APPENDIX 7. PROCESSES THREATENING AUSTRALIA'S ENDANGERED AND VULNERABLE TERRESTRIAL REPTILES.

Most of these threats are speculative; few have been confirmed by research. See individual recovery outlines for further explanation of the processes which are believed to be responsible for declines.

SPECIES	THREATENING PROCESS																	
	Habitat clear-ance	Over-grazing by stock	Cropping	Pre-dation	Urban develop-ment	Pasture improve-ment	Fire regime	Soil degrad -ation	Visitor disturb -ance	Soil &/or water pollution	Mining	Native forest logging	Climatic vari-ation	Rabbit grazing	Habitat fragment-ation	Weed invasion	Habitat drainage	Rock removal	Other threats
Elseya sp. nov.	*							*		*							? *		
Emydura signata								*		*		*							Fishing ?water supply scheme
Pseudemydura umbrina	*		*	*	*		*				*		*				*		
Rheodytes leukops	*		*							*	*								
Gen. nov. sp. nov. (Chelidae)	*	*	*	*					*	*	*								Irrigation Captive trade
Christinus guentheri				*				*						*					
Lepidodactylus listeri	*			*							*					*			Displaced by introduced sp.
Nephrurus deleani		*						*						*					
Underwoodisaurus sphyrurus	*	*										*							Dam building
Aprasia aurita	*		*				*												
Aprasia pseudopulchella	*	*	*		*	*													
Aprasia rostrata rostrata				*					*										
Delma impar	*	*	*		*	*	*								*	*		*	

SPECIES	THREATENING PROCESS																		
	Habitat clear-ance	Over-grazing by stock	Cropping	Pre-dation	Urban develop-ment	Pasture improve-ment	Fire regime	Soil degrad-ation	Visitor disturb-ance	Soil &/or water pollution	Mining	Native forest logging	Climatic vari-ation	Rabbit grazing	Habitat fragment-ation	Weed invasion	Habitat drainage	Rock removal	Other threats
Delma labialis	*	*			*				*										
Delma torquata	*	*			*	*													
Ophidiocephalus taeniatus		*						*					*	*					Loss of litter
Paradelma orientalis	*	*	*			*						*							
Ctenophorus yinnietharra		*																	
Tympanocryptis lineata pinguicolla	*	*	*		*	*	*							*	*	*		*	Irrigation
Anomalopus mackayi	*	*	*					*		*									Loss of litter Irrigation
Coeranoscincus reticulatus	*	*	*			*						*			*				
Ctenotus lancelini									*							*			Disturbance by gull colony
Ctenotus zastictus		*					*		? *										
Egernia kintorei				*			*							*					Hunted for food
Egernia pulchra longicauda				*			*		*										Competition from introd. sp.
Egernia stokesii aethiops				*									*						Competition from native sp.
Egernia stokesii badia	*	*	*																

SPECIES	THREATENING PROCESS																		
	Habitat clear-ance	Over-grazing by stock	Cropping	Pre-dation	Urban develop-ment	Pasture improve-ment	Fire regime	Soil degrad -ation	Visitor disturb -ance	Soil &/or water pollution	Mining	Native forest logging	Climatic vari-ation	Rabbit grazing	Habitat fragment-ation	Weed invasion	Habitat drainage	Rock removal	Other threats
Egernia stokesii stokesii				*									*						
Eulamprus leuraensis				?*	*				*	*		*							Plantations
Eulamprus tympanum ssp. nov.	*																	*	
Lerista allanae		*	*			*													
Lerista vittata	*					*													
Niveoscincus palfreymani				*									*						Loss of food source
Pseudemoia lichenigera				*				*						*					
Tiliqua adelaidensis			*		*	*													
Ramphotyphlops exocoeti	*							*			*								
Aspidites ramsayi	*		*	?*															
Morelia spilota imbricata	*	*	*			*													
Austrelaps labialis	*		*	*	*														
Denisonia maculata	*	*	*		*	*													?poisoned by introd. sp.
Echiopsis atriceps	*		*								*								
Echiopsis curta	*	*	*				?*												

SPECIES	THREATENING PROCESS																		
	Habitat clear-ance	Over-grazing by stock	Cropping	Pre-dation	Urban develop-ment	Pasture improve-ment	Fire regime	Soil degrad -ation	Visitor disturb -ance	Soil &/or water pollution	Mining	Native forest logging	Climatic vari-ation	Rabbit grazing	Habitat fragment-ation	Weed invasion	Habitat drainage	Rock removal	Other threats
Elapognathus minor	*				*							*					*		Competition from native sp.
Furina dunmalli	*	*	*		*	*											? *		
Hoplocephalus bungaroides	*				*				*						*			*	Captive trade
Notechis ater ater	*	*					*	*		*									?Loss of food source
Simoselaps calonotus	*		*		*		*								*	*			
TOTAL	30	21	21	14	14	12	10	9	8	7	6	6	5	6	5	5	4	4	

APPENDIX 8.1 WORLDMAP - Analysis of Priority Areas for Conservation of Reptiles

Threatened species represent a high-priority subset of the overall biodiversity of any given area. The measurement of biodiversity, whether in geographical, geo-taxonomic or simply taxonomic terms, continues to present biologists with a major problem.

In practice, biodiversity is usually measured by some simple index of taxonomic diversity such as species richness. But species richness is only one measure of diversity, and one which is often inappropriate to conservation action because it weights all species equally. Consequently phylogenetically-distinctive organisms (such as species representing monotypic families or orders) must be separately identified and given special emphasis in conservation where appropriate.

The supplemental variables in the Millsap *et al.* (1990) ranking system described in Appendix 10 attempt, with some success, to assign higher values to phylogenetically significant taxa. However in recent years a number of attempts have been made to utilise a wide range of variables (including phylogenetic significance) in identifying areas or habitats of special conservation significance and in assigning conservation priorities (eg Pressey *et al.*, 1993). All such methodologies eventually depend for their effectiveness on the quality of their underlying database, and on the rigour of their underlying mathematical model.

These problems have been very thoroughly addressed by Vane-Wright *et al.* (1991) and Williams *et al.* (1991, 1993). These authors point out that phylogenies based on cladistic methods provide an effective measure of phylogenetic uniqueness, and Williams has developed special computer software ("WORLDMAP") to measure various components of biodiversity and, through a series of elegant algorithms, to use various criteria to identify geographic areas (on a variety of scales) of high biodiversity conservation value and hence of potential value as reserves.

While this software is still in the development stage, the Consultants are indebted to Dr Paul Williams and his colleagues at the British Museum (Natural History) for making copies of their software available for trialing in the Australian Reptile Action Plan.

In order to exploit the full capabilities of WORLDMAP it could be necessary to have available a cladistic analysis of the fauna being treated. However few groups of Australian reptiles have been subject to rigorous cladistic analysis.

Fortunately WORLDMAP currently uses only the *number of nodes* between the species and the root of the cladogram, and not *internodal distances*, as the principal measure of cladistic divergence. Consequently an equal-weight cladogram based on the current classification of the Australian reptile fauna provides the necessary cladistic input for a WORLDMAP analysis, and for the construction of the necessary cladistic codes.

The full WORLDMAP methodology, including the mathematical and statistical bases for the various analyses, is explained in the papers referred to above and should be consulted by the reader. The following brief descriptions of the nine principal biodiversity measures are extracted and only slightly modified from the WORLDMAP manual. As pointed out by Vane-Wright *et al.* (1991) no one measure can meet all of the criteria which need to be considered in setting biodiversity reserve priorities.

The following nine analyses were applied only to the 11 Endangered and 36 Vulnerable terrestrial reptiles.

Species richness
One of the simplest measures of diversity is unweighted species richness, an estimate of the number of species in an area.

The Species Richness maps (Appendices 5.2-5.4) display the unweighted numbers of species per square plotted as the raw numbers of species in the clade. The species richness map for marine turtles is shown in Appendix 6.1.

Endemism
While endemism is not a direct biodiversity measure, it represents an important criterion for conservation biologists seeking to prioritise protection measures for particular taxa. Centres of endemism can be identified by the co-occurrence of large numbers of species with very restricted distributions.

The Endemism map (Appendix 8.2) shows for Endangered and Vulnerable species combined, the sum of the rarity scores (the inverse of the number of squares with records) for the species plotted as a percentage of the total rarity scores for all of the species in the clade.

"Close-to-root" species
Taxonomic root weighting measures diversity as species richness with higher weights for the early-diverging, "relict" species.

The Root Weight map (Appendix 8.3) displays for Endangered and Vulnerable species combined, the numbers of species per square, each weighted by its individual root weight, plotted as a percentage of the total root score for all of the species in the clade.

Mean root weight
Weighted faunal diversity scores can be thought of as consisting of two components: (A) the number of species per square, and (B) the mean weight per species in that square.

The Mean Root Weight map (Appendix 8.4) plots for Endangered and Vulnerable species combined, the weight component B and the mean root weighting per species for the fauna of each square as a percentage of the sum of the root weights of all of the species in the clade.

Higher-taxon richness
Higher-taxon richness weighting measures diversity as species richness with higher weights for faunas with more of the species from the more early-diverging, higher taxa, irrespective of the number of surviving species in these higher taxa.

The Higher Taxon Weighting map (Appendix 8.5) plots for Endangered and Vulnerable species combined, the numbers of species per square, weighted by the higher-taxon richness weight, as a percentage of the total higher-taxon richness score for all of the species in the clade.

Note that because higher-taxon richness is measured in terms of pairwise divergences, there must be at least two species in a square before its score can be greater than zero.

Mean higher taxonomic weight
Weighted faunal diversity scores can be thought of as consisting of two components: (A) the number of species per square, and (B) the mean weight per species in that square.

The Mean Higher Taxonomic Weight map (Appendix 8.6) plots for Endangered and Vulnerable species combined, the weight component B, the mean higher-taxon richness weighting per species for the fauna of each square as a percentage of the higher-taxon richness score for all of the species in the clade.

Spanning-tree length
Spanning-tree length weighting measures diversity as species richness, with higher weights for faunas with a greater variety of species as shown by the proportion of the classification represented.

The Span (unrooted-subtree) Weight map (Appendix 8.7) plots for Endangered and Vulnerable species combined, the numbers of species per square, weighted by the spanning-tree length weight, as a percentage of the total spanning-tree length score for all of the species in the clade.

Note that because spanning-tree length is measured in terms of the number of branching points between species, there must be at least two species in a square before its score can be greater than zero.

Mean spanning-tree weight
Weighted faunal diversity scores can be thought of as consisting of two components: (A) the number of species per square, and (B) the mean weight per species in that square.

The Mean Spanning Tree Weight map (Appendix 8.8) plots for Endangered and Vulnerable species combined, the weight component B, the mean spanning-tree length weighting per species for the fauna of each square, as a percentage of the entire spanning-tree length score for all of the species in the clade.

Taxonomic dispersion
Taxonomic dispersion weighting measures diversity as species richness, with higher weights for faunas with species that represent the variety of subgroups in the classification more evenly.

The Dispersion Weight map (Appendix 8.9) plots for Endangered and Vulnerable species combined, the numbers of species per square, weighted by their dispersion weight, as a percentage of the total dispersion score for all of the species in the clade.

Note that because cladistic dispersion is measured in terms of the evenness of pairwise divergences, there must be at least three species in a square before its dispersion score can be greater than zero.

Mean taxonomic dispersion weight
Pairwise weighted faunal diversity scores can be thought of as consisting of two components: (A) the number of species per square, and (B) the mean pairwise weight per species in that square.

The Mean Dispersion Weight map (Appendix 8.10) plots for Endangered and Vulnerable species combined, the weight component B, the mean dispersion weighting per species for the fauna of each square, on the grid as a percentage of the dispersion score for all of the species in the clade.

Priority areas
Table 3 below shows the 13 areas (at a resolution of 2° of latitude and longitude) which rank highest in the various biodiversity analyses. In grid numerical order they are:

110 Christmas Island, Indian Ocean
345 Emerald, QLD
346 Rockhampton, QLD
383 Maryborough, QLD
418 Dalby, QLD
435 Houtman Abrolhos, WA
472 Perth, WA
473 Northam, WA
490 Armidale, NSW
520 Peterborough, SA
556 Adelaide, SA
593 Mt Gambier, SA & VIC
594 Ballarat, VIC

These areas therefore warrant special attention when designating new reserves or managing existing reserves to conserve Australia's Endangered and Vulnerable terrestrial reptiles.

References:

Pressey, R.L., Humphries, C.J., Margules, C.R., Vane-Wright, R.I. and Williams, P.H. 1993. Beyond opportunism: key principles for systematic reserve selection. Trends in Ecology and Evolution 8(4): 124-128.

Millsap, B.A., Gore, J.A., Runde, D.E. and Cerulean, S.I. 1990. Setting priorities for the conservation of fish and wildlife species in Florida. Wildlife Monographs 111: 1-57.

Vane-Wright, R.I., Humphries, C.J. and Williams, P.H. 1991. What to protect? - systematics and the agony of choice. Biological Conservation 55: 235-254.

Williams, P.H., Humphries, C.J. and Vane-Wright, R.I. 1991. Measuring biodiversity: taxonomic relatedness for conservation priorities. Australian Systematic Botany 4: 665-679.

Williams, P.H., Vane-Wright, R.I. and Humphries, C.J. 1993. Measuring biodiversity for choosing conservation areas. pp. 309-328 in J. LaSalle and I.D. Gauld (eds) Hymenoptera and Biodiversity. CAB International, Wallingford, UK.

TABLE 3 PRIORITY CONSERVATION AREAS (LISTED AS NUMBERED 2° GRID SQUARES) IDENTIFIED BY WORLDMAP'S NINE BIODIVERSITY MEASURES

	SEQUENCE OF PRIORITY FOR CONSERVATION AREAS			
BIODIVERSITY MEASURE	PRIORITY 1	PRIORITY 2	PRIORITY 3	PRIORITY 4
Species Richness	472	473	556,346,418	
Endemism	472	110	520	418
Root Weight	472	473	346	
Mean Root Weight	383	345,110		
Higher Taxon Weight	472	473	346	345
Mean Higher Taxon Weight	490	345	346	
Span Weight	472	473	594	556,346
Mean Span Weight	435, 593, 490	594		
Dispersion Weight	472	473	594	
Mean Dispersion Weight	594	435,593,490		

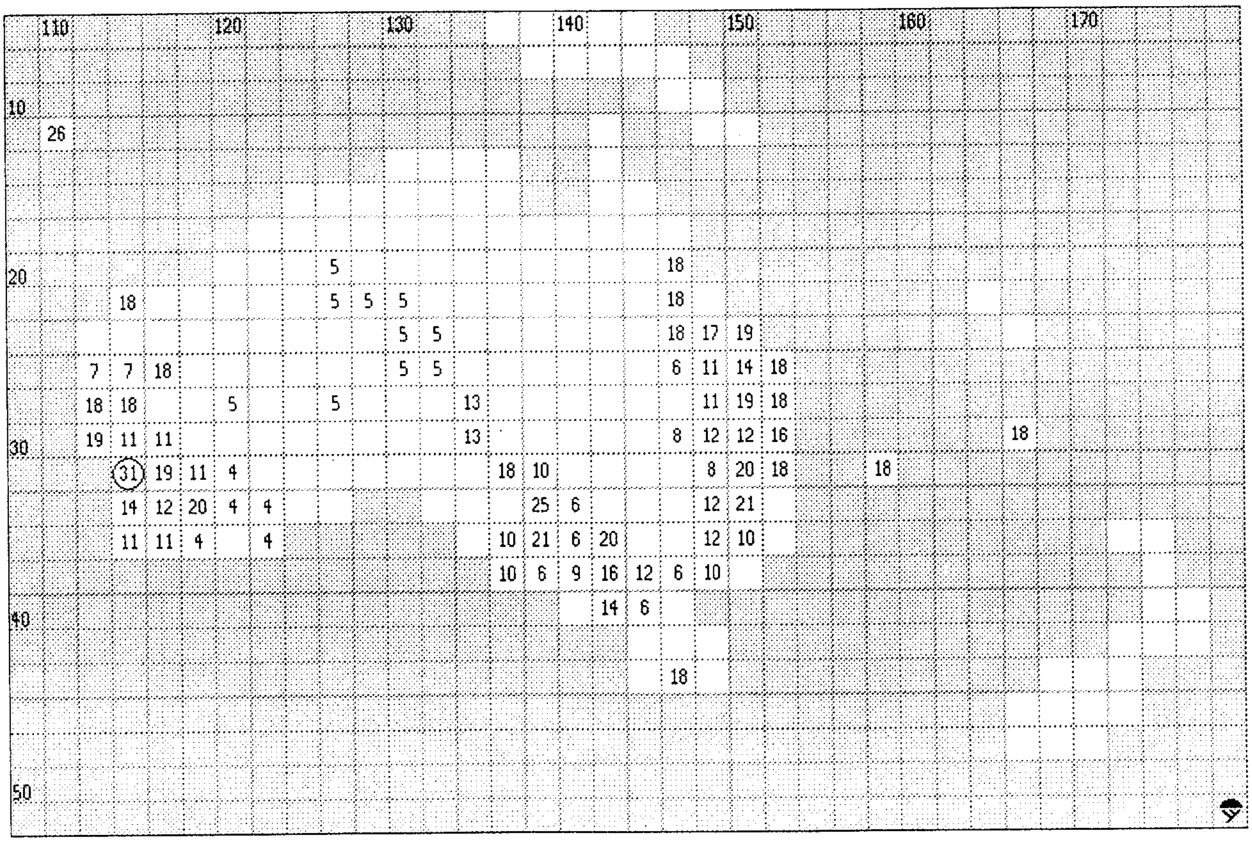
NUMBERS AND NAMES APPLIED TO THE 2° GRID SQUARES USED IN THE WORLDMAP ANALYSES

110	Christmas Island
120	Melville Island
121	Cobourg Peninsula
122	Cape Stewart
123	Cape Wessel
126	Cape York
155	Cape Ford
156	Darwin
157	Alligator Rivers
158	Arnhem Land
159	Gove Peninsula
161	Weipa
162	Iron Range
189	Bonaparte Archipel.
190	Forrest River
191	Wyndham
192	Daly River
193	Katherine
194	Roper River
195	Sir Edward Pellew
197	Edward River
198	Musgrave
199	Cooktown
224	Broome
225	King Leopold Ranges
226	Durack Range
227	Lake Argyle
228	Victoria River Downs
229	Newcastle Waters
230	Anthony Lagoon
231	Borroloola
232	Mornington Island
233	Normanton
234	Mitchell River
235	Cairns
236	Innisfail
259	Lagrange
260	Dampier Downs
261	Fitzroy Crossing
262	Halls Creek
263	Gardner Range
264	Hooker Creek
265	Renner Springs
266	Tennant Creek
267	Alexandria
268	Gunpowder
269	Norman River
270	Croydon
271	Herbert River
272	Townsville
292	North West Cape

293	Dampier
294	Port Hedland
295	Oakover River
296	Lake Dora
297	Percival Lakes
298	Balgo
299	Lake Dennis
300	The Granites
301	Barrow Creek
302	Hatches Creek
303	Austral Downs
304	Mount Isa
305	Cloncurry
306	Richmond
307	Hughenden
308	Charters Towers
309	Mackay
310	Percy Isles
327	Ningaloo
328	Exmouth Gulf
329	Tome Price
330	Newman
331	Jigalong
332	Lake Disappointment
333	Traeger Hills
334	Gibson Desert
335	Lake Mackay
336	Haast Bluff
337	Alice Springs
338	Plenty River
339	Glenormiston
340	Boulia
341	Diamantina Lakes
342	Winton
343	Longreach
344	Clermont
345	Emerald
346	Rockhampton
363	Carnarvon
364	Gascoyne Junction
365	Yinnietharra
366	Peak Hill
367	Canning Gap
368	Glenayle
369	Gibson Desert
370	Rawlinson Range
371	Docker River
372	Ayers Rock
373	Erldunda
374	Finke
375	Simpson Desert
376	Birdsville
377	Diamantina River
378	Windorah
379	Blackall
380	Tambo
381	Taroom
382	Mundubbera
383	Maryborough
399	Edel Land
400	Murchison River
401	Nicholson Range
402	Meekatharra
403	Wiluna
404	Lake Wells
405	Great Victoria
406	Warburton
407	Tomkinson Ranges
408	Musgrave Ranges
409	Ernabella
410	Oodnadatta
411	Macumba Creek
412	Warburton Creek
413	Cooper Creek
414	Eromanga
415	Quilpie
416	Charleville
417	Roma
418	Dalby
419	Brisbane
435	Houtman Abrolhos
436	Geraldton
437	Mount Magnet
438	Lake Barlee
439	Leonora
440	Laverton
441	Rason Lake
442	Jubilee Lake
443	Serpentine Lakes
444	Lake Maurice
445	Lake Maramangye
446	Coober Pedy
447	Lake Eyre
448	Lake Blanche
449	Cameron Corner
450	Tibooburra
451	Cunnamulla
452	Brewarrina
453	Moree
454	Inverell
455	Lismore
462	Norfolk Island
472	Perth
473	Northam
474	Merredin
475	Kalgoorlie
476	Cundeelee
477	Rawlinna
478	Nullarbor
479	Forrest
480	Cook
481	Immarna
482	Tarcoola
483	Woomera
484	Leigh Creek
485	Broken Hill
486	Wilcannia
487	Bourke
488	Nyngan
489	Narrabri
490	Armidale
491	Port Macquarie
494	Lord Howe Island
508	Bunbury
509	Narrogin
510	Lake Grace
511	Esperance
512	Balladonia
513	Point Culver
514	Eyre
517	Ceduna
518	Eyre Peninsula
519	Whyalla
520	Peterborough
521	Lake Victoria
522	Menindee
523	Ivanhoe
524	Lake Cargelligo
525	Bathurst
526	Sydney
527	Myall Lakes
544	Cape Leeuwin
545	Albany
546	Cheyne Bay
554	Port Lincoln
555	Kangaroo Island
556	Adelaide
557	Renmark
558	Mildura
559	Deniliquin
560	Griffith
561	Canberra
562	Wollongong
591	South Kangaroo I.
592	Coorong
593	Mount Gambier
594	Ballarat
595	Melbourne
596	Albury
597	Cooma
598	Narooma
629	Portland
630	Warrnambool
631	Wilsons Promontory
632	Bass Strait
667	NW Tasmania
668	Launceston
669	NE Tasmania
703	SW Tasmania
704	Hobart
705	SE Tasmania

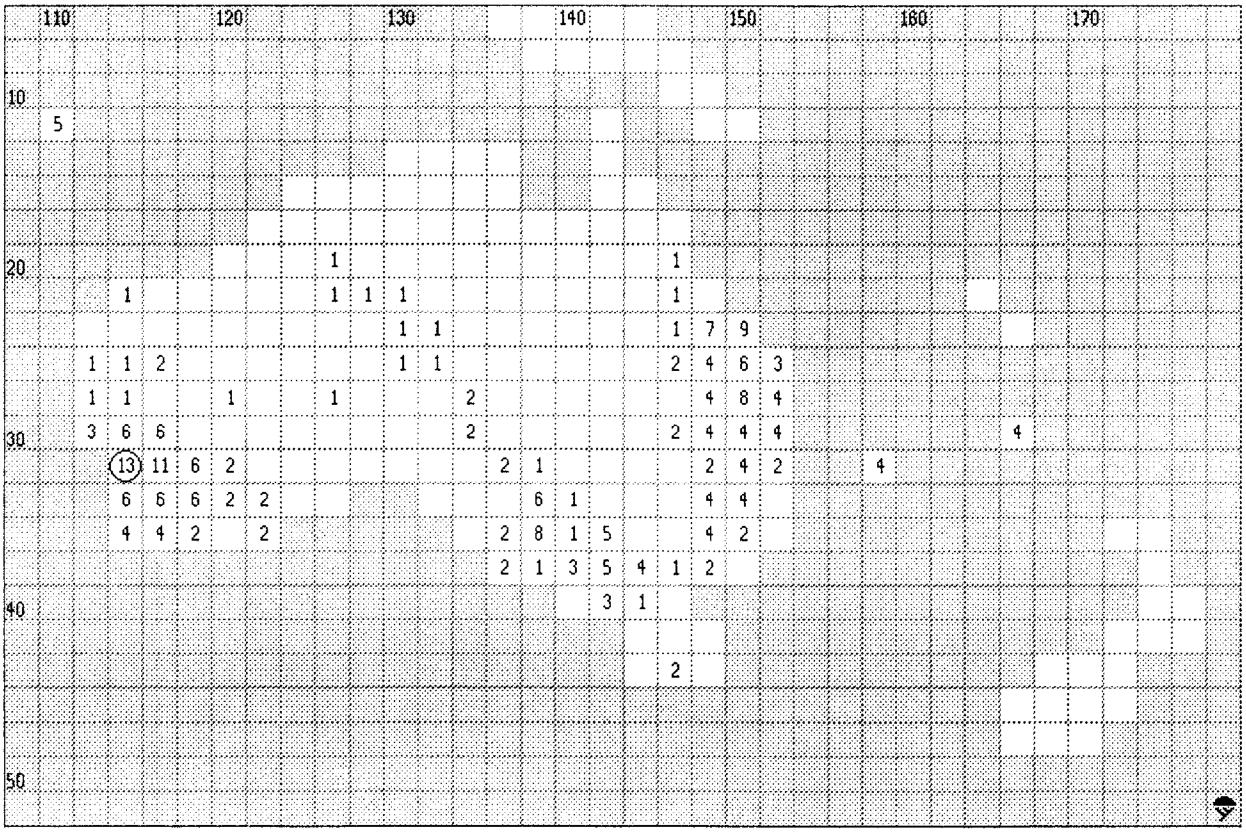
APPENDIX 8.2 MAP OF ENDEMISM VALUES BASED ON THE 47 TERRESTRIAL SPECIES OR GEOGRAPHICALLY DISCRETE POPULATIONS OF AUSTRALIAN REPTILES PROPOSED AS ENDANGERED OR VULNERABLE.

Highest endemism values are assigned to grid squares 472 (Perth, south-western WA), 110 (Christmas Island) and 520 (Peterborough, SA).



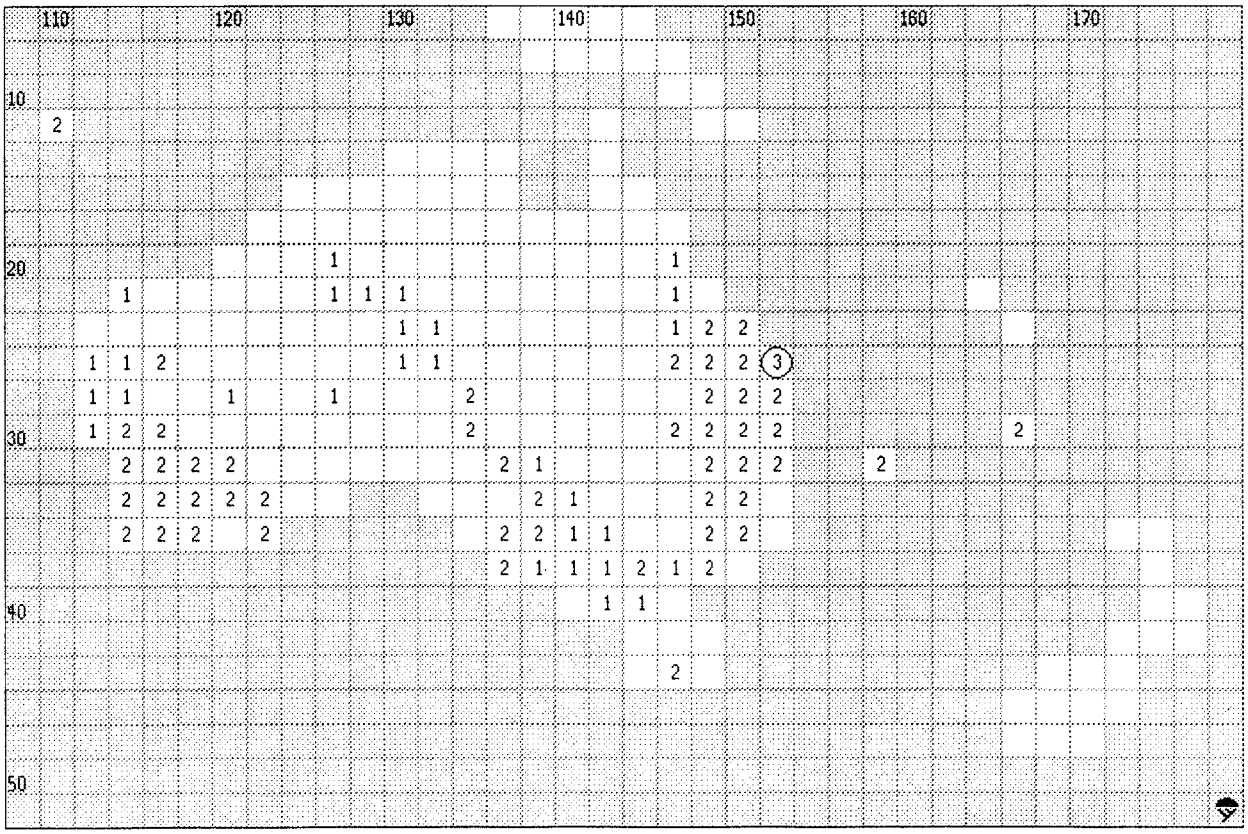
APPENDIX 8.3 MAP OF ROOT WEIGHT VALUES BASED ON THE 47 TERRESTRIAL SPECIES OR GEOGRAPHICALLY DISCRETE POPULATIONS OF AUSTRALIAN REPTILES PROPOSED AS ENDANGERED OR VULNERABLE.

Sequence of highest root weight values is found in grid squares 472 (Perth, south-western WA), 473 (Northam, southern WA), and 346 (Rockhampton, QLD).



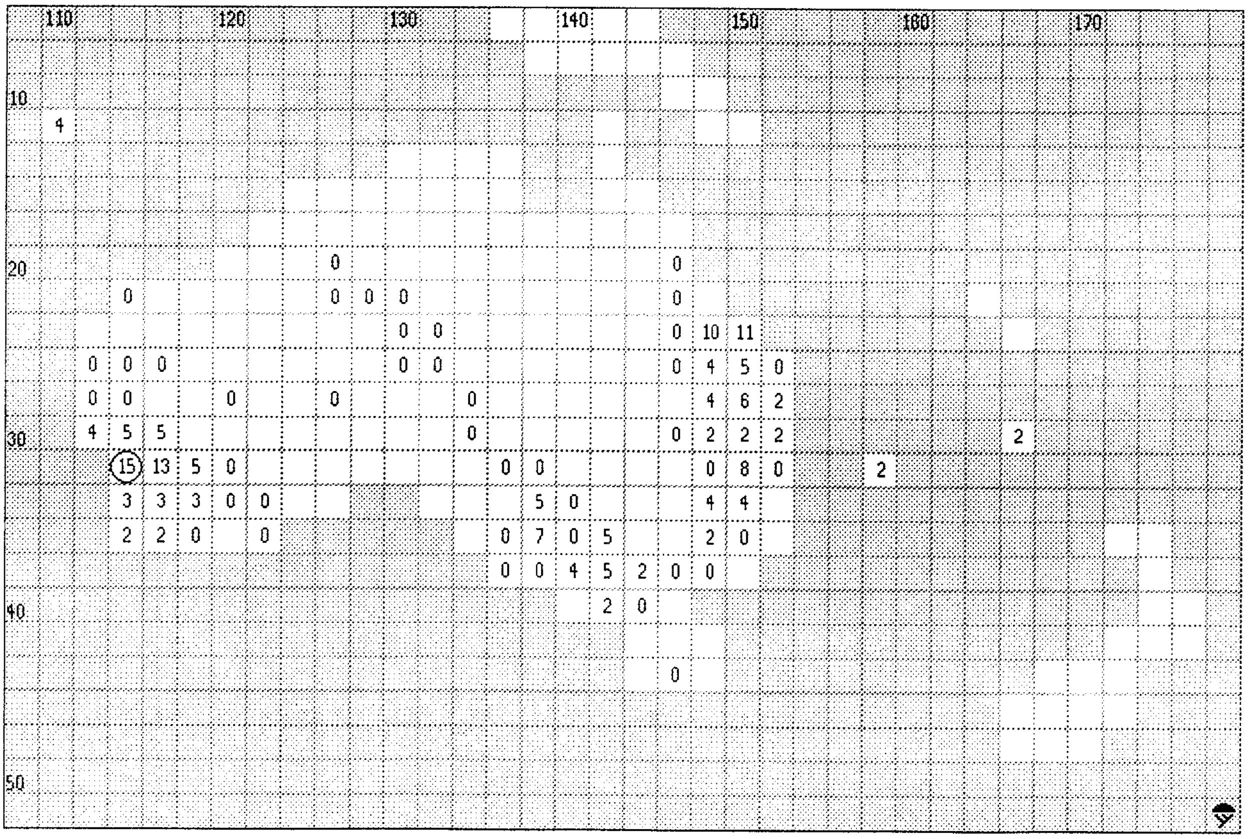
APPENDIX 8.4 MAP OF MEAN ROOT WEIGHT VALUES BASED ON THE 47 TERRESTRIAL SPECIES OR GEOGRAPHICALLY DISCRETE POPULATIONS OF AUSTRALIAN REPTILES PROPOSED AS ENDANGERED OR VULNERABLE.

Highest mean root weight value is assigned to grid square 383 (Maryborough, QLD).



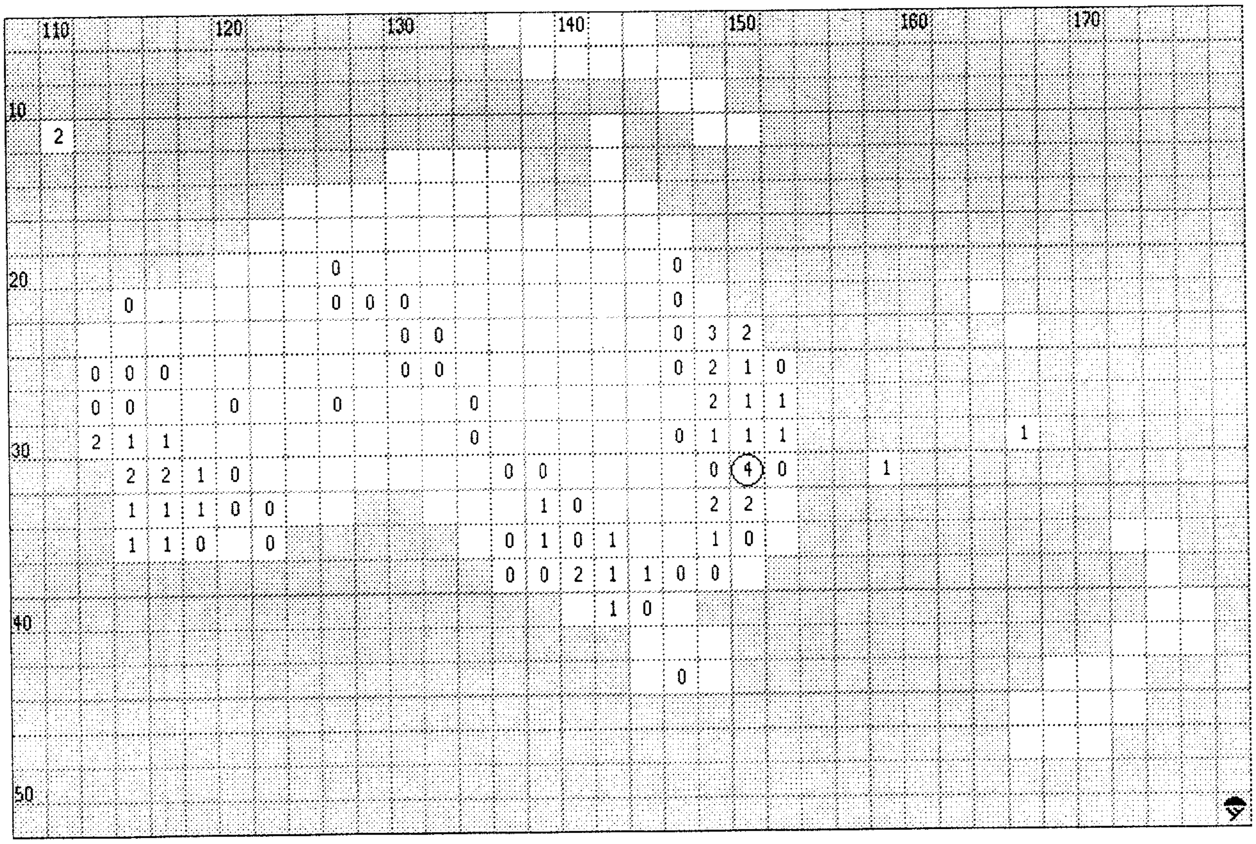
APPENDIX 8.5 MAP OF HIGHER TAXON WEIGHTINGS BASED ON THE 47 TERRESTRIAL SPECIES OR GEOGRAPHICALLY DISCRETE POPULATIONS OF AUSTRALIAN REPTILES PROPOSED AS ENDANGERED OR VULNERABLE.

Sequence of highest higher taxon weight values is found in grid squares 472 (Perth, southern WA), 473 (Northam, southern WA), 346 (Rockhampton, QLD) and 345 (Emerald, QLD). Note that grid squares represented by a single species or geographically discrete population will automatically be assigned zero values by this algorithm.



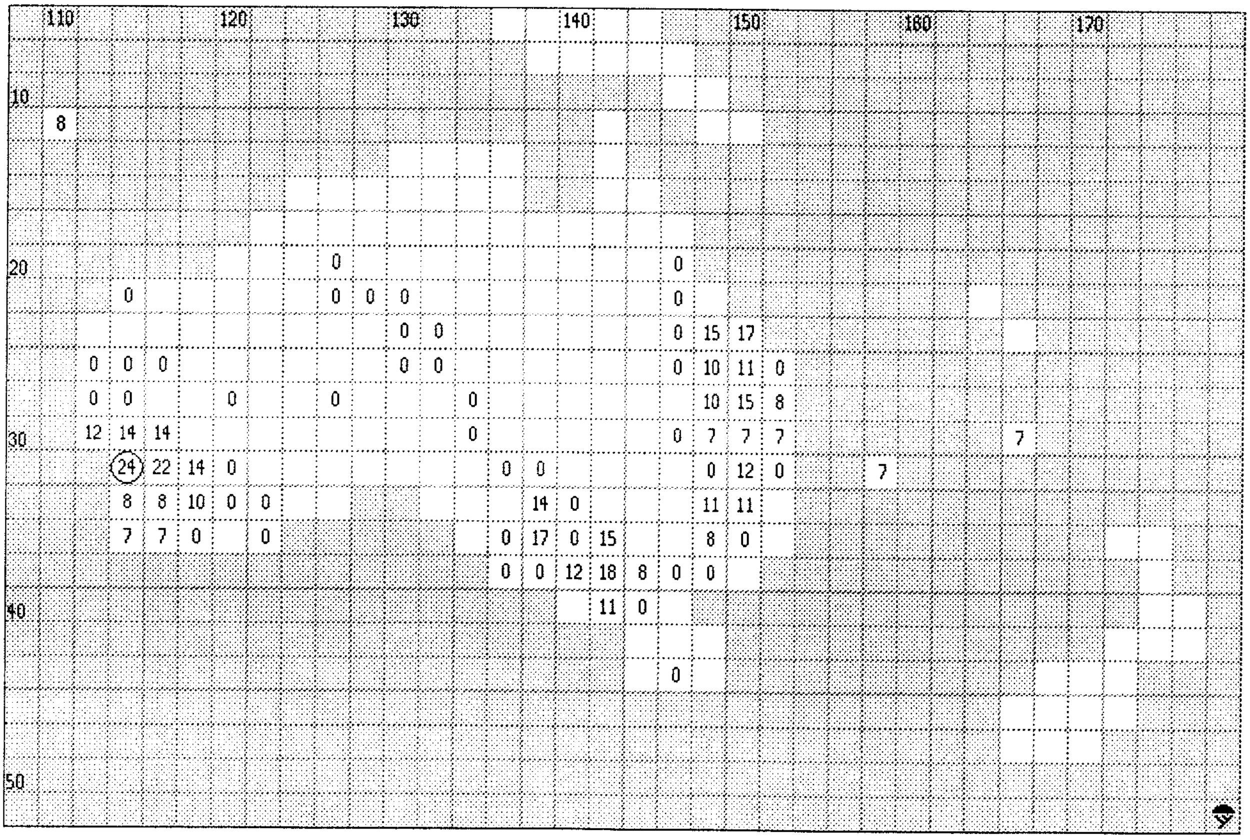
APPENDIX 8.6 MAP OF MEAN HIGHER TAXON WEIGHTINGS BASED ON THE 47 TERRESTRIAL SPECIES OR GEOGRAPHICALLY DISCRETE POPULATIONS OF AUSTRALIAN REPTILES PROPOSED AS ENDANGERED OR VULNERABLE.

Highest mean higher taxon values are found in grid squares 490 (Armidale, NSW), 345 (Emerald, QLD) and 346 (Rockhampton, QLD).



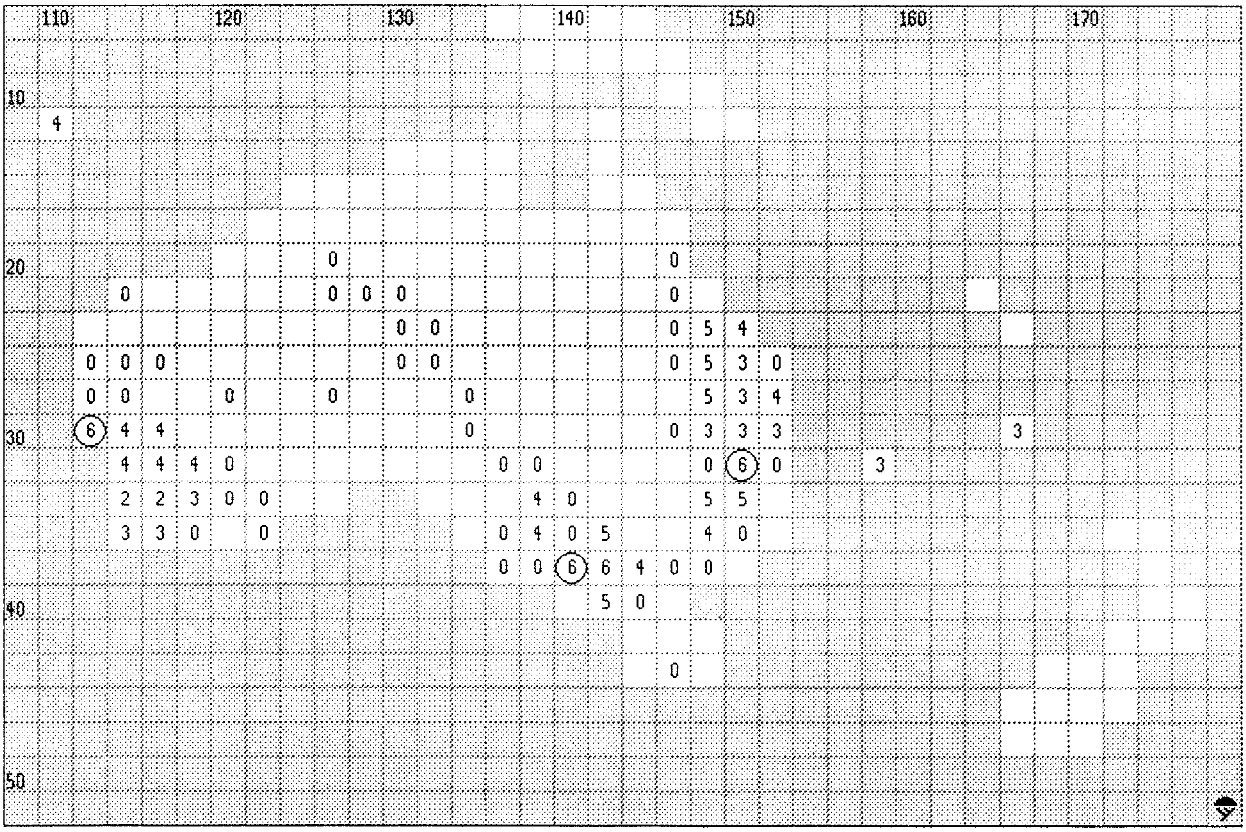
APPENDIX 8.7 MAP OF SPAN (UNROOTED-SUBTREE) WEIGHT VALUES BASED ON THE 47 TERRESTRIAL SPECIES OR GEOGRAPHICALLY DISCRETE POPULATIONS OF AUSTRALIAN REPTILES PROPOSED AS ENDANGERED OR VULNERABLE.

Highest span weight values are found in grid squares 472 (Perth, southern WA), 473 (Northam, WA), 594 (Ballarat, VIC) and 556 (Adelaide, SA).



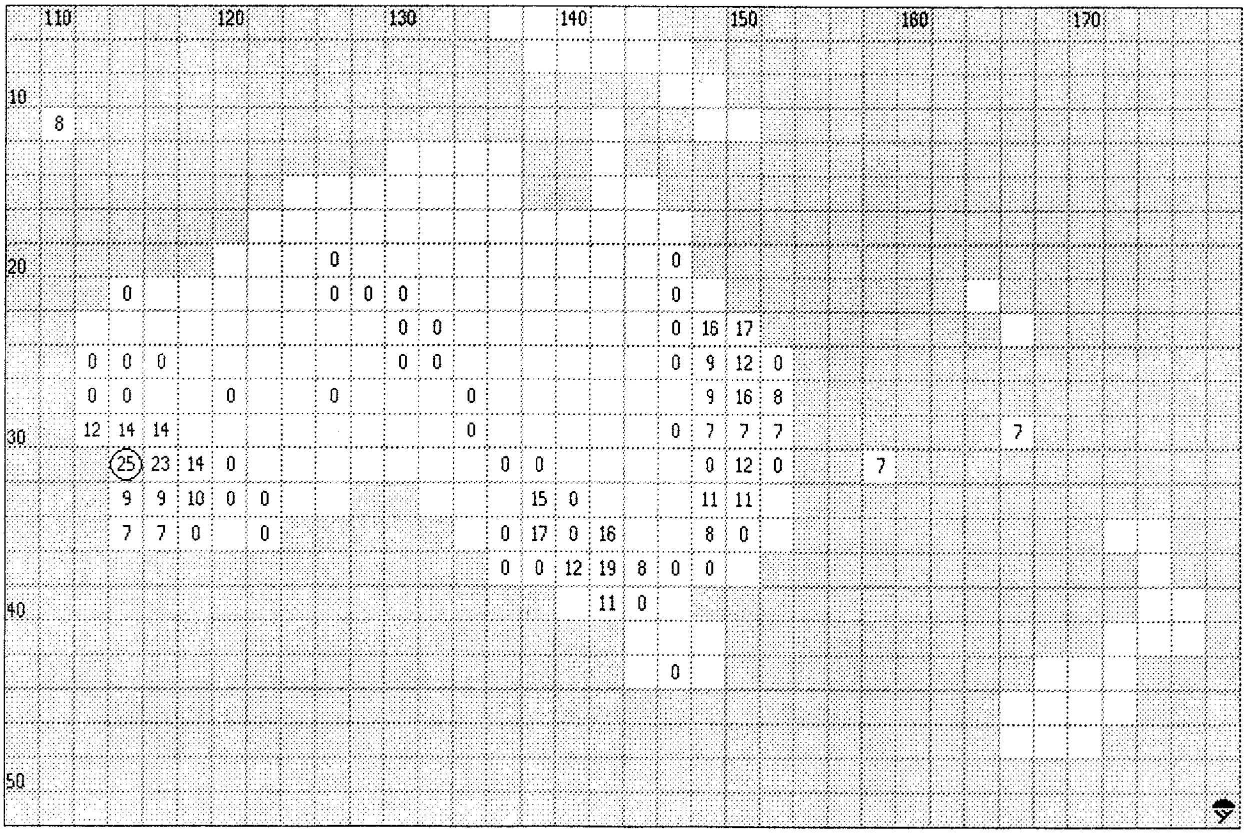
APPENDIX 8.8 MAP OF MEAN SPAN (UNROOTED-SUBTREE) WEIGHT VALUES BASED ON THE 47 TERRESTRIAL SPECIES OR GEOGRAPHICALLY DISCRETE POPULATIONS OF AUSTRALIAN REPTILES PROPOSED AS ENDANGERED OR VULNERABLE.

Highest mean span weight values are found in grid squares 435 (Houtman Abrolhos, WA), 593 (Mount Gambier, SA), 490 (Armidale, NSW) and 594 (Ballarat, VIC).



APPENDIX 8.9. MAP OF DISPERSION WEIGHT VALUES BASED ON THE 47 TERRESTRIAL SPECIES OR GEOGRAPHICALLY DISCRETE POPULATIONS OF AUSTRALIAN REPTILES PROPOSED AS ENDANGERED OR VULNERABLE.

Sequence of highest dispersion weight values is found in grid squares 472 (Perth, southern WA) and 473 (Northam, WA).



APPENDIX 8.10 MAP OF MEAN DISPERSION WEIGHT VALUES BASED ON THE 47 TERRESTRIAL SPECIES OR GEOGRAPHICALLY DISCRETE POPULATIONS OF AUSTRALIAN REPTILES PROPOSED AS ENDANGERED OR VULNERABLE.

The highest mean dispersion weight value is found in grid square 594 (Ballarat, VIC), 435 (Houtman Abrolhos, WA), 593 (Mt Gambier, SA) and 490 (Armidale, NSW).