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# ATTRIBUTION AND MODELLING OF FAUNA FOR THE SOUTH-WEST FOREST REGION COMPREHENSIVE REGIONAL ASSESSMENT

A Report to the Commonwealth and Western Australian Governments for the Western Australian Regional Forest Agreement

by

The Western Australian Museum of Natural Science

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# Project Report:

## *Attribution and Modelling of Fauna for the South-west Forest Region CRA*

**Scope items**

I Attribution of taxa groups with National Estate and JANIS criteria. Identification of species on federal and state endangered, rare, vulnerable and threatened lists.

II Prioritise taxa list for modelling purposes using expert opinion to identify the most critical suitable taxa for modelling.

III From I and II above, the draft list to be provided to CALM and/or other relevant experts for comment and response.

IV. Modification of priority taxa list based on received comment.

V Modelling of taxa including:

a) modelling of selected priority species,

b) production of point distribution maps for the balance of priority species, and

c) investigation of thematic modelling of relict and endemic taxa groups for use with integration phase.

Outcomes of this phase, particularly the number of species involved are heavily dependent on time-frames but 15 modelled species and 70 point distributions are considered to be reasonable outcomes in the time frame. It is understood that the budget in Attachment 1 reflects this commitment.

VI Validation of map outputs by relevant experts.

VII Capture and point distribution mapping of additional restricted National Estate and JANIS criteria relictual and endemic invertebrate species (not originally covered by database) through consultation with relevant experts.

VIII Conversion of steps I-VII into GIS format suitable for input into the integration tool. This involves producing individual species coverages for input into integration.

IX Prepare report summarising process taken in attribution and selection of priority taxa. Identify any limitations of modelled outputs. Provide evaluation of modelled outputs and suitability for inclusion in integration.

**Database Acquisition**

The contents of databases acquired and compiled for this project are summarised in Table 1.

The Data Review and Evaluation Project had identified a variety of fauna datasets apart from those held by the WA Museum. Additional fauna databases were also investigated through consultation with staff of CALM and the Water Corporation and through contact with Dr Owen Nichols (Alcoa of Australia Pty Ltd) and academic staff and students of various tertiary institutions.

A number of databases identified during the Data Audit project were not incorporated in the compilation process. This was either because they could not be made available within the very short time frame available (2 weeks) or because several small datasets were judged to cover too few taxa or localities to be of any real value to this project. In general, emphasis was placed on acquiring supplementary data for taxa which were already represented by one or more substantial databases (ie., mammals, birds, herpetofauna).

Databasing of the selected taxa was funded under the former "Species of Special Interest" project and coordinated through the WA Museum. Data from 27 forest bird species were available from the Storr-Johnstone bird database, an extensive, paper-based compilation of information taken from museum records, literature sources and private sightings for over 90 years. Data covering the same 27 bird species were supplied by the RAOU (WA Section) via Dr Alan Burbidge of CALM-Science and Information Division (SID). Data on the distribution of the Red-tailed Black Cockatoo was provided by Dr Denis Saunders, CSIRO. Data on endangered and vulnerable species were obtained from the CALM Threatened Fauna Database. Detailed bird, mammal and herpetofauna census data were made available by Alcoa of Australia Pty Ltd, including both published (Nichols and Watkins 1984, Nichols *et al.* 1981) and unpublished materials. Survey data generated by Worsley Alumina Pty Ltd (1985) and for the Water Authority (1987) as part of a pre-dam assessment process were entered from the published reports.

After additional validation, the WA Museum collection databases for mammal and herpetofauna were accessed. Four significant mammal datasets were contributed by CALM-SID on Numbat, Chuditch, Ringtail Possum and Quokka distributions; the latter two including WA Museum voucher-based and sub-fossil records.

The distribution of freshwater fishes in south-west WA has been databased recently by Murdoch University, School of Biological and Environmental Science. WA Museum specimen records and published CALM records were already incorporated into this comprehensive database.

Data for south-west WA Crustacea were compiled by staff of Edith Cowan University, School of Environmental Management and the WA Museum of Natural Science. Data were taken from the Museum voucher records as well as literature sources.

New data were captured from the Museum of Natural Science collections for the molluscan genus *Bothriembryon* and for a selection of arachnids and centipedes. Geocodes were calculated using EGAZ or directly from maps in the case of complex localities. The arachnid and centipede taxa were selected on the basis of their biogeographic significance, distribution and representation in the WA Museum of Natural Science collection. Taxa which were already partially computerised were given special emphasis.

All databases are held in standard format *dbf* tables within a Foxpro 2.6 application at the WA Museum of Natural Science; the primary data format is shown in Table 2. The individual tables can be readily combined to produce a single fauna database.

Databases were curtailed to the south-west land-mass of Western Australia with the geographic limits of south of 29°30' S and west of 120° 00' E.

**Database Validation**

As indicated in Table 1, the great majority of fauna data for the south-west RFA region are derived from voucher specimen collections or observational records from non-systematic surveys.

The collections of the Western Australian Museum of Natural Science are based on voucher specimens of taxa and are stored in electronic form in order to facilitate collection management and systematic studies. These voucher specimens were acquired from an array of sources and were frequently assigned geographic co-ordinates that have poor precision values. Similarly, the observational data of the bird species are frequently taken from literature and notebooks where location data is poorly referenced.

Systematic, transect/quadrat based vertebrate fauna survey data are available from a relatively small number of tightly clustered sites, most of which have been investigated in relation to bauxite mining operations (Alcoa of Australia Pty Ltd and Worsley Alumina Pty Ltd) or during pre-dam assessment surveys (Water Corporation, formerly Water Authority). Some of the Museum of Natural Science (How *et al.* 1987), CALM and RAOU bird data also derive from systematic effort at transect/quadrat based sampling localities. The great majority of these systematic survey sites are, however, located in the northern Jarrah forest.

There have been no formal surveys of native snails (*Bothriembryon* spp.) in the south-west of Western Australia, consequently, there are no data to assess the temporal changes that may have occurred or even the distributional limits of many of the species. The same applies to the remaining invertebrate taxa databased, with no systematic surveys of sites over an extended geographic range.

**Attribution and Ranking**

The species in all taxon databases were given attributes using categories derived from the National Estate and JANIS criteria (Appendix I).

The Western Australian Museum of Natural Science also considered additional criteria that related to the phylogenetic status and distinctiveness of taxa in order to highlight areas where composite species groups might exist and the most recent evaluation of species status.

The zoogeographic affinities, microhabitat requirements, range limits and disjunctions were documented by taxonomic experts from the Museum of Natural Science. These opinions were validated by a detailed examination of the temporal and spatial relationship of records of nearly 200 vertebrate and over 300 invertebrate taxa using ARCVIEW.

The taxa listed on the National and Western Australian lists identifying endangered, rare, vulnerable or threatened species were documented during attribution.

The number of records for each vertebrate taxa inside and outside of RFA and the level of precision for the individual records inside the RFA were also considered in each vertebrate attribution database.

These attributions were then summarised for each group and the taxa ranked. Ranking criteria varied between taxonomic groups (Appendix II a-g).

Various experts and specialists (Table 3) from other institutions were consulted and asked to pass comment and offer criticism on the prepared vertebrate ranking tables. The rankings were then modified and used in the subsequent modelling and point distribution phases.

**Modelling**

Ranked vertebrate taxa were submitted to modelling using the Species Distribution Modelling Toolkit (SPMODEL). Time constraints resulted in modelling being confined to vertebrate species only. These groups tended to have larger datasets for individual taxa.

The modelling process was conducted by a developer of the model, Mr Dave Barratt, in conjunction with staff of the Museum of Natural Science.

The surfaces used and available to the modelling process are recorded in Table 4. The Mattiske (Forest Ecosystems) vegetation coverage was used in the model in its reduced 40+ unit form, but the AgWest soil was not in suitable grid form to be used in the modelling process.

Caveats were imposed on the data such that modelling could occur only on data records where:

1. The records fell within the model's spatial limits of south of 31° S and west of 118° E.
2. The level of precision in the geocoding was less than the grid size for the model surfaces (9 seconds). Only birds and mammals provided sufficient records to fulfil this caveat.
3. Where insufficient records were available at a precision <0.15 minutes, the criteria in the dataset were relaxed to include records of precision <1 minute. This applied to frogs and reptiles.

Precision = 1 equates to a resolution of one minute or about 1700 m at the latitude of the RFA region, while precision <0.15 minutes equates to 9 seconds or about 250m.

Both the Generalised Linear Model (GLM) and the Generalised Additive Model (GAM) from the SPMODEL Toolkit were applied to each taxon with sufficient data points to be modelled. These models were applied for presence only data and without geographic space. The resultant predictive models were subjected to examination by relevant specialists in the taxa for their opinion as to the accuracy of the prediction as well as the model's relationship to the database records.

In all, modelling was applied to over 100 vertebrate taxa.

The 24 vertebrate taxa with acceptable model predictions of distribution were supplied in grid coverage for use in the integration phase of the project. Species models were rejected where the model's predictions either missed or showed very low (<0.2) probability of occurrence over parts of the region where the species was/is known to occur.

Very few of the species with acceptable models had predictive values above the 0.7 level, indicating that the predicted ranges of the species within the RFA region were poorly represented by the significant predictive variables used in each model. Birds, with the largest and generally most precise database, had only half the 28 taxa with realistic predictive models and all of these models were acceptable only when the probability was based at the 0.4 level or above. The low number of realistic predictive models for mammal taxa can be accounted for by the limited number of records for most species within the RFA region. Most mammal species had far more extended ranges in historic times (a fact that was excluded by the geographic limits placed on the model) and many have shown marked decline in distribution over the past 50-100 years.

In general, the acceptable models selected climatic variable as the most significant predictors and less than three used geographic, geological or vegetational predictors.

## Species Point Distribution Maps

Ranked species whose models were inaccurate, or for which the model would not develop predictive models, were evaluated from their Point Distribution Maps. These maps cover the species distribution within the area south of 29°30'S and west of 120° 00'E that includes the RFA region.

All ranked species were compiled into separate databases for each of the major taxonomic groupings to evaluate their point distribution in the integration phase as discussed with the project coordinator, Mr Cameron Slatyer. There were 148 discrete taxa compiled for point distribution and consideration in the integration phase.

For both mammals and birds it is possible to examine the data within three major time periods; the first covering the 116 years of European settlement to 1945, the second from 1946 to 1970 and the third post 1971 when detailed regional and site specific surveys became the norm. The temporal changes in distribution and local extinctions in a few selected vertebrate taxa are exemplified by the species maps presented in Appendix III.

## National Estate Species

Relictual and endemic invertebrate (most not covered in original databases) and some vertebrate species in the RFA region were captured for point distribution mapping by consultation with relevant experts and authorities (Table 5).

There was a total of 89 taxa with 381 records of these species that were considered to be relictual and endemic to the south-west of Western Australia (Table 6). These restricted taxa were attributed with both National Estate and JANIS criteria and compiled into a separate database.

## Evaluation

The quality of information acquired and processed for the attribution and modelling of fauna for the south-west forest region CRA has been limited by numerous factors:

- the restricted time frame (2 weeks) available to acquire and validate databases
- the inaccessibility of numerous key databases covering the RFA region
- the poor geocoded precision of the records in databases that consist principally of voucher specimen and observational records
- the limited spatial extent of the records in most databases, reflecting poor systematic sampling/collecting within the RFA region
- the modelling of vertebrate taxa with refined geocodes (precision <0.15 minutes) was confined to birds and some mammals
- insufficient time to adjust the model to best suit the format and precision of the data
- restricted edaphic and biotic coverages available in the modelling process for vertebrates
- a model that operated more effectively with continuous variables (mainly climatic) as opposed to discrete variables such as vegetation and soil grids that are more appropriate for bio-prediction.

The most compelling finding of the fauna database attribution and modelling project has been the almost total absence of systematic fauna survey data from precise locations within the RFA region. This applies to all invertebrate and the great majority of vertebrate taxa; the latter having only been systematically surveyed in a limited number of locations in the northern jarrah forest.

**Literature Cited**

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Nichols, O.G. and Watkins, D. 1984. Bird utilisation of rehabilitated bauxite minesites. *Biological Conservation* **30**:109-131.

Nichols, O.G., Glossop, B.L. and Smurthwaite, A.J. 1981. A method for assessing the likely effects of bauxite mining on conservation of flora and fauna management priority areas. *Environmental Research Bulletin No. 12.*

Worsley Alumina Pty Ltd. 1985. *Worsley Alumina Project. Flora and Fauna Studies , Phase Two.* pp 348. Worsley Alumina Pty Ltd, Perth.

Water Authority of Western Australia. 1987. A fauna assessment of four water supply sources in the Darling Ranges. ERMP Supporting Document. *Next major public water supply source for Perth (post 1992).* J.N.Dunlop and Associates and Ninox Wildlife Consulting.

**Table 1.** Final database statistics. Codes are as follows: Record Type: V = voucher specimen, T = quadrat-based, S = incidental, F = subfossil, O = unspecified or other, e.g. scat; Custodian: MNS = Museum of Natural Science, CA = CALM, CS = CSIRO, AL = Alcoa, WO = Worsley, WC = Water Corporation, EC = Edith Cowan Univ/WA Museum, MU = Murdoch University, RO = RAOU).

| Database | No.Records | No.Taxa | No.Distinct Localities | Record Type | Custodian |
|---|---|---|---|---|---|
| Arachnology | 5475 | 162 | 1132 | V - 5475 | MNS - 5475 |
| Birds | 22878 | 102 | 5267 | V- 1853 | MNS - 15630 |
| | | | | T - 4005 | RO - 2593 |
| | | | | S - 17020? | CA - 2358 |
| | | | | | AL - 1106 |
| | | | | | WO - 535 |
| | | | | | WC - 493 |
| | | | | | CS - 163 |
| Crustacea | 4460 | 393 | 670 | V - 1355 | EC - 3105 |
| | | | | O - 3105 | MNS - 1355 |
| Fish | 886 | 17 | 301 | T - 886 | MNS/MU - 886 |
| Frogs | 8113 | 24 | 1123 | V - 8002 | MNS - 8002 |
| | | | | T - 111 | WC - 38 |
| | | | | | AL - 37 |
| | | | | | WO - 36 |
| Mammals | 9289 | 54 | 2876 | V - 7949 | MNS - 8044 |
| | | | | T - 695 | CA - 1057 |
| | | | | S - 493 | WO - 70 |
| | | | | F - 95 | AL - 69 |
| | | | | O - 57 | WC - 49 |
| Mollusca | 2817 | 86 | 1023 | V - 2817 | MNS 2817 |
| National Estate | 381 | 89 | 221 | O - 381 | MNS - 381 |
| Reptiles | 21027 | 89 | 3188 | V -20560 | MNS - 20561 |
| | | | | T - 466 | WO - 138 |
| | | | | S - 1 | AL - 165 |
| | | | | | WC - 163 |
| **TOTAL** | **75326** | **1016** | | | |

**Table 2.** Primary Data Format. Fields for the taxon databases required for the DAM analysis and the additional fields identifying record custodian and type.

| *Field* | *Field Name* | *Field Type* | *Width* |
|---|---|---|---|
| 1 | SITE_NO | Character | 10 |
| 2 | LONGDEC | Character | 11 |
| 3 | LATDEC | Character | 10 |
| 4 | PRECISION | Character | 6 |
| 5 | YEAR | Character | 4 |
| 6 | MONTH | Character | 2 |
| 7 | DAY | Character | 2 |
| 8 | SURVEY | Character | 4 |
| 9 | EFFORT | Character | 8 |
| 10 | SPECIES_NO | Character | 5 |
| 11 | ABUNDANCE | Character | 5 |
| 12 | TAXON | Character | 40 |
| 13 | INSTITUTIO | Character | 10 |
| 14 | ID_METHOD | Character | 10 |

**Table 3.** Specialists consulted either during attribution, ranking or modelling

| **Specialist - INSTITUTION** | **TAXON** |
|---|---|
| Dr Mark Harvey - WAMNS | Arachnids |
| Ms Julianne Waldock - WAMNS | Arachnids |
| Dr Barbara Main - UWA | Arachnids |
| Dr Ian Abbott - CALM | Birds |
| Dr Allan Burbidge - CALM | Birds |
| Dr Owen Nicholls - ALCOA/Consultant | Birds |
| Mr Ron Johnstone - WAMNS | Birds |
| Dr Pierre Horwitz - ECU | Crustacea |
| Mr Simon Judd - ECU | Crustacea |
| Ms Diana Jones - WAMNS | Crustacea |
| Dr Howard Gill - MU | Fish |
| Mr Dave Morgan - MU | Fish |
| Dr Barry Hutchins - WAMNS | Fish |
| Dr Dale Roberts - UWA | Frogs |
| Mr Laurie Smith - WAMNS | Frogs/Reptiles |
| Mr Norm McKenzie - CALM | Mammals |
| Dr Lincoln Schmitt - UWA | Mammals |
| Mr Keith Morris - CALM | Mammals |
| Ms Norah Cooper - WAMNS | Mammals |
| Mr George Kendrick - Private | Molluscs |
| Mrs Shirley Slack-Smith - WAMNS | Molluscs |
| Mr John Dell - WAMNS | Vertebrates |
| Mr Mark Cowan - WAMNS | Vertebrates |
| Dr Ric How - WAMNS | Vertebrates |

WAMNS = WA Museum of Natural Science, CALM = Department of Conservation and Land Management, UWA = University of Western Australia, ALCOA = Alcoa of Australia, ECU = Edith Cowan University, MU = Murdoch University

**Table 4.** Coverages used in the modelling of vertebrate taxa.

Longitude
Latitude
Annual Mean Temperature
Aspect
Slope
Ridges/Valleys
Annual Precipitation
Max. Temp of Warmest Period
Min. Temp of Coldest Period
Annual Mean Radiation
Annual Moisture Index
Precipitation of Wettest Period
Precipitation of Driest Period
Mean Temp. of Wettest Q.
Mean Temp. of Driest Q.
Mean Temp. of Coldest Q.
Precipitation of Wettest Q.
Precipitation of Driest Q.
Precipitation of Warmest Q.
Precipitation of Coldest Q.
Geology (Regolith + Precam)
Forest ecosystems (Mattiske Coverage)
Mean Diurnal Range
Isothermality
Temperature Seasonality
Temperature Annual Range
Precipitation Seasonality
Radiation Seasonality
Radiation Wettest Quarter
Radiation Driest Quarter
Radiation Warmest Quarter
Radiation Coldest Quarter
Highest Period Moisture Index
Lowest Period Moisture Index
Moisture Index Seasonality
Mean Moist Index High Quarter
Mean Moist Index Low Quarter
Mean Moist Index Warm Quarter
Mean Moist Index Cold Quarter
Highest Period Radiation
Lowest Period Radiation

**Table 5.** Specialists approached and able to provide information on taxa with relictual, gondwanic or endemic distributions in the RFA region.

| **Specialist - INSTITUTION** | **TAXON** |
|---|---|
| Dr. Barbara Main - UWA | Araneae |
| Dr. Mark Harvey - WAMNS | Arachnids |
| A/Prof. Jonathon Major/ Dr. Brian Hetterick - CU | Hymenoptera |
| Dr. Brenton Knott/ Ms Edyta Jasinska- UWA | Aquatic subterranean fauna |
| Ms Diana Jones - WAMNS | Oligochaeta |
| Dr. Bill Humphreys - WAMNS | Cave fauna |
| Mr. Magnus Peterson - Private | Coleoptera/Odonata/Diplura |
| Mrs. Shirley Slack-Smith - WAMNS | *Bothriembryon* |
| Mr George Kendrick - Private | *Bothriembryon* |
| Dr. Dale Roberts - UWA | Frogs |
| Dr. Pierre Horwitz - ECU | Crustacea |
| Mr. Dave Morgan - MU | Fish |

WAMNS = WA Museum of Natural Science, CALM = Department of Conservation and Land Management, UWA = University of Western Australia, ECU = Edith Cowan University, MU = Murdoch University

Table 6. Taxa included in the National Estate database as representing relictual and/or endemic species of the RFA region.

| Class | Order | Family | Genus | species |
|---|---|---|---|---|
| Arachnida | Acarina | Aturidae | *Wheenyoides* | *cooki* |
| Arachnida | Acarina | Aturidae | *Gen. nov. "T"* | *sp.* |
| Arachnida | Acarina | Hydryphantidae | *Pseudohydryphantes* | *doegi* |
| Arachnida | Acarina | Hydryphantidae | *Tartarothyas* | *sp.* |
| Arachnida | Acarina | Labidostommatidae | *Sellnickiella* | *biunguiculata* |
| Arachnida | Acarina | Mideopsidae | *Penemideopsis* | *pusilla* |
| Arachnida | Acarina | Mideopsidae | *Tillia* | *davisae* |
| Arachnida | Acarina | Pionidae | *Acercella* | *poorginup* |
| Arachnida | Acarina | Pionidae | *Larri* | *laffa* |
| Arachnida | Araneae | Actinopodidae | *Missulena* | *torbayensis* |
| Arachnida | Araneae | Anapidae | *Chasmocephalon* | *sp.* |
| Arachnida | Araneae | Anapidae | *Chasmocephalon* | *flinders* |
| Arachnida | Araneae | Anapidae | *Chasmocephalon* | *pemberton* |
| Arachnida | Araneae | Anapidae | *Chasmocephalon* | *tingle* |
| Arachnida | Araneae | Archaeidae | *Austrarchaea* | *sp.* |
| Arachnida | Araneae | Barychelidae | *Synothele* | *harveyi* |
| Arachnida | Araneae | Barychelidae | *Synothele* | *longbottomi* |
| Arachnida | Araneae | Barychelidae | *Synothele* | *rastelloides* |
| Arachnida | Araneae | Barychelidae | *Synothele* | *rubripes* |
| Arachnida | Araneae | Cyatholipidae | *Gen. Nov.* | *sp. nov.* |
| Arachnida | Araneae | Idiopidae | *Arbanitis* | *festivus* |
| Arachnida | Araneae | Idiopidae | *Arbanitis* | *inornatus* |
| Arachnida | Araneae | Idiopidae | *Idiosoma* | *hills sp. nov.* |
| Arachnida | Araneae | Nemesiidae | *Chenistonia* | *boranup* |
| Arachnida | Araneae | Nemesiidae | *Chenistonia* | *paludigena* |
| Arachnida | Araneae | Nemesiidae | *Stanwellia* | *karri* |
| Arachnida | Araneae | Orsolobidae | *Tasmanoonops* | *sp.* |
| Arachnida | Araneae | Orsolobidae | *Tasmanoonops* | *australis* |
| Arachnida | Araneae | Symphytognathidae | *Symphytognatha* | *picta* |
| Arachnida | Araneae | Theridiidiidae | *Cf. Pholcomma* | *sp.* |
| Arachnida | Araneae | Theridiosomatidae | *Baalzebub* | *sp.* |
| Arachnida | Opilionida | Caddidae | *Hesperopilio* | *mainae* |
| Arachnida | Opilionida | Triaenonychidae | *Calliuncus* | *labyrinthus* |
| Arachnida | Opilionida | Triaenonychidae | *Dingupa* | *glauerti* |

| Class | Order | Family | Genus | species |
|---|---|---|---|---|
| Arachnida | Pseudoscorpionida | Cheliferidae | *Protochelifer* | *sp.* |
| Arachnida | Pseudoscorpionida | Chthoniidae | *Pseudotyrannochthonius* | *giganteus* |
| Arachnida | Pseudoscorpionida | Chthoniidae | *Pseudotyrannochthonius* | *sp. nov.* |
| Arachnida | Hydracarina | Mideopsidae | *Tillia* | *nov.* |
| Chilopoda | Scolopendrida | Scolopendridae | *Cormocephalus* | *michaelseni* |
| Crustacea | Amphipoda | Paramelitidae | | *sp. nov. 2* |
| Crustacea | Amphipoda | Paramelitidae | *Et Sp. N. 1* | |
| Crustacea | Amphipoda | Paramelitidae | *Et Sp. N. 3* | |
| Crustacea | Amphipoda | Paramelitidae | *Hurleya* | *nov.* |
| Crustacea | Amphipoda | Paramelitidae ?? | *Sp. Nov.* | |
| Crustacea | Amphipoda | Paramelitidae? | *Et Sp. N. 4* | |
| Crustacea | Amphipoda | Perthiidae | *Perthia* | *aff. acutitelson* |
| Crustacea | Amphipoda | Perthiidae | *Perthia* | *nov. 1* |
| Crustacea | Bathynellacea | | *Et Sp. N. 1* | |
| Crustacea | Isopoda | | | *new* |
| Crustacea | Isopoda | Janiridae | *Et Sp. N. 1* | |
| Diplopoda | Sphaerotheriida | Sphaerotheriidae | *Cynotelopus* | *notabilis* |
| Gastropoda | Mesogastropoda | Hydrobiidae | *(?) Et Sp. N.* | |
| Gastropoda | Stylommatophora | Bulimulidae | *Bothriembryon* | *sp. nov augusta* |
| Gastropoda | Stylommatophora | Bulimulidae | *Bothriembryon* | *sp. nov boddington* |
| Gastropoda | Stylommatophora | Bulimulidae | *Bothriembryon* | *sp. nov denmarkb* |
| Gastropoda | Stylommatophora | Bulimulidae | *Bothriembryon* | *sp. nov manjimup* |
| Gastropoda | Stylommatophora | Bulimulidae | *Bothriembryon* | *sp. nov nannup* |
| Gastropoda | Stylommatophora | Bulimulidae | *Bothriembryon* | *sp. nov pt d'entrecasteaux* |
| Insecta | Coleoptera | Buprestidae | *Castiarina* | *elongata* |
| Insecta | Coleoptera | Carabidae | *Trichosternus* | *relictus* |
| Insecta | Coleoptera | Cupedidae | *Adinolepis* | *apodema* |
| Insecta | Coleoptera | Curculionidae | *Acantholophus* | *cupreomicans* |
| Insecta | Coleoptera | Curculionidae | *Catasarcus* | *laevior* |
| Insecta | Coleoptera | Curculionidae | *Catasarcus* | *ustulatus* |
| Insecta | Coleoptera | Lucanidae | *Syndesus* | *macleayi* |
| Insecta | Diplura | Japygidae | *?Holjapyx* | *sp. 1* |
| Insecta | Diplura | Japygidae | *?Holjapyx* | *sp. 2* |

| Class | Order | Family | Genus | species |
|---|---|---|---|---|
| Insecta | Hymenoptera | Formicidae | *Myopias* | *cf. tasmaniensis* |
| Insecta | Hymenoptera | Formicidae | *Myrmecorhynchus* | *near carteri* |
| Insecta | Hymenoptera | Formicidae | *Oligomyrmex* | *?* |
| Insecta | Hymenoptera | Formicidae | *Orectognathus* | *clarki* |
| Insecta | Odonata | Gomphidae | *Armagomphus* | *armiger* |
| Insecta | Odonata | Gomphidae | *Austrogomphus* | *lateralis* |
| Insecta | Odonata | Gomphomacromiidae | *Hesperocordulia* | *berthoudi* |
| Insecta | Odonata | Gomphomacromiidae | *Lathrocordulia* | *metallica* |
| Insecta | Odonata | Petaluridae | *Petalura* | *hesperia* |
| Insecta | Odonata | Synthemistidae | *Archaeosynthemis* | *cyanitincta* |
| Insecta | Odonata | Synthemistidae | *Archaeosynthemis* | *occidentalis* |
| Insecta | Odonata | Synthemistidae | *Archaeosynthemis* | *spiniger* |
| Oligochaeta | Haplotaxida | Enchytraeidae | *Fridericia* | *cylindrica* |
| Oligochaeta | Haplotaxida | Enchytraeidae | *Fridericia* | *giniata* |
| Oligochaeta | Haplotaxida | Enchytraeidae | *Fridericia* | *holmesa* |
| Oligochaeta | Haplotaxida | Haplotaxidae | *Pelodrilus* | *darlingensis* |
| Onychophora | Onychophora | Peripatopsidae | *Occiperipatoides* | *gilesii* |
| Onychophora | Onychophora | Peripatopsidae | *Occiperipatoides* | *occidentalis* |
| Turbellaria | Alloeocoela | | | |
| Vertebrata | Anura | Myobatrachidae | *Geocrinia* | *alba* |
| Vertebrata | Anura | Myobatrachidae | *Geocrinia* | *vitellina* |
| Vertebrata | Anura | Myobatrachidae | *Spicospina* | *flammocaerulea* |

**APPENDIX IIa**

# ARACHNIDS COMPILED FOR RFA MAPPING

| FAMILY | SPECIES | SP. NO. |
|---|---|---|
| Idiopidae | *Aganippe rhaphiduca* | 2103 |
| Nicodamidae | *Ambicodamus marae* | 2188 |
| Bothriuridae | *Cercophonius sulcatus* | 2219 |
| Scorpionidae | *Urodacus planimanus* | 2222 |
| Scolopendridae | *Cormocephalus hartmeyeri* | 2228 |

**APPENDIX IIb**

# BIRDS RANKED FOR RFA MODELLING AND MAPPING

| SPECIES | COMMON NAME | SP. NO. | SP. RANK | MODEL | PROB. |
|---|---|---|---|---|---|
| [3]*Cacatua pastinator pastinator* | Western Long-billed Corella | 41 | 1 | GAM | >0.5 |
| *Calyptorhynchus banksii naso* | Red-tailed Black Cockatoo | 43 | 1 | GAM | >0.4 |
| [2]*Calyptorhynchus baudinii* | Baudin's Cockatoo | 44 | 1 | GAM | >0.5 |
| [2]*Calyptorhynchus latirostris* | Carnaby's Cockatoo | 45 | 1 | | |
| *Ninox connivens* | Barking Owl | 180 | 1 | | |
| [2]*Calyptorhynchus baudinii/latirostris* | White-tailed Black Cockatoos | 195 | 2 | | |
| *Climacteris rufa* | Rufous Treecreeper | 57 | 2 | GAM | >0.5 |
| *Coturnix ypsilophora* | Brown Quail | 145 | 2 | | |
| *Falcunculus frontatus leucogaster* | Crested Shrike-tit | 112 | 2 | | |
| [3]*Leiopoa ocellata* | Mallee Fowl | 91 | 2 | | |
| *Lophoictinia isura* | Square-tailed Kite | 8 | 2 | GAM | >0.4 |
| *Stagonopleura oculata* | Red-eared Firetail | 131 | 2 | GAM | >0.5 |
| *Stipiturus malachurus westernensis* | Southern Emu-wren | 90 | 2 | GAM | >0.4 |
| *Eopsaltria georgiana* | White-breasted Robin | 136 | 3 | GLM | >0.5 |
| *Malurus elegans* | Red-winged Fairy-wren | 86 | 3 | GAM | >0.55 |
| *Phaps elegans* | Brush Bronzewing | 60 | 3 | | |
| *Polytelis anthopeplus westralis* | Regent Parrot | 159 | 3 | GLM | >0.6 |
| *Turnix varia varia* | Painted Button-quail | 191 | 3 | GLM | >0.5 |
| *Tyto novaehollandiae* | Masked Owl | 193 | 3 | | |
| *Ninox novaeseelandiae* | Boobook Owl | 181 | 4 | | |
| *Pardalotus striatus* | Striated Pardalote | 125 | 4 | GAM | >0.5 |
| *Platycercus icterotis* | Western Rosella | 156 | 4 | | |
| *Platycercus spurius* | Red-capped Parrot | 157 | 4 | | |
| *Barnardius zonarius* | Australian Ringneck | 151 | 5 | GLM | >0.5 |
| [2]*Falco peregrinus* | Peregrine Falcon | 78 | 5 | | |
| *Neophema elegans* | Elegant Parrot | 153 | 5 | GLM | >0.55 |
| *Tyto alba* | Barn Owl | 192 | 5 | | |
| *Dacelo novaeguinea* | Laughing Kookaburra | 79 | | | |

[1] Federal List; [2] State List; [3] Both Lists

**Criteria for ranking selected species.**

Species have been ranked (1-5) for selection to model on the basis of :

1. Major population declines and/or range reductions impacting on conservation status
2. Species with naturally restricted ranges, specific habitat requirements or general population/range reductions
3. Species with somewhat restricted ranges, ground feeders or species with broad ranges but only occupying limited number of habitats
4. Widespread species but endemic forest species dependent on a general but widespread resource eg. tree hollows
5. Widespread species not dependent on, but utilising some forest resources

## Species not databased but with important populations in the RFA forest region

**Selection 1**

- Lewin's Water Rail *Rallus pectoralis clelandi* - Endemic south-west subspecies, now probably extinct. Formerly ranging north to Margaret River and east to King George Sound. Confined to wetlands.
- Dusky Moorhen *Gallinula tenebrosa* - Isolated south-west population confined largely to wetlands of forest areas i.e. north to lower Moore River and east to Albany.
- Bush Stone-curlew *Burhinus grallarius* - Patchy distribution in south-west, has declined greatly since 1920.
- Scarlet Robin *Petroica multicolor campbelli* - Largely confined to humid south-west. Endemic WA subspecies.
- Yellow Robin *Eopsaltria australis griseogularis* - Patchy distribution in south-west, has declined on Swan Coastal Plain and in much of wheat belt. Endemic subspecies.
- White-browed Babbler *Pomatostomus superciliosus* - Isolated population on humid south coast from Denmark west to Warren River and inland to Manjimup. Also formerly on lower west coast about the Vasse River.
- Restless Flycatcher *Myiagra inquieta inquieta* - Patchy distribution in south-west and appears to be declining.
- Grey Currawong *Strepera versicolor plumbea* - Patchy distribution in south-west. Has declined greatly along south west coast both in forests and coastal scrubs. Endemic subspecies.

**Selection 2.**

- Little Bittern *Ixobrychus minutus* - Isolated south-west population ranging north to Moora and east to Two Peoples Bay. Confined to wetlands.
- Black Bittern *Ixobrychus flavicollis* - Isolated south-west population ranging north to Yanchep and Northam and east to Albany. Confined to wetlands.
- Australasian Bittern *Botaurus poiciloptilus* - Patchy distribution in south-west, has declined on Swan Coastal Plain. Confined to wetlands.
- Baillon's Crake *Porzana pusilla* - Isolated south-west population. Confined to wetlands.
- Spotless Crake *Porzana tabuensis* - Isolated south-west population. Confined to wetlands.
- Purple Swamphen *Porphyrio porphyrio bellus* -Endemic south-western subspecies. Confined to wetlands.
- Purple-crowned Lorikeet *Glossopsitta porphyrocephala* - Obligate hollow nester, but ranging well out of south-west forest area. Blossom nomad.
- Western White-naped Honeyeater *Melithreptus chloropsis* - Largely confined to south-west forest areas north to New Norcia and east to Esperance. Endemic to WA.
- Yellow-plumed Honeyeater *Meliphaga ornata* - Isolated populations in northern Darling Range (Gooseberry Hill south to Kelmscott); also isolated coastal plain population in Tuarts from Yanchep to Wonnerup. Occurs mainly east of forest block with another isolated population on far south-east WA coast.

**Selection 3.**

- White-browed Scrubwren *Sericornis frontalis maculatus* - South-west population almost broken to north and east of forest block.
- Western Thornbill *Acanthiza inornata* - WA endemic largely confined to south-west forests.
- Brown-headed Honeyeater *Melithreptus brevirostris leucogenys* - Apparently several isolated populations in forest area i.e. Darling Range from Helena River south to Harvey River; also Wooroloo; and around Boyup Brook and Bridgetown. Endemic WA subspecies. Expanding into the forest since disturbance and clearing.
- Western Spinebill *Acanthorhynchus superciliosus* - Largely confined to south-western forests. Endemic to WA.
- Little Wattlebird *Anthochaera chrysoptera lunulata* - Patchy distribution in south-west. Endemic subspecies.
- Grey Fantail *Rhipidura fuliginosa preissi* - Endemic subspecies.
- Dusky Woodswallow *Artamus cyanopterus* - Recent colonist to parts of the deep south-west since partial clearing of the denser forests.
- Grey Butcherbird *Cracticus torquatus torquatus* - Has expanded its range in the deep south-west with clearing of the heavy eucalypt forests.
- Tree Martin *Hirundo nigricans* - Obligate hollow nester. Ranges well outside forest area.
- Fan-tailed Cuckoo *Cacomantis flabelliformis* - Largely confined to south-west forest region.
- Shining Bronze Cuckoo *Chrysococcyx lucidus* - Breeding largely confined to south-west forest region where it is a migrant.
- Sacred Kingfisher *Todiramphus sanctus* - Obligate hollow nester but extends (migrates?) well out of south-west region.
- Spotted Pardalote *Pardalotus punctatus* - Mainly breeding in deep south-west with an outlier in Stirling Range. A partial migrant.
- Brown Honeyeater *Lichmera indistincta indistincta* - Distribution in south-west patchy, absent from much of Darling Range and deep south-west. Blossom nomad.
- White-cheeked Honeyeater *Phylidonyris nigra mystacalis* - Isolated south-west population on coast from Cape Naturaliste to Scott River; also another isolated coastal population from Cliff Head south to Swan River area. Otherwise largely absent from forest block.

**APPENDIX IIc**

# CRUSTACEA RANKED FOR RFA MAPPING

| FAMILY | GENUS | SPECIES | SP. NO. | SP. RANK |
|---|---|---|---|---|
| Parastacidae | *Cherax* | *crassimanus* | 1698 | high |
| Parastacidae | *Cherax* | *quinquecarinatus* | 1708 | high |
| Parastacidae | *Chrax* | *glaber* | 1701 | high |
| Parastacidae | *Engaewa* | *subcoerulea* | 1721 | high |
| Perthiidae | *Perthia* | *acutitelson* | 1530 | high |
| Perthiidae | *Perthia* | *branchialis* | 1531 | high |
| Parastacidae | *Cherax* | *tenuimanus* | 1709/1710/1711 | mod/high |
| Parastacidae | *Cherax* | *preissii* | 1706/1707 | mod/high |
| Ceinidae | *Austrochiltonia* | | 1535 | mod |
| Palaemonidae | *Palaemonetes* | *australis* | 1727 | mod |
| Styloniscidae | | | 1821 | low/mod |
| Talitridae | | | 1537 | low/mod |
| Talitridae | *Austrotroides* | *occidentalis* | 1540 | low/mod |
| Amphisopodidae | *Amphisopus* | | 1826 | low |
| Armadillidiidae | | | 1805 | low |
| Centropagidae | *Calamoecia* | *attenuata* | 1562 | low |
| Centropagidae | *Calamoecia* | *tasmanica* | 1565 | low |
| Chydoridae | *Pleuroxus* | | 1616 | low |

**APPENDIX IId**

# FISH SPECIES COMPILED FOR RFA MAPPING

| GENUS | SPECIES | SP. NO. | LIST STATUS | ENDEMISM |
|---|---|---|---|---|
| *Afurcagobius* | *suppositus* | 701 | - | 1 |
| *Bostockia* | *porosa* | 702 | - | 1 |
| *Edelia* | *vittata* | 703 | - | 1 |
| *Galaxias* | *occidentalis* | 704 | - | 1 |
| *Galaxias* | *truttaceus* | 705 | - | - |
| *Galaxiella* | *munda* | 706 | ASFB | 1 |
| *Galaxiella* | *nigrostriata* | 707 | ASFB | 1 |
| *Gambusia* | *holbrooki* | 708 | - | - |
| *Geotria* | *australis* | 709 | - | - |
| *Lepidogalaxias* | *salamandroides* | 711 | ASFB | 1 |
| *Leptatherina* | *wallacei* | 712 | - | 1 |
| *Nannatherina* | *balstoni* | 713 | ASFB | 1 |
| *Galaxias* | *maculatus* | 718 | - | - |
| *Perca* | *flaviatilis* | 714 | - | - |
| *Pseudogobius* | *olorum* | 715 | - | - |
| *Trout* | *species* | 717 | - | - |
| *Tandanus* | *bostocki* | 716 | - | 1 |

ASFB: Australian Society of Fish Biology listing of threatened fishes. 1= Endemic to the RFA region.

**APPENDIX IIe**

# FROGS RANKED FOR RFA MODELLING AND MAPPING

| SPECIES | COMMON NAME | SP. NO. | SP. RANK | MODEL | PRED. |
|---|---|---|---|---|---|
| [3]*Geocrinia alba* | White-bellied Frog | 309 | 2 | | |
| [2]*Geocrinia lutea* | Nornalup Frog | 311 | 2 | | |
| [3]*Geocrinia vitellina* | Yellow-bellied Frog | 313 | 2 | | |
| *Heleioporus barycragus* | Western Marsh Frog | 315 | 2 | | |
| *Spicospina flammocaerulea* | Sunset Frog | 299 | 2 | | |
| *Crinia subinsignifera* | Squelching Froglet | 308 | 3 | | |
| *Geocrinia rosea* | Roseate Frog | 312 | 3 | | |
| *Heleioporus inornatus* | Plain Frog | 317 | 3 | | |
| *Heleioporus psammophilus* | Sand Frog | 318 | 3 | GAM | >0.45 |
| *Metacrinia nichollsi* | Nicholls' Toadlet | 320 | 3 | | |
| *Myobatrachus gouldii* | Turtle Frog | 321 | 3 | | |
| *Litoria adelaidensis* | Slender Tree Frog | 301 | 4 | | |
| *Litoria moorei* | Motorbike Frog | 303 | 4 | | |
| *Crinia georgiana* | Quacking Frog | 304 | 4 | GAM | >0.6 |
| *Crinia glauerti* | Glauert's Froglet | 305 | 4 | GLM | >0.6 |
| *Crinia pseudinsignifera* | Bleating Froglet | 307 | 4 | | |
| *Geocrinia leai* | Lea's Frog | 310 | 4 | GLM | >0.6 |
| *Limnodynastes dorsalis* | Banjo Frog | 319 | 4 | | |
| *Pseudophryne guentheri* | Guenther's Toadlet | 324 | 4 | | |

[1] Federal List; [2] State List; [3] Both Lists

**Criteria for ranking selected species.**

Species have been ranked (1-5) for selection to model on the basis of :

1. Major population declines and/or range reductions impacting on conservation status
2. Species with naturally restricted ranges, specific habitat requirements or general population/range reductions
3. Species with somewhat restricted ranges or species with broad ranges but only occupying limited number of habitats
4. Widespread species but endemic forest species dependent on a general but widespread resource eg. stream zones or swamps

**APPENDIX IIf**

# MAMMALS RANKED FOR RFA MODELLING AND MAPPING

| SPECIES | COMMON NAME | SP. NO. | SP. RANK | MODEL | PRED. |
|---|---|---|---|---|---|
| [3]*Dasyurus geoffroii* | Chuditch | 610 | 1 | | |
| [2]*Macropus eugenii* | Tammar Wallaby | 615 | 1 | | |
| [2]*Setonix brachyurus* | Quokka | 645 | 1 | | |
| [3]*Myrmecobius fasciatus* | Numbat | 622 | 1 | | |
| [3]*Bettongia penicillata* | Brush-tailed Bettong | 604 | 1 | | |
| [3]*Pseudocheirus occidentalis* | Western Ringtail Possum | 639 | 1 | | |
| *Antechinus flavipes* | Mardo | 602 | 2 | | |
| [3]*Phascogale calura* | Red-tailed Phascogale | 636 | 2 | GLM | >0.6 |
| *Phascogale tapoatafa* | Brush-tailed Phascogale | 637 | 2 | | |
| *Sminthopsis gilberti* | Gilbert's Dunnart | 648 | 2 | | |
| *Sminthopsis griseoventer* | Grey-bellied Dunnart | 651 | 2 | | |
| *Macropus irma* | Western Brush Wallaby | 617 | 2 | | |
| *Hydromys chrysogaster* | Water-rat | 612 | 2 | | |
| [2]*Isoodon obesulus* | Quenda | 613 | 2 | | |
| *Falsistrellus mackenziei* | Western False Pipistrelle | 611 | 2 | | |
| *Nyctophilus gouldi* | Gould's Long-eared Bat | 627 | 2 | | |
| *Cercatetus concinnus* | Western Pygmy-possum | 606 | 3 | | |
| *Rattus fuscipes* | Bush Rat | 644 | 3 | GAM | >0.5 |
| *Trichosurus vulpecula* | Common Brushtail Possum | 658 | 3 | | |
| *Tarsipes rostratus* | Honey Possum | 657 | 3 | | |

[1] Federal List; [2] State List; [3] Both Lists

**Criteria for ranking selected species.**

Species have been ranked (1-5) for selection to model on the basis of :

1. Major population declines and/or range reductions impacting on conservation status
2. Species with naturally restricted ranges, specific habitat requirements or general population/range reductions
3. Species with somewhat restricted ranges or species with broad ranges but only occupying limited number of habitats

**APPENDIX IIg**

# MOLLUSCS RANKED FOR RFA MAPPING

| SPECIES | SP. NO. | SP. RANK |
|---|---|---|
| *Bothriembryon indutus* | 1015 | 2* |
| *Bothriembryon* sp.nov. "Boddington" | 1043 | 2** |
| *Bothriembryon fuscus* | 1012 | 2 |
| *Bothriembryon revectus* | 1033 | 2 |
| *Bothriembryon* sp.nov. "Augusta" | 1041 | 2 |
| *Bothriembryon* sp.nov. "DenmarkB" | 1049 | 2 |
| *Bothriembryon* sp.nov. "Nannup" | 1071 | 2 |
| *Bothriembryon* sp.nov. "PtD'Entrecasteaux" | 1074 | 2 |
| *Bothriembryon leeuwinensis* | 1021 | 3 |
| *Bothriembryon sayi* | 1036 | 3 |
| *Bothriembryon serpentinus* | 1038 | 3 |
| *Bothriembryon* sp.nov. "Manjimup" | 1061 | 3 |
| *Bothriembryon* sp.nov. "SWCaves" | 1076 | 3 |
| *Bothriembryon brazieri* | 1005 | 4 |
| *Bothriembryon jacksoni* cf. | 1018 | 4 |
| *Bothriembryon naturalistarum* | 1025 | 4 |
| *Bothriembryon bulla* | 1006 | 5 |
| *Bothriembryon jacksoni* | 1017 | 5 |
| *Bothriembryon kendricki* | 1019 | 5 |
| *Bothriembryon kingii* | 1020 | 5 |

* = extremely isolated population on limestone areas of river slope of Kings Park under threat although populations along Darling Escarpment protected among granitic/doleritic boulders,

** = only one specimen known, but from an area poorly frequented and never surveyed

**Criteria for ranking selected species**

Species are ranked (1-5) for selection to model on the basis of:

1. Major population declines and/or range reductions impacting on conservation status
2. Species with naturally restricted ranges or specific habitat requirements
3. Species with somewhat restricted ranges or species with broad ranges but only occupying a limited number of habitats
4. Widespread but endemic forest species dependent on a general but widespread resource
5. Widespread non-forest species with a small distribution in the forest and utilising some forest resources

**APPENDIX IIh**

# REPTILES RANKED FOR RFA MODELLING AND MAPPING

| SPECIES | SP. NO. | SP. RANK | MODEL | PRED. |
|---|---|---|---|---|
| [2]*Morelia spilota imbricata* | 333 | 1 | | |
| *Egernia luctuosa* | 406 | 1 | | |
| *Ctenotus delli* | 395 | 2 | | |
| *Egernia pulchra* | 461 | 2 | | |
| *Elapognathus minor* | 341 | 2 | | |
| *Rhinoplocephalus bicolor* | 351 | 2 | | |
| *Ctenophorus ornatus* | 465 | 3 | | |
| *Egernia kingii* | 405 | 3 | GAM | >0.4 |
| *Glaphyromorphus gracilipes* | 412 | 3 | GLM | >0.9 |
| *Lerista microtis* | 424 | 3 | | |
| *Ramphotyphlops pinguis* | 434 | 3 | | |
| *Suta nigriceps* | 361 | 3 | | |
| *Acritoscincus trilineatum* | 390 | 4 | GAM | >0.8 |
| *Aprasia pulchella* | 380 | 4 | | |
| *Ctenotus labillardieri* | 399 | 4 | GAM | >0.9 |
| *Diplodactylus polyophthalmus* | 369 | 4 | | |
| *Hemiergis initialis* | 415 | 4 | | |
| *Hemiergis peronii tridactyla* | 417 | 4 | | |
| *Lerista distinguenda* | 419 | 4 | | |
| *Oedura reticulata* | 453 | 4 | | |
| *Suta gouldii* | 359 | 4 | | |
| *Underwoodisaurus milii* | 377 | 4 | | |

[1] Federal List; [2] State List; [3] Both Lists

**Criteria for ranking selected species.**

Species have been ranked (1-5) for selection to model on the basis of :

1. Major population declines and/or range reductions impacting on conservation status
2. Species with naturally restricted ranges that have a core population in the RFA area.
3. Species with restricted ranges or specific habitat requirements and having a range limit within the RFA area.
4. Widespread species but with a range limit within the RFA region.

**APPENDIX I.**

**Notes to accompany taxon attribute table - ATTRIB.DBF**

An attribute table has been produced for each major taxon group.
This table has three sections:

- 1. Taxon details
- 2. Information on the state of systematic knowledge
- 3. Information on phylogenetic and zoogeographic significance

## Taxon details

Order, Family, Genus, Species, Subspecies

## State of systematic knowledge

**revis_who** : name of last reviser (eg, Smith, B.)
**revis_when** : year of last revision (eg 1978)
**revis_stat** : status of last revision (**P**: Published; **M**: Manuscript; **T**: Thesis; **O**: Ongoing)
**revis_how** : basis of revision (**M**: Morphology; **G**: Genetic; **B**: Biology; or combine, eg, MG)
**status** : overall summary of taxonomic status, ranked as:

1. **well-defined taxon**, good evidence of taxon integrity
2. **apparently straightforward**, no grounds for suspicion
3. **possibly composite**, grounds for suspicion
4. **probably composite**, evidence to doubt taxon integrity
5. **possibly not valid**, grounds for suspicion
6. **probably not valid**, evidence to doubt taxon distinctness

## Taxon significance

**phyl_dist :** Phlogenetic distinctiveness, considered globally*, ranked as:

1. monotypic higher taxon (suprafamilial)
2. monotypic family
3. monotypic genus
4. distinctive species
5. member of species group

* ie in context of the taxons wider distribution, not solely in context of SW forest

**zoog_stat :** Special zoogeographic status, according to following criteria:

1. relictual, from past 'wetter' phase
2. relictual, from past 'drier' phase
3. restricted, product of localised speciation

**zoog_affin :** General zoogeographic affinity, according to following criteria:

1. core distribution in forest
2. mainly coastal habitats, extending into forests
3. mainly wheatbelt, extending into forests
4. widespread, coastal to woodland

**microhab :** Special microhabitat requirement (from list, or type in **mh_other**; use two or more categories if appropriate, eg, 5,8). Add your own number codes if this is useful (eg, 10 - limestone rocks) but be sure to type the description into **mh_other** for the first occurrence, so that we know what the codes mean!

1. tree hollow
2. tree bark
3. fallen logs
4. permanently moist litter
5. seasonal standing water
6. permanent standing water
7. granite outcrop
8. sand
9. laterite rocks

**mh_other :** type brief description (1-3 words)

**list_status :**

1. Federal
2. State
3. Both

**disjunct :**

1. more or less continuous distribution
2. primary range + peripheral isolates
3. several major parts to range, separated by significant gap
4. small discrete patches, clustered within small area
5. small discrete patches, widely separated

**endemism :**

1. endemic to RFA region (ie, found nowhere else)
2. restricted to RFA region within southwest WA, but found outside of southwest WA (eg, present in SA)

**range_limit :**

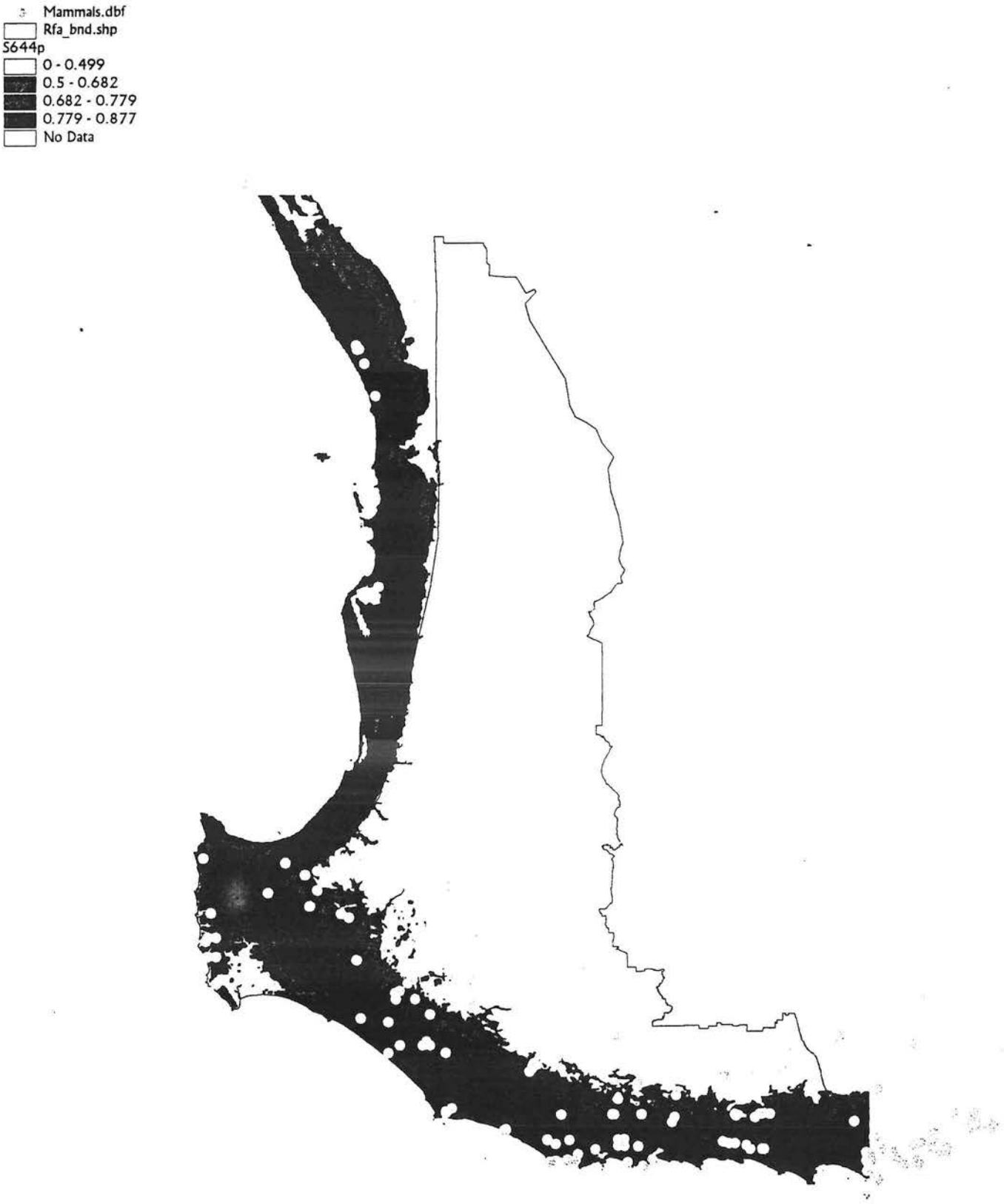
1. range completely overlaps RFA, no range limits within RFA region
2. confined to part of RFA region, hence reaches limits within RFA by default
3. taxon reaches limit of range partway through the RFA region

**migratory (birds only) :**

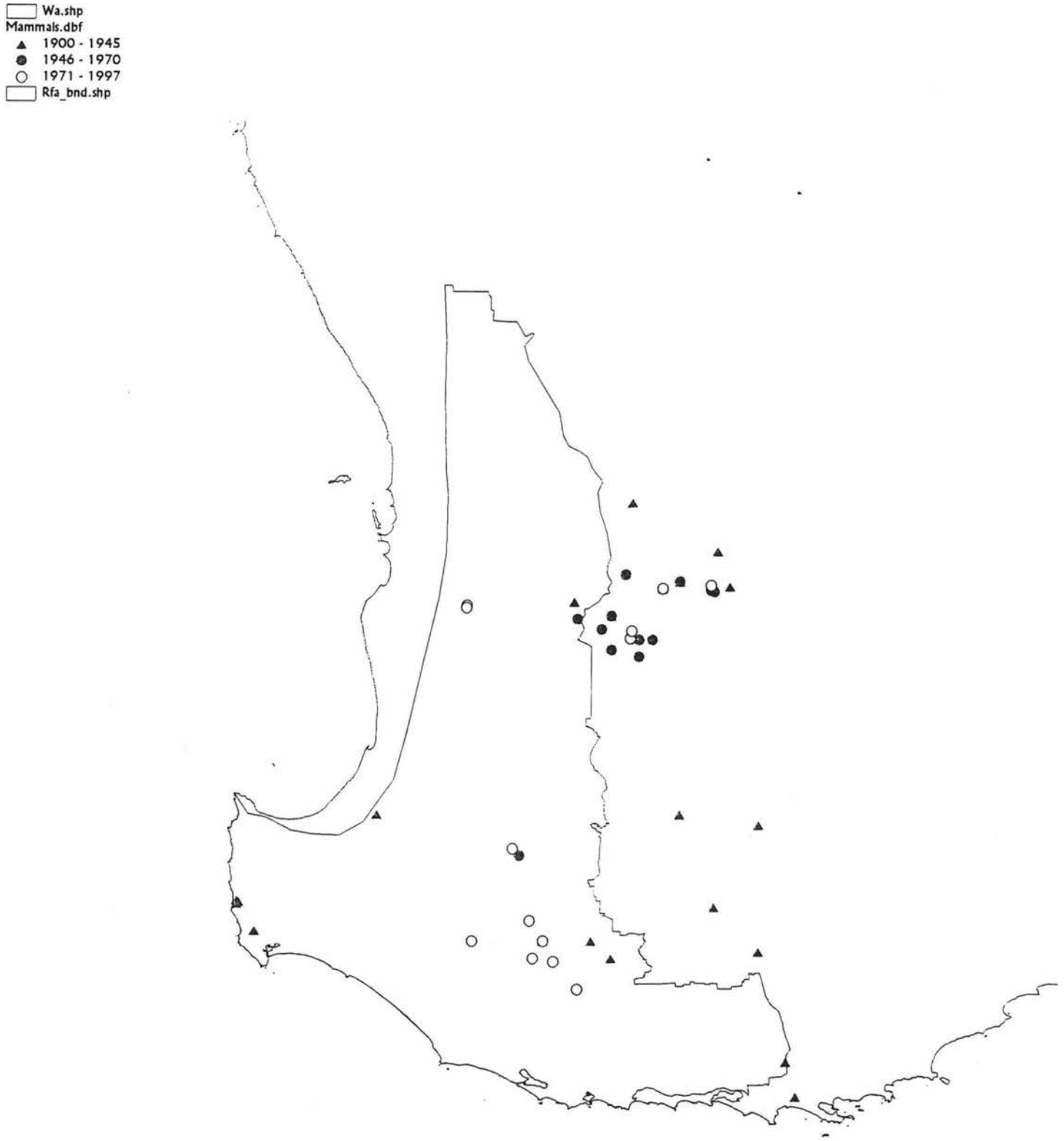
1. sedentary
2. migratory (long distance)
3. movements within RFA and adjacent regions

**APPENDIX III.** Model output for the Bush Rat, *Rattus fuscipes*, and range shifts in selected vertebrates since European settlement as illustrated by their point maps. The map for the Australian Ringneck Parrot, *Barnardius zonarius*, exemplifies the bias to roadside records in this taxon.

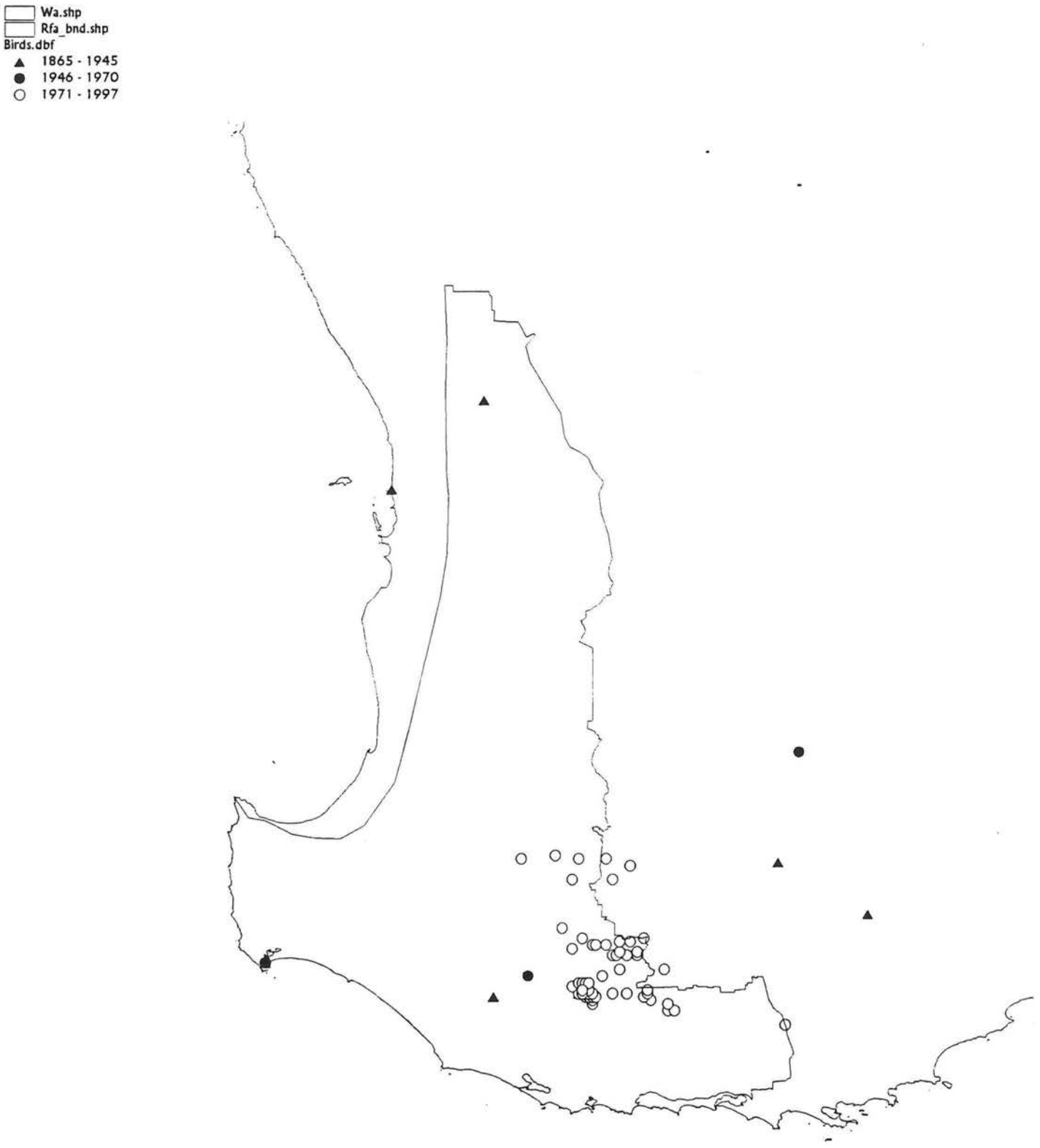
# Rattus fuscipes



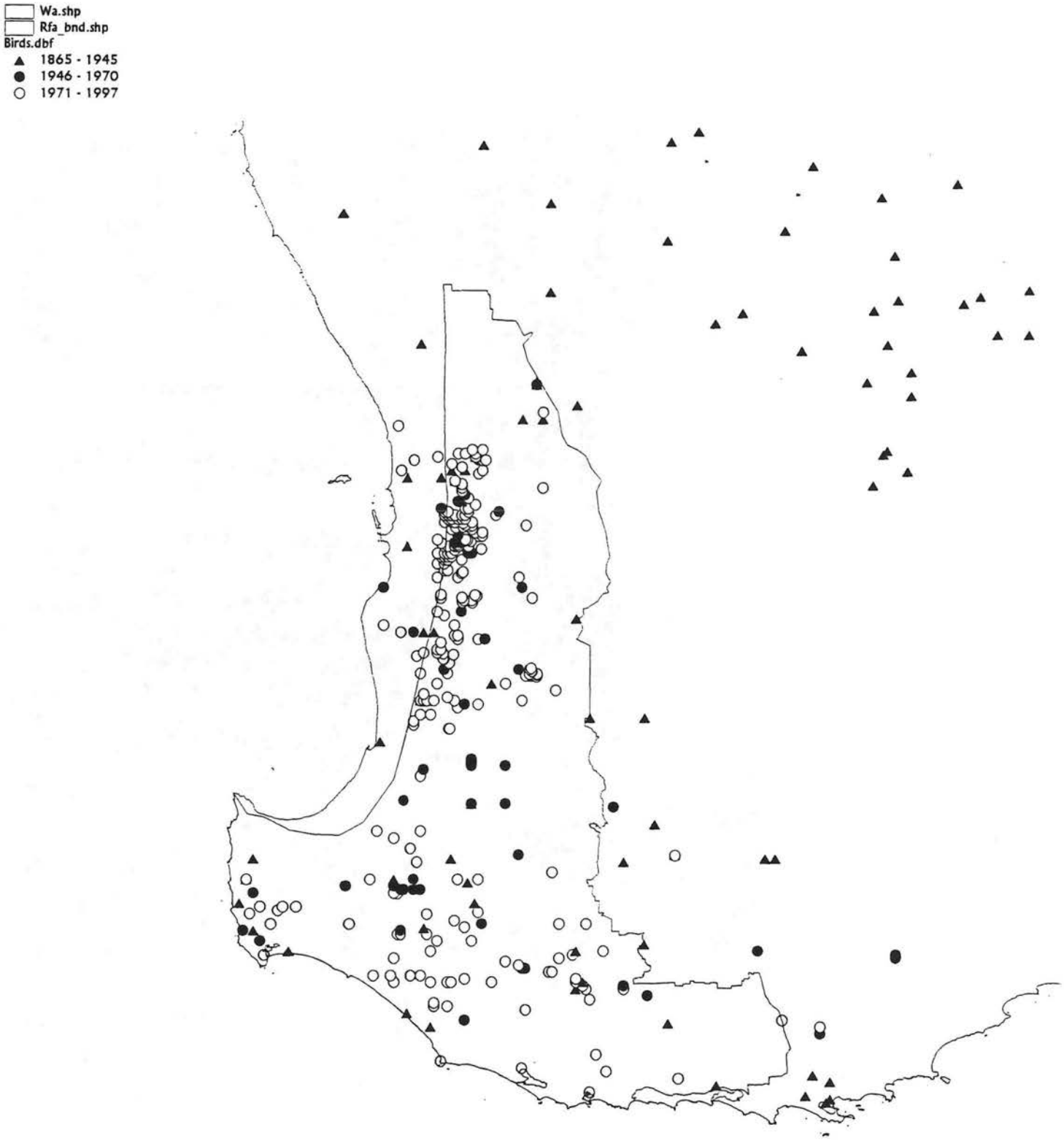
# Bettongia penicillata



# Cacatua pastinator



# Calyptorhynchus banksii naso



# Barnardius zonarius