3 TAWNY ROCK DRAGON REPORT

SILVERTON WIND FARM DEVELOPMENTS

Proposed development of

Stage 1b and 1c, Silverton Wind Farm,

far western New South Wales

Status and distribution of the Tawny Rock Dragon and their habitat

FINAL

December 2008

ngh environmental

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Cover photos: Tawny Rock Dragon, rocky outcrop and feral goats

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1 INTRODUCTION

On behalf of Silverton Wind Farm Developments Pty. Ltd (SWFD), further biodiversity assessments to investigate the potential expansion of the Stage 1 Project Approval application (proposed turbine increase from 120 to 289) were undertaken and documented in the form of a Biodiversity Addendum.

The Biodiversity Addendum presented the findings of investigations into biodiversity values and likely impacts associated with development within these additional Stage 1 areas (known as Stage 1b & c) of the proposed wind farm at Silverton, near Broken Hill in far western New South Wales (Map 1). The Biodiversity Addendum accompanies the Biodiversity Assessment for the Stage 1 project application which is now referred to as Stage 1a.

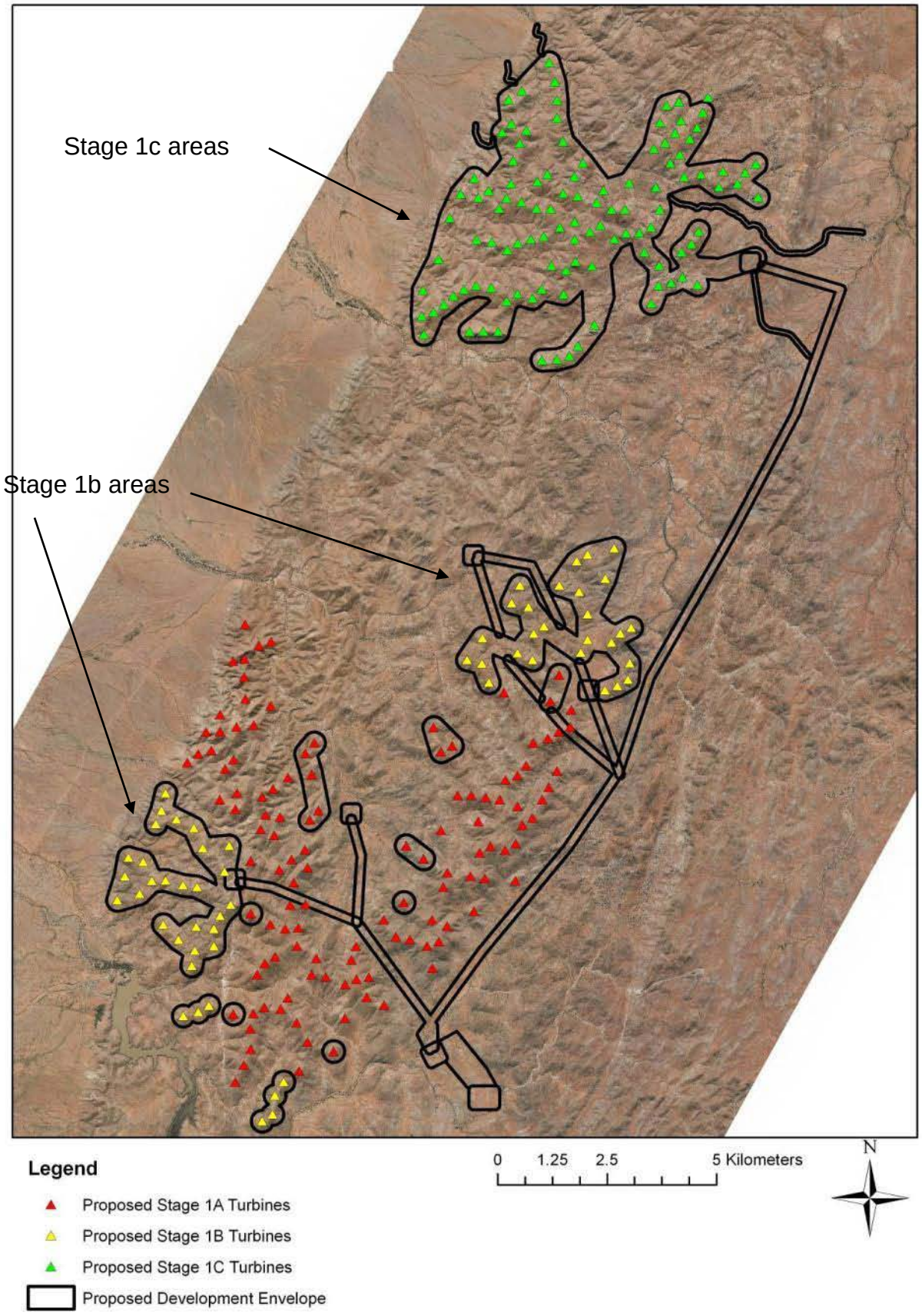
The Tawny Rock Dragon (*Ctenophorus decressi*) was identified in the initial surveys of the Stage 1a proposal in 2007. This species is currently listed as Endangered under Schedule 1 of the NSW *Threatened Species Conservation Act 1995*M (DECC 2008b). The Biodiversity Addendum recommended that a study on the status and distribution of the Tawny Rock Dragon and their habitat be undertaken for the Stage 1b and 1c areas by conducting a detailed survey and assessment.

As such, this study has the following aims and objectives:

- Determine the presence of Tawny Rock Dragon across the Stage 1b and 1c areas.
- Determine if the rocky outcrops identified in the biodiversity technical report provide habitat for Tawny Rock Dragon in the Stage 1b and 1c areas.
- Identify any 'hot spots' for Tawny Rock Dragon (ie, areas of high abundance or area occupied).
- Determine if any locations of Tawny Rock Dragon occur outside of the development envelopes.
- Undertake an analysis of microhabitats based on presence/absence of Tawny Rock Dragon in an effort to gain a greater understanding of their habitat.
- Determine if Tawny Rock Dragon occurrence is inversely correlated to the occurrence of another rock-obligate species, the Gidgee Skink, *Egernia stokesii.*
- Provide discussion on the population of the Tawny Rock Dragon in the study area, the original Stage 1 study area, and the locality.
- Discuss the rocky outcrops identified in the biodiversity technical report for their potential to provide habitat for Tawny Rock Dragon in Stage 1b and 1c areas.

- Provide discussion as to likely outcomes of a goat management plan on the Tawny Rock Dragon population.
- Provide a clear set of recommendations for the management of this species in the Stage 1b & c area.
- Provide an assessment of significance on the Tawny Rock Dragon based on the findings and recommendations of this study.

This report is intended to meet the assessment requirements under Part 3A of the NSW *Environmental Planning and Assessment Act 1979* and the NSW *Threatened Species Conservation Act 1995*.



Map 1-1: Proposed additional areas of the Stage 1 development (Stage 1b & 1c)

The Stage 1 development envelope (now termed 'Stage 1a') and 'Stage 1b and 1c' envelope were assessed within two separate biodiversity assessments. This document is an addendum to the Stage 1b and 1c Biodiversity Addendum.

2 METHODOLOGY

2.1 Literature review

Information on the Tawny Rock Dragon was sought from a variety of information sources. These included:

1. The Biodiversity Constraints Technical Report (NGHEnvironmental, 2008a).
2. Data collected during the 2007 and 2008 fauna surveys, covering the Stage 1a, 1b and 1c development envelopes .
3. DECC Wildlife Atlas searches based on the Broken Hill and Unincorporated area (DECC, 2008a).
4. DECC Threatened species databases (DECC, 2008b).
5. Searches of ecological scientific journal databases such as, Science Direct, JSTOR, Wiley Interscience, Springer Link, OVID and Google Scholar.
6. Searches of the Australian Museum online reptile database (BioNet, 2008).
7. Discussions with a number of herpetologists.

2.2 Field sampling techniques

2.2.1 Tawny Rock Dragon

Surveys for Tawny Rock Dragon were conducted between the 24th and 29th November 2008. Fieldwork sought to determine the presence and distribution of Tawny Rock Dragon and their habitat across the study area. These were conducted using two teams of two; each team consisted of an experienced ecologist and an assistant.

Walking transects were conducted through areas of potential habitat either on foot, or by vehicle by slowing driving on tracks within the study area after Blomberg and Shine (Blomberg and Shine, 1996). While the development envelope includes transmission line routes and tracks these have only been considered where they overlap with suitable habitat. The longer road and transmission line routes which traverse lower areas which do not contain suitable rocky habitat have not been targeted. Both observers visually scanned areas of potential habitat using high-powered binoculars seeking active animals (ie. engaged in display, combat, foraging, movement) and inactive animals (basking, resting).

Records of Tawny Rock Dragon collected during the field work for the Biodiversity Addendum (NGHEnvironmental, 2008b) are also incorporated into the results; while the cooler temperatures during the former surveys were not considered optimal for adequate detection of the Tawny Rock Dragon, the species was recorded at several locations and this data is included. The Tawny Rock Dragon has been known to be recorded in low temperatures, in thermally stable rocky

environments such as the study area. One researcher who studied the Tawny Rock Dragon for a PhD suggests that they can be detected in temperatures as low as 20 degrees Celsius in such environments (Louise Osborne, pers.comm).

Additionally, many of the Stage 1b areas in the south of the study area near Umberumberka Dam were traversed on foot in November 2007 (NGHEnvironmental, 2008c) while gaining access to the Stage 1a area. Therefore, all data relevant to the Tawny Rock Dragon from all surveys in the study area are incorporated into this study.

Surveys were also conducted in areas offsite (outside of areas proposed to be impacted by site development) to determine if the Tawny Rock Dragon was present in other rocky outcrops. The location of these searches was based on the potential for suitable habitat (rocky ridges) and practicalities of access (Map 2-4).

All sampling was carried out under Scientific Research Permit S10433 issued by the Department of Environment and Climate Change (Parks and Wildlife Division) and the authority of a Department of Primary Industries Director-General Animal Care and Ethics Committee determination. Total survey effort for Tawny Rock Dragon across the study area totals 338 hours and is shown (Mapset 2, Table 1).

Table 1: Survey effort for Tawny Rock Dragon

Survey period	Area	Effort
November 2007	Stage 1a and lower sections of part of 1b	Four persons for 5 days - 160 hours
September 2008	Stage 1b and 1c	7 hours reptile searches plus opportunistic sightings as part of wider biodiversity effort
November 2008	Stage 1b and 1c	Four persons for 2 ½ days Six persons for 1 ½ days – totalling 171 hours

2.2.2 Habitat assessment

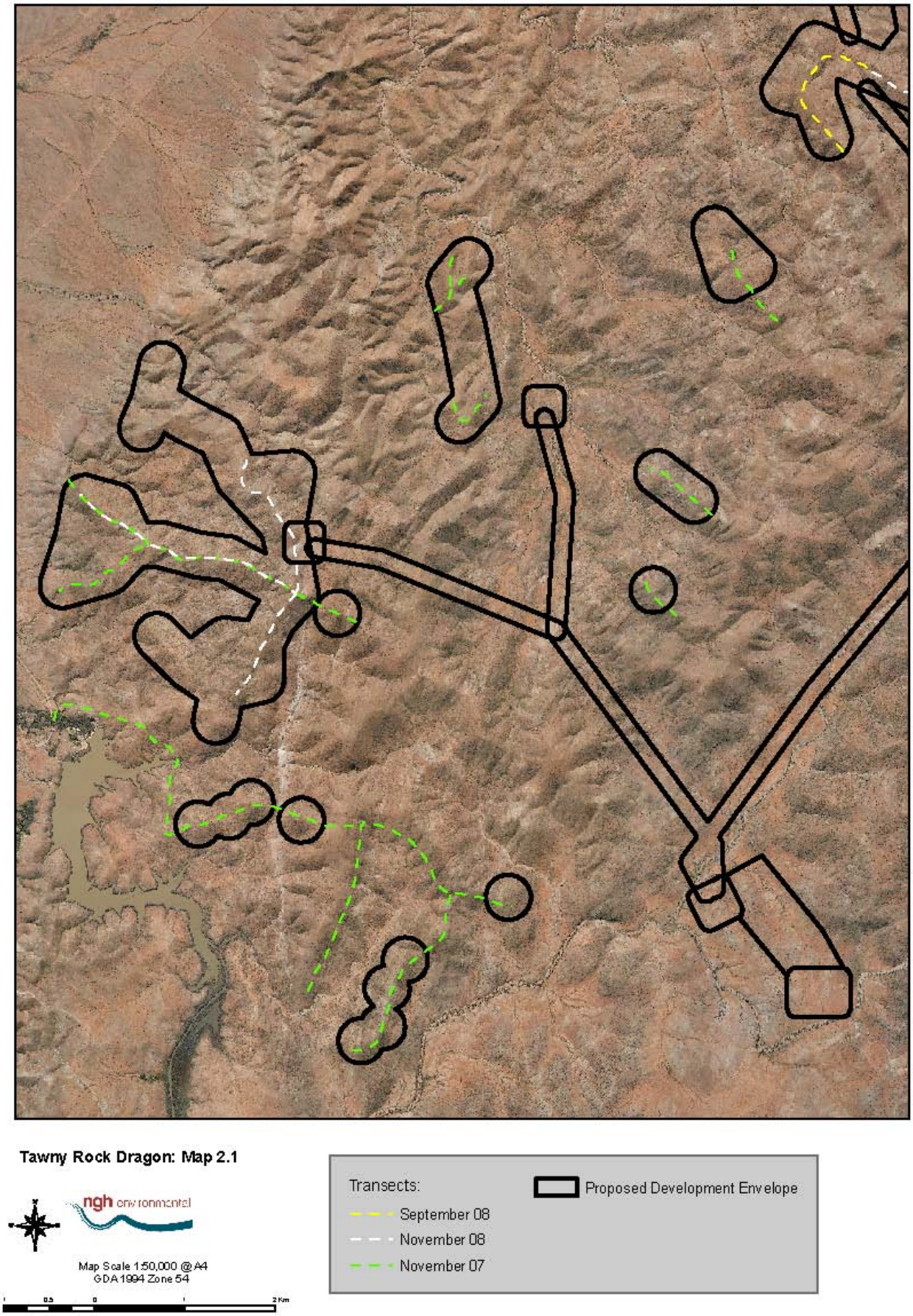
Habitat variables were measured considering the known ecological requirements of the Tawny Rock Dragon and other members of the *Ctenophorus* genus (DECC, 2008b, Gibbons and Lillywhite, 1981, Swan et al., 2004, NGHEnvironmental, 2008c, Stuart-Fox and Owens, 2003, Osborne, 2005a, Osborne, 2005b). Other habitat attributes that are also known to have an influence on reptile presence/absence such as grazing level and the composition of ground

microhabitat variables were also included (Sass, 2004, Hecnar and M'Closkey, 1998, Fischer, 2004).

Habitat variables were measured from a 10m x 10m quadrat at sites where the Tawny Rock Dragon was recorded and not recorded. Within each quadrat, 19 variables were measured (Table 2). The locations of habitat assessments are provided (Appendix C).

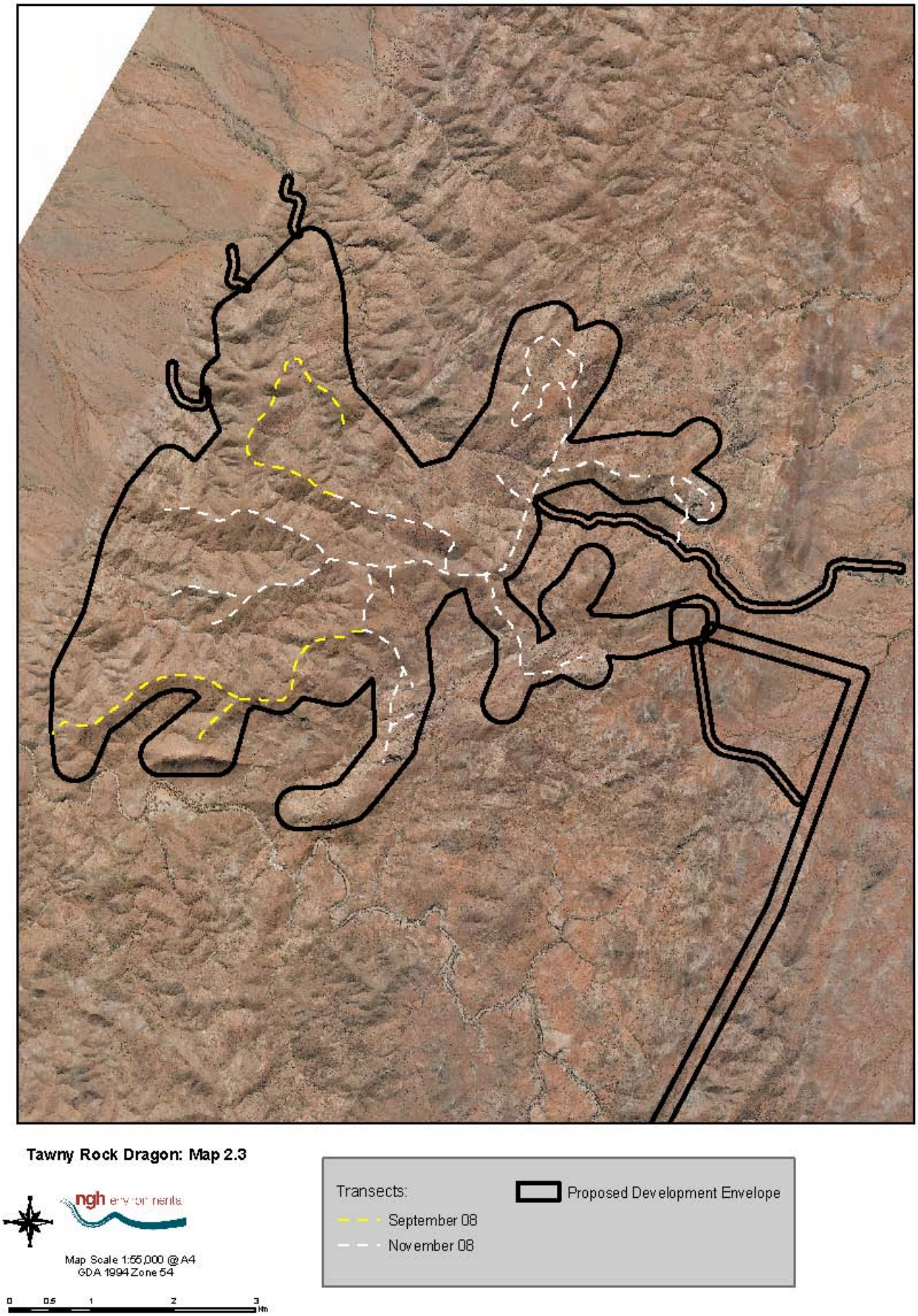
Table 2: Summary of habitat variables measured within each quadrat.

Habitat variable – fragment	Abbreviation	Details
1. Vegetation cover	%GVEG	Percentage cover of ground vegetation
2. Bare ground	%BRGR	Percentage cover of bare ground
3. Rock outcropping	%ROCK	Percentage cover of exposed rock outcropping
4. Fallen timber	%TIMB	Percentage cover of fallen timber
5. Level of grazing	#SCATS	Number of pats (feral or native) as a surrogate for the current grazing level
6. Rock size (0-100mm)	%ROCK0100	Percentage cover of rocks between 0-100mm
7. Rock size (101-250mm)	%ROCK101250	Percentage cover of rocks between 101-250mm
8. Rock size (251-500mm)	%ROCK251500	Percentage cover of rocks between 251-500mm
9. Rock size (501-1000mm)	%ROCK501-1000	Percentage cover of rocks between 501-1000mm
10. Rock size (>1000mm)	%ROCK1000+	Percentage cover of rocks greater than 1000mm
11. Crevice width (0-25mm)	#CREV025	Number of rock crevices between 0-25mm wide
12. Crevice width (26-50mm)	#CREV2650	Number of rock crevices between 26-50mm wide
13. Crevice width (51-100mm)	#CREV51100	Number of rock crevices between 51-100mm wide
14. Crevice width (>100mm)	#CREV100+	Number of rock crevices greater than 100mm wide
15. Degradation of crevices	%CREVSCAT	Percentage of crevices with scats within
16. Gidgee skinks	GIDGE	Presence or Absence of Gidgee skinks
17. Gidgee skink scats	GIDGESCAT	Presence or Absence of Gidgee skink scats
18. Landscape position	LAND	Position in the landscape (Ridge, Mid-slope, Valley)
19. Micro-landscape position	MICROLND	Position of the site (Slope, Flat, Gully)

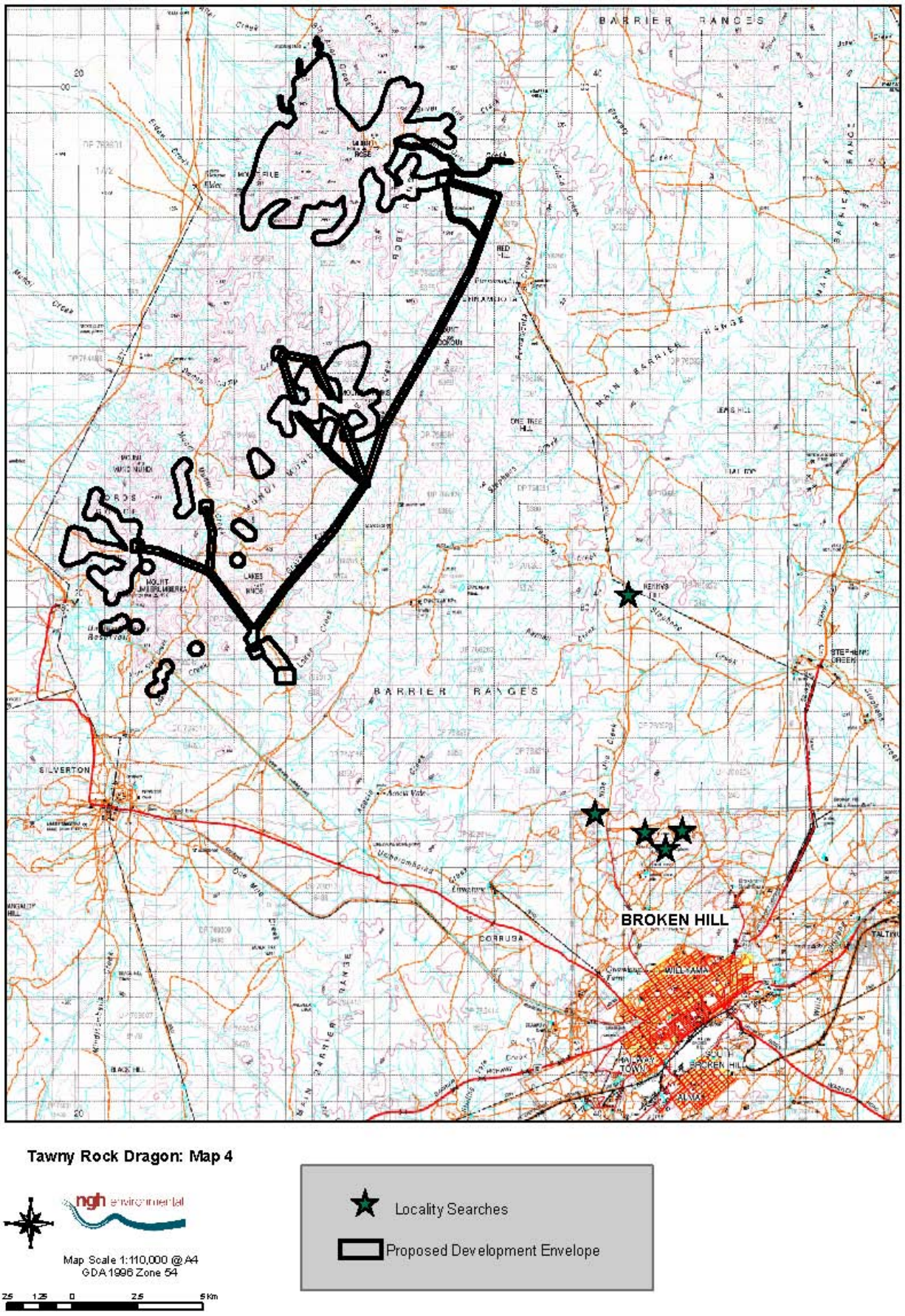


Map 2-1: Survey transects

Map 2-2: Survey transects



Map 2-3: Survey transects



Map 2-4: Location of offsite Tawny Rock Dragon searches

2.3 Data analysis

2.3.1 Status and distribution of the Tawny Rock Dragon

Distribution of Tawny Rock Dragon presence was mapped using ArcGIS 9.2. Maps produced with this software were then used to visualise distribution patterns across the study area.

Limited behavioural data was also collected to provide a greater understanding of the species. This included the age of the dragon (adult or yearling), the sex (male or female) and the behaviour of the dragon when first observed (basking, feeding, displaying, mating).

2.3.2 Habitat variables

Habitat variables were examined to determine potential differences in habitat in the study area. This data was then analysed using non-metric multidimensional scaling (MDS) analyses using the software package PRIMER 5.2.9 (Primer Ltd 2001). Multi-dimensional scaling (MDS) ordination was performed in order to create a visual representation of the relationships between each habitat assessment (Clarke, 1993, Minchin, 1987). Ordinations were performed in two dimensions, with 100 iterations for each dimension to guard against dissolute explanation (Wilkinson, 1989). Non-metric multidimensional scaling (MDS) was used for this analysis because it is considered more robust to non-lineal effects when compared to other ordination techniques (Minchin, 1987). Of the 64 sites where a habitat evaluation was undertaken, similarities between the habitat variables were calculated using the Bray-Curtis similarity measure (Bray and Curtis, 1957). One-way analysis of similarities (ANOSIM) was then performed in order to compare each site and the presence of Tawny Rock Dragon (Minchin 1987) using a 0.05 level of significance.

Results from ANOSIM also calculate a test statistic 'R' identifying the observed differences between the habitats (Clarke and Warwick, 1994). 'R' values are generated for both global and pairwise comparisons and can be interpreted as follows:

R = 1	indicates total separation of areas
R = >0.75	indicates the areas are well separated
R = >0.5	there may be overlap but the areas remain different
R = <0.25	indicates the areas are hardly separated
R = 0	indicates the areas are indistinguishable from one another

Where differences were identified between groups through ANOSIM, these were further examined using SIMPER analysis in PRIMER (Primer Ltd 2001).

To facilitate interpretation of the MDS, Spearman rank correlations were conducted between the scores of each dimension and the habitat variables. This procedure allowed determination of the

variables that were most correlated with each of the two dimensional MDS axes and likely to be important habitat to Tawny Rock Dragon.

2.3.3 Tawny Rock Dragon 'hot spots' and road management zones

The study aimed to identify key areas of Tawny Rock Dragon presence in the study area. For the purpose of this study, areas of natural habitat where five or more Tawny Rock Dragon was recorded in close proximity and were not isolated from one another by an inhospitable matrix, were defined as a 'hot spot'.

In addition, road management zones were defined based on the same criteria (with the exception of the inclusion of artificial areas of habitat) after numerous Tawny Rock Dragons were observed using the road spoil as a basking and displaying location.

These areas were determined by undertaking a visual inspection of the distribution data as well as on-ground verification of habitat connectivity between dragon territories and habitat use.

Hot spots and road management zones were mapped using ArcGIS 9.2.

2.3.4 Tawny Rock Dragon occurrence compared with other rock-obligate species

Circumstantial evidence suggests that the presence of Tawny Rock Dragons may be influenced by the presence of other rock-obligate species such as Gidgee Skink (DECC, 2008b). In fact, Swan & Foster (2005) in their survey of Mutawinji National Park where the Tawny Rock Dragon also occurs did not locate any Gidgee Skink. This may be due to the likelihood of competition for limited resources such as crevices (Langkilde and Shine, 2004).

Data collected during the habitat assessment included the presence and absence of Gidgee Skink or their signs such as scats.

3 RESULTS

3.1 Tawny Rock Dragon

3.1.1 Status and distribution across the study area

Surveys for the Tawny Rock Dragon across the study area revealed 173 individuals (161 in November 2008, 12 in September 2008) (Map 3.1 and 3.2). All of these individuals were recorded within the Stage 1b and 1c area. This is additional to the 36 individuals recorded in the Stage 1a surveys. To date, 209 Tawny Rock Dragon have been recorded across the Stage 1a, 1b and 1c area (Map 3.3). Of the 161 individuals in which population data was recorded (November 2008 surveys), these were comprised of 123 males and 38 females with an obvious bias between adults and yearlings (Figure 1). The detection rate was 0.95 animals every person hour during the November survey.

Distribution across the Stage 1b and 1c areas was highly skewed, with only 31 Tawny Rock Dragons recorded in the Stage 1b area (all in the Mount Franks section) while 142 individuals were recorded in the Stage 1c area (refer to Maps 3.1 & 3.2).

All Tawny Rock Dragon recorded were located on the main ridge systems that comprise the study area. The majority of these were found on the flatter tops of ridges (67%) with the remainder on the downslope away from the ridge top and in one case, in a creek gully (directly to the south of Mt Franks).

The activity observed of each Tawny Rock Dragon showed that 54% were displaying, 44% were basking and 2% were feeding (Figure 2). No mating activity was observed.

Locality searches failed to reveal the presence of Tawny Rock Dragon beyond the boundaries of the proposed development envelope.

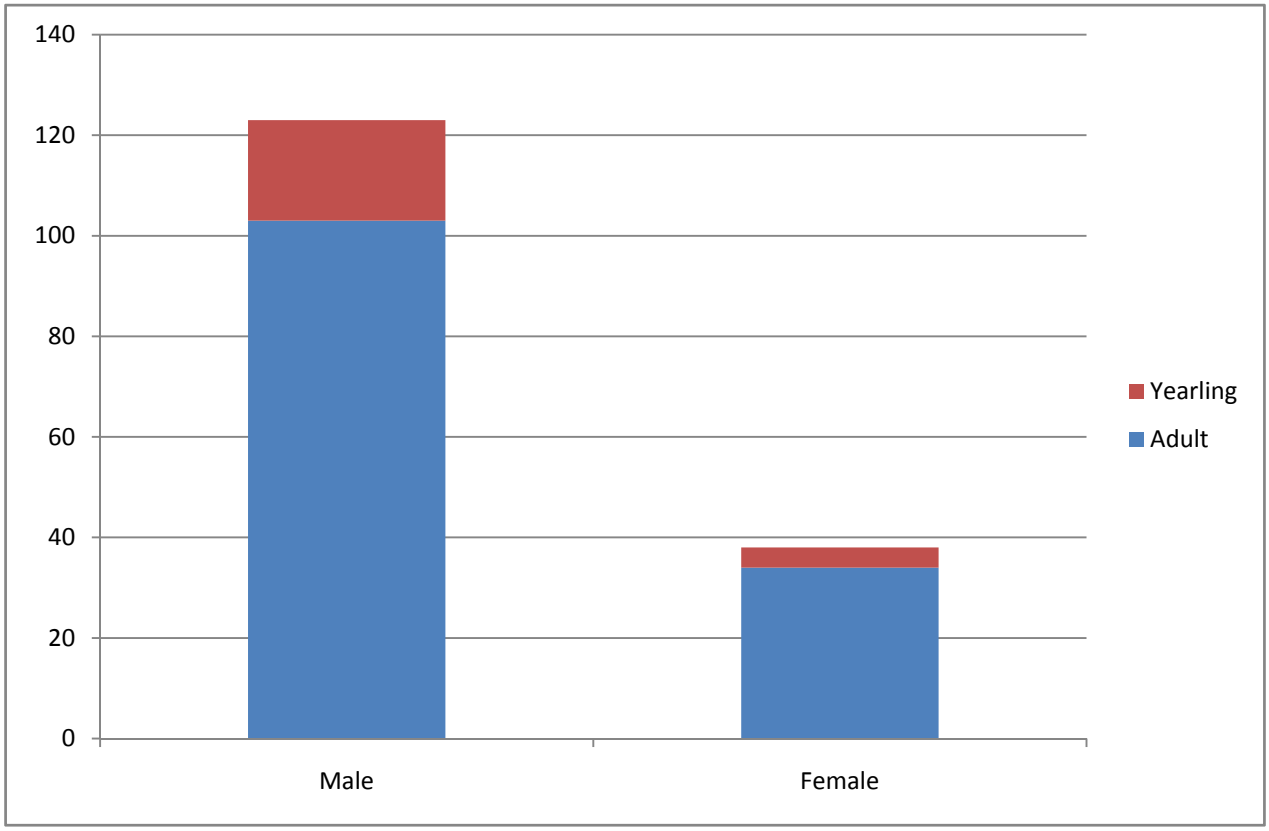


Figure 1: Sex and age structure of Tawny Rock Dragon individuals recorded during the study.

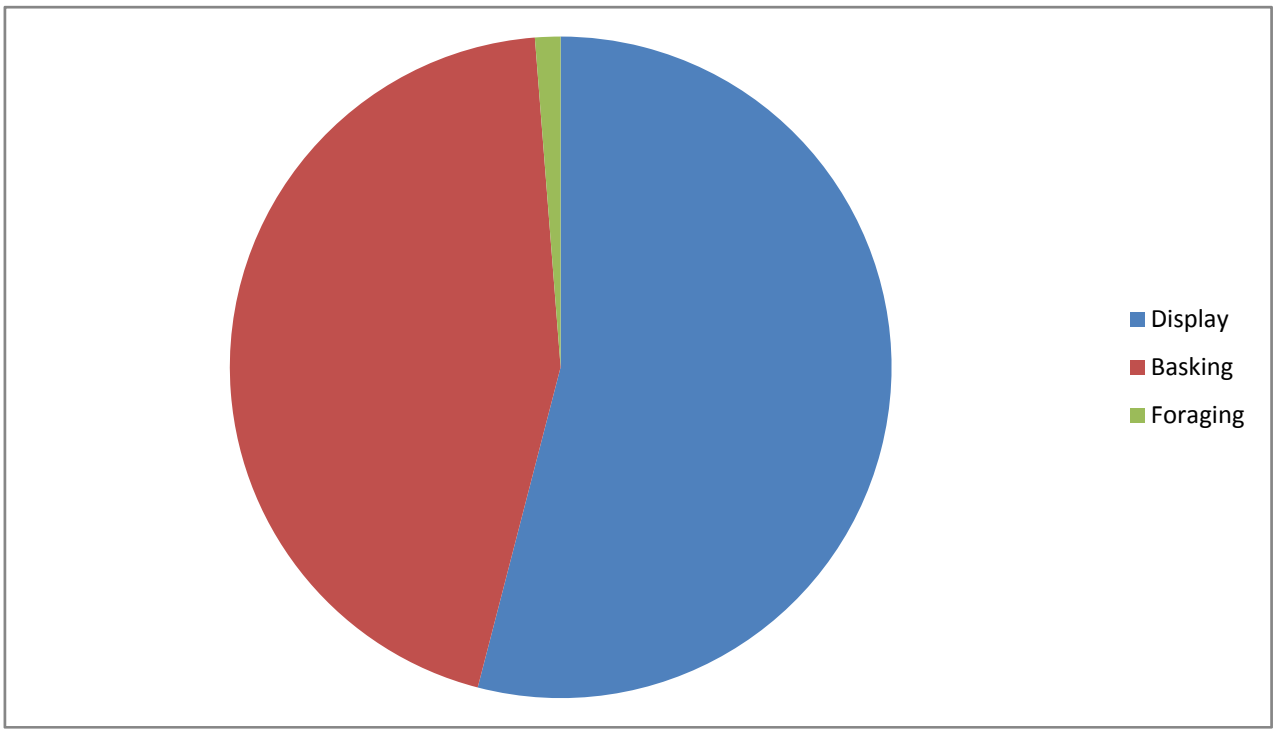
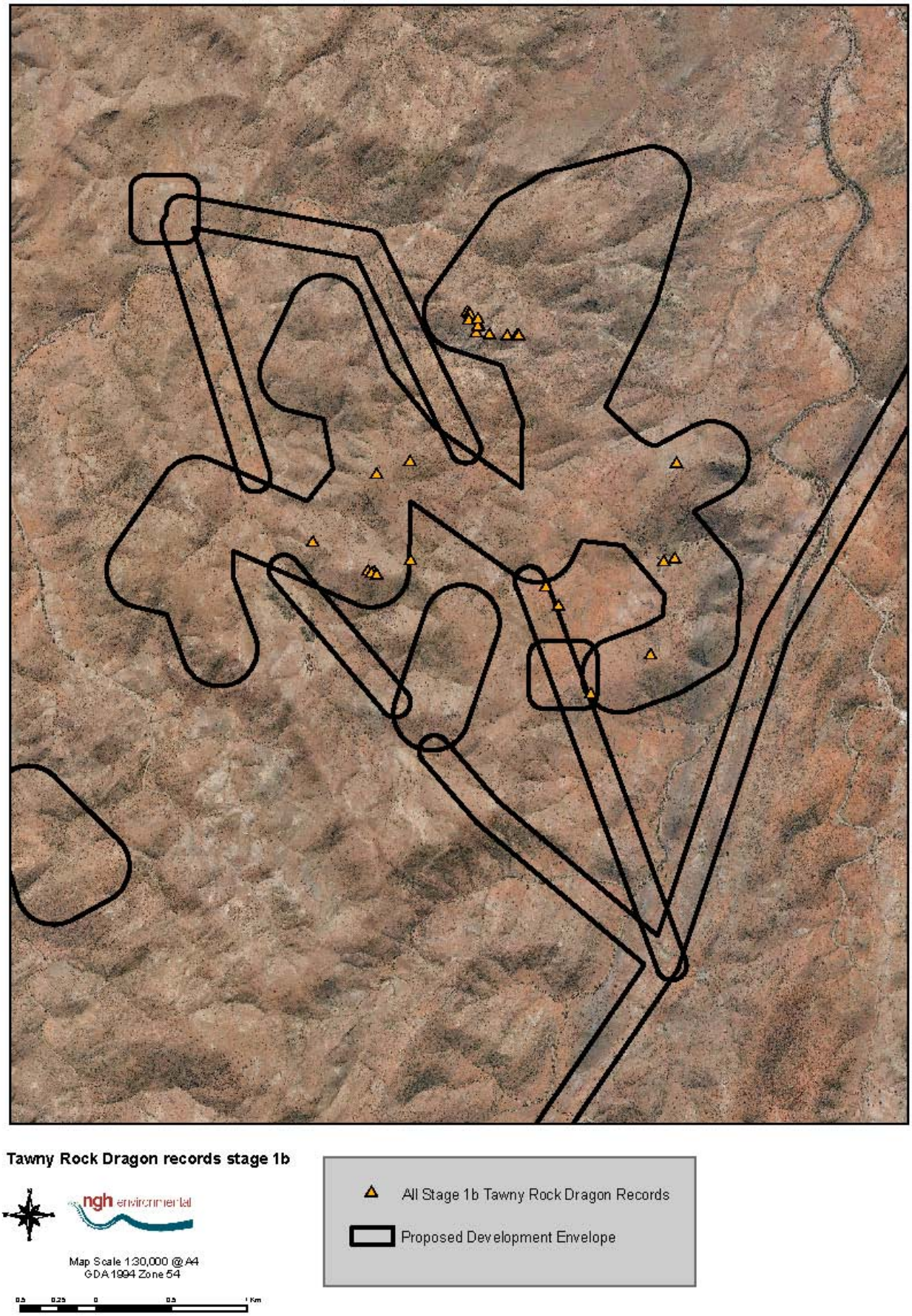


Figure 2: Observed activity of Tawny Rock Dragon during this study**.**



Map 3-1: Tawny Rock Dragon records in northern section of Stage 1b (Mount Franks Section)

Map 3-2: Tawny Rock Dragon records in Stage 1c.

Map 3-3: All Tawny Rock Dragon records across the Stage 1a, 1b and 1c areas.

3.1.2 Occurrence compared with other rock-obligate species

Of the 64 sites where a detailed habitat assessment was undertaken, only four sites were identified that presented evidence of co-occurrence of Gidgee Skink and Tawny Rock Dragon. In all cases, scats were identified that were likely a larger reptile, such as a Gidgee Skink perched on rock outcrop peaks. However, no Gidgee Skinks were recorded and the scats did not appear to be recent.

Conversely, during offsite surveys, individual Gidgee Skinks were commonly observed and no Tawny Rock Dragons were recorded.

3.2 Habitat assessment

The MDS ordination revealed that two dimensions were sufficient to provide a reliable representation of the 17 habitat variables specific to microhabitat analysis (stress value = 0.19). Habitat variables across each of the 64 sites could not be separated based on a visual inspection of the MDS ordinations where the Tawny Rock Dragon was present and sites where none were recorded, however, a slight pattern appears to be emerging with some grouping in the absent sites (Figure 3). Analysis of Similarities (ANOSIM) comparing present and absent sites found a statistically significant difference between habitats (*global R*=1, *p*=0.027). Further analysis using SIMPER revealed that the percentage cover of exposed rock outcropping contributed to 43% and percentage cover of rocks between 251-500mm contributed to 14% of the differences in habitat.

Where Tawny Rock Dragon was recorded, additional MDS ordination revealed that no particular pattern was evident in habitat variables (Figure 4). The 17 habitat variables were then correlated within each MDS dimension using Spearman-rank correlations (Table 3).

Using a 0.01 level of significance, seven of the 17 habitat variables were significantly correlated to the first dimension, whilst three variables were significantly correlated to the second dimension.

Significant correlations with the first dimension were percent cover of ground vegetation, level of grazing, rock size (101-250mm, 501-1000mm, >1000mm), crevice width (51-100mm) and the degradation of crevices. For the second dimension, the level of grazing, rock size (251-500mm) and degradation of crevices were significant correlations.

Interestingly, some overlap between variables across each dimension occurred. These were the level of grazing and the degradation of crevices which are contributing most to levels of habitat quality.

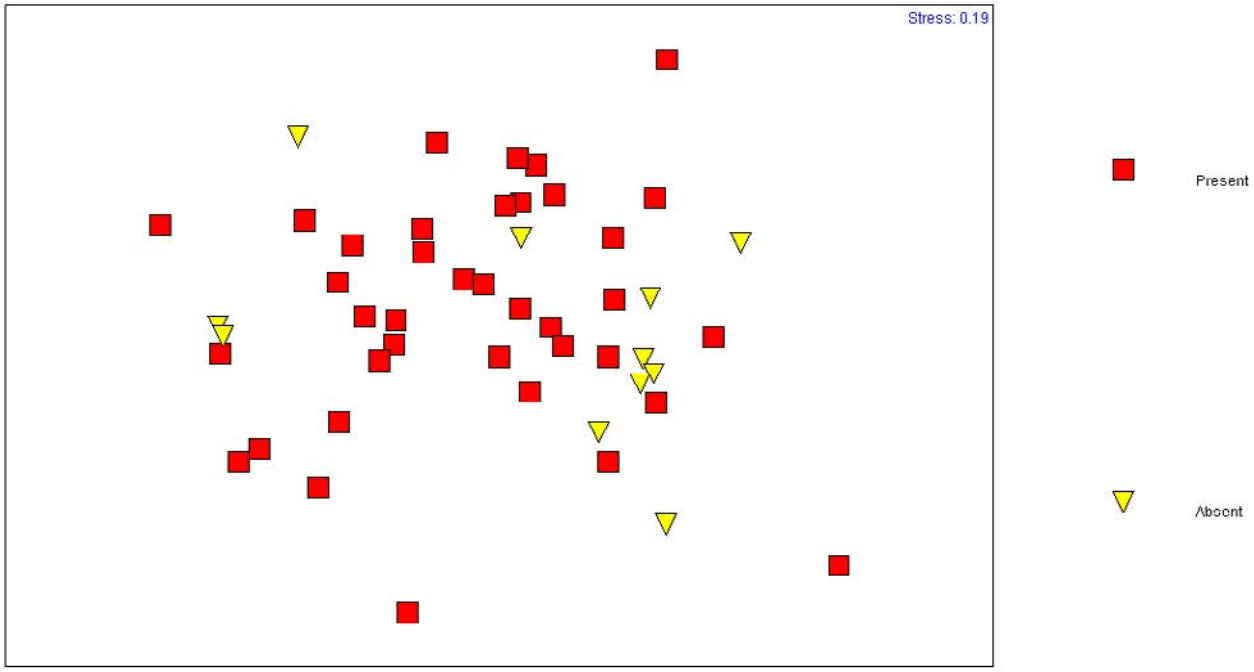


Figure 3: Graphical representation of the MDS ordination of the habitat variables at sites where Tawny Rock Dragon was present, and sites where it was absent.

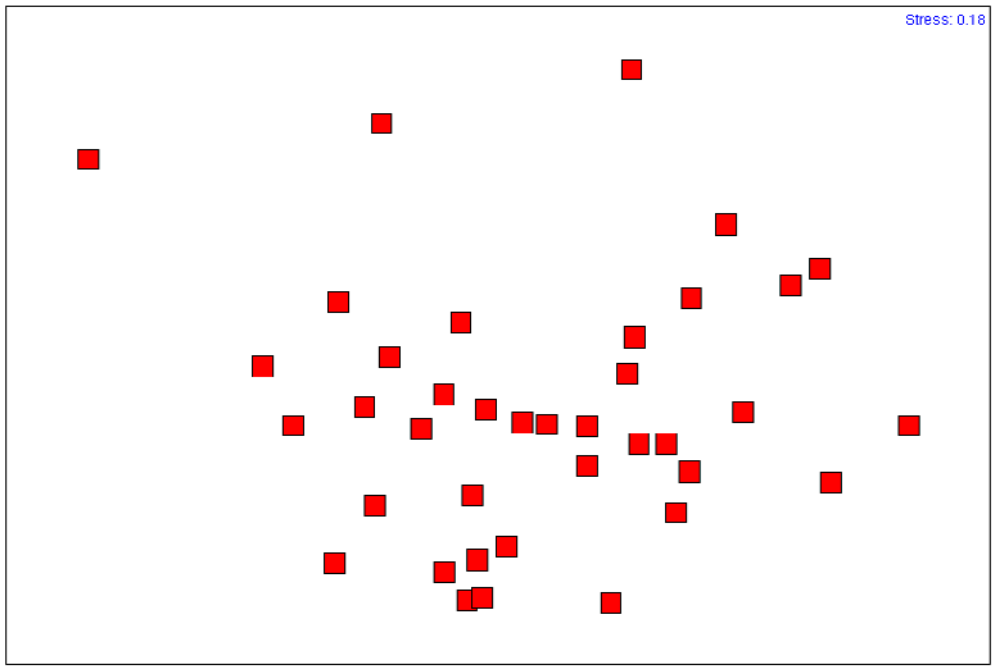


Figure 4: Graphical representation of the MDS ordination of the habitat variables at sites where Tawny Rock Dragon was present.

Table 3: Spearman-rank correlations coefficients of the 17 habitat variables against the two MDS dimensions. Significance at 0.01 is marked with two asterisks, 0.05 with one asterisk (two-tailed).

Habitat variable – fragment	Dimension 1	Dimension 2
1. Vegetation cover	**0.376****	0.214
2. Bare ground	-0.075	-0.19
3. Rock outcropping	0.72	-0.218
4. Fallen timber	**-0.272***	**0.346***
5. Level of grazing	**0.469****	**0.606****
6. Rock size (0-100mm)	**-0.811***	0.190
7. Rock size (101-250mm)	**-0.767****	0.211
8. Rock size (251-500mm)	-0.137	-**0.486****
9. Rock size (501-1000mm)	**0.725****	0.214
10. Rock size (>1000mm)	**0.809****	-0.030
11. Crevice width (0-25mm)	-0.42	-0.160
12. Crevice width (26-50mm)	0.298*	0.227
13. Crevice width (51-100mm)	**0.589****	**0.275***
14. Crevice width (>100mm)	**0.527***	0.099
15. Degradation of crevices	**0.352****	**0.453****
16. Gidgee skinks	-	-
17. Gidgee skink scats	0.290*	0.430*

Tawny Rock Dragons were more often recorded on an aggregation of rocks (89% of records) than a single, isolated rock. Along existing tracks, 15 Tawny Rock Dragons were observed displaying or basking on the road spoil.

The numbers of scat clumps were extremely common at almost all sites (92%). However, the number of scats within the 10m x 10m quadrat varied from low amounts (0-5 clumps) to more than 40 clumps (Figure 5). Feral goat scats contributed to almost all of the scat clumps observed.

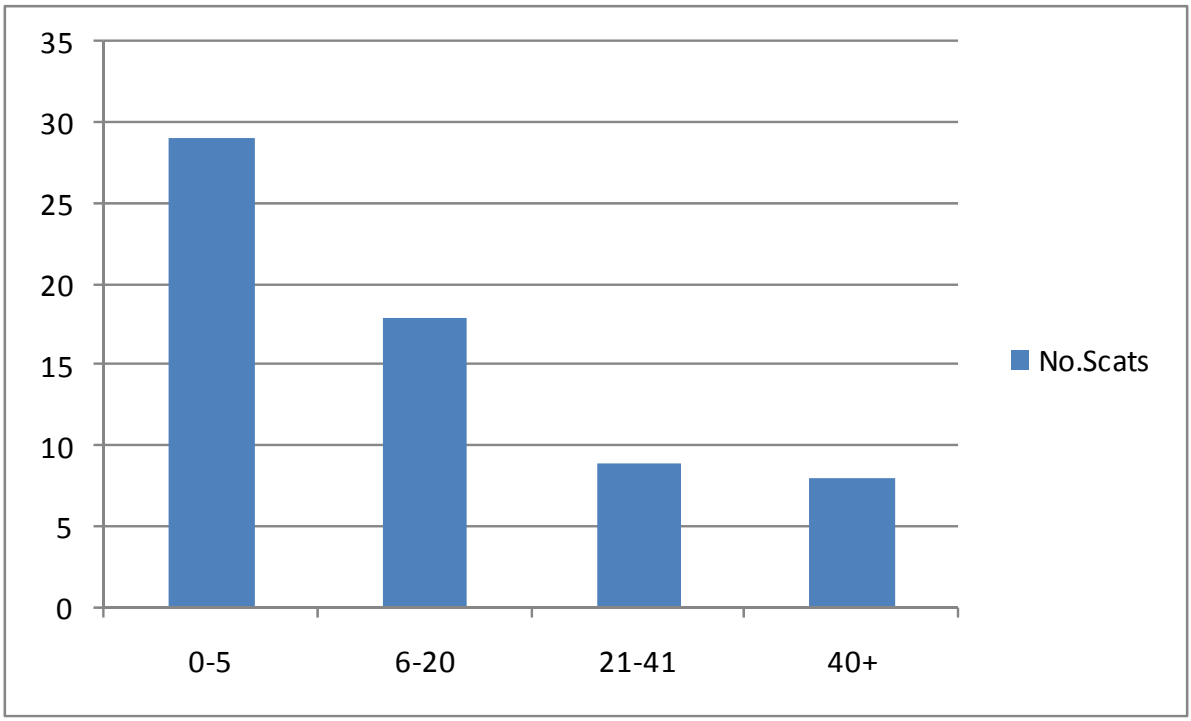
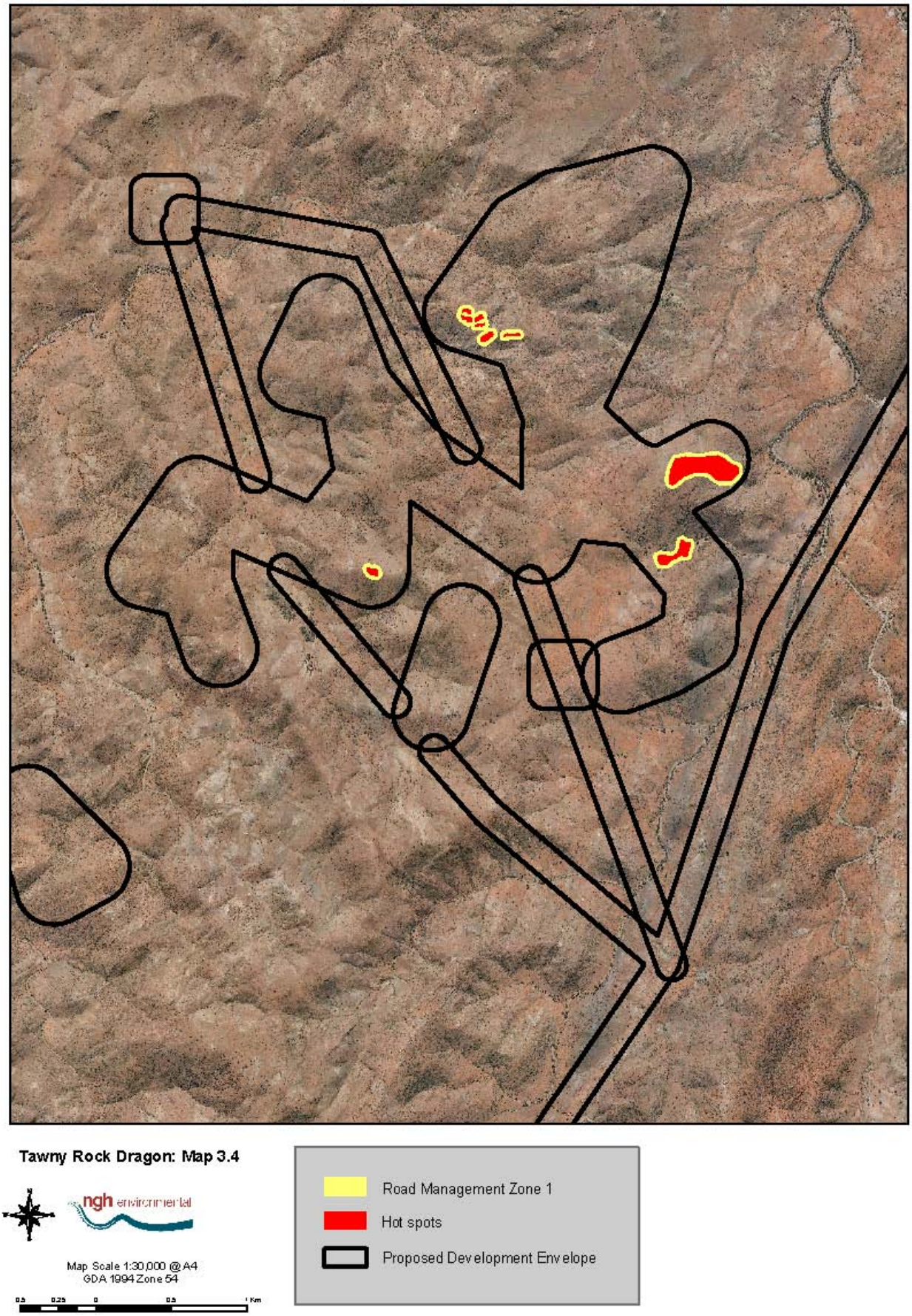


Figure 5: Number of scat clumps recorded within each 10m x 10m quadrat.

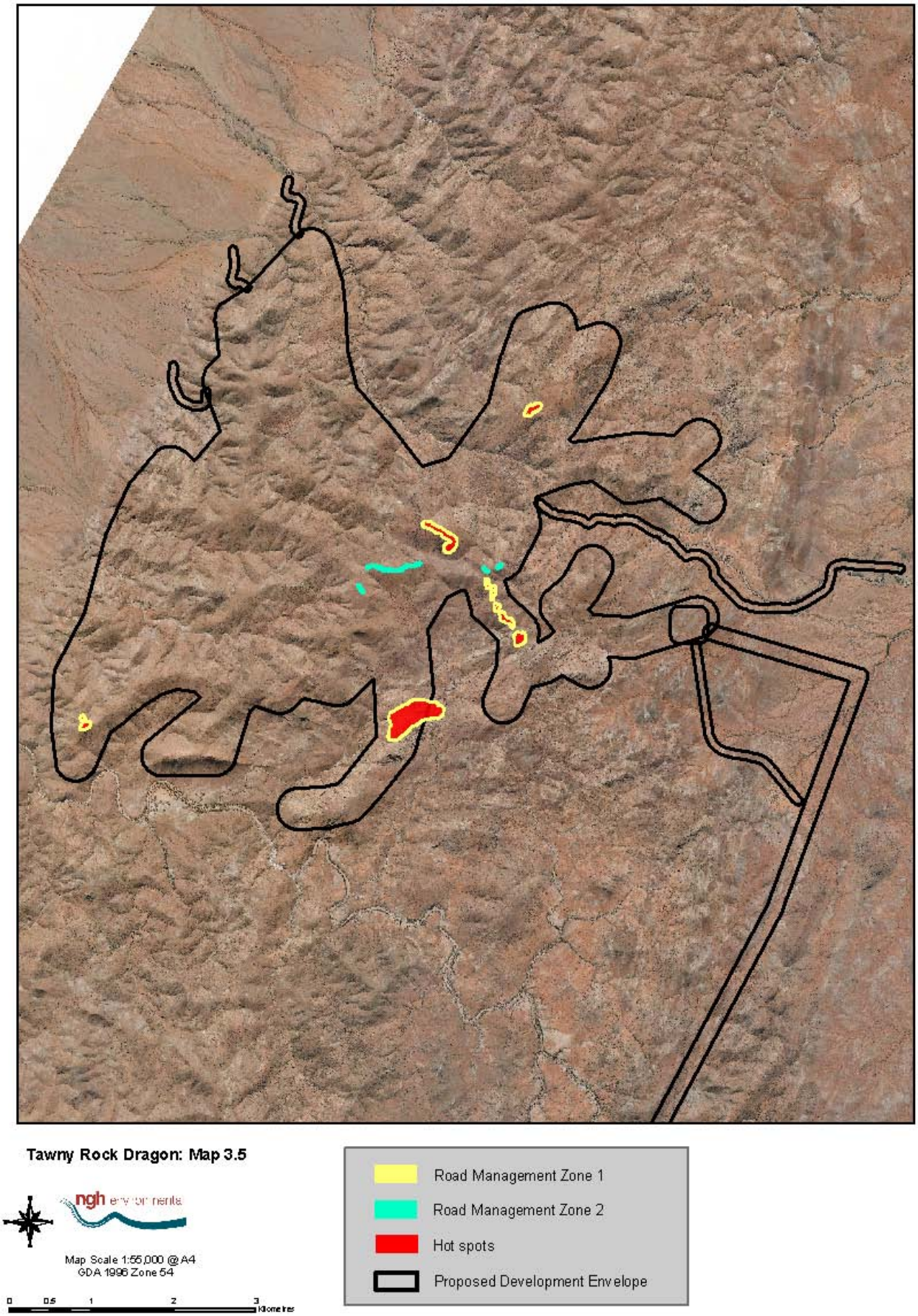
3.3 Tawny Rock Dragon 'hot spots' and road management zones

Nine hotspots in the Stage 1b area and eight hotspots in the Stage 1c area of varying size were identified (Map 3.4 & 3.5). Road management zones were also defined (see section 2.3.3) after numerous Tawny Rock Dragons were observed using the road spoil as a basking and displaying location. Road management zones were placed around all hotspots and in four other locations (Map 3.4 & 3.5).

These areas were determined by undertaking a visual inspection of the distribution data as well as on-ground verification of habitat connectivity between dragon territories and habitat use.



Map 3-4: Tawny Rock Dragon hot spots and road management zones in Stage 1b



Map 3-5: Tawny Rock Dragon hot spots and road management zones in Stage 1c

4 DISCUSSION

4.1 Tawny Rock Dragon

Prior to the initial surveys in 2007, the only known records were a population of at least 50 animals at Mutawinji National Park (to the north-east of the study area) (Swan and Foster, 2005), and single museum specimen from Koonaberry Mountain (north of Mutawinji). Subsequent searches of the latter site have not revealed any Tawny Rock Dragon (Gerry Swan, pers.comm) and the Mutawinji population were considered the only known population. However, the population of the study area should now be regarded as the stronghold for the species in NSW considering the moderately restricted national distribution (Sadlier and Pressey, 1994).

Their distribution across the study area appears skewed, with only 36 and 41 animals were recorded in the Stage 1a and 1b areas respectively, whilst 142 animals have been recorded in the Stage 1c area. In Stage 1b, Tawny Rock Dragons are only present within the Mt Franks section. Searches of the remaining 1b areas near Umberumberka Dam did not reveal any Tawny Rock Dragons. This is not considered surprising given that no Tawny Rock Dragon were recorded in the southern sections of Stage 1a (NGHEnvironmental, 2008c). The higher abundance of males recorded is likely not reflective of true sexual orientations of the population, rather an artefact of the ability to detect males as they prominently stand high on rocks display to defend their territories. The ability to detect Tawny Rock Dragon presence is made relatively simple by the male's prominent positions on rock when displaying and defending their territory hence, the distribution detected in the field is considered an accurate representation of the male Tawny Rock Dragon distribution.

Several hypotheses could be used to explain the variable distribution pattern of the Tawny Rock Dragon in the study area: suitable habitat, naturally patchy distribution; impacts from goat grazing; or a combination of these.

Goat grazing was found to be a key factor currently determining the level and quality of habitat on the site for many native species (NGHEnvironmental, 2008c). The NSW Scientific Committee has listed 'Competition and habitat degradation by Feral Goats' as a Key Threatening Process. Twenty-three threatened species were listed in the Committee's determination as being at risk due to this process, including the Tawny Rock Dragon (DECC, 2008b). The impacts of grazing on arid Australia are well known (Letnic, 2007, James, 2003). In western NSW, a study on feral goats were found to make daily movements of 3.1 km, focussing movements around intermittent lakes and creeks with abundant tree and shrub cover (Freudenberger and Barber, 1999). Umberumberka Dam is likely to be a key resource to goats in the local area and this could explain an apparent higher abundance of goats and impacts in the southern part of the study area (James et al., 1999). The impacts of heavy grazing by any stock is already known to be detrimental to

reptile fauna (Beutel et al., 2003, Brown et al., 2008, Fischer et al., 2004, Sass, 2004, Hadden and Westbrooke, 1996, Sadlier and Pressey, 1994) and this is also likely to be the case for Tawny Rock Dragon. Hadden & Westbrooke (1996) found that reptile fauna were affected by changes in vegetation structure by overgrazing as these reduce microhabitat availability and subsequently habitat quality. Sadlier & Pressey (1994) identified that grazing is likely to adversely affect reptile species in the western division of NSW.

Faunal distribution patterns are known to be influenced by resource availability; populations are not distributed evenly across landscapes (Dickman et al., 2001, James, 1991, James and Shine, 2000, Morton and James, 1988). For the Tawny Rock Dragon, their patchy distribution across the study area and absence from seemingly suitable habitat may be a result of such resource patchiness.

Nonetheless, it is likely an interaction between both theories that is limiting the distribution of the species in the study area. Only 8% of sites were free of goat scats, which confirm that goats are present where Tawny Rock Dragons are also present. At 23% of the sites, the scat frequency was very high (above 20 clumps of scats). While there is no long-term data on the feral-goat population within the study area, it is difficult to gain a detailed understanding on their effects on the Tawny Rock Dragon population. However, feral goats have already been attributed to the degradation of rocky habitats for other rock-crevice specialists such as the Broad-headed snake (*Hoplocephalus bungaroides*) (Murphy, 1996) and the Centralian Ranges Rock-skink (*Egernia margaretae*) (NPWS, 2000). For the Tawny Rock Dragon, rock crevices filled, or partially filled with goat scats is undoubtedly impacting on both habitat quality and therefore the extent of suitable habitat. As a result, it is hypothesised that combined with their low dispersal capability and low fecundity, seemingly suitable habitat becomes unoccupied likely the result of local extinctions of individuals. These factors could assist in explaining the limited and patchy distribution of the Tawny Rock Dragon across the study area.

Competition with other rock-obligate reptile species for crevices is known to be highly correlated with species' body size in creating a dominance hierarchy (Langkilde and Shine, 2004). DECC (2008a) hypothesise that the presence of the much larger Gidgee Skink may be a limiting factor on the presence of the Tawny Rock Dragon. At all five locations of the off-site locality surveys, Gidgee Skinks were common but no Tawny Rock Dragons were recorded. Within the study area, scats were identified that were likely a larger reptile, such as a Gidgee Skink. However, no Gidgee Skinks were recorded and individual Tawny Rock Dragons were present. These results suggest that Tawny Rock Dragon occurrence could be inversely correlated to the occurrence of Gidgee Skink.

4.2 Tawny Rock Dragon habitat

Differences in habitat qualities were apparent where the Tawny Rock Dragon was present and absent with rock cover and rock size contributed most to these differences. Significant correlations across each MDS dimension were observed including percent cover of ground vegetation, the level of grazing, all rock sizes, rock crevice width (51-100mm) and the degradation of crevices. This provides important information to guide in the management of the Tawny Rock Dragon in the study area with specific regard to habitat restoration and rehabilitation. More significantly, the level of grazing and the degradation of crevices amongst rock outcrops contributed to both dimensions which provide further evidence that feral goat grazing is currently impacting on the qualities of rock outcrops. The majority of sightings of the Tawny Rock Dragon were on an aggregation of rocks and in almost all cases, along the main ridge system. The provision of rock piles obtained when excavating turbine footings and vehicular tracks has the potential to create artificial habitat.

As earlier discussed, the potential for the occurrence of the Tawny Rock Dragon is not necessarily related to the availability of suitable habitat. This study has shown that previous mapping undertaken of significant rock outcrops in the study area (NGHEnvironmental, 2008a) has virtually no relationship to the distribution of the Tawny Rock Dragon across the study area. Rather, that their absence across seemingly suitable habitat may be explained by a number of factors (see section 4.1).

Interestingly, numerous individuals were observed in the vicinity of vehicular tracks in the study area. In all cases, individuals were recorded displaying or basking on the rocks that had been pushed aside for the construction of these tracks. More importantly, these individuals were more commonly observed where soil was absent from this spoil (ie only rocks and crevices). Most of these individuals were yearling Tawny Rock Dragons. Their presence in this environment suggests that disturbance to the rock substrate, which provides 'new' habitat opportunities by creating a rock pile and crevices, may not be detrimental. Pushed soil heaps however, creates no new habitat and may in fact fill rock crevices and thereby remove habitat.

In conclusion, these results confirm that the Tawny Rock Dragon is a rock-obligate species with habitat relationships associated to the level of grazing and rock and crevice size. The occurrence of this species within the rock spoil of recently constructed tracks also suggests potential for habitat creation similar to that which has been accomplished for the conservation of other threatened rock-obligate reptiles such as Broad-headed snake (*Hoplocephalus bungaroides*) and their prey Lesueur's velvet gecko (*Oedura lesueurii*) (Webb and Shine, 2000).

4.3 Tawny Rock Dragon 'hot spots' and road management zones

Seventeen hotspots were identified across the Stage 1b and 1c area. These areas of habitat supported a higher abundance of Tawny Rock Dragons than surrounding areas. Resource availability has long been known to be a determinant of reptile diversity and abundance (Pianka, 1973, Pianka, 1966, Pianka, 1974, Pianka, 1968). While the vast majority of the knowledge on Australian reptile fauna is limited to a number of field guides (Cogger 2000; Swan et al. 2004; Wilson & Swan 2003), that although provide an excellent source of background material, they do not provide information on specific ecological requirements that can be translated into studies on a poorly-studied species such as the Tawny Rock Dragon. With a paucity of knowledge of these basic ecological requirements, it is difficult to determine what factors in terms of the coarseness or complexity of the necessary data need to be studied and this is likely to be limiting our understanding of such a species as the Tawny Rock Dragon. Further, reptiles may also be responding differently to the changes across the landscape across the study area as they are known to in other areas. Indeed, reptiles do respond to different factors idiosyncratic to regions and vegetation types (Hadden and Westbrooke, 1996, Ishwar et al., 2003, Jellinek et al., 2004, Smith et al., 1996, Sass, 2007). The hotspot approach allows individual Tawny Rock Dragons themselves to define areas of higher importance to the local population.

Identifying areas of higher abundance also provides an opportunity to protect important resources and interactions. Given the context of prolonged drought and goat grazing pressure, the areas may also be acting as an important refuge such as seen in other landscapes (Michael et al., 2008, Sass, 2003). It will be extremely important to protect these hot spots from any kind of impact, and as such, under no circumstances should any persons, equipment, infrastructure or materials impede on any defined hotspots.

In light of the abundance of individuals along the vehicular tracks within the study area, the concept of road management zones was formulated. Forman & Alexander (1998) revealed that roads are a major source of mortality for fauna and that a local population may suffer decline where the roadkill rate exceeds the rate of reproduction and immigration (Forman and Alexander, 1998). For a low fecundity and low dispersal species such as the Tawny Rock Dragon, road management is particularly relevant. Reducing vehicle speed provides both animals and drivers with longer reaction times to avoid impact (Schaefer et al., 2003). For this reason, road management zones (RMZ) around all hotspots and in four other locations have been developed at times of the year when the species is considered most active. Reducing the speed limit in areas where there is a higher probability of a collision with a Tawny Rock Dragon should result in road-related mortality being minimised, if not avoided. Maximum speed limits of 15km/h in RMZ 1 and 25km/h in RMZ 2 should provide vehicles and Tawny Rock Dragons' opportunity for avoidance.

4.4 Future management

Given what is understood of the Tawny Rock Dragon population within the study area, appropriate management is considered extremely important for what should now be considered the NSW stronghold for the species.

The study area is considered under extreme pressure by feral goat grazing which is compounding the effects of drought, leading to widespread habitat degradation across the study area to all forms of biodiversity. For the Tawny Rock Dragon, rock crevices filled, or partially filled with goat scats is undoubtedly impacting on both habitat quality and therefore the extent of suitable habitat which is likely to be impacting on the existing population. Grazing is known for its negative impacts on both individual reptile species and communities across a wide variety of landscapes (Fischer et al., 2003, Fischer et al., 2004, Wassens et al., 2005, Sass, 2004, James, 2003). The listing of the key threatening process 'Competition and habitat degradation by Feral Goats' by the NSW Scientific Committee (DECC, 2008b) is particularly relevant to the Tawny Rock Dragon within the study area.

It has been proposed that a goat management plan should be undertaken as part of the proposal and ongoing land management within the development (NGHEnvironmental, 2008b, NGHEnvironmental, 2008c). The continued existence of feral goats within the study area has the potential to cause a catastrophic decline in the Tawny Rock Dragon population considering the impacts this species has directly on rock crevice availability and quality and vegetation quality; all fundamental attributes that the Tawny Rock Dragon are likely to require in maintaining population viability. The absence of Tawny Rock Dragon from many parts of the study area, and in particular in areas where seemingly suitable habitat exists may suggest that feral goats may have already had some negative impacts on this species.

A goat management plan with the aim of reducing feral goat abundance to the lowest possible levels from the study area would only benefit the Tawny Rock Dragon. Improvements in vegetation quality are likely to result in indirect increases to invertebrate availability (Brown et al., 1999) therefore, increasing food availability. Continued degradation of rock crevices would cease, allowing the crevices to slowly rehabilitate themselves as goat scats and nutrient levels passed. These increases in resource availability would almost certainly benefit this species, with the potential for the population to expand and colonise currently absent rock outcrops over the long term. If goat management allows for the expansion of the local Tawny Rock Dragon population into apparently suitable adjacent habitat, this would be a tremendous biodiversity gain resulting from the proposal.

Finally, ongoing monitoring of the Tawny Rock Dragon population should be undertaken during and post-construction which should include determining the effects of the goat management plan.

5 ASSESSMENT OF SIGNIFICANCE

While an Assessment of Significance (or 7-part test) is not required under Part 3A of the Environmental Planning and Assessment Act 1979, it provides a transparent and systematic approach for determining if the proposed activity '*is likely to have a significant effect on the threatened species, populations or ecological communities, or their habitats'* that are listed as under the Schedule 1 & 2 of the *Threatened Species Conservation Act 1995.*

The Assessment of Significance has determined that the proposed Stage 1b and 1c areas of the Silverton Wind Farm is *'unlikely'* to have a *'significant effect'* on the Tawny Rock Dragon or their habitat in concurrence with the recommendations outlined in Section 6.

(a) in the case of a threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction

The Tawny Rock Dragon is highly specialised in its habitat requirements, being restricted to rock outcrops in ranges and gorges (Swan et al., 2004, Wilson and Swan, 2008) and prior to the 2007, was known from one current population in Mutawinjii National Park. The population of the study area should be considered as an important stronghold in NSW.

Goat grazing was found to be a key factor currently determining the level and quality of habitat on the site for many native species (NGHEnvironmental, 2008c). The NSW Scientific Committee has listed 'Competition and habitat degradation by Feral Goats' as a Key Threatening Process. Twenty-three threatened species were listed in the Committee's determination as being at risk due to this process, including the Tawny Rock Dragon (DECC, 2008b). Feral animal grazing, particularly by goats, is likely to threaten the long-term viability of Tawny Rock Dragons in the study area.Rock crevices filled, or partially filled with goat scats is undoubtedly impacting on both habitat quality and therefore the extent of suitable habitat which would likely result in local extinctions of individuals at some sites. As a result, and combined with their low dispersal capability and low fecundity, seemingly suitable habitat becomes unoccupied. These factors could assist in explaining the limited and patchy distribution of the Tawny Rock Dragon across the study area.

The Tawny Rock Dragon is a short lived animal, which is likely to make them particularly vulnerable to the ongoing degradation by feral goats. Individuals are known to live only a short period of time compared with other dragons, living around two years from birth (Gerry Swan, pers.com. Dec 2007). Adults generally inhabit the higher quality habitat with rock outcrops for

territorial and mating display, while juveniles are forced to occupy the outer fringes of these areas (Gerry Swan, pers. com Dec 2007).

A goat management plan with the aim of reducing goat abundance to the lowest possible levels would only benefit the Tawny Rock Dragon. The continued existence of feral goats within the study area has the potential to cause a catastrophic decline in the Tawny Rock Dragon population considering the impacts this species has directly on rock crevice availability and quality and vegetation quality; all fundamental attributes that the Tawny Rock Dragon are likely to require in maintaining population viability. The absence of Tawny Rock Dragon from many parts of the study area, and in particular in areas where seemingly suitable habitat exists may suggest that feral goats may have already had some negative impacts on this species.

Anticipated improvements in habitat quality and extent from a goat management plan as part of the proposed activity as discussed in section 4.4, are likely to not only avoid having a negative impact on the life cycle of a viable local population of the Tawny Rock Dragon but remove key threats to the life cycle and therefore, improve the long-term survival of this species in the study area.

(b) in the case of an endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the endangered population such that a viable local population of the species is likely to be placed at risk of extinction,

There is no listed endangered population of the Tawny Rock Dragon under the TSC Act.

(c) in the case of an endangered ecological community or critically endangered ecological community, whether the action proposed:

(i) is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction, or

(ii) is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction,

The Tawny Rock Dragon is not listed as an endangered or critically endangered ecological community under the TSC Act.

(d) in relation to the habitat of a threatened species, population or ecological community:

(i) the extent to which habitat is likely to be removed or modified as a result of the action proposed, and

Table 4 of the Biodiversity Addendum provides an estimate of the type and quantum of native vegetation loss required for the development of Stage 1b and 1c of the wind farm not assessed in the initial biodiversity assessment (NGHEnvironmental, 2008b). Based on these calculations, the proposed works would displace approximately 132 hectares of native vegetation. Approximately 11 hectares of native vegetation would be disturbed to enable the construction of the turbines; this could be rehabilitated after the construction phase. An additional 97 hectares could be rehabilitated after the life of the project. Approximately 24 hectares of native vegetation would be permanently displaced (footings would remain insitu after the project is decommissioned).

The Tawny Rock Dragon is loosely distributed across the Stage 1c area, with fewer records in the Stage 1b area suggesting that it occurs in a number of discrete locations. The identification of hotspots ensures that key areas that contain a higher abundance of Tawny Rock Dragon are protected from any direct or indirect impacts. Preliminary data also suggests that Tawny Rock Dragon may be amenable to general construction activities. Numerous Tawny Rock Dragons were observed displaying on rock spoil from vehicular track construction, which have provided vertical habitat ideal for territory guarding. This demonstrates that the species is not likely to be impacted by such levels of disturbance.

It could be considered that the proposed development would result in the removal or modification of habitat for this species. However, the implementation of a goat management plan provides an enormous environmental benefit to all forms of biodiversity, including the Tawny Rock Dragon. The continued existence of feral goats within the study area has the potential to cause a catastrophic decline in the Tawny Rock Dragon population considering the impacts this species has directly on rock crevice availability and quality and vegetation quality; all fundamental attributes that the Tawny Rock Dragon are likely to require in maintaining population viability. The absence of Tawny Rock Dragon from many parts of the study area, and in particular in areas where seemingly suitable habitat exists suggests that feral goats may have already had some negative impacts on this species. This evidence, along with that presented in the scientific literature and DECC key threatening processes determinations, confirms that feral goat grazing has a negative impact on threatened species and habitats in general, and more specifically the Tawny Rock Dragon and their habitats. If goat management allows for the expansion of the local Tawny Rock Dragon population into apparently suitable adjacent habitat, this would be a tremendous biodiversity gain resulting from the proposal.

(ii) whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action, and

The current distribution of the Tawny Rock Dragon appears quite patchy across the study area, with many areas existing in isolation from one another. The identification of hotspots provides protections for areas that are considered of high importance to the Tawny Rock Dragon as they present high levels of abundance than other areas across the site. While many of these exist in isolation, the construction and development of turbines and tracks is not considered to be contributing to current levels of isolation and fragmentation that currently occur. Rather, the implementation of a goat management plan that aims to reduce goat abundance to the lowest possible levels from the study area may increase levels of connectivity between existing populations as vegetation condition improves and current barriers to dispersal and genetic exchange lessened.

(iii) the importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality,

Given what is now considered to be the NSW stronghold for the species, the study area is regarded as extremely important to the long-term survival of the species in NSW.

However, it is highly likely that the long-term survival of the Tawny Rock Dragon population of the study area is threatened given the extent of feral goat degradation to their habitats. Further, the dragon's absence from seemingly suitable habitat suggests that feral goats may have already had some negative effects. Conversely, the proposed development will improve the management of this landscape, with the implementation of a goat management plan aiming to reduce goat abundance to the lowest possible levels from the study area. This would likely result in Improvements to vegetation and habitat quality. Continued degradation of rock crevices would cease, allowing the crevices to slowly rehabilitate themselves as goat scats and nutrient levels passed. These increases in resource availability would almost certainly benefit the Tawny Rock Dragon populations. As such, it is considered that the removal of a small proportion of habitat in comparison to the larger extent of the study area and the environmental benefits gained from a goat management plan would provide greater certainty to the long-term survival of this species than is currently present.

(e) whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly)

There is no critical habitat defined for the Tawny Rock Dragon as listed by the *TSC Act.*

(f) whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan,

The Tawny Rock Dragon is not the subject of a final or draft recovery plan. However, 12 priority actions (PA) have been identified to aid in the recovery of this species. Relevant to this proposal are:

1. To conduct long-term monitoring to determine changes in populations
2. Control feral goats at known populations
3. Determine vegetation associations at known populations
4. Encourage the retention and rehabilitation of habitat connectivity between populations
5. Establish the extent and distribution of populations in NSW
6. Research the ecology and habitat requirements of the species
7. Study movement patterns and habitat use.

This study has provided preliminary data on the Tawny Rock Dragon population and their habitats within the study area (PA1,5,6,7) . Given that it should now be considered the NSW stronghold for the species, the implementation of a goat management plan will have positive benefits (PA2,4). This study has made a variety of recommendations to further improve the habitat quality and land management of the population and to implement a longer term monitoring program of the Tawny Rock Dragon (PA1,2,4,5,6,7).

Therefore, it is considered that the proposal is consistent with the objectives of the priority actions identified for the Tawny Rock Dragon.

(g) whether the action proposed constitutes or is part of a key threatening process or is likely to result in the operation of, or increase the impact of, a key threatening process.

Several listed Key Threatening Processes (KTPs) are relevant to this species: bushrock removal, clearing of native vegetation, competition and habitat degradation by feral goats, predation by the red fox and human-caused climate change

Bushrock removal can remove or disturb the habitat of many native species, which may find shelter in or under rocks, use rocks for basking, or which grow in rocky areas. This study has confirmed that the Tawny Rock Dragon is a rock-obligate species. The creation of roads and hardstand areas may redistribute but would not remove rocks from the site which, as demonstrated, would not remove habitat if piled with soil.

Clearing of native vegetation constitutes destruction of flora and fauna habitat and is considered the major cause of loss of biological diversity. For species of restricted distribution, clearing of native vegetation may result in total extinction, for more widespread species there may be loss of local genotypes (NSW Scientific Committee 2001). The proposed works would result in approximately 132 hectares of native vegetation loss. Further more, the area is sparsely vegetated. Combined heavy goat grazing and drought are likely to have been responsible for

extensive die back of a large proportion of all vegetation strata onsite; trees, shrubs and ground cover. However, the implementation of a goat management plan as part of the proposal is likely to provide considerable environmental benefits to the study area including the native vegetation.

Competition and habitat degradation by feral goats was listed as a key threatened process in 2004. A goat management plan with the aim of reducing goat abundance to the lowest possible levels from the study area would be of considerable benefit to the Tawny Rock Dragon. Improvements in vegetation quality are likely to result in indirect increases to invertebrate availability therefore, increasing food availability. Continued degradation of rock crevices would cease, allowing the crevices to slowly rehabilitate themselves as goat scats and nutrient levels passed. The removal of goats from the study area would be a significant biodiversity gain resulting from the proposal.

Predation by the red fox has been implicated in limiting habitat choice and population size of a number of medium-sized marsupials. Even at low densities foxes can eliminate remnant populations and instigate localised declines. Foxes are also one of several factors which have been implicated in the disappearance of many medium-sized, ground-dwelling mammals from the arid and semi-arid regions of New South Wales. As discussed, this species is known to occur onsite. While tracks can often be seen to facilitate the movement of this species, the existing openness of the site could already be considered to allow unrestricted access of this species over the site.

Human-caused climate change is recognised as likely to generate a different response from organisms than the climate change that has occurred through geologic history. Modelling suggests that many species will be adversely affected including those with long generations, poor mobility, narrow ranges, specific host relationships, isolate and specialised species and those with large home ranges (Hughes and Westoby 1994). Pest species may also be advantaged by climate change. The proposal to develop a wind farm would not have immediate or local effects in this regard, it constitutes a significant part of NSW's strategy to address climate change.

Conclusion

The Assessment of Significance has determined that the proposed Stage 1b and 1c areas of the Silverton Wind Farm is *'unlikely'* to have a *'significant effect'* on the Tawny Rock Dragon or their habitat in concurrence with the recommendations outlined in Section 6. Further, the proposal provides a unique opportunity to secure the long-term survival of the NSW stronghold of the Tawny Rock Dragon provided a goat management plan is adopted to improve habitat and remove known threats to the species.

6 RECOMMENDATIONS

The following recommendations are provided based on the information detailed within this report.

1. A goat management plan must be adopted for the development envelope. This plan would aim for the reduction of goat numbers at the site to the lowest possible level. As part of the goat management plan, ongoing monitoring of the Tawny Rock Dragon population should be designed and undertaken by a suitably qualified herpetologist. This would provide assistance in determining the effects of the goat management plan and provide scientific data relevant to the priority actions identified for this species (see Section 5, Page 32 & 33).
2. All construction works and associated infrastructure must avoid identified Tawny Rock Dragon hotspots.
3. Road management zones (RMZ) must be included in the final design and enforced during construction and maintenance activities between the 1st October and 30th March inclusive when Tawny Rock Dragon are most likely active. Recommended maximum speed limits of 15km/h in RMZ 1 and 25km/h in RMZ 2 should also be applied.
4. Under no circumstances should any persons, equipment, infrastructure or materials impact directly or indirectly on any mapped hotspots (Map 3-4 & 3-5). For example, where track construction flanks hotspots, no spoil or sedimentation from these activities are permitted to enter the hotspot.
5. Habitat creation could be undertaken when excavating turbine footings and vehicular tracks by utilizing any excess rock waste when it is available. In order of priority, excess rock waste should be placed into rock piles around the vicinity of:
    - Turbines
    - Hotspots (not within the hotspot, but adjacent to)
    - Vehicular tracks

    As a general guide, rock piles should be between 0.5 – 1m in height and cover an area as large as 4m x 4m in area. Multiple rock piles can be provided if excess rock waste allows. Soil should not be mixed in with or placed onto these rock piles.
6. Excavated soil should not be placed on top of any existing rocky outcrops. The placement of soil into existing rock crevices will remove potential habitat for the Tawny Rock Dragon.
7. All pre, during and post construction staff should be made aware of the significance of this species in the study area through education and awareness and their obligations in regard to hotspots and road management zones.

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APPENDIX A: RELEVANT PHOTOGRAPHS

Plate 1: Male Tawny Rock Dragon *Ctenophorus decressi* (Photo:Steven Sass)

Plate 2: Female Tawny Rock Dragon *Ctenophorus decressi* (Photo:Steven Sass)

Plate 3: Typical Tawny Rock Dragon habitat (Photo:Jacqui Coughlan)

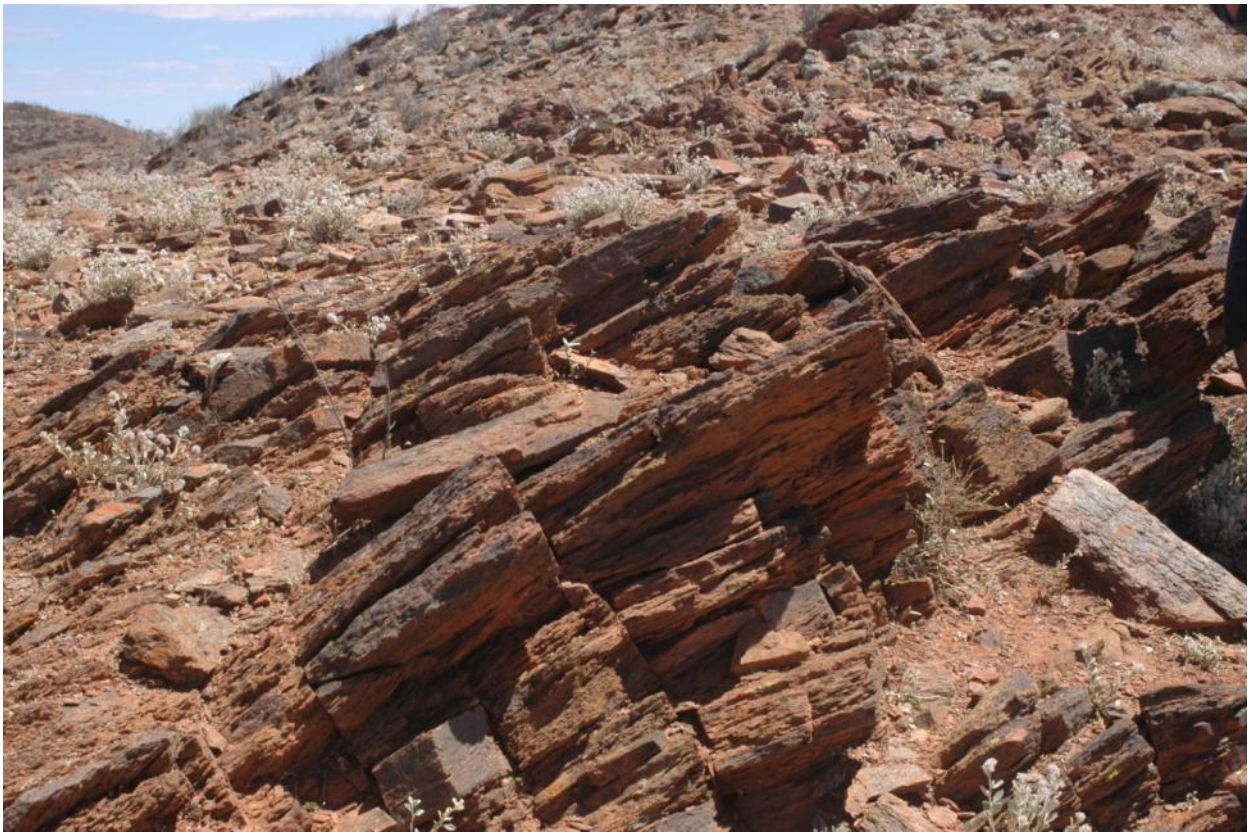

Plate 4: Male Tawny Rock Dragon inside a rock crevice (Photo: Daniela Brozek-Cordier)

APPENDIX B: QUALIFICATIONS AND EXPERIENCE OF PERSONNEL

The following personnel contributed to the field surveys and writing of this report.

Name	Role	Specialist skills and abilities
Nicholas Graham-Higgs	**Project Director – Project management and senior review**	Nicholas has worked as an environmental planning and resource consultant since 1992, specialising in natural resource management. A wide range of assignments covering diverse natural and modified environments, have enabled Nick to develop a broad knowledge base in the area of natural resource planning and management. Nick is accredited as a Certified Environmental Practitioner by the Environment Institute of Australia and New Zealand.
Brooke Marshall	**Project Manager - Internal review**	Brooke is a first class honours Natural Resources graduate of the University of New England (UNE). She specialised in wildlife management, ecosystem rehabilitation and natural resource management in developing countries. Brooke has prepared impact assessment and biodiversity assessment reports relating to a variety of infrastructure development (including roads, windfarms, telecommunications, water supply management and residential development) as well as river modification and prescribed burning works. These reports have included threatened floral and fauna species assessments, research, fieldwork and GIS components. Her major projects have included design of monitoring program for a potentially threatened population of Yellow-bellied Gliders on the South Coast, impact assessments and biodiversity assessments for a number of wind farm developments on the Southern Tablelands, a Species Impact Statement involving 33 subject species near Eden, and strategic biodiversity planning reports for the Snowy River Shire and Bega Valley Shire.

Name	Role	Specialist skills and abilities
Steven Sass B. App. Sci. (Env.Sci) (Hons)	**Senior Ecologist/ Herpetologist/ Senior Author**	Steven joined **ngh**environmental in August 2006 with expertise in environmental consulting and biodiversity assessment. In the four years prior, he played a key role at Charles Sturt University, undertaking flora and fauna impact assessment for the Johnstone Centre (Environmental Consulting) and as a senior research officer within the biodiversity research and education team with much of his work in western NSW. Steven is an experienced ecologist having undertaken more than 400 aquatic and terrestrial threatened flora and fauna surveys and habitat assessments. As a Certified Environmental Practitioner by the Environment Institute of Australia and New Zealand.and Senior Ecologist, Steven provides technical advice and peer-review to the **ngh**environmental ecology team. Steven is a highly experienced herpetologist and provides specialist advice, research and assessment on frog and reptile fauna and their habitats across NSW to a variety of projects and clients. These include studies of frog and reptile populations in the Murrumbidgee Irrigation Area (over 200,000 hectares) through surveys and habitat assessments at 160 sites, the impact of fire on reptile communities in a large reserve system (over 250,000 hectares) in western NSW, threatened frog and reptile surveys for the Hume Highway duplication between Wagga Hill and Albury and specialist advice on reptiles and frogs for the Queensland Hunter Gas Pipeline, a 650km project connecting Newcastle to gas infrastructure in Queensland. Steven, and in collaboration with other researchers, has published, submitted or is currently preparing a number of scientific journal manuscripts, which provide a significant contribution to the ecological knowledge of reptiles and frogs. A poorly studied fauna group, these papers aim to provide natural resource managers with updated inventories and species distribution and ecology which will be an invaluable tool in developing strategies for their future management. He is an Adjunct Associate of the Ecology and Biodiversity group within the Institute for Land, Water and Society, a leading research group at Charles Sturt University, Australia's largest regional university.

Name	Role	Specialist skills and abilities
Jacqui Coughlan B.Sc, PhD (Bird Ecology)	**Ecologist**	Jacqui's practical ecological skills in terrestrial and freshwater ecology have been developed over 20 years in several states. She has designed, conducted and managed numerous fauna and flora surveys in New South Wales, Queensland and Western Australia and has a thorough working knowledge of State and Commonwealth legislation related to flora and fauna. She has a broad knowledge base of ecological issues and is able to provide clients with sound and practical advice regarding environmental legislation and assessment protocols. Jacqui has conducted several years of research on freshwater ecosystems in mountain rainforest streams. Her PhD focused on the ecology of bird communities in rare dry rainforest vegetation in far north Queensland. Jacqui is experienced in all vertebrate fauna survey techniques including specialist threatened species surveys and habitat assessments and has conducted surveys in a broad range of environments including forest, woodland, grassland, mangrove, wetland, coastal and island communities. Jacqui's specialist skills in bird ecology have been used in impact assessment in Australia and internationally in grasslands and wetlands of Inner Mongolia. Jacqui is currently conducting research on implementation of international biodiversity conventions as part of her Masters in Environmental Law. Jacqui provides project management and mentoring advice for the environment team as well as personally contributing vital technical expertise to environment projects and leading field survey teams for large projects. Her current professional interests and project focus include biodiversity impact assessment, wind farms and linear infrastructure corridors. Jacqui has worked for a broad range of private and government clients including Department of Defence, NSW RTA, British Gas, WWF, Stockland Developments, Landcom and Sydney Water.
Daniela Brozek-Cordier B.Sc (Geo & Env St) Grad Dip Env St (Hons)	**Assistant Ecologist**	Daniela's interests include environmental planning and management, site rehabilitation, sustainable tourism, environmental education, and also planning for bushfire protection. With **ngh**environmental, Daniela has also carried out numerous environmental impact assessments for proposals within Kosciuszko National Park, on the Monaro plains and on the South Coast of NSW. These have included several major water transfer proposals, tourist accommodation developments and provision of other services, often affecting protected areas. Daniela has recently prepared a number of significant Environmental Management Plans (EMPs) for such projects as a cloud seeding trial in the Snowy Mountains, major pipeline works, and the management of six popular walking tracks within the alpine zone of Kosciuszko National Park.

Name	Role	Specialist skills and abilities
Bianca Heinze B.AppSc. (Env Res Mgt & Coastal Mgt)	**Assistant Ecologist**	Bianca completed her Bachelor of Applied Science (Environmental Resource/Coastal Management) at Southern Cross University, Lismore in 2006. Since joining **ngh**environmental Bianca has been mentored in the preparation of Assessments of Significance for threatened biota (7-part tests), Biodiversity Assessments and Review of Environmental Factors for clients including Epuron and Country Energy. Bianca also has field experience in biodiversity assessments including terrestrial fauna surveys and habitat evaluation across a variety of ecosystems. Prior to joining **ngh**environmental, Bianca was employed with the Department of Sustainability & Environment, Victoria, in the field of fire management. During her 2 years, she was involved with fire operations planning, community engagement and fire suppression. Bianca has also volunteered on a number of projects including humpback whale and Fleay's barred frog surveys on the NSW North Coast, design of teachers' resources for waste education with Coffs City Council and water quality monitoring. Bianca holds several professional memberships including the Ecological Society of Australia and Birds Australia.
Ally Madden B.Sc (App.Geo) (Hons)	**Spatial Analyst**	Ally graduated as a first class Honours student at the University of NSW in 2006. Since the completion of her studies she has specialised in Geographic Information Systems (GIS) working with ArcMap version 9.2. Prior to joining **ngh**environmental, Ally worked for the National Parks and Wildlife Service managing the design and development of interactive park maps for the NPWS website. Ally was also involved in mapping fire management strategies, Aboriginal Cultural Heritage sites and worked on the mapping and data analysis for the SE Koala Discovery Surveys. Ally is now involved in managing GIS data and the preparation and presentation of maps for biodiversity, heritage and environmental assessment projects, including wind farm projects and other major infrastructure projects across NSW.

APPENDIX C: LOCATIONS OF HABITAT ASSESSMENT

Site No.	EASTING	NORTHING
1	532355	6498962
2	532143	6499013
3	532236	6499105
143	521877	6482844
145	529357	6488072
146	529137	6487988
147	529363	6487419
148	529122	6487343
149	528717	6487540
150	529079	6487348
151	529105	6487334
152	529138	6487322
153	530952	6486794
178	530583	6495253
179	530612	6495251
180	530652	6495347
181	530712	6495489
182	530726	6495700
183	530533	6496185
184	530179	6496677
185	528683	6496724
186	528407	6496810
187	528257	6496869
188	529566	6497436
277	530066	6488911
278	530072	6488908
279	530077	6488906
280	530003	6488907
281	529884	6488916
282	529796	6488926
283	529815	6488971
284	529815	6488971
285	529810	6488970
286	529810	6488969
287	529734	6489062
288	529752	6489057
289	529754	6489048
290	529754	6489048
291	529747	6489011
292	529810	6489017

Site No.	EASTING	NORTHING
293	531121	6488061
307	531607	6496966
308	531606	6496959
309	531606	6496955
310	531601	6496943
311	531618	6496909
312	531618	6496899
313	531617	6496897
315	531694	6496879
316	531680	6496871
317	531697	6496830
319	531675	6496755
320	531673	6496756
322	531709	6496670
327	531788	6496539
328	531793	6496536
334	531901	6496458
338	531926	6496341
342	532037	6496259
349	531594	6497102
354	531128	6497388
355	531128	6497388
360	531099	6497542
364	530910	6497646