BIOGEOGRAPHY AND ITS USE FOR SETTING OF PRIORITIES FOR MANAGEMENT

IAN ABBOTT
Workshop Leader
Department of Conservation and Land Management,
Como Research Centre, P.O. Box 104, Como, W.A. 6152.

INTRODUCTION

This workshop discussion was organized around four themes: the scope of biogeography, the choice of species for study, the use of biogeographical data in setting priorities for management of conservation values and land, and using the experience of managers of conservation values and land to assist in the setting of priorities for the biogeographer.

SCOPE OF BIOGEOGRAPHY

It is difficult to define the scope of biogeography. This is partly semantic (many geographers use the term synonymously with ecology) but is important because the discipline has recently undergone a rebirth. Consequently it is now considered quite insufficient for a biogeographer to produce maps of the distribution of species, to describe patterns of distribution and to infer historical explanations for the patterns discovered. Over two decades ago, MacArthur and Wilson (1963) showed that it was possible to make interesting and practical predictions about the number of species present in well defined areas without necessarily considering history or having to work from detailed distribution maps.

The scope of biogeographical studies is best illustrated by showing their intimate relationship to population and community ecology. Population ecology considers the distribution and abundance of a particular species chosen for detailed study (e.g. a pest insect, a rare plant, a colonially nesting seabird) and tries to explain why that species is found where it is (and not elsewhere), why it is more common at some locations than others, and why fluctuation in numbers at the same locality occur over a particular period. Counts of individuals are necessarily involved and there is a recent trend to distinguish by experiment the importance of factors such as habitat characteristics, intraspecific competition, interspecific competition and predation in determining the distribution and abundance of the species being studied.

Community ecology involves studying assemblages of species at a local scale e.g. the nectariphagous birds found together in a heathland, the seabird species nesting on an island, the species of parrot fish found on a coral reef. Its essence is that a lot of detailed data is collected from a particular place. Originally, community ecology studies were descriptive (e.g. a checklist of plant species occurring in a particular reserve) but the recent trend is towards estimating numbers of species and investigating the effect of some disturbance on the set of species studied (e.g. effect of logging on the birds in a forest stand, impact of fire on soil and litter fauna).

Biogeography is still more general in scope. Like community ecology it embraces the study of assemblages of species but at a broader scale, regional to global. Because of its breadth it cannot often be experimental because experiments at such grand scales are very costly and require large teams of people to manage them. Similarly, it is often difficult to synchronize the collection of census data over a regional scale. For these reasons, biogeography is mostly descriptive (presence/absence of species or abundance on an ordinal scale) but is always comparative, i.e. the species checklists collected from many localities within a region are compared. These checklists are really basic resource inventories and can be used to generate detailed site-vegetation types or simple measures such as species diversity indices or total number of species present for the taxa of interest. These checklists also serve as the context in which the conservation value of other pieces of land can be judged.

Biogeographical studies provide a framework in which it is possible to:

1.determine accurately how particular ecosystems are put together;

2.evaluate the effects of habitat fragmentation on species richness;

3.calculate the size of reserves optimal for particular groups of organisms;

4.infer how some of the component species may interact;

5.infer how disturbance affects species in an ecosystem; and

6.monitor stability of species in an ecosystem over time.

Experimental validation of 4, 5 and 6 involves working at the community ecology level.

Examples of these uses of biogeographical studies follow.

1aIdentifying patterns in species richness e.g. Isoflor maps for species of *Eucalyptus* and *Acacia* (Hopper 1979), similar maps for vertebrates (Pianka and Schall 1981). Biogeographers try to associate these patterns with environmental characteristics such as average annual rainfall, soil types and altitude.

The other way of studying these patterns is more rigorous, and involves multiple regressions between species richness and a host of environmental attributes (e.g. Kitchener et al. 1982, Abbott 1985). This approach can often indicate which factors are worth manipulating in experiments. (It seems pointless to consider further those factors which do not significantly regress on species richness).

1bIdentifying patterns in the distribution of particular species (e.g. Abbott 1981).

2&3Determining species/area relationships and the minimum area necessary for the long term survival of particular species (e.g. Kitchener et al 1982, Abbott 1981). Identifying the dependence of certain species on particular habitat types (e.g. Kitchener 1982, Humphreys & Kitchener 1982). In the jarrah (*Eucalyptus marginata*) forest, rare and endangered plant species are found on granite outcrops or on the western edge of the Darling Scarp and not in areas where forest is logged (Hopper pers. comm.).

4.Identifying chequerboard patterns in the distribution of ecologically similar species (e.g. Main 1961).

5.Comparing disturbed areas with nearby areas which are less disturbed (e.g. Nichols and Watkins 1984) (the rare plant species *Acacia guineti* occurs more commonly on disturbed areas).

6.Repeated visits to specific plots or quadrats enable detection of any trends in distribution (e.g. a contraction or expansion in range of species over several decades). Subtle changes in abundance would not be detected (they are the province of community or population ecology).

All the above can help identify species, communities or habitats requiring more intensive research or management. These features can contribute to the formulation of a land use planning scheme for future short and long term management.

WHICH SPECIES TO STUDY?

The ecological verity that larger areas support more species than smaller areas makes difficulties for the biogeographer in selecting taxa for recording. This is illustrated by data collected from the forest ecosystem of south-western Australia, which contains more than 120 000 species of organisms, more than 50 site-vegetation types and at least 28 vegetation complexes (Table 1). Biogeographical studies to data (Christensen et al. 1985) have emphasized vertebrates and the vascular flora, about 1.5% of the total number of species probably available for study, and hardly representative. This emphasis on higher organisms simply reflects the training of biogeographers, the considerable scientific progress made over 150 years in formally naming Western Australian species of vertebrates and vascular plants, the comparative ease of studying these organisms, and the interest shown by the wider community.

CAN BIOGEOGRAPHICAL DATA HELP IN THE SETTING OF PRIORITIES FOR CONSERVATION AND LAND MANAGEMENT?

The goal of the biogeographer is not only to accumulate useful biogeographical information but also to disseminate it in a form useful to

Table 1. Species richness, site-vegetation types and vegetation complexes of the forest ecosystem of South-western Australia.

		Authority
Area	5x106 ha	
Taxa		
Mammals	32 species	Batini 1974, Strahan 1983
Land Birds	94	Kimber & Christensen 1977
Reptiles	67	Storr et al. 1981, 1983, 1986; Cogger 1975
Frogs	19	Tyler et al. 1984
Insects	16 000 est.	Abbott, unpubl.
Other invertebrates	1 500 est.	Anon., pers. comm.
Vascular plants	1 500 est.	Marchant, pers. comm.
Bryophytes	150 est.	Marchant, pers. comm.
Macrofungi	3 000 est.	Hilton, pers. comm.
Microfungi	100 000 est.	Hilton, pers. comm.
Site-vegetation types		
Northern Jarrah Forest	21	Havel 1975
Southern Jarrah Forest	17	Strelein unpubl.
Karri Forest	12 est.	Inions, pers. comm.
Sunklands	6	McCutcheon 1980
Vegetation Complexes		
System 6	28	Heddle et al. 1980
System 1	?	-
System 2	?	-

managers of conservation values and land. There are two possibilities. First, these biographical data can contribute to the formulation of a land use scheme. Second, land which already has a designated land use scheme can assist the biogeographer's choice of species to be studied (addressed in the next section).

Biogeographical data can be used to formulate a land use scheme for a newly acquired reserve, particularly if rare, endangered or otherwise biologically interesting species are present. Repeated biological surveys indicate which species have small distributions and might be rare or endangered, and identify scientifically interesting distributional outliers (e.g. jarrah at Jilakin Rock and Mt Lesueur). It is likely that one-off surveys would miss many species, so it is essential to repeat surveys at different times of the year.

Biogeographical data can also be used to ensure representativeness of conservation reserves. In Western Australia such use has helped in the reservation of adequate areas in the Kimberley (Biological Survey Committee 1981, 1985), arid zone (Burbidge & McKenzie 1983, McKenzie 1981, McKenzie & Burbidge 1979) and the south west (Forests Department 1978, McKenzie et al. 1973).

Many of the efforts of earlier naturalists and scientists in Western Australia (e.g. Preiss, Gilbert, Drummond, Hartmeyer and Michaelsen) were spoiled by their failure to record precise localities. Therefore biogeographical data, to be useful in the long term, must be referable to specific sites. These data form a baseline for future monitoring of the effects of managers and permit appraisal of their efficiency (whether a particular species still survives in a reserve, whether a particular habitat has not been degraded). Thus, the biogeographer could advise the manager that the current fire regime applied to a reserve appears to be associated with a decline in a a particular species or habitat. The next step is for a properly designed research project to examine if the association is in fact cause and effect. Pending such research, the manager can at least alter or introduce more variety into the fire regime after seeking expert advice.

The sorts of management questions that land and conservation managers could turn to biogeographers for are set out in Table 2. Local managerial knowledge about the precise location of rare, endangered or scientifically important species or habitat types would help answer questions 1-4, and 7-9. Knowledge of the occurrence of obligate seed-regenerating plant species could help answer question 4. Concerning question 7 : yes, if the unvested land is particularly rich in species, or if the region has not enough representative reserves. A reserve with many species of Proteaceae could be at risk if the fungus *Phytophthora cinnamomi* established (Question 10).

USING THE EXPERIENCE OF MANAGERS OF CONSERVATION AND LAND IN SETTING PRIORITIES FOR THE BIOGEOGRAPHERS

The previous section described how the biogeographer can help conservation and land management. It should also be recognized that the manager can aid the biogeographer. The example in Table 1 shows that the biogeographer has more indigenous species and communities to study than resources to study them with. The manager knows (Table 2) the kinds of information that he/she is lacking in order to manage effectively a piece of land. The manager could therefore advise the biogeographer on organisms worthy of study.

The land use plan that is already available for a piece of land very much dictates how the land is to be managed. For example, the Western Australian State Forest ecosystem has had seven types of land use : flora, fauna and landscape; scientific study and education; protection; wood production; water production; recreation; and mining (Forests Department of W.A. 1982). Thus if an area of forest is set aside for recreation it would be prudent for the biogeographer to accumulate data on the distribution of weeds and of indigenous plant species sensitive to soil compaction, whereas in forest managed for flora, fauna and landscape several of the rarer species of vertebrates of plants and habitat types might be the object of biogeographical study.

CONCLUSION

Biogeographical information can make a useful contribution to the setting of priorities in the management of forests, national parks and nature reserves. This information can be used to ensure representativeness of conservation reserves. However because most biogeographical data rep-

Table 2. Some questions often asked by conservation and land managers and which biogeographical information can help answer.

1. Where should access tracks be put?
2. Where should fire breaks be put?
3. Which access tracks should be closed?
4. When and how should the land be burned?
5. Where precisely are populations of rare, endangered or scientifically interesting species located?
6. Should my Department consider purchasing land adjacent to land already managed by my Department?
7. Should my Department consider bidding for some unvested Crown Land in my District?
8. Where can sites for camping, picnicking, beekeeping, extraction of gravel and trails for horseriding and bike riding be located?
9. Of all the land under my control, which reserves are most important biogeographically and therefore require the closest management?
10. Does any land under my control contain many species susceptible to the introduction or spread of Phytophthora cinnamomi?

resent documentation and description, the manager of conservation values and land still needs to liaise with community and population ecologists who could offer more detailed advice derived from experimental studies.

ACKNOWLEDGEMENT

I thank S. Hopper for the record of discussion, all members for contributing so thoughtfully to the discussion, and the authorities cited in Table 1 for providing the information requested.

REFERENCES

Abbott, I. (1981). The composition of landbird faunas of islands around south-western Australia : Is there evidence for competitive exclusion? J. Biogeog. 8 : 135-44.

Abbott, I. (1985). Influence of some environmental factors on indigenous earthworms in the northern jarrah forest of Western Australia. Aust. J. Soil Res. 23:171-90.

Batini, F. (1974). Distribution of modern mammals in the south west of western australia. Forests Department of Western Australia, unpublished report.

Biological Survey Committee (1981). "Biological Survey of the Mitchell Plateau and Admiralty Gulf, Western Australia." Western Australia, Perth.

Biological Survey Committee (1985). "The Biological Survey of the Eastern Goldfields of Western Australia. Part 3, Jackson-Kalgoorlie study area." Western Australian Museum, Perth.

Burbidge, A.A. & McKenzie, N.L. (eds) (1983). The wildlife of the Great Sandy Desert, Western Australia. Western Australian Wildlife Research Bulletin No. 12.

Christensen, P., Annels, A., Liddlow, G. & Skinner, P. (1985). Vertebrate fauna in the southern forest of Western Australia. A survey. Forests Department of Western australia, Bulletin No. 94.

Cogger, H.G. (1975). "Reptiles and Amphibians of Australia." Reed, Sydney.

Forests Department of Western Australia (1978). Land Use Management Programme. Northern Jarrah Forest Management Priority Areas. Perth.

Forest Department of Western Australia (1982). General Working Plan for State Forests in Western Australia. Perth.

Havel, J.J. (1975). Site-vegetation mapping in the northern jarrah forest (Darling Range). 1. Definition of site-vegetation types. Western Australian Forests Department Bulletin No. 86.

Heddle, E.M., Loneragan, O.W., and Havel, J.J. (1980) Vegetation complexes of the Darling System Western Australia. pp. 37-72. In : "Atlas of Natural Resources Darling System Western Australia". Department of Conservation and Environment, Perth.

Hopper, S.D. (1979). Biogeographical aspects of speciation in the Southwest Australian flora. Ann. Rev. Ecol. and Syst. 10 : 399-422.

Humphreys, W.F. & Kitchener, D.J. (1982). The effect of habitat utilization on species-area curves : implications for optimal reserve area. J. Biogeog. 9 : 391-6.

Kimber, P. & Christensen, P. (1977). Birds of Western Australian forests. Western Australian Forests Department Information Sheet No. 12.

Kitchener, D.J. (1982). Predictors of vertebrate species richness in nature reserves in the Western Australian Wheatbelt. Aust Wildl. Res. 9 : 1-7.

Kitchener, D.J., Dell, J., Muir, B.G. & Palmer, M. (1982). Birds in Western Australian Wheatbelt reserves - implications for conservation. Biol. Conserv. 22 : 127-63.

Main, A.R. (1961). The occurrence of Macropodidae on islands and its climatic and ecological implications. J. Roy. Soc. West. Aust. 44 : 84-9.

McArthur, R.H. & Wilson, E.O. (1963). An equilibrium theory of insular biogeography. Evolution 17 : 373-87.

McCutcheon, G.S. (1980). Field classification of vegetation types as an aid to soil survey. Forests Department of Western Australia, Research Paper No. 57.

McKenzie, N.L. (ed.) (1981). Wildlife of the Edgar Ranges area, south-west Kimberley, Western Australia. Western Australian Wildlife Research Bulletin No. 10.

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. Western Australian Wildlife Research Bulletin No. 8.

McKenzie, N.L., Burbidge, A.A. & Marchant, N.G. (1973). Results of a biological survey of a proposed wildlife sanctuary at Dragon Rocks, near Hyden, Western Australia. Western Australian Department of Fisheries and Wildlife Report No. 12.

Nichols, O.G. & Watkins, D. (1984). Bird utilisation of rehabilitated bauxite minesites in Western Australia. Biol. Conserv. 30; 109-31.

Pianka, E.R. & Schall, J.J. (1981). Species densities of Australian vertebrates. Pp. 1675-94. In : "Ecological Biogeography of Australia" (ed. Keast, A.) Junk, Den Haag.
Storr, G.M., Smith, L.A. & Johnstone, R.E. (1981). "Lizards of Western Australia I. Skinks." Western Australian Museum, Perth.
Storr, G.M., Smith, L.A. & Johnstone, R.E. (1983). "Lizards of Western Australia II. Dragon and Monitors." Western Australian Museum, Perth.
Storr, G.M., Smith, L.A. & Johnstone, R.E. (1986). "Snakes of Western Australia." Western Australian Museum, Perth.
Strahan, R. (ed). (1983). "The Australian Museum Complete Book of Australian Mammals." Angus & Robertson, Sydney.
Tyler, M.J., Smith, L.A. & Johnstone, R.E. (1984). "Frogs of Western Australia." Western Australian Museum, Perth.