

## 7. CONCLUSIONS AND MANAGEMENT RECOMMENDATIONS

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### 7.1 Conclusions

It is apparent from Chapters 2, 3 and 4 that the Abydos-Woodstock Reserve has a diverse and complex pattern of geological and physiographic elements that form an area of considerable environmental heterogeneity within the context of the northeast Pilbara region.

The early focus of ecological research on Abydos-Woodstock (Burbidge 1943, 1959; Ealey *et al.* 1965; Ealey 1967a, b; Ealey and Main, 1967; and Suijendorp 1955, 1967), together with the present investigation, make this Reserve the most intensively studied area in the Pilbara. No other area is better documented with regard to its history of inappropriate pastoral practices, resultant ecological changes and subsequent partial recovery.

The role of fire in the Pilbara region was first examined in the *Triodia* communities of the Abydos-Woodstock Reserve, nearly fifty years ago. Fire continues to be the major environmental factor that shapes the structure of communities on the Reserve. The impact of fire on the vegetation associations of the Reserve are described by Tinley in Chapter 4, while the impact on the terrestrial vertebrates is documented in Chapter 5. Large scale fires are more likely to occur in the dry seasons following exceptionally high rainfall, as was predicted by Tinley (1988) and confirmed during the course of the fauna survey. The impact of fire on communities in the arid zone continues to be evaluated, but it has been implicated as a prime factor in creating the exceptionally rich lizard faunas found in arid Australia (Pianka 1989) and has been shown to be responsible for the replacement of *Triodia* dominated communities with seral stages of perennial grasses (Suijendorp 1967; see Tinley, Chapter 4).

The inappropriateness of the Reserve for grazing sheep has been dramatically established. While cattle do not have the same detrimental effect on the vegetation as sheep, they still do substantial erosional damage, as do feral donkeys. Cattle grazing should continue to be for non-commercial purposes only with a low stocking density. It appears that goats have never occurred on the Reserve. It is considered that they have potential to be extremely damaging to the vegetation and fauna and should be kept out at all costs.

The overgrazing of arid regions is not confined to the Pilbara region of the arid zone, but has been common practice in other states. Friedal *et al.* (1960) give a detailed account of the effects of 'over-enthusiastic stocking rates' after good seasons in arid central Australia with the resultant loss of saltbush and subsequent erosion of the top 3-6 inches of soil as conditions returned to drought; a pattern that was repeated in many regions in arid Australia, and exacerbated by the plagues of rabbits. The impact of European

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settlement on the vertebrate fauna of arid Australia has been comprehensively reviewed by Morton (1990), who concluded that the arrival of grazing stock and rabbits disturbed the balance of local disappearance and reinvasion after droughts by changing the vegetation of habitats essential to the survival of the native species during droughts. This alteration was compounded by pressure from introduced predators and altered fire patterns that resulted in the broadscale extinctions of vertebrates, particularly mammals, in the arid zone. The impact of rabbits at Abydos-Woodstock Reserve has been almost negligible and this may explain the continued presence of mammal species that are extinct elsewhere.

Within the Reserve, and extending slightly to the east, it is possible to define a "core area" with best representation of the three main physiographic units and their vegetation types (Figure 4.11a). This area also contains the greatest diversity and richness of the faunal groups recorded and the greatest concentrations of rock engravings making it suitable for special management attention.

Of particular concern at the commencement of this study was the possible conflict of management options for the preservation of aboriginal rock art and the conservation of Rothschild's Rock-wallaby. The practice of ring-burning tors to protect the rock engravings from intense fires had been considered to be a possible cause for the apparent decline of the rock-wallaby population as it was thought to decrease availability of grazing. The observable facts in the field are that:

Rock-wallabies are mobile and move between nearby tors as shown by their tracks. Without exception all the isolated tors inspected where either ring-burning or uncontrolled fires had come through, were surrounded by a mosaic of regrowth stages plus mature unburnt spinifex, providing suitable pasture and shelter for rock-wallaby. Unburnt spinifex and other grasses were present on the tors themselves. In some sites there were also patches of senile spinifex (grey dead hummocks). Spinifex grassland seldom burns evenly, as most clearly seen from the air, because hummock spacing is uneven and clumped. Also, with a strong wind, bands of unburnt spinifex are left between the advancing tongues of fire. The danger of single large scale fires burning out vast areas at a time occurs in dry seasons following exceptionally high rainfalls as has occurred at the end of March 1988. Ring-burning has in fact protected the tors from being burnt out and there is no evidence that it has been the cause of the rock-wallaby decline.

There is ample evidence of foxes in the vicinity of the tors and fox predation is considered to be the greatest threat to persistence of rock-wallabies and Bilbies in the Reserve. It may also be coincidental, but the capture of the dasyurids, *Dasyercus cristicauda* and *Pseudantechinus macdonnellensis*, occurred only after the fox baiting programme commenced.

The Reserve has a particularly rich assemblage of reptiles and small mammals that is as high as any recorded elsewhere in the Pilbara, including the Hammersley Range National Park which is four times larger. The lizard fauna alone is one of the richest recorded anywhere in the Australian arid zone. The bird assemblage is typical of the arid

interior regions of the Pilbara (Storr 1984) and is dominated after good rains by granivorous species that take advantage of the seeding grasses. Four species of mammal (Rothschild's Rock-wallaby (*Petrogale rothschildii*), Mulgara (*Dasycercus cristicaudata*), Bilby (*Macrotis lagotis*) and spectacled Hare-wallaby (*Lagorchestes conspicillatus*) and one reptile (Olive Python (*Morelia olivacea barroni*)) recorded on the Reserve are currently gazetted on the Western Australian list of rare species that are in need of special protection. Coupled with this is the occurrence of an endemic (*Ctenotus nigrilineatus*) skink and numerous endemic invertebrate taxa, not least of which is a spider belonging to an undescribed family, that have been recorded nowhere else. This may in part reflect the poor state of knowledge of the invertebrate fauna of the Pilbara, but it also highlights the potential for high levels of endemism in the region. This point is further illustrated by the finding that two relatively common Pilbara reptile taxa are now considered to be polytypic as a result of this survey.

Evaluation of the responses of vertebrate taxa to changing seasonal events in the area has shown that birds in general responded first to the improvement in resources following heavy rains, and peaked in their breeding the spring after major March rainfall. Small ground mammals peaked numerically twelve months later after a second successive summer of above average rains, while lizard reproduction was also maximal at that time. Both the abundance of vertebrate species and their reproduction was lowest at the end of the study when conditions were at their most severe following 16 months of below average rainfall; body mass indices of lizards was also at their lowest then.

The results of this study show that the vegetation on the Reserve has significantly recovered to what can be inferred to be approaching the pre-pastoral situation. If this situation is to be maintained, an appropriate burning regime will need to be implemented, taking into account Suijndorp's (1955) findings. Most importantly these were that annual burns decrease ground cover progressively each year and that an interval of at least four years between summer burns, with reduced grazing pressure after burning, most effectively increases the diversity of perennial grass and dicotyledonous species.

With this background, a unique opportunity exists for integrated management of the natural and cultural heritage of Abydos-Woodstock.

## 7.2 Management Recommendations.

1. The "core area" (Figure 4.11a) which includes the highest concentrations of rock art and ecological diversity within the Reserve should be recognised and targeted for special management of rock art, fauna and flora.
2. Grazing should not be permitted in the core area and all feral animals should be removed from it.
3. Grazing of cattle should be confined to the area west of the railway line and south of the proposed new position of the Hillside-Marble Bar road (see 7 below). The effective south boundary of the core area should be the new position of this road.
4. All internal fencing within the core area should be removed.

5. Within the core area all access tracks should be repositioned where possible to run along drainage divides and make use of landscape positions that minimise erosion. Saltflats should be skirted as their clays are impassable after heavy rains.
6. Within the core area the remaining artificial surface water distribution points should be closed and all materials removed; all natural pools and waterholes should be maintained for access by animals as was done by early Aboriginal hunter-gatherers i.e. dug clean of sediment infill; protected against drainage loss from erosion incision of the sill containing the pool; removal of dead animals.
7. The main dirt road to Marble Bar off the new tarred Wittenoom-Port Hedland Highway, which at present cuts through the heart of the core area past Woodstock homestead and Gallery Hill to Hillside, should have the first section up to Tambourah relocated southwards.

The new position suggested (Figure 4.11a) should be along the lesser divide between the main Yule branch and Coonarrie Creek which takes off 2 km south of the Yule River from the railway road eastwards to Tambourah around the south side of Red Granite Hill (see suggested 'minimal distance route' on map), or further south depending on terrain opportunities and constraints.

The present position of this main road is a major impediment to effective management of the core area. Similarly, any proposal to site a new main road route to the north of Coorong Creek past Abydos Fine Gold Camp must be strongly opposed for the same reasons.

8. For many ecological reasons it is important that large scale single burns are avoided altogether. A mosaic regime of summer patch burning cycles should be initiated across the Reserve area. This would ensure that all stages of post-fire regrowth occur together with unburnt mature and senile patches of spinifex, thus forming a mosaic of habitats with changing species content and structure, and degrees of value as pasture or cover. The most productive fire regime applicable to spinifex grasslands with a highly erratic summer rainfall occurrence has been determined by Suidendorp's 1955 research based on field trials in the Abydos-Woodstock Reserve area itself. His findings proved that the best chances of regrowth occurring successfully was for burning to be done in November, ideally after some preliminary showers, with a 4 to 5 year minimum interval return time.
9. A 10 km wide extension to the present eastern Reserve boundary would be a desirable addition to the Reserve. This would give it better representation of the unique Soansville Plateau system and a greater variety of rock types. If this is difficult to achieve it might still be managed under its existing vesting as an eastern buffer to the core area, allowing mineral exploration and exploitation to continue, but under conditions of minimal environmental disturbance.
10. The annual baiting programme for foxes carried out in 1989 and 1990 should be continued in collaboration with the Agricultural Protection Board.
11. Regular control of feral donkeys and camels should be continued in collaboration with the Agriculture Protection Board (see 2 above).

12. Periodic surveys should be undertaken to monitor the status of fauna and flora communities.
13. Stock grazing should be restricted to cattle and for non-commercial purposes i.e. at low stocking rates and with precedence given to management of the natural and cultural heritage values of the Reserve (see 2 and 3 above).

## 8. ACKNOWLEDGEMENTS

This project was funded under the National Estate Programme, a Commonwealth Financial Grants Scheme administered by the Australian Heritage Commission (Federal Government) and the Heritage Council of Western Australia (State Government).

The survey of the fauna of the Abydos-Woodstock Reserve was greatly assisted by Darrell Kitchener and Bill Humphreys in the initial planning of this investigation. Support funds for the project were generously provided by W.H. & M. Butler.

For assistance with field data collection we are grateful to Ken Aplin, Brian Hanich, Jan Henry, Bill Humphreys, Helen Miller, Shane Pavlinovich, Jean Thipthorp, Julianne Waldock and Graham Hall. Laboratory assistance was provided by Jenny Demasi and Brett Scourse. Barbara Main kindly assisted in the identification of the mygalomorph spiders.

Mark Adams of the Evolutionary Biology Unit, South Australian Museum provided electrophoretic analysis of mammal and reptile tissues. Brian Wren of the Salinity and Hydrology Branch of the WA Department of Agriculture did the soil analyses for the habitat profiles. Ray Cranfield, Sue Patrick, Bruce Maslin and Terry McFarlane of the WA Herbarium identified plant specimens.

To the Woodstock rangers Kevin and Rita Young, Archie and Pam Bryce and John Patterson we are grateful for providing logistical support. Max Richardson and Syd Baker provided detailed information on local natural history, and Andrew Chapman allowed access to his unpublished notes.

Lynne and Janine Tinley accompanied Ken Tinley for three months at Abydos-Woodstock and gave much support. Doug Elford and Anne Nevin of the WA Museum produced the prints and typed the manuscript respectively. Gordon Friend, Ken Aplin, Denis Saunders, Stephen Van Leeuwen and Hank Suijendorp provided valuable comment on earlier drafts of this manuscript.

## 9. REFERENCES

- Anonymous (n.d.) *Abydos-Woodstock Pastoral Research Station 1946-1976*. Western Australian Dept. Agriculture summary report. 43 pp.
- Archer, M. (1975). *Ningai*, a new genus of tiny dasyurids (Marsupialia) and two new species, *N. timealeyi* and *N. ridei* from arid Western Australia. *Mem. Qld. Mus.* 17: 237-249.
- Australian Bureau of Meteorology (1972). Climatic Survey: Region 6 Northwest Western Australia. Australian Govt. Printer, Canberra.
- Australian Bureau of Meteorology (1983a). The climate and meteorology of Western Australia. In: *Western Australian Year Book* No. 21 (New Series) 36/51. pp. 36-51.
- Australian Bureau of Meteorology (1983b). Climate of Australia. In: *Year Book Australia* No. 67. Australian Govt. Printer, Canberra.
- Bagnouls, F. & Gaussen, H. (1957). Les climats ecologiques et leur classification. *Annls. Geogr.* 66: 193-220.
- Barker, W.R. Greenslade, P.J.M. (eds.) (1982). *Evolution of the flora and fauna of arid Australia*. Peacock Publ. ASBC, ANZAAS, S. Australia.
- Barlow, B.A. (1981). The Loranthaceous mistletoes in Australia. In: Keast, A. (ed.) *Ecological Biogeography of Australia* (3 vols). Dr W. Junk Publ., The Hague, Netherlands. pp. 555-574.
- Battye, J.W. (1915). History of the North West of Australia. V.K. Jones & Co., Perth.
- Beard, J.S. (1975). *The Vegetation of the Pilbara Area*. Explanatory Notes to Map Sheet 5 of the Vegetation Survey of Western Australia: Pilbara. University of Western Australia Press, Nedlands, Perth.
- Beard, J.S. (1979). *The Vegetation of the Kimberley Area*. Explanatory Notes to Map Sheet 1 of the Vegetation survey of Western Australia: Kimberley. University of Western Australia Press, Nedlands, Perth.
- Beard, J.S. (1980). A new phytogeographic map of Western Australia. *Western Australian Herbarium Research Notes* No. 3: 37-58.
- Beard, J.S. & Webb, M.J. (1974). *The Vegetation of the Great Sandy Desert Area*. Explanatory Notes to Map Sheet 2 of the Vegetation Survey of Western Australia: Great Sandy Desert. University of Western Australia Press, Nedlands, Perth.
- Begg, R.J. (1981). The small mammals of Little Nourlangie Rock, N.T. IV: Ecology of *Zygomys woodwardi*, the large rock-rat, and *Z. argurus*, the common rock-rat (Rodentia: Muridae). *Aust. Wildl. Res.* 8: 307-320.
- Bettenay, E. & Churchward, H.M. (1974). Morphology and stratigraphic relationships of the Wiluna Hardpan in Arid Western Australia. *J. Geol. Soc. Australia* 21: 73-80.
- Bettenay, E., Churchward, H.M., McArthur, W.M. & Northcote, K.H. (1967). *Atlas of Australian Soils: Sheet 6, Meekatharra-Hamersley Range area* (with Explanatory Booklet). CSIRO and Melbourne University Press., Melbourne.
- Bindon, P. (1979). Abydos-Woodstock Reserve: History of Management and mismanagement. In: Archeological Resource Management in Australia and Oceania. 49th ANZAAS Congress. Auckland 1979. pp 83-85.
- Blakers, M., Davies, S.J.J.F. & Reilly, P.N. (1984). *The atlas of Australian birds*. Melbourne. Melbourne University Press. 738 pp.
- Blockley, J.G. (1975). Pilbara Block. In: *Geology of Western Australia*. West. Australian Geol. Survey Memoir No. 2: 81-93.
- Bradley, A.J., Kemper, C.M., Kitchener, D.J., Humphries, W.F., How, R.A. & Schmitt, L.H. (1988). Population ecology and Physiology of the Common Rock Rat, *Zygomys argurus* (Rodentia: Muridae) in tropical northwestern Australia. *J. Mammal* 69(4): 749-64.
- Bradshaw, S.D. (1986). *Ecophysiology of Desert Reptiles*. Academic Press, Sydney 324 pp.
- Breed, W.G. (1982). Control of mammalian and avian reproduction in the Australian arid zone, with special reference to rodents. In: *Evolution of the Flora and Fauna of Arid Australia* (ed. W.R. Barker & P.J.M. Greenslade) pp. 185-190. Peacock Publications, S.A.

## References

- Brooker, M.G., Ridpath, M.G., Estbergs, A.J., Bywater, J., Hart, D.S. & Jones, M.S. (1979). Bird observations on the north-western Nullarbor Plain and neighbouring regions, 1967-1978. *Emu* 79: 176-190.
- Burbidge, A.A. (1985). Fire and mammals in hummock grasslands of the arid zone. In: Fire Ecology and Management in Western Australian Ecosystems (ed. J.R. Ford). Proceedings of May 1985 Symposium. WAIT Environmental Studies Group. Report No. 14, pp 91-94.
- Burbidge, N.T. (1943). Ecological succession observed during regeneration of *Triodia pungens* R. Br. after burning. *J. Roy. Soc. W. Australia*. 28: 149-156.
- Burbidge, N.T. (1945). Ecological notes on the De Grey-Coongan area with special reference to physiography. *J. Roy. Soc. W. Australia*. 29: 151-161.
- Burbidge, N.T. (1959). Notes on plants and plant habitats observed in the Abydos-Woodstock area, Pilbara District, Western Australia. *CSIRO, Division of Plant Industry Techn. Paper No. 12*.
- Caughley, J. (1985). Effect of fire on reptile fauna of Mallee. In: *Biology of Australian Frogs and Reptiles* (eds Grigg, G., Shine, R. and Ehmann, H.) pp. 31-34. Roy. Zool. Soc. N.S.W. Sydney.
- Churchward, H.M. & McArthur, W.M. (1981). The soil pattern in relation to physiography and geology in the Northern Pilbara Region, Western Australia. *CSIRO, Australia: Land Resources Manag. Techn. Paper No. 6* plus soil map 1:250 000.
- Clifford, H.T. & Simon, B.K. (1981). The biogeography of Australian grasses. In: Keast, A. (ed.) *Ecological Biogeography of Australia* (3 vols). Dr W. Junk Publ., The Hague, Netherlands. pp. 537-554.
- Cloudsley-Thompson, J.L. & Chadwick, M.J. (1964). *Life in Deserts*. G.T. Foulis, London.
- Cody, M.L. (1985). Habitat selection in grassland and open-country birds. In: *Habitat selection in birds*. London. Academic Press. 191-223.
- Cogger, H.G. & Heatwole, H. (1981). The Australian Reptiles: origins, biogeography, distribution patterns and island evolution. In: *Ecological Biogeography of Australia* (ed. A. Keast) pp. 1331-74. Junk Hague.
- Dasmann, R.F. (1974). *Biotic Provinces of the World*. IUCN Occasional Paper No. 9, Morgues, Switzerland.
- Davidson, D. (1984). Dispersal in acacia. *Ecology* 65(4): 1038-1051.
- Davies, S.J.J.F. (1977). The time of breeding by the Zebra Finch *Taeniopygia castanotis* at Mileura, Western Australia. *Ibis* 119: 369-72.
- De Baar, M. (1985). The Ant, the Butterfly and the Mistletoe. *Geo* 7(2): 84-95.
- Dunlop, J.N. & Sawle, M. (1980). The small mammals of the eastern Pilbara and Hamersley Range National Park. In: *A Fauna Survey of Karijini National Park* (ed. B.G. Muir) pp. 26-30 National Parks Authority of W.A. Bull. No. 1.
- Dunlop, J.N. & Sawle, M. (1982). The habitat and life history of the Pilbara Ningau, *Ningau timealyi*. *Rec. West. Aust. Mus.* 10: 47-52.
- Ealey, E.H.M. (1967a). Ecology of the Euro *Macropus robustus* (Gould) in north-western Australia: I: The environment and changes in euro and sheep populations. *CSIRO Wildl. Res.* 12: 9-25.
- Ealey, E.H.M. (1967b). II Behaviour, Movements and Drinking Patterns. *CSIRO Wildl. Res.* 12: 27-51.
- Ealey, E.H.M. and Main, A.R. (1967). III Seasonal changes in Nutrition. *CSIRO Wildl. Res.* 12: 53-65.
- Ealey, E.H.M., Bentley, P.J. and Main, A.R. (1965). Studies on water metabolism of the Hill Kangaroo, *Macropus robustus* (Gould), in northwestern Australia. *Ecology* 46(4): 473-479.
- Ealey, E.H.M. and Richardson, T.M. (1960). A successful campaign against the euro. *J. Agr. West. Aust.* 4(1): 757-769.
- Fox, B.J. (1983). Mammal species diversity in Australian heathlands: the importance of pyric succession and habitat diversity. In: *Mediterranean-Type Ecosystems — the Role of Nutrients*. (eds F.J. Kruger, D.T. Mitchell & J.U.M. Jarvis) pp. 473-89. Springer-Verlag, Berlin.
- Friedel, M.H., Foran, B.D. & Stafford Smith, D.M. (1990). Where the creeks run dry or ten feet high; pastoral management in arid Australia. *Proc. Ecol. Soc. Aust.* 16: 185-94.
- Fyfe, G. (1980). The effect of fire on lizard communities in central Australia. *Herpetofauna*. 12: 1-9.
- Gentili, J. (1971). *Climates of Australia and New Zealand*. World Survey of Climatology Vol. 13. Elsevier Publ. Co., Amsterdam, London, N.Y.

## References

- Green, P. (1985). The Odd Couple. *Geo* 7(2): 96-103.
- Greer, A.E. (1989). *Biology and Evolution of Australian Lizards*. Surrey Beatty and Sons, Sydney. 264 pp.
- Hallam, S.J. (1985). The history of Aboriginal firing. In: *Fire Ecology and Management in Western Australian Ecosystems* (ed. J.R. Ford). Proceedings of May 1985 Symposium. WAIT Environmental Studies Group. Report No. 14, pp 7-20.
- Harvey, M.S. (1987). *Grymeus*, a new genus of pouched oonopid spider from Australia (Chelicerata: Araneae). *Mem. Mus. Vict.* 48: 123-130.
- Heatwole, H. & Taylor, J. (1987). *Ecology of Reptiles*. Surrey Beatty & Sons, Sydney, 324 pp.
- Hickman, A.H. & Lipple, S.L. (1978). Marble Bar, Western Australia. *West. Australia Geol. Series Explanatory Notes* Sheet SF 50-8.
- Hirst, D.B. (1989). A revision of the genus *Pediana* Simon (Heteropodidae: Araneae) in Australia. *Rec. South Aust. Mus.* 23: 113-126.
- Holdridge, L.R. (1947). Determination of World plant formations from simple climatic data. *Science* 105: 267-368.
- Holdridge, L.R. (1967). *Life Zone Ecology*. (2<sup>nd</sup> ed.) Research Centre, San Jose, Costa Rica.
- Huntley, B.J. (1982). Southern African Savannas. In: Huntley, B.J. & Walker, B.H. (eds.) *Ecology of Tropical Savannas*. Springer-Verlag, Heidelberg, W. Germany. Ecological Studies Series Vol. 42: 101-141.
- Huntley, B.J. & Walker, B.H. (eds.) (1982). *Ecology of Tropical Savannas*. Springer-Verlag, Heidelberg, W. Germany. Ecological Studies Series Vol. 42.
- Immelmann, K. (1982). *Australian Finches*. Angus & Robertson, Sydney.
- Jacobs, S.W.L. (1984). Spinifex. In: Cogger, H.G. & Cameron, E.E. (eds) *Arid Australia*. Symposium Proceedings, Australian Museum, Sydney. pp. 131-142.
- Jacobs, S.W.L. & Chapman, E. (1984). Photosynthesis in some Arid Zone plants. In: Cogger, H.G. & Cameron, E.E. (eds) *Arid Australia*. Symposium Proceedings, Australian Museum, Sydney. pp. 121-130.
- Johnstone, R.E. (1983a). Herpetofauna of the Hamersley Range National Park, Western Australia. In: A Fauna Survey of the Hamersley Range National Park Western Australia. *National Parks Authority WA Bull.* 1.
- Johnstone, R.E. (1983b). Avifauna of the Hamersley Range National Park, Western Australia. In: A Fauna Survey of the Hamersley Range National Park Western Australia. *National Parks Authority WA Bull.* 1.
- Keast, A. (ed.) (1981). *Ecological Biogeography of Australia*. (3 vols). Dr. W. Junk Publ., The Hague, Netherlands.
- King, D.R. (1989). An assessment of the hazard posed to Northern Quolls (*Dasyurus hallucatus*) by aerial baiting with 1080 to control dingoes. *Aust. Wildl. Res.* 16: 131-40.
- King, D.R. (1990). The distribution of European rabbits *Oryctolagus cuniculus* in Western Australia. *W.A. Nat.* 18: 71-74.
- Kitchener, D.J. (1980). A new species of *Pseudomys* (Rodentia: Muridae), from Western Australia. *Rec. West. Aust. Mus.* 8: 405-414.
- Kitchener, D.J. & Cooper, N.K. (1986). Reproduction in the male *Ningau* (Marsupialia: Dasyuridae). *Aust. Wildl. Res.* 13: 13-25.
- Koch, L.E. (1977). The taxonomy, geographic distribution and evolutionary radiation of Australo-Papuan scorpions. *Rec. West. Aust. Mus.* 5: 83-367.
- Koch, L.E. (1983a). Occurrence in Australia of the centipede genus *Asanada* Meinert (Chilopoda: Scolopendridae: Scolopendrinae). *Rec. West. Aust. Mus.* 11: 75-76.
- Koch, L.E. (1983b). Revision of the Australian centipedes of the genus *Cormocephalus* Newport (Chilopoda: Scolopendridae: Scolopendrinae). *Aust. J. Zool.* 31: 799-833.
- Koch, L.E. (1985). Pincushion millipedes (Diplopoda: Polyxenida): their aggregations and identity in Western Australia. *West. Aust. Nat.* 16: 30-32.
- Köppen, W. and Geiger, R. (1954). *Klima der Erde* (map). Darmstadt, Germany. Nystrom Co. Chicago.
- Kriewaldt, M.J.B. & Ryan, G.R. (1967). Pyramid, Western Australia. *West. Australian Geol. Survey* 1:250 000 Geol. Series Explanatory Notes.



## References

- Lee, A.K. & Cockburn, A. (1986). *Evolutionary ecology of marsupials*. Cambridge Uni. Press. 274 pp.
- Lee, A.K., Woolley, P. & Braithwaite, R.W. (1982). Life history strategies of dasyurid marsupials. In: *Carnivorous Marsupials* (ed. M. Archer) pp 1-11. Sydney Royal Zoological Society.
- Levi, H.W. (1983). The orb-weaver genera *Argiope*, *Gea* and *Neogea* from the western Pacific region (Araneae: Araneidae, Argiopinae). *Bull. Mus. Comp. Zool.* **150**: 247-338.
- Lourensz, R.S. (1981). Tropical cyclones in the Australian region July 1909-1980. The Australian bureau of meteorology. Government Publishing Service, Canberra.
- McDonald, R.C. Isbell, R.F., Steight, J.C., Walker, J. and Hopkins, M.S. (1984). Australian soil and land survey. Field Handbook. Incarter Press. Melbourne.
- McKenzie, N.L. (1981). Mammals of the Phanerozoic southwest Kimberley, Western Australia: Biogeography and recent changes. *J. Biogeog.* **8**: 263-280.
- McKenzie, N.L. (ed.) (1983). Wildlife of the Dampier Peninsula, southwest Kimberley, Western Australia. *Wildl. Res. Bull. West. Aust.* No. 11.
- McKenzie, N.L. & Burbidge, A.A. (1979). The Wildlife of some existing and proposed Nature Reserves in the Gibson, Little Sandy and Great Victoria Deserts, Western Australia. *Wildl. Res. Bull. West. Aust.* No. 8.
- Main, B.Y. (1987). A new genus of clubionoid spider from Western Australia (Arachnida: Araneomorphae). *Aust. ent. Mag.* **13**: 77-81.
- Medina, E. (1982). Physiological ecology of Neotropical Savanna plants. In: Huntley, B.J. & Walker, B.H. (eds) *Ecology of Tropical Savannas*. Ecological Studies Series Vol. 42: 308-335.
- Miller, A.A. (1953). *Climatology*. Methuen, London/E.P. Dutton, N.Y.
- Morton, S.R. (1990). The impact of European settlement on the vertebrate animals of arid Australia: a conceptual model. *Proc. Ecol. Soc. Aust.* **16**: 201-13.
- Morton, S.R. & Davies, P.H. (1983). Food of the Zebra Finch (*Poephila guttata*), and an examination of granivory birds of the Australian arid zone. *Aust. J. Ecol.* **8**: 235-243.
- Morton, S.R. and James, C.D. (1988). The diversity and abundance of lizards in arid Australia: a new hypothesis. *Am. Nat.* **132**: 237-56.
- Muir, B.G. (1977). Biological Survey of the Western Australian Wheatbelt. Part 2: Vegetation and habitat of Bendinger Reserve. *Rec. West. Aust. Mus. Suppl.* **3**.
- Muir, B.G. (ed) (1983). A Fauna Survey of Karijini National Park, Western Australia. *Western Australia National Parks Bulletin* No. 1.
- Munsell (1954). *Munsell Soil Color Charts*. Munsell Color Company, Inc. Baltimore.
- Newsome, A.E., McIlroy, J. & Catling, P. (1975). The effects of an extensive wildfire on populations of twenty ground vertebrates in south-east Australia. *Proc. Ecol. Soc. Aust.* **9**: 107-123.
- Nix, H.A. (1976). Environmental control of breeding, post-breeding dispersal and migration of birds in the Australian region. *16th Int. Orn. Congress*. Canberra. 272-305.
- Nix, H.A. (1981). The environment of *Terra Australis*. In: Keast A. (ed.) *Ecological Biogeography of Australia*. Dr W. Junk Publ., The Hague, Netherlands. pp. 103-133.
- Nix, H.A. (1982). Environmental determinants of biogeography and evolution in *Terra Australis*. In: Barber, W.R. & Greenslade, P.J.M. (eds.) *Evolution of the Flora and Fauna of Arid Australia*. Peacock Publ., Australian Syst. Bot. Soc. & ANZAAS, South Australia pp. 47-66.
- Northcote, K.H. (1960). *A factual key for the recognition of Australian soils*. 4th ed. Rellim Techn. Publ., Adelaide.
- Odum, E.P. (1971). *Fundamentals of Ecology* (3<sup>d</sup> ed.). W.B. Saunders Co. Philadelphia, USA.
- Petheram, R.J. & Kok, B. (1983). *Plants of the Kimberley Region of Western Australia*. University of Western Australia Press, Perth.
- Pianka, E.R. (1986). *Ecology and Natural History of Desert Lizards*. Princeton University Press, Princeton, N.J. USA.
- Pianka, E.R. (1989). Desert lizard diversity: additional comments and some data. *Am. Nat.* **134**: 344-64.
- Prescott, J.A., Collins, J.A. & Shirpurkar, G.R. (1952). The comparative climatology of Australia and Argentina. *Geog. Rev.* **42**: 118-133.

- Ride, W.D.L. (1964). *Antechinus rosamondae*, a new species of dasyurid marsupial from the Pilbara district of Western Australia; with remarks on the classification of *Antechinus*. *West. Aust. Nat.* 9: 58-65.
- Roberts, F.H.S. (1970). *Australian Ticks*. CSIRO: Melbourne.
- Roberts, N. (1988). Dambos in development: Management of a fragile ecological resource. *J. Biogeography* 15: 141-148.
- Saunders, D.A. and Curry, P.J. (1990). The impact of agricultural and pastoral industries on birds in the southern half of Western Australia: past, present and future. *Proc. Ecol. Soc. Aust.* 1990: 303-321.
- Schmitt, L.H., Bradley, A.J., Kemper, C.M., Kitchener, D.J., Humphreys, W.F. and How, R.A. (1989). Ecology and physiology of the northern quoll, *Dasyurus hallucatus*, (Marsupialia: Dasyuridae) at Mitchell Plateau, Kimberley, Western Australia. *J. Zool., Lond.* 217:
- Schodde, R. (1982). Origin, adaptation and evolution of birds in arid Australia. In: *Evolution of the Flora and Fauna of Arid Australia* (ed. W.R. Barker & P.J.M. Greenslade) pp. 191-224. Peacock Publications, S.A.
- Semeniuk, C.A. (1987). Wetlands of the Darling System — A geomorphic approach to habitat classification. *J. Roy. Soc. W. Australia* 69(3): 95-112.
- Southgate, R. (1990). A dietary study of the Bilby *Macrotis lagotis*. M. Sc. thesis.
- Specht, R.L. (1981a). Major vegetation formations in Australia. In: Keast, A. (ed.) *Ecological biogeography of Australia*. Dr W. Junk Publ., The Hague, Netherlands. pp. 163-297.
- Specht, R.L. (1981b). Ecophysiological principles determining the biogeography of major vegetation formations in Australia. In: Keast, A. (ed.) *Ecological Biogeography of Australia*. Dr W. Junk Publ., The Hague, Netherlands. pp. 299-333.
- Stocker, O. (1964). A plant-geographical climatic diagram. *Israel J. Bot.* 13: 154-165.
- Storr, G.M. (1984). Birds of the Pilbara Region, Western Australia. *Rec. West. Aust. Mus. Suppl.* 16.
- Storr, G.M. (1990). The *Ctenotus colletti* complex (Lacertilia: Scincidae) including a new species from the Pilbara. *Rec. West. Aust. Mus.* 623-626.
- Strahan, R. (1983). *The Australian Museum Complete Book of Australian Mammals*. Angus & Robertson. Sydney.
- Suijndorp, H. (1955). Changes in pastoral vegetation can provide a guide to management. *J. Agr. West. Aust.* 4: 683-687.
- Suijndorp, H. (1967). *A study of the influence of management practises on "spinifex" (Triodia pungens) grazing*. MSc. Agric. Thesis, Western Australia.
- Suijndorp, H. (1980). Pastoral development and research in the Pilbara region of Western Australia. *Aust. Rangel. J.* 2(1): 115-123.
- Suijndorp, H. (1988). An early history of Woodstock Station. Unpublished report prepared for Department of Agriculture field day at Woodstock Reserve, 1988. 4 pp.
- Thomas, M.F. (1974). *Tropical Geomorphology*. MacMillan, London.
- Tinley, K.L. (1975). Habitat physiognomy, structure and relationships. In: The Mammal Research Institute 1966-1975 Symposium Proceedings. *University of Pretoria, South Africa, Publ. New Series* No. 97: 69-77.
- Tinley, K.L. (1982). The influence of soil moisture balance on ecosystem patterns in southern Africa. In: Huntley, B.J. & Walker, B.H. (eds) *Ecology of Tropical Savannas*. Springer-Verlag, Berlin. pp. 175-192.
- Tinley, K.L. (1986). Ecological Regions of Western Australia: The basis for co-ordinated Planning and Management of Conservation and Development. In: *Towards a State Conservation Strategy: Invited Review Papers*. Dept. Conservation and Environment, Western Australia BULLETIN No. 251: 217-233
- Tinley, K.L. (1987). Achieving a balance between long and short term research. Pp. 347-350 In: Saunders, D.A., Arnold, G.W., Burbidge, A.A. & Hopkins, A.J.M. (eds) *Nature Conservation: The Role of Remnants of Native Vegetation*. Surrey Beatty & Sons, N.S.W.
- Tinley, K.L. (1988). Habitat Survey of the Abydos Woodstock Reserve, North Pilbara Region. Unpublished Report. W.A. Museum.
- Udvardy, M.D.F. (1975). *A Classification of the Biogeographic Provinces of the World*. IUCN Occasional Paper No. 18, Morgues, Switzerland.

References

- Walter, H. & Breckle, S-W. (1986). *Tropical and Subtropical Zonobiomes*. Vol. 2 of Ecological Systems of the Geobiosphere. Springer-Verlag, Berlin.
- Walter, H. & Lieth, H. (1967). *Klimadiagramm-Weltatlas*. VEB, Gustav Fischer Verlag, Jena.
- Wardell-Johnson, G. (1987). A Year in Lilliput. *Landscape* 2(3): 17-21.
- Walter, H. (1979). *Vegetation of the earth in relation to climate and the ecophysiological conditions*. (2<sup>nd</sup> German edition translated by Joy Vieser). English Universities Press, London.
- Wiens, J.A. & Johnston R.F. (1977). Adaptive correlates of granivory in birds. *In: Granivorous birds in ecosystems*. Cambridge. Cambridge University Press. 301-340.
- Woolley, P.A. (1991a). Reproduction in *Pseudantechinus macdonnellensis* (Marsupialia: Dasyuridae): Field and Laboratory Observations. *Aust. Wildl. Res.* **18**.
- Woolley, P.A. (1991b). Reproduction in *Dasykaluta rosamondae* (Marsupialia: Dasyuridae): field and laboratory observations. *Aust. J. Zool.* **39**.
- Wyndham, E. (1978). Birds of the Milparinka District and Cooper Creek Basin. *Emu* **78**: 179-187.

## 10. APPENDIX I

### Woodstock Site Descriptions

- WS1 *Eucalyptus camaldulensis*, *Melaleuca leucadendra* 5-8 m tall, 35% canopy cover, over *Acacia* sp. 1-2 m tall, c. 5% canopy cover over *Cenchrus ciliaris* <0.5 m tall, c. 90% canopy cover. Site is narrow belt of riverine woodland on edge of Coorong Creek. Soil is deep alluvium. Site is equivalent to B1 in Tinley (this report).
- WS2 *Acacia pyrifolia*, 2-3 m tall, 3% canopy cover, *Hakea suberea*, 2-3 m tall, <0.5% canopy cover and *Acacia* sp. 2-3 m tall, <0.5% canopy cover over *Triodia* spp (2) c. 0.5 m tall, 80% canopy cover. Soil coarse sandy loam with granite bedrock at 30-40 cm. Site was burnt in January 1990.
- WS3 *Triodia* spp <1 m tall c. 60% canopy cover with occasional *Acacia* spp as emergents. Soil red sandy loam. Site is equivalent to Plate 47 (Tinley, this report). Site was burnt in January 1990.
- WS4 *A. pyrifolia*, 2-4 m tall, c. 5% canopy cover, over *A. ancistrocarpa*, 1.5-2 m tall, 50%-70% canopy cover. Occasional ephemerals after rain. Soil red sandy loam, >60 cm deep. Site was burnt in January 1990.
- WS5 *T. secunda* and *T. longiceps* <0.5 m tall, c. 70% canopy cover. Soil white sandy silt over clay. Site is Plate 50 (Tinley, this report).
- WS6 *A. orthocarpa*, 3-4 m tall, c. 7% canopy cover, and occasional *A. pyrifolia*, over *T. lanigera* c. 0.5 m tall, 50% canopy cover. Soil is described in Figure 11 (Tinley, this report).
- WS7 Granite outcrop with large surface boulders. Broad leaf wattle and *Triodia* in crevices.
- WS8 *E. terminalis*, 3-5 m tall, c. 2% canopy cover, over oval leaf wattle 1-1.5 m tall, c. 2% canopy cover, over *Triodia* c. 0.5 m tall, c. 40% canopy cover. Site includes valley between, and the steep slopes of calcrete mesas. Valley soil is calcareous clay loam. See Plate 31 (Tinley this report).
- WS9 Banks of upper Coorong Creek with granite floor and scour pools and alluvium or granite banks. See Plate 23 (Tinley, this report).
- WS10 *Acacia* sp. 1.5-2.5 m tall, <0.5% canopy cover, *Hakea* sp. 1.5-2.5 m tall, <0.5% canopy cover, over *Acacia* sp. <1m tall, c. 3% canopy cover, over *Triodia* sp. <0.5 m tall c. 160% canopy cover. Deep red loamy sand. Extensive surface water after heavy rain.
- WS1 1,13,31 Gallery Hill tors. Piles of granite boulders with occasional shrubs described in A5 (Tinley, this report).
- WS15 Cadjeput Gorge. *E. camaldulensis* and *M. leucadendra* trees in high walled ravine with permanent plunge-pool on north facing edge of Soansville Plateau. *Ficus* sp. grows in crevices of ravine walls.
- WS16 Bowerbird Gorge. Deep walled gorge on north-western edge of Soansville Plateau.
- WS17 Tim Ealey Hill. Granite tor similar to Gallery Hill tors.
- WS18 Pullcunah Hill. The tallest and most isolated of the granite tors (see plate 4, Tinley, this report).
- WS20 Abydos Wall dolerite dyke (see Plate 56, Tinley this report).
- WS21 Ironstone mesa remnants of the Fold Range (see Plate 6, Tinley this report).
- WS22, 23 Stony undulating base of fold hills with *Triodia* sp. <0.5 m tall c. 30% canopy cover. Site is foreground in Plate 2 (Tinley this report).
- WS24 Transition from Sites WS22, 23 to *A. pyrifolia* Scrub Savanna. Site consists of *A. pyrifolia* 2-3 m tall, c. 5% canopy cover over *Triodia* sp. <1.0 m tall c. 40% canopy cover. Soil is red loam with surface quartz pebbles.
- WS29 Granite tor near edge of fold ranges.
- WS30 Regenerating *A. pyrifolia* Scrub Savanna which was burnt in January/February 1989.
- WS32 Southern slopes of Soansville Plateau. Bloodwood Savanna (*E. terminalis*). Surface pebbles consisted of calcrete and quartz.
- WS33 Gregory's Folly granite tor similar to WS17.