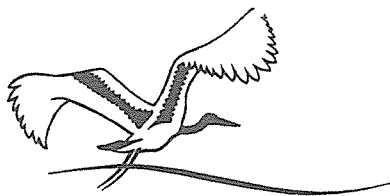




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FAUNA SURVEY



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BRADSHAW STATION

BASELINE FAUNA SURVEY

for

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by

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COMMERCIAL-IN-CONFIDENCE

Prepared for: Connell Wagner

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EXECUTIVE SUMMARY

A baseline fauna survey of Bradshaw Station was conducted between June-August 1997 with additional data gathered in October 1996. The major sampling zones were Angalarri Plain, Koolendong Valley including Mosquito Flat, and Yambarran Plateau. Six broad fauna habitats were categorised as: closed forest, open forest and woodland, rocky slopes and hills, streams and associated riparian strips, grasslands, and swamps; these fauna habitats are integrated with a land unit classification system based on soils, topography and vegetation, as determined in other baseline surveys.

A total of 310 vertebrate species were recorded comprising 24 species of fishes, 19 frogs, 56 reptiles, 171 birds, 34 native mammals and 6 feral mammals. Two undescribed species and extensions of ranges for six species were recorded. No endangered species, one vulnerable species and five near-threatened species were recorded; all these species of conservation significance appeared to be widely distributed and fairly abundant on Bradshaw. A number of species are listed under international agreements: JAMBA (5 species), CAMBA (6), BONN (51) and CITES (2). Bradshaw Station therefore is a biologically diverse area with important regional value. Diversity and value will be maintained or enhanced by management strategies that maintain or enhance habitats.

The previously recorded Gouldian Finch, Purple-crowned Fairy-wren, Kimberley Crested Shrike-tit and Grey Falcon, all of conservation significance, were not recorded on this baseline survey.

Excluding fishes, a similar species richness was recorded across the major sampling zones: Koolendong Valley, Yambarran Plateau and Angalarri Plain. Significantly more species of native mammals were recorded in rocky slopes and hills than in other habitats, and relatively more species of frogs, reptiles, birds, bats and feral mammals were recorded in riparian habitat than in other habitats. Significantly fewer species (all taxa combined) were recorded than expected in woodland habitats; this is probably related to the impact of cattle grazing.

Core fauna habitats identified were: rocky slopes and gullies with closed forest (as at various locations on the slopes of Yambarran Plateau), streams and riparian habitats associated with rocky hills (as at Lobby Creek and surrounding areas at the entrance to Koolendong Valley), and grasslands with swamps (as at Mosquito Flat).

The impacts of Defence activities are likely to be essentially minimal during the construction phase and potentially greater during the operational phase. Minimal impacts on fauna populations will be achieved by managing core fauna habitats and allowing other habitats to

recover following major activities. It is recommended that no training activities, other than transit, should occur in core fauna habitats and other sensitive areas.

Feral cats, Feral Pigs and Feral Donkeys appear to be the greatest feral animal threat to fauna and habitats; these pests can be eliminated by regular management including shooting and use of the 'Judas' technique. Control of feral animals will be maximised if linked with regional control activities conducted by Government agencies.

Monitoring of habitats and major fauna groups is essential to assess the effects of training activities and environmental management programs. It is recommended that appropriate additional sites be added to sites established in the baseline survey. Research for management of habitats, especially the fire management of grasslands, would be an important component of monitoring.

1 OBJECTIVES

- To survey the land and freshwater vertebrate fauna (excluding specific sampling for bats) on Bradshaw Station but excluding designated areas,
- To compile checklists of freshwater fishes, frogs, reptiles, birds and mammals,
- To evaluate the conservation status of rare, vulnerable and endangered species from a Northern Territory, national and international perspective,
- To evaluate the use of Bradshaw Station by migratory birds that are listed under international conventions,
- To relate fauna habitats to land units (soil and vegetation classifications) as determined from collaborative studies,
- To indicate special diversity (core) fauna habitats,
- To evaluate the status of feral animals and recommendations for their management,
- To recommend prescribed fire regimes for the conservation of fauna assemblages,
- To recommend management strategies to avert or minimise military operational impacts on native fauna and habitats, and
- To recommend monitoring strategies to assess the effect of military operations and environmental management programs on fauna and habitats.

2 METHODS

2.1 Establishing sampling sites

The designated broad survey areas were the Angalarri Plain, Koolendong Valley, Yambarran Plateau and Mosquito Flat. On advice from Connell-Wagner, areas excluded from sampling were the Western Hills, estuarine and coastal flats, and areas immediately south of the Fitzmaurice River.

A reconnaissance survey of the broad survey areas (except Yambarran Plateau) was conducted in early October 1996 to identify major sampling sites in representative (1) vegetation and soil habitats, (2) physical terrains (stream flats, valley floors, rocky slopes and plateaux), (3) areas of relatively high and low cattle grazing pressure and (4) areas where Defence activity was likely to be concentrated; and most sampling sites including pitfall systems were established later that month.

2.2 Field surveys

Four surveys were conducted by ERAES personnel in June 1997 (2 surveys, terrestrial vertebrates, Angalarri Plain and Koolendong Valley), July 1997 (all taxa, Yambarran Plateau) and August 1997 (mostly aquatic vertebrates, Angalarri Plain and Koolendong Valley). Access to the Yambarran Plateau was by helicopter (Heli-muster Pty Ltd). The field assistance of Sven Sewell (ERAES), Tony Hertog (CSIRO), Dean Stephens, Mark Spain and Mick Gill is gratefully acknowledged.

In addition, as part of a Ranger training program, the Parks and Wildlife Commission of the Northern Territory (PWCNT) sampled terrestrial vertebrates (including bats) in June 1997 at sites centred on Lobby Creek in the Koolendong Valley and Mosquito Flat. The collaboration of Alaric Fisher, John Woinarski and other members of the PWCNT team is much appreciated.

2.3 Sampling techniques

2.3.1 Fishes and other aquatic fauna

All sampling was conducted in freshwater streams and waterbodies. Fishes and other aquatic vertebrates were sampled in waterholes using gill-nets and seine nets. Large waterholes in which saltwater crocodiles and/or large numbers of freshwater crocodiles were observed were not netted. Small scoop-nets were employed to sample fishes among the waterplants and under leaf and log litter along the margins of waterbodies. Bait pots, fishing lines and spotlighting were also used. Specific details are given below:

Seine Nets: An 8 m long seine net with a 1 m drop (8 mm woven multifilament mesh) was pulled three times at most sites. Also, a 20 m long seine net with a 2 m drop (8 mm woven multifilament mesh) was pulled twice at some sites. These nets are particularly useful for capturing small diurnally active nektonic fishes that inhabit the middle to upper strata of open water.

Gill Nets: Two 15 m x 2 m multi-panelled gill nets (monofilament mesh of 26, 44 and 58 mm) were set for one night at most sites. Also a 20 m x 2 m multi-panelled gill net (monofilament mesh of 76, 100, 126, and 150 mm) was set for one night at one site. These nets are particularly suited to catching variously sized nektonic and demersal species including both nocturnal and crepuscular species that rest by day in snags or beneath the sediment or below undercut banks.

Baited Lines: Fishing lines (baited with salami) were set overnight at some sites. These are useful for catching large nocturnal and crepuscular scavenging and carnivorous species of fishes.

Lured Lines: Fishing lines (with various lure designs) were pulled at some sites. These are useful for catching large carnivorous species of fishes.

Dip Nets: Dip nets (1 mm mesh) were pulled 6 to 10 times at most sites. These nets are useful for catching small, slow moving pelagic and demersal fishes as well as aquatic invertebrates (such as macrocrustaceans and molluscs) especially from shallow waterbodies, undercut banks, amongst the sediment and in aquatic vegetation.

Crustacean Traps: Three collapsible box-shaped crustacean traps (2 mm mesh, baited with salami or commercially available cat food or fresh fish) were set overnight at most sites. Two collapsible semi-spherical-shaped crustacean traps (8 mm mesh, baited as above) were set overnight at most sites. These methods are particularly useful for catching macrocrustaceans and small scavenging fishes.

Visual Examination: Each sample site was visually examined during daylight hours. This method is particularly useful for diurnally active pelagic species, crustaceans and gastropod molluscs. Spotlighting was also conducted to record crocodiles and other nocturnally active species such as water rats and some fishes.

2.3.2 Herpetofauna

Reptiles and frogs were captured in pit-trap systems comprising two sets of 2 x 20 litre buried plastic buckets each connected by a 12 m x 30 cm high drift fence. On the Yambarran Plateau, smaller metal pit traps (11 L) were installed immediately prior to sampling. Diurnal and nocturnal searches were also conducted along the edges of waterbodies, and within major sampling sites.

2.3.3 Mammals

Mammals were captured in standard Elliot traps (baited with a mixture of peanut butter/oats/bacon/budgerygar seed), wire cage traps (baited with apple/Elliot trap mix/cat food), and pit-traps. Some species were recorded from animal sign (scats,

tracks, scratches) in raked earth along the drift fences; or by spotlight surveys along the edges of waterbodies, and within major sampling sites.

2.3.4 Birds

The presence and estimated abundance of bushbirds and waterbirds were obtained from vocalisations and by sight within major sampling sites and along the edges of waterbodies, and especially during early morning sampling sessions commencing about 1 hour after dawn.

2.3.5 Other methods

Opportunistic observations of all species were also recorded at all times during field trips.

The PWCNT used similar techniques as described above to sample birds, herpetofauna and mammals. In addition, mist nets and harp traps were used to sample bats and small birds.

Nomenclature for taxa generally followed Strahan (1995) for mammals, Christidis and Bowles (1994) for birds, Cogger (1996) for reptiles, Barker *et al.* (1995) for frogs and Allen (1989) for fishes.

Voucher specimens were collected under appropriate permits from the PWCNT and the NT Department of Primary Industry and Fisheries. Sampling techniques were approved by an appropriate Animal Ethics Committee.

2.4 Sampling zones and fauna habitats

Major sampling zones were categorised as:

- Angalarri Plain: a major plain east of Yambarran Range including the Angalarri and Ikymbon Rivers and associated tributaries (see Plates 1-3),
- Koolendong Valley: a major valley between the Western Hills and Yambarran Range including Lobby and Lalngang Creeks (see Plate 4),
- Victoria River Frontage: a strip of river frontage up to 10 km wide, including Mosquito Flat and grasslands near King Billabong airstrip (see Plate 1) , and

- Yambarran Plateau: an extensive plateau between Koolendong Valley and Angalarri Plain including the headwaters of Lobby Creek, Little Fitzmaurice River and other unnamed streams (see Plate 5).

Within each of these zones, habitats were broadly categorised as:

- Closed: closed forest (including rainforest) (see Plates 6-7) ,
- Woodland: open forest and woodland (see Plates 8-10),
- Rocky: rocky slopes and hills (see Plates 16-17),
- Riparian: streams and riparian strips bordering streams (see Plates 11-15),
- Grassland: open grasslands and savannas (see Plates 18-21), and
- Swamps: permanent and ephemeral swamps (including dams) (see Plates 21-23).

Land units (soil types and vegetation) associated with these fauna habitats are given in Table 1.

2.5 Data analysis

Mann-Whitney, ANOVA and X^2 were used to compare species richness between zones and habitats.

3 RESULTS

3.1 Sampling sites

Fauna was sampled from 62 sites (Figure 1, Appendix 1). The size of the actual area sampled and sampling techniques used varied between sites. At most sites, techniques were standardised so that the number and design of pit traps, mammal traps and fish nets, and the approximate area traversed and/or time spent searching in transects was similar. However, as the survey proceeded, it became apparent that further sites were required in particular habitats or particular fauna groups required targetting; for these sites, non-standardised sampling techniques were frequently used. Given that additional sites were established in each of the major sampling zones, the overall sampling intensity between the major sampling zones and

between habitats was considered to be broadly comparable so that species richness was comparable between zones and habitats.

3.2 Species Richness

A total of 310 species were recorded during this survey comprising 24 species of fishes, 19 frogs, 56 reptiles, 171 birds and 40 mammals (Figure 2, Appendix 2, Tables 2 and 3). For mammals, there were 23 non-flying native species, 11 bats and 6 ferals.

Additional species (14 birds, 2 mammals) recorded on Bradshaw Station prior to this baseline survey are given in Appendix 3 so that the total recorded list for Bradshaw Station is 327 species of vertebrates. However this list is known to be incomplete because extra species have been seen on Bradshaw by experienced naturalists in recent years. For example, the Nabarlek (*Peradorcas concinna*) near Lobby Creek (Sampling Site 53); the Rufous Owl (*Ninox rufa*) in the northeast corner of Angalarri Plain; the Black Swan (*Cygnus atratus*) near Mosquito Flat; the White-lined Honeyeater (*Meliphaga albilineata*) at Mussel Waterhole (Sampling Site 26); and the Yellow-rumped Manniken (*Lonchura flaviprymna*) in the northern Koolendong Valley (P. Roper, personal communication).

Several species of invertebrates were recorded during aquatic surveys: the shrimps *Macrobrachium rosenbergii* (Angalarri Plain, Koolendong Valley Yambarran Plateau), *Macrobrachium lar* (Angalarri Plain, Koolendong Valley); the mussel *Velesunio angassi* (Angalarri Plain, Koolendong Valley); and the snails *Thiara amarula* (Victoria River frontage) and *Notopala* sp. (Koolendong Valley). All these species appeared to be fairly abundant.

The distribution of vertebrate taxa across the major sampling zones is shown in Figure 3. Relatively more species were recorded in the Koolendong Valley ($n = 232$, Table 2) than in the Angalarri Plain (173), Yambarran Plateau (134) and the Victoria River Frontage (194); however, these differences in species richness were not significant ($F = 0.14$, $P > 0.05$). There were also no significant differences in species richness for each of the major taxa (fishes, frogs, reptiles, birds, non-flying native mammals, bats and feral mammals) between major sampling zones.

3.3 Species of national conservation significance

Definitions of conservation status are given in Appendix 5 and listed species recorded on Bradshaw Station are indicated in Table 4. The numbers of additional

listed species which, on the basis of species' distribution maps, could occur on Bradshaw Station are indicated in Table 5.

For this baseline survey, no species were recorded that are listed in the Endangered Species Act as critically endangered or endangered, one species (Dingo) is considered by authorities to be vulnerable and five species (Exquisite Rainbowfish, Copland's Rock Frog, Star Finch, Northern Quoll, Pygmy Long-eared Bat) are listed in the Endangered Species Act as near threatened (LR-nt).

Prior to this baseline survey, the following species of conservation significance were recorded : Gouldian Finch (EN), Kimberley Crested Shriketit (EN), Purple-crowned Fairy-wren (VU), Ghost Bat (VU) and Grey Falcon (LR-nt).

Comments on these species follow:

Gouldian Finch (*Erythrura gouldiae*) EN - Despite intensive searching, this species was not recorded during this baseline survey. It was previously recorded from the Angalarri Plain, including breeding records near Mt Thymanan (P. Dostine, personal communication) and from the Koolendong Valley (P. Roper, personal communication). Once widespread across northern Australia, this species is now found reliably only at a few sites between the west Kimberley region and Katherine. Breeding is usually confined to open woodland with a grassy understorey but in the western part of its range in the Northern Territory it breeds on rocky slopes dominated by Snappy Gum (*Eucalyptus brevifolia*). In the non-breeding season, it occupies a wide variety of woodland habitats. Both the range and abundance of this species have decreased greatly over the past two decades. Populations that remain appear to be suffering excessively high mortality. The cause of the decline is unknown but the most likely are inappropriate fire regimes affecting food supply and grazing by Cattle. Other possible reasons include: infection with an airsac mite (*Sternostoma tracheacolum*) a parasite in aviary birds that has escaped into the wild, a species-specific disease, burning of suitable nest trees, trapping for the bird trade, alteration of habitat and disturbance by mining.

Kimberley Crested Shriketit (*Falcunculus frontatus*) EN - The northern subspecies (*Falcunculus frontatus whitei*) occurs from the McArthur River (Gulf of Carpentaria) west to the Kimberley and is classified as endangered. The other subspecies (*F.f.leucogaster*, *F.f.frontatus*) are considered to be rare (LR-nt) and secure (LR-lc) respectively. The habitat of the northern subspecies is woodland with eucalypts and/or paperbarks that have peeling bark. Although no decline has been recorded,

there are only 24 records of this subspecies over the past 80 years or so. This subspecies may be naturally rare but the increased frequency of late dry season fires may have decreased the availability of invertebrate food under peeling bark. The Kimberley Crested Shrike-tit was not recorded on Bradshaw during this baseline survey.

Purple-crowned Fairy-wren (*Malurus coronatus*) VU - This species is not listed by the Endangered Species Act. However, the Action Plan for Australian Birds (Garnett 1992a) classifies the western subspecies (*Malurus coronatus coronatus*), found in north-west Western Australia and western Northern Territory, as vulnerable. Also, the Parks and Wildlife Commission of the Northern Territory consider this species to be threatened because of small and restricted areas of suitable grassland habitat. The favoured habitat is tall canegrass (*Mnesithea rottboellioides*) and screwpalm (*Pandanus* sp.) immediately adjacent to permanent rivers and associated swamps. Reasons for the decline of this species are overgrazing and trampling of habitat by stock and excessively frequent burning, which causes degradation and/or loss of habitat and, ultimately, abandonment of the habitat. Although previously recorded on Bradshaw Station, the Purple-crowned Fairy-wren was not recorded on Bradshaw Station during this baseline survey despite intensive searching by ERAES and PWCNT personnel. It was, however, recorded in grassy embankments bordering the Victoria River about 100 km to the east of the property which suggests that this species could have been overlooked during the baseline survey.

Dingo (*Canis lupus dingo*) VU - Although not evaluated by conservation authorities such as the Endangered Species Act, recent research (Corbett 1995) indicates that the dingo should be classified as vulnerable. There are three subspecies in Australia. Although the tropical form is common, and subject to control in some areas, it is increasingly under threat of hybridisation with Domestic Dogs. In eastern Australia, the alpine form is probably extinct, and only Feral Dogs and hybrids remain in that region. On Bradshaw Station, dingoes were widespread in most habitats but numbers appeared to be low, possible due to a persistent control campaign (poisoning and shooting) used by the local pastoralists. Most dingoes observed on Bradshaw Station appeared to be 'pure'.

Ghost Bat (*Macroderma gigas*) VU - This is Australia's only carnivorous bat which kills large insects, frogs, lizards, birds and small mammals including other bats. Most prey are killed on the ground; the Ghost Bat swoops on prey, envelops it in its wings and kills with powerful bites, then returns to an established site to feed. The present patchy and widespread distribution of the Ghost Bat in northern Australia includes

habitats as diverse as the arid Pilbara and lush north Queensland rainforests. Most colonies are small and range in size from a few to about 400; groups over 1000 individuals are unusual. One of the largest colonies known is near Pine Creek. Ghost Bats are sensitive to human disturbances which, in conjunction with their rarity and contraction in range, provide reasons for their vulnerable conservation status. Prior records of the Ghost Bat on Bradshaw are from rocky habitats in the northwest of the Angalarri Plain.

Exquisite Rainbowfish (*Melanotaenia exquisita*) LR (nt) - Although found chiefly in upland habitats in the Katherine, Edith, Mary, South Alligator, Fergusson and Victoria Rivers of the Timor drainage, this species apparently has one of the most restricted distributions of Australia's rainbowfishes. On Bradshaw Station, this species was widespread (Sampling Sites 33, 35, 36, 37) and fairly abundant.

Copland's Rock Frog (*Litoria coplandi*) LR (nt) - This species is unusual because of its habit of living on rock faces near escarpments, however, it is common in this fairly small but widespread habitat. On Bradshaw Station, this frog was fairly abundant but appeared to be restricted to rocky areas along the Victoria River frontage and the entrance to Koolendong Valley (Sampling Sites 1, 45, 52, 53, 54).

Star Finch (*Neochmia ruficauda*) LR (nt) - The northern subspecies (*Neochmia ruficauda clarescens*) occurs across northern Australia from the Pilbara to north Queensland and is considered to be rare. However, this finch was fairly abundant and widespread on Bradshaw Station (Sampling Sites 3, 4, 17, 21, 23, 28) where it was recorded in pure and mixed flocks with other finch species. Within its range, it is mostly restricted to vegetation beside watercourses and swamps; grassy flats with few bushes and low trees. The eastern subspecies (*Neochmia ruficauda ruficaudata*) is considered to be endangered due to degradation of its habitat (dense grass beside permanent freshwater) by Sheep, Cattle and Rabbits.

Grey Falcon (*Falco hypoleucos*) LR (nt) - This species occurs throughout inland and the drier coastal parts of all mainland States. Populations are small and the usual habitats are open grassy plains, timbered watercourses and pastoral lands. None were recorded on Bradshaw Station on this baseline survey.

Northern Quoll (*Dasyurus hallucatus*) LR(nt) - This species is now restricted to six regions within a former range that occurred across northern Australia from the Pilbara to south-eastern Queensland and is considered to be rare. On Bradshaw Station, the Northern Quoll was not uncommon (6 records) but appeared to be

restricted to rocky and riparian habitats in Koolendong Valley (Sampling Sites 9, 43, 53, 58), and in woodland along the Victoria River frontage (Sampling Site 6, nr. barge terminal). Much of its substantial reduction in range since European settlement has occurred in recent memory. Most breeding occurs in habitats that include watercourses. Males usually die after the mating season and females undergo high stress during the breeding season and afterwards when they care for the young. Frequent and hot fires, especially late in the dry season, are believed to be associated with habitat degradation. The presumed decrease in food quality and/or availability associated with a run of below-average wet seasons has also been implicated in the decline of Northern Quolls (Braithwaite and Muller, in press).

Pygmy Long-eared Bat (*Nyctophilus walkeri*) LR(nt) - According to Strahan (1995), only a few specimens of this species had been collected since 1891. However, with improved recording techniques for bats and more surveys conducted in the Northern Territory in recent years, the Pygmy Long-eared Bat is now considered to be common and widespread (J. Woinarski, personal communication). On Bradshaw Station, 21 records were obtained in riparian and rocky habitats of Koolendong Valley (Sampling Site 53) and Yambarran Plateau (nr. Sampling Site 51). Very little is known of its biology and ecology except that it appears to be closely associated with watercourses and the diet includes bugs, beetles and wasps.

3.4 Species of international importance

Species listed under international agreements are indicated in Appendices 2, 3 and 4; and Tables 4 and 5.

Convention on the Conservation of Migratory Species of Wild Animals (Bonn Convention).

The contracting parties agree to conserve migratory species and their habitats by (1) promoting, cooperating in and supporting research on migratory species, (2) endeavouring to provide immediate protection for migratory species, and (3) endeavouring to conclude agreements covering the conservation and management of migratory species.

Appendix I of the Bonn Convention lists Australian migratory species that are endangered. None of these species (turtles and whales) have been recorded at Bradshaw Station, but it is possible that some may occur there (see Appendix 4).

Appendix II of the Bonn Convention lists Australian migratory species that have an unfavourable conservation status and which require, or would benefit from, international agreements for their conservation and management. At Bradshaw Station, one of the seven listed reptiles, none of the four listed mammals, and 51 of the 172 listed birds were recorded in this survey (Table 4). However, based on species' distribution maps, further surveys in other areas of Bradshaw and in other seasons might record a further four species of reptiles and 41 species of birds (Table 5). Bradshaw land managers can contribute to this agreement by appropriate management strategies that maintain or enhance the quality of habitats for these species.

Agreement between the Government of Australia and the Government of Japan for the Protection of Migratory Birds in Danger of Extinction and their Environment (JAMBA).

This agreement provides for cooperation between the two Governments to protect birds that migrate between the two countries, to protect birds in danger of extinction and to protect their environment. Of the 76 species listed under this agreement, 5 were recorded at Bradshaw Station in this survey (Table 4). However, based on species' distribution maps, further surveys in other areas of Bradshaw and in other seasons, a further 42 listed species might also occur there (Table 5). Bradshaw land managers can contribute to this agreement by appropriate management strategies that maintain or enhance the quality of habitats for these species.

Agreement between the peoples' Republic of China and the Government of Australia for the Protection of Migratory Birds and their Environment (CAMBA).

This agreement promotes cooperative measures that include: (1) controlling the taking and the trade or exchange of migratory birds and their eggs, (2) establishing sanctuaries and other facilities for the management and protection of migratory birds and their habitats, and (3) undertaking joint research and exchanging information and publications on migratory birds. Of the 81 species listed under this agreement, 6 were recorded in this survey of Bradshaw Station (Table 4). However, based on species' distribution maps, further surveys in other areas of Bradshaw and in other seasons might record, a further 40 listed species might occur there (Table 5). Bradshaw land managers can contribute to this agreement by appropriate management strategies that maintain or enhance the quality of habitats for these species.

Convention on International Trade in Endangered Species of Wild Fauna and Plants (CITES).

This convention regulates trade of species (and items manufactured from their parts) perceived to be in danger of extinction partially or wholly through international trade. The Saltwater crocodile and the Freshwater Crocodile, both fairly common on Bradshaw Station, are listed in Appendix 2 of this convention. Bradshaw land managers can contribute to this convention by appropriate management strategies that maintain or enhance the quality of habitats for these species.

Wader flyways.

Waders (shorebirds) occur in both wetland and non-wetland areas across Australia. There are 15 species of waders that are resident in Australia (4 recorded at BFTA), 36 species that are regular migrants (2 recorded at BFTA) and 16 vagrants (none recorded at BFTA). Most waders that migrate to Australia are trans-equatorial migrants that breed in Asia in June and July. However the Australian Pratincole is one exception that breeds in Australia and migrates to Asia between March and November.

The migration paths are termed flyways and birds concentrate in areas deemed to be of international or national importance. For the Northern Territory, eight areas of international importance for waders and two areas of national importance for waders have been identified, but none are located on Bradshaw Station (Watkins 1993).

3.5 Wetlands of national and international importance

Australian Wetlands of National Importance.

There are no listed wetlands on Bradshaw Station, the nearest being the Legune Wetlands (Legune Homestead Swamps, Osmans Lake System) immediately west of Bradshaw (Whitehead and Chatto 1996).

Convention on Wetlands of International Importance (Ramsar Convention).

There are no listed wetlands on Bradshaw Station or surrounding areas, the nearest being Kakadu National Park.

3.6 Notable findings

An undescribed gecko (*Gehyra* aff. *australis*) was recorded on rocky slopes in three widely separated areas of the Yambarran Plateau suggesting that this species may be widespread on Bradshaw Station in this habitat. This gecko has been previously recorded from The Victoria River District and the Bungle Bungle in WA.

Despite fairly intense sampling along the Ikymbon River and elsewhere on Bradshaw Station, the Angalarri Grunter (*Scortum neilli*) was not recorded on this survey. This species was previously known from nine specimens taken from a single location on the headwaters of the Angalarri River in 1981 (Midgley 1981) in the north-east region of Bradshaw Station (this location was not sampled on this survey due to difficulty of access), and two specimens from the East Baines River immediately south of Bradshaw Station (Allen *et al.* 1993). On the basis of these data, the Angalarri Grunter appears to be rare in a restricted range, and virtually nothing is known of its biology and ecology.

Four specimens of the Whip Snake (*Demansia simplex*) were recorded by PWCNT personnel from claypan/grassland habitats in Mosquito Flat (Sampling Site 61). This species was previously known only from a few scattered localities west of Katherine to Pine Creek in the NT (J. Woinarski, personal communication), and the north-western Kimberley region in open tropical woodland (Cogger 1996). The Bradshaw records represent an additional habitat for this species and suggest that this species is probably widely distributed but uncommon.

Records of the skink (*Ctenotus tantillus*) on Bradshaw Station represents a small easterly extension to its previously known range in the northern Kimberley of Western Australia (Cogger 1996). Similarly for the skink (*Lerista griffini*) which is known from only three, fairly small and isolated populations: one in Dampier Land, WA, one around the top end of the WA/NT border region (Cogger 1996), and one in the vicinity of the Carpentaria Highway (A. Fisher, personal communication).

Records of the Pied Cormorant (*Phalacrocorax varius*), Great Cormorant (*Phalacrocorax carbo*), Black-eared Cuckoo (*Chrysococcyx osculans*), Masked owl (*Tyto novaehollandiae*) and Clamorous Reed-warbler (*Acrocephalus stentoreus*) are useful records because, although within their known range, these species are infrequently recorded in the tropics or in habitats represented on Bradshaw Station.

Records of the Ningbing Pseudantechinus (*Pseudantechinus ningbing*) from the Koolendong Valley (Sampling Site 52) and Yambarran Plateau (Sampling Sites 29, 51) represent an important easterly extension to its formerly known range in the Kimberleys of WA (Strahan 1995), and from the vicinity of Keep River National Park (A. Fisher, personal communication).

Both the common form and the rarer rock form of the Long-tailed Planigale (*Planigale ingrami*) were recorded on Bradshaw Station.

The Kakadu Dunnart (*Sminthopsis bindi*), a small marsupial first recorded in Kakadu National Park in 1980, was recorded on rocky slopes in the Koolendong Valley (Sampling Sites 40, 49). These records represent a major westward extension to its previously known range in the Top End of the NT (Strahan 1995).

Recent research by the PWCNT suggests that the Lakeland Downs Mouse (*Leggadina lakedownensis*) is widespread and moderately common in southern regions of the Top End of the NT. This is supported by records from Bradshaw Station where this species was fairly abundant in grassland and rocky habitats in Mosquito Flat (Sampling Sites 8, 58, 59).

The Rock Ringtail Possum (*Petropseudes dahli*) is fairly common in restricted habitats in the Kimberley, Alligator Rivers Region and the Gulf District. The two records from Bradshaw (Sampling Sites 24, 51) are the first from the intervening region between the Kimberley and Gulf District populations and represent an extension of range for this species (M. Runcle, personal communication).

The Spotted Grass Frog (*Limnodynastes tasmaniensis*) is a native Australian species that normally occurs over most of southeastern Australia. It was first recorded in northern Australia (at Kununurra) in 1978 where its presence is generally believed to be the result of an accidental introduction. This species was fairly abundant on Bradshaw Station where it appeared to be restricted to grassland and wooded habitats bordering the Victoria River (Sampling sites 3, 4, 5, 7, 8, 61, 62). In southeastern Australia, the Spotted Grass Frog is found typically in marshy country, particularly in the vicinity of grass-lined streams and ponds, or flooded paddocks. With appropriate rains, breeding can occur at any time of year and they frequently make use of temporary waters such as roadside ditches. Given their ability to exist in a wide range of habitats and their flexible breeding pattern, it is possible for this species to reach high population numbers and thus compete with local native species, possibly to the detriment of the latter.

3.7 Feral animals

Feral Cat (*Felis catus*) - Feral Cats are ubiquitous and generally common throughout Australia. They are known to eat invertebrates, frogs, reptiles, birds and mammals and occupy a wide variety of habitats. Although the Feral Cat obviously poses a threat to native wildlife, its impact has never been measured except on offshore islands where Feral Cats have decimated populations of small mammals (eg. the Golden Bandicoot on Hermit Island) and sea-birds; and in central Australia where predation by Feral Cats severely hampered the reintroduction of the Rufous Hare-wallaby (*Lagorchestes hirsutus*). At Bradshaw Station, Feral cats were common and recorded in all major sampling areas and habitats except closed forest; however, they are also likely to occur there.

Brumby (*Equus caballus*) - Feral Horses are common and occur over about half of Australia in a variety of habitats associated with abundant pasture and drinking water. When present in large numbers, the Brumby can be a pest, destroying fences, fouling watering points and consuming pasture. In the wet-dry tropics of northern Australia, Brumbies may have an adverse impact on small native mammals by decreasing the quantity and quality of waters in dry season refugia. At Bradshaw Station, brumbies were recorded in fairly low numbers in riparian and grassland habitats in Angalarri Plain and Victoria River frontage; however, they are also likely to occur in all other zones and habitats.

Feral Donkey (*Equus asinus*) - Feral Donkeys have a similar distribution and habitat preferences as Brumbies. Originally imported as pack and haul animals, they were particularly used in the Kimberley and Victoria River Districts because 'walkabout sickness' (caused by an endemic toxic plant) restricted the use of Horses. Probably as a result, these regions currently hold the highest densities of Feral Donkeys in Australia, more than 10/km² in some areas. Feral Donkeys are agricultural and environmental pests because they compete with stock and native grazers for food and water; and they cause extensive erosion in rugged hill country. At Bradshaw Station, Feral Donkeys were common in Angalarri Plain and Koolendong Valley in woodland, riparian and swamp habitats.

Feral Pig (*Sus scrofa*) - Feral Pigs are widespread and common in northern and eastern Australia with scattered populations in coastal regions of Western Australia. They occupy a variety of habitats that provide appropriate food, water and undisturbed shelter. Feral Pigs are opportunistic omnivores and compete with stock

and native herbivores for ephemeral swamp vegetation, eat carrion and predate on small mammals, frogs, reptiles and ground-nesting birds. Digging activity ('rooting') has environmental effects such as disturbance to soil arthropod populations, altering soil nutrients and temperature, reducing plant cover, effecting soil erosion and altering plant species composition including the introduction and spread of weeds. Feral Pigs pose a threat to human health because they are commonly affected with viruses such as Murray Valley encephalitis and Ross River fever, melioidosis, brucellosis, leptospirosis and sparganosis. They also pose a huge threat to the pastoral industry in their potential role as an infection reservoir and/or transmitter of exotic disease, such as foot-and-mouth and rinderpest, should they enter Australia. At Bradshaw Station, Feral Pigs were fairly abundant in all sampling zones and all habitats except rocky hills and rocky slopes.

Feral Cattle (*Bos* spp.) - Feral cattle occur in small numbers throughout Australia especially in northern Australia. They pose similar environmental threats as Feral Horses as well as being a potential reservoir of some exotic diseases. At Bradshaw Station, small numbers of Feral Cattle were recorded in all sampling zones and all habitats except rocky hills and rocky slopes.

Swamp Buffalo (*Bubalus bubalis*) - The species is generally confined to the wet-dry tropical coastal regions of the Northern Territory. In the recent past, they have caused severe environmental damage, including accelerated soil erosion, channelling of floodwaters, saltwater intrusion into freshwater habitats, loss of vegetative cover, reduction in the diversity and abundance of flora and fauna and disfigurement of landscapes by their wallows, trails and dung pats. Swamp Buffalo also spread cattle diseases, particularly tuberculosis. However, since the mid-1980s, feral Swamp Buffalo have been virtually eliminated from the northern wetlands by live-capture (for domestication) and shooting. At Bradshaw Station, small numbers of Swamp Buffalo were recorded in the central and northern parts of Koolendong Valley, and Yambarran Plateau. They were seen in all major habitats except rocky slopes/hills and swamps, although they would be expected to occur in swamp habitats.

3.8 Further species that may occur on Bradshaw Station

Although not specifically recorded from Bradshaw Station, Appendix 4 lists species that have been recorded in the general vicinity of the property and therefore possibly could occur on Bradshaw Station. The list indicates 38 species of fishes, 12 frogs,

101 reptiles, 113 birds and 35 mammals. Many of these species are of conservation significance (Table 5).

3.9 Fauna habitats

3.9.1 Habitat availability

Table 1 indicates the frequency of occurrence of fauna habitats that occur within designated land units on Bradshaw Station. Woodland habitats (41.1% of all habitats) were recorded most frequently followed by rocky habitats (23.2%), riparian habitats (16.5%), swampy habitats (10.9%), grassland habitats (6.1%) and closed forest habitats (2.1%). There appeared to be a trend of increasing overall species richness with habitat availability (Figure 4) but this regression was not significant ($r = 0.58$, $P > 0.05$). This may have been because fewer species (all taxa) than expected were recorded in woodland habitats ($X^2 = 14.33$, $P < 0.05$) and closed forest habitats, and relatively more species than expected were recorded in riparian habitats (Figure 4).

3.9.2 Species in habitats

Excluding fishes, all major taxa were recorded in all major habitats except for bats in swamp habitats (Figure 5, Table 3). However, species richness was not distributed equally across habitats (Figure 6, $F = 30.65$, $P < 0.001$); significantly more non-flying native mammals were recorded in rocky habitats ($X^2 = 9.87$, $d.f = 4$, $P < 0.05$).

3.10 Core habitats

Basically, a core habitat is prime sanctuary for important species. It may include representative groups of most taxa, and/or high species diversity and abundance, and/or high fidelity species (species restricted to single habitats), and/or endemic species; and refugia for species that are rare, endangered and/or of conservation significance. Refugia assist species to survive periods of adversity such as drought, intense wildfire, overgrazing or disturbance from development such as mining or military activities. Following severe perturbation, core habitats may provide the founders to repopulate adjacent areas.

The baseline survey identified three core habitats that contain a high species diversity representative of Bradshaw Station. These habitats and their location on Bradshaw are outlined below:

- rocky habitats generally appear to be the most important habitat for mammals, reptiles, frogs and birds, and several species are restricted to this habitat. Specifically, the most important rocky habitats are rocky slopes and gullies with closed forest (monsoon forest) and good examples are located at Sampling Sites 26, 27 and 5 km southeast of Sampling Site 31 (see Plate 6);
- streams and riparian habitats associated with rocky hills. The best example is Lobby Creek and surrounding areas at the entrance to Koolendong Valley (Sampling Sites 9, 10, 42-48, 51-55). Sampling Site 26, 29 and 30 are also good examples of this habitat;
- grasslands with swamps. The best example is Mosquito Flat (Sampling Sites 7,8,56-62).

Mosquito Flat and the adjacent rocky hills (including riparian areas along Lobby Creek - See Figure 1) represents a core fauna area because all types of core habitats are present. Also habitat-restricted species and species that utilise several habitats both occur in this area.

However, it should be noted that other core habitats may be identified when other areas of Bradshaw Station are surveyed (see Section 4). Further, not all areas of Angalarri Plain, Koolendong Valley and Yambarran Plateau were closely examined so that better examples of core habitat may exist than those indicated above.

3.11 Regional significance of Bradshaw Station

Australia has been categorised into a number of biogeographic regions (bioregion) to assist in the assessment of conservation values, the current reservation of those values, and land use planning. Bradshaw Station (8,710 km²) occurs in the Victoria-Bonaparte bioregion of the Northern Territory (Connors *et al.* 1996). Within this bioregion (53,444 km², 24 properties), 13 species of rare and endangered vertebrates have been recorded and nine of these species occur on Bradshaw. Only one species, a skink, is restricted in the NT to this bioregion (with records from Bradshaw), and another four species (2 on Bradshaw) have been mostly recorded (>50% records) from this bioregion. There are only two species (frogs, not recorded on Bradshaw) that have not been recorded in reserves in this bioregion.

Within the Victoria-Bonaparte bioregion, there are two protected areas and one area of restricted access: Gregory National Park (9 483 km²) to the south and south-east

of Bradshaw Station, Keep River National Park (293 km²) to the west, and Daly River/Port Keats Aboriginal Land Trust (13 467 km²) to the north of Bradshaw.

There is only one wetland site of national significance in this bioregion - the legume wetlands where 47 species of waterbirds (14 of them listed under treaties) and at least 7 species of migratory waders have been recorded (Whitehead and Chatto 1996).

The Victoria-Bonaparte bioregion contains two vegetation types (*Melaleuca minutifolia* low woodland and *Xerochloa* grasslands) that occur mainly in this bioregion but are poorly represented in reserves. These vegetation types are fairly well represented on Bradshaw and are likely to increase after destocking, particularly the *Xerochloa* grasslands. As indicated elsewhere, several species of conservation significance (including the Purple-crowned Fairy-wren, Star Finch and Gouldian Finch) are also likely to benefit from an increase in grassland habitats. This is probably the most regionally significant aspect of Bradshaw Station.

The Bradshaw region did not receive high priority in a literature survey of reptiles, mammals and birds across north-western Australia that aimed at planning an ecological reserve system (Woinarski 1992). This may have been due to the lack of extensive wildlife surveys in this bioregion and/or because there are relatively few unreserved vertebrate species known from this bioregion.

However, overall, Bradshaw Station does have regionally significant environmental values. Bradshaw Station has about 70% of the bioregions' rare and endangered species, all species that are restricted in the NT to this bioregion; and important vegetation types are well represented. At about 16% of the land area of the bioregion and virtually surrounded by protected areas, Bradshaw Station is an important component of this conservation network.

4 LIMITATIONS OF BASELINE SURVEY

Major zones not surveyed during the baseline survey were:

- Coastal flats,
- Western Hills,
- Little Fitzmaurice River frontage,

- Northern regions of the Yambarran Plateau, and
- Hills to the north-east of Angalarri Plain.

Major habitats not included in the baseline survey were:

- Sandstone escarpment,
- Brackish waters in the upper reaches of tidal streams,
- Marine and coastal.

The baseline survey was essentially conducted during one dry season (June-August). As it happened, temperatures were quite cold throughout the day and night in July (average minimum temperature about 7°C recorded in camps) so that reptile activity was low. The species richness of reptiles would therefore increase if surveys were conducted during warmer months. Similarly, surveys during the dry-wet transition period (October-December) and the wet season would provide the best opportunity to record migratory birds (many of international significance) and frogs.

The baseline survey has provided minimal coverage of designated survey areas and a minimum sampling frequency. Although these data are believed to be useful as baseline information, one further survey would greatly improve information on the distribution and abundance of taxa, as well as providing monitoring data.

Adequate sampling techniques were used in the baseline survey for all taxonomic groups except bats. Future surveys should use standard bat sampling techniques (including electronic bat recorders) at appropriate sampling sites.

5 IMPACT ASSESSMENT AND MANAGEMENT

5.1 General threatening processes to fauna and habitats

The major cause of declining fish populations in Australia is habitat degradation and/or interactions with introduced fishes such as Mosquito Fish. Examples of habitat degradation include changes to natural flow regimes, clearing of catchment vegetation, increased sediment load, alteration of river beds and banks, desnagging, reducing water quality and creating artificial barriers to fish movement. If riparian vegetation is removed, there will be decreased bank stability, fewer snags and other

aquatic microhabitats, and decreased food (leaves, insects etc). Water temperature will also increase. The increased siltation load will smother riffle areas, invertebrate food sources and demersal fish eggs.

The major threatening processes to frogs, reptiles, birds and mammals are habitat clearance or modification, overgrazing by stock and feral animals, cropping, urban development and predation by introduced animals (principally foxes, cats and rats) and anthropogenic fires. Additional threats for birds are hunting and trapping for the bird trade.

At Bradshaw, Defence activities (both construction and training) have the potential to impact in some of these ways. For example, the effect of firing heavy ordnance at or close by rocky slopes may cause rock slides and damage fauna habitat.

5.2 Impact of proposed Defence infrastructure and activities

Defence activities (as indicated in the draft EIS proposal, file X853.01\admin\repc01ms.doc, September 1997) will have direct and indirect impacts on fauna and habitats. Habitats will be directly impacted by firing ordnance and vehicle manoeuvres where the degree of impact will vary with the size of ordnance and vehicles, and with the frequency of use. Areas that are used most frequently with heavy ordnance and with heavy traffic will clearly suffer the greatest impact. The nature and severity of potential impacts on fauna and habitats can be broadly summarised as essentially minimal impacts during the construction phase and potentially greater impacts during the operational phase. Comments on particular proposals that have potential impacts are discussed below.

5.2.1 Potential impacts during construction and infrastructure development

Construction activities and infrastructures (including airstrips) will result in a very small loss of habitat that is well represented elsewhere on Bradshaw. No threatened fauna are likely to be dependent on habitats in which infrastructure is proposed, and common resident species are likely to either habituate to construction activities or move into the abundant and similar habitats nearby.

Roads are unlikely to be a major barrier to fauna movement and the use of causeways is unlikely to significantly interfere with fish migrations. Pylons associated with bridges may provide increased opportunities for 'ambush' predators to attack migrating fishes, but the overall effect on fish populations is likely to be negligible.

Introduced and feral animals, particularly Cane Toads (*Bufo marinus*), if introduced to Bradshaw Station on vehicles and equipment, are likely to predate upon or compete with native species; probably to the detriment of the latter. The front of this population in the Northern Territory is currently close to Mataranka and is moving at about 50 km each year (P. Catling, personal communication). Increased vehicular traffic to and in Bradshaw Station is likely to increase the probability of introduction via 'hitch-hiking'. When Cane Toads are detected, obvious sources of assistance to their movement and survival should be addressed. This includes regular inspection of vehicles at washdown stations on initial arrival at Bradshaw Station.

Activities in core fauna habitats should be minimised to avoid disturbance to fauna. For example, Rock Possums are known to desert areas of frequent human disturbance (Strahan 1995) and breeding birds may desert nests. Extensive use of water from waterholes in core fauna refugia may lower water tables and consequently cause a decrease in species richness and/or species abundance. This effect has been recorded in Kakadu National Park (Braithwaite and Muller, in press). Thus it is recommended that a specific management policy be implemented to govern the use of water supply point 17 (Barramundi Waterhole) and Mussel Waterhole to protect habitats and fauna. Such policies might include:

- limits on the amount of water taken,
- limits on clearing vegetation along banks, and
- procedures to minimise water turbidity.

If possible, the use of alternative water supplies should be considered.

It is recommended that the Landing craft hard infrastructure should not be located near the junction of Lobby Creek and Victoria River as this may compromise the integrity of the identified core fauna habitats at Mosquito Flat. Potential impacts include the associated access roads which would dissect the grasslands, offloading and other training activities that may disturb fauna, and the increased chance of non-prescribed fire.

5.2.2 Potential impacts during operation

Individual animals will inevitably be killed or displaced from their home range by all training activities (field firing, dismounted training, manoeuvres). Populations,

however, should not decline if habitats in which training occurs are allowed to recover after major exercises and core fauna habitats are excluded from all training activities (except transit).

Most of the nine Training Sectors contain elements of core fauna habitats as indicated below. Generally, the core fauna habitats represent a small proportion of the total Training Sector (see Figure 1). It is recommended that all training activities except transit be excluded from core habitats and that specific management policies be implemented to manage and protect core habitats (see Section 5.3 below).

Koolendong Training Sector. Two core habitat types were identified: rocky slopes with monsoon forest, and streams and riparian habitats associated with rocky hills. These are generally located along the western edge of the Yambarran escarpment, and in particular Sampling Sites 26 and 27.

Yambarran Training Sector. Three core habitat types were identified. Rocky slopes with monsoon forest, and streams and riparian habitats associated with rocky hills are generally located on the edge of the Yambarran escarpment and throughout the Yambarran plateau; and in particular the Lobby Creek area at the entrance to the Koolendong Valley and Sampling Site 29. Core habitat grasslands with swamps are located at Mosquito Flat. Together, Mosquito Flat, the adjacent rocky hills and Lobby Creek constitutes a core fauna area.

Fitzmaurice Training Sector. This Sector contains rocky slopes with monsoon forest, and streams and riparian habitats associated with rocky hills. They are generally located in gorges throughout the plateau, and in particular along an unnamed river (Sampling Site 30).

Angalarri Training Sector. This Sector contains rocky slopes with monsoon forest generally located along the eastern edge of the Yambarran escarpment, and in particular a valley approximately 3 km southeast of Sampling Site 31 (648500 E, 8315000 N).

Mt Thymanan Training Sector. No core fauna habitats were identified in this Sector, however, two sensitive areas were identified. First, the Wombungi HEIA includes the original collecting site (707899 E, 8342660 N) of the Angalarri Grunter, a rare fish with restricted distribution. The ecology of this species is virtually unknown. Until further scientific information is obtained for a management plan, it is recommended

that minimal training activities should be conducted in the general vicinity of this tributary of the Angalarri River.

The second sensitive area relates to the conservation of the Gouldian Finch. This endangered species has been previously recorded in the Angalarri HEIA including breeding records near Mt Thymanan. This is one of the few known breeding areas in northern Australia for this species. It is highly unlikely that, if present, it will continue to breed in the presence of training activities, particularly field firing activities that pose a high fire risk to vegetation. Until further field surveys confirm the presence or absence of breeding Gouldian Finches in this general region, it is recommended that minimal training activities should occur there. Given the current paucity of knowledge regarding the local distribution of this species, it is difficult to recommend how large this general area should be, however, an area of approximately 50 km² to the east of Mt Thymanan to the Ikymbon River is suggested to provide coverage of the recorded breeding site, and suitable breeding habitat and watering points. It is further recommended that, should the presence of breeding Gouldian Finches be subsequently confirmed, advice is sought from the PWCNT on an appropriate management policy to protect this species and its habitat.

Ikymbon Training Sector. No core fauna habitats were identified in this Sector.

The Western Hills Training Sector was not surveyed for fauna so it is not possible to indicate core areas and potential impacts. However, this Sector contains coastal flats and dissected sandstone habitats. Elsewhere in northern Australia these habitats contain a high species richness of waders and endemic birds, respectively, and it is highly likely that distinctive species also occur in this Sector.

The Lalngang Training Sector, and the Little Fitzmaurice Training Sector were not surveyed.

5.3 Management of core fauna habitats

It is recommended that no training activities should occur within core fauna habitats nor within a surrounding buffer area of about 500 m to incorporate the activities of fauna that utilise the perimeter of core habitats as well as to provide a buffer against disturbance of the core habitat itself from military activities. Management of core areas should entail monitoring of species richness and abundance (Section 5.4), feral animal control (Section 5.4), weed management and fire management (both reported elsewhere).

Regarding fire management for fauna, research in Kakadu National Park indicated that no particular fire regime is universally good or bad for terrestrial vertebrates (Corbett *et al.* 1997). Both late dry season fires and a 'no fire' regime tended to be more detrimental than beneficial to fauna. Early dry season fires had the least impact on fauna which suggests that this regime is the most appropriate to maintain a status quo in fauna diversity on Bradshaw Station. However, consideration should be given to set more intense fires in Angalarri Plain and Koolendong Valley every 4-5 years or so to stimulate habitat diversity. It is also recommended that core fauna areas with monsoon forest habitats should be protected by backburning from the margins as early as possible in the dry season to protect them from late season wild fires that are potentially destructive to fire sensitive habitats.

The baseline survey identified Mosquito Flat and the adjacent rocky hills (including riparian areas along Lobby Creek) as a core fauna area. After stock are removed from Bradshaw, the grassland habitats in this area will be enhanced, especially stands of rice grass (*Xerochloa* sp.). As a result, it is likely that populations of rare and threatened species such as the Purpled-crowned Fairy-wren, the Gouldian Finch and the Star Finch will increase. Land managers can protect and enhance this core grassland habitat by maintaining effective feral animal control and conducting research to improve the fire management of grasslands. To minimise disturbance to fauna and habitats, it is recommended that training activities in this habitat should be restricted to transit between the Angalarri Plain and Koolendong Valley via a single road located on the northern boundary of the grasslands. As indicated elsewhere, it is further recommended that the Landing Craft Hard facilities should not be situated near the junction of Lobby Creek and the Victoria River.

5.4 Management of feral animals

It is recommended that the overall feral animal control on Bradshaw Station be incorporated within the broad control program coordinated by Northern Territory Government agencies. However, additional and follow-up programs can be conducted by Bradshaw land managers to maximise the effectiveness of broad scale control.

Based on data from the baseline survey, the effective control of Feral Cats, Feral Pigs and feral stock should be high priorities in a feral animal management plan. The following comments suggest possible methods that may be employed to control these species.

Although populations of Feral Cats are difficult to eradicate, numbers can be reduced by shooting over spotlights particularly in open grassland habitats; and by trapping with baited cage traps in closed forests. Also, it is recommended that resident personnel should not keep pet cats.

Populations of feral stock (donkeys, buffalo, horses, cattle) and Feral Pigs can be initially reduced by a large-scale shooting program from the ground and by helicopter. Subsequent, regular management to eradicate or minimise populations can use the 'Judas' technique. This technique involves releasing radio-collared animals into a particular area and, after a sufficient period to allow them to join congeners, tracking them down and culling the other individuals associated with them. Recent studies of Feral Pigs in south-eastern Australia (McIlroy and Gifford 1997) indicated that the technique worked best with sows captured in the target area. Each of the captured sows established contact with 1-8 other pigs in the target area within 1-7 days of release and was located with at least one other pig on 60-100% of occasions. In contrast, sows and boars from outside the target area took longer to establish contact with 'local' pigs and associated with them much less frequently.

As an alternative to shooting, the 'Judas' pigs can be used to indicate areas where to lay poison (warfarin) baits from a helicopter. This technique has been successful in eradicating a small colony of Feral Pigs in central Australia and is proving successful for control of Feral Pigs and other ungulates in other parts of Australia and New Zealand (McIlroy and Gifford 1997).

Populations of Feral Donkeys and Feral Horses have been eliminated in some areas of the Kimberleys by the Western Australian Department of Agriculture using a modified 'Judas' method. For example, 3000 donkeys and 300 horses on the 2700 km² Brooking Springs Station (near Fitzroy Crossing) were eliminated over about 6 years (A. Johnson, personal communication). Given the similarity of climate and habitats, it should also be possible to eliminate these species from Bradshaw Station by the 'Judas' technique. Experienced staff from the Western Australian Department of Agriculture may be contracted to undertake control.

The 'Judas' method has also been used by the NT Department of Primary Industries and Fisheries to virtually eliminate Feral Buffalo from Kakadu National Park and other areas in the Top End.

Cane Toads, if introduced to Bradshaw Station on vehicles and equipment during training exercises, are likely to predate upon or compete with native species; probably to the detriment of the latter. As previously indicated (Section 5.2.1) constant vigilance needs to be maintained at washdown stations at entry points to Bradshaw.

The Spotted Grass Frog is a conservation conundrum as it appears to be well established on Bradshaw Station and might be considered as an acclimatised native species. Advice should be sought from the PWCNT and other conservation agencies as to whether or not this species should be managed.

Should trained Dogs, including free-ranging guard Dogs, be used in on Bradshaw Station, appropriate housing and field use should be undertaken to avoid opportunities for hybridisation with Dingoes.

5.5 Monitoring strategy

Monitoring of ecosystems is vital to provide the data on which land managers base their decisions. At Bradshaw, it is recommended that land managers aim to assess short term and long term changes caused by Defence activities; as well as assessing the effectiveness of management programs for control of feral animals, weeds and fire.

Permanent monitoring (sampling) sites need to be established in control and treatment areas. Control sites represent relatively undisturbed areas that reflect natural changes to the environment and would include core habitats and other undisturbed areas in each of the training sectors. Treatment sites (areas of disturbance) would need to be established in each of the training sectors and in areas that reflect various training activities (field firing, dismounted training, manoeuvres).

It is recommended that monitoring sites be established prior to training activities to provide benchmark data so that comparative data sets can be obtained for BACI (before-after control impact) comparisons. This will provide information on the relative severity of different training exercises on habitats as well as estimates on recovery times for habitats following damage.

Fauna sampling sites that have been established in the baseline studies can be used as the basis of future monitoring programs. However, as indicated above, additional

appropriate sites will (1) enhance the representativeness of the current network, (2) include additional areas not surveyed in this baseline study, and (3) include sites within impact areas.

Measurements taken at monitoring sites should include species diversity and estimates (indices) of abundance for all major vertebrate taxa - fishes, frogs, reptiles, birds and mammals. It is also recommended that data be gathered on aquatic macroinvertebrates in streams and associated riparian habitats. This would provide the most accurate benchmark information to assess impacts on freshwater habitats and comply with recommendations of the National River Health Program (Scholfield and Davies 1996). Environmental measurements taken at each site such as recent rainfall, recent fire, fruiting and flowering vegetation and temperature will enhance the quality of monitoring data.

It is recommended that regular monitoring of fauna in all areas of Bradshaw Station occur about every two years. In addition, specific monitoring associated with particular training field operations such as Full Brigade exercises that have the potential to cause severe environmental damage, is also recommended.

Besides the prime objective of assessing specific changes (negative and positive) related to training activities, monitoring will also provide valuable data on (1) the long-term effects of cattle grazing and weeds, and (2) baseline data on biota in relation to seasonal and year to year changes. First, knowledge on the recovery of rangelands following long term grazing by stock is poor and a unique opportunity exists for the future managers of Bradshaw to contribute to the Nation's knowledge of conservation biology. In this respect, the Army may consider cooperative projects with the Cooperative Research Centre for Sustainable Use of Tropical Savannas. Second, regular assessment of monitoring data will provide feedback to fine tune management strategies so that they remain appropriate and effective.

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Table 1

Frequency of occurrence of fauna habitats within land units

Fauna habitat	Land units*																													
	1a	1b	1c	2a	2b	2c	2d	2	2f	2g	2h	2i	2j	2k	3a	3b	3c	3d	3	3f	4a	4b	4c	4d	5a	5b	5c	5d	5	5f
Closed forest		2			2																	4								
Woodland	2	2		2		7	4		1	1	1		2	1	16	20	14	1	1	1	5				1	1		42	25	4
Rocky																5					20	20		42						
Riparian				2	2		12	4					2				28					5						7		
Grassland	2					14											7													
Swamp			1			28						4												7			1			

*Data from Soils Baseline Survey (I Hollingsworth, personal communication)

1a - c Estuarine and deltaic plains

2a - k Alluvial plains

3a - f Gently sloping to undulating rises

4a - d Rugged terrains

5a - f Plateau

COMMERCIAL-IN-CONFIDENCE

Table 2

Species richness in major sampling zones

	Angalarri	Koolendong	Victoria	Yambarran	Total
Fishes	16	16	4	12	24
Frogs	9	13	9	7	19
Reptiles	21	40	29	18	56
Birds	110	132	132	74	171
Non-flying native mammals	9	18	16	15	23
Bats	3	8	0	4	11
Feral mammals	5	5	4	4	6
Total	173	232	194	134	310

Table 3

Species richness in major fauna habitats

	Closed	Woodland	Rocky	Riparian	Grassland	Swamp
Frogs	5	5	10	12	5	4
Reptiles	3	20	26	28	11	9
Birds	33	97	67	116	68	88
Non-flying native mammals	4	8	20	12	10	1
Bats	1	1	4	8	1	0
Feral mammals	3	5	1	6	5	4
Total	49	136	128	182	100	106

COMMERCIAL-IN-CONFIDENCE

Table 4

Species of conservation and international significance recorded on Bradshaw Station

Taxa	Number of species *										
	EN	VU	LR(nt)	DD	NE	J	C	B	CITES	Intro	Feral
Fishes	0	0	Exquisite Rainbowfish	5	0			0	0	0	0
Frogs	0	0	Copland's Rock Frog	1	0			0	0	1	0
Reptiles	0	0	0	3	1			1	2	0	0
Birds	Kimberley Crested Shrike Tit** Gouldian Finch*	Purple-crowned Fairy-wren**	Star Finch Grey Falcon**	2	0	5	6	51	0	0	0
Mammals	0	Dingo Ghost Bat**	Northern Quoll Pygmy Long-eared Bat	1	0			0	0	0	6

* See Appendix 2 and 3 for names of species

** Recorded on Bradshaw Station prior to baseline survey

EN, endangered

VU, vulnerable

LR(nt), low risk - near threatened

DD, data deficient

NE, not evaluated

J, JAMBA

C, CAMBA

B, BONN

CITES

Intro, native species introduced from elsewhere in Australia

Feral, exotic species

COMMERCIAL-IN-CONFIDENCE

Table 5

Additional species of conservation and international significance that might be recorded on Bradshaw Station

Taxa	Number of species *										
	EN	VU	LR(nt)	DD	NE	J	C	B	CITES	Intro	Feral
Fishes	0	0	0	4	3			0	0	0	1
Frogs	0	0	0	0	0			0	0	0	0
Reptiles	Loggerhead Turtle	Green Turtle Hawksbill Turtle	0	8	2			4	0	0	0
Birds	Little Tern Cicadabird	Red Goshawk Beach Stone-curlew Partridge Pigeon	0	1	0	42	40	41	0	0	3
Mammals	Golden Bandicoot	Mulgara Orange Leafnosed-bat Golden-backed Tree-rat	Spectacled Hare-wallaby Northern Leafnosed-bat	0	0			0	0	0	6

* See Appendix 4 for names of species

EN, endangered

VU, vulnerable

LR(nt), low risk - near threatened

DD, data deficient

NE, not evaluated

J, JAMBA

C, CAMBA

B, BONN

CITES

Intro, native species introduced from elsewhere in Australia

Feral, exotic species

COMMERCIAL-IN-CONFIDENCE

Fig 2. Total taxa recorded

Bradshaw Station baseline survey

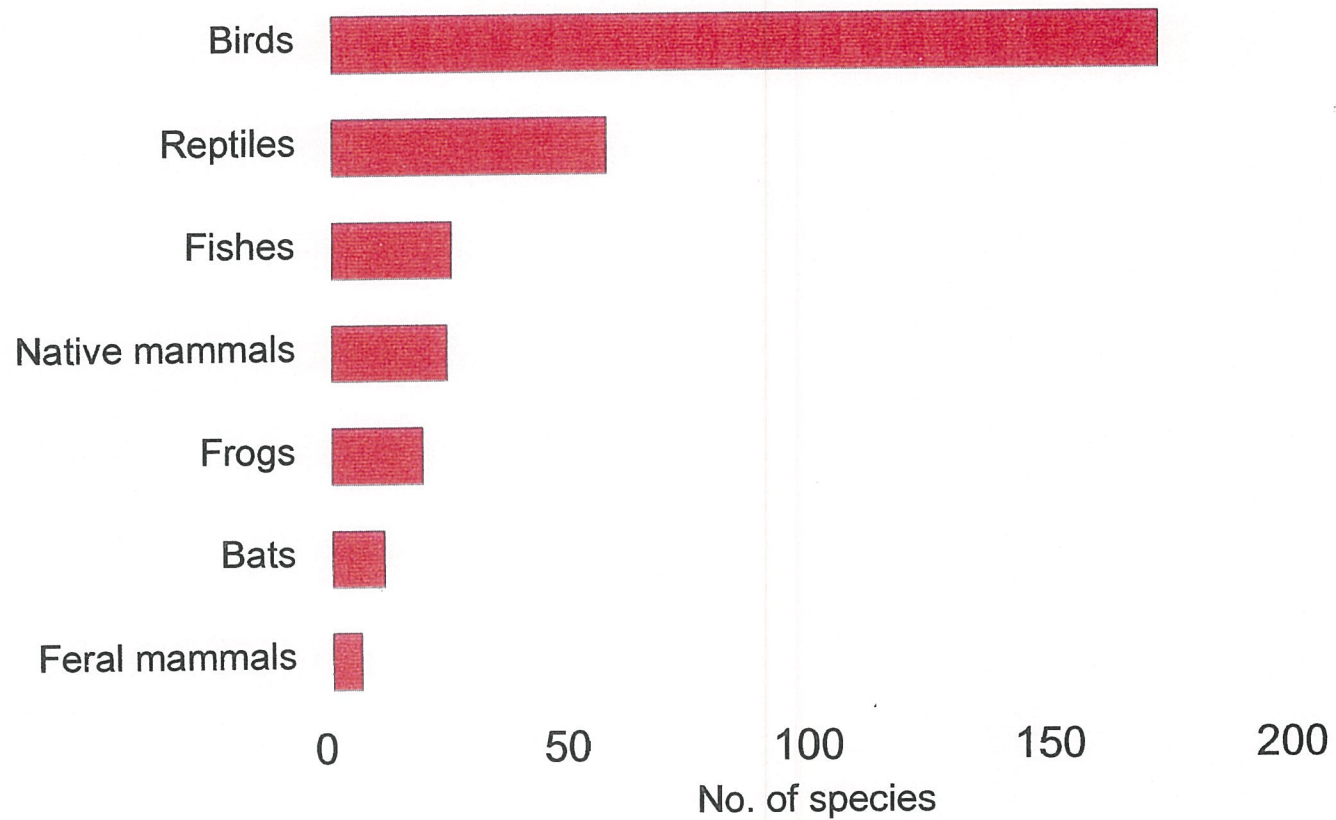


Fig 3. Taxa in major sampling zones

Bradshaw Station baseline survey

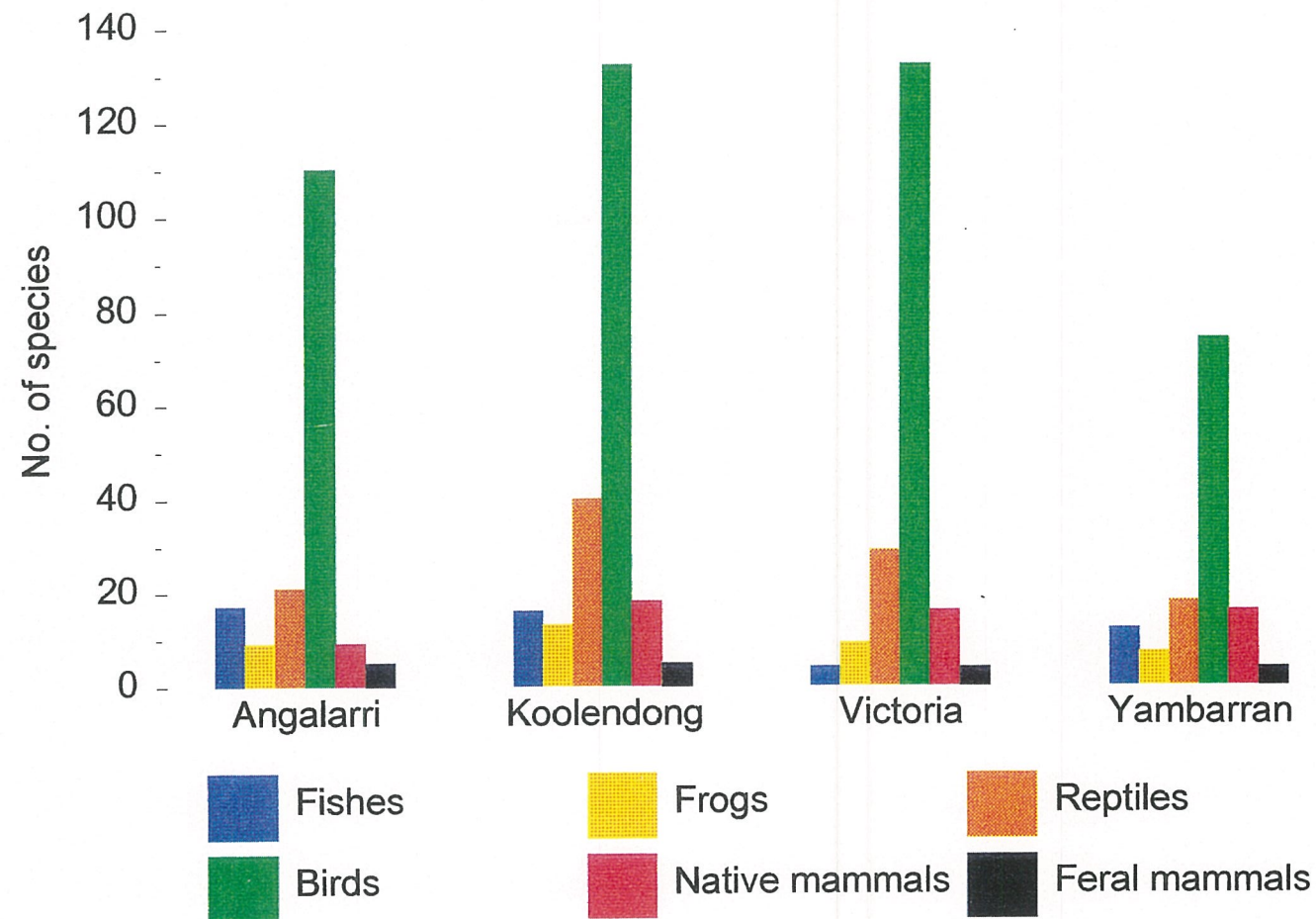


Fig 4. Available habitats and species

Bradshaw Station baseline survey

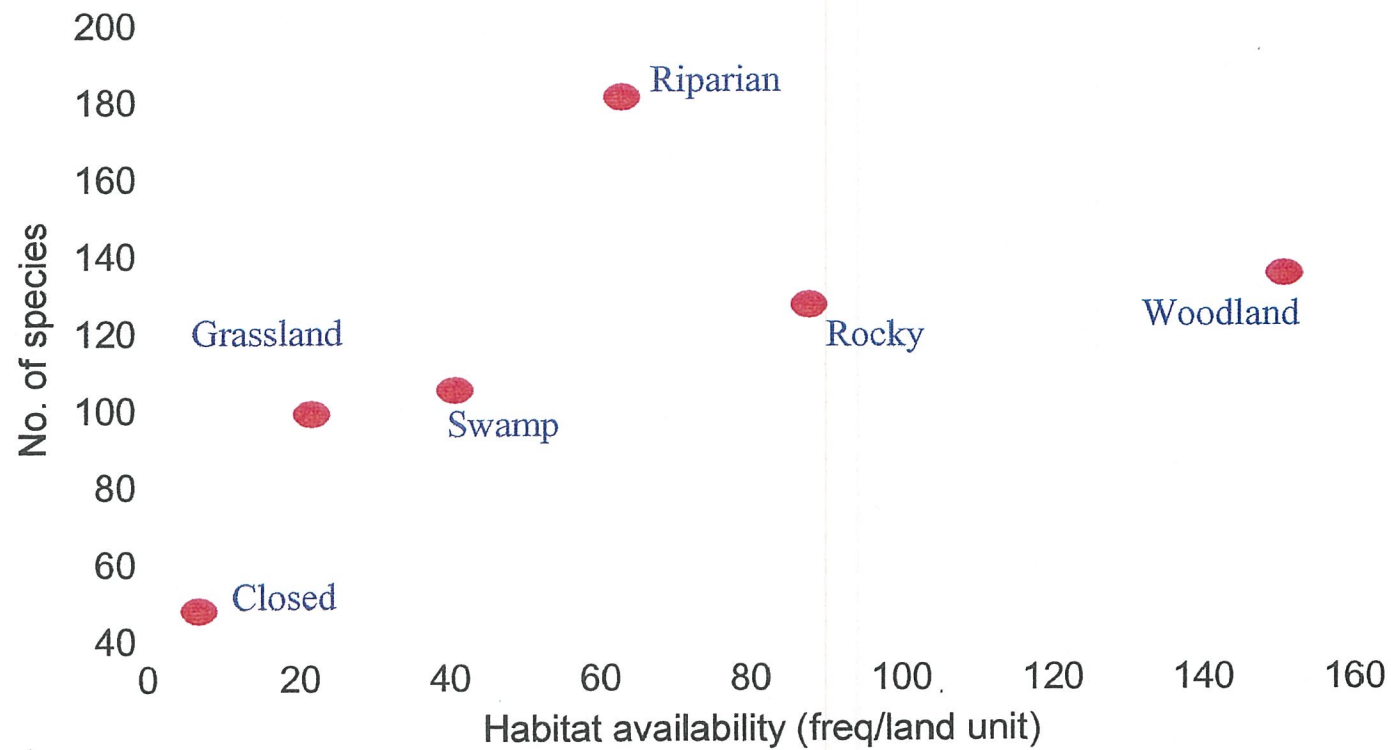


Fig 5. Taxa in major habitats

Bradshaw Station baseline survey

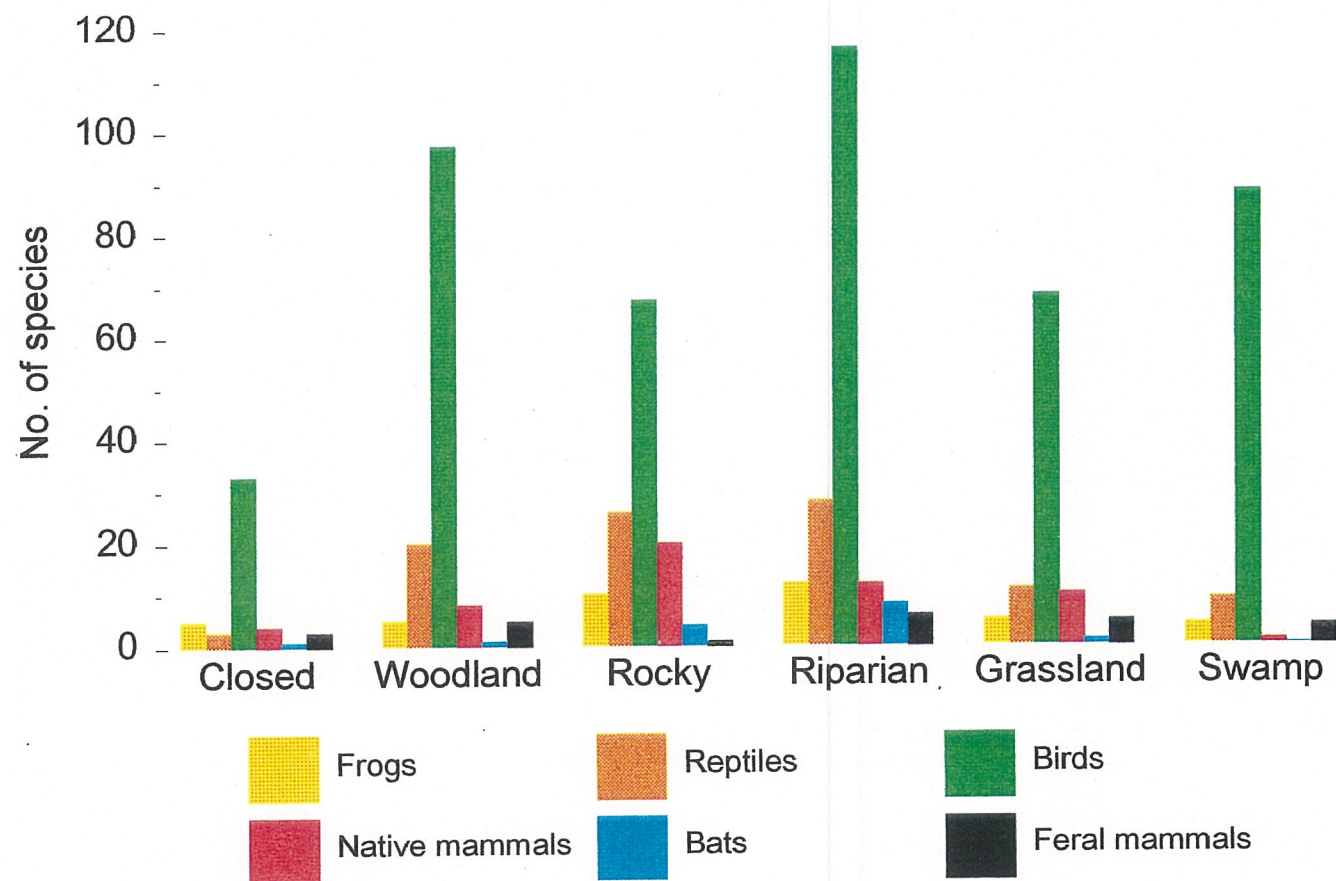


Fig 6. Habitat use by taxa **Bradshaw Station baseline survey**

