PROJECT NO : EH 1.1.2A

FOREST VERTEBRATE FAUNA STUDY FOR A COMPREHENSIVE REGIONAL ASSESSMENT IN SOUTH-EAST QUEENSLAND. STAGE IIA: ANALYSIS AND RESERVE OPTION EXAMPLE.

QUEENSLAND CRA/RFA STEERING COMMITTEE

FOREST VERTEBRATE FAUNA STUDY FOR A COMPREHENSIVE REGIONAL ASSESSMENT IN SOUTH-EAST QUEENSLAND. STAGE IIA : ANALYSIS AND RESERVE OPTION EXAMPLE.

Dr David C. McFarland

Forest Assessment Unit, Department of Environment.

QUEENSLAND CRA/RFA STEERING COMMITTEE

For more information contact:

Regional Forest Assessments, Department of Natural Resources

Block C, 80 Meiers Road
INDOOROOPILLY QLD 4068

phone: 07 3896 9836
fax: 07 3896 9858

Forests Taskforce, Department of Prime Minister and Cabinet

3-5 National Circuit
BARTON ACT 2600

phone**:** 02 6271 5181
fax: 02 6271 5511

This project has been jointly funded by the Queensland and Commonwealth Governments. The work undertaken within this project has been managed by the joint Queensland / Commonwealth CRA RFA Steering Committee and overseen by the Environment and Heritage Technical Committee.

ISBN xxxxx]

ACKNOWLEDGEMENTS

This report was made possible through the endeavours of an incredible number of people, past and present, who have collected information on the fauna of Queensland. For the SEQ region in particular, special thanks to the members of the systematic survey teams for their exceptional effort in collecting so much data in so little time. A more comprehensive list of contributors for the historical database is given in McFarland (1998). To anyone inadvertently overlooked my sincerest apologies and deepest thanks.

Thanks to John Kehl (DNR) for permission to use the draft Species Management Profiles in the development of the species summaries in the Attachment.

My thanks to the members of the GPC and subsequent FAU core team for their understanding and support during the project. This is especially so to Jane Wickers (GIS wizard) for generating the species and diversity maps, running the DAMs analysis and for producing and intersecting the tenure and vegetation coverages with the fauna data. Also to Hans Dillewaard for undertaking (often repeatedly) the PATN analyses.

I am also grateful to my wife Carolyn for proof reading all the reports and references, and generally bearing with me through the grumpy times.

CONTENTS

APPENDICES - See attached volume for details.

LIST OF TABLES

LIST OF FIGURES

SUMMARY

This report has been prepared for the joint Commonwealth/State Steering Committee which oversees the Comprehensive Regional Assessment (CRA) of forests in the South-east Queensland CRA region.

The Comprehensive Regional Assessment provides the scientific basis on which the State and Commonwealth governments will sign a Regional Forest Agreement (RFA) for the forests of the South East Queensland CRA region. This agreement will determine the future of the region's forests, providing a balance between conservation and ecologically sustainable use of forest resources.

This report was undertaken to analyse and interpret the accumulated fauna data to provide input into discussions on reserve options and forest management. The analyses used only known information and included an assessment of data adequacy; identification of regional patterns (based on individual species or species assemblages) at tenure, grouped vegetation unit and regional ecosystem levels; examining the requirements of priority taxa; and the formulation of reserve options that attempt to address the CAR criteria with respect to fauna.

The available information was reasonable for the purposes of this assessment although more data for certain taxonomic groups (reptiles and bats) and certain habitat types (semi-evergreen vine thicket and non-eucalypt dominated forests) would have been desirable.

The areas with highest species richness tended to have similar species compositions and were spread throughout the region. These areas also contained a number of well-separated National Parks. Most species were found throughout the region wherever suitable broad habitat types (dry to wet forest) were present. There were very few clearly defined species associations based on either grouped vegetation units or regional ecosystems. Examination of 155 priority and 37 secondary assessment taxa revealed that the majority were insufficiently reserved particularly with respect to the representativeness criterion.

Examination of the spatial and environmental distributions of faunal values at the broad level (biodiversity, priority and endemic species), species assemblages (habitat and functional associations) and individual taxon (priority and secondary assessment taxa) resulted in the following conclusions about forest fauna in SEQ. In terms of comprehensiveness, the majority of terrestrial vertebrate species (90% of 544 species) recorded in SEQ have been found in at least one National Park. Those not accounted for included species not necessarily typical of the region, e.g. vagrants from adjacent bioregions (7%), several highly restricted endemics or patchily distributed species (1.3%) and a few widespread but difficult to detect species (1.1%). In marked contrast, the analyses indicated major deficiencies in the representativeness of the reserve system. Spatially and environmentally, National Parks were lacking in the dry forest types (mixed, western/ironbark and *Corymbia citriodora*) especially in the northern and central inland and western parts of the region, *Eucalyptus saligna* wet forest, and dry rainforest (*Araucaria*-dominated and semi-evergreen vine thicket) in the central and northern inland areas. Consequently, the faunas associated with these vegetation types were also poorly represented. Adequacy could not be assessed directly or quantitatively (i.e. number of animals/populations required or amount of habitat needed). Indirectly, the representativeness deficiencies would suggest inadequacy for those species present in the habitats and areas mentioned previously.

A reserve option example, based solely on faunal values and using rules to indicate where, what extent, and possible alternative sites, is examined with respect to a comprehensive, adequate and representative reserve system. Within the rules used, the option is reasonably successful (100% reservable species & species associations; 95% of taxa on ≥3 conservation areas; improved representativeness for 84% of priority taxa). In developing reserve options, the potential exists for the use of regional ecosystem mapping to indicate possible distributions of both individual taxa or species associations (either habitat or functional groups). For some forest types, e.g. dry and wet eucalypt, there is also scope for using umbrella species (*Petaurus australis australis, Petauroides volans, Ninox strenua* & *Tyto tenebricosa*) to address adequacy of proposed reservation areas.

However, not all taxa are catered for within the reserve design, particularly those not known from any Crown Land. The development of ecologically sustainable forest management and its application at a landscape level, irrespective of tenure, is essential for the conservation of all forest-dwelling fauna.

1. INTRODUCTION

1.1 BACKGROUND

One of the principal objectives of the National Forest Policy Statement (NFPS) is the protection of nature conservation values in forests including their associated aquatic habitats (CoA 1992) by maintaining an extensive and permanent native forest estate which is managed in an ecologically sustainable way. This will be achieved through the development of a comprehensive, adequate and representative (CAR) reserve system and ecologically sustainable forest management (ESFM) derived from information collected and evaluated in a comprehensive regional assessment. The NFPS describes the three principles underpinning the reserve system (modified to relate specifically to fauna):

- comprehensiveness - samples the full range of species and communities;
- adequacy - is sufficient to maintain the ecological viability and integrity of populations, species and communities; and
- representativeness - includes samples that reflect the diversity of the species and communities within the region.

These criteria are further refined and elaborated on in JANIS (1996), especially the comprehensiveness aspect, with attention drawn to rare, vulnerable and endangered species, migratory species, areas of high diversity and centres of endemism.

1.2 OBJECTIVES & OUTCOMES

The project *Forest Vertebrate Fauna Study for Comprehensive Regional Assessment in South-east Queensland* [SEQ CRA] *Stage II : Fauna Analysis and Interpretation* (EH 1.1.2; Eyre & McFarland 1997) was proposed to utilise the information collected from historical sources and through the systematic fauna surveys (EH 1.1.1) to provide inputs for CAR reserve system options and ESFM practices. The project focuses on all terrestrial forest-dwelling vertebrate species and on forest priority taxa (including selected invertebrates) and secondary assessment taxa listed in McFarland

(1997). The priority animals include all of those examined in the Response to Disturbance project (EH 1.1.5) with the exception of several invertebrate species.

Specific objectives of this report are to :

- Assess the adequacy of the sampling - are there sufficient data with which to assess the faunal values of the SEQ CRA region?
- Discern and describe any patterns in the composition and distribution of species assemblages across the Crown Lands of the region - where are the richest areas and which areas are most similar to each other in terms of fauna; which species tend to be found together; and what species/species assemblages are absent or poorly represented in the existing reserve system? This is addressed in terms of broad categories (total species, priority taxa which includes endemic and threatened species, and species assemblages at the habitat or function level) with respect to tenure (broad spatial scale), grouped vegetation units (broad environmental scale) and regional ecosystems (fine spatial and environmental scale).
- Examine priority taxa in terms of known past and present distributions, life history traits, threatening processes and reservation status - i.e. which species are adequately reserved, could be conserved with increased reservation, or require both on- and off-reserve actions for their conservation? A number of other species, either marginal to being listed as priority or considered representative of certain JANIS (1996) criteria (e.g. migratory species) are also assessed with respect to their reservation status as secondary assessment taxa.
- Explore a reserve option example using the above information - how coulf the available fauna information be used to determine what areas, alternative areas and management actions are important in the conservation of regional faunal values, and how well would proposed areas satisfy the CAR criteria?

It must be stressed that the last objective is very much an example only. In attempting the last objective, comprehensiveness will be examined by determining what species or species assemblages do not occur in protected areas and what sites are needed to remedy this situation. Adequacy, or determining how big reserves need to be to conserve a species, cannot be directly assessed in this project. To be realistic, without the detailed quantitative life history data required one cannot determine, objectively and with some degree of confidence, minimum viable population sizes, the number of populations needed and requirements for such populations (macro- and micro-habitat composition, area and configuration). Rather than ignore the criterion in this project, adequacy will be addressed through increasing the proportion or number of populations of priority taxa in reserves (increased size of certain reserves and replication across a species' range, i.e. basically an increased emphasis on representativeness). The assumption is that the more a species is reserved and appropriately managed the greater the probability of its long-term survival (JANIS 1996). The representativeness criterion is investigated through the visual inspection of distribution maps of species associations and specific species (both known and modelled) to determine habitat use and areas and habitats currently absent from reserves.

2. METHODS

2.1 GENERAL

2.1.1 Study Area

Various aspects of the SEQ CRA study area have already been described in general (Eyre *et al.* 1998; McFarland 1998) and in detail (Forest ecosystem mapping and analysis project EH 1.2).

2.1.1 Data Sources

The primary sources of fauna information used in the analyses were the Queensland Historical Fauna Database (McFarland 1998) and the CRA fauna survey database (Eyre *et al.* 1998). The data used were restricted to native, terrestrial vertebrates, priority fish and invertebrate taxa. Nomenclature follows that described in McFarland (1998) with the addition of two as yet undescribed frog taxa (*Litoria* sp. cf. *cooloolensis* and *Litoria* sp. cf. *barringtonensis*). Due to difficulties in identification, numerous records for certain bat groups (*Mormopterus* and *Scotorepens* spp.) from the CRA fauna surveys were recorded only to genus level. These records were excluded from the analysis. As the CRA fauna surveys were restricted to terrestrial vertebrates, all fish species except designated priority taxa were omitted from the analyses.

Predicted distributions of certain priority taxa produced using the Species Distribution Modelling Toolkit (SPMODEL) (Bennett *et al.* 1997a) and expert opinion, are detailed in Eyre & Venz (1998). However, at the time of this analysis the outputs from the modelling have yet to be validated and consequently they were not included.

The tenure coverage for the various Crown Lands of interest within the CRA process, e.g. National Parks, State Forests, various leasehold categories and Unallocated State Land (Table 2.1), was derived primarily from the Digital Cadastral DataBase (DCDB, Department of Natural Resources) and Protected Areas (Department of Environment) layers (Wickers *pers comm.*). A coverage of the grouped vegetation units was compiled from the SEQ 1:100,000 vegetation mapping project (EH 1.2; Wickers *pers comm.*). For a description of the grouped vegetation units see Table 2.2 (also

Figure 3.1 in McFarland 1998). The vegetation mapping was also converted into a regional ecosystem coverage (Dillewaard *pers comm.*). Each regional ecosystem type is described in Young (in press) and Young *et al*. (in press).

TABLE 2.1 BROAD TENURE CATEGORIES USED IN FAUNA ANALYSES.

Tenure Category	Category	DCDB Items	Lease Types
NP	National Park	Protected areas (DoE)	
NPP	National Park Proposal	Various (sourced from DoE)	
SF	State Forest	State Forest	
TR	Timber Reserve	Timber Reserve	
SR	State Reserve	Reserve	
COM	Commonwealth Land	Commonwealth Acquisition Transferred property	
USL	Unallocated State Land	State Land	
FL	Freeholding Lease	Lands Lease	e.g. Agricultural Farm (AF) Auction Perpetual Lease (APL) Freeholding Lease (FL) Grazing Homestead Freeholding Lease (GHFL) Purchase Lease (PL) Perpetual Lease Selection (PLS) Special Lease Purchase Freehold (SLPF)
PPL	Perpetual Lease	Lands Lease	Grazing Homestead Perpetual Lease (GHPL) Non Competitive Lease (NCL) Perpetual Lease (PPL)
TL	Term Lease	Lands Lease	e.g. Development Lease (DL) Pastoral Holding (PH) Preferential Pastoral Holding (PPH) Stud Holding (SH) Special Lease (SL) Term Lease (TL)
OR	Occupation Rights	Lands Lease	Occupation Licence (OL) Permit to Occupy (PO) Road Licence (RL)
ULL	Unclassified Lands Lease	Lands Lease	Unclassified Lands Lease
OTH	Other	e.g. Action Pending Marine Park; Railway Water Resources Commission	

TABLE 2.2 DESCRIPTION OF GROUPED VEGETATION UNITS RECOGNISED FOR FAUNA ASSESSMENTS. THE UNGROUPED VEGETATION UNITS ARE THOSE DESCRIBED IN THE 1:100 000 MAPPING OF SEQ. BIOREGIONAL ECOSYSTEM NUMBERS AFTER YOUNG (IN PRESS) AND YOUNG *ET AL*. (IN PRESS).

Grouped Vegetation Unit	Description of Unit
1a	Wet forest with *Eucalyptus grandis, E. microcorys, E. cloeziana* & *Syncarpia glomulifera*
1b	*Eucalyptus saligna* dominated wet forest
2	Wet to mixed forest dominated by *Eucalyptus pilularis*
3a	Higher quality dry forest dominated by *Corymbia citriodora*
3b	Lower quality dry forest dominated by *C. citriodora*
4a	Mixed dry forest with *Eucalyptus siderophloia, E. propinqua* & *Corymbia intermedia*
4b	*Eucalyptus tereticornis* on alluvial lowlands
5a	Coastal dry eucalypt forest dominated by *Eucalyptus racemosa, C. intermedia* & *Angophora leiocarpa*
5b	Dry western forest including ironbark forest dominated by *Eucalyptus crebra* & *E. melanophloia*
6a	Upland cool rainforest CNVF/MVF
6b	Lowland cool rainforest CNVF/MVF
6c	*Araucaria* dominated rainforest
6d	Vine forest SEVT
7	Rainforest with eucalypt emergents
8a	*Melaleuca* woodland
8b	Other non-eucalypt dominated forest & woodland (*Callitris* & *Casuarina*)
9	Non-eucalypt non-forest vegetation (grassland, saltpan, heathland, *Banksia* forest, mangrove & low coastal complex <5m)
10	Non-vegetation (sand blows, water bodies, urban and rural cleared land)
11	Plantation
12	Heterogeneous/mixed vegetation types - no clear dominant

2.2 DATA ANALYSIS

2.2.1 Data Adequacy

An assessment of the adequacy of the available fauna data was undertaken using the Data Audit Methodology (DAM) software (Bennett *et al.* 1997b) with the environmental strata being the grouped vegetation units. Only records with a precision value of less than or equal to 1800m were used.

The results are compared to those obtained from a previous analysis of only the historical fauna data (McFarland 1998) to evaluate the impact of the systematic fauna survey (Eyre *et al.* 1998).

2.2.2 Diversity Assessment

Faunal values

The spatial dispersion of faunal values were addressed at the level of species and species assemblages. In the former, four categories were examined:

1) Total species (all forest-dwelling species listed in McFarland 1998) which comprised selected invertebrates and freshwater and terrestrial vertebrates.

2) Priority taxa as per those listed in McFarland (1997) which included all taxa used in the Response to Disturbance project (Rounsevell *et al*. 1998) except those invertebrates not in the *Nature Conservation Legislation Amendment Regulation (No. 2) 1997*.

3) Endemic species which were those with >75% of their known range contained within a single biogeographical region or have a total range of 100,000 square km or less (CoA 1995), as well as those listed by JSAG (1997).

4) Threatened species, being those taxa currently considered endangered or vulnerable as per *Nature Conservation Legislation Amendment Regulation (No. 2) 1997*. The last two categories were largely subsets of the priority group (93% endemics and 100% of the threatened species).

Limits of range for, and disjunct distributions of individual taxa were not examined in this analysis. Without extensive spatial and temporal survey data it would be difficult to be sure the edges or isolates indicated by records truely reflected either boundaries of viable populations (rather than chance extensions by single individuals) or simply a lack of sampling in intervening areas in the case of disjunct ranges. This would be particularly important for highly mobile groups (birds and bats).

Two types of species assemblages were investigated - habitat-associations (distribution of species that associate with each other), and functional associations (distribution of species with a commonality in certain ecological attributes). Both the species categories and species assemblages were examined with respect to tenure, grouped vegetation units and regional ecosystems.

Data attachments

After combining the historical and survey data, the site co-ordinates were intersected with tenure, grouped vegetation and regional ecosystem coverages. A unique tenure identifier (lotplan number) and a general identifier (e.g. NP = National Park, SF = State Forest, USL = Unallocated State Land) was attached to those sites where tenure could be determined from the site description or where the precision value was ≤ 900m. [In all further analyses and discussion National Park includes National Park Proposal, and State Forest includes Timber Reserve.] A grouped vegetation unit number and regional ecosystem number was also attached but only to those sites where the precision value was ≤ 500m (i.e. site likely to be in the vegetation/ecosystem polygon).

For the fauna analyses, tenure (as lotplan number) was considered a more useful spatial unit than a grid approach for several reasons. First, the filtering of the fauna data down to a specific grid cell size (e.g. 5km x 5km) would have resulted in a considerable loss of information. This was especially true for National Parks, where much of the available data were derived from species lists compiled for the whole park, which would cover a number of grid cells. Second, unless the grid was quite small, where the grid overlapped different tenures there may be no way of determining to which tenure the derived faunal values apply. Third, as a first approximation in the preparation of reserve options it was much easier to operate within the existing framework used to describe parcels of land. [Further refinement of boundaries, e.g. through more critical interrogation of the data or new field assessment, can then be made within specific lotplans to address the requirements of a CAR reserve system.] Some anomalies were encountered in the use of lotplan number, particularly for National Parks that comprise several different parcels due to additions over time. Despite this problem, lotplan number was still preferable over National Park name, which during recent times has seen the amalgamation of several spatially separate areas under single names.

Analyses

Initially, lists of fauna species were generated at four spatial and/or environmental levels: general tenure category, lotplan number, grouped vegetation unit and regional ecosystem type.

In describing the spatial arrangement of the individual species categories, maps indicating numbers of species by lotplan could produce misleading patterns and questionable conservation recommendations because of the variation in search effort across tenures (Remsen 1994; Fagan & Kareiva 1997). That is, some areas may appear species rich simply because they had been visited more often rather than because they have intrinsically greater biodiversity. In an attempt to overcome this, diversity indices were calculated based on a generalised species accumulation curve, i.e. with increasing effort the number of new species detected declines to an asymptote. Consequently, the number of species recorded for each lotplan was divided by $\log_{10}(x + 1)$, where x was the cumulative search effort for that lotplan. Search effort was derived from the information in the EFFORT field in the fauna database (usually based on days spent at the site) attached to each source listed as collecting data at the site. This calculation does have limitations, especially where too little information was in the original source to ascribe the correct search effort, resulting in a tendency to under-estimate the effort. However, by at least trying to compensate for unequal effort the inter-site comparisons in the faunal values are more realistic that just straight species numbers.

Maps describing richness were produced for all, priority, endemic and threatened species, with the indices grouped into five arbitrary divisions. These maps provided possible starting points for reserve selection. However, to address the comprehensiveness criterion one has to discern the similarity between lotplans in terms of their species composition, to determine which area should be selected next to provide additional new species. This pattern analysis was examined through a series of modules in the PATN package (Belbin 1995). Similarity between sites was measured using ASO and based on the Bray-Curtis association index. The sites were then classified according to species composition using the agglomerative hierarchical clustering procedure (flexible Unweighted Pair Group ArithMetic Average, UPGMA) of the program FUSE with a Beta value of -0.1 . Dendrograms were produced through DEND while group definitions were created using GDEF. To assess which species tend to be found together, the data were transposed (DATN) and TWAY used to generate a two way table (Belbin 1991).

A similar process was used to determine which habitat classifications were similar in terms of their faunal composition at the grouped vegetation unit and the regional ecosystem levels. The first provided a general overview of what species were found in those broad vegetation types across the SEQ CRA region. The second was an attempt to examine possible variation in species composition in each ecosystem type within the region, i.e. were the rainforest assemblages in the north the same as those in the south? The presence of such assemblages, when combined with information on the distribution of ecosystem types across the region, may enable some prediction about the possible presence of species in various land parcels that have not been surveyed.

Within the three analyses (tenure, grouped vegetation and regional ecosystem) run using all species, to make interpretation of the results easier and more meaningful, a mask was imposed on the matrices. The data used was confined to tenures with >50 species/lotplan, grouped vegetation with >3 species/unit and ecosystems with >10 species/site. For the analyses conducted on priority, endemic and threatened species in relation to ecosystems, the PATN program was unable to function with an excessive number of sites with only one species. Consequently, a mask was used to exclude such sites. The species in these three categories were dealt with in more detail in sections 2.2.3 and 3.3.

In the examination of species composition by habitat (grouped vegetation unit and regional ecosystem), Blackdown Tableland was omitted from the analyses because of an incomplete coverage at the time of analysis. However, species lists from detailed sites were compared, non-analytically, with other areas in the main SEQ CRA region for any significant differences.

2.2.3 Species Summaries

For all the priority and secondary assessment taxa identified by McFarland (1997), species summaries were compiled from various databases, literature sources, unpublished reports and personal communications from people familiar with the species. The summaries contain basic information on each animal's distribution (general and within SEQ), life history traits (abundance, habitat use, foraging and breeding biology), threatening processes (known and suspected) and reservation category (derived from life history traits and the number of different Crown lotplans within each of the broad tenure categories where the taxa has been recorded). The reservation category was an assessment of the representativeness criterion as applied to each species and is further described in the Attachment.

The individual species assessed fell into six categories :

a) those at risk and living in forests (already listed as endangered, vulnerable or rare under State and Commonwealth legislation, plus additional species considered priority);
b) regional endemics, i.e. restricted distribution (included as priority);
c) relictual species, i.e. of evolutionary significance (included as priority);
d) culturally significant species (listed under State legislation, included as priority);
e) migratory species undertaking within- and between-region movements (species selected on basis of season of visitation (summer/winter) and direction of movement (latitude/altitude) (listed as secondary assessment); and
f) those that may be risk based on assessments conducted elsewhere (listed as secondary assessment).

In this report, as in the previous report (McFarland 1998), the Major Mitchell's Cockatoo *Cacatua leadbeateri* was not included among the priority taxa even though it is currently listed as vulnerable. There were 13 records of this species for the SEQ CRA region, but in all cases, the individual(s) observed were suspected or known to be aviary escapees (or derived from aviary stock). Hence it was not considered a natural member of the region's fauna.

2.2.4 Reserve Option Example

For this exercise, a few simple but arbitrary rules were set to examine how fauna values in SEQ CRA region could be incorporated into a reserve system. These rules were:
1) to have as many species as possible within protected areas (= Comprehensiveness);
2) each species should occur in at least three different areas (if the species known from less than three areas then all of these should be in reserves) (= Adequacy);
3) all major faunal associations but in particular all priority and secondary assessment taxa (migratory species) should be found in reserves across their geographical/environmental ranges (= Representativeness);
4) all priority taxa had equal weighting; and
5) areas of interest to be selected from Crown Land estate.

A number of assumptions were made in this process. First, that historical records indicated the presence of populations of a species or at least suitable habitat for that species. Second, that reserves were the only means by which species could survive, i.e. ignores the possibility that species may survive in non-reserved forest given appropriate management.

Faunal values were assessed at various levels. a) Individual taxa: to comply with the reserve goals, emphasis was placed on priority taxa with restricted distributions (i.e. few or no alternative localities) and those requiring additional reservation. Habitat and geographical requirements of these taxa, as well as information on genetics, provided additional direction for area selection. (Data on the spatial variation in genetic composition was derived from Moritz & Playford (1998) who examined six frog and reptile species that were generally common in the region, had low dispersal abilities and were found in wet or dry forests.) b) Species associations: for this exercise, not all associations (habitat or functional) were analysed in terms of potential distribution within the region. Areas were targeted that contained habitat groups that were poorly represented in reserves. Only one functional group (arboreal marsupials) was studied and used to illustrate how alternative species associations could assist in choosing areas of interest. c) Broad categories: measurements of species richness (all, priority, endemic and threatened) of areas and the degree of similarity between areas based on these categories was used to identify significant localities that had to be accommodated in the selection process. Places of conservation interest were initially selected at the tenure scale but site information was used, where possible, to delineate core areas.

The baseline for the start of this process was the existing reserve system. To refine the focus to unreserved and reservable SEQ biota, certain taxa were omitted from the process - a) vagrant birds and bats (< 3 records; 11spp.), b) species with high detection and identification problems (*Ramphotyphlops* spp. & *Scotorepens* sp. (Parnaby); 10 spp.), c) those lacking any confirmed recent records (>1975) and considered regionally extinct (*Simoselaps warro, Psephotus pulcherrimus* and *Poephila cincta cincta*), d) introduced native species (*Cacatua tenuirostris* and *C. leadbeateri*), e) species whose presence on Crown Land was limited to National Parks (16 spp.), and f) species that were not known from any Crown Land tenure (24 spp.). Several species could have been listed in more than one category. Records from the first two groups tend to be chance reports and any actions taken to conserve single localities where species may or may not occur again would be considered wasteful effort within the context of protecting faunal biodiversity representative of the region.

Irreplaceable sites (those containing geographically restricted priority taxa) were selected first (maximise comprehensiveness) with subsequent areas being added on the basis of their contribution to the CAR goals (adequacy and representativeness). The success of the selection process was evaluated both quantitatively (percentage of forest-dwelling species and species associations reserved; percentage of species recorded in three or more conservation areas, and percentage of priority & secondary assessment taxa with habitat/geographical representation) and qualitatively (degree to which broader habitat & geographical deficiencies were addressed). Where possible, alternative areas were identified based on earlier PATN analysis (similar species composition) and inspection of known distributions of priority taxa (Attachment).

3. RESULTS

3.1 DATA ADEQUACY

The CRA fauna surveys added 24,894 records and four new species to the list compiled from historical sources for the SEQ CRA region (McFarland 1998). The species included two reptiles (*Phyllurus* sp. 'Oakview' and *Menetia timlowi*), one bird (*Manorina flavigula*) and one mammal (*Scotorepens balstoni*). Recording rates for all functional groups increased compared to that for historical data alone, with the greatest changes being for bats, small terrestrial mammals and nocturnal birds (Table 3.1). [Since drafting of the report, *Phyllurus* sp. 'Oakview' is now considered to be *P. caudiannulatus* - Couper *pers. comm.*]

TABLE 3.1 RECORDING RATE (RECORDS/SPECIES) FOR FUNCTIONAL GROUPS OF FOREST-DWELLING VERTEBRATE SPECIES BASED ON HISTORICAL AND COMBINED DATA (NUMBER OF SPECIES GIVEN IN PARENTHESES).

Functional Group	Historical Data	Combined Data	Percentage Increase
Amphibians	178 (49)	192 (49)	7.9
Reptiles	125 (148)	139 (150)	11.2
Diurnal birds	1046 (230)	1116 (231)	6.7
Nocturnal birds	428 (12)	499 (12)	16.6
Arboreal mammals	1015 (10)	1094 (10)	7.8
Large mammals	241 (12)	263 (12)	9.1
Bats	92 (39)	119 (40)	29.3
Small mammals	179 (26)	228 (26)	27.4

The DAMs analysis showed that of the grouped vegetation units only lower quality dry forests dominated by *Corymbia citriodora* (3b) and dry western forests including ironbark forests (5b) were undersampled in terms of sites per unit area (Appendix 1-Histogram). More revealing was that there was greater than a 5% chance of finding a new species with further surveys in four vegetation units - rainforest with eucalypt emergents (unit 7, probability = 1), other non-eucalypt dominated forests and woodland (8b, probability = 0.11), vine forest-SEVT (6d, probability = 0.08) and coastal dry eucalypt forest (5a, probability = 0.06) (Appendix 1-Species accumulation curves).

3.2 DIVERSITY ASSESSMENT

With the inclusion of several taxa (1 fish, 2 frogs and 2 reptiles) whose taxonomy has not been resolved, 548 species were listed for the analyses (Appendix 2 - 533 terrestrial vertebrates and 15 invertebrates and freshwater fish). However, no historical or survey records were found for three species considered priority taxa for the SEQ CRA region (*Denisonia maculata, Furina barnardi* and *Vespadelus regulus*) and the report of *Scotorepens sanborni* was unconfirmed. The absence of records does not necessarily mean the species were not in the region, especially in the little-surveyed northern (e.g. Blackdown Tableland) and south-western range areas. Consequently, these species were omitted from the analyses (leaving 544 taxa for the region) but were still dealt with in general terms in the species summaries (3.3.1 and Attachment).

3.2.1 Tenure

General

Among Crown Land tenures, the National Park and State Forest categories had the largest and most similar species numbers for all faunal groups (Table 3.2). These two tenure categories accounted for 99.4% (519/522) of all species known from Crown Lands. The remaining three species all occurred on State Reserves and Unallocated State Land. A further 22 species were recorded only from the Other category which was predominantly freehold title. Twenty-eight species noted for State Forests were not found in any National Parks (Table 3.3).

Sixty species were rarely recorded and largely unconserved (Table 3.3). Of these, 52% were reported on only one or two occasions and 78% were at some limit of their range (62% were at range limit and not on any reserve). These species were mostly typical of western regions with only occasional records east of the Great Dividing Range. Among the endemics, three (2 *Phyllurus* spp. and *Nangura spinosa*) were restricted to three specific State Forests while the *Elusor macrurus* was known only from the Mary River in non-Crown Land. The scarcity of records for genera such as *Ramphotyphlops,* which are largely fossorial, reflected more the difficulty in detection rather than known rarity.

TABLE 3.2 NUMBER OF FAUNA SPECIES BY BROAD TENURE CATEGORY (CATEGORIES AS PER TABLE 2.1, LEASE INCLUDES COM, FL, PPL, TL, OR AND ULL). BROAD GROUPS INCLUDE PRIORITY INVERTEBRATE AND FISH TAXA WHILE FUNCTIONAL GROUPS RESTRICTED TO TERRESTRIAL VERTEBRATES.

Fauna Groups	Number of Species per Broad Tenure Category					
	NP	SF	SR	USL	LEASE	OTHER
Broad Groups						
Total Species	490	476	368	287	302	523
Priority taxa	127	122	65	37	45	136
Endemic	36	33	18	10	13	36
Threatened	32	34	17	12	11	38
Functional Groups						
Amphibians	50	47	32	27	25	49
Reptiles	119	112	78	52	53	139
Diurnal birds	218	211	192	153	166	228
Nocturnal birds	12	12	9	8	8	12
Arboreal mammals	10	10	9	8	9	10
Large mammals	12	11	8	7	9	12
Bats	34	40	18	13	18	34
Small mammals	26	23	16	14	9	26

TABLE 3.3 LIST OF SPECIES WHICH WERE NOT RECORDED FROM ANY CROWN LAND TENURE (A), WERE RECORDED FROM STATE FOREST BUT NOT FROM NATIONAL PARK (B), AND/OR HAD LESS THAN THREE RECORDS FOR THE SEQ CRA REGION (C).

Scientific Name	Common Name	Status	A	B	C	SEQ Status
Jalmenus evagoras eubulus		V		X		Eastern limit
Galaxias olidus	Mountain Galaxias	P			X	Northern limit
Limnodynastes dumerilii	Grey-bellied Pobblebonk			X		Northern limit
Cyclorana novaehollandiae	Eastern Snapping-Frog			X		Eastern limit
Elusor macrurus	Mary River Tortoise	V	X			Restricted endemic
Lophognathus gilberti	Gilbert's Dragon				X	Eastern limit[c]
Diplodactylus steindachneri				X	X	Eastern limit[d]
Diplodactylus williamsi			X		X	Eastern limit
Gehyra catenata					X	Eastern limit[c]
Oedura marmorata	Marbled Velvet Gecko			X	X	Eastern limit[d]
Phyllurus caudiannulatus	Banded Leaf-tailed Gecko	R		X		Restricted endemic
Phyllurus sp. 'Oakview'		P		X	X	Restricted endemic[a]
Scientific Name	**Common Name**	**Status**	**A**	**B**	**C**	**SEQ Status**
Delma inornata			X		X	Northern limit
Varanus semiremex	Rusty Monitor	R	X		X	Southern limit
Calyptotis temporalis				X		Southern limit

Carlia tetradactyla			X			Southern limit
Cryptoblepharus carnabyi			X		X	Eastern limit[b]
Ctenotus strauchii			X		X	Eastern limit[b]
Egernia mcpheei					X	Northern limit
Egernia rugosa	Yakka Skink	V	X		X	Patchy distribution
Egernia saxatilis	Black Rock Skink				X	Northern limit[b]
Menetia greyii				X		Eastern limit
Menetia timlowi		P		X		Southern limit
Nangura spinosa	Nangur Skink	R		X		Restricted endemic
Trachydosaurus rugosus	Shingle-back		X		X	Eastern limit[b]
Demansia torquata	Collared Whip Snake		X		X	Southern limit
Furina dunmalli	Dunmall's Snake	V		X		Eastern limit
Furina ornata	Orange-naped Snake		X			Southern limit
Hemiaspis damelii	Grey Snake	P		X		Eastern limit
Pseudechis australis	King Brown Snake		X			Patchy distribution
Rhinoplocephalus boschmai	Carpentaria Whip Snake			X		Southern limit
Rhinoplocephalus nigrostriatus	Black-striped Snake				X	Southern limit
Simoselaps australis	Coral Snake	SA		X		Patchy distribution
Simoselaps warro		R	X		X	Southern limit
Ramphotyphlops affinis			X			Widespread distribution
Ramphotyphlops broomi		R			X	Widespread distribution
Ramphotyphlops diversus			X		X	Widespread distribution
Ramphotyphlops unguirostris			X		X	Widespread distribution
Turnix velox	Little Button-quail			X		Eastern limit
Cacatua leadbeateri	Major Mitchell's Cockatoo	V	X			Aviary escapee stock
Glossopsitta porphyrocephala	Purple-crowned Lorikeet		X		X	Northern limit[b]
Chrysococcyx osculans	Black-eared Cuckoo			X		Eastern limit
Pyrrholaemus brunneus	Redthroat	R			X	Eastern limit[c]
Acanthiza apicalis	Inland Thornbill				X	Eastern limit
Manorina flavigula	Yellow-throated Miner			X	X	Eastern limit[c]
Lichenostomus penicillatus	White-plumed Honeyeater			X		Eastern limit
Ramsayornis fasciatus	Bar-breasted Honeyeater				X	Southern limit
Certhionyx niger	Black Honeyeater		X			Eastern limit[b]
Epthianura tricolor	Crimson Chat		X			Eastern limit[b]
Pomatostomus superciliosus	White-browed Babbler		X		X	Eastern limit
Oreoica gutturalis	Crested Bellbird		X		X	Eastern limit[b]
Corvus bennetti	Little Crow			X		Eastern limit[b]
Poephila cincta cincta	Black-throated Finch (sth subsp.)	V		X		Eastern limit
Sminthopsis macroura	Stripe-faced Dunnart			X	X	Eastern limit[c]
Macroderma gigas	Ghost Bat	V		X	X	Southern limit
Taphozous australis	Coastal Sheathtail-bat	V		X	X	Southern limit
Hipposideros semoni	Semon's Leafnosed-bat	V		X		Southern limit
Scotorepens balstoni	Inland Broad-nosed Bat			X		Eastern limit
Scotorepens sp.(Parnaby)		P		X		Northern limit
Vespadelus troughtoni	Eastern Cave Bat	P		X		Widespread distribution

a - unresolved taxonomy

b - well beyond known range

c - within SEQ CRA region found only at Blackdown Tableland

d - within SEQ CRA region found only in Bania SF54.

Of the 544 species recorded for the SEQ CRA bioregion, 90% have been found in one or more National Parks. However, while comprehensive in minimalist terms, most species were poorly represented compared to the State Forest estate. Some 67.8% of the 519 species known from Crown Lands occurred on more State Forests than National Parks. In those instances where differences could be tested (n = 310 spp.) 51.9% of species occurred on a significantly greater proportion of State Forests compared to National Parks, e.g. *Lamprpholis amicula, Ninox strenua, Melithreptus gularis*, *Petaurus australis australis* and *Petauroides volans* (Table 3.4, Appendix 2). Only 22% (1.3% significant) of species were more prevalent on National Parks than State Forests. Most of these species were typical of wallum and mangrove habitats, e.g. *Litoria cooloolensis, Todiramphus chloris*, *Lichenostomus fasciogularis* and *Gerygone levigaster* (Appendix 2).

TABLE 3.4 DISTRIBUTION PATTERNS OF SPECIES WITH RESPECT TO TENURE (NUMBER OF LOTPLANS RECORDED ON), PRIMARILY NATIONAL PARK (NP) AND STATE FOREST (SF). TOTALS ARE THE NUMBER OF SPECIES THAT OCCURRED IN MORE (>) OR LESS (<) NP THAN SF, OR AT SIMILAR FREQUENCY (=), OR ONLY IN OTHER CROWN AND NON-CROWN TENURES. DISTRIBUTION PATTERNS ARE BASED ON RAW NUMBERS (GENERAL) AND STATISTICAL ANALYSIS (CONTINGENCY X^2 TEST, P < 0.05). NA = NOT ANALYSED.

Fauna Category	Number of Species Exhibiting Pattern				
	NP >SF	NP < SF	NP = SF	Non NP/SF Crown	Non-Crown
General - All	115	352	52	3	25
Priority	44	77	21	1	8
Endemic	15	19	4	0	1
Threatened	15	18	5	0	2
X^2 test - All	4	161	145	NA	NA
Priority	1	25	38	NA	NA
Endemic	1	7	2	NA	NA
Threatened	0	4	5	NA	NA

Among the other fauna categories, especially priority taxa, more species occur at greater frequency on State Forests than National Parks (54.2% general and 39% tested). In the general section the numbers for endemic and threatened groups were similar for the two tenures but for those significantly different the results favoured State Forests, 70% and 44.4% respectively (Table 3.4).

More species were found on more State Forests than National Parks (Fig. 3.1) despite the fact that the two tenures had similar total species numbers (Table 3.2), number of lotplans (NP = 260, SF = 222) and search effort distributions (Contingency $X^2 = 2.62$, df = 4; P > 0.05).

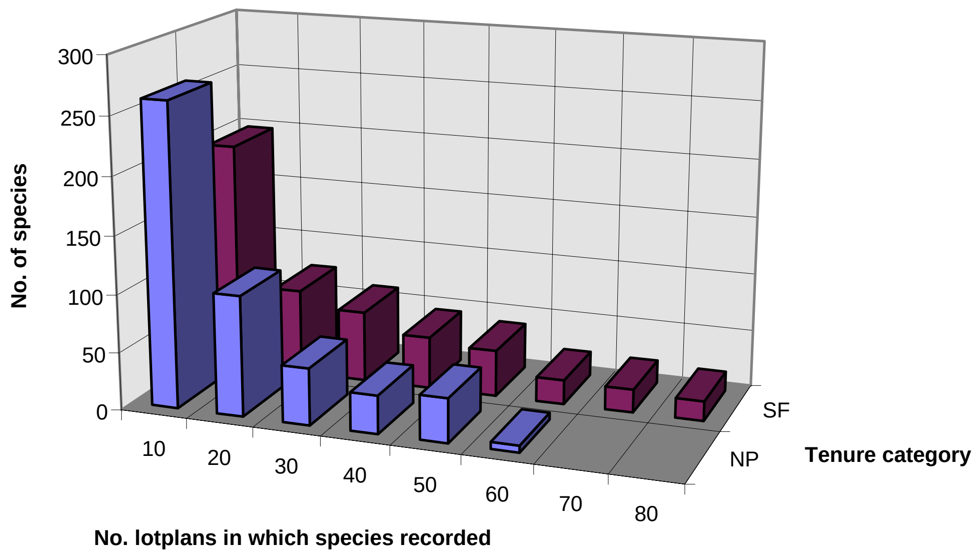

FIGURE 3.1 FREQUENCY OF SPECIES BY NUMBER OF LOTPLANS SPECIES RECORDED IN (GROUPED IN DIVISIONS OF 10) FOR NATIONAL PARK (NP) AND STATE FOREST (SF).

Diversity Indices by Specific Tenure

Figures 3.2 to 3.5 describe the spatial distribution of species diversity across the SEQ CRA region for all, priority, endemic and threatened species, while Tables 3.5 to 3.8 list the lotplans and their respective diversity indices for the two highest divisions. A full listing of diversity indices by lotplan is given in Appendix 2A.

Of the 29 locations listed in the all species category, only 6 (20.7%) were National Park while there were 13 State Forests (44.8%) with Bania SF54 and Dundas (southern D'Aguilar Range) SF1355 being in the top group (scores greater than 150, Table 3.5). The only National Parks of any size to rank were Blackdown NP 181, Great Sandy (Cooloola & Fraser Island) NP21 and Lamington NP496. Most of the other lotplans were small parcels of State Reserve, Title Lease or Unallocated State Land (Table 3.5, Fig. 3.2).

TABLE 3.5 LIST OF LOTPLANS WITH HIGHEST SPECIES DIVERSITY INDICES BASED ON ALL SPECIES.

Tenure	Lotplan Number	Lotplan Name	Diversity Index
SR	500CG807392	Southern area on Bribie Island	198.9
SF	SF 54FTY 1683	Bania SF 54	183.3
SR	459SL6882	Redbank Rifle Range area	179.9
TL	9YL998	Sliver adjoining Bompa (Bulburin) SF 391	174.0
SR	700RP881903	Upper Caboolture area	171.7
NP	246NPW526	White Rock Conservation Park	169.6
SR	300RP851688	Upper Caboolture area	168.8
TL	171MCH2477	Mary River-Yabba Creek junction, Conondale area	159.3
SF	SF 1355FTY 1526	Dundas (D'Aguilar) SF 1355	150.3
USL	1USL26534	Mouth of Caboolture River	150.2
SF	SF 343FTY 525	Monsildale SF 343	149.6
USL	431USL26441	Southern end of Bribie Island	148.8
SF	SF 792FTY 1681	Conondale SF 792	148.4
NP	181NPW491	Blackdown NP	143.6
SF	SF 50FTY 1641	Glenbar SF 50	140.4
SF	SF 391FTY 1007	Bompa (Bulburin) SF 391	138.5
SF	SF 289FTY 1640	Cooyar SF 289	137.5
SR	279SL815015	Bald Hills-Deepwater Bend Reserve area	137.3
SF	SF 118FTY 1342	Tarong SF 118	137.3
NP	144SL8113	Sheep Station Creek Conservation Park	134.9
NP	21NPW473	Great Sandy NP	132.3
SF	SF 316FTY 1328	Winterbourne (Kroombit Tops) SF 316	131.5
SF	SF 616FTY 1512	Lockyer SF 616	130.1
SF	SF 546FTY 1315	Kandanga SF 546	128.7
NP	496NPW225	Lamington NP	128.2
NPP	1RP83174	Addition to Ravensbourne NP	127.8
SF	SF 639FTY 902	Manumbar SF 639	127.3
SF	SF 135FTY 1638	Brooloo SF 135	126.6
SR	191WD800476	Coombabah Lake area	125.9

For priority species, National Parks had improved representation (35%) with three areas (Lamington, Conondale NP102 and Main Range NP933) being in the top group (scores 20 or greater). Twelve (60%) of the listed areas were State Forest, including Dundas, Conondale (SF

792, Bania, Kandanga SF546 and Winterbourne (Kroombit Tops) SF316. The only location in the list that was not designated either National Park or State Forest was a sliver of Title Lease adjoining Bompa (Bulburin) SF391 (Table 3.6, Fig. 3.3).

TABLE 3.6 LIST OF LOTPLANS WITH HIGHEST SPECIES DIVERSITY INDICES BASED ON PRIORITY SPECIES.

Tenure	Lotplan Number	Lotplan Name	Diversity Index
NP	496NPW225	Lamington NP	28.8
SF	SF 1355FTY 1526	Dundas (D'Aguilar) SF 1355	24.1
SF	SF 792FTY 1681	Conondale SF 792	23.5
NP	102NPW513	Conondale NP	23.0
NP	933NPW485	Main Range NP	21.9
SF	SF 54FTY 1683	Bania SF 54	21.6
SF	SF 546FTY 1315	Kandanga SF 546	21.1
TL	9YL998	Sliver adjoining Bompa (Bulburin) SF 391	21.0
SF	SF 316FTY 1328	Winterbourne (Kroombit Tops) SF 316	20.4
SF	SF 343FTY 525	Monsildale SF 343	19.6
SF	SF 391FTY 1007	Bompa (Bulburin) SF 391	19.3
NP	21NPW473	Great Sandy NP	19.1
NP	737NPW495	Mount Barney NP	18.9
SF	SF 135FTY 1638	Brooloo SF 135	18.9
SF	SF 893FTY 1532	Byron (Mt Mee) SF 893	18.2
SF	SF 750FTY 1605	East Haldon SF 750	18.0
NP	441NPW469	Tamborine NP	17.9
SF	SF 274FTY 1680	Conondale SF 274	17.1
SF	SF 639FTY 902	Manumbar SF 639	16.9
NPP	1RP83174	Addition to Ravensbourne NP	16.6

The number of highly ranked National Parks based on endemic species was identical to that of State Forests (41.2%, Table 3.7, Fig. 3.4). Only in the threatened category did National Parks outperform State Forests (54.5% vs 36.4%) with four in the top six (Conondale, Lamington, Mount Barney and Main Range) (Table 3.8, Fig. 3.5).

For all fauna categories, the most diverse areas were spread across the region with recurrent localities being Lamington NP, Mount Barney NP, Main Range NP, Dundas SF, Monsildale SF343, Brooloo SF135, Conondale NP and SF792, Great Sandy NP and a small area of Title Lease on the western side of Bompa SF. All ranked in the top two groups of three or all of the four categories.

In the next level (listed in 2/4 categories) were Byron SF893, Conondale SF788, Manumbar SF639, Kandanga SF, Bania SF, Bompa (Bulburin) SF and Winterbourne (Kroombit Tops) SF.

TABLE 3.7 LIST OF LOTPLANS WITH HIGHEST SPECIES DIVERSITY INDICES BASED ON ENDEMIC SPECIES.

Tenure	Lotplan Number	Lotplan Name	Diversity Index
SF	SF 893FTY 1532	Byron (Mt Mee) SF 893	7.6
NP	102NPW513	Conondale NP	6.7
SR	1010SL12725	The Gap area, Brisbane	6.6
TL	9YL998	Sliver adjoining Bompa (Bulburin) SF 391	6.3
NP	21NPW473	Great Sandy NP	6.2
SF	SF 792FTY 1681	Conondale SF 792	6.2
SF	SF 788FTY 1682	Conondale SF 788	6.1
SF	SF 135FTY 1638	Brooloo SF 135	6.1
SF	SF 343FTY 525	Monsildale SF 343	6.0
NP	737NPW495	Mount Barney NP	5.9
NP	496NPW225	Lamington NP	5.6
SF	SF 832FTY 1616	Durundur (Bellthorpe) SF 832	5.4
NP	546NPW369	Kondalilla NP	5.2
TL	66CP845958	Marcus Beach area, Sunshine Coast	5.1
NP	933NPW485	Main Range NP	5.1
SF	SF 1355FTY 1526	Dundas (D'Aguilar) SF 1355	5.1
NP	1327NPW352	D'Aguilar NP	5

TABLE 3.8 LIST OF LOTPLANS WITH HIGHEST SPECIES DIVERSITY INDICES BASED ON THREATENED SPECIES.

Tenure	Lotplan Number	Lotplan Name	Diversity Index
SR	104CG3794	Southern end of Bribie Island	10.0
NP	102NPW513	Conondale NP	7.3
NP	496NPW225	Lamington NP	6.9
TL	9YL998	Sliver adjoining Bompa (Bulburin) SF 391	6.3
NP	737NPW495	Mount Barney NP	5.9
NP	933NPW485	Main Range NP	5.6
SF	SF 788FTY 1682	Conondale SF 788	5.5
SF	SF 135FTY 1638	Brooloo SF 135	5.5
NP	21NPW473	Great Sandy NP	5.1
NP	495NPW544	Springbrook NP	5.0
SF	SF 792FTY 1681	Conondale SF 792	5.0

Similarity among Specific Tenure

All Species

Comparison of lotplans using all species revealed 35 sub-groups in four major divisions (Fig. 3.6, with the divisions indicated by green, blue-purple, pink-red and yellow-brown colours; Appendix 4). The the sub-groups were defined at fusion level of 0.44 from visual inspection of the dendrogram.

Spatially, a number of patterns can be identified. In the green division there were some noticeable geographical affinities with certain areas very similar to each other, e.g. much of the Conondale SF and NP, Bellthorpe and D'Aguilar areas, the Bania-Bulburin-Kroombit group, and Lamington NP-Main Range NP with parts of D'Aguilar and Conondale areas (Fig. 3.6, Appendix 4). Within the blue division there were several distinct and similar sub-groups : the coastal mainland localities north of Maryborough, offshore sand islands (Moreton and Fraser Islands), and a sub-coastal - western area from Gatton to Beerwah to north-west of Bundaberg, including Blackdown Tableland. The remaining areas in the pink and yellow divisions had smaller numbers of records and may reflect some selective sampling of faunal groups, e.g. arboreal mammals and microchiropteran bats in St Marys SF.

The majority of sub-groups recognised in the first and second divisions contained several State Forests and at least one National Park. Notable exceptions lacking National Parks were sub-groups 5, 6 and 7 (Fig. 3.6) located mostly west of the coastal ranges, although Kroombit NP was next similar (sub-group 8). National Parks were poorly represented in sub-group 4 (1/6 lotplans) covering western central areas, and sub-group 10 (1/21) which included sub-coastal forests north of Beerwah and western forests north of the Lockyer Valley (Fig. 3.6). At the other extreme, sub-groups 11 and 12 (sandy coastal and island areas) contained mostly National Parks (Fig. 3.6).

The species associations dendrogram seemed to have four major divisions containing 23 sub-groups delineated at a fusion level of 1.1 (Appendix 5). Three of the divisions equated to single sub-groups of 70, 159 and 74 species. These three groups contained species that were from riparian/wet eucalypt/rainforest, all major forest types (widely distributed) and dry eucalypt forest respectively. The remaining 20 sub-groups were generally unassociated species recorded only in specific localities, e.g. Blackdown Tableland or Lamington-Main Range area. Species groupings will be examined in more detail at the grouped vegetation unit and regional ecosystem level in 3.2.2 and 3.3.3.

The two-way table, detailing species by tenure (Appendix 6), showed that the species in the third species sub-group and parts of the second were almost ubiquitous across all tenure groups. Tenure sub-groups higher than sub-group 32 tended to have species compositions that were subsets of higher order tenures. The higher order tenures also had more of the species from the first species sub-group.

Priority Species

Analysis of priority species by tenure produced four divisions with 37 sub-groups with the fusion level at 0.7 (Fig. 3.7, same colour divisions as per all species analysis; Appendix 7). Several patterns were apparent. Among the green division there were similarities between Lamington-Main Range and D'Aguilar Range areas (sub-group 1), and the Conondale complex and Kroombit Tops-Bania-Bulburin and D'Aguilar Range (sub-group 2).The next closest areas were west of the Conondales through to Bunya Mountains (sub-groups 3-6). Other associations included the northern coastal cluster (sub-group 17), a sub-coastal collection (sub-groups 18-19) adjacent to sub-group 17 that extends to Blackdown Tableland, and an eastern coastal set (sub-groups 32-34).

The dendrogram for priority species is presented in Appendix 8 while the two-way table for this analysis is in Appendix 9. Priority taxa will be assessed in more detail in 3.3.3 and the Attachment.

Endemic Species

As endemics formed a subset of the priority category, many of the tenure and species patterns described above were present. Strong similarities were exhibited among tenures of the southern ranges (sub-group 1), D'Aguilar-Conondale-north-west uplands (sub-group 2) and the coastal region (sub-groups 7 & 8) (Fig. 3.8; Appendix 10). Various species groups were identified and these were further split into sub-groups representing widespread and restricted distributions with respect to tenure (Appendix 10).

Threatened Species

Endangered and vulnerable species also formed a part of the priority category, and again there was repetition of certain tenure and species associations (Fig. 3.9, Appendix 11). As only 37 species were used in the analysis, the presence or absence of a single species had considerable impact on the sub-groups defined. In general, there were four main groups. a) A south-west cluster (sub-group 1) based on the *Petrogale penicillata*. b) A coastal group (sub-groups 2-6) dominated by acid frogs, wallum freshwater fish, two butterfly species, *Calyptorhynchus lathami* and *Xeromys myoides* (Blackdown Tableland was included here because of the cockatoo and one of the butterflies). c) An upland association (sub-group 7) extending from the New South Wales border north to Bulburin with common species being *Cyclopsitta diophthalma coxeni* and *Potorous tridactylus*. d) A central group (sub-groups 8 & 9) which could be considered subsets of sub-group 7 but with a reduced species number and a similarity based on the presence of *Calyptorhynchus lathami*, *Ninox strenua* and *Turnix melanogaster*. The majority of the remaining sub-groups had only one threatened species present, most of which were in the other higher order sub-groups.

3.2.2 Grouped Vegetation Unit

Analysis of species by grouped vegetation unit revealed that most vegetation units were similar in their faunistic composition (Fig. 3.10) with individual species and groups of species occurring across the range of forest types (Appendix 12). The results were considered a reasonably accurate picture given that sampling effort (number of sites) was roughly proportional to the area of each vegetation unit (Table 3.9).

Among the native forest vegetation units, the non-eucalypt types (8a, 8b) separated out early, then groups comprising upland rainforest/moist eucalypt forest (6a, 1b) and semi-evergreen vine thicket (6d) followed by a wide range of units close together (Fig. 3.10). This last aggregation contained recognisable sub-groups of dry (4b & 5a; 3b, 4a & 5b) and wet (6b, 6c & 1a) forest types but their dissimilarity was not exceptional.

TABLE 3.9 NUMBER OF SITES PER GROUPED VEGETATION UNIT AND THE AREA OF SUCH UNITS ON CROWN TENURES (VALUES IN PARENTHESES ARE PERCENTAGES).

Grouped Vegetation Unit	Number of Sampling Sites	Area of Vegetation (Ha)
1a	257 (5.7)	20643 (1.4)
1b	270 (6.0)	12752 (0.9)
2	239 (5.3)	45078 (3.0)
3a	55 (1.2)	9201 (0.6)
3b	555 (12.3)	306172 (20.7)
4a	1146 (25.3)	289671 (19.6)
4b	141 (3.1)	36296 (2.6)
5a	325 (7.1)	253971 (17.2)
5b	263 (5.8)	150862 (10.2)
6a	215 (4.7)	22158 (1.5)
6b	371 (8.2)	57527 (3.9)
6c	325 (7.2)	93372 (6.3)
6d	8 (0.2)	9466 (0.6)
7	3 (0.07)	311 (0.02)
8a	51 (1.1)	27728 (1.9)
8b	5 (0.1)	1853 (0.1)
9	184 (4.0)	100197 (6.8)
12	116 (2.6)	41056 (2.8)

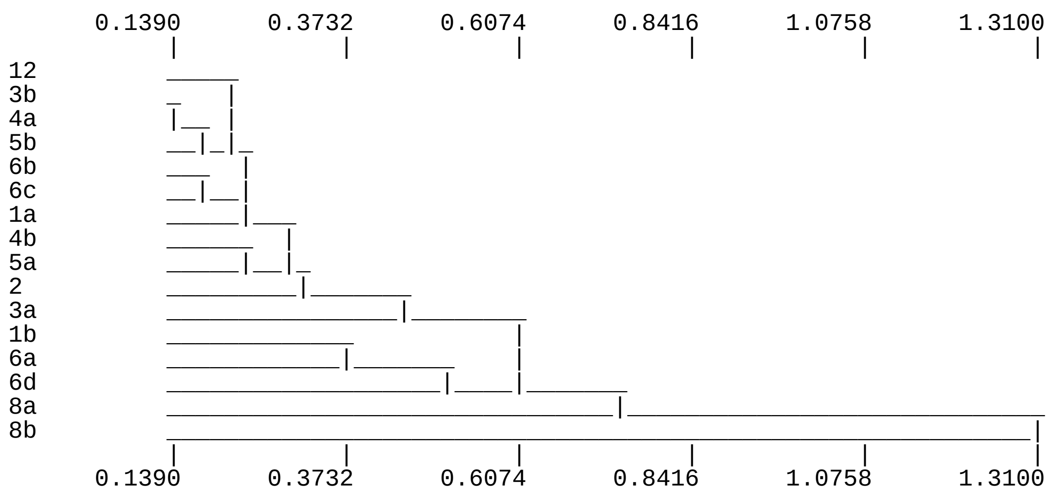

FIGURE 3.10 DENDROGRAM OF GROUPED VEGETATION UNITS (NATIVE FOREST ONLY) USING SPECIES COMPOSITION.

Most of the vegetation sub-groups listed above had a high degree of faunal overlap, particularly for species sub-groups 11 and 12 (Appendix 12). Species groups present in one vegetation unit were often found, either partially or wholly, within other vegetation units. A small number of species were recorded only in one particular vegetation unit, e.g. acid frogs and wallum freshwater fish (species sub-group 15) in coastal dry eucalypt forest (5a), and a variety of vertebrate taxa (sub-groups 17, 18, 20 & 21) in *Corymbia citriodora* dry forest (3b), upland cool rainforest (6a), dry western forest (5b) and mixed dry forest (4a) respectively. In many cases, the species concerned had restricted distributions in the region, being recorded at only a few locations.

While the greatest numbers of vertebrate species were found in mixed dry forest (4a) and *Corymbia citriodora* dry forest (3b) (Table 3.10), the unit with the highest percentage of its species in the priority, endemic and threatened categories was upland cool rainforest (6a). Other units high in all faunal categories were *Eucalyptus saligna* wet forest (1b), wet to mixed forest (2) and lowland cool rainforest (6a).

However, in terms of where the greatest numbers of each category were found, the unit with the highest percentages in all cases was mixed dry forest (4a). Dry western forest (5b) had the next highest percentage for priority taxa. Lowland cool rainforest (6b) was not much less, and this unit also had high values for endemic and threatened classes (Table 3.10).

TABLE 3.10 TOTAL NUMBER OF SPECIES AND PERCENTAGE OF SPECIES IN EACH FAUNAL CATEGORY RECORDED IN EACH GROUPED VEGETATION UNIT. ONLY NATIVE FOREST UNITS CONSIDERED AND UNIT 7 AND 8B DELETED DUE TO LACK OF DATA.

Faunal	Grouped Vegetation Unit (GVU) for Native Forest														
Category	1a	1b	2	3a	3b	4a	4b	5a	5b	6a	6b	6c	6d	8a	12
Total species	251	117	200	145	308	351	226	247	279	176	248	266	111	86	235
As percentage of total species in GVU															
Priority	16.7	20.5	19.0	11.7	15.6	19.4	15.0	17.8	17.9	25.0	19.4	15.0	9.9	8.1	12.8
Endemic	4.0	6.0	7.0	2.8	3.2	4.8	3.1	5.7	2.2	8.0	6.5	4.1	0.9	0	3.0
Threatened	3.6	5.1	4.0	3.4	2.9	3.7	3.5	4.9	3.6	5.7	4.8	3.0	0.9	1.1	2.1
As percentage of total species in faunal category															
Priority (n=123)	34.1	19.5	30.9	13.8	39.0	55.3	27.6	35.8	40.7	35.8	39.0	32.5	8.9	5.7	24.4
Endemic (n=38)	26.3	18.4	36.8	10.5	26.3	44.7	18.4	36.8	15.8	36.8	42.1	28.9	2.6	0	18.4
Threatened (n=32)	25.7	17.1	22.9	14.3	25.7	37.1	22.9	34.3	28.6	28.6	34.3	22.9	2.9	2.9	14.3

3.2.3 Regional Ecosystem

Interpretation of species associations at the environmental scale of regional ecosystems (RE) assumes that the RE attached to each site, based on an intersection of coverages, accurately reflects the vegetation at that site. To test this assumption, a comparison was made between the RE and habitat descriptions using those sites for which some form of habitat information was available. For those sites with a general structural description, e.g. rainforest, eucalypt forest or open forest, (n = 1553 sites) the agreement with the RE was 82%. Where added structure and/or floristic detail, e.g. tall open *Eucalyptus pilularis* forest or notophyll rainforest, was given (n = 685 sites) the concurrence was 77%. There were a number of obvious sources for RE-site discrepancies including 1) the fact that each fauna site covered up to 80ha and could contain a mosaic of ecosystems, 2) mapping errors including interpretation of ecosystem type and scale of mapping (often the differences were between adjacent habitats, e.g. rainforest and wet sclerophyll forest), and 3) the site was in an ecosystem patch too small to be mapped as a separate RE (e.g. small remnant and thin riparian forests). Despite these concerns, for a regional assessment of fauna the use of attached RE descriptions appears reasonable.

Habitat Associations

All Species

At a fusion level of 0.84, 75 sub-groups in three major divisions were discerned in the site dendrogram (Fig. 3.11, Appendix 13). What was immediately obvious was that sites classified together because of similar faunal composition could be from widely separated locations, e.g. sub-group 3 and 4 contained sites from Kroombit Tops (Winterbourne) south to the Main Range, as well as Conondale and Great Sandy areas (Table 3.11). In the 27 major sub-groups, that made up the first two divisions and accounted for 74% of the 760 sites used in the analysis, all except five had National Park representation from at least one but up to six different reserves. The five without reserves (sub-groups 12, 17, 21, 24 and 25) were primarily northern sub-coastal and western areas (Table 3.11). Even among the 48 sub-groups from the third division, National Parks were found in half, and those without were again from areas in the north and west of the coastal ranges, e.g. Gundiah, Warrah, Monsildale, Gallangowan and Cooyar.

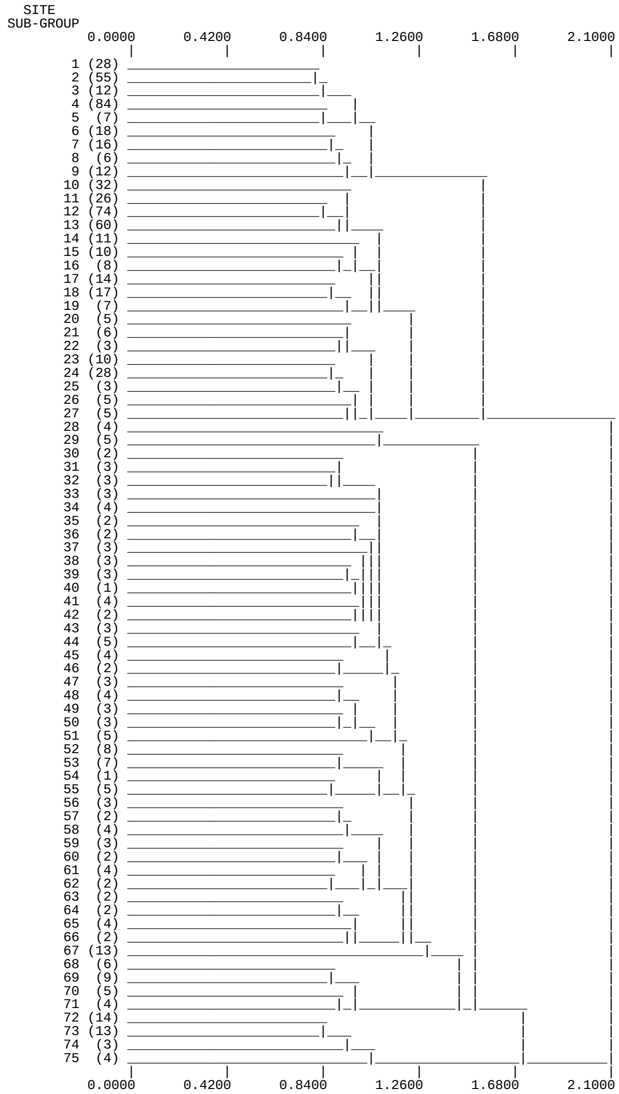

FIGURE 3.11 DENDROGRAM SHOWING SITE CLASSIFICATION BASED ON SPECIES COMPOSITION (NUMBER OF SITES PER SUB-GROUP IN PARENTHESES).

TABLE 3.11 SUMMARY OF SITE LOCATIONS FOR 27 MAJOR SUB-GROUPS (RANKING FROM PATN ANALYSIS), TOTAL NUMBER OF REGIONAL ECOSYSTEMS (RE), THE NUMBER OF MAIN RE RECORDED, THEIR FREQUENCY AND GENERAL VEGETATION FOR EACH SUB-GROUP. VEGETATION DESCRIPTION FROM RE DESCRIPTION IN YOUNG (IN PRESS).

Sub-group No.	Lotname	Lotplan Number	Total RE	Major RE Recorded	Freq.	Vegetation Description
1	BYRON	SF 893FTY 1532	20	12.12.2	7	Tall open shrubby forest (wet sclerophyll) - *Eucalyptus pilularis,*
1	COLINTON	SF 283FTY 1651		12.11.3	5	*E. siderophloia, E. propinqua, E. grandis*; also notophyll/microphyll
1	CONONDALE	SF 274FTY 1680		12.3.2	4	rainforest and mixed shrubby woodland.
1	CONONDALE	SF 788FTY 1682		12.12.14	4	
1	CONONDALE	SF 792FTY 1681		12.12.15	4	
1	DAWES	TR 353FTY 628		12.8.4	3	
1	DEONGWAR	SF 528FTY 1041		12.9-10.16	3	
1	DURUNDUR	SF 832FTY 1616		12.9-10.20	3	
1	KANDANGA	SF 546FTY 1315				
1	KENILWORTH	SF1239FTY 1255				
1	LOCKYER	SF 616FTY 1512				
1	Mount Barney National Park	737NPW495				
2	CONONDALE	SF 274FTY 1680	22	12.11.3	18	Tall open forest (wet sclerophyll) - *Eucalyptus pilularis, E. grandis,*
2	CONONDALE	SF 788FTY 1682		12.12.15	13	*E. siderophloia, E. propinqua, E. saligna, Lophostemon confertus*; also
2	CONONDALE	SF 792FTY 1681		12.12.2	8	open forest/woodland - *E. tereticornis, E. melliodora.*
2	Conondale National Park	102NPW513		12.8.1	7	
2	DEONGWAR	SF 528FTY 1041		12.11.9	6	
2	DUNDAS	SF1355FTY 1526		12.8.9	5	
2	DURUNDUR	SF 832FTY 1616		12.11.2	4	
2	EAST HALDON	SF 750FTY 1605		12.8.14	3	
2	ENOGGERA	SF 309FTY 1307				
2	MANUMBAR	SF 639FTY 902				
2	MONSILDALE	SF 343FTY 525				
2	Mount Barney National Park	737NPW495				
2	ST JOHN	SF 809FTY 1630				
3	Conondale National Park	102NPW513	14	12.8.4	2	Mixture of sub-groups1 and 2 - complex notophyll rainforest to wet
3	DEONGWAR	SF 528FTY 1041		12.8.14	2	sclerophyll, mixed tall open forest and grassy woodland/open forest.
3	DURUNDUR	SF 832FTY 1616		12.12.2	2	
3	EAST HALDON	SF 750FTY 1605				
3	GILBERT	SF 401FTY 1186				
3	KING	SF 575FTY 906				
3	Kroombit Tops National Park	435NPW457				
3	Main Range National Park	933NPW485				
3	MELCOMBE	SF 735FTY 1109				
4	AVOCA	SF 618FTY 1626	29	12.12.16	10	Notophyll and microphyll rainforest and tall open forest (mostly wet

Sub-group No.	Lotname	Lotplan Number	Total RE	Major RE Recorded	Freq.	Vegetation Description
4	BOMPA	SF 391FTY 1007		12.11.3	9	sclerophyll forest) - *E. grandis, E. siderophloia, E. propinqua, E. saligna*.
4	BOOMPA	SF1344FTY 1534		12.11.10	9	
4	BRIBIE	SF 561FTY 1655		12.12.13	9	
4	BROOYAR	SF 82FTY 1310		12.3.2	5	
4	Bunya Mountains National Park	603NPW60		12.8.5	4	
4	BYRON	SF 893FTY 1532		12.8.7	4	
4	CONONDALE	SF 792FTY 1681		12.8.13	4	
4	Conondale National Park	102NPW513		12.11.2	4	
4	COOYAR	SF 257FTY 1509		12.12.15	4	
4	D'Aguilar National Park	796NPW80		12.12.20	4	
4	DAWES	TR 353FTY 628				
4	DUNDAS	SF1355FTY 1526				
4	DURUNDUR	SF 832FTY 1616				
4	EAST HALDON	SF 750FTY 1605				
4	GILBERT	SF 401FTY 1186				
4	Great Sandy National Park	21NPW473				
4	GRONGAH	SF 67FTY 1173				
4	KANDANGA	SF 546FTY 1315				
4	KENILWORTH	SF1239FTY 1255				
4	KILKIVAN	SF 220FTY 457				
4	Main Range National Park	933NPW485				
4	MANUMBAR	SF 639FTY 902				
4	MONSILDALE	SF 343FTY 525				
4	NEW CANNINDAH	SF 695FTY 1570				
4	Springbrook National Park	495NPW544				
4	TEEBAR	SF 648FTY 515				
4	WARRAH	SF1294FTY 1705				
4	WINTERBOURNE	SF 316FTY 1328				
4	WOONDUM	SF 393FTY 1146				
5	BANIA	SF 54FTY 1683	9	12.9-10.20	3	Shrubby tall open forest - *E. saligna, E. grandis* and open forest -
5	CONONDALE	SF 274FTY 1680		12.12.20	3	*E. campanulata, E. tereticornis*.
5	Mount Walsh National Park	107NPW543				
5	WINTERBOURNE	SF 316FTY 1328				
6	CONONDALE	SF 274FTY 1680	14	12.12.13	3	Microphyll/notophyll/araucarian rainforest; also wet sclerophyll forest
6	COOYAR	SF 257FTY 1509				and open forest/woodland - *E. crebra, E. moluccana*.
6	DEONGWAR	SF 528FTY 1041				
6	DURUNDUR	SF 832FTY 1616				
6	Lamington National Park	496NPW225				
6	MANUMBAR	SF 639FTY 902				

Sub-group No.	Lotname	Lotplan Number	Total RE	Major RE Recorded	Freq.	Vegetation Description
6	MARODIAN	SF 632FTY 625				
6	Mount Barney National Park	737NPW495				
6	WINTERBOURNE	SF 316FTY 1328				
7	BEERWAH	SF 589FTY 1657	12	12.9-10.20	4	Shrubby tall open forest - *E. saligna, E. siderophloia, E. acmenoides,*
7	BRIBIE	SF 561FTY 1655		12.12.20	4	*Corymbia citriodora.*
7	DUNDAS	SF1355FTY 1526		12.11.5	3	
7	DURUNDUR	SF 832FTY 1616				
7	ENOGGERA	SF 309FTY 1307				
7	Mount Barney National Park	737NPW495				
7	WINTERBOURNE	SF 316FTY 1328				
8	BOMPA	SF 391FTY 1007	8	12.11.2	2	Tall open forest (wet sclerophyll forest) - *E. saligna, E. grandis*; also
8	CONONDALE	SF 274FTY 1680				notophyll rainforest.
8	Conondale National Park	102NPW513				
8	Mount Barney National Park	737NPW495				
8	WINTERBOURNE	SF 316FTY 1328				
9	CONONDALE	SF 274FTY 1680	8	12.8.9	6	Tall open forest - *L. confertus, E. campanulata, E. siderophloia,*
9	EAST HALDON	SF 750FTY 1605		12.8.1	5	*C. citriodora, E. pilularis*; also complex notophyll rainforest.
9	Lamington National Park	496NPW225				
9	MELCOMBE	SF 735FTY 1109				
9	Mount Barney National Park	737NPW495				
9	Springbrook National Park	495NPW544				
10	BANIA	SF 54FTY 1683	30	12.9-10.17	5	Tall open forest to open forest - *E. siderophloia, E. microcorys,*
10	BOMPA	SF 391FTY 1007		12.12.15	4	*E. tereticornis, C. citriodora, C. intermedia*; also notophyll rainforest
10	BOOMPA	SF1344FTY 1534		12.3.3	3	and heathland.
10	BOOROOM	SF 53FTY 1192		12.12.5	3	
10	CHERBOURG	SF 12FTY 1580		12.12.16	3	
10	COOYAR	SF 289FTY 1640		12.12.20	3	
10	DEGILBO	TR 581FTY 1445				
10	Eurimbula National Park	278NPW193				
10	KILKIVAN	SF 220FTY 457				
10	Kroombit Tops National Park	435NPW457				
10	LITTABELLA	SF 898FTY 1636				
10	MANUMBAR	SF 639FTY 902				
10	MONSILDALE	SF 343FTY 525				
10	Pine Ridge Conservation Park	2CP862915				
10	STANTON	SF 832FTY 1631				
10	Tamborine National Park	158WD4696				
10	TARONG	SF 118FTY 1342				
10	TEEBAR	SF 465FTY 669				
10	WINTERBOURNE	SF 316FTY 1328				

10	MONSILDALE	SF 343FTY 525				
11	BOMPA	SF 391FTY 1007	23	12.11.3	5	Tall open forest to open forest - *E. siderophloia, C. citriodora,*
11	BOOROOM	SF 53FTY 1192		12.11.5	5	*E. propinqua, E. moluccana, E. acmenoides, E. fibrosa.*
11	BRIBIE	SF 561FTY 1655		12.9-10.3	4	
11	BYRON	SF 893FTY 1532				
11	CONONDALE	SF 274FTY 1680				
Sub-group No.	**Lotname**	**Lotplan Number**	**Total RE**	**Major RE Recorded**	**Freq.**	**Vegetation Description**
11	COOYAR	SF 289FTY 1640				
11	GYMPIE	SF 700FTY 1491				
11	LITTABELLA	SF 898FTY 1636				
11	LOCKYER	SF 616FTY 1512				
11	MANUMBAR	SF 639FTY 902				
11	NUMINBAH	SF 702FTY 1554				
11	Springbrook National Park	495NPW544				
11	STANTON	SF 832FTY 1631				
12	AVOCA	SF 329FTY 1604	35	12.11.5	14	Tall open forest to open forest - *C. citriodora, E. siderophloia,*
12	BANIA	SF 54FTY 1683		12.12.3	10	*E. acmenoides*; also tall woodland - *C. trachyphloia, C. intermedia,*
12	BINGERA	SF 840FTY 1633		12.11.6	9	*E. tereticornis, E. moluccana.*
12	BOMPA	SF 391FTY 1007		12.12.5	9	
12	BOOIE	SF 721FTY 1004		12.12.27	6	
12	BOOMPA	SF1344FTY 1534		12.9-10.21	5	
12	BROOYAR	SF 82FTY 1310		12.11.17	5	
12	BYRON	SF 893FTY 1532		12.12.23	5	
12	CHERBOURG	SF 12FTY 1580		12.12.28	5	
12	COLINTON	SF 283FTY 1651				
12	COOYAR	SF 289FTY 1640				
12	DAWES	TR 353FTY 628				
12	GRONGAH	SF 67FTY 1173				
12	GYMPIE	SF 700FTY 1491				
12	KANDANGA	SF 546FTY 1315				
12	KING	SF 575FTY 906				
12	LOCKYER	SF 616FTY 1512				
12	MARODIAN	SF 632FTY 625				
12	WINTERBOURNE	SF 316FTY 1328				
13	BINGERA	SF 840FTY 1633	27	12.3.11	16	Tall open forest to open forest - *C. citriodora, E. siderophloia,*
13	BROOYAR	SF 82FTY 1310		12.9-10.17	16	*E. moluccana, E. fibrosa, E. acmenoides.*
13	CHERBOURG	SF 12FTY 1580		12.9-10.3	11	
13	Eurimbula National Park	278NPW193		12.9-10.19	9	
13	GLENBAR	SF 50FTY 1641		12.9-10.2	8	
13	GUNDIAH	SF 958FTY 1578		12.11.19	8	
13	LITTABELLA	SF 898FTY 1636		12.9-10.9	7	

13	Littabella National Park	301NPW121		12.9-10.21	6	
13	LOCKYER	SF 616FTY 1512		12.11.5	6	
13	ST MARY	SF 57FTY 1519				
13	STANTON	SF 832FTY 1631				
13	WARRAH	SF1294FTY 1705				
13	WARRO	SF 424FTY 1658				
13	WINTERBOURNE	SF 316FTY 1328				
14	BOOMPA	SF1344FTY 1534	11	12.9-10.3	3	Open forest - *E. moluccana, C. citriodora*; also notophyll rainforest to
Sub-group No.	**Lotname**	**Lotplan Number**	**Total RE**	**Major RE Recorded**	**Freq.**	**Vegetation Description**
14	BYRON	SF 893FTY 1532		12.12.16	2	mixed tall open forest and woodland.
14	Conondale National Park	102NPW513				
14	COOYAR	SF 289FTY 1640				
14	NUMINBAH	SF 702FTY 1554				
14	WARRO	SF 424FTY 1658				
14	WOOCOO	SF 38FTY 1396				
15	Great Sandy National Park	21NPW473	5	12.3.12	3	Open forest - *E. umbra, E. racemosa*; also *Banksia* woodland.
				12.2.6	2	
16	BANIA	SF 54FTY 1683	12	12.5.7	3	Tall woodland - *C. citriodora, Melaleuca quinquenervia* and open
16	BINGERA	SF 840FTY 1633		12.3.6	2	forest - *C. intermedia, E. umbra.*
16	Eurimbula National Park	278NPW193		12.5.12	2	
16	LITTABELLA	SF 898FTY 1636				
17	BOMPA	SF 391FTY 1007	18	12.11.3	6	Tall open forest - *E. siderophloia, E. propinqua, C. citriodora* and
17	BOOMPA	SF1344FTY 1534		12.12.3	5	grassy woodland - *E. crebra.*
17	BYRON	SF 893FTY 1532		12.11.7	4	
17	CONONDALE	SF 792FTY 1681		12.12.7	4	
17	KENILWORTH	SF1239FTY 1255				
17	KILKIVAN	SF 220FTY 457				
17	MANUMBAR	SF 639FTY 902				
17	ST MARY	SF 57FTY 1519				
17	WARRO	SF 424FTY 1658				
18	BOMPA	SF 391FTY 1007	15	12.3.11	3	Tall woodland/open forest - *C. citriodora, C. intermedia, E. siderophloia*;
18	GLENBAR	SF 50FTY 1641		12.5.7	3	also notophyll rainforest with eucalypt emergents.
18	GUNDIAH	SF 958FTY 1578		12.12.5	3	
18	GYMPIE	SF 700FTY 1491				
18	KILKIVAN	SF 220FTY 457				
18	Kroombit Tops National Park	435NPW457				
18	LITTABELLA	SF 898FTY 1636				
18	MANUMBAR	SF 639FTY 902				
19	BOMPA	SF 391FTY 1007	9	12.11.15	2	Tall open forest/open forest - *E. siderophloia, C. citriodora,*
19	GYMPIE	SF 700FTY 1491				*E. acmenoides.*

19	MANUMBAR	SF 639FTY 902				
19	Mount Barney National Park	737NPW495				
19	WINTERBOURNE	SF 316FTY 1328				
20	BYRON	SF 893FTY 1532	9	None dominant - 12.2.1,	All 1	Mixture including notophyll rainforest to mixed tall open forest -
20	COLINTON	SF 283FTY 1651		12.2.5, 12.9-10.7, 12.11.3,		*C. citriodora*, *E. siderophloia* and grassy woodland - *E. crebra*.
20	GOOMBOORIAN	SF 627FTY 409		12.11.5, 12.11.10, 12.11.16		
20	MARODIAN	SF 632FTY 625		12.12.3, 12.12.5		
20	Noosa National Park	340NPW511				
21	BINGERA	SF 840FTY 1633	6	12.12.5	3	Open forest/woodland - *C. citriodora*, *E. siderophloia*, *E. crebra*.
21	BOMPA	SF 391FTY 1007				
21	BROOYAR	SF 82FTY 1310				
Sub-group No.	**Lotname**	**Lotplan Number**	**Total RE**	**Major RE Recorded**	**Freq.**	**Vegetation Description**
21	MARODIAN	SF 632FTY 625				
21	WARRO	SF 424FTY 1658				
22	COLINTON	SF 283FTY 1651	5	None dominant - 12.8.14,	All 1	Grassy open forest/woodland - *C. citriodora*, *E. tereticornis*,
22	Lamington National Park	496NPW225		12.9-10.3, 12.9-10.7,		*E. moluccana*, *E. crebra*, *E. acmenoides*.
22	WINTERBOURNE	SF 316FTY 1328		12.9-10.21, 12.12.23		
23	Great Sandy National Park	21NPW473	10	12.12.5	4	Open forest/woodland - *C. citriodora*, *E. crebra*, *E. siderophloia*,
23	GUNDIAH	SF 958FTY 1578		12.3.11	3	*C. intermedia*.
23	MARODIAN	SF 632FTY 625		12.11.6	3	
23	WARRO	SF 424FTY 1658				
23	WINTERBOURNE	SF 316FTY 1328				
24	BANIA	SF 54FTY 1683	21	12.9-10.21	9	Open forest/woodland - *C. citriodora*, *E. crebra*, *E. acmenoides*,
24	BINGERA	SF 840FTY 1633		12.9-10.19	8	*E. fibrosa*, *E. moluccana*.
24	BOMPA	SF 391FTY 1007		12.11.6	7	
24	GYMPIE	SF 700FTY 1491		12.9-10.2	5	
24	LITTABELLA	SF 898FTY 1636				
24	LOCKYER	SF 616FTY 1512				
24	STANTON	SF 832FTY 1631				
24	WARRO	SF 424FTY 1658				
25	STANTON	SF 832FTY 1631	4	12.9-10.21	3	Open forest - *C. citriodora*, *E. acmenoides*, *E. fibrosa*.
				12.9-10.19	2	
26	BOMPA	SF 391FTY 1007	7	12.12.3	3	Tall open forest/woodland - *C. citriodora*, *E. siderophloia*, *E. fibrosa*.
26	Littabella National Park	301NPW121		12.12.5	2	
26	MARODIAN	SF 632FTY 625				
27	LITTABELLA	SF 898FTY 1636	7	12.9-10.19	2	Open forest - *C. citriodora*, *E. acmenoides*, *E. fibrosa*.
27	Main Range National Park	933NPW485		12.9-10.21	2	
27	STANTON	SF 832FTY 1631				
27	TARONG	SF 118FTY 1342				

Within each of the 27 sub-groups, there was a range of regional ecosystems present (Table 3.10), though some commonality existed between sites in each sub-group and between sub-groups in each of the two divisions. The first division (sub-groups 1-9) comprised sites in moist forest types - rainforest and tall open/wet sclerophyll forest (*Eucalyptus grandis, E. saligna, E. pilularis*) while in the second division (sub-groups 10-27) contained primarily dry open forest and woodland (*Corymbia citriodora, E. crebra, E. acmenoides*).

Few species were found to be closely associated, with low order branchings in the species dendrogram being rare (Appendix 14). There were only seven groups of three or more species where the branching was below the fusion level of 0.6. The lack of clearly defined species groups across the sites within the 27 major site sub-groups was also evident in the two-way matrix (Appendix 15). The only major conspicuous groupings were species found across most habitats (wet and dry) and those associated with either dry eucalypt/riparian or moist eucalypt/rainforest vegetation. Beyond sub-group 27, the classification tended to reflect a) selective sampling of particular taxonomic groups at particular sites (usually involving particular detection methods), e.g. bats (Anabat), small mammals (Elliott traps), small reptiles (pitfall traps) and frogs (watercourse searches), b) species detected at a few sites due to an association with features not used in the regional ecosystem definitions, e.g. acidic water and rocky outcrops, and c) species whose ranges just entered the region. The 27 sub-groups contained 397 or 87% of the species known from SEQ forests.

The size and complexity of the matrix in Appendix 15 makes it difficult to use. One way of extracting meaningful information is through maps based on the regional ecosystems attached to the sites. These maps could be of either sites grouped on the basis of similar species compositions (assuming the species listed for the site are typical of the assigned ecosystem), or of species that tend to be found together. Each map provides an estimation of the potential habitat available for the species groups in a more comprehendible fashion that through a list of sites.

Figure 3.12A and B are the regional ecosystem maps for site sub-groups comprising wet forest (sub-group 5) and dry forest (sub-group 21) sites and defines areas with broadly similar species compositions (Table 3.12). Using these two sub-group examples one can then analyse the distribution of potential habitat by tenure (Table 3.13). The wet forest sub-group is spread throughout the region and an estimated 13.9% of the habitats used by the species involved are in reserves. In contrast, the dry forest sub-group whose habitats are concentrated in the northern inland is almost completely unrepresented in National Parks. These results confirm the initial indication of reservation through the list of sites in each sub-group with one National Park site in sub-group 5 but none in sub-group 21 (Table 3.11).

TABLE 3.12 SPECIES FOUND IN SITE AND SPECIES SUB-GROUPS CLASSIFIED IN THE PATN ANALYSIS AND USED AS THE BASIS FOR FIGURES 3.12A,B AND 3.13A,B.

Sub-group	Species
Sites	
Wet forest	*Hemisphaeriodon gerrardii, Lampropholis adonis, Cacophis squamulosus, Rhinoplocephalus nigrescens, Alectura lathami, Columba leucomela, Macropygia amboinensis, Leucosarcia melanoleuca, Ptilinopus magnificus, Lopholaimus antarcticus, Cacatua galerita, Trichoglossus haematodus, T. chlorolepidotus, Alisterus scapularis, Cacomantis flabelliformis, Chrysococcyx lucidus, Ninox novaeseelandiae, Tyto tenebricosa, T. novaehollandiae, Podargus strigoides, P. ocellatus plumiferus, Aegotheles cristatus, Dacelo novaeguineae, Pitta versicolor, Cormobates leucophaeus, Climacteris erythrops, Malurus lamberti, Pardalotus punctatus, P. striatus, Sericornis citreogularis, S. frontalis, S. magnirostris, Gerygone mouki, Acanthiza pusilla, Meliphaga lewinii; Lichenostomus chrysops, Melithreptus albogularis, M. lunatus, Acanthorhynchus tenuirostris, Myzomela sanguinolenta, Eopsaltria australis, Psophodes olivaceus, Pachycephala pectoralis, Colluricincla harmonica, Rhipidura rufifrons, R. fuliginosa, Coracina novaehollandiae, Strepera graculina, Ptiloris paradiseus, Ailuroedus crassirostris, Ptilonorhynchus violaceus, Dicaeum hirundinaceum, Zosterops lateralis, Phascolarctos cinereus, Pseudocheirus peregrinus, Trichosurus caninus, Wallabia bicolor, Rhinolophus megaphyllus, Miniopterus australis, Nyctophilus bifax, Vespadelus pumilus, Melomys cervinipes, Canis lupus dingo.*
Dry forest	*Limnodynastes tasmaniensis, Pseudophryne coriacea, Pseudophryne major, Litoria lesueuri, Carlia vivax, Dromaius novaehollandiae, Aquila audax, Burhinus grallarius, Trichoglossus haematodus, Glossopsitta pusilla, Alisterus scapularis, Ninox novaeseelandiae, D. novaeguineae, P. striatus, Philemon corniculatus, P. citreogularis, Entomyzon cyanotis, Lichenostomus chrysops, L. melanops, Melithreptus gularis, M. albogularis, M. lunatus, Lichmera indistincta, M. sanguinolenta, Pachycephala rufiventris, Myiagra rubecula, Grallina cyanoleuca, Rhipidura fuliginosa, R. leucophrys, Cracticus nigrogularis, Corvus orru, Tachyglossus aculeatus, Isoodon macrourus, Petaurus australis australis, Petauroides volans, Macropus parryi, Mormopterus beccarii*.
Species	
Restricted	*Notechis scutatus, Menura alberti, Atrichornis rufescens, Pachycephala olivacea, Cercartetus nanus.*
Widespread	*C. leucophaeus, P. punctatus, S. frontalis, A. pusilla, M. lewinii, L. chrysops, E. australis, P. olivaceus, P. pectoralis, C. harmonica, R. fuliginosa, S. graculina.*

Figure 3.13A and B are maps for two species associations, one of restricted habitat specialists (sub-group 8) recorded at a few sites and the other of widespread habitat generalists (part of sub-group 18) found in numerous sites (Table 3.12), and defines areas where each of these species groups are found. These maps can be assessed in the same way as the site sub-group maps. The restricted sub-group appears to be well reserved with 50.7% of potential habitat in National Park. While the widespread sub-group has only 16.3% of it potential habitat reserved. However, in absolute terms this equates to 205,601ha or 58% of all current National Park forests (Table 3.13).

TABLE 3.13 POTENTIAL HABITAT BY TENURE THAT MAY BE USED BY SPECIES ASSOCIATIONS DEFINED AS WET AND DRY FOREST SITE SUB-GROUPS AND RESTRICTED AND WIDESPREAD SPECIES SUB-GROUPS (SPECIES IN EACH SUB-GROUP LISTED IN TABLE 3.12 AND DISTRIBUTIONS SHOWN IN FIGURES 3.12 & 3.13, PERCENTAGES GIVEN IN PARENTHESES).

Tenure	Area of Potential Habitat per Sub-group (ha)			
	Wet	Dry	Restricted	Widespread
National Park	4.060 (13.9)	0.18 (0)	18,175 (50.7)	205,601 (16.3)
State Forest	18,364 (63.0)	41, 199 (35.6)	5,864 (16.4)	465,951 (37.0)
Other Crown Land[a]	1,346 (4.6)	23,997 (20.7)	789 (2.1)	116,714 (9.4)
Non-Crown Land[b]	5,372 (18.5)	50,494 (43.7)	11,037 (30.8)	469,547 (37.3)

[a] - includes those tenures listed in Table 2.1 apart from NP, NPP, SF, TR and OTH.

[b] - includes Crown tenures listed as OTH in Table 2.1 and freehold title.

Priority Species

Appendix 16 describes the distribution of 10 priority species sub-groups among the 22 site sub-groups classified in the PATN analysis. Only sites with two or more priority species were used.

Sites in National Parks were present in 18 of the site sub-groups. For three groups nearly all the sites were in reserves (sub-group 4 - Great Sandy, Conondale & Kroombit NP; 5 - Lamington NP; 6 - Moreton & Great Sandy NP) and accounted for most of the records for two species sub-groups (7 - *Assa darlingtoni, Lechriodus fletcheri, Philoria loveridgei* & *Pachycephala olivacea*; and 9 - *Rhadinocentrus ornatus, Pseudomugil mellis, Nannoperca oxleyana* & *Litoria cooloolensis*) and for two species in sub-group 2 (*Nyctimene robinsoni* & *Syconcyteris australis*) (Appendix 19).

The areas without National Park representation (sub-groups 11, 12, 17 & 20) were typically inland State Forests in the north and central parts of the region, e.g. Winterbourne, Stanton, Cherbourg, Brooyar, Gundiah and Toolara. For three areas, the species common to all sites within each sub-group were from the species sub-group 3 (site sub-group 11 - *Lichenostomus melanops*, 12 - *Ctenotus arcanus*, 20 - *Petaurus australis australis* & *Petauroides volans*). Many of the taxa in the species sub-groups 1, 2 and 3 were spread across most of the site sub-groups. *Petaurus australis australis* and *P. volans*, in particular, were recorded in other site sub-groups (Appendix 16). Site sub-group 17 comprised sites located in remnant vegetation in pine plantations and were the only places where *Maccullochella peelii mariensis* and *Neoceratodus forsteri* (species sub-group 10) were recorded together.

Endemic Species

Inspection of the site and species dendrograms revealed that the data for endemic species could be classified into 18 and 14 sub-groups respectively (Appendix 17). In the analysis, single record sites were not used which resulted in a relatively small dataset. Most site sub-groups contained sites that were either all State Forest (10 sub-groups) or all National Park (4 sub-groups). Given that endemics were largely a subset of the priority category it was not unexpected that certain patterns were repeated, e.g. particular fish and frog species were confined to coastal and montane National Parks (species sub-groups 1, 4, 13 & 14 in site sub-groups 6, 13, 8 & 9 respectively; Appendix 17).

Among the other species sub-groups, especially 6 and 9, individual taxa were recorded across numerous site sub-groups although 9 (*Ctenotus arcanus, Eulamprus martini* & *Lampropholis amicula*) had little National Park representation (1 of 35 sites). Most of the sites where this species association was found were in the north and central inland (Winterbourne, Manumbar, Monsildale and Gundiah).

Threatened Species

Again the masking procedure for the PATN analysis meant that the data for endangered and vulnerable species (where ≥ 2 spp/site) were limited. The analysis used only 17 species from 44 sites resulting in 12 site sub-groups and 6 species sub-groups (Appendix 18).

While the “acidic water” fauna (certain freshwater fish and frogs - sub-groups 5 & 6) were concentrated in coastal National Parks (sub-groups 10-12) and some other species combinations occurred in an upland reserve (*Litoria pearsoniana* & *Podargus ocellatus plumiferus* in Conondale NP), most other associations were only in State Forests (species sub-groups 1, 2, 3 and part of 4). The areas with these species groups were in the north (Winterbourne & Bompa) and south-west (East Haldon).

Blackdown Tableland

Due to the absence of a regional ecosystem coverage for Blackdown Tableland at the time of the analysis, it was not assessed with the rest of the region. In the tenure analysis, Blackdown National Park and State Forest were found to be similar to each other and to a range of State Forests in the central and northern inland part of the region, including Warro SF424, Stanton SF832, Warrah SF1294 and Cherbourg SF12 (Fig. 3.6). The majority of species listed for Blackdown were typical of dry forest habitats and were similar to the species found in site sub-group 13 (Table 3.11; Appendix 15), especially Gundiah SF958 and to a lesser extent Warro SF424, Littabella SF898, Stanton SF 832, Cherbourg SF12, Warrah SF1294 and Glenbar SF50. Forests in this sub-group were predominantly tall open to open forest dominated by *Corymbia citriodora* and/or a number of *Eucalyptus* species which matches in general terms the regional ecosystems found in Blackdown, i.e. 11.10.5 and 11.10.13 - tall open to open forest with several *Corymbia* and *Eucalyptus* species (e.g. *C. bunites, C. trachyphloia, E. sphaerocarpa, E. cloeziana*; Young *et al.* in press).

The close affinities between Blackdown and the various State Forests listed above was also evident in a range of priority taxa, e.g. *Paradelma orientalis, Geophaps scripta scripta, Petrogale herberti, Taphozous georgianus, Chalinolobus picatus, Vespadelus troughtoni* and *Pseudomys patriu*, present in Blackdown that also have northern and/or western distributions in SEQ CRA region. [Most of these taxa have ranges extending well beyond the region.] The priority taxa found on the tableland were similar to those recorded at sites in Marodian SF632, Winterbourne SF316 and Warrah SF 1294.

Despite these similarities, Blackdown Tableland also exhibited a degree of faunal uniqueness compared to the rest of south-east Queensland. The area provided the only regional records for *Nephrurus asper, Eulamprus sokosoma, Pyrrholaemus brunneus, Manorina flavigula, Hipposideros ater, Scotorepens sanborni* (unconfirmed) and *Sminthopsis macroura*. The presence of these more typically western or northern species was not surprising given the area's situation as an "island" within the Brigalow Belt South bioregion.

Functional Associations

The preceding analyses examined the distribution of groups of species classified by the extent they associated with each other or shared certain tenures, or habitat types (regional ecosystems). Another way of investigating faunal patterns was to create species associations/assemblages/guilds based on some feature common to all species placed in a group and relevant to the study in general. Due to time constraints only one assemblage was selected to explore the usefulness of this approach. The group chosen was arboreal marsupials - species dependent on trees for food and shelter (most specifically use hollows) and considered vulnerable to effects of major forest disturbances, i.e. fire and timber harvesting. The animals included in this group were *Phascolarctos cinereus*, *Petaurus australis australis*, *P. breviceps*, *P. norfolcensis*, *Petauroides volans*, *Pseudocheirus peregrinus*, *Trichosurus caninus*, *T. vulpecula*, *Cercartetus nanus* and *Acrobates pygmaeus*.

Potential areas of high arboreal marsupial diversity, indicated by the number of species recorded in various regional ecosystems, were spread across the SEQ CRA region (Fig. 3.14). The distribution of possible habitat by tenure revealed that National Parks contained relatively large areas of low richness (1-2 spp.) while for the other diversity classes most of the habitat was in State Forest (Table 3.14).

TABLE 3.14 RELATIONSHIP BETWEEN ARBOREAL MARSUPIAL RICHNESS AND POTENTIAL HABITAT ON VARIOUS LAND TENURES. BASED ON DISTRIBUTIONS ILLUSTRATED IN FIGURE 3.14 (PERCENTAGES GIVEN IN PARENTHESES AND TENURE CATEGORIES AS PER TABLE 3.13).

Tenure	Area of Potential Habitat (ha) with Arboreal Marsupial Species Numbering			
	1 - 2	3 - 5	6 - 7	8
National Park	199,691 (31.8)	46, 948 (14.5)	16,383 (5.2)	8,802 (12.6)
State Forest	156,455 (24.9)	147,256 (45.6)	142,379 (45.9)	30,871 (44.1)
Other Crown Land	55,829 (8.8)	16,788 (5.3)	31,712 (10.2)	1,832 (2.5)
Non-Crown Land	216,726 (34.5)	111,745 (34.6)	119,521 (38.6)	28,568 (40.8)

Four individual species from the assemblage were mapped (Fig. 3.15). Those used were two species regularly found in surveys (>75 records - *P. australis australis* and *P. volans*) and two noted less often (<45 records - *P. norfolcensis* and *T. caninus*). All species had reasonable areas of potential forest habitat within National Parks although as a percentage of that available throughout the region the amounts ranged from 6.7 to 22.6% (Table 3.15).

TABLE 3.15 POTENTIAL HABITAT AREA BY TENURE FOR SPECIFIC ARBOREAL MARSUPIALS. DISTRIBUTIONS ILLUSTRATED IN FIGURE 3.15, PERCENTAGES GIVEN IN PARENTHESES AND TENURE CATEGORIES AS PER TABLE 3.13). ALSO THE PERCENTAGE OF TEST RECORDS FOR EACH SPECIES THAT COINCIDED WITH PREDICTED DISTRIBUTIONS (TOTAL NUMBER OF RECORDS GIVEN IN PARENTHESES).

Tenure	Area of Potential Habitat (ha) for			
	P. australis	***P. volans***	***P. norfolcensis***	***T. caninus***
National Park	73,735 (8.7)	45,405 (6.7)	93,303 (22.6)	49,070 (15.9)
State Forest	452,438 (53.4)	394,933 (58.7)	137,789 (33.4)	144,825 (46.8)
Other Crown Land	66,718 (7.9)	37,677 (5.6)	53,733 (13.0)	5,993 (1.9)
Non-Crown Land	254,681 (30.0)	195,248 (29.0)	127,710 (31.0)	109,685 (35.4)
Percentage of Correct Test Records using Datasets:				
with NatureSearch	90.3 (72)	77.2 (162)	50.3 (143)	86.7 (150)
w/o NatureSearch	76.0 (25)	81.7 (82)	32.2 (31)	87.0 (23)

The usefulness of the predicted distributions and their subsequent interpretation depends on their reliability. As a measure of this for each species, point-location data (>500m and <5000m precision, reported since 1975 and from forested land) not used to create the regional ecosystem maps (Fig. 3.15), were intersected with predicted distributions. Two datasets were used - one with NatureSearch records (provided a reasonable number of records but had an inherent spatial bias toward the south-east corner in largely disturbed habitat where forest remnants may not have been mapped), and one without NatureSearch data (severely restricted the number of records available but reduced spatial/habitat bias). A buffer of 5000m was included around the mapped regional ecosystem polygons to account for the broad precision values attached to some records.

Irrespective of the datasets used, three of the four species consistently scored above 75% for the number of test records in or within 5km of the distribution predicted by the regional ecosystem coverage (Table 3.15). Agreement between test records and distribution for *P. norfolcensis* was low in both assessments which, to some extent, could be explained by the difficulties in detecting this species (poor eyeshine and tendency to be in upper canopy) compared to other gliders (Eyre & Venz 1998).

3.3 PRIORITY AND SECONDARY ASSESSMENT TAXA

Given that some 192 species were assessed (155 priority and 37 secondary assessment), to avoid the creation of a single massive document the individual taxon summaries are provided in the Attachment.

Examination of the reservation status and requirements of individual taxa assessed in the Attachment revealed a number of important points (Table 3.16). Irrespective of whether the taxon was priority or secondary assessment, it was apparent that:
a) the majority required more conservation action - actual increase in reserve area, combined on- and off-reserve management or assessment in other bioregions;
b) for those requiring reservation increases, the habitats most needed were mixed dry forest and *Corymbia citriodora* dry forest (and wet sclerophyll forest for several priority taxa); and,
c) the areas where reserves appear to be most needed were in the northern inland and western parts of the SEQ CRA region, as well as coastal areas for some priority taxa.

In both the focal habitats and focal areas identified in Table 3.16, several taxa were recorded in more than one category.

TABLE 3.16 SUMMARY OF THE RESERVATION STATUS AND REQUIREMENTS (HABITAT TYPE AND GENERAL LOCATIONS) FOR PRIORITY AND SECONDARY ASSESSMENT TAXA. IN THE FOCAL HABITATS AND AREAS SOME SPECIES REQUIRED RESERVATION IN SEVERAL CATEGORIES (PERCENTAGES GIVEN IN PARENTHESES).

Reservation Characteristic	Number of Taxa	
	Priority	Secondary
Reservation Category		
Reserved	20 (13)	3 (8)
More reservation required	100 (64)	31 (84)
SEQ on- and off-reserve action	21 (4)	3 (8)
Non-SEQ assessment	14 (9)	0 (0)
TOTAL	155	37
Focal Habitats for Future Reserves		
Upland rainforest (6a)	17 (7)	6 (9)
Lowland rainforest (6b)	19 (9)	6 (9)
Araucarian rainforest (6c)	16 (7)	5 (7)
Semi-evergreen Vine Thicket (6d)	3 (1)	0 (0)
Wet sclerophyll forest (1a, 1b, 2)	31 (14)	5 (7)
Corymbia citriodora forest (3a, 3b)	26 (12)	12 (18)
Mixed dry forest (4a)	42 (19)	26 (38)
Eucalyptus tereticornis forest (4b)	8 (4)	1 (2)
Coastal dry forest (5a)	11 (5)	1 (2)
Western dry forest (5b)	23 (10)	3 (4)
Other (wallum, mangrove, etc.)	13 (6)	0 (0)
Waterbodies & river catchments	14 (6)	3 (4)
Focal Areas for Future Reserves		
Northern inland	33 (43)	18 (62)
Central inland	10 (13)	4 (14)
Southern	3 (4)	0 (0)
Western	13 (17)	7 (24)
Coastal	14 (18)	0 (0)
South-western corner	4 (5)	0 (0)

With respect to the various status criteria applied in selecting priority taxa, again most of the species fell into the more reservation or on- and off-reserve action categories (Table 3.17).

TABLE 3.17 DISTRIBUTION OF PRIORITY TAXA AMONG STATUS CRITERIA BY RESERVATION CATEGORY (AT RISK = ENDANGERED, VULNERABLE, RARE AND THOSE AFFECTED BY FOREST DISTURBANCES). SEVERAL TAXA INCLUDED IN MORE THAN ONE RESERVATION CATEGORY.

Reservation	Number of Taxa in Status Criteria			
Category	At Risk	Endemic	Relictual	Cultural
Reserved	16	10	1	0
More reservation	99	25	1	1
On- and off-reserve action	21	4	1	1
Non-SEQ assessment	14	0	0	0

For 25% of the taxa (16 priority and 17 secondary assessment) requiring increased reservation (n = 131), the added area was needed to address the representativeness criterion. At face value (percentage of known localities in National Park), these taxa would have been considered reserved but not all the habitats they use occurred within the current conservation estate. This was particularly true for those secondary assessment taxa included as examples of the migratory bird assemblages, where eight of the ten did not have reserves in all areas visited at some time of the year.

A number of priority taxa were largely found outside National Parks and State Forests. Tenures, such as State Reserve and Unallocated State Land contained significant proportions of known records for *Litoria* sp. cf. *cooloolensis, Egernia modesta, Macropus agilis, Wallabia bicolor welsbyi* and *Xeromys myoides*. Several taxa were known mostly from non-Crown land, e.g. *Limnodynastes salmini, Varanus semiremex* and *Egernia rugosa*. Some species, such as *Maccullochella peelii mariensis* and *Ramphotyphlops silvia*, were recorded from remnant native habitat in exotic pine plantations (e.g. Poona SF915 & Toolara SF1004).

The majority of taxa assessed under the secondary assessment category were not found to warrant any upgrade to priority status. For many, the reservation category assigned addressed a representativeness deficiency for that taxa. However, for a number of taxa their level of reservation or extent on Crown tenure was low enough to merit consideration of priority status. The species were *Egernia modesta, Simoselaps australis, Scotorepens orion* and *Pseudomys gracilicaudatus*

(Attachment pg. 63, 92, 231 & 238). [Those priority taxa listed as reserved in the Attachment should remain priority given that for most, threatening processes still need to be addressed through appropriate management and this management is irrespective of tenure.]

Among poorly reserved species (occur on ≤ 2 National Parks) that were not assessed under either priority or secondary assessment categories, most were more widespread outside of the SEQ CRA region particularly to the north and west. Only *Saltuarius salebrosus* might be of some concern. Those more common to the south lay outside Queensland jurisdiction and so their distribution in the State was restricted and hence may be of State significance. The species included *Limnodynastes dumerilii, Amphibolurus muricatus, Egernia cunninghamii, E. mcpheei, E. saxatilis, E. whitii, Hylacola pyrrhopygia* and *Anthochaera carunculata.* All except *E. mcpheei* were probably best addressed through reservation and management in Brigalow Belt South, New England Tableland and Nandewar bioregions. *Egernia mcpheei* was confined to the Queensland-New South Wales border ranges, e.g. Mt Barney, and could be considered reserved given the area of National Park within its known distribution.

3.4 RESERVE OPTION EXAMPLE

The option process was not automated and hence was inefficient timewise. However, this approach more readily enabled the incorporation of a wide range of values from the landscape level (tenure based diversity indices, habitat and geographical representativeness) through to species associations and down to individual taxa and genetically distinct populations.

Table 3.18 lists the areas of conservation value from a faunal perspective. Apart from allocating the selected areas to the two categories (CAR and AR), no attempt is made to rank the importance of each area. As in any iterative type process the significance of the next site chosen is contextual, i.e. dependent on the values in areas already selected and the types of values being targeted. While the whole State Forest is named, the actual area of interest, in most cases, relates to only part of the forested area. Comprehensiveness, adequacy and representativeness are addressed in that order.

TABLE 3.18 FAUNAL VALUES CAPTURED BY THE CROWN LAND AREAS CHOSEN IN EXAMPLE RESERVE SELECTION PROCESS. CAR - CONTRIBUTES TO COMPREHENSIVENESS (C), ADEQUACY (A) & REPRESENTATIVENESS (R) FOR ALL FAUNA CONSIDERED. GENETIC UNITS FROM MORITZ & PLAYFORD (1998). SPECIES SIMILARITY BASED ON SUB-GROUPS IDENTIFIED BY PATN ANALYSIS - SAME LETTER INDICATES SAME SUB-GROUP (FIG. 3.6 - 3.9); DIVERSITY LEVEL BASED ON INDICES (FIG. 3.2 - 3.5); HABITAT AND GEOGRAPHY VALUES DERIVED FROM PRIORITY & SECONDARY ASSESSMENT TAXA ANALYSIS (TABLE 3.16) AND KNOWN GAPS IN CURRENT NATIONAL PARK ESTATE (FIG. 4.1).

	Location	Priority Taxa			Secondary	Other taxa	Genetic	Species	Habitat	Geography	Diversity level
		Comprehensiveness	Adequacy	Representativeness	Assessment	(comprehen.)	variation	similarity			
CAR	Winterbourne 316 (Kroombit)	*Litoria* sp. cf. *barringtonensis, Hipposideros semoni, Vespadelus troughtoni*	*Litoria* sp. cf. *barringtonensis, Taudactylus pleione, Geophaps scripta scripta, Hipposideros semoni, Vespadelus troughtoni, Pseudomys patrius*	44 taxa, northern isolates of *Hoplocephalus stephensii, Tyto tenebricosa, Ptiloris paradiseus, Sericulus chrysocephalus*	23 taxa including all 11 migratory bird spp.	*Cyclorana novaehollandiae*	Kroombit Tops unit	All spp - A Priority - J Endemic - Q Threat. - a	Upland cool rainforest, wet and dry eucalypt forest (2, 4a, 6a).	North western	All species: HIGH Priority: VERY HIGH Endemic: MEDIUM Threatened: LOW
CAR	Bompa 391 (Bulburin)	*Jalmenus evagoras eubulus Phyllurus caudiannulatus,*	*Jalmenus evagoras eubulus Phyllurus caudiannulatus, Geophaps scripta scripta*	35 taxa, northern isolates/limits of *Cyclopsitta diophthalma coxeni, Podargus ocellatus plumiferus, Potorous tridactylus*	22 taxa including all 11 migratory bird spp.	*Calyptotis temporalis, Corvus bennetti*	D'Aguilar-Bulburin unit	All spp - A Priority - J Endemic - Q Threat. - b	Araucarian rainforest, mixed and dry eucalypt forest (3b, 4a, 6c)	North western	All species: HIGH Priority: HIGH Endemic: MEDIUM Threatened: MEDIUM
CAR	Nangur 74	*Nangura spinosa*	*Nangura spinosa*	10 taxa including *Turnix melanogaster*	11 taxa including 7 migratory bird spp.	*Menetia greyii*		All spp - B Priority - K Endemic - R Threat. - c	Semi-evergreen vine thicket and dry/western eucalypt forest (3b, 5b, 6d)	Central western	All species: LOW Priority: LOW Endemic: MEDIUM Threatened: VERY LOW

	Location	Priority Taxa			Secondary	Other taxa	Genetic	Species	Habitat	Geography	Diversity level
		Comprehensiveness	Adequacy	Representativeness	Assessment	(comprehen.)	variation	similarity			
C A R	Lockyer 616 (Helidon Hills)	*Hemiaspis daemelii*	*Delma torquata, Hemiaspis daemelii, Chalinolobus picatus*	16 taxa, inlcuding *Erythrotriorchis radiatus, Potorous tridactylus, Petrogale penicillata*	13 taxa including all 11 migratory bird spp.			All spp - C Priority - M Endemic - T Threat. - a	Wet to mixed eucalypt forest (2,12)	South western	All species: HIGH Priority: MEDIUM Endemic: LOW Threatened: MEDIUM
C A R	Warro 424	*Menetia timlowi*	*Menetia timlowi, Vespadelus troughtoni, Pseudomys patrius*	14 taxa including *Chlamydosaurus kingii*	9 taxa including 2 migratory bird spp.			All spp - C Priority - L Endemic - S Threat. - d	Dry eucalypt forest (3b, 4a)	North sub-coastal	All species: MEDIUM Priority: MEDIUM Endemic: VERY LOW Threatened: LOW
C A R	Kunioon 117 (Archookoora)	*Furina dunmalli*	*Furina dunmalli, Hoplocephalus bitorquatus*	5 taxa including *Pseudechis guttatus*				All spp - D Priority - N Endemic - U Threat. - a	Mostly *Araucaria* plantation	Central western	All species: VERY LOW Priority: LOW Endemic: 0 Threatened: VERY LOW
C A R	Gundiah 958 (Bauple)	*Elseya* sp. cf. *dentata*	*Elseya* sp. cf. *dentata*	17 taxa	14 taxa including 6 migratory bird spp.			All spp - C Priority - L Endemic - Q Threat. - e	Dry eucalypt forest (3b, 4a)	Central sub-coastal	All species: MEDIUM Priority: MEDIUM Endemic: LOW Threatened: VERY LOW
C A R	East Haldon 750 (Goomburra)		*Philoria kundagungan*	29 taxa including *Mixophyes fleayi, Atrichornis rufescens, Pachycephala olivacea, Dasyurus maculatus maculatus*	18 taxa including 9 migratory bird spp.	*Limnodynastes dumerilii*	Main Range unit	All spp - A Priority - O Endemic - V Threat. - b	Upland cool rainforest and wet eucalypt forest (1a, 6a)	South-west corner	All species: VERY LOW Priority: LOW Endemic: VERY LOW Threatened: LOW

	Location	Priority Taxa Comprehensiveness	Adequacy	Representativeness	Secondary Assessment	Other taxa (comprehen.)	Genetic variation	Species similarity	Habitat	Geography	Diversity level
CAR	Stanton 832 (Cordalba)		*Chalinolobus picatus*	15 taxa including northern limit of *Litoria brevipalmata*	16 taxa including 8 migratory bird spp.	*Rhinoplocephalus boschmai, Simoselaps australis*		All spp - C Priority - L Endemic - W Threat. - d	Dry eucalypt forest (3b, 4a, 5b)	North sub-coastal	All species: MEDIUM Priority: LOW Endemic: 0 Threatened: VERY LOW
CAR	Cherbourg 12 (Wondai)		*Menetia timlowi*	15 taxa including *Turnix melanogaster, Chalinolobus picatus*	7 taxa including 3 migratory bird spp.	*Chrysococcyx osculans, Scotorepens balstoni*		All spp - C Priority - L Endemic - X Threat. - e	Dry eucalypt forest (3b)	Central western	All species: MEDIUM Priority: MEDIUM Endemic: VERY LOW Threatened: VERY LOW
CAR	Cooyar 289 (Yarraman)		*Grantiella picta, Vespadelus vulturnus*	19 taxa including western limit of *Litoria brevipalmata*	19 taxa including 9 migratory bird spp.	*Turnix velox*		All spp - C Priority - P Endemic - T Threat. - d	Mostly *Araucaria* plantation with some rainforest (6c)	Central western	All species: HIGH Priority: MEDIUM Endemic: LOW Threatened: VERY LOW
CAR	Bania 54			27 taxa	23 taxa including all 11 migratory bird spp.	*Diplodactylus steindachneri, Oedura marmorata*	Bania unit	All spp - A Priority - J Endemic - Q Threat. - d	Araucarian rainforest and dry eucalypt forest (3b, 4a, 6c)	North western	All species: VERY HIGH Priority: VERY HIGH Endemic: MEDIUM Threatened: LOW

	Location	Priority Taxa			Secondary	Other taxa	Genetic	Species	Habitat	Geography	Diversity level
		Comprehensiveness	Adequacy	Representativeness	Assessment	(comprehen.)	variation	similarity			
CAR	Gilbert 327 (Spicer's Gap)			8 taxa including *Dasyornis brachypterus*	9 taxa including 6 migratory bird spp.	*Lichenostomus penicillatus*	Main Range unit	All spp - E Priority - M Endemic - Y Threat. - f	Wet and dry eucalypt forest (2a, 4a)	South-west corner	All species: LOW Priority: LOW Endemic: VERY LOW Threatened: VERY LOW
CAR	Four SR and USL lots		*Argyreus hyperbius inconstans,*	1 taxon		*Egernia modesta*				Scattered	
AR	Two SR		*Acrodipsas illidgei*	1 taxon	1 taxon					Scattered	
AR	Assorted SR USL on North Stradbroke Is.		*Litoria* sp. cf. *cooloolensis,* *Macropus agilis,* *Wallabia bicolor welsbyi,* *Xeromys myoides*	14 taxa including *Ophioscincus truncatus*	4 taxa including 4 migratory bird spp.			All spp - F Priority - N Endemic - Z Threat. - g	Dry eucalypt and non-eucalypt forest (5a, 9)	South coast	All species: VERY LOW Priority: LOW Endemic: VERY LOW Threatened: LOW
AR	Kilkivan 220 (Oakview)		*Phyllurus caudiannulatus,* *Nangura spinosa*	12 taxa including *Ophioscincus ophioscincus*	12 taxa including 8 migratory bird spp.			All spp - G Priority - O Endemic - Y Threat. - e	Mixed eucalypt forest and araucaria plantation (12)	Central inland	All species: LOW Priority: LOW Endemic: LOW Threatened: VERY LOW
AR	Grongah 67			10 taxa including *Delma torquata,* *Pseudomys patrius*	8 taxa including 3 migratory bird spp.		D'Aguilar-Bulburin unit	All spp - B Priority - O Endemic - T Threat. - f	Araucarian rainforest and dry eucalypt forest (5b, 6c)	Central inland	All species: LOW Priority: LOW Endemic: MEDIUM Threatened: LOW

	Location	Priority Taxa			Secondary	Other taxa	Genetic	Species	Habitat	Geography	Diversity level
		Comprehensiveness	Adequacy	Representativeness	Assessment	(comprehen.)	variation	similarity			
AR	Emu Vale 661 (Gambubal)		*Cautula zia, Chalinolobus dwyeri*	11 taxa including *Dasyurus maculatus maculatus, Pseudomys oralis*	6 taxa including 4 migratory bird spp.		Main Range unit	All spp - H Priority - P Endemic - Y Threat. - h	Upland cool rainforest (6a)	South-west corner	All species: VERY LOW Priority: LOW Endemic: VERY LOW Threatened: LOW
AR	Blackdown 175	*Scotorepens sanborni* (unconfirmed)	*Anomalopus brevicollis, Vespadelus troughtoni*	12 taxa including *Nesolycaena albosericea, Adelotis brevis*	9 taxa including 3 migratory bird spp.		Blackdown unit	All spp - C Priority - L Endemic - R Threat. - i	Dry eucalypt forest (ecosystems 11.10.5 & 11.10.13)	North-west outlier	All species: LOW Priority: LOW Endemic: VERY LOW Threatened: VERY LOW
AR	Tarong 118		*Anomalopus leuckartii, Vespadelus vulturnus*	10 taxa	5 taxa including 2 migratory bird spp.			All spp - C Priority - O Endemic - R Threat. - c	Dry eucalypt forest (5b)	Central western	All species: HIGH Priority: MEDIUM Endemic: LOW Threatened: VERY LOW
AR	Maleny 783		*Maccullochella peelii mariensis, Rheobatrachus silus*	9 taxa including *Litoria pearsoniana, Erythtotriochis radiatus, Podargus ocellatus plumiferus*	4 taxa including 2 migratory bird spp.		D'Aguilar-Bulburin unit	All spp - I Priority - J Endemic - Q Threat. - j	Lowland rainforest and wet eucalypt forest (1b, 6a)	Central sub-coastal	All species: VERY LOW Priority: LOW Endemic: LOW Threatened: LOW
AR	Dundas 1355 (Brisbane Forest Park)		*Delma plebeia, Pseudechis guttatus*	49 taxa including *Litoria pearsoniana, Climacteris erythrops*	32 taxa including all 11 migratory bird spp.		D'Aguilar-Bulburin unit	All spp - A Priority - J Endemic - Q Threat. - b	Lowland rainforest and dry eucalypt forest (3b, 4a, 6a)	South sub-coastal	All species: HIGH Priority: VERY HIGH Endemic: HIGH Threatened: MEDIUM

3.4.1 Comprehensiveness

The number of taxa used in the selection process totaled 478 (66 omitted on the basis of the criteria listed in 2.2.4) of which 94.8% had already been recorded on at least one National Park. The addition of the 13 State Forests and 2 State Reserves listed with the CAR code in Table 3.18 would result in 100% of the reservable taxa, either as individual species or species associations, being found in a conservation area.

3.4.2 Adequacy

The inclusion of parts of another seven State Forests and several State Reserves and Unallocated State Lands (mostly coastal and North Stradbroke Island) (Table 3.18) increased the number of taxa found on three or more conservation areas from 80.5% to 95.2%.

Of the 23 taxa failing the adequacy objective 4 were known from only one Crown Land area and 19 from two areas. Among the seven priority taxa, two (*Neoceratodus forsteri* & *Maccullochella peelii mariensis*) were recorded in streams in exotic pine plantations (Poona 915, Toolara 1004 & Neerdie 1419), three others from single State Forests (*Dasyurus hallucatus* - Neumgna 151; *Cercartetus nanus* - Melcombe 735; *Nyctophilus timoriensis* - Bribie 561) and two (*Anomalopus leuckartii* & *Lathamus discolor*) were on non-State Forest Crown Lands, e.g. State Reserves, Unallocated State Land, Term Lease and Freeholding Lease. The 16 non-priority taxa were spread over a range of State Forests (*Craterocephalus marjoriae* - Brooyar 82; *Litoria alboguttata* - Toolara 1004; *Egernia whitii* - Conondale 274; *Rhinoplocephalus boschmai* - Bribie 561; *Hamirostra melanosternon* & *Mormopterus loriae* - Manumbar 639; *Falco subniger* & *Chrysococcyx osculans* - Moggill 494; *Turnix velox* & *Coracina maxima* - Kenilworth 1239; *Melopsittacus undulatus* - Enoggera 309; and *Chlamydera maculata* - Bunya 69) and non-State Forest lands (*Pseudonaja nuchalis, Suta spectabilis, Elanus scriptus* & *Conopophila rufogularis*). So, even including all known locations of some species would still not achieve the prescribed adequacy level.

In terms of species richness, the option outlined in Table 3.18 would also result in a greater sampling of those areas high in both total species and priority taxa (Table 3.19).

Those locations in Table 3.18 coded as CAR were considered almost irreplaceable if comprehensiveness, i.e. all typical SEQ terrestrial vertebrate taxa known from Crown Lands into a conservation area, was to be achieved. However, for those areas coded as AR, the majority had a number of potential alternative selections depending on the type of faunal value being sought, e.g. general fauna composition (all, priority, endemic & threatened species) (Table 3.20). These possible alternatives were based on the PATN analysis and have the limitation of not necessarily taking into account certain geographically restricted taxa.

TABLE 3.19 PERCENTAGE OF LOTPLANS, LISTED IN THE TWO HIGHEST SCORE GROUPS IN TABLES 3.5 - 3.8, DESIGNATED AS CONSERVATION AREAS BEFORE AND AFTER THE IMPLEMENTATION OF THE OPTION DESCRIBED IN TABLE 3.18. (N = NUMBER OF LOTPLANS).

Faunal Category	N	Before	After
All species (Table 3.5)	29	20.7%	51.7%
Priority taxa (Table 3.6)	20	35.0%	65.0%
Endemic taxa (Table 3.7)	17	41.2%	52.9%
Threatened taxa (Table 3.8)	11	54.5%	63.6%

TABLE 3.20 POTENTIAL ALTERNATIVE LOCATIONS FOR RESERVE OPTIONS BASED ON SPECIES SIMILARITY (CODES SAME AS IN TABLE 3.18) FOR VARIOUS FAUNAL CATEGORIES.

Faunal Category	Spp. similarity Code	Potential Alternative Locations
All species	A	Conondale 274, 788, 792; Manumbar 639; Brooloo 135; Kenilworth 1239; Durunder 832; Mt Mee 893; Enoggera 309.
	B	Dawes 353; Marodian 632; Curra 700; Avoca 329.
	C	Littabella 898; Bingera 840; Warrah 1294; Glenbar 50; Monsildale 343; Clinton 283.
	G	Boompa 1344.
Priority taxa	J	As per A in All species.
	L	Dawes 353; Littabella 898; Bingera 840; Warrah 1294; St Mary 57; Marodian 632; Curra 700.
	M	Bunya 151; Emu Vale 401.
	P	Monsildale 207; Avoca 329.
	O	Woondum 393; Benarkin 283.
Endemic taxa	Q	As per A in All species.
	R	Warrah 1294; Glenbar 50; Woondum 393; Benarkin 283.

Faunal Category	Spp. similarity Code	Potential Alternative Locations
	S	Bingera 840.
	T	Boompa 1344; Marodian 632; Curra 700.
Threatened taxa	a	Littabella 898; Numinbah 702.
	b	As per A in All species.
	c	Yabba 986; Avoca 329; Bunya 151.
	d	Warrah 1294; Marodian 632.
	e	Boompa 1344; St Mary 57; Curra 700.
	f	Manumbar 639; Monsildale 207, 343; Benarkin 283.

3.4.3 Representativeness

Without the areas noted in Table 3.18, only 13% of the priority taxa examined in this study were considered to be reserved (i.e. present in a certain number of conservation areas across known range, see Attachment - Species Summaries; Table 3.16). The inclusion of the selected locations greatly improved the representativeness for 102 of the 122 (83.6%) priority taxa in the list of reservable species. The areas chosen purely on the comprehensiveness criterion also satisfied the major reservation gaps in both habitat (dry and upland wet eucalypt forest types and semi-evergreen vine thicket) and geography (northern and central sub-coastal and inland, and southern inland including south-west corner). This applied to both individual priority taxa (Table 3.16) but also to species associations, e.g. under-represented assemblage typical of the dry forest ecosystems of the northern inland illustrated in Figure 3.12B and Tables 3.12, 3.13).

The selected areas in the CAR group also captured locations potentially rich in arboreal marsupials (8 spp.) across the region, e.g. northern parts of Bulburin and Bania, southern part of Cherbourg and central part of Nangur (Fig. 3.14). Portions of Lockyer, Gundiah and Warro contributed habitats with possibly 6-7 arboreal species. Among the AR coded group, Emu Vale complemented the above areas in providing habitat for up to 8 species in the south-west uplands (Fig. 3.14).

For those taxa still lacking representative reservation, the common features were an absence of protection in the lowlands of both the coast (mainland opposite South Stradbroke Island and Sunshine Coast including the hinterland area) and major river valleys (Brisbane, Mary & Burnett Rivers). The lack of substantial Crown Lands in these areas limited any chance of readily improving representativeness. Of special interest was a suite of species recorded in aquatic and riparian habitats in exotic pine plantations in the Great Sandy (Poona 915; Toolara 1004, Neerdie 1419) and Beerwah areas (Bribie 561, Beerwah 611). For some taxa (*N. forsteri*, *M. peelii mariensis, Tyto novaehollandiae*), these forests represented important occurrences in Crown Land tenure. For others (*Rhadinocentrus ornatus, Pseudomugil mellis, Nannoperca oxleyana, Crinia tinnula, Litoria freycineti, L. olongburensis, Xeromys myoides*), the pine forests constituted significant parts of their mainland distributions.

There were also certain habitat types not fully represented, e.g. araucarian rainforest from the central part of the region. Such remaining gaps could be addressed through the selection of State Forests that also contributed to the adequacy and/or representativeness of specific species, e.g. *Dasyurus maculatus maculatus* in the Conondale Range area.

4. DISCUSSION

4.1 DATA ADEQUACY

Four species not previously recorded in the SEQ CRA region were detected in the systematic surveys. Three (*Menetia timlowi, Manorina flavigula* and *Scotorepens balstoni*) could be considered marginal inhabitants of the region with their core distributions centred to the north and west (Blakers *et al*. 1984; Strahan 1995; Cogger 1996). In fact the last two species were found only in the Blackdown Tableland area which is an 'island' outlier of SEQ in the Brigalow Belt South bioregion. The taxonomic status of *Phyllurus* sp. 'Oakview' is unconfirmed but is likely to be a southward range extension of *P. caudiannulatus* (Couper *pers comm*.).

In terms of increased numbers of records, the results for bats, small mammals and nocturnal birds reflects the increased use of targeted techniques, e.g. variety of trapping and playback methods. The rate for bats would have been higher but for the ongoing identification difficulties for certain groups (*Mormopterus* and *Scotorepens* genera, Parnaby 1995). Reptiles and bats are still undersampled compared to other vertebrate classes.

Despite the addition of 24,894 records from the surveys, the outputs from the DAMs analysis are not very different from those described for the historical data (McFarland 1998). This is not surprising given that the sampling strategy imposed on the survey design was systematic across all vegetation types, i.e. all units sampled in proportion to their areal extent. Only some spatial indication of where surveys should be undertaken was provided from an initial assessment of the historical data. While low quality *C. citriodora* (3b) and dry western (5b) forests had relatively low densities of sites, the probability of new species being detected in future surveys is low (<0.02). Those vegetation units where the chances of new species being found is greater than 0.05 (units 7, 8a, 6d and 5a) account for less than 15% of the forested area. Where the probability is greater than 0.1 the forest area involved is less than 2%. Consequently, there appears to be adequate fauna information for 85% of the forested area in the SEQ CRA region upon which some analyses can be made. However, information at the finer scale is not extensive.

The majority of historical records are from incidental sources and have a number of limitations (McFarland 1998) foremost of which is their unsystematic nature, both spatially and methodologically. This means they represent presence only results and are less useful in statistical modelling. However, even systematic data can be flawed due to the impact of a range of variables such as weather (Slater 1994; Debus 1995), observer skill (Catterall *et al.* 1996), sampling effort (Debus 1995), relative efficiency and use of different techniques (Cockburn *et al*. 1979; Kehl & Borsboom 1984; Slater 1994; Lindenmayer *et al.* 1995b), technique format (Morton *et al.* 1988; Friend *et al.* 1989) and habitat heterogeneity/proximity (Horsup *et al.* 1993; Remsen 1994). Systematic data by itself does not guarantee an accurate picture of the distribution, abundance and habitat use of the organisms under study.

Both historical and survey data are merely samples of the region's fauna, not comprehensive inventories. The latter also tends to be somewhat restricted in describing temporal patterns (Remsen 1994; MacNally 1996). [Because of time and resource constraints, the systematic data information available for the SEQ CRA (Eyre *et al.* 1998) was collected over single winter and spring/summer periods and hence has only limited exposure to regular and stochastic temporal variations in animal presence.] The spatial problem of converting such samples into region-wide coverages is being addressed through various techniques to model species distributions (Nix & Switzer 1991; NSWNPWS 1994,1995; Lindenmayer *et al.* 1995a; Neave *et al*. 1996a). However, these methods are still being assessed (Ferrier 1991; Lindenmayer *et al.* 1994a, 1995a; Cork & Catling 1996; Ferrier & Pearce 1996; Ferrier & Watson 1996) and have yet to be accepted in terms of generating reliable outputs that can be included in reserve selection processes (e.g. Purdie 1987; Scott *et al.* 1993; Pressey & Nicholls 1989a). With respect to the temporal problem, this can be partially accounted for by the use of historical data which covers a much wider time frame than any of the systematic surveys undertaken in the region.

The data used in the project relates to either presence-absence or presence only, with no consideration of abundance of each species. At present, this cannot be addressed because of the paucity of both abundance data and an adequate way of using the information (distribution modelling derived from relative abundance data is still being evaluated - NSWNPWS 1995). Alternatives, such as predicting animal numbers based on habitat quality (derived from environmental variables) assumes a knowledge of the relationship between abundance and these variables, and having complete regional coverages of the variables at a fine enough scale to produce useful results.

Another concern about the fauna data is that the focus for the systematic survey work was on forests National Parks and State Forests. Consequently, there are only the historical data available to describe the fauna present on freehold and other Crown tenures. This is significant especially where certain priority taxa, e.g. *Egernia rugosa* and *Xeromys myoides*, are predominately known from these land types. In addition this assessment relates almost solely to vertebrates. Freshwater and terrestrial invertebrates, which can be extremely diverse in eucalypt communities (e.g. Recher *et al.* 1996), are largely and typically overlooked (Hill & Michaelis 1988). Both of these drawbacks are due to resource constraints and other pre-conditions set on the fauna project objectives.

Keeping in mind these data caveats, the outcomes produced in this report are based on the best available known information. However, this should not preclude further fauna surveys being conducted within the region to improve both the known and predicted (using refined models) distributions of species and their ecology (abundance, micro-habitat requirements, response to disturbances). In fact, more extensive and systematic regional assessments and autecological projects are needed if the CAR reserve and ESFM objectives are to be fully addressed at any time in the future irrespective of the current CRA process.

4.2 SPECIES DIVERSITY AND ASSEMBLAGE ASSESSMENT

4.2.1 General

Of the 544 native forest-dwelling taxa used in the analyses, most of the 48 of the 60 taxa rarely found and/or largely unreserved are vagrants or marginal to the SEQ CRA region (Table 3.3). National Parks and State Forests contain 519 of the species found in the region (490 present on at least one NP). However, in terms of frequency of occurrence, over two thirds of these species are less well represented in the National Park estate compared with State Forests. While there may be more National Parks than State Forests, the former covers only 6.7% of the region and contains 12.8% of the forests while the latter has 14.0% and 31.9% respectively.

The difference between the two tenures is not just one of forest extent but also one of forest composition. At the grouped vegetation level, the contrast between National Parks and State Forests, let alone between National Parks and all other forested lands, is marked (Table. 4.1, Fig 4.1). In absolute terms, conserved areas are well endowed with coastal dry eucalypt forest (5a) and non-eucalypt, non-forest vegetation, e.g. heathland, wallum and mangrove (9) (Fig. 4.1). Those few fauna species that occur on more reserves than State Forests are typical of these habitats (e.g. *Litoria cooloolensis*, *Todiramphus chloris* and *Gerygone levigaster*). As a proportion of the forest available, National Parks also have reasonable amounts of certain wet forests (1a, 2), coastal dry eucalypt forest (5a), cool rainforest (6a, 6b), *Melaleuca* woodland (8a) and other non-eucalypt forest/woodland (8b) (Table 4.1). However, parks rate poorly in both absolute and relative terms for several major types - *Eucalyptus saligna* wet forest (1a), *Corymbia citriodora* dry forest (3a, 3b), mixed dry forest (4a), *E. tereticornis* on alluvial lowland (4b), dry western forest (5b), *Araucaria*-dominated and semi-evergreen vine forest (6c, 6d) and heterogeneous vegetation (12) (Fig. 4.1, Table 4.1).

TABLE 4.1 COMPARISON OF GROUPED VEGETATION UNITS (% AREA NATIVE FOREST ONLY) FOUND IN NATIONAL PARK COMPARED TO STATE FOREST, ALL CROWN LAND TENURES , AND ALL TENURES (INCLUDING FREEHOLD). UNIT 7 OMITTED DUE TO SMALL AREA. FOR DESCRIPTION OF GROUPED VEGETATION UNITS SEE TABLE 2.2

Tenure comparison	Percentage Area of Grouped Vegetation Unit															
	1a	1b	2	3a	3b	4a	4b	5a	5b	6a	6b	6c	6d	8a	8b	12
NP cf. SF	39	27	47	32	8	13	18	80	34	74	43	17	13	86	93	3
NP cf. All Crown	37	27	46	23	5	11	10	62	22	74	43	16	11	66	77	2
NP cf. All tenure	27	13	31	4	2	7	3	47	8	63	32	12	5	35	35	1

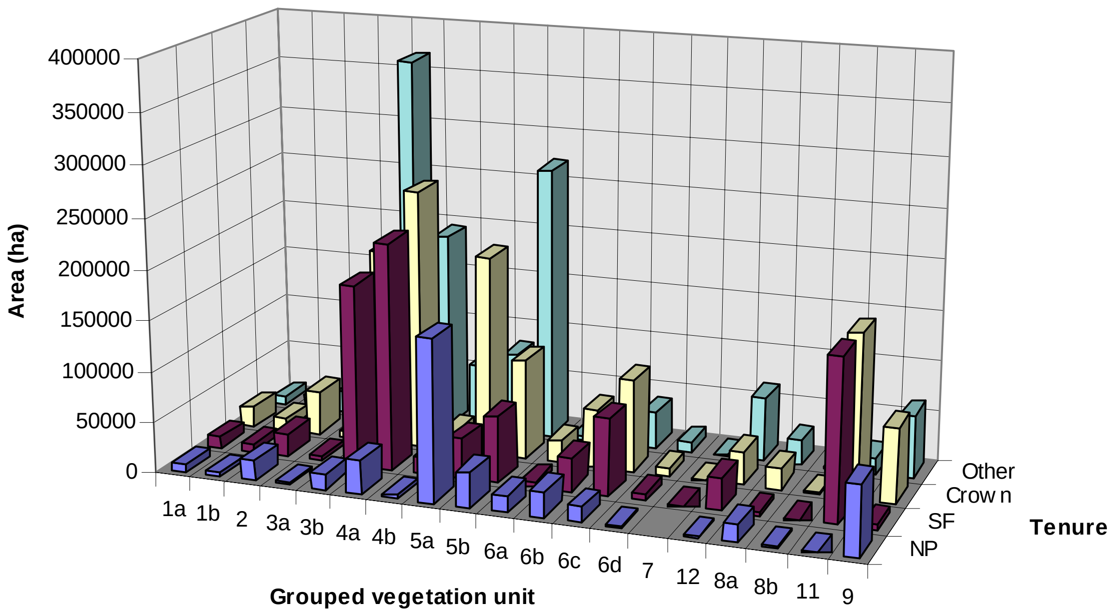

FIGURE 4.1 AREAL DISTRIBUTION OF GROUPED VEGETATION UNITS BY TENURE CATEGORIES (CROWN INCLUDES ALL TENURES IN TABLE 2.1 EXCEPT NP, NPP, SF & TR; OTHER INCLUDES FREEHOLD TITLE). NON-VEGETATION CATEGORY 10 WAS OMITTED. FOR DESCRIPTION OF GROUPED VEGETATION UNITS SEE TABLE 2.2.

It appears that for forest fauna in the SEQ CRA region, just in terms of habitat within the reserve system, representativeness and adequacy are more pressing issues than comprehensiveness. This perception is reinforced with the analyses of actual fauna data relating to species associations and individual taxa.

4.2.2 Faunal Patterns

Analyses of species compositions at various spatial and environmental scales (tenure, grouped vegetation unit and regional ecosystem) all indicate that only a few species associations are clearly defined on either habitat or geography. Most species occupy broad niches aligned along a moisture gradient and most species occur throughout the region given the availability of appropriate broad habitat types. An area with a high habitat diversity (mixture of wet and dry forest types) and exposed to adequate search effort results in the detection of most species typical of SEQ and subsequently high species diversity indices, irrespective of its geographical location (Fig. 3.2 - 3.5). Those areas with similar habitat diversities have similar species compositions (Fig. 3.6 - 3.9). Consequently, many of the animals that use the wet forests on Fraser Island are also likely to be present in the wet forests of Kroombit Tops and Lamington Plateau. This 'non-result' has important implications in that it may simplify the reserve selection process at least where the majority of SEQ terrestrial vertebrate fauna is concerned.

The discrete assemblages that are apparent, occur in well-defined forest habitats at the extremes of environmental gradients, such as low fertility wallum on sandy soils with acidic water (e.g. *Nannoperca oxleyana, Pseudomugil mellis, Litoria cooloolensis*), mangroves (e.g. *Todiramphus chloris, Gerygone levigaster, Lichenostomus fasciogularis*) and high elevation southern rainforest (e.g. *Atrichornis rufescens, Pachycephala olivacea, Antechinus swainsonii, Cercartetus nanus*).

Of course there are some species differences between localities due to latitudinal/longitudinal range limits of individual taxa, vagrants, cryptic species and species with highly restricted distributions. Distributional limits are difficult to define with any degree of certainty while the detection of vagrants and cryptic species tends to rely on chance. Species that are geographically restricted, e.g. *Nangura spinosa*, are the most easily accommodated into a reserve system.

The general absence of discrete faunal assemblages, with species occupying a range of forest types within broad divisions (all types, dry types and wet types), is consistent with the findings for most vertebrate groups examined in south-east Queensland and north-east New South Wales (Kikkawa 1968; Dwyer *et al.* 1979; Winter 1988; Slater 1995; Catling & Burt 1997). Such patterns are not unique to this region, being reported in other forest assessments in northern and south-eastern Australia (Woinarski *et al.* 1988; Bennett *et al.* 1991; Recher *et al.* 1991; Catling & Burt 1995a,b; Neave *et al.* 1996b). Species may simply be found together because they respond in similar, but not the same, ways to various environmental gradients, e.g. foliage nutrients/productivity (Barry 1984; Braithwaite 1986, 1994; Recher *et al.* 1996; Pausas *et al.* 1996), structural complexity of understorey vegetation (Catling & Burt 1995a; Slater 1995; Cork & Catling 1996) and forest type (moisture, elevation, floristic influences) (Bennett *et al.* 1991; Kavanagh *et al.* 1995; Kavanagh & Stanton 1998).

Alternatively, there may be other factors operating that blur animal-environment relationships. For example, the scale of assessment (plot sample size) may encompass a high degree of habitat heterogeneity (Woinarski *et al.* 1988) or proximity to other habitats from which atypical species use as sources of seasonal foods or as disturbance refugia (Dwyer *et al.* 1979; Horsup *et al.* 1993). There may also be temporal changes associated with changes in micro- and macro-habitat structure and availability (impact of fire, grazing, logging, storm damage and weed invasion) (Loyn 1980; Bennett 1987; Lunney 1987; Lunney & Ashby 1987; Lunney *et al.* 1991; Kutt 1993; Catling & Burt 1995a,b). Some temporal variations in fauna composition are not necessarily due to habitat alterations but to other factors, e.g. effect of native and introduced predators and competitors (Kavanagh 1988; Lunney & Leary 1988), disease (Gordon *et al.* 1990), drought (Gordon *et al*. 1990; Slater 1995) and migratory species (Braithwaite *et al.* 1989; MacNally 1996; Catterall *et al.* 1998). Where migrants are concerned, any or all of these factors could be operating anywhere in their total ranges. Hence, changes in species composition and abundance at one locality may be the result of events outside the region being studied.

Faunal patterns can also be obscured through recent and historical impacts. In relatively recent times, Australia's forests including those in south-east Queensland have undergone a massive reduction and fragmentation, especially on the alluvial and coastal lowlands (Catterall & Kingston 1993; Braithwaite 1996; Catterall *et al.* 1997b). This has resulted in: a) loss of species closely associated with those forest types (e.g. *Psephotus pulcherrimus* and *Poephila cincta cincta* from grassy woodlands on riverine plains), b) the communities in small remnants being invaded by species from adjacent modified habitats (e.g. *Manorina melanocephala* in urban and rural areas), and c) faunas of large forested areas on the slopes and ranges containing "survivors" from lowland assemblages that are persisting in what may be for them only marginal habitat (e.g. *Erythrotriorchis radiatus, Cyclopsitta diophthalma coxeni* and *Dasyurus maculatus maculatus* now mostly known from rugged terrains).

The fauna of SEQ has also been developing under selection pressures operating on a geological time scale. The region's unique physical attributes (climate, landforms and soils) has seen a mixing of not only of northern and southern species but also those of the far south that are restricted to topographical isolates within SEQ (Nix 1993). Being a zone of overlap, it is not surprising the region is a centre of species richness for several invertebrate and vertebrate groups including papilionoid butterflies (Kitching 1981), frogs (Roberts 1993), chelid turtles (Legler & Georges 1993), elapid snakes (Longmore 1986), scincid lizards (Cogger & Heatwole 1981), birds and marsupials (Pianka & Schall 1981). Within the small ground-dwelling mammal fauna of eucalypt forest, south-east Queensland is more diverse than the long recognised rich north-east New South Wales (35 spp. cf. 25 spp.; Catling & Burt 1997). In the region, heathlands and closed forests in particular have experienced similar evolutionary histories and so exhibit comparable biogeographical patterns (Kikkawa *et al*. 1979). This is reflected in that the primary habitat for 74.3% of the region's endemic taxa is rainforest and/or heathland/wallum vegetation types. Certain priority species, such as *Ophioscincus cooloolensis, O. truncatus, Dasyornis brachypterus, Antechinus swainsonii*, *Cercartetus nanus* and *Potorous tridactylus* use both habitats, being dependent on either moist friable substrates or dense understorey. Several taxa, e.g. *Phylidonyris novaehollandiae* and *Pseudomys novaehollandiae*, recorded only in elevated tall open forest in south-east Queensland are more typically heathland users further south.

Irrespective of the biogeographical origins of the south-east Queensland terrestrial vertebrate fauna, the current species associations are not fully represented in the reserve system. Assessment of the region's taxa under the broad categories (all species, priority, endemic and threatened taxa) across the landscape reveal recurring patterns of reserve deficiencies. The most prominent gap is of dry forest (mixed, western and *Corymbia* citriodora) faunal communities, especially those in the northern inland, central inland and western parts of the region. Other gaps include faunas of *Araucaria*-dominated rainforest and semi-evergreen vine thicket. In contrast, certain animal assemblages, e.g. southern unpland wet forest (Fig. 3.13A, Tables 3.12, 3.13), are well represented in conservation areas. While the spatial patterns and assemblage compositions may not be as well defined as those found when examining areas covering several bioregions (Whitehead *et al.* 1992; Woinarski 1992), they are still important in determining future assessment and reserve priorities at smaller scales.

4.2.3 Regional Ecosystems as Surrogates for Species Associations

While regional ecosystems may provide a conservative estimation of where certain species are likely to be present, they have a number of limitations typical of environmental classifications used as surrogates for fauna (Pressey 1994). Firstly, the distributions are based on presence only records and so they cannot predict beyond the ecosystems actually surveyed, unlike statistical or BIOCLIM based models (e.g. Neave *et al.* 1996a,b). For example, in Figures 3.13B and 3.14 there are noticeable distribution gaps for certain dry forests along the western boundary of the region around Gayndah and south of Toowoomba, and coastal forests between Bundaberg and Cooloola. These gaps may be due to either a true absence of the species examined or because the regional ecosystems restricted to these areas were not sampled. One way this could be addressed would be through determining how similar the ecosystems surveyed are to those not visited (based on climate, soils, landform, vegetation structure and floristics) and using this to expand upon where species may occur. Further surveys would be needed to test the validity of such an extrapolation approach. Secondly, the prediction relates to presence only and gives no indication of the abundance of the species. Again, more surveys are necessary to provide reasonable relative abundance measures for individual taxa. Thirdly, the regional ecosystems may not take into account certain taxa whose spatial and temporal variability in distribution and abundance are the result of factors other than those used to define the ecosystems, e.g. the effect of tree hollow availability on arboreal marsupials or fire frequency on terrestrial mammals. These taxa often have priority status and, whether species or genetically distinct populations, are best addressed in a case-by-case manner.

The use of regional ecosystems to predict the distribution of groups of species, either as habitat or functional assemblages or individual species, is not rigorously tested in this analysis. The fact that the majority of species are ubiquitous across the region limits the options for predicting the distribution of particular groups of species (Neave *et al.* 1996b). For individual species, the preliminary assessment of four arboreal marsupials shows that there is potential for using regional ecosystems to predict conservative distributions. Used in conjunction with maps produced through more extrapolative techniques, such as statistical modelling, this method may hold promise in terms of predicting where certain species may be present. For the use of regional ecosystems alone, far more validation is required, i.e. larger datasets and more surveying in any extensive but unsampled regional ecosystems in the region.

Where regional ecosystems provide a reasonable estimate of potential habitat then there is scope for assessing the adequacy of current reserves for species where habitat requirements to sustain a viable population have also been determined. For example, Goldingay & Possingham (1995) in their population viability analysis of *Petaurus australis australis* found that 150 groups are needed per population. Using a home range size of 65ha/group, the required forest area ranges from 9,750ha (100% habitat occupancy) up to 35,000ha (28% habitat occupancy - more typical of encounter rate in field surveys) (Goldingay & Possingham 1995). Based on these values, of the 58 National Parks in the SEQ CRA region with potential glider habitat, only two would have sufficient to support viable populations at the 100% habitat occupancy level (Great Sandy NP21 and Lamington NP496; Table 4.2). In south-eastern New South Wales, Goldingay & Possingham (1995) found only one of fifteen reserves large enough to sustain a viable population. Assuming *Petauroides volans* also required 150 groups (pairs), then at 4ha/pr, the area of forest needed for this species is from 600 to 2,143ha (100-28% occupancy). Fifty-one National Parks have potential habitat and of these, ten could contain viable populations at the 100% level and six at the 28% level (Table 4.2).

TABLE 4.2 POPULATION VIABILITY OF *PETAURUS AUSTRALIS AUSTRALIS* AND *PETAUROIDES VOLANS* IN EXISTING NATIONAL PARKS IN THE SEQ CRA REGION, BASED ON POTENTIAL HABITAT IN EACH PARK AND DIFFERING LEVELS OF HABITAT OCCUPANCY (100% & 28%). (Y = VIABLE POPULATION; N = NOT VIABLE POPULATION; ONLY TEN NP WITH LARGEST POTENTIAL HABITAT AREAS SHOWN.)

National Park	Potential habitat (ha)	*P. australis australis*		Potential habitat (ha)	*P. volans*	
		100%	28%		100%	28%
Great Sandy NP21	19,425	**Y**	N	789	**Y**	N
Lamington NP469	12,656	**Y**	N	5,363	**Y**	**Y**
Main Range NP933	7,467	N	N	5,909	**Y**	**Y**
Kroombit NP435	3,733	N	N	2,188	**Y**	**Y**
Blackdown NP181	4,000	N	N	4,000	**Y**	**Y**
Conondale NP102	3,068	N	N	6,130	**Y**	**Y**
Bunya Mts NP603	3,004	N	N	1,210	**Y**	N
Mt Barney NP737	1,585	N	N	4,515	**Y**	**Y**
Springbrook NP495	307	N	N	585	**Y**	N
Eurimbula NP278	2,430	N	N	573	**Y**	N

4.3 PRIORITY TAXA

4.3.1 Individual Taxa

General

In terms of the CAR criteria, comprehensiveness is not an issue for an individual taxon and adequacy is being assessed primarily through the Response to Disturbance project (calculation of minimum habitat areas - Rounsevell *et al*. 1998). Within this project, representativeness is evaluated through the SEQ appraisal (especially reservation category) undertaken for each taxon listed in McFarland (1997) and outlined in the Attachment.

The reservation category makes a number of assumptions. Foremost of these is that the reported locations for each animal represent extant and viable populations. Assessment of such qualities for every record was beyond the scope of this study. Besides which, for most there is probably no means of making such an evaluation given few reports contained any measures of abundance and the original observers are no longer reachable. The use of modelling either directly (species densities) or indirectly (habitat quality) has been suggested as means of determining the location and size of areas required for adequate populations. However, this approach requires intimate knowledge of the factors affecting species' distribution and abundance, and having complete coverages describing the spatial variability for all those factors. At present, models tend to be limited because of unmeasured and/or unmapped on-site and context variables (NSWNPWS 1995). Population viability analysis combined with estimates of potential habitat give indications as to the adequacy of a reserve system (e.g. Goldingay & Possingham 1995) but again detailed empirical data are needed to perform the analysis.

For the individual taxa assessed, the current status includes those that could be considered reserved (23 spp.), those that could be protected by more reservation (131 spp.), those that can only be really conserved through combined on and off-reserve action (24 spp.), and those that are really members of faunas in other bioregions and require assessment in those areas (14 spp.) (Table 3.16, Attachment). Within each of the categories where action in SEQ is needed there are a number of recurring patterns. Species rated as reserved are nearly all restricted to the Main Range-McPherson Range area, e.g. *Philoria* spp., *Cautula zia*, *Atrichornis rufescens*, *Pachycephala olivacea* and *Cercartetus nanus*. For those taxa needing more reservation, the gaps in their current reservation tend to be in non-coastal dry eucalypt forests and wet sclerophyll forest, and in northern inland and western parts of the SEQ CRA region (Table 3.16). However, this general trend does not mean lesser importance is attached to other focal habitats and areas identified as being needed for particular taxa. This is especially so for priority animals such as endemics known from only one or two localities, e.g. *Taudactylus pleione* (Kroombit Tops), *Nangura spinosa* (Nangur & Oakview) and *Phyllurus caudiannulatus* (Bulburin & Oakview).

The "on- and off-reserve" animals are those dependent on integrated landscape management. That is species for which reserves alone are unlikely to cater for all their ecological requirements. For example, species with large home ranges containing a mosaic of habitats (e.g. *Erythrotriorchis radiatus, Tyto novaehollandiae*), species that utilise ephemeral and widely spaced food supplies such as flowering trees (e.g. *Lathamus discolor, Xanthomyza phrygia, Pteropus* spp.), or species that occupy habitats such as river catchments whose quality is readily influenced by activities well beyond any reserve boundaries (e.g. *Neoceratodus forsteri, Maccullochella peelii mariensis, Elusor macrurus*). Of all the species mentioned *E. macrurus*, listed as endangered and an endemic to the region (confined to parts of the Mary River and tributaries) deserves special attention as it is also currently unknown from any Crown Land. The species is a prime candidate for off-reserve conservation measures aimed at whole-of-catchment management to protect water quality, as well as localised actions to safeguard nesting sites from predation and egg collecting. Actions taken for this species may also benefit three other stream-dwelling priority taxa found in the same catchments (*N. forsteri, M. peelii mariensis* and *Elseya* sp. cf. *dentata* 'Burnett River'). Other taxa generally found on non-Crown Land and needing off-reserve action include *Varanus semiremex, Egernia modesta, E. rugosa, Simoselaps australis* and *Dasyurus hallucatus*.

In the analysis, the priority category includes several groups that need to be addressed in the development of a CAR reserve system. These groups comprise taxa that are listed as threatened (endangered, vulnerable & rare), considered by some to be of concern (adversely affected by processes operating in forests or have restricted distributions), endemic to the region, relictual, or of cultural significance. Species at limits of range or those with disjunct distributions are not specifically examined but at least 64 taxa recognised as members of these groups are assessed under other categories. Indeed, a substantial number of the priority taxa occur in more than one category and includes those considered as relictual species (*N. forsteri* also endemic, both *C. zia* and *Eroticoscincus graciloides* also listed as rare). Of the two species assessed because of their deemed cultural significance (*Ornithorhynchus anatinus* and *Phascolarctos cinereus*) neither are considered under any other official category. As when all priority taxa were considered together, the reservation categories for the species in these other groups are also spread across the potential range (Table 3.17).

The group containing migratory species was examined in the secondary assessment category and will be discussed in 4.3.1.

Indicator Species

Several researchers have advocated the use of a selection of gliders and large owls (*Petaurus australis, Petauroides volans, Ninox strenua* and *Tyto tenebricosa*) as indicator species (Kavanagh 1991; Goldingay & Kavanagh 1991, Milledge *et al*. 1991). These species are considered because of their ecology (type of forest used, home range size, trophic level and hollow-dependency) and response to habitat change (mostly logging) or association with unlogged forest. The assumption underpinning indicator species is that the taxa are sensitive to disturbance and reservation and/or management aimed at protecting these animals results in the conservation of a wide range of sympatric forest species.

There are two parts to this assumption. First is the disturbance sensitivity which for some species (*P. australis, N. strenua*) there is conflicting evidence (e.g. Milledge *et al.* 1991 cf. Kavanagh *et al.* 1995). Despite this, both species mentioned are forest dependent and require large tracts of forest to support viable populations (e.g. Goldingay & Possingham 1995). Consequently, protection of enough forest for these species may confer benefits on other animals. In this context such species are not so much indicator but umbrella species (*sensu* Simberloff 1998). The second part of the assumption is that a wide range of forest-dwelling taxa are sympatric with these particular species. Of the four species considered, *P. australis* has the greatest number of co-occurring species (based only on site data with ≤ 500m precision), accounting for 73% of taxa recorded from such sites and 59% or all forest-dwelling taxa known from the SEQ CRA region (Table 4.3). Using all four increases the coverage to 83% and 67% respectively (Table 4.3).

TABLE 4.3 NUMBER OF SPECIES ASSOCIATED WITH DESIGNATED TAXA AND GIVEN AS PERCENTAGES OF ALL TAXA RECORDED ON SITES WITH ≤ 500M PRECISION (N = 436) AND ALL FOREST-DWELLING TAXA IN REGION (N = 544).

Taxon	Number of spp. (no. new added)	% of site spp.	% of region spp.

Petaurus australis	320 (320)	73.4	58.8
Petauroides volans	308 (24)	70.6	56.6
Ninox strenua	244 (10)	56.0	44.9
Tyto tenebricosa	224 (8)	51.4	41.2
TOTAL	362	83	66.5

Among the species “missed” by the umbrella group are 37 priority taxa. Twenty-five of these are typically found in freshwater (14 taxa), rainforest (9), mangrove (1) and wallum (1) habitats. Such habitats are little used by the umbrella species. However, for the majority of forest-dwelling animals, the use of the umbrella species as broadscale conservation ‘tools’ is worth considering. The extent to which management of the individual umbrella species is compatible with each other and to the rest of the forest fauna needs to be examined.

4.3.2 Migratory Species

The SEQ CRA region is considered of major importance for migrant birds, particularly over-wintering species (Nix 1993; Catterall *et al*. 1997a). Within the region, several species are sensitive to forest fragmentation, modification (understorey loss) and destruction, e.g. *Lichenostomus chrysops*, *Petroica rosea* and *Pachycephala pectoralis*, while others such as *Rhipidura fuliginosa* are capable of persisting in modified bushland (Catterall *et al*. 1998; Sewell & Catterall 1998). The continuing loss and degradation of forest in the region, particularly lowland types (e.g. *Eucalyptus tereticornis* on alluvial soils and *Melaleuca* wetlands) (Catterall *et al.* 1997b) is likely to have significant repercussions on the movments and survival of the migrant assemblage.

Seasonal use of forests by altitudinal and latitudinal migrants is complicated by portions of populations being resident throughout the year (Nix 1993; Attachment pg. 112, 130, 140, 142, 154, 160, 167-170). Of the ten migrants examined, only *P. rosea* exhibits almost complete departure from the region (Attachment pg. 160). In terms of reservation, nine require added protection to account for forest types and areas used by these species at some time in the year but are currently missing from the existing National Park estate. The major gaps in the conservation network again revolve around dry and wet eucalypt forest in the northern part of the region, and lowland rainforest.

For six species (*Columba leucomela*, *Ptilinopus regina*, *Monarcha trivirgatus*, *P. pectoralis*, *Rhipidura rufifrons* and *R. fuliginosa*) the Sunshine Coast hinterland (Mooloolah to Eumundi) is highlighted as a lowland area where birds are present in all seasons. The region is distinctive in terms of various BIOCLIM variables (climatic and landform features) and has close affinities to the offshore islands of Moreton and North Stradbroke (Cotterell unpubl. data). All the areas exhibit a maritime climate (absence of extremes) with a low undulating landscape. However, unlike the islands that are predominantly sand and of low fertility, the soils of the hinterland region are either on, or derived from, richer volcanic substrates. An equitable climate combined with potentially high productivity soils may result in year-round availability of foods (insects and fruit) in a relatively low stress environment that is capable of supporting populations of migrants at times when they would normally move. For the migratory birds, use of this "off-season" refugia avoids the risks involved in any long distance movements.

4.4 FAUNA AND A COMPREHENSIVE, ADEQUATE & REPRESENTATIVE RESERVE SYSTEM

4.4.1 Area Selection

The aim of the reserve option example was to show how, working largely within the limitations of the data, the fauna information available for the SEQ RFA process could be used in the selection of future reserves.

Historically, reserve acquisition has proceeded in an *ad hoc* and inefficient manner (Benson 1990; Saetersdal *et al*. 1993; Pressey & Tully 1994). As a consequence, the current estate is highly biased in the types of habitats reserved, with a preponderance of infertile and/or rugged environments (Pressey *et al.* 1996, Catterall *et al.* 1997b). This situation often includes duplication of values, resulting in such comprehensiveness and representativeness deficiencies that to achieve these criteria more land is needed than would otherwise be necessary (Pressey & Tully 1994). While assessments such as the CRA employ more objective methodologies, one cannot escape the fact that final reserve options are also significantly affected by political factors in the decision-making process and a lack of funding to acquire and manage important areas (Benson 1990).

A variety of methods are available for reserve selection. Population viability analysis provides quantitative targets but only for single species and not communities (Soule & Simberloff 1986; Goldingay & Possingham 1995). For broadscale assessments, tools such as GAP analysis usually requires complete coverages and for fauna these are often derived from presumed, and not necessarily actual, distributions (Woinarski 1992; Scott *et al.* 1993; Kiester *et al.* 1996). Partial GAP analysis can also be applied with fauna attributes in existing reserves compared to those outside (Woinarski 1992; Lombard *et al.* 1995) in order to determine which taxa are already reserved and need not influence further site selection ("elimination planning" *sensu* Kirkpatrick & Brown 1991). These often involve other selection techniques such as scoring and/or iterative algorithms. The former uses indices to identify areas of richness or rarity (Purdie 1987) but can be inefficient except where ground-truthing is included to fine tune outcomes (Pressey & Nicholls 1989a; Williams *et al.* 1996). Iterative reserve selection algorithms employ a looping procedure whereby the potential contribution of unselected sites to the reserve goals are reassessed each time a site is added to the reserve option list (e.g. Kirkpatrick 1983; Margules 1989; Pressey & Nicholls 1989b; Margules *et al.* 1991; Rebelo & Siegfried 1992; Lombard *et al.* 1995). Variations to this method attempt to account for reserve design principles (spatial arrangement of potential sites) and the provision of possible alternatives to chosen sites (Bedward *et al.* 1992; Nicholls & Margules 1993; Williams *et al.* 1996). For some taxa, iteration selects sites in diversity and rarity "hotspots" in order to achieve comprehensiveness (Lombard *et al.* 1992) but the applicability of this outcome to other taxa may result in inefficiencies with endangered species being missed (Williams *et al*. 1996; Fagan & Kareiva 1997). A preoccupation with comprehensiveness can also come at a cost to representativeness. To more fully address the latter, numerical classifications (e.g. PATN) are useful in assessing the spatial distribution of areas similar/dissimilar in certain values (Austin & Margules 1986; Mackey *et al.* 1989).

The criteria used for making additions to reserves appears to vary primarily in how specific values are viewed. Some are considered on the basis of their current representation in protected areas (Kirkpatrick 1983) or their irreplaceability (often geographically restricted values; Pressey *et al.* 1994). Alternatively, degree of dissimilarity to the values already in reserves can be used (Woinarski *et al.* 1996). Each has its own advantages and disadvantages depending on the conservation goals set, scale of the assessment and other constraints imposed, e.g. availability of funding and land for reserve acquisition (Woinarski *et al*. 1996).

The selection of potential reserves based on faunal information in the SEQ CRA region involves a heirarchical approach (Noss 1990) integrating the principles behind the above techniques with contributions from analyses at the level of region (tenure - 3.2.1 & grouped vegetation unit - 3.2.2), community (species associations in regional ecosystems - 3.2.3), individual species (priority and secondary assessment taxa- 3.3) and genetic variation (selected species - Moritz & Playford 1998). At the landscape scale (regional and community levels), further information is incorporated through the use of all species but also three subset caetgories - priority, endemic and threatened species. This approach is an attempt to reconcile the reservation and management requirements of both ecosystems (species associations) and individual taxa (Kirkpatrick & Brown 1991; Recher *et al.* 1991; Simberloff 1998).

The reserve option explored in 3.4 comprises 20 State Forests (9% of region's total) and a number of State Reserves and Unallocated State Lands. Under the rules described in 2.2.4, the example delivers 100% comprehensiveness and 95% adequacy for all the fauna considered, as well as a significant improvment in the representativeness for 84% of the priority taxa. The option also addresses and, to a large extent, satisfies other faunal values. All of the major geographical units identified as foci of genetic variability (Moritz & Playford 1998) are sampled and, in most cases, replicated. Similarly, species associations and areas of species richness are accounted for in the selection process. General habitat gaps, such as dry eucalypt forest, in the current conservation estate are also accommodated across the SEQ CRA region. Also, the broad geographical gaps noted in this analysis and in McFarland (1998) are addressed with selected areas of conservation interest located in all provinces, especially those in the west (Provinces 5, 6), central north (7, 8) and northern inland (10, 16).

In this process, the adequacy rule of presence on three of more conservation areas gives no indication of the actual areas required for forest fauna. The use of umbrella species, such as *Petaurus australis australis* which needs 10,000 - 35,000ha for a viable population, may be one means of reserving sufficient forest for up to 320 other sympatric species (Table 4.3).

Blackdown and Bania, included in the reserve option, can be considered ecotonal areas because of their positions in and straddling the adjacent Brigalow Belt South bioregion. South-east Queensland records for seven typically western species are restricted to these two localities. Apart from these species and a certain genetic distinctness, the other faunal values of the two areas are very similar to sites already selected in the option. Whether the need to account for these "marginal" species under the comprehensiveness criterion should drive reserve selection depends on the conservation goals set and the presence of other constraints.

Full representativeness cannot be reached within the rules applied. This is primarily due to the relative lack of forested Crown Land at low altitude (Catterall *et al.* 1997b). Consequently, certain habitats, e.g. *Eucalyptus tereticornis* on alluvial lowlands, and their associated faunas may only be fully catered for through acquisition, establishment of Nature Refuges and/or implementation of appropriate management. The selection techniques discussed previously can also be used for targeting off-reserve management (Pressey & Logan 1997), especially where the reserve selection process results in a reserve design unachievable in terms of acquisition and/or management or still fails any of the CAR criteria (Rebelo & Siegfried 1992; Price *et al.* 1995).

While various State Forests are identified, the actual areas required for the formation of reserves only involves parts rather than entire State Forests. Selection of a whole forest would only eventuate with the inclusion of numerous other conservation values, relating to flora species, regional ecosystems and cultural heritage, and make sense in terms of a regional reserve design.

Because of the ubiquitous distribution of many of the SEQ fauna, inclusion of the areas listed in the reserve options will inevitably result in the duplication of attributes, especially common species. However, the conserving of multiples of the values in a regional context should not be seen as a negative. Rather it should be considered as replication with the benefits of a) increasing the representativeness of the reserve system (accounting for areas/habitats poorly sampled) and b) as safeguards against the impact of local stochastic events, e.g. fire and disease, on particular faunal values.

To some extent the analysis, in a quantitative way, supports existing views about the importance of certain habitats, e.g. upland dry forests/woodlands (Gordon & Atherton 1991; Nix 1993) and wet sclerophyll forest (Roberts 1977); and specific locations, e.g. Kroombit Tops (Roberts 1978a; Schulz 1994) and Bulburin (Roberts 1978b). However, what has been generally overlooked are the extensive reserve gaps in lowland dry eucalypt forest types, especially in northern, central and western parts of the region, and semi-evergreen vine thicket.

Irrespective of the final products of any quantitative analysis there needs to be: a) an on-the-ground assessment to determine whether the values identified will, in reality, be provided for and to refine the boundaries to any proposed reserves, and b) the development of appropriate management across all tenures to ensure long-term conservation of reserved and non-reserved taxa.

4.4.2 Ecologically Sustainable Forest Management

While a comprehensive, adequate and representative reserve system is a laudable goal it may not be possible in a real world because of design, financial and social constraints operating on the selection outcomes (Benson 1990; Lombard *et al.* 1995; Price *et al.* 1995; Pressey & Logan 1997). Often it can be unique values such as endangered taxa that fall through the selection net, e.g. *Elusor macrurus*. This is especially so where the process is driven by surrogates (Saetersdal *et al.* 1993; Pressey 1994; Price *et al*. 1995) that cannot account for particular attributes of these values, e.g. home range and food requirements of sedentary, nomadic and migratory species (see 4.3.1 & 4.3.2). For such values, it is imperative that off-reserve management on both public and private land be implemented (Pressey *et al*. 1996; Pressey & Logan 1997; Lindenmayer & Recher 1998).

The reserve option analysis (3.4) and previous discussion (4.4.1) is based on the premise that species are unable to survive outside of protected areas. Such an assumption may or may not be valid depending on the behaviour and ecology of the species considered. For forest-dwelling animals to be conserved in non-reserve areas, ecologically sustainable forest management (ESFM) practices need to be developed, applied and monitored. Indeed, a CAR reserve system does not and can not guarantee long-term survival of species unless certain threatening processes are addressed. Consequently, ESFM is just a relevant to National Parks as to other land tenures public and private. A landscape approach is needed, particularly where threatening processes, e.g. fire, feral plants/animals and fragmentation, require intensive management irrespective of tenure.

What must be also remembered is that animals are mobile and occupy home ranges of varying size from a few square metres to many square kilometres and, in the case of migratory taxa, several thousand square kilometres. A species recorded at one location on one day may or may not be present the next for all manner of reasons. To address this, habitat management whether passive (e.g. reservation) or active (e.g. imposition of specific fire regime), needs to operate beyond just known point-locations of that species.

Currently, much of the remaining large tracts of forested land in south-east Queensland is in State Forest and so they must play a significant role in off-reserve conservation (e.g. McEvoy *et al.* 1979;

Parris & Norton 1997). The co-existence of conservation and commercial forestry is possible (Recher 1985; Attiwill 1994), despite some debate (Attiwill 1995; Lindenmayer 1995), but would require compromise on both sides and a general improvement in timber management (Recher 1985; Lindenmayer & Recher 1998). The major obstacle to any compromise is that information on the impact of even the most fundamental forest disturbances (logging, fire and grazing) on native fauna is rarely available and in some cases is conflicting.

Disturbances like timber harvesting and fires have indirect effects on fauna at the abiotic level, e.g. changes in nutrient status, soil permeability and streamwater quality. The size of the impacts varies with the type of disturbance, e.g. clear-felling, high intensity burns and roading, and the management actions taken, e.g. width of riparian buffer strip (Riley 1984; Gillman *et al*. 1985; Cornish & Binns 1987; Hopmans *et al.* 1987, 1993; Stewart *et al.* 1990; Davies & Nelson 1994).

In Australia, most of the studies dealing with direct impacts of timber harvesting on fauna are confined to temperate forests subject to clear-felling operations (Loyn 1980; Recher *et al.* 1980; Kavanagh *et al.* 1985; Lunney 1987; Lunney & Ashby 1987; Lunney *et al.* 1987, 1988; Catling 1991; Milledge *et al.* 1991; Lindenmayer 1992; Kavanagh & Bamkin 1995; Catling & Burt 1995a; Law 1996). Certain animal responses are consistent although differences do occur due to location variables (forest type, disturbance type and scale of assessment). For some taxonomic groups, e.g. reptiles, the impacts do not appear to be as severe (Lunney *et al*. 1991; Kutt 1993; Goldingay *et al.* 1995) compared to some arboreal marsupials (Meredith 1984, Lunney 1987; Milledge *et al*. 1991; Kavanagh & Bamkin 1995). Responses also vary with the type of forest treatment, e.g. thinning and selective logging, which affect different taxa in different ways (Meredith 1984; Kutt 1993, 1995, 1996; Taylor & Haseler 1995). In some instances, it can be difficult to unravel the disturbance effect from the underlying spatio-temporal variability in animal distribution and abundance due to natural gradients such as elevation, moisture and forest type (e.g. Kavanagh *et al.* 1995), or where several different disturbances (fire and drought) are also operating within the study period (e.g. Lunney 1987; Lunney *et al.* 1987, 1991).

All of these studies assist in identifying important attributes in or associated with forests and the factors that affect such resources. The resources may be biotic, e.g. tree hollows both arboreal (Mackowski 1984; Gibbons & Lindenmayer 1997) and terrestrial (Williams & Faunt 1997), and fallen timber (Dickman 1991; Laven & MacNally 1998), and abiotic, e.g. caves and abandoned mines (Hamilton-Smith 1968; Hall *et al*. 1997). The hollow-dependent fauna (arboreal marsupials & large owls) are relatively well known but cave-dependent species (mostly microchiropteran bats) are poorly studied. Protection of cave roosts in forests appears of particular importance in the north of the SEQ region with priority bat taxa in Winterbourne (e.g. *Hipposideros semoni, Taphozous australis, T. georgianus, Miniopterus australis, M. schreibersii* & *Vespadelus troughtoni*) and Littabella (*Macroderma gigas*).

Recently, the scale of assessment has expanded to consider the effects of disturbance on fauna and their resources in terms of forest fragmentation within the landscape. The spatial scope ranges from remnants in forested areas (e.g. Recher *et al.* 1987; Lindenmayer *et al.* 1993, 1994), to those in both rural (Loyn 1987; Bennett 1987; Barratt *et al.* 1994; Bennett *et al.* 1994) and urban contexts (Bentley *et al.* 1997; Catterall *et al.* 1997a, 1998). Fragmentation is of critical importance for species reliant on large areas, e.g. raptors (diurnal and nocturnal), migratory birds and flying-foxes.

The usefulness of the majority of the papers cited above in respect to their applicability to south-east Queensland forests is unknown. Only limited information is available on animal-disturbance interactions in sub-tropical forests of this region and adjacent north-east New South Wales. In this region timber harvesting is primarily selective but silvicultural treatment (thinning) and more intensive logging/post operation burns also occur in certain wet forest types (Barry 1984; Kehl & Corben 1991; Smith *et al*. 1994; Kavanagh *et al.* 1995; Eyre & Smith 1997), fires are mostly prescribed burns (Porter & Henderson 1983; Hannah 1994a,b; Smith *et al.* 1994), and cattle grazing is a relatively common practice (Smith *et al.* 1994). None of these studies are satisfactory in providing definitive consequences of disturbance on the forest fauna. More research is needed (Verner 1992; Taplin *et al.* 1993), not only at the species level (autecological studies) but also on factors influencing important habitat attributes (e.g. tree hollows - Smyth *pers. comm.*) and species identification (Parnaby 1991, 1995). Critical to any new work is the use of a manipulative/ experimental approach (e.g. Goldingay & Kavanagh 1991) to determine animal responses to controlled changes and to test the effectiveness of management prescriptions.

For major forested lands (State Forests and National Parks), ESFM can be implemented as a matter of government policy. However, much of the remnant forest, particularly those types restricted to fertile and coastal areas (eucalypt & rainforest on alluvial flats and melaleuca wetlands), are in private tenure (Braithwaite 1996; Catterall *et al.* 1997b). To achieve conservation of fauna on tenures used largely by individuals (leasehold and freehold) requires education and financial encouragement. Programs, such as Nature Refuges, Bushcare and Land for Wildlife, are some of the major avenues for improving off-reserve management (see papers in Bennett *et al.* 1995b, Hale & Lamb 1997). These sorts of programs are important for the conservation of both endangered species, e.g. *Elusor macrurus* in the Mary River catchment (4.3.1) and *Cyclopsitta diophthalma coxeni* in riparian and littoral rainforest patches in the Bulburin-Bundaberg area, and highly mobile species, e.g. latitudinal and altitudinal migratory birds in the Sunshine Coast hinterland (4.3.2) and flying-foxes throughout the region.

To properly address faunal conservation on a regional scale there needs to be integrated land management in which reserves and ESFM are two components (Recher 1985; Norton & Lindenmayer 1991) and the final result will involve using a combination of single species and ecosystem conservation approaches (Noss 1990; Simberloff 1998).

REFERENCES

Attiwill, P.M. (1994). Ecological disturbance and the conservative management of eucalypt forests in Australia. *For. Ecol. Manage.* **63**, 301-346.

Attiwill, P.M. (1995). Managing Leadbeater's possum in the mountain ash forests of Victoria, Australia - Reply. *For. Ecol. Manage.* **74**, 233-237.

Austin, M.P. & Margules, C.R. (1986). Assessing representativeness. In : *Wildlife Conservation Evaluation* (Ed. Usher, M.B.), pp. 45-67. Chapman & Hall : London.

Barrett, G.W., Ford, H.A. & Recher, H.F. (1994). Conservation of woodland birds in a fragmented rural landscape. *Pac. Conserv. Biol.* **1**, 245-256.

Barry, S.J. (1984). Small mammals in a south-east Queensland rainforest: the effects of soil fertility and past logging disturbance. *Aust. Wildl. Res.* **11**, 31-39.

Bedward, M., Pressey, R.L. & Keith, D.A. (1992). A new approach for selecting fully representative reserve networks: addressing efficiency, reserve design and land suitability with an iterative analysis. *Biol. Conserv.* **62**, 115-125.

Belbin, L. (1991). The analysis of pattern in bio-survey data. In : *Nature Conservation: Cost Effective Biological Surveys and Data Analysis* (Eds Margules, C.R. & Austin, M.P.), pp. 176-190. CSIRO : Melbourne.

Belbin, L. (1995). *PATN Pattern Analysis Package*. CSIRO Division of Wildlife and Ecology : Canberra.

Bennett, A.F. (1987). Conservation of mammals within a fragmented forest environment: the contributions of insular biogeography and autecology. In : *Nature Conservation: The Role of Remnants of Native Vegetation* (Eds Saunders, D.A., Arnold, G.W., Burbidge, A.A. & Hopkins, A.J.M.), pp. 41-52. Surrey Beatty : Chipping Norton, NSW.

Bennett, A.F., Lumsden, L.F., Alexander, J.S.A., Duncan, P.E., Johnson, P.G., Robertson, P. & Silveira, C.E. (1991). Habitat use by arboreal mammals along an environmental gradient in north-eastern Victoria. *Wildl. Res.* **18**, 125-146.

Bennett, A., Backhouse, G. & Clark, T. (Eds)(1995). *People and Nature Conservation.* Transactions of the Royal Society of NSW : Mosman, NSW.

Bennett, A.F., Lumsden, L.F. & Nicholls, A.O. (1994). Tree hollows as a resource for wildlife in remnant woodlands: spatial and temporal patterns across the northern plains of Victoria, Australia. *Pac. Conserv. Biol.* **1**, 222-235.

Bennett, S., Bugg, A. & Barratt, D. (1997a). *User's Guide : Data Audit Methodology Toolkit. Version 1.1.* Draft report of Environment Australia Forest Group, Environment Australia : Canberra.

Bennett, S., Watson, G. & Barratt, D. (1997b). *User's Manual : Species Distribution Modelling Toolkit (SPMODEL). August 1997.* Draft report of Environment Australia Forest Group, Environment Australia : Canberra.

Benson, J.S. (1990). Scientific knowledge: The basis for establishing reserves. *Aust. Zool.* **26**, 80-83.

Bentley, J.M. & Catterall, C.P. (1997). The use of bushland, corridors, and linear remnants by birds in southeastern Queensland, Australia. *Conserv. Biol.* **11**, 1173-1189.

Braithwaite, L.W. (1984). The identification of conservation areas for possums and gliders within the Eden woodpulp concession district. In : *Possums and Gliders* (Eds Smith, A.P. & Hume, I.D.), pp. 501-508. Australian Mammal Society : Sydney.

Braithwaite, L.W. (1996). Conservation of arboreal herbivores: The Australian scene. *Aust. J. Ecol.* **21**, 21-30.

Braithwaite, L.W., Austin, M.P., Clayton, M., Turner, J. & Nicholls, A.O. (1989). On predicting the presence of birds in *Eucalyptus* forest types. *Biol. Conserv.* **50**, 33-50.

Catling, P.C. (1991). Ecological effects of prescribed burning practices on the mammals of southeastern Australia. In : *Conservation of Australia's Forest Fauna* (Ed. Lunney, D.), pp. 353-363. Royal Zoological Society of NSW : Mosman, NSW.

Catling, P.C. & Burt, R.J. (1995a). Studies of the ground-dwelling mammals of eucalypt forests in south-eastern New South Wales: the effect of habitat variables on distribution and abundance. *Wildl. Res.* **22**, 271-288.

Catling, P.C. & Burt, R.J. (1995b). Studies of the ground-dwelling mammals of eucalypt forests in south-eastern New South Wales: the effect of environmental variables on distribution and abundance. *Wildl. Res.* **22**, 669-685.

Catling, P.C. & Burt, R.J. (1997). Studies of the ground-dwelling mammals of eucalypt forests in north-eastern New South Wales: the species, their distribution and abundance. *Wildl. Res.* **24**, 1-19.

Catterall, C.P., Johnson, G.P., Arito, E., Arthur, J.M. & Park, K. (1996). *Influence of observer experience, individual variation and context of observation on the quality of bird count data.* Draft report to Australian Nature Conservation Agency. Faculty of Environmental Sciences, Griffith University : Nathan, Qld.

Catterall, C.P. & Kingston, M. (1993). *Remnant Bushland of South East Queensland in the 1990's : its distribution, loss, ecological consequences, and future prospects.* Institute of Applied Environmental Research, Griffith University & Brisbane City Council : Brisbane.

Catterall, C.P., Kingston, M.B. & Park, K. (1997a). Use of remnant forest habitat by birds during winter in subtropical Australia: pattern and processes. *Pac. Conserv. Biol.* **3**, 262-274.

Catterall, C.P., Kingston, M.B., Park, K. & Sewell, S. (1998). Deforestation, urbanisation and seasonality: interacting effects on a regional bird assemblage. *Biol. Conserv.* **84**, 65-81.

Catterall, C.P., Storey, R. & Kingston, M. (1997b). Reality versus rhetoric: a case study monitoring regional deforestation. In : *Conservation Outside Nature Reserves* (Eds Hale, P. & Lamb, D.), pp. 367-377. Centre for Conservation Biology, University of Queensland : Brisbane.

CoA -Commonwealth of Australia (1992). *National Forest Policy Statement: A New Focus for Australia's Forests.* Advance Press : Perth.

CoA - Commonwealth of Australia (1995). Proposed Guidelines for Biological Diversity Assessment - a component of the regional forest agreement process. In : *Regional Forest Agreements - The Commonwealth Position*. Commonwealth of Australia : Canberra.

Cockburn, A., Fleming, M. & Wainer, J. (1979). The comparative effectiveness of drift fence pitfall trapping and conventional cage trapping of vertebrates in the Big Desert, north-western Victoria. *Vict. Nat.* **96**, 92-95.

Cogger, H.G. & Heatwole, H. (1981). The Australian reptiles : origins, biogeography, distribution patterns and island evolution. In : *Ecological Biogeography of Australia*. (Ed. Keast, A.), pp 1331-1373. W. Junk : The Hague.

Cork, S.J. & Catling, P.C. (1996). Modelling distributions of arboreal and ground-dwelling mammals in relation to climate, nutrients, plant chemical defences and vegetation structure in the eucalypt forests of southeastern Australia. *For. Ecol. Manage.* **85**, 163-175.

Cornish, P.M. & Binns, D. (1987). Streamwater quality following logging and wildfire in a dry sclerophyll forest in southeastern Australia. *For. Ecol. Manage.* **22**, 1-28.

Davies, P.E. & Nelson, M. (1994). Relationships between riparian buffer widths and the effects of logging on stream quality, invertebrate community composition and fish abundance. *Aust. J. Mar. Freshwater Res.* **45**, 1289-1305.

Debus, S.J.S. (1995). Surveys of large owls in northern New South Wales: methodology, calling behaviour and owl responses. *Corella* **19**, 38-50.

Dickman, C.R. (1991). Use of trees by ground-dwelling mammals: implications for management. In : *Conservation of Australia's Forest Fauna* (Ed. Lunney, D.), pp. 125-136. Royal Zoological Society of NSW : Mosman, NSW.

Dwyer, P.D., Kikkawa, J. & Ingram, G.J. (1979). Habitat relations of vertebrates in subtropical heathlands of coastal southeastern Queensland. In : *Ecosystems of the World 9A: Heathlands and Shrublands* (Ed. Specht, R.L.), pp. 281-299. Elsevier : Amsterdam.

Eby, P. (1991). "Finger-winged night workers": managing forests to conserve the role of Grey-headed Flying Foxes as pollinators and seed dispersers. In : *Conservation of Australia's Forest Fauna* (Ed. Lunney, D.), pp. 91-100. Royal Zoological Society of NSW : Mosman, NSW.

Eyre, T., Krieger, G., Venz, M., Haseler, M., Hines, B. & Hannah, D. (1998). *Systematic Vertebrate Fauna Survey Project*. Draft report to Queensland CRA/RFA Steering Committee.

Eyre, T.J. & Smith, A.P. (1997). Floristic and structural habitat preferences of yellow-bellied gliders (*Petaurus australis*) and selective logging impacts in southeast Queensland, Australia. *For. Ecol. Manage.* **98**, 281-295.

Eyre, T. & Venz, M. (1998). *Systematic Vertebrate Fauna Survey Project. Stage II - Assessment of Habitat Quality for Priority Species in Southeast Queensland Bioregion.* Draft report to Queensland CRA/RFA Steering Committee.

Fagan, W.F. & Kareiva, P.M. (1997). Using compiled species lists to make biodiversity comparisons among regions: a test case using Oregon butterflies. *Biol. Conserv.* **80**, 249-259.

Ferrier, S. (1991). Computor-based spatial extension of forest fauna survey data: current issues, problems and directions. In : *Conservation of Australia's Forest Fauna* (Ed. Lunney, D.), pp. 221-227. Royal Zoological Society of NSW : Mosman, NSW.

Ferrier, S. & Pearce, J. (1996). *An Evaluation of the Accuracy of Habitat Models for Vertebrates and Vascular Plants*. Report to Australian Nature Conservation Agency on Project No. FBU NP6. New South Wales National Parks and Wildlife Service : Armidale, NSW.

Ferrier, S. & Watson, G. (1996). *An Evaluation of the Effectiveness of Environmental Surrogates and Modelling Techniques in Predicting the Distribution of Biological Diversity.* Report to Department of Environment, Sport and Territories. New South Wales National Parks and Wildlife Service : Armidale, NSW.

Friend, G.R., Smith, G.T., Mitchell, D.S. & Dickman, C.R. (1989). Influence of pitfall and drift fence design on capture rates of small vertebrates in semi-arid habitats of Western Australia. *Aust. Wildl. Res.* **16**, 1-10.

Georges, A. & Adams, M. (1992). A phylogeny for Australian chelid turtles based on allozyme electrophoresis. *Aust. J. Zool*. **40**, 453-476.

Gibbons, P. & Lindenmayer, D.B. (1997). *Conserving Hollow-dependent Fauna in Timber-production Forests.* Environmental Heritage Monograph Series No. 3. NSW National Parks & Wildlife Service : Hurstville, NSW.

Gillman, G.P., Sinclair, D.F., Knowlton, R. & Keys, M.G. (1985). The effect on some soil chemical properties of the selective logging of a north Queensland rainforest. *For. Ecol. Manage.* **12**, 195-214.

Goldingay, R., Daly, G. & Lemckert, F. (1996). Assessing the impacts of logging on reptiles and frogs in the montane forests of southern New South Wales. *Wildl. Res.* **23**, 495-510.

Goldingay, R.L. & Kavanagh, R.P. (1991). The Yellow-bellied Glider: a review of its ecology, and management considerations. In : *Conservation of Australia's Forest Fauna* (Ed. Lunney, D.), pp. 365-375. Royal Zoological Society of NSW : Mosman, NSW.

Goldingay, R. & Possingham, H. (1995). Area requirements for viable populations of the Australian gliding marsupial *Petaurus australis*. *Biol. Conserv.* **73**, 161-167.

Gordon, G. & Atherton, R.A. (1991). *Fauna Survey of the Dry Open Forest, Conondales.* Unpublised report by Department of Environment & Heritage.

Gordon, G., McGreevy, D.G. & Lawrie, B.C. (1990). Koala populations in Queensland: major limiting factors. In : *Biology of the Koala*. (Eds Lee, A.K., Handasyde, K.A. & Sanson, G.D.), pp. 85-95. Surrey Beatty : Sydney.

Hale, P. & Lamb, D. (Eds)(1997). *Conservation Outside Nature Reserves*. Centre for Conservation Biology, University of Queensland : Brisbane.

Hall, L., Richards, G., McKenzie, N. & Dunlop, N. (1997). The importance of abandoned mines as habitat for bats. In : *Conservation Outside Nature Reserves* (Eds Hale, P. & Lamb, D.), pp. 326-333. Centre for Conservation Biology, University of Queensland : Brisbane.

Hamilton-Smith, E. (1968). Biological aspects of cave conservation. *Aust. Bat Res. News* **8**, 3-8.

Hannah, D. (1994a). *The Effects of Fire on Ground Fauna, Beerwah Scientific Purpose Area 1, South East Queensland.* Unpublished report by Fauna Conservation and Ecology Section, DPI Forest Service.

Hannah, D. (1994b). *The Effects of Fire on Ground Fauna in the Twins Buffer Strip Pine Plantation, South East Queensland.* Unpublished report by Fauna Conservation and Ecology Section, DPI Forest Service.

Hill, L. & Michaelis, F.B. (1988). *Conservation of Insects and Related Wildlife*. Occasional Paper No. 13, ANPWS : Canberra.

Hopmans, P., Flinn, D.W. & Farrell, P.W. (1987). Nutrient dynamics of forested catchments in southeastern Australia and changes in water quality and nutrient exports following clearing. *For. Ecol. Manage.* **20**, 209-231.

Hopmans, P., Stewart, H.T.L. & Flinn, D.W. (1993). Impacts of harvesting on nutrients in a eucalypt ecosystem in southeastern Australia. *For. Ecol. Manage.* **59**, 29-51.

Horsup, A., James, C. & Porter, G. (1993). Vertebrates of dry rainforest of south and mideastern Queensland. *Mem. Qd Mus.* **34**, 215-228.

JANIS (1996). *Proposed Nationally Agreed Criteria for the Establishment of a Comprehensive, Adequate and Representative Reserve System for Forests in Australia.* A report by the Joint ANZECCC/MCFFA National Forest Policy Statement Implementation Sub-committee. Department of Environment, Sport and Territories and Department of Primary Industries and Energy : Canberra.

JSAG (1997). *Joint Scientific Advisory Group Review of South-east Queensland Interim Management Arrangements.* Draft report of 30th April 1997.

Kavanagh, R.P. (1988). The impact of predation by the powerful owl, *Ninox strenua*, on a population of greater glider, *Petauroides volans*. *Aust. J. Ecol.* **13**, 445-450.

Kavanagh, R.P. (1991). The target species approach to wildlife management: gliders and owls in the forests of southeastern New South Wales. In : *Conservation of Australia's Forest Fauna* (Ed. Lunney, D.), pp. 377-383. Royal Zoological Society of NSW : Mosman, NSW.

Kavanagh, R.P. & Bamkin, K.L. (1995). Distribution of nocturnal forest birds and mammals in relation to the logging mosaic in south-eastern New South Wales, Australia. *Biol. Conserv.* **71**, 41-53.

Kavanagh, R.P., Debus, S., Tweedie, T. & Webster, R. (1995). Distribution of nocturnal forest birds and mammals in north-eastern New South Wales: relationships with environmental variables and management history. *Wildl. Res.* **22**, 359-377.

Kavanagh, R.P., Shields, J.M., Recher, H.F. & Rohan-Jones, W.G. (1985). Bird populations of logged and unlogged forest mosaic at Eden, New South Wales. In : *Birds of Eucalypt*

Forests and Woodlands: Ecology, Conservation, Management (Eds Keast, A., Recher, H.F., Ford, H.A. & Saunders, D.), pp. 273-281. RAOU & Surrey Beatty : Chipping Norton, NSW.

Kavanagh, R.P. & Stanton, M.A. (1998). Nocturnal birds and arboreal marsupials of the southwestern slopes, New South Wales. *Aust. Zool.* **30**, 449-466.

Kehl, J.C. & Borsboom, A.C. (1984). Effectiveness of mammal survey techniques in the coastal lowlands of S.E. Queensland. *Aust. Mamm. Soc. Bull.* **8**(2), 26.

Kehl, J.C. & Corben, C. (1991). *The Fauna of the Closed Forests of the Conondale Ranges with particular reference to Conservation and Future Land Use.* Unpublished report by Forest Zoology Section, DPI Queensland Forest Service.

Kiester, A.R., Scott, J.M., Csuti, B., Noss, R.F., Butterfield, B., Sahr, K. & White, D. (1996). Conservation prioritization using GAP data. *Conserv. Biol.* **10**, 1332-1342.

Kikkawa, J. (1968). Ecological association of bird species and habitats in eastern Australia; similarity analysis. *J. Anim. Ecol.* **37**, 143-165.

Kikkawa, J., Ingram, G.J. & Dwyer, P.D. (1979). The vertebrate fauna of Australian heathlands - an evolutionary perspective. In : *Ecosystems of the World 9A: Heathlands and Shrublands* (Ed. Specht, R.L.), pp. 231-279. Elsevier : Amsterdam.

Kirkpatrick, J.B. (1983). An iterative method for establishing priorities for the selection of nature reserves: an example from Tasmania. *Biol. Conserv.* **25**, 127-134.

Kirkpatrick, J.B. & Brown, M.J. (1991). Planning for species conservation. In : *Nature Conservation: Cost Effective Biological Surveys and Data Analysis* (Eds Margules, C.R. & Austin, M.P.), pp. 83-89. CSIRO : Melbourne.

Kitching, R.L. (1981). The Geography of the Australian Papilionoidea. In : *Ecological Biogeography of Australia*. (Ed. Keast, A.), pp. 977-1005. W. Junk : The Hague.

Kutt, A. (1993). Initial observations on the effect of thinning Eucalypt regrowth on heliothermic skinks in lowland forest, East Gippsland. In : *Herpetology in Australia: A Diverse Discipline* (Eds Lunney, D. & Ayers, D.), pp. 187-196. Transactions of the Royal Society of NSW : Mosman, NSW.

Kutt, A. (1995). Activity and stratification of microchiropteran bat communities in thinned, unthinned and old lowland regrowth forest, East Gippsland. *Vict. Nat.* **112**, 86-92.

Kutt, A. (1996). Bird populations density in thinned, unthinned and old lowland regrowth forest, East Gippsland, Victoria. *Emu* **96**, 280-284.

Laven, N.H. & MacNally, R. (1998). Association of birds with fallen timber in box-ironbark forest of central Victoria. *Corella* **22**, 56-60.

Law, B.S. (1996). The ecology of bats in south-east Australian forests and potential impacts of forestry practices: a review. *Pac. Conserv. Biol.* **2**, 363-374.

Legler, J.M. & Georges, A. (1993). Family Chelidae. In : *Fauna of Australia. Volume 2A. Amphibia & Reptilia*. (Eds Glasby, C.J., Ross, G.J.B. & Beesley, P.L.), pp. 142-152. Australian Government Publishing Service : Canberra.

Lindenmayer, D.B. (1992). Some impacts on arboreal marsupials of clearfelling on a 80-120 year rotation in Mountain Ash (*Eucalyptus regnans*) forests in the Central Highlands of Victoria. *Vict. Nat.* **109**, 181-186.

Lindenmayer, D.B. (1995). Forest disturbance, forest wildlife conservation and the conservative basis for forest management in the mountain ash forests of Victoria - Comment. *For. Ecol. Manage.* **74**, 223-231.

Lindenmayer, D.B., Cunningham, R.B. & Donnelly, C.F. (1993). The conservation of arboreal marsupials in the montane ash forests of the Central Highlands of Victoria, south-east Australia, IV. The presence and abundance of arboreal marsupials in retained linear habitats (wildlife corridors) within logged forest. *Biol. Conserv.* **66**, 207-221.

Lindenmayer, D.B., Cunningham, R.B. & Donnelly, C.F. (1994a). The conservation of arboreal marsupials in the montane ash forests of the Central Highlands of Victoria, south-east Australia, VI. The performance of statistical models of the nest tree and habitat requirements of arboreal marsupials applied to new survey data. *Biol. Conserv.* **70**, 143-147.

Lindenmayer, D.B., Cunningham, R.B., Donnelly, C.F., Triggs, B.E. & Belvedere, M. (1994b). Factors influencing the occurrence of mammals in retained linear strips (wildlife corridors) and contiguous stands of montane ash forest in the Central Highlands of Victoria, southeastern Australia. *For. Ecol. Manage.* **67**, 113-133.

Lindenmayer, D.B. & Recher, H.F. (1998). Aspects of ecologically sustainable forestry in temperate eucalypt forests - beyond an expanded reserve system. *Pac. Conserv. Biol.* **4**, 4-10.

Lindenmayer, D.B., Ritman, K., Cunningham, R.B., Smith, J.D.B. & Horvath, D. (1995a). A method for predicting the spatial distribution of arboreal marsupials. *Wildl. Res.* **22**, 445-456.

Lindenmayer, D.B., Wong, A.D. & Triggs, B.E. (1995b). A comparison of the detection of small mammals by hairtubing and by scat analysis. *Aust. Mammal.* **18**, 91-92.

Lombard, A.T., Nicholls, A.O. & August, P.V. (1995). Where should nature reserves be located in South Africa? A snake's perspective. *Conserv. Biol.* **9**, 363-372.

Longmore, R. (1986) (Ed). *Atlas of Elapid Snakes of Australia*. Australian Flora and Fauna Series No. 7. Australian Government Publishing Service : Canberra.

Loyn, R.H. (1980). Bird populations in a mixed eucalypt forest used for production of wood in Gippsland, Victoria. *Emu* **80**, 145-156.

Loyn, R.H. (1987). Effects of patch area and habitat on bird abundances, species numbers and tree health in fragmented Victorian forests. In : *Nature Conservation: The Role of Remnants of Native Vegetation* (Eds Saunders, D.A., Arnold, G.W., Burbidge, A.A. & Hopkins, A.J.M.), pp. 65-77. Surrey Beatty : Chipping Norton, NSW.

Lunney, D. (1987). Effects of logging, fire and drought on possums and gliders in the coastal forests near Bega, N.S.W. *Aust. Wildl. Res.* **14**, 263-274.

Lunney, D. & Ashby, E. (1987). Population changes in *Sminthopsis leucopus* (Gray) (Marsupialia : Dasyuridae), and other small mammal species, in forest regenerating from logging and fire near Bega, New South Wales. *Aust. Wildl. Res.* **14**, 275-284.

Lunney, D., Cullis, B. & Eby, P. (1987). Effects of logging and fire on small mammals in Mumbulla State Forest, near Bega, New South Wales. *Aust. Wildl. Res.* **14**, 163-181.

Lunney, D. Barker, J., Priddel, D. & O'Connell, M. (1988). Roost selection by Gould's long-eared bat, *Nyctophilus gouldii* Tomes (Chiroptera: Vespertilionidae), in logged forest on the south coast of New South Wales. *Aust. Wildl. Res.* **15**, 375-384.

Lunney, D., Eby, P. & O'Connell, M. (1991). Effects of logging, fire and drought on three species of lizards in Mumballa State Forest on the south coast of New South Wales. *Aust. J. Ecol.* **16**, 33-46.

Lunney, D. & Leary, T. (1988). The impact on native mammals of land-use changes and exotic species in the Bega district, New South Wales, since settlement. *Aust. J. Ecol.* **13**, 67-92.

Mackey, B.G., Nix, H.A., Stein, J.A., Cork, S.E. & Bullen, F.T. (1989). Assessing the representativeness of the Wet Tropics of Queensland World Heritage property. *Biol. Conserv.* **50**, 279-303.

Mackowski, C.M. (1984). The ontogeny of hollows in Blackbutt (*Eucalyptus pilularis*) and its relevance to the management of forests for possums, gliders and timber. In : *Possums and Gliders* (Eds Smith, A.P. & Hume, I.D.), pp. 553-567. Australian Mammal Society : Sydney.

MacNally, R. (1996). A winter's tale: Among-year variation in bird community structure in a southeastern Australian forest. *Aust. J. Ecol.* **21**, 280-291.

Margules, C.R. (1989). Selecting nature reserves in South Australia. In : *Mediterranean Landscapes in Australia - Mallee Ecosystems and their Management* (Eds Noble, J.C. & Bradstock, R.A.), pp. 398-405. CSIRO Australia : East Melbourne.

Margules, C.R., Pressey, R.L. & Nicholls, A.O. (1991). Selecting nature reserves. In : *Nature Conservation: Cost Effective Biological Surveys and Data Analysis* (Eds Margules, C.R. & Austin, M.P.), pp. 90-97. CSIRO : Melbourne.

McEvoy, J.S., McDonald, K.R. & Searle, A.K. (1979). Mammals, birds, reptiles and amphibians of the Kilcoy Shire, Queensland. *Qd. J. Agricult. Anim. Sci.* **36**, 167-180.

McFarland, D.C. (1997). *Priority and Secondary Assessment Fauna Taxa Listings for the South-east Queensland Comprehensive Regional Assessment.* Revised discussion paper, Forest Assessment Unit, Department of Environment & Heritage : Brisbane.

McFarland, D.C. (1998). *Forest Vertebrate Fauna Study for a Comprehensive Regional Assessment in South-east Queensland. Stage IA: Data Audit and Gap Assessment.* Draft report to Queensland CRA/RFA Steering Committee.

Meredith, C.W. (1984). Possums or poles? - The effects of silvicultural management on the possums of Chiltern State Park, northeast Victoria. In : *Possums and Gliders* (Eds Smith, A.P. & Hume, I.D.), pp. 575-577. Australian Mammal Society : Sydney.

Milledge, D.R., Palmer, C.L. & Nelson, J.L. (1991). "Barometers of change": the distribution of large owls and gliders in Mountain Ash forests of the Victorian Central Highlands and their potential as management indicators. In : *Conservation of Australia's Forest Fauna* (Ed. Lunney, D.), pp. 53-65. Royal Zoological Society of NSW : Mosman, NSW.

Moritz, C. & Playford, J. (1998). *Genetic Diversity and the Design of a Comprehensive, Adequate and Representative Reserve System for Forests in South-east Queensland.* Final report to Queensland Department of Environment & Heritage.

Morton, S.R., Gillam, M.W., Jones, K.R. & Fleming, M.R. (1988). Relative efficiency of different pit-trap systems for sampling reptiles in spinifex grasslands. *Aust. Wildl. Res.* **15**, 571-577.

Neave, H.M., Cunningham, R.B., Norton, T.W. & Nix, H.A. (1996a). Biological inventory for conservation evaluation III. Relationships between birds, vegetation and environmental attributes in southern Australia. *For. Ecol. Manage.* **85,** 197-218.

Neave, H.M., Norton, T.W. & Nix, H.A. (1996b). Biological inventory for conservation evaluation II. Composition, functional relationships and spatial prediction of bird assemblages in southern Australia. *For. Ecol. Manage.* **85**, 123-148.

Nicholls, A.O. & Margules, C.R. (1993). An upgraded reserve selection algorithm. *Biol. Conserv.* **64**, 165-169.

Nix, H.A. (1993). Bird distributions in relation to imperatives for habitat conservation in Queensland. In : *Birds and Their Habitats: Status and Conservation in Queensland* (Eds Catterall, C.P., Driscoll, P., Hulsman, K., Muir, D. & Taplin, A.), pp. 12-21. Queensland Ornithological Society : Brisbane.

Nix, H.A. & Switzer, M.A. (1991). *Rainforest Animals: Atlas of Vertebrates Endemic to Australia's Wet Tropics.* ANPWS : Canberra.

Norton, T.W. & Lindenmayer, D.B. (1991). Integrated management of forest wildlife: towards a coherent strategy across state borders and land tenures. In : *Conservation of Australia's Forest Fauna* (Ed. Lunney, D.), pp. 237-244. Royal Zoological Society of NSW : Mosman, NSW.

Noss, R.F. (1990). Indicators for monitoring biodiversity: a hierarchical approach. *Conserv. Biol.* **4**, 355-364.

NSWNPWS. (1994). *Fauna of north-east NSW forests.* North East Forests Biodiversity Study Report No. 3, unpublished report, NSW National Parks and Wildlife Service.

NSWNPWS. (1995). *Vertebrates of Upper North East New South Wales.* A report by the New South Wales National Parks and Wildlife Service for the Natural Resources Audit Council.

Parnaby, H. (1991). A sound species taxonomy is crucial to the conservation of forest bats. In : *Conservation of Australia's Forest Fauna* (Ed. Lunney, D.), pp. 101-112. Royal Zoological Society of NSW : Mosman, NSW.

Parnaby, H. (1995). Appendix A. Identification criteria and taxonomic clarification of some problematic bat species in north-eastern NSW. In : *Vertebrates of Upper North East New South Wales.* (Ed. NSW National Parks and Wildlife Service), pp A1-A26. New South Wales National Parks and Wildlife Service : Hurstville, NSW.

Parris, K. & Norton, T. (1997). The significance of State Forests for conservation of *Litoria pearsoniana* (Copland) and associated amphibians. In : *Conservation Outside Nature Reserves* (Eds Hale, P. & Lamb, D.), pp. 521-526. Centre for Conservation Biology, University of Queensland : Brisbane.

Pausas, J.G., Braithwaite, L.W. & Austin, M.P. (1995). Modelling habitat quality for arboreal marsupials in the south coastal forests of New South Wales, Australia. *For. Ecol. Manage.* **78**, 39-49.

Pianka, E.R. & Schall, J.J. (1981). Species densities of Australian vertebrates. In : *Ecological Biogeography of Australia*. (Ed. Keast, A.), pp. 1675-1694. W. Junk : The Hague.

Porter, J.W. & Henderson, R. (1983). Birds and burning histories of open forest at Gundiah, south eastern Queensland. *Sunbird* **13**, 61-68.

Pressey, R.L. (1994). Land classifications are necessary for conservation planning but what do they tell us about fauna? In : *Future of the Fauna of Western New South Wales* (Eds Lunney, D., Hand, S., Reed, P. & Butcher, D.), pp. 31-41. Royal Zoological Society of NSW : Mosman, NSW

Pressey, R.L., Ferrier, S., Hager, T.C., Woods, C.A., Tully, S.L. & Weinman, K.M. (1996). How well protected are the forests of north-eastern New South Wales? - Analyses of forest environments in relation to formal protection measures, land tenure, and vulnerability to clearing. *For. Ecol. Manage.* **85**, 311-333.

Pressey, R.L., Johnson, I.R. & Wilson, P.D. (1994). Shades of irreplaceability: toward a measure of the contribution of sites to a reservation goal. *Biodiversity and Conservation* **3**, 242-262.

Pressey, R.L. & Logan, V.S. (1997). Inside looking out: findings of research on reserve selection relevant to “off-reserve” nature conservation. In : *Conservation Outside Nature Reserves* (Eds Hale, P. & Lamb, D.), pp. 407-418. Centre for Conservation Biology, University of Queensland : Brisbane.

Pressey, R.L. & Nicholls, A.O. (1989a). Efficiency in conservation evaluation: scoring versus iterative approaches. *Biol. Conserv.* **50**, 199-218.

Pressey, R.L. & Nicholls, A.O. (1989b). Application of a numerical algorithm to the selection of reserves in semi-arid New South Wales. *Biol Conserv.* **50**, 263-278.

Pressey, R.L. & Tully, S.L. (1994). The cost of *ad hoc* reservation: a case study in western New South Wales. *Aust. J. Ecol.* **19**, 375-384.

Price, O., Woinarski, J.C.Z., Liddle, D.L. & Russell-Smith, J. (1995). Patterns of species composition and reserve design for a fragmented estate: monsoon rainforests in the Northern Territory, Australia. *Biol. Conserv.* **74**, 9-19.

Purdie, R.W. (1987). Selection of key area networks for regional nature conservation - the revised Bolton and Specht method. *Proc. R.. Soc. Qd* **98**, 59-71.

Rebelo, A.G. & Siegfried, W.R. (1992). Where should nature reserves be located in the Cape Floristic Region, South Africa? Models for the spatial configuration of a reserve network aimed at maximizing the protection of floral diversity. *Conserv. Biol.* **6**, 243-252.

Recher, H.F. (1985). A diminishing resource: Mature forest and its role in forest management. In : *Wildlife Management in the Forests and Forestry-controlled Lands in the Tropics and the Southern Hemisphere* (Ed. Kikkawa, J.), pp. 28-33. IUFRO, University of Queensland : Brisbane.

Recher, H.F., Kavanagh, R.P., Shields, J.M. & Lind, P. (1991). Ecological association of habitats and bird species during the breeding season in southeastern New South Wales. *Aust. J. Ecol.* **16**, 337-352.

Recher, H.F., Majer, J.D. & Ganesh, S. (1996). Eucalypts, arthropods and birds: on the relation between foliar nutrients and species richness. *For. Ecol. Manage.* **85**, 177-195.

Recher, H.F., Rohan-Jones, W. & Smith, P. (1980). *Effects of the Eden woodchip industry on terrestrial vertebrates.* Research Note No. 42, Forestry Commission of New South Wales : Sydney.

Recher, H.F., Shields, J., Kavanagh, R. & Webb, G. (1987). Retaining remnant mature forest for nature conservation at Eden, New South Wales: A review of theory and practice. In : *Nature Conservation: The Role of Remnants of Native Vegetation* (Eds Saunders, D.A., Arnold, G.W., Burbidge, A.A. & Hopkins, A.J.M.), pp. 177-194. Surrey Beatty : Chipping Norton, NSW.

Remsen, J.V. (1994). Use and misuse of bird lists in community ecology and conservation. *Auk* **111**, 225-227.

Richards, G.C. (1991). The conservation of forest bats in Australia: do we really know the problems and solutions? In : *Conservation of Australia's Forest Fauna* (Ed. Lunney, D.), pp. 81-90. Royal Zoological Society of NSW : Mosman, NSW.

Riley, S.J. (1984). Effect of clearing and roading operations on the permeability of forest soils, Karuah catchment, New South Wales, Australia. *For. Ecol. Manage.* **9**, 283-293.

Roberts, G.J. (1977). Birds and conservation in Queensland. *Sunbird* **8**, 73-82.

Roberts, G.J. (1978a). *Report of a Fauna Survey : Kroombit Tops.* Unpublished report of Wildlife Research Group (Qld) to National Parks & Wildlife Service.

Roberts, G.J. (1978b). *Report of a Fauna Survey : Bulburin State Forest-Granite Creek, Many Peaks Range.* Unpublished report of Wildlife Research Group (Qld) to National Parks & Wildlife Service.

Roberts, J.D. (1993). Natural History of the Anura. In : *Fauna of Australia. Volume 2A. Amphibia & Reptilia*. (Eds Glasby, C.J., Ross, G.J.B. & Beesley, P.L.), pp. 28-34. Australian Government Publishing Service : Canberra.

Rounsevell, D., Drury, W. & Smyth, A.K.. (1998). *Towards Reserve Options for Forest Taxa in South-east Queensland: Taxa at Risk, Threats, Conservation Requirements and Recovery Planning.* Draft report to Queensland CRA/RFA Steering Committee by Queensland Department of Environment, Queensland Department of Natural Resources and Commonwealth Environment Taskforce.

Saetersdal, M., Line, J.M. & Birks, H.J.B. (1993). How to maximise biological diversity in nature reserve selection: Vascular plants and breeding birds in deciduous woodlands, western Norway. *Biol. Conserv.* **66**, 131-138.

Sewell, S.R. & Catterall, C.P. (1998). Bushland modification and styles of urban development: their effects on birds in south-east Queensland. *Wildl. Res.* **25**, 41-63.

Schulz, M. (1994). *The Fauna of Kroombit Tops State Forest.* Unpublished DPI Forest Service Internal Report.

Scott, J.M., Davis, F., Csuti, B., Noss, R., Butterfield, B., Groves, C., Anderson, H., Caicco, S., D'Erchia, F., Edwards, T.C., Ulliman, J. & Wright, R.G. (1993). Gap Analysis: a geographic approach to protection of biological diversity. *Wildl. Monogr.* **123**, 1-41.

Simberloff, D. (1998). Flagships, umbrellas, and keystones: is single-species management passe in the landscape era? *Biol. Conserv.* **83**, 247-257.

Slater, P.J. (1994). Factors affecting the efficiency of the area search method of censusing birds in open forests and woodlands. *Emu* **94**, 9-16.

Slater, P.J. (1995). The interaction of bird communities with vegetation and season in Brisbane Forest Park. *Emu* **96**, 194-207.

Smith, A.P., Andrews, S.P. & Moore, D.M. (1994). *Grafton-Casino Management Areas EIS Supporting Document No. 1. Terrestrial Fauna of the Grafton and Casino State Forest Management Areas - Description and Assessment of Forestry Impacts.* Austeco & State Forests of NSW : Armidale, NSW.

Soule, M.E. & Simberloff, D. (1986). What do genetics and ecology tell us about the design of nature reserves? *Biol. Conserv.* **35**, 19-40.

Stewart, H.T.L., Hopmans, P., Flinn, D.W. & Croatto, G. (1990). Harvesting effects on phosphorus availability in a mixed eucalypt ecosystem in south-eastern Australia. *For. Ecol. Manage.* **36**, 149-162.

Taplin, A., Catterall, C.P. & Driscoll, P.V. (1993). Birds and their habitats in Queensland: overview of status and priorities for action. In : *Birds and Their Habitats: Status and Conservation in*

Queensland (Eds Catterall, C.P., Driscoll, P., Hulsman, K., Muir, D. & Taplin, A.), pp. 1-6. Queensland Ornithological Society : Brisbane.

Taylor, R.J. & Haseler, M.E. (1995). Effects of partial logging systems on bird assemblages in Tasmania. *For. Ecol. Manage.* **72**, 131-149.

Verner, J. (1992). Data needs for avian conservation biology: Have we avoided critical research? *Condor* **94**, 301-303.

Whitehead, P.J., Bowman, D.M.J.S., Tidemann, S.C. (1992). Biogeographic patterns, environmental correlates and conservation of avifauna in the Northern Territory, Australia. *J. Biogeography* **19**, 151-161.

Williams, M.R. & Faunt, K. (1997). Factors affecting the abundance of hollows in logs in jarrah forest of south-western Australia. *For. Ecol. Manage.* **95**, 153-160.

Williams, P., Gibbons, P., Margules, C., Rebelo, A., Humphries, C. & Pressey, R. (1996). A comparison of richness hotspots, rarity hotspots, and complementary areas for conserving diversity of British birds. *Conserv. Biol.* **10**, 155-174.

Winter, J.W. (1988). Ecological specialization of mammals in Australian tropical and sub-tropical rainforest: refugial or ecological determinism? *Proc. Ecol. Soc. Aust.* **15**, 127-138.

Woinarski, J.C.Z. (1992). Biogeography and conservation of reptiles, mammals and birds across north-western Australia: an inventory and base for planning an ecological reserve system. *Wildl. Res.* **19**, 665-705.

Woinarski, J.C.Z., Price, O. & Faith, D.P. (1996). Application of a taxon priority system for conservation planning by selecting areas which are most distinct from environments already reserved. *Biol. Conserv.* **76**, 147-159.

Woinarski, J.C.Z., Tidemann, S.C. & Kerin, S. (1988). Birds in a tropical mosaic: the distribution of bird species in relation to vegetation patterns. *Aust. Wildl. Res.* **15**, 171-196.

Young, P.A.R. (in press). Chapter 12: South-east Queensland. In : *The Conservation Status of Queensland's Bioregional Ecosystems.* (Eds Sattler, P.S. & Williams, R.D.). Conservation Technical Report of Queensland Department of Environment, Brisbane.

Young, P.A.R., Wilson, B.A., McCosker, J.C., Fensham, R.J., Morgan, G. & Taylor, P.M. (in press). Chapter 11 : Brigalow Belt. In : *The Conservation Status of Queensland's Bioregional Ecosystems.* (Eds Sattler, P.S. & Williams, R.D.). Conservation Technical Report of Queensland Department of Environment, Brisbane.