2. METHODS

2.1. DISTRIBUTION DATA

Distributional data on all terrestrial vertebrates were collected during intensive field surveys across the region and by collating all available sources from literature and institutional databases. Realistic distribution models require good coverage of the range of environments present within the distribution of each species, and thus the regional coverage of both geographic and environmental space was analysed and additional standardised surveys were carried out to fill gaps in both geographic and environmental space as much as possible.

Total survey effort across the bioregion included over 1,200 bird surveys, 600 reptile surveys, 300 spotlighting transects, approximately 50,000 trap nights for small mammals, 150 stream-frog surveys, 300 microhylid frog surveys and approximately 7,000 miscellaneous records collected during field work. Other major sources of data included the Birds Australia *Atlas of Australian Birds* and the *QPWS WildNet* fauna database of the Queensland Parks and Wildlife Service. Individual biologists who have worked in the Wet Tropics provided important additional records (see special reference section in Williams *et al*. 1996). The resulting database contains about 100,000 spatially referenced records of over 600 terrestrial vertebrate species. Each record was checked for both positional and taxonomic reliability and only records of high reliability were retained in the analyses.

2.2. DISTRIBUTION MAPS

The maps presented in this report are my best estimate of the distribution of each species given available data. The production of each distribution map involved a three-step process:

a) A bioclimatic model of the spatial distribution of the species was produced;
b) The resulting climatic map was clipped using the habitat preferences of each species; and
c) Maps were then clipped by known biogeographic limits of the species distribution.

The aim was to produce a distribution map that was as accurate as possible within the limits of my knowledge of each species. The process is ongoing and all new data improves the accuracy of the maps. Each of these three steps is outlined in more detail below.

2.2.1. Bioclimatic Models of Species Distribution

The modeling program we used was BIOCLIM, a part of the ANUCLIM 5.1 package (Houlder *et al.* 2000). The digital elevation model used for the region had a pixel resolution of 80m x 80m. BIOCLIM generates up to thirty-five climatic parameters based on maximum temperature, minimum temperature, rainfall, radiation and evaporation. However, unrestricted use of so many variables in a climatic envelope method results in over-parameterisation and loss of predictive power of the models, therefore we restricted the environmental variables to ten parameters that had previously demonstrated significance in explaining biological patterns of diversity within the region:

1. The mean annual temperature;
2. Intra-annual variability of monthly mean temperature;
3. Maximum temperature of the warmest quarter;
4. Minimum temperature of the coldest quarter;

5. Mean annual precipitation;
6. Intra-annual variability of monthly mean precipitation;
7. Precipitation of the wettest quarter;
8. Precipitation of the driest quarter;
9. Annual mean radiation; and
10. Intra-annual variability of monthly mean radiation.

This set of variables was selected after extensive multiple regression modeling of each vertebrate group, combined with biological knowledge on each group. The aim was to use the minimum number of variables possible that filled several criteria, where:

a) The variable was consistently significant in statistical analyses relating to the spatial patterns of biodiversity and abundance of vertebrates; and
b) The set of variables represented minimums, maximums and means of both temperature and rainfall.

Restricting the analysis to these relatively simple climatic variables makes the biological significance of the variables easier to interpret. Core environmental distribution was defined as the areas where the climatic parameters fall within the fifth and ninety-fifth percentiles of the values of the parameters in the species profile.

Bioclimatic envelope methods such as BIOCLIM generally overestimate distribution area since, by definition, they do not take habitat preferences, biotic exclusion (e.g. due to competition) or biogeographic barriers into account. Each distribution map from the bioclimatic modeling was therefore clipped by habitat preferences and known biogeographic limits. In any cases where there was uncertainty in habitat preference or the species biogeographic distribution was poorly known, the models were not clipped to make them as conservative as possible.

2.2.2. Biogeographic Limits

Current distribution models were evaluated by comparison with known patterns of subregional occurrence (Williams *et al.* 1996) and a huge investment in fieldwork over the last ten years has gone into checking these biogeographical distributions. Based on these data, the subregional distribution patterns of most species are well known. When the bioclimatic model predicted suitable environment in a subregion where I was highly confident that the species was not present due to a biogeographic barrier (e.g. Herbert River gorge), the predicted area was removed from the map. If there was any doubt that the species might occur there, the predicted distribution was not edited. Just as some species have been overestimated, I am sure that some species with few records will have been underestimated.

2.2.3. Habitat Preference

Often, the correct climatic combination may be present but in areas of unsuitable habitat. In order to take this into account as best as possible, I allocated each species a ranking from 0 (zero) to six (6) to describe their relative degree of rainforest specialisation, with a 6 being a rainforest obligate and 0 (zero) being a species that does not occur in rainforest (see Appendix A). The rankings are basically my opinion; however, they are based on quantitative measures of abundance based on over two thousand surveys across the region and across rainforest habitat boundaries. For many species, detailed quantitative data is available but the ranking used was considered to be the highest resolution that could consistently be applied across all species presented here.

2.2.4. Prediction of Climate Change Impacts

I chose a range of temperature increase scenarios to encompass the predicted range (1.4 to 5.8°C in Houghton *et al.* 2001) including temperature increases of + 1°C, + 3.5°C, + 5°C and + 7°C. These increases were applied to each of the three temperature variables uniformly across the region. We used the bioclimatic models based on current species distribution to predict distributional changes with increasing temperature and subsequent changes to regional patterns of biodiversity. The area of core environment remaining at the different temperature scenarios formed the basis of analyses. Overlaying species distribution models within each climate change scenario produced species richness maps. These climate change impact predictions have been previously published in Williams *et al.* (2003) and Thomas *et al*. (2004a; 2004b).

2.2.5. Species Richness Maps

Continuous maps of species richness were produced by overlaying the distribution maps of each species in ARC-GIS and counting the number of species within a given taxonomic group whose core distribution was predicted to occur in each grid cell (80 m x 80 m pixels). Since only species with enough data to enable a reasonable predictive map of distribution can be included in the analysis, and since I chose only to include the bioclimatic core distribution area, these maps represent spatial maps of relative species richness, not absolute total species richness. The absolute numbers will not be completely correct, with total species richness being greater than the mapped numbers. However, the relative pattern of species richness is realistic and has been confirmed by many other analyses of empirical field data using my standardised survey data. The spatial patterns of diversity hotspots, etc. should be realistic and useful for broad regional scale conservation planning.