BIOGEOGRAPHY AND ITS USE FOR SETTING PRIORITIES FOR MANAGEMENT

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INTRODUCTION

The session began with an introductory description of differences between biogeography (including descriptive ecology) and experimental ecology. Its purpose was to provide common ground for the ensuing discussion on the implications and limitations of biogeographic studies for management. To emphasise the local context I have tried to use Western Australian studies to illustrate both the introduction and the points raised during the discussion.

Biogeographic studies describe the present and/or past patterns in the geographic distribution of organisms over periods ranging from decades to millions of years and / or usually over areas as least as large as a natural district. For the purposes of this discussion the term "descriptive ecology" will be used to distinguish non-experimental studies confined to relatively small study areas such as a single reserve, or along a corridor between reserves.

Most studies of field ecology in Western Australia include elements belonging to the "descriptive ecology-biogeography" continuum, because they contribute to our knowledge of: (1) patterns in the distributions of species or in the composition and diversity (eg. species richness) of communities; (2) the status (eg. rarity, endemism, commonness, relictualism) of species and communities; (3) the geographic and temporal scales at which various species operate; or (4) the influence that physical and biological factors have on ecological boundaries, the relative abundance (eg. presence or absence) of species, and the complexity and dynamic nature of communities, at various localities at various times. Examples include: disturbers (fire, exotic species), environmental gradients (scalars such as substrates, altitude, climates), barriers to dispersal, and connections with other organisms (food chains, competition for resources).

A large, and ever increasing, body of such data has been provided for Western Australia by biologists of the W.A. Museum, W.A. Herbarium, various CALM and CSIRO research centres, universities, mining companies, private organizations (eg RAOU) and individuals.

As our knowledge of the biota has become more detailed, there has been a realization of the problems confronting native species, the limited research and management resources available to conservation organizations, and the fragmented nature of our data-base. The W.A. Biological Surveys Committee was convened in 1977 to coordinatate biological research. Its aim is to improve the coverage of the available data in terms of both the biological diversity and the geographic extent of the State.

Biogeographic studies in W.A. (see McKenzie 1984) have moved away from comparisons of land-unit or regional species lists (e.g. McKenzie 1981) and the provision of biotic maps based only on the distributions of individual species or of a few attributes such as structurally dominant plant species and superficial geology (see Beard 1980). Instead, recent investigations of biogeographic pattern (the "what and where") have emphasised quantitative analyses that attempt to explain the observed patterns in terms of environmental factors. For example, certain recent studies of the biogeography of individual species have sought explanations through correlations with climatic (Nix & Gilleson 1985) attributes.

Similarly, studies of the biogeography of communities (Hnatiuk & Hopkins 1981, Biological Survey Committee 1984, McKenzie & Robinson 1987) have adopted sampling designs that provide quantitative assemblage data because such data-sets retain spatial discrimination and are amenable to the same analytical techniques as descriptive ecological data-sets. The last two of the studies just cited, aim at reasonably exhaustive species composition data for a wide array of organisms (so that a variety of different parts of ecological networks are represented), at a large number of quadrats (quadrat sampling designs acknowledge connectance between species in an assemblage) positioned to represent the geographic extent of study areas more than 250 000 square kilometres in area. Such data-bases provide data of the "what and where" sort, at broad geographic scales, that better represents entire ecological networks. They also yield insights into "how and why" similar to those provided by descriptive ecology, but at regional scales. The latter is gained through the identification of physical scalars such as substrate, climatic or altitude gradients (Austin et al. 1984) that are strongly correlated with biotic patterns, and by resampling the quadrats at various points in time to monitor changes in species composition across the entire district. Members of the discussion group had indicated concern that the value of biogeographic data was limited because it had no value in elucidating the ecological processes (the "how and why") needed to manage the biota effectively.

Sometimes biogeographic patterns have been used as a basis for testing ecological theories such as species interactions (e.g. competition and community structure), density-dependent habitat selection, r - K strategies, minimum viable population sizes, equilibrium theory of island biogeography, and species richness versus area *in relation to habitat patch-size or habitat* heterogeneity. Examples include Hopper (1979), Kitchener (1982), Hopkins & Hnatiuk (1983), McKenzie & Rolfe (1986) and Moran & Hopper (1987), as well as the recent interest in species richness-area relationships (Kitchener et al. 1980) although, in the context of designing representative nature reserve systems, SLOSS (single small or several large) relationships have proved too superficial (Zimmerman & Bierregaard 1986, Shafer & Sanson 1986).

On the other hand, it has been difficult to do experimental biogeography; that is, to manipulate biological and/or physical parameters across large enough areas, or for long enough, to be termed biogeography rather than ecology. As a result, attempts to test hypotheses concerning the processes of ecological patterning at these larger geographic or temporal scales have relied on "natural experiments" (descriptive data) that correlate patterns in species composition, richness, etc. with gradients in biophysical scalars or disturbers imposed on the region's biota (discussed above). The problem of identifying causation from "natural" experiments in ecology has been discussed by Diamond (1983) and is aggravated for biogeographers. At biogeographic scales it is especially difficult to set up and maintain valid "control" quadrats, yet these are needed to untangle (isolate) the variety of disturbers, scalars, and ongoing biotic processes present in natural systems across study areas as big as regions. The discussion group took the view that causes were most likely to be identified through autecological studies.

Thus, while biogeography has been able to provide insights into "how and why" over large study areas (from correlations and other circumstantial evidence), the actual causes have rarely been isolated. Nevertheless, when setting priorities between management programs it is essential to have the regional "what and where" context and only broad-scale studies can provide these insights in an objective manner; for instance, such data allow planners to distinguish localised events from regional trends that affect the persistence of native species. Elton (1966) summed this up as follows; "it is one of the tasks of ecological survey to provide the strategic setting for population studies".

DISCUSSION

There was no dispute among members of the *discussion group that this "what and where" (the regional context) is fundamental to setting* priorities for the management of wildlife, although it was pointed out that perhaps biogeographic survey effort should be directed to areas where resources were available to incorporate the findings into management activities. Managers of large areas with limited resources disagreed as they find themselves being asked to predict conservation values for areas of land about which there was little or no data. More biogeographic data are necessary to help them make such decisions.

A model of biogeographic survey (Fig. 1) currently being researched by the Western Australian Department of Conservation and Land Management, was presented to stimulate discussion on the opportunities quantitative

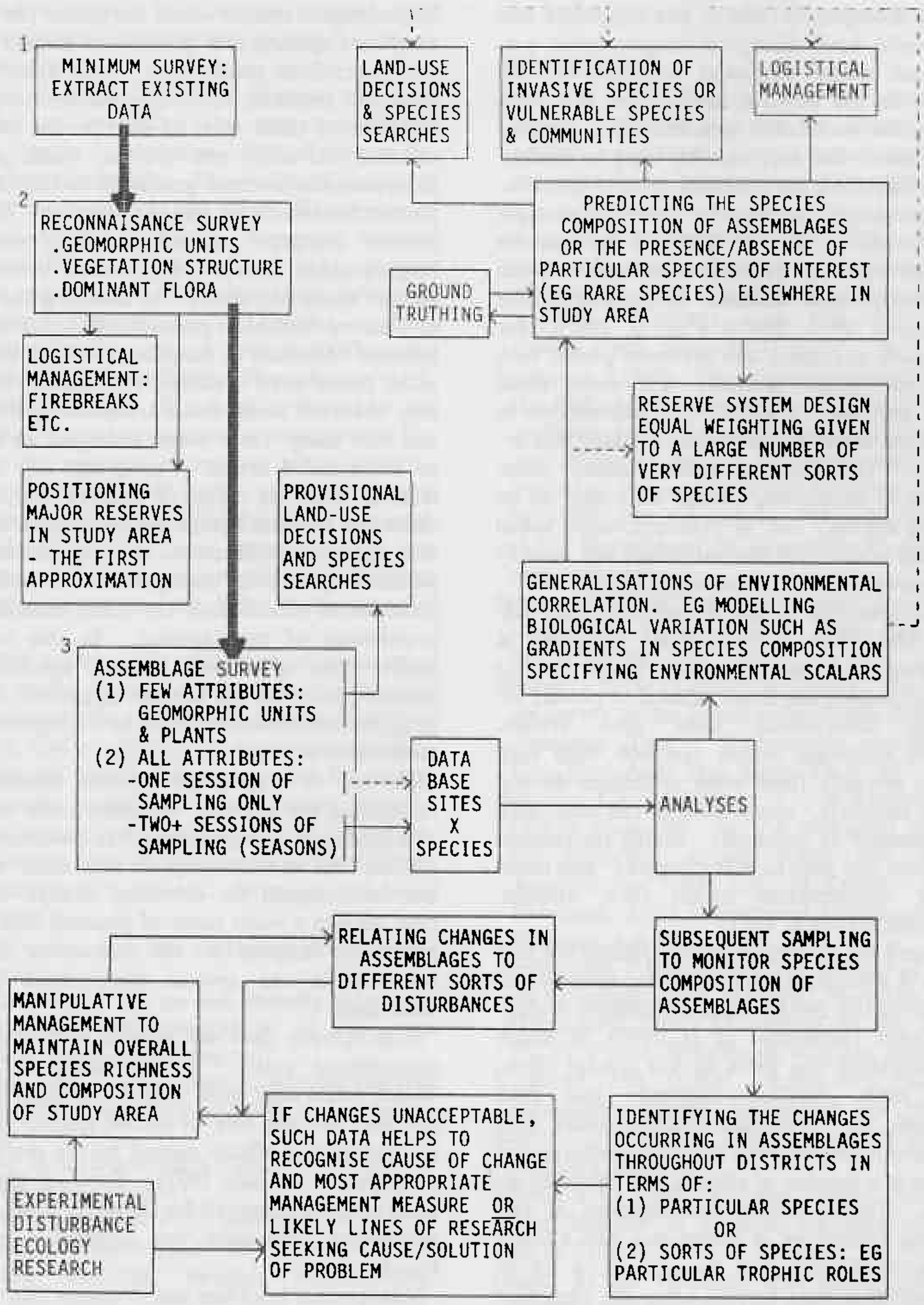

Figure 1. A model of biogeographic survey. The "Reconnaisance Survey" provides a basis for positioning the sampling quadrats used in the "Assemblage Survey".

biogeographic data can provide for discriminating and investigating biotic patterns, and for using the derived patterns as an explicit basis for setting priorities for management.

It was pointed out that disturbers have been rampant across Western Australia since settlement by Europeans, and it was suggested that these would have disrupted biogeographic patterns and would confound attempts to find gradients in the physical environment that have such a close correlation with the biotic patterns discriminated that they can be used as scalars. Would this reduce the potential value of quantitative biogeographic analyses by thwarting attempts at prediction? This was likely to be true for groups of organisms (such as mammals) in which many species have declined or become extinct (see Baynes 1987, Boscacci et al. 1987); for others, such as reptiles and perennial plants, such disruptions would probably not mask these original patterns. Further work was needed to find out the extent to which such masking had occurred. Disturbances would create some problems in monitoring (things were sure to be changing anyway) but, in principal, some initial "what and where" was needed before any soundly based management decisions could begin.

Several members of the discussion group suggested that data derived from sampling at biogeographic (regional) scales would be too sparse to provide the detail needed to predict assemblage composition from such scalars. Problems requiring further research were seen with the intensity (how many organisms do you need to sample?), extent (size of the study-area versus number of quadrats), timing (in relation to seasonal and year-to-year changes), and localized or unpredictable events (fire, drought, windstorms, tree-falls, etc.).

To dispell the pessimism, it was pointed out that analysis of a biogeographic data-base recently collected from the 260000 square kilometre Nullarbor District (McKenzie et al. 1987), in which equal weighting was given to 373 species (comprising birds, reptiles, mammals and both ephemeral and perennial plants), found very close correlations between biological patterns and gradients in a number of climatic and substrate attributes. During further investigations of this data-base, carried out in conjunction with CSIRO Division of Wildlife and Rangelands, a set of predictive maps was derived using the identified scalars; subsequent ground-truthing, by sampling at 10 new quadrats, substantiated the predictions with somewhere near 80% accuracy (for assemblage composition). However, most of the Nullarbor District had a subdued topography that simplified the modelling.

There was some concern that broad scale biogeographic studies would not detect (or represent) rare species; that generalized scalars would give generalized predictions. Thus, reserve systems and priorities for management selected on the basis of these sorts of data would overlook relictual and other rare species. Such populations comprise extreme genotypes so they are important for conserving genetic variation. The discussion group agreed that systematic biogeographic surveys were needed to evaluate species status objectively. In assessing the status of Western Australian plants from Herbarium collections, Marchant & Keighery (1979) found that many plants were considered "common" because they occurred along roads travelled by botanists and that many "rare" plants belonged to remote or inaccessable areas. The group also agreed that as wide an array of species as possible should be sampled though the importance of common species should not be overlooked, and that particular priority in management, including the provision of special reserves, would be needed by populations of rare species. In this context, studies that specialized in rare species were needed (and exist, see Hopper et al. 1982, Friend et al. 1982, Christensen 1980) as a complement to generalized surveys.

The use of biogeographic survey quadrats for monitoring (by carrying out subsequent sessions of sampling at the quadrats) was considered important and it was accepted that these surveys can be designed for detecting change through time, though a wider range of physical data would give better insights into the reasons for changes observed in the species composition of assemblages.

Biogeography does not provide solutions to all management issues. For instance, the above model would have little value for gaining insights into the "how and why" of marine systems because of randomising affects caused by the mobility of propagules (see Sale 1977). Even so, the sampling strategy proposed for Ningaloo Reef during subsequent discussion was quadrat / transect based.

Management priorities and decisions that are influenced or determined by biogeographic data include: legislation to protect species and communities; positioning of firebreaks and facilities for public use; selection of optimum areas of land in reserve system design, and other land-use decisions; searches for additional populations of particular species, guilds or communities of interest; and priorities in more specific research, such as manipulative experiments on populations or communities.

It was questioned whether biogeographic approaches to optimizing the representativeness (sensu, Austin & Margules 1984) of reserve systems were worthwhile. The reality of acquiring reserves today (e.g. in the Shark Bay region of Western Australia) involves accepting virtually every available patch of land and, in the context of "the real versus ideal" in setting priorities, ecosystem boundaries derived from biogeographic data are not necessairily the same as management boundaries. Nevertheless, while pragmatic decisions often have to be taken, the processes of setting priorities for management (including the selection of reserves when acquiring reserve systems) should have a rational biological basis; the more relevant and the better the available biological data, the more effective the decisions are likely to be (see Game & Peterken 1984, Margules & Nicholls 1987, Robinson et al. 1987).

In this context, the managers and planners present at the discussion were asked to consider practical examples of decisions they regularly had to make, and to identify the sorts of information they thought would be most useful for setting priorities for management. A request to relinquish a reserve was suggested as an example. Four discrete sorts of data were identified during the discussion that followed. All woe of the "what and where" sort.

(1) Are any rare or endangered species present?

(2) What is the species diversity (especially in richness and composition of the communities found in each region)?

(3) What are the major geographic patterns in diversity (especially richness and composition)?

(4) Is each ecosystem / community / species protected by a reserve?

Reference to Figure 1 indicates that these categories of information are all available or potentially available through biogeographic studies.

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