Survey for Night Parrots along the proposed Tanami gas pipeline, Northern Territory: Habitat assessment and acoustic survey

Adaptive NRM Pty Ltd

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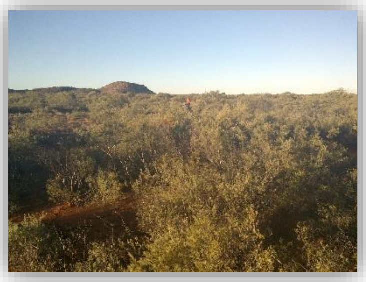

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1. Scope of this report

The report provides details about the methods, results and conclusions of a targeted, field-based Night Parrot survey along a proposed gas pipeline corridor in the Tanami Desert, Northern Territory in May 2018. It accompanies a previous report (Adaptive NRM 2018) that presents the methods and results of desktop spatial analyses for the same area, which concluded there was enough evidence and reason to undertake field assessments.

2. Contributors

Name (organisation)	**Role in this project**
Stephen Murphy (ANRM)	principal analyst, field ecologist and lead author
Rachel Paltridge (Desert Wildlife Services)	analyst, field ecologist and author
Nick Leseberg (ANRM; UQ)	acoustic proofing
Matthew McKown (Conservation Metrics Inc.).	lead acoustic analyst
Hafiz Stewart (ELA)	field ecologist

3. Summary

- Using field data, we aimed to validate the findings of desktop analyses (Adaptive NRM 2018) that assessed the potential for Night Parrot habitat along the proposed Tanami gas pipeline. A rapid habitat survey protocol showed there was statistically significant agreement in habitat scores between the desktop assessment and the field-based assessment, although the former did tend to overestimate habitat quality (but not significantly).
- A series of focal surveys at the most likely looking sites along the alignment showed there were areas that were structurally and floristically suitable for Night Parrots. However, predation pressure by introduced mammals (cats and foxes) and total grazing pressure (rabbits, cattle, horses/donkeys and camels) appeared to be higher than that recorded at sites permanently occupied by Night Parrots in Queensland.
- More than 1000 hours of acoustic data collected at 13 of the most likely Night Parrot sites along the pipeline alignment failed to detect the species. The equipment, sampling strategy and analytical method we used in this study are known to be very reliable methods to detect Night Parrots elsewhere.
- We conclude that, despite some areas being floristically and structurally suitable, the pipeline corridor is unlikely to support Night Parrots, mainly because of frequent, widespread fires, predation pressure and grazing pressure.

4. Introduction

Night Parrots (*Pezoporus occidentalis*) are listed as Endangered in the federal *Environment Protection and Biodiversity Conservation Act 1999*. Historical records show that the species once had a widespread distribution throughout Australia's arid zone (Higgins 1999). Over the past 100 or so years, a combination of increased predation by introduced cats and foxes, and widespread fires has reduced their distribution markedly, such that they are known only from a few widely separated locations in Queensland and Western Australia (Murphy *et al.* 2017b). However, thanks to a recent increase in our understanding of Night Parrot ecology coupled with advancements in acoustic field survey technology, it is likely that more populations will be found.

This report provides details about a targeted Night Parrot survey in the Tanami Desert in May 2018. It was commissioned as part of an environmental assessment process for the construction of a proposed gas pipeline (Figure 1). This report is an extension of earlier desktop analyses (Adaptive NRM 2018) which combined the contemporary knowledge of Night Parrot ecology, spatial data and local knowledge of the Tanami to conclude there was a "*reasonable case for conducting targeted field-based Night Parrot surveys*" along the proposed pipeline corridor. Generally speaking this conclusion was based on:

- historical Night Parrot sightings in the region (Murphy *et al.* 2009)
- a low introduced predator density (especially in the north (Southgate *et al.* 2007))
- the presence of other threatened species, most notably Greater Bilbies (*Macrotis lagotis*) and Great Desert Skinks (*Liopholis kintorei*). Threatened species are spatially correlated with Night Parrot occurrence elsewhere (Murphy *et al.* 2017b).
- some areas of long-unburnt vegetation which could act as long-term roosting/breeding refugia for Night Parrots (based on moderate resolution fire scar mapping)
- the presence of potential Night Parrot feeding areas and food plants

It was acknowledged that the spatial datasets that underpinned the desktop analyses were error-prone, both in terms of attribute comprehensiveness and spatial accuracy, and that field validation was required to inform any subsequent targeted Night Parrot surveys. Consequently, a field survey was undertaken in May 2018 that had three objectives:

1. to validate the desktop habitat analyses presented in Adaptive NRM (2018)
2. to select sites that field inspection and expert opinion suggested had a reasonable chance of supporting Night Parrots and install automated sound recording devices
3. a subsequent objective was to analyse the acoustic data using the best available automated systems, coupled with manual listening of a subset of data.

This report outlines the methods, results and conclusions of these objectives.

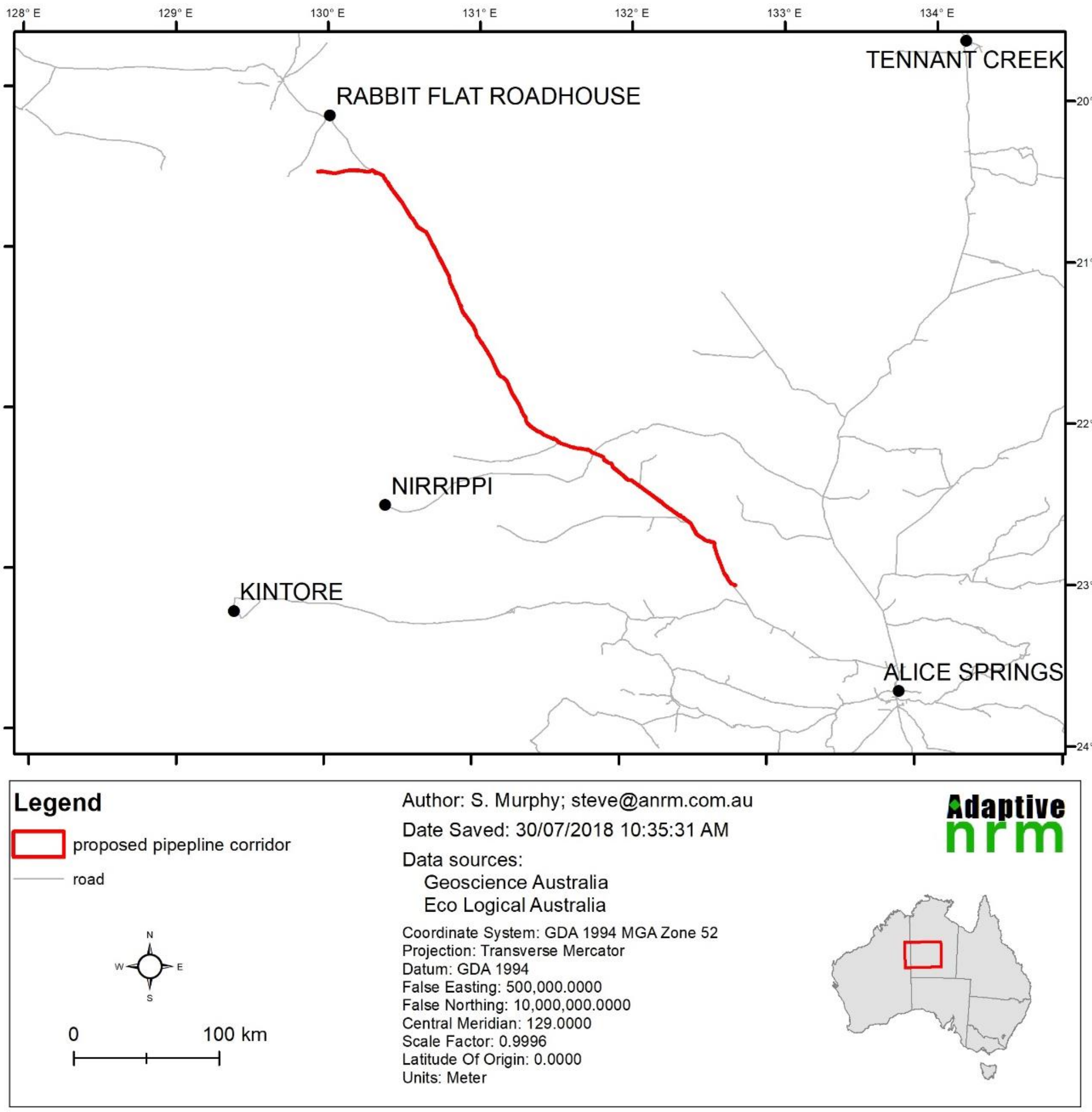

Figure 1. Location of proposed pipeline corridor.

5. Methods

5.1. Rapid habitat assessment

The desktop analyses presented in Adaptive NRM (2018) calculated a "priority score" for 118 5x5 km cells along the pipeline corridor. The scores were based on the suitability of each cell for Night Parrots using quantitative assessments of:

1. presence of threatened species
2. presence of long-unburnt habitat
3. presence of suitable *Triodia* for roosting/breeding
4. presence of potential feeding areas, based on floristics and run-on zones (which have been shown to be important feeding areas)

We aimed to validate the priority scores of as many of the 118 cells as possible using a rapid field survey protocol. Not all cells could be inspected due to access restrictions near the Granites Gold Mine: cells 107-118 could not be assessed. Table 1 defines the four attributes that were assessed for each cell using a binary (1/0) score. For cells that had heterogeneous qualities, the attribute that best defined the majority of the cell was used. Scores were given as we drove through or alongside each cell at less than 40km/h. Where the Tanami Track diverged from the alignment, we either walked in or used binoculars for closer inspection. For subsequent analyses, the binary scores were summed to give a total score for each cell. The proforma used in the field is shown in Appendix 1.

Table 1. Attributes scored during rapid assessments

Attribute	Rationale
Complex vegetation structure	A complex vegetation structure (i.e. one with multiple age classes) typically reflects a patchy fire history that could be conducive to the maintenance of Night Parrot habitat, compared to areas that are maintained in a simple structure by frequent and widespread fires.
Suitable *Triodia* species present	Research in QLD (Murphy *et al.* 2017c; Murphy *et al.* 2017a) and WA (Jackett *et al.* 2017) shows that Night Parrots rely on *Triodia* hummocks for roosting and breeding. Not all *Triodia* species form hummocks that are structurally suitable for Night Parrots. We scored *T. basedowii*, *T. spicata*, *T. schinzii* and *T. pungens* (Palya form) as suitable. Areas that supported these species but that were recently burnt or in earlier stages of post-fire recovery were considered suitable, because past or future appropriate fire patterns could make them usable by parrots.
Presence of potential run-on areas	Murphy *et al.* (2017c) shows that run-on areas are important feeding areas for Night Parrots. These can be very small features only a few metres across.
Overall expert opinion of suitability	An overall assessment of a cell's suitability for Night Parrots, based on expert opinion. This qualitative attribute considered the above qualities, and also included aspects such as juxtaposition of feeding and breeding/roosting habitats, overall habitat quality and similarity of the cell to known occupied sites in Queensland.

5.2. Focal habitat assessment

For a subset of cells, we undertook a detailed field inspection involving an approximately 10-15 minute focal search by three experienced ecologists (RP, HS and SM) within an area of approximately 2 ha. The attributes we scored, their scale and rationale appear in Table 2.

In addition to providing a greater understanding of habitat quality, these assessments helped inform and justify site selection for further acoustic surveys. The subset of cells chosen for focal surveys was based on those with high scores from the rapid habitat assessment and/or because they contained sites of particular interest such as locations proposed to build temporary construction camps.

The specific locations of the 2ha searches within the prioritised 5 x 5 km cells were partially informed by a refinement of site prioritisation by an ecologist with local expertise in Tanami Desert vegetation communities (RP). Local knowledge of habitats likely to support succulent food plants preferred by Night Parrots suggested that palaeodrainage and/or salt lake margin vegetation communities were the run-on habitats that were most likely to provide suitable feeding areas. This emphasised the importance of searching cells along the corridor that lay in the vicinity of Lake Lewis, Chilla Well and Sangster's Bore. The salt lake systems associated with Lake Lewis and Sangster's Bore were also considered the most suitable habitats for the Palya form of *Triodia pungens*. A third reason for prioritising habitats near the salt lakes and palaeodrainage channels was that the drainage lines provide barriers to fire and often protect refugial stands of unburnt spinifex.

Within these three general areas we examined the most recent cloud-free Landsat 8 satellite image to select the areas of oldest spinifex within the pipeline corridor.

A fourth area that was prioritised was rocky range habitat within the Yuendumu hills area, because it supports *Triodia spicata* which is considered likely to produce suitable hummocks for roosting. The oldest patches of spinifex habitat along the section of corridor throughout the Yuendumu hills were selected for ground truthing.

The site refinement process produced a list of 20 KP sites that required ground-truthing as to their suitability for further survey. Although this provided a useful guide to direct our efforts, ultimately the specific sites chosen for ground survey could only be chosen in the field when we could see the structure of the spinifex hummocks and observe other influences such as grazing pressure. Some sites were immediately discounted if the spinifex structure was clearly unsuitable; others were moved to nearby sections of corridor if better habitat was found to occur nearby.

Table 2. Attributes scored during focal habitat surveys

Attribute	Score	Rationale
Suitable *Triodia* species present	<u>Ordinal 0-3</u> 0 = none 1 = some scattered suitable hummocks among unsuitable matrix 2 = suitable hummocks common, but area dominated by unsuitable 3 = suitable hummocks dominant Suitable hummocks were deemed to be at least knee high and of a density such that the ground could not be seen when viewing from above.	See Table 1
Presence of potential run-on areas	<u>Binary 0/1</u> 0 = no run-on observed 1 = run-on observed, no matter how small and including that created by earthworks (e.g. roadside table drains)	Murphy *et al.* (2017c) shows that run-on areas are important feeding areas for Night Parrots. These can be very small features only a few metres across.
Herbaceous diversity score	<u>Ordinal 1-3</u> 1 = 1-2 morphospecies 2 = 3-5 morphospecies 3 > 5 morphospecies	Night Parrots are known to eat a range of small herbaceous plants. In the absence of doing comprehensive floristic surveys (which time did not permit), we counted the number of morpho-species which informed the ordinal score
Significant area of non-wooded vegetation	<u>Binary 0/1</u> 0 = no open areas (non-woody) observed 1 = open areas (non-woody) observed > 1ha	Murphy *et al.* (2017c) demonstrates that Night Parrots seem to prefer habitats that have a very sparse woody stem density. Accordingly, we recorded whether or not there were large areas of non-woody habitat greater than about 1 ha.
Presence/absence of: • rabbits • cows • horses/donkeys • camels • cats • foxes • dingoes/wild dogs • bilby • mulgara • great desert skinks	<u>Binary 0/1</u> 0 = absence 1 = presence	Rabbits, cows, horses/donkeys and camels are thought to reduce the availability of food available to Night Parrots by grazing. Cats and foxes are almost certainly important predators of Night Parrots (Murphy *et al.* 2017b) Dingoes/wild dogs could exert a regulatory effect on cats and foxes, and their presence is probably beneficial (Murphy *et al.* 2017b) Bilbies, Mulgaras and Great Desert Skinks are the other likely threatened species in the project area. In Queensland, the occurrence of Night Parrots is spatially correlated with the presence of other threatened species.

5.3. Acoustic survey

Leseberg *et al.* (in prep) demonstrate that Night Parrots are reliably vocal birds at their *Triodia* roost sites. They also show that passive, automated acoustic recorders are a reliable way to detect the species.

We installed Song Meter 4 (SM4; Wildlife Acoustics, Massachusetts, USA) at 13 locations deemed to have either (1) the highest likelihood of supporting Night Parrots along the pipeline corridor or n = 11); or (2) were near to a proposed construction camp (n = 2).

SM4s were set to record from dusk until dawn for a minimum of 6 nights. At occupied sites in Queensland, the probability of not detecting a Night Parrot over 6 nights is almost 0 (Leseberg *et al.* in prep). Recordings were made in mono with 48 kHz sample rate and in uncompressed wav file format.

Analyses of the acoustic data from one site (KP48) was expedited to avoid delays in the pipeline planning process, given that construction will begin from the south and KP48 is an outlier (all other potential sites are significantly farther north). While all the data from KP48 was subsequently included in the comprehensive machine learning analyses presented below, a subsample of audio files collected during known peak calling periods was manually screened by eye (using spectrograms) and by ear to detect Night Parrot calls. The results of this analysis is presented in a previous report (Murphy and Leseberg 2018).

Acoustic data were analysed using a deep neural network (DNN) model that is trained to identify three distinct Night Parrot vocalisations: *dink-dink*, *croak* and *hollow whistle*. Field observations in Queensland and Western Australia show that these calls are given at both places and as such it is reasonable to assume that Night Parrots elsewhere, including in the Tanami, make the same calls. Results from the automated DNN analyses were proofed by ear by people with extensive experience listening to Night Parrots in the field (SM and NL).

6. Results

6.1. Rapid habitat assessment

106 out of 118 (90%) of cells were scored along approx. 380km of the proposed pipeline corridor. Figure 2 shows a histogram of cell score values. Figure 3 shows a map of the cells and their associated score.

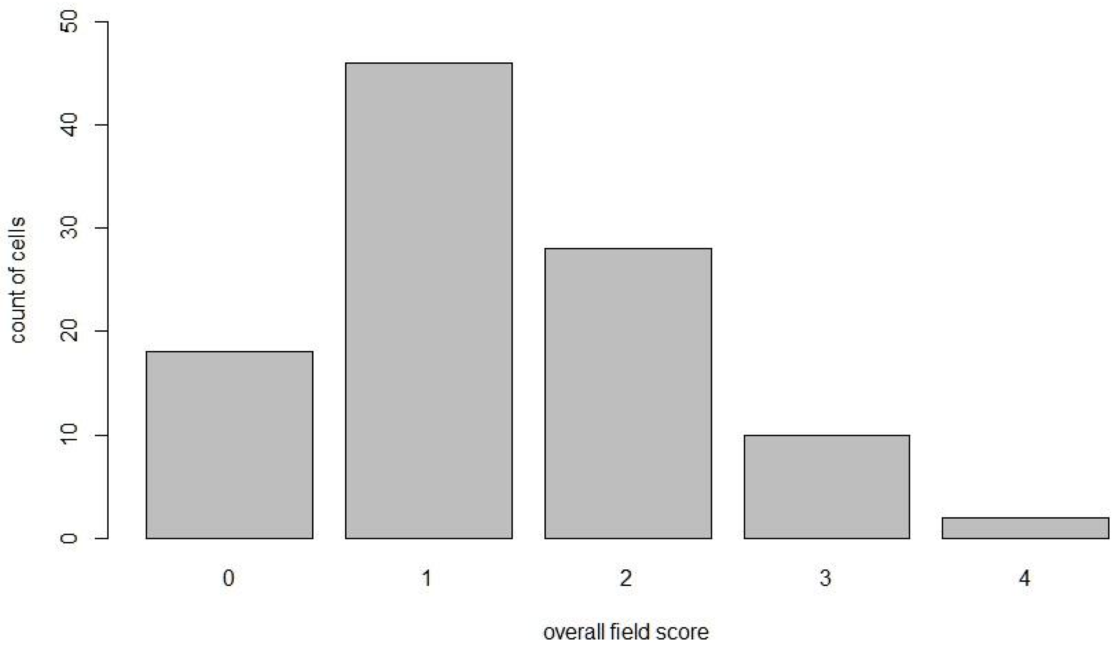

Figure 2. Histogram of scores for 106 cells along the pipeline corridor.

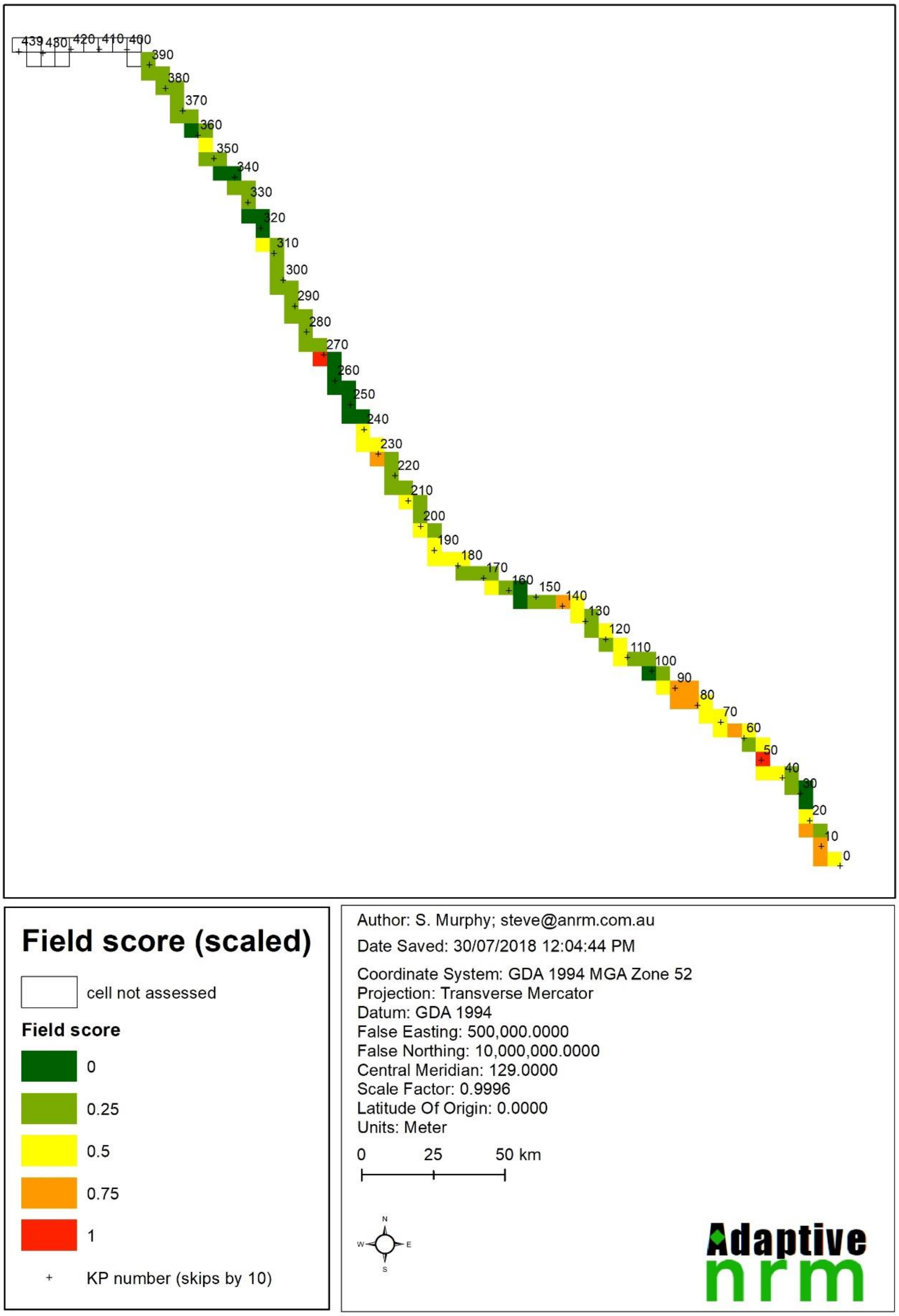

Figure 3. Map showing field-based score for each 5x5km cell along the alignment.

The field scores matched the desktop scores reasonably well, as demonstrated by the statistically significant relationship between the two (Adjusted R-squared = 0.1153; $F_{1,104} = 14.68$, $p < 0.001$; Figure 4). There was a tendency for the desktop scores to overestimate habitat suitability (i.e. give higher scores) which explains the relatively modest slope of the line in Figure 4 (i.e. the low Adjusted R-squared value). Note that for this analysis the scores were re-scaled to make them comparable.

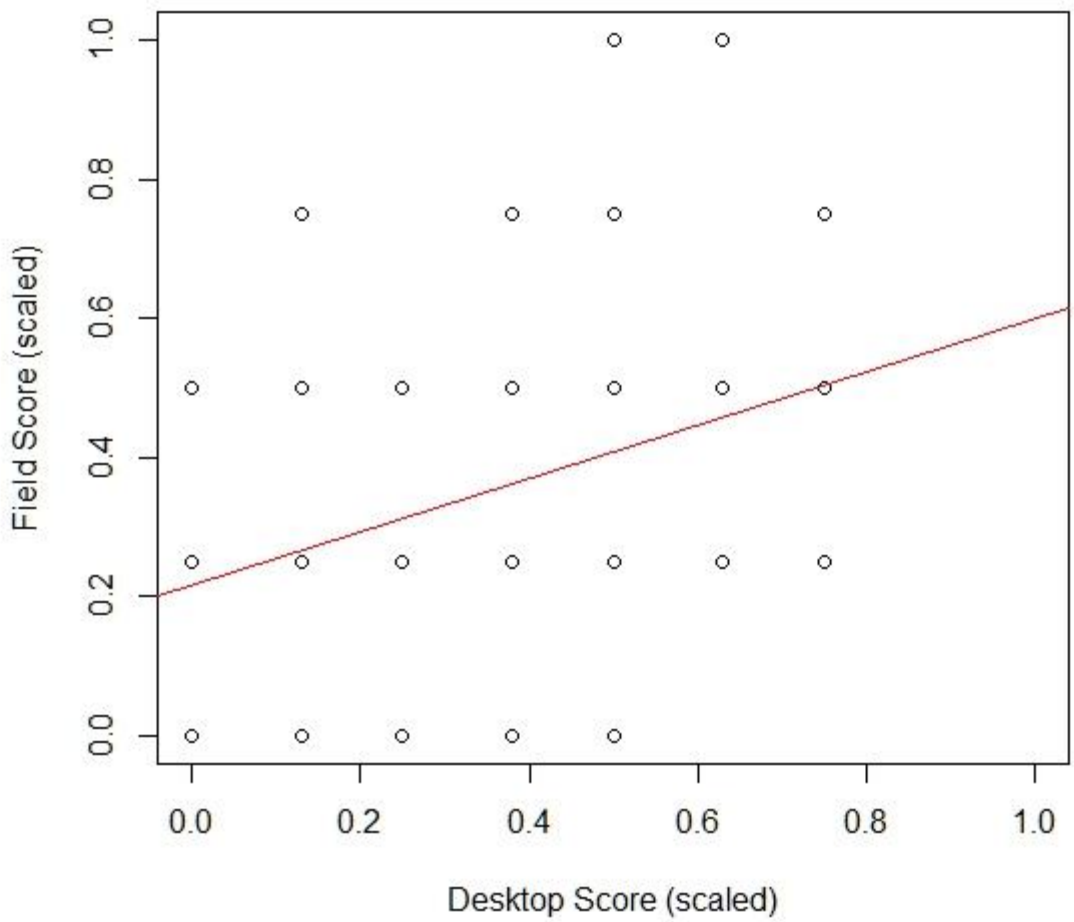

Figure 4. Field score as a function of desktop score, showing significant agreement.

Most of the corridor was deemed to be of low value for Night Parrots, based on our current understanding of their ecology (Table 3; Figure 5). Just over half of the cells (58%) exhibited a simple vegetation structure, reflecting the region's history of repeated, large-scale single fire events. Cells that did have a complex vegetation structure were more likely to be woodlands and not suitable for Night Parrots. Cells with suitable run-on areas were not uncommon (36%) and 53% of cells contained suitable *Triodia* hummocks. However, expert opinion rated only a small number of cells as having high quality Night Parrot habitat (4%), which was mostly driven by the region's history of repeated large fires that has impacted on the availability of long-unburnt Night Parrot habitat.

Table 3. Numerical summary of rapid habitat assessment

	Complex Vegetation	**Suitable Hummocks**	**Run-On Areas**	**Expert Opinion**
0	62	50	68	102
1	44	56	38	4

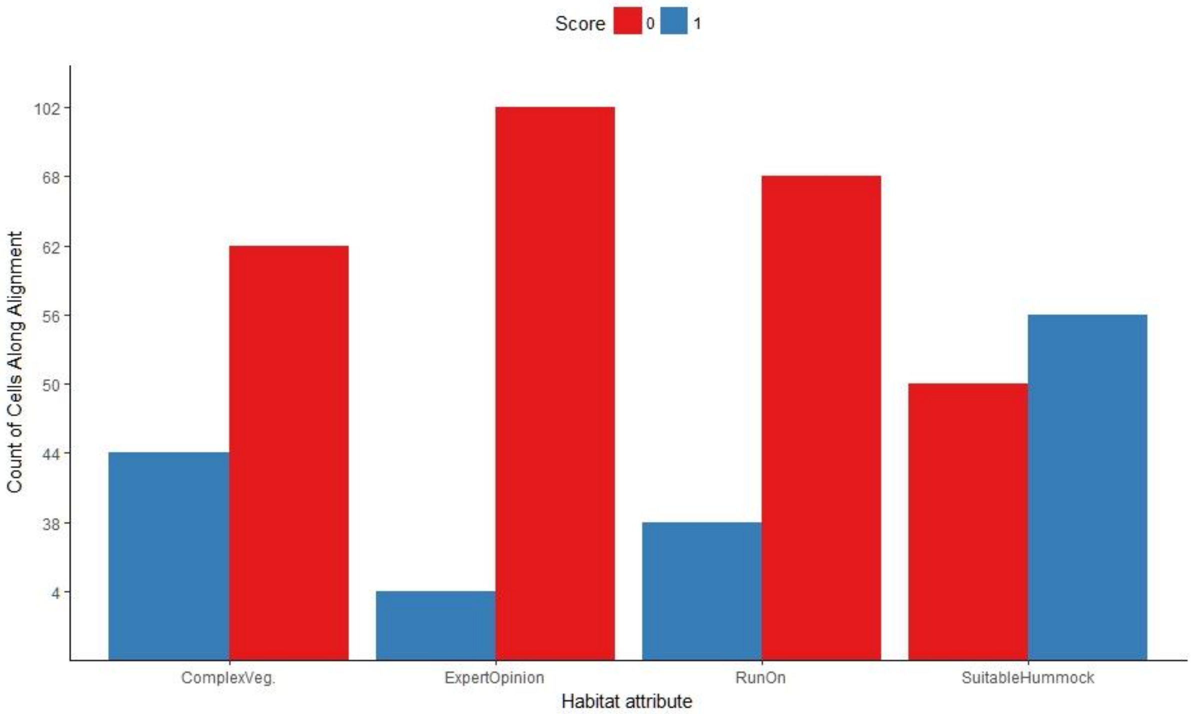

Figure 5. Plot of habitat attributes observed along the corridor from rapid assessment

6.2. Focal habitat assessment

Eighteen focal habitat surveys were conducted in areas deemed to have reasonable quality Night Parrot roosting/breeding or feeding habitat (n = 16), and/or areas considered a high priority due to the imminent construction of accommodation camps (n = 2; Table 5; Figure 6). The 16 sites not associated with camp construction all had some qualities that we considered could make them important for Night Parrots, including structurally suitable *Triodia* hummocks and/or floristically diverse run-on areas (including observations of some known Night Parrot food plants e.g. *Trianthema triquetra*), and were often accompanied by the presence of other threatened species.

Observations for habitat attributes for each focal assessment site is shown in Table 5. Table 6 shows a descriptive summary of the data where some attributes are combined and summed across scores. "N/A" values are not applicable due to the scoring system (described in Section 5.2). There was bimodality in suitable hummocks and run-on areas, which reflected our predisposition to select the best potential feeding and roosting/breeding areas we could find. Similarly, the high frequency of sites with non-wooded areas reflects our non-random site selection. Of greater interest is the relatively low herbaceous diversity scores, which could reflect the season in which we sampled (i.e. cool and dry, and not optimal for detecting annual plants) or a depauperate flora (perhaps due to frequent fire), or both. Cats and foxes were commonly detected with 28% of sites having one or the other, and 17% of sites having both. Dingoes/wild dogs were also commonly detected (56% of sites). Total grazing pressure (including rabbits, cattle, horses/donkeys and camels) was high, with 67% of sites having one grazing species and 17% having two or more. Threatened species were detected reasonably often, with 33% of sites having either mulgaras or great desert skinks, while no sites had both.

We attempted to discover relationships among some habitat attributes that might indicate the presence of ecological processes that are known to relate to the presence of threatened species elsewhere (including Night Parrots (Murphy *et al.* 2017b)). We did this by fitting linear models using the software "R" (R Core Team 2016). Models and results are presented in Table 4. None of the relationships were significant, although we note that our sample size was small.

Table 4. Models exploring key ecological processes

Model	F-statistic	p-value	Significance
Threatened species ~ Predation pressure (cats/foxes)	$F_{1,16} = 0.04$	$p > 0.8$	Not significant
Predation pressure (cats/foxes) ~ Dingoes/wild dogs	$F_{1,16} = 0.4444$	$p = 0.5$	Not significant
Grazing pressure ~ Dingoes/wild dogs	$F_{1,16} = 0.003$	$p > 0.9$	Not significant

Table 5. Observations of habitat attributes recorded during focal surveys

FOCAL SURVEY NUMBER	NEAREST KP	LAT	LON	SUITABLE HUMM	RUNON	HERB DIV SCORE	SIG.NON-WOODED AREAS	RABBIT	CAT	FOX	DOG	COW	HORSE/DONK	CAMEL	BILBY	MULGARA	G.D.SKINK	NOTES
1	17	-22.948069	132.661623	2	1	1	1	0	0	1	1	1	0	0	0	1	0	Dense melaleuca
2	212	-21.92392	131.254996	2	0	1	1	0	0	0	1	1	0	0	0	0	0	Expansive; T. pungens Payla; heavily grazed
3	267	-21.509236	130.988394	2	1	1	0	0	0	1	0	0	0	1	0	0	0	
4	268	-21.501443	130.981251	0	1	3	1	1	0	0	1	1	1	1	0	0	0	Trianthema and Tecticornia (NP foods)
5	138	-22.276911	131.82386	3	0	1	1	0	0	0	0	1	0	1	0	0	0	Triodia spicata
6	355	-20.831098	130.572379	0	1	2	1	0	0	0	1	0	0	0	0	0	1	Near tower
7	353	-20.847183	130.583132	0	1	2	1	0	0	0	1	0	0	1	0	0	0	Trianthema
8	343	-20.904374	130.654684	3	1	2	1	0	0	0	1	0	0	1	0	0	1	Trianthema; Probable Spectacled Hare-wallaby tracks
9	342	-20.90898	130.658158	3	1	2	1	0	1	0	1	0	0	1	0	0	0	Trianthema
10	342	-20.914973	130.66131	3	1	2	1	0	1	1	1	0	0	1	0	0	0	
11	330	-21.007518	130.715543	2	1	1	1	1	0	1	0	0	0	1	0	1	0	T. pungens and T. schinzii
12	309	-21.17327	130.808692	2	0	1	1	0	1	1	0	0	0	1	0	0	0	
13	295	-21.291386	130.858243	2	0	1	1	0	1	1	0	0	0	1	0	1	0	Patches of long unburnt
14	286	-21.364834	130.889654	0	0	1	1	0	0	0	0	1	0	0	0	0	0	Proposed camp site; Emu tracks
15	171	-22.180184	131.520796	0	0	1	0	0	0	0	0	1	0	0	0	0	0	Proposed camp site; grazed mulga woodland
16	48	-22.757153	132.491816	2	0	3	1	0	0	0	1	0	0	1	0	0	0	T. spicata on adjacent slope
17	389	-20.58192	130.38467	2	0	1	1	0	0	0	0	0	0	0	0	1	0	Lge patch of open Triodia grassland, with 50% shrub cover
18	385	-20.6082	130.40488	3	0	1	1	0	1	0	1	0	0	0	0	0	0	Mature, good quality Triodia; possible Mulgara

Table 6. Summary of attributes recorded during focal surveys

	Suitable hummocks	Run-On Areas	Herbaceous diversity	Non-woody areas	Predation pressure	Dogs	Grazing pressure	Threatened species
0	5	9	n/a	2	10	8	3	12
1	0	9	11	16	5	10	12	6
2	8	n/a	5	n/a	3	n/a	2	n/a
3	5	n/a	2	n/a	n/a	n/a	1	n/a

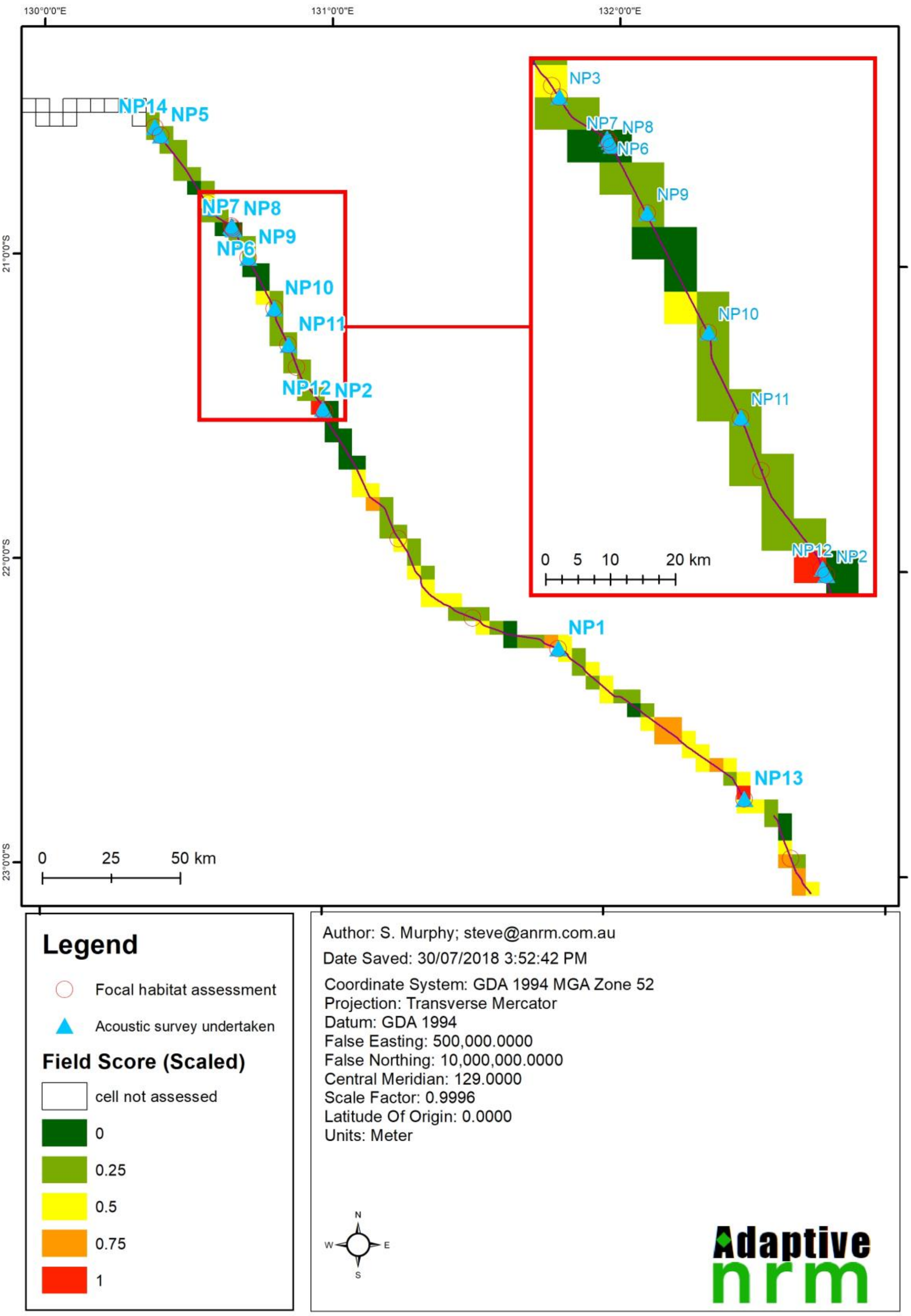

Figure 6. Map of focal habitat assessment and acoustic surveys

6.3. Acoustic survey

6.3.1. Effort

Thirteen SM4s were deployed between May 23 and June 1 (Figure 6; Figure 7). They recorded 1,102.35 hours of acoustic monitoring data across 97 sensor-nights (Table 7).

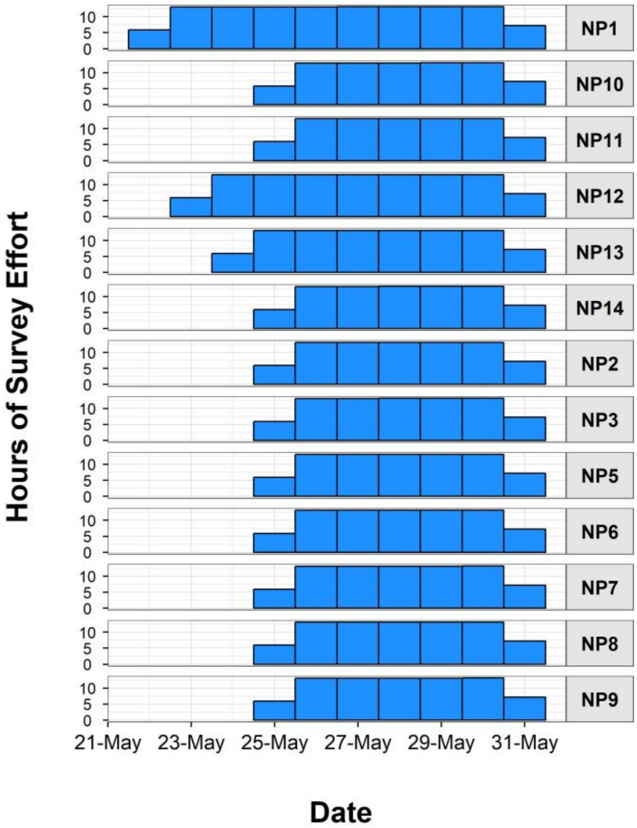

Figure 7. Acoustic survey effort by date and site.

Table 7. Acoustic survey effort

Site	Total Nights	Total Hours
NP1	10	117.93
NP2	7	78.82
NP3	7	78.82
NP5	7	78.82
NP6	7	78.82
NP7	7	78.82
NP8	7	78.82
NP9	7	78.82
NP10	7	78.27
NP11	7	78.82
NP12	9	104.87
NP13	8	91.9
NP14	7	78.82
TOTAL	**97**	**1102.35**

6.3.2. Model performance

The accepted method of evaluating real-world performance of a DNN model requires creation of a test dataset that is independent of both the model training and model cross-validation datasets. The model can then be run on the independent test dataset, and accuracy (ratio of false positives to total positives) and sensitivity (ratio of true positives to false negatives) can be calculated. Ideally, a test dataset should contain a representative sample of data from all monitoring sites, sampling from across the monitoring period, and sampling across the range of acoustic conditions in local soundscapes. It should also contain randomly selected examples of positive events (target species vocalizations), and negative events, in the same proportion that they occur in the natural soundscape. Thus, creation of an ideal test dataset is a challenge that requires manual review and labelling of many thousands of randomly selected clips of acoustic data. Due to the rarity of the calls being searched for in this survey, it was impossible for us to develop this ideal type of test dataset.

We instead evaluated model performance using a sample of validated calls from the full range of Night Parrot acoustic monitoring data that we currently have access to. This includes negative examples from data collected at locations across the spatial range of this survey effort, as well as both positive and negative examples from surveys conducted in Queensland with a higher concentration of Night Parrot activity. Since our current model was trained largely on Queensland data, the representation of performance presented here is likely to be positively biased.

We manually reviewed all acoustic events that our model determined to have a signal probability greater than .001. At this probability threshold, accuracy on the model evaluation dataset is 11.8% and 10.5% for ‘croak’ and ‘dink dink’, respectively. The model sensitivity is 100% for both signals at this threshold. We do not have enough confirmed Night Parrot hollow whistle calls to determine model performance for this signal.

6.3.3. Detections

The DNN analysis identified five calls resembling the Night Parrot *hollow whistle* call. Four of these calls occurred within a one-minute period at NP03, and one solitary call occurred at NP14. The Pallid Cuckoo (*Cacomantis pallidus*) gives a call that is very similar to the Night Parrot’s *hollow whistle*. Consequently, these calls were reviewed multiple times by experienced observers and the conclusion drawn that they lack the tonal consistently and percussion of confirmed Night Parrot *hollow whistle* calls. It is unlikely that these calls were made by Night Parrots.

7. Conclusion

Our rapid habitat assessments suggest that most of the habitat along the gas pipeline alignment is unsuitable for Night Parrots. The previous desktop analyses (Adaptive NRM 2018) tended to overscore habitat quality, although the overall conclusions of those analyses were supported, given there was a statistically significant relationship between desktop scores and those based on field data. In areas that appeared to be floristically suitable (i.e. with suitable hummock-forming *Triodia* species) the main factor driving overall poor habitat quality along the alignment appeared to be a long history of large-scale, single fires.

A relatively small number of sites appeared to be better quality Night Parrot habitat (n = 16), and the focal habitat surveys confirmed that these did indeed have attributes that could conceivably support Night Parrots (suitable hummocks, open non-wooded areas and/or potential feeding areas).

However, cats and foxes were detected commonly, as too were introduced herbivores. We suspect that these factors lower the overall value of habitat that otherwise appears suitable for Night Parrots. This relates to a key finding by Murphy *et al.* (2017b) who showed that a relatively lower predation pressure, driven by the complete absence of foxes and mesopredator regulation by dingoes, and a system that is resilient to grazing pressure, has allowed Night Parrots to persist at key sites in Queensland.

Subsequent acoustic analysis of over 1000 hours of recordings at 13 of the most likely Night Parrot sites along the alignment failed to detect Night Parrots.

We conclude that the poor quality of the habitat means that Night Parrots are unlikely to occur along the pipeline corridor. It is possible that individuals may use some parts at some times, but the likelihood that the area is permanently occupied is extremely low. Our observations suggest that this is driven by frequent fire, coupled with the relatively high cat/fox predation and total grazing pressure.

8. References

Adaptive NRM (2018). *The identification of potential Night Parrot habitats along the proposed Tanami gas pipeline, Northern Territory. Report to Eco Logical Australia*. Adaptive NRM, Malanda.

Higgins, P.J. (Ed.) (1999). *Handbook of Australian, New Zealand and Antarctic Birds. Vol. 4. Parrots to Dollarbird*. (Oxford University Press; Melbourne).

Jackett, N., Greatwich, B., Swann, G., and Boyle, A. (2017). A nesting record and vocalisations of the Night Parrot Pezoporus occidentalis from the East Murchison, Western Australia. *Australian Field Ornithology* **34**, 144-150.

Leseberg, N.P., Murphy, S.A., and *et al.* (in prep). Vocalisations of the night parrot *Pezoporus occidentalis*, and acoustic survey recommendations.

Murphy, S., Burbidge, A.H., Joseph, L., McAllan, I.A.W., Venables, W., and King, E. (2009). *Wanted: a bigger needle or a smaller haystack. Explaining and predicting the occurrence of Night Parrots in a vast landscape.* Presented at Fifth Biennial Australasian Ornithological Conference, Armidale, NSW.

Murphy, S., and Leseberg, N. (2018). *Night Parrot Surveys for Tanami Gas Pipeline Construction: KP48 Song Scope analysis and peak calling period manual screening*. Adaptive NRM, Malanda.

Murphy, S.A., Austin, J.J., Murphy, R.K., Silcock, J., Joseph, L., Garnett, S.T., Leseberg, N.P., Watson, J.E.M., and Burbidge, A.H. (2017a). Observations on breeding Night Parrots (*Pezoporus occidentalis*) in western Queensland. *Emu - Austral Ornithology* **117**, 107-113.

Murphy, S.A., Paltridge, R., Silcock, J., Murphy, R., Kutt, A.S., and Read, J. (2017b). Understanding and managing the threats to Night Parrots in south-western Queensland. *The Emu - Austral Ornithology* **117**, 135-145.

Murphy, S.A., Silcock, J., Murphy, R., Reid, J., and Austin, J.J. (2017c). Movements and habitat use of the night parrot *Pezoporus occidentalis* in south-western Queensland. *Austral Ecology* **42**, 858-868.

R Core Team (2016). R: A language and environment for statistical computing.

Southgate, R., Paltridge, R., Masters, P., and Ostendorf, B. (2007). Modelling introduced predator and herbivore distribution in the Tanami Desert, Australia. *Journal of Arid Environments* **68**, 438-464.

9. Appendices

9.1. Appendix One – Rapid assessment proforma

Tanami gas pipeline - NIGHT PARROT HABITAT RAPID ASSESSMENT						
CELL ID	DESKT. SCORE	COMPLEX VEG. STRUCTURE 1/0	SUITABLE HUMMOCK 1/0	RUN-ON 1/0	EXPERT OPINION 1/0	NOTES
1	0.5					
2	0.5					
3	1.5					
4	1.5					
5	1.5					
6	2.5					
7	1.5					
8	1.5					
9	3					
10	2.5					
11	2.5					
12	3					
13	2					
14	1					
15	1					
16	2					
17	2					
18	2					
19	1					
20	1					
21	1					
22	3					
23	2					
24	2					
25	2					