. Mean (± 1 SE) densities of a) Brown and b) Stubble Quail flushed from barley and chickpea crops surveyed during harvest near Inverell, NSW.

Interestingly, despite Brown Quail being at higher density in barley crops, and Stubble Quail more often encountered in chickpea crops on a within-species level, there was a strong positive correlation of 0.952 between the two species presence in a paddock. This correlation differed significantly from zero ($t=13.526$, $df=19$, $p<0.05$), indicating that numbers of the two species were positively correlated in all paddocks sampled, regardless of crop type.

OBJECTIVE 3: TEST THE EFFICACY OF NON-TRADITIONAL SURVEY TECHNIQUES TO FACILITATE FASTER AND MORE COMPREHENSIVE SURVEYS OF TARGET SPECIES IN THE FUTURE

CAMERA TRAPS:

A total of 10 camera trap units (Bushnell Trophy Cam HD Aggressor) were deployed at the Inverell site near stations baited with seed likely to attract all four target species. In total, the cameras captured more than 10,000 images; mainly of livestock, rabbits, hares and foxes. The cameras proved very limited in terms of their ability to record images of birds *per se*, and were particularly poor in capturing images of quail and pigeons.

Despite success in capturing a range of non-target species, the method has not proved to be a successful one for monitoring the species of interest. The same two individual Stubble Quail were captured across a series of 16 images (e.g., Fig. 12), and no pictures were recorded of pigeons, despite them being common at the Inverell site. Given this, the use of camera traps was deemed unsuitable as a survey technique that was not pursued further.

Figure 12: Two Stubble Quail identified at a site near Inverell using a Bushnell Camera Trophy HD camera trap. The two individuals are standing on the orange soil to the centre right of frame.

Bioacoustic surveys:

To effectively survey both quail species in a cost and time-effective manner, a new survey technique was required. Our previous research has established that passive bioacoustic recorders can record quail vocalisations, and that the peak calling period is during the two hours following civil dawn (McDonald et al. 2015).

Using a sound level meter (Digitech QM-159) we were able to determine that the average amplitude of vocalisations produced by Brown Quail, when standardised to levels at 1m using the formula outlined in Naguib and Wiley (2001), were 68.6dB ± 5SD (n=7 individuals). Stubble Quail were louder, averaging 86.9dB ± 8SD (n=17). Standardised playbacks of recorded vocalisations at these levels indicated that observers viewing spectrograms could reliably discern target vocalisations from typical background noise at a radius of 100m of the recorder (BAR units, Frontier Labs, Australia).

Next, to generate a model utilising detected call rates of birds an hour after civil dawn, we deployed BAR recorders throughout the centre of paddocks to be harvested (Fig. 13). Two different crop types were harvested: barley and chickpea as per the results above, with 28 recorders deployed in each. The call rate of birds vocalising within 100m of each recorder the morning of harvests was then quantified by visualising call spectrograms using Raven Pro 1.5 (Charif et al. 2010). If paddocks had calling birds and quail were flushed from the paddock during harvest, we then compared the number of adult birds flushed per hectare with the mean number of calls detected for that species per hour. Thus, while recorders are sampling an area of radius 100m around each unit, these data were used to generate an estimate of the number of quail present per hectare at each recorder site.

It should be noted that these models are preliminary in nature, as there was some evidence of potential seasonal differences in occupation and/or habitat differences as outlined above. Further, as this is a snapshot survey undertaken at the time of harvest, call rates of either quail species may differ if surveys are undertaken at different times of the year, and/or in different habitats. Obviously the use of a harvester to flush birds from areas is not an approach that is feasibly applied to every site, so instead Ms Smallwood's PhD project will continue to quantify these issues and compare calling rates to the density of birds identified through spotlight-based nocturnal surveys of key areas. These data will help inform ongoing fine-tuning of these models for more accurate estimates of quail density.

Figure 13: A Bioacoustic Recorder (BAR; Frontier Labs) setup in a likely habitat for monitoring target quail species. Calls were recorded for several days during known calling periods for the target species, prior to the area being harvested and the number of quail flushed recorded. BARs were placed at least 200m apart in the centre of paddocks to be harvested.

Despite this, preliminary models were highly successful in explaining a high degree of variance in the number of animals flushed from a given paddock. Brown Quail showed a positive relationship between the number of calls detected and the number of individuals flushed during harvest later that same morning, accounting for 32% of variation in this dataset although the model did not reach statistical significance (R^2 = 0.32, $F_{1,9}$ = 4.268, p = 0.07). However, as a preliminary model the number of Brown Quail flushed per hectare surveyed (Fig. 14) could be approximated by the formula:

Brown Quail Number flushed / hectare = 0.00314(Mean call rate per hour) + 0.677

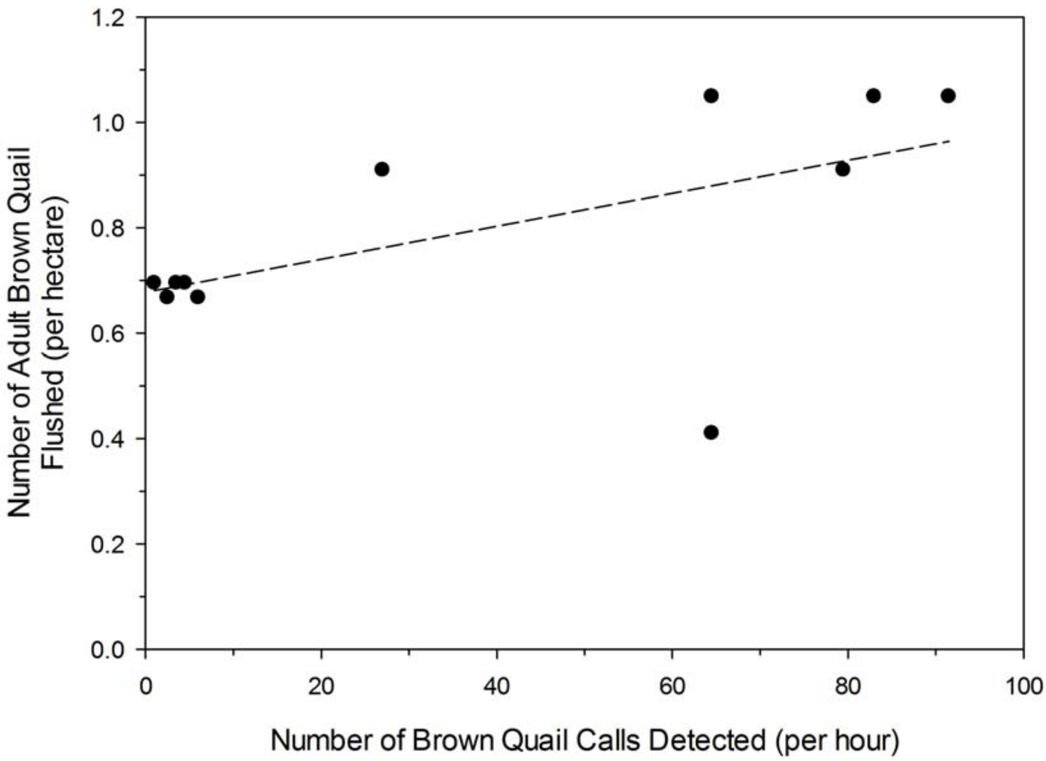

Figure 14. A model comparing the number of adult Brown Quail flushed from paddocks where recorders identified the mean hourly calling rate detected in the two hours following civil dawn on the morning of harvest. Best fit line: y = 0.00314x + 0.677.

Similarly, although there was one outlier paddock removed from analysis, indicating more research is required to elucidate fine-scale factors influencing the relationship, nevertheless there was again a positive relationship between call and flush rate for Stubble Quail in our data (Fig. 15). Again, a relatively high proportion of variation in the data was explained using this approach, although the relationship did not reach statistical significance (R^2 = 0.27, $F_{1,5}$ = 1.892, p = 0.23). However, as a preliminary model the number of Stubble Quail flushed per hectare surveyed could be approximated by the formula:

Stubble Quail Number flushed / hectare = 0.0261(Mean call rate per hour) + 1.672

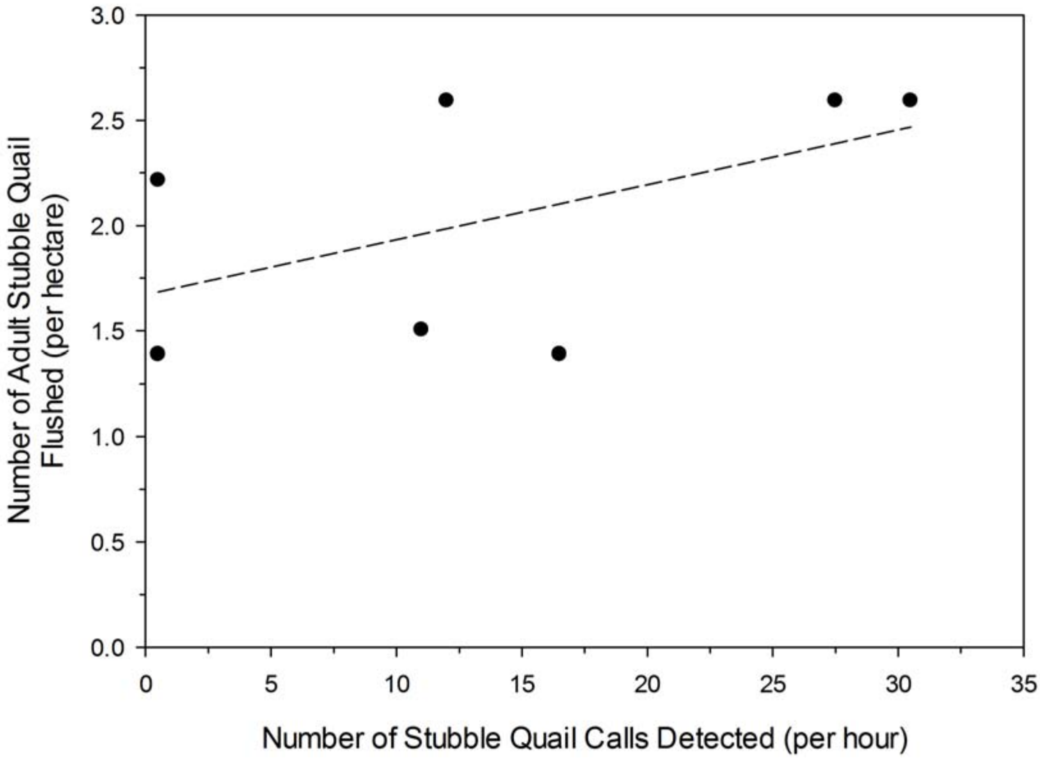

Figure 15. A model comparing the number of adult Stubble Quail flushed from paddocks where recorders identified the mean hourly calling rate detected in the two hours following civil dawn on the morning of harvest. Best fit line: y = 0.0261x + 1.672.

Together these data demonstrate the potential of the technique that can be fine-tuned with additional data quantifying the relative importance and impact of covariates such as season, climatic variables, habitat type and area across the surveyed landscape. That said, we have used these preliminary models as indicative measures of these likely final relationships to generate population estimations for birds recorded in the four GLU Administrative Zones under Objective Four below.

OBJECTIVE 4: COMBINE LINES OF EVIDENCE TO PROVIDE SUSTAINABLE HARVEST ESTIMATES FOR EACH OF THE FOUR FOCAL SPECIES THROUGHOUT NSW.

RESULTS:

To achieve the greatest efficacy of monitoring, a mixed approach of vehicular-based line transects targeting the pigeon species was combined with a passive, bioacoustic monitoring regime for the two focal quail species. Results from camera trap-based surveys were sufficient to allow us to rule these out as effective means of monitoring the four target species throughout NSW, and as such these are not considered further.

PIGEON POPULATION ESTIMATES

The pigeon surveys revealed small numbers of Common Bronzewing pigeons throughout all four surveyed GLU Administrative Zones. We have not proceeded further with this species in calculating sustainable harvest estimates, as the numbers detected are sufficiently small that any harvest would not appear to be warranted currently.

Whilst we observed more Crested Pigeons throughout the surveys than Common Bronzewings, the clumped nature of the observations around anthropomorphic resources suggests that a harvest of Crested Pigeons is also not currently viable. Consequently we have not provided harvest estimates for either of the targeted pigeon species.

QUAIL POPULATION ESTIMATES

After establishing passive acoustic monitoring as a viable technique for both Brown and Stubble Quail, and building preliminary models for estimating the number of individuals present per hectare, we deployed a total of 76 additional recording units throughout the four GLU Administrative Zones we surveyed for a minimum of 14 days (Table 2; barley crops were the exception given the unpredictable time between placement and harvest initiation). Collectively, these recorders sampled a total of 4981 hours of sampling for minimal labour requirements. Ultimately the use of BARs will be more labour effective and thus facilitate broader scale monitoring than other techniques currently used (Hall 2013).

We choose 4 days across these 14-day sampled periods and assessed the mean number of calls present for each recorder at each site. Using those figures, we were able to extract a mean call rate per recorder for each GLU Zone, which was then used to calculate an estimate of adult bird density in areas of suitable habitat using the preliminary models developed under Objective 3. These are presented below in Table 3.

Table 2. Location and numbers of passive bioacoustic recorders deployed during the survey in each of the four GLU Administrative Zones surveyed.

GLU Zone	Location	Habitat	Meters deployed	Number of days	Number of hours recorded	Total hours deployed
Northern Tablelands	Inverell	Barley	28	3	7	161
		Chickpea	28	18	4	2016
	Armidale	Improved pasture	6	14	4	336
North Coast	Coffs Harbour	Bellingen Forest	4	19	4	304
		Nana Glen Forest	6	19	4	456
Western	Forbes	Wheat stubble	9	14	4	504
South West Riverina	Jerilderie	Wheat stubble	9	14	4	504
	Hay	Native Grassland	11	14	4	616
Total			**104**			**4981**

Table 3. The mean number of calls per sampling period detected at recorders placed in each of the four GLU Administrative zone locations during the study for a) Brown Quail and b) Stubble Quail. These figures have been used in conjunction with preliminary models above to generate estimates of adult bird density per hectare of suitable habitat in each zone, with a 95% Confidence Interval for each mean also presented.

GLU Zone	**Mean hourly call rate (± 1SE)**	**Number of sampling days assayed**	**Estimated density per hectare of suitable habitat (Mean and 95%CI)**
a) Brown Quail			
Northern Tablelands	36.9 ± 6.93SE	47	0.793 (0.765 – 0.821)
Western	0	32	None detected
South West Riverina	0	77	None detected
North Coast	0	39	None detected
b) Stubble Quail			
Northern Tablelands	5.3 ± 3.31	47	1.810 (1.700 – 1.921)
Western	10.3 ± 2.99SE	32	1.940 (1.863 - 2.016)
South West Riverina	44.7 ± 14.75SE	77	2.837 (2.453 - 3.222)
North Coast	0	39	None detected

From perusal of Table 3, it is clear that there are insufficient Quail of either species in the North Coast GLU Administrative Zone to support a season. Despite hearing and seeing quail during preliminary visits at these sites, and landholders stating that quail visited these areas regularly, our passive recorders did not detect a single call across 39 sampling days for 10 different recorder locations.

For Brown Quail, no birds were detected in the Western or South West Riverina area recording data, which would also indicate that a harvest of Brown Quail in these areas was also not justified. There were only modest numbers of Brown Quail on the

Northern Tableland sites, with estimates lower than a 1 bird per hectare in suitable habitat. Given this low density, again it would seem prudent to not harvest this species in this GLU Zone at the current time.

Stubble Quail were detected at three GLU Administrative Zone recorder sites: Western, South West Riverina and the Northern Tablelands. Densities ranged from mean estimates of 1.8 birds to 2.8 birds per hectare of suitable habitat. Given these higher densities, particularly in the South West Riverina, a small, closely regulated and monitored harvest may be feasible for this species in those three GLU Zones.

Given the preliminary nature of the acoustic models, we strongly recommend that further verification of call rate data relative to habitat, time of year and Administrative Zone be undertaken to ensure robust predictive models are finalised, allowing any harvest planned to be sustainable. Key to this aim will be determining critical information on reproductive success, growth rates and basic population ecology data of both quail species and enabling this to be further considered when calculating sustainable harvest levels.

RECOMMENDATIONS FOR FUTURE INVESTIGATION

PIGEON SPECIES:

For Common Bronzewings, other regions should be surveyed that may have larger populations than the four GLU Administrative Zones monitored herein.

Crested Pigeon surveys in more western GLU Administration Zones may be able to determine regions where their distribution is more differentiated from human habitation than in the areas currently surveyed. This should be examined.

QUAIL SPECIES:

Current knowledge of *Coturnix* movements and population ecology in Australia is very poorly known, largely due to the difficulties of monitoring these species.

Herein we have demonstrated the efficacy of the acoustic survey approach, however the complexity of habitat and seasonal variations has yet to be fully elucidated.

Ideally, a minimum 12 month surveying period across a range of habitats and regions of NSW need to be visually and acoustically surveyed regularly so that the influence of habitat type on calling behaviour, and any effect of changing call rate with season, can be fully built into models. This would facilitate region wide surveys using acoustic recorders alone in subsequent years, potentially after identifying the most appropriate time of year to do so (e.g., early Spring).

ALL SPECIES:

Key to building definitive models for generating sustainable harvest data are information on reproductive rates, density dependence and the covariance introduced to these by factors such as climatic variables. The species vary in terms of current knowledge on these fronts, but all would benefit from a greater understanding of these factors.

Finally, any harvest program must be accompanied by ongoing monitoring so that future harvests can be adapted accordingly in terms of raising or lowering harvest estimates in following years.

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