# Conservation of Ecosystems and Ecological Communities in Western Australia.

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**Principal Investigator:** AJM Hopkins

**Consultant:** R Morgan

**Department of Conservation and Land Management, Western Australia**

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**Summary**

This is the first of a series of public discussion papers for the project *"An interim framework for developing a comprehensive, adequate and representative protected areas system in Western Australia."* The main aim of the project is to compile a database of the (supratidal) ecosystems and ecological communities in Western Australia, assess the conservation status of each one, and develop priorities for their protection. The database will include spatial data in a Geographical Information System (GIS) linked to descriptive data, and information on possible threatening processes.

For the database to be useful for planning, each of the ecosystems and ecological communities must be defined spatially as well as being characterised biologically and in terms of environmental factors. There is no map of ecosystems and/or ecological communities in Western Australia at present, so a major task of this project is to develop such a map, based on an agreed understanding of what constitutes an ecosystem and an ecological community. This discussion paper outlines ecosystem and ecological community concepts and gives definitions that are proposed for use in this project.

The discussion paper also indicates sources of data that are to be used for the project Vegetation associations mapped at the scale of 1:250,000 will be used as a primary surrogate for ecosystems. Where there are consistent map coverages of relevant environmental data, these data will be used to refine the ecosystems defined on vegetation alone. Ecosystems defined on the basis of other data sets will also be included in the database.

Ecological communities nominated for consideration as a Threatened Ecological Community (TEC), and included in the TEC database will be considered for incorporation into the database established for this project.

Community input will be sought through consultation with members of the scientific community, Aboriginal communities, members of local natural history organisations, Landcare groups and individuals.

# 1. Introduction

## *1.1 Background*

Western Australia is almost one third of Australia's land mass and encompasses a diversity of environments from tropical rainforest patches through desert grasslands to temperate/mediterranean-climate forests and species-rich shrublands, as well as coasts and islands, estuaries and inland water bodies. The biota is rich but incompletely documented. For example, Western Australia contains about 12,000 species of vascular plants (of which about 7,500 are described), which is nearly half of the estimated total for Australia and includes 45% of the nation's rare and threatened flora. The State has a more proportionally rich vertebrate fauna than most parts of Australia comprising over 2,700 species (including fish). The invertebrate fauna is thought to include tens of thousands of species, many of which are undescribed — for example, 50% of the scorpion species collected in the Southern Carnarvon Basin were new to science (Smith and McKenzie in press). Western Australia also contains 26 of the 80 Biogeographic Regions defined for Australia, some of those having the highest numbers of endangered and vulnerable species in Australia, and with high levels of extinctions recorded. For example, the recently survey of the southern Carnarvon Basin found that 48% of mammal species thought to have occurred originally in the region are now extinct (McKenzie *et al.* in press). *In-situ* conservation of this rich and varied biota poses a great challenge.

Preliminary assessments of the current conservation reserve system in Western Australia, conducted by the Department of Conservation and Land Management in collaboration with Environment Australia, have highlighted the existence of major gaps in the system. The study underpinning the development of the Interim Biogeographic Regionalisation for Australia (IBRA) found that only four of the 26 Bioregions could be described as adequately reserved (Thackway and Cresswell, 1995). A subsequent, more detailed study based on the Vegetation Types mapped by JS Beard found that, of the of the 769 Types originally identified, only 163 are adequately represented in the existing reserve system, 246 are poorly represented and 360 are not represented at all (Hopkins *et al.*, 1996). Particularly high numbers of inadequately reserved Vegetation Types occur in the Avon Wheatbelt, Murchison, Carnarvon, Coolgardie, Pilbara, Mallee, Dampierland, Ord-Victoria Plains, Central Kimberley, Gascoyne, Yalgoo and Geraldton Sandplains Bioregions.

Other studies of the State, based on land-use, distribution of flora and/or fauna, geomorphic units and other environmental data have identified areas in need of conservation action (eg Environmental Protection Authority 1975,1976,1980,1983; Burbidge *et al.*, 1991), and regions in need of conservation action because of threat to the biota from pressures such as grazing and trampling, rising water tables and salinization (eg Gascoyne-Murchison Rangeland Strategy Steering Group, 1997; State Salinity Council, 1996:). However, there is no single State-wide database which brings together nature conservation values, existing bioregional classifications, threats to those nature conservation values and land-use for the purposes of regional planning.

In order to address some of the above problems, Environment Australia, the Commonwealth Government department with responsibility for nature conservation, environmental management and heritage, has commissioned a project in Western Australia that aims to produce a framework for *in-situ* nature conservation in this State. The project is titled "*An interim framework for developing a comprehensive, adequate and representative protected areas system in Western Australia*". The project is under the National Reserves System Program, which was developed to establish a comprehensive, adequate and representative (CAR) system of protected areas for nature conservation throughout Australia.

The project will generate an agreed, preliminary list of ecosystems and ecological communities in the State which will be used to assess the adequacy of the current reserve system in Western Australia, and to provide a first approximation of priorities for land acquisition and development of off-reserve management agreements and indigenous protected areas. The outcomes of the project will help to ensure that the limited resources available for nature conservation are used in a cost-effective manner in the establishment of the Western Australian component of the National Reserves System.

This discussion paper seeks, through a consultative process, to develop an agreed definition or set of definitions that can then be applied on a State-wide basis to generate the preliminary list of ecosystems and ecological communities. The paper first outlines the need for a basic conservation unit that can be used for the purposes of nature conservation in Western Australia, and suggests the ecosystem as a useful basic unit. The history of the ecosystem concept is discussed in Section 2.2, in relation to its present use as a central concept in ecology. Sections 2.3 and 2.4 discuss the concept of ecosystems and ecological communities as mappable ecological units. This is followed by an explanation of the current definitions of ecosystems and ecological communities as outlined in Commonwealth and State legislation. The final sections present the proposed definitions and sources of data for the project.

### *1.2 Project objectives*

The objectives of the project titled "*An interim framework for developing a comprehensive, adequate and representative protected areas system in Western Australia*" are:

- to identify and list the major ecosystems and ecological communities in each Bioregion within Western Australia;
- to provide an assessment of the reservation status of each of the major ecosystems;
- to provide an assessment of threats to each of those ecosystems;
- to outline procedures within Western Australia, both existing and proposed, for conserving major ecosystems, including establishing priorities for action, and choosing conservation action (ie reservation, management agreement, indigenous protected area); and
- to apply those procedures to develop priorities and a 5 year work plan.

The project will have two major outputs:

a) a document which lists the ecosystems and ecological communities, and gives an assessment of conservation status of, and threats to, each one, and;
b) a document outlining approaches to improving the conservation status of these ecosystems and ecological communities throughout the State.

## 2. Ecosystems and ecological communities

### *2.1 A basic unit for conservation planning*

*In-situ* nature conservation requires that areas of importance for conservation are identified, and then managed to maintain their natural values. These areas may be known to support populations of particular species of plants or animals (or micro-organisms etc), or they may be areas of habitat that potentially support populations of those species, or samples or examples of environments that should be included in a comprehensive, adequate and representative (CAR)[1] reserve system (DPM&C 1995). The CAR approach to conservation reserve planning tacitly acknowledges that data on species distributions, population dynamics and habitat requirements are incomplete. In the absence of that knowledge, it requires the establishment of a conservation reserve system that includes samples of every environmental unit known to exist in the jurisdiction.

This raises the question, what is the appropriate environmental unit for this planning process? It must be mappable, reasonably consistent in map coverage across the jurisdiction, and biologically meaningful. Also, for the purposes of this project, the mapping units must be able to be compiled within the time frame of the project. In answering the question, it is useful to look back over the history of the development of the CAR approach.

The first national approach to establishing a conservation reserve system in Australia came in 1958 when the Australian Academy of Science established the Committee on National Parks and Nature Reserves to provide information that might lead to the establishment of a comprehensive system of reserves for the Australian continent. The Western Australian Sub-committee presented its report to the Academy in 1962 (later published, WAS 1965). This report was a landmark in the history of nature conservation in Western Australia: not only did it lead to the

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[1] Whilst there is some redundancy in the terminology, comprehensive, adequate and representative (CAR), together the terms capture the desired concept of the ideal nature conservation reserve system. The principle of comprehensiveness requires that the reserve system includes at least one example of each community as distinguished at a particular scale. To achieve the goal of adequacy, reserves need to be of suitable size, number and arrangement, and all elements of biodiversity should be present in numbers and spatial arrangements that give high chance of survival in the long-term and allow continuing evolution. The principle of representativeness involves incorporating the full range of community, species and genetic variation that exists across the landscape within the reserve system. In effect, comprehensiveness is an initial approximation on the way to representativeness; both terms are included in descriptions of the ideal reserve system in recognition of the limits to our knowledge of communities and species, the genetic variation within those species, and the processes supporting ongoing evolution.

establishment of new reserves, but also, and perhaps more importantly, it legitimised the view that there should be a system of reserves representing all natural ecosystems and scenic types throughout the State.

A subsequent national study as part of the International Biological Program by Specht *et al.* (1974) argued that long-term conservation objectives could be achieved by focussing at the level of preserving whole ecosystems.

The recently endorsed *National Strategy for the Conservation of Australia's Biological Diversity* (Commonwealth of Australia, 1996) defines ecosystem as:

> A dynamic complex of plant, animal, fungal and microorganism communities and the associated non-living environment interacting as an ecological unit (p50).

The *National Strategy* recognises three levels of biological diversity:

- genetic diversity;
- species diversity;
- and ecosystem diversity

Ecosystem diversity is considered to encompass the variety of habitats, biotic communities and ecological processes. The *National Strategy* recommends conservation of biodiversity through the maintenance of viable ecosystems and ecological communities. There is broad consensus that the focus on ecosystems is essential for the conservation of the numerous species that exist in the environment, and for the protection of habitat (*eg.* Armstrong, 1993; Franklin, 1993; Heywood and Baste, 1995).

Finally, there is the view that the ecosystem approach may be the only way to preserve ecological processes and species in habitats for which little information is available (Franklin, 1993). For example, a survey of the cave fauna of Cape Range found that the caves are highly susceptible to threatening processes, the effects of which cannot be fully predicted, but that species protection alone is not enough to ensure the persistence of the caves and their fauna (Humphreys, 1991). Likewise, groups such as the invertebrates, bacteria, mosses and fungi are often poorly known and overlooked in species conservation despite their crucial role in the functioning of ecosystems. The loss of biodiversity associated with the degradation of a whole ecosystem or the loss of a community is often not fully known due to incomplete knowledge of the species present. The *National Strategy* recognises that lack of knowledge should not postpone action to conserve biological diversity, and that the preservation of whole ecosystems is a particularly useful approach in such situations.

### *2.2 History of the ecosystem concept*

In 1935, the noted British plant ecologist A G Tansley introduced a new word into the language of biology. Tansley proposed the concept of the *ecosystem* as a holistic one that combined living organisms and their physical environments into an integrated unit or system. At the time, there were two schools of thought on the nature of plant communities. One view held that species responded individually to environmental gradients to form a continuum of vegetation, and that overlap in species distribution was due to the chance occurrence of different species with similar environmental needs (the *individualistic* concept). The other held that the climax vegetation of a region consisted of groups of coevolved species that formed a complex organism which exhibited a life cycle much the same as that of the individual organism (the *community* concept). Tansley attempted to unite these opposing views by proposing that the combination of organisms and their physical environment together comprise a system, the *ecosystem*, which could be viewed as the basic unit of nature:

> But the more fundamental conception is, as it seems to me, the whole *system* (in the sense of physics), including not only the organism complex, but also the whole complex of physical factors forming what we call the environment of the biome—the habitat factors in the widest sense.
>
> It is the systems so formed which, from the point of view of the ecologist, are the basic units of nature on the face of the earth.
>
> These *ecosystems*, as we may call them, are of the most various kinds and sizes. They form one category of the multitudinous physical systems of the universe, which range from the universe as a whole down to the atom. (Tansley 1935, p 299).

It was some time before the ecosystem concept began to appear in the ecological literature (Golley 1993). Originally the concept was applied to aquatic ecology, since the boundaries of aquatic ecosystems were relatively easy to define. Lindeman (1942) studied trophic dynamics within a lake by comparing the amount of energy or food flowing from one trophic level to another, and was the first to quantitatively implement Tansley's ecosystem concept. Most importantly, Lindeman's rudimentary mathematical description of the ecosystem included not only energy and nutrient flows between species, but also between species populations and the non-living components of the system.

The ecosystem concept became popularised with the publication of E P Odum's *Fundamentals of Ecology* (Odum 1953) so that, by the mid-1960s it was a dominant concept in ecology. At the same time, ecosystem studies progressed, but with an increasing concentration on individual properties of the system – the reductionist approach that was a feature of the times – and few attempted to study the ecosystem as a whole.

There was, however, confusion about the application of the concept, due to multiple usages of the term ecosystem, problems of boundary definition, and disagreements between holistic and reductionist approaches. The landmark study of a terrestrial ecosystem in terms of chemical nutrient flow by Bormann and Likens (1967, 1979)

addressed these problems to some extent— they defined their ecosystem as a complete catchment, bounded by watersheds. The interpretation of a terrestrial ecosystem as a geographical unit, and its study as a whole, provided the impetus to shift the focus of ecosystem studies back towards understanding major features of ecosystem processes.

As the environmental movement gained momentum in the late 1950s, public awareness of the detrimental effects of human activity on natural systems increased. The concept became popular as a means of understanding the place of humans in nature, and use of the term ecosystem signified an understanding of the interrelatedness of natural processes (Golley, 1993). This use of the ecosystem concept has persisted in the area of nature conservation, perhaps due to the fact that it can be applied at any level. Large-scale environmental problems have stimulated the science of global biogeochemistry, which treats the earth as a single ecosystem, while smaller scale ecosystem studies are useful for assessing the effects of human interactions with the environment at a local or regional level.

While studies of whole ecosystems are still relevant to some areas of ecology, rapid environmental change means that land use planning decisions must often be made on the basis of available information, without the benefit of long-term ecosystem studies. In the case of reserve system planning, defining ecological units as ecosystems acknowledges the desire to conserve all biotic and abiotic components within a specified area. The reserve system can then be aimed at maintaining representative samples of all original ecosystems for the purposes of *in-situ* nature conservation. Applied in this way, the ecosystem concept provides a useful means of reducing the complexity of natural systems to manageable units.

### *2.3 Ecosystems as mappable units*

As noted above, effective planning of a conservation reserve system requires a mappable environmental unit for consistent assessment and upgrading of the system. Although the definition of an ecosystem is unambiguous, in that it incorporates all abiotic and biotic components of natural systems, the application of the concept is difficult at a practical level (Haila *et al.*, 1993). The energy and nutrient flows of an ecosystem include input from, and output to, other natural systems, creating a web of interactions that link ecosystems in a continuum across the landscape. In other words, there is no absolute concept of an ecosystem (or ecological community) in surveying and mapping, since the concept refers to natural processes and habitats at a range of scales (Beard, 1981). The scale used and the way in which units are represented on the map affect both the number and size of the ecosystems and ecological communities defined.

To overcome these problems, ecosystem classifications use synthetic ecological units derived from biotic and abiotic classifications. In essence, these classifications are based on the structural entities of ecosystems, with functional aspects implied. For example, the *Guidelines for Establishing the National Representative System of Marine Protected Areas* (Environment Australia, 1998) summarises the representation of ecosystems as geographical units as follows:

> An ecosystem classification may be derived by digital and/or manual spatial classification of abiotic and/or biotic data and be represented as mapped units. An ecosystem map unit should normally be discriminated at a resolution requiring a map-standard scale of 1:1,000,000 to 1:250,000.

The Biogeoclimatic Ecosystem Classification (BEC) for terrestrial ecosystems uses vegetation and soils to define each ecosystem (Meidinger and Pojar, 1991). These factors were chosen based on the fact that climate, organisms, topography, parent material, and time combine to produce vegetation and soil. In addition, soils and plants are easy to observe and assess. Using this method, ecosystems are delineated on the basis of the extent of a plant community and its associated soil type. The BEC has been used successfully in forest management in British Columbia since 1975.

In Victoria, the approach now is to define and map units called Ecological Vegetation Classes (EVCs) across the State. The Ecological Vegetation Classes system identifies:

> floristic communities that grow under comparable environmental conditions [and] have similar life forms and vegetation structure (Woodgate et al. 1994).

Other ecosystem classifications also use vegetation classifications mapped at a consistent scale, combined with geoclimatic data, to represent ecosystems (Host et al.,1996; Noss et al., 1995). However, there are many ecosystems that are not covered by this approach, such as caves, groundwater systems and ecosystems dominated by microbial assemblages. Furthermore, some species, particularly animals, have distributions that do not conform with vegetation patterns, and/or are not accurately predicted by physical environmental parameters. Thus, it is necessary to identify ecosystems at a range of spatial scales and from the perspective of a variety of different types of organisms in order to identify important elements of the hierarchy of ecosystems that may be obscured by classification at a single scale (*eg.* Noss *et al.*, 1995). The identification of ecological communities at a range of scales is discussed below.

### *2.4 Concept of ecological communities*

The concept of a community of organisms coexisting as a discrete and independent unit in space has long been debated in the ecological literature (Andersen, 1995; Clements (1936); Gleason 1926a; Walter and Paterson, 1994, 1995). As discussed above, the original debate centred around whether species were individualistic or existed as communities of coevolved species. It is now generally accepted that species assemblages do often occur in repeated patterns (cf. English and Blyth, 1997; Paine, 1980), and that the distribution and abundance of species within these communities can be explained by a variety of biotic (Patterson and Brown, 1991) and abiotic factors (Austin and Heyligers, 1989; Crawley, 1993; Wright *et al.*, 1998), but without the assumption of coevolution of species (Andersen, 1995). This does not exclude species interactions, but merely accepts that interactions between species did not necessarily cause their co-occurrence.

Like the ecosystem concept, there is no absolute definition of a community, as it may refer to species assemblages at a number of scales. However, since communities are often the result of overlap of distribution of species with similar environmental needs, they are usually defined by their collective response to environmental scalars such as temperature, altitude and soil moisture. Of course, it should not be overlooked that communities operate in environmental space and can co-occur in geographical space, for instance, depending on the intersections in the relevant environmental scalars (eg. McKenzie *et al.*, in press). For pragmatic reasons, ecological communities are converted to geographical units for land use planning. The Endangered Species Scientific Subcommittee (1995) considers that the recognition of the boundaries of a community or ecosystem is a matter of scientific judgement in the same way as species definition.

*Ecological community* is a synthetic term, designed for use in an operational sense. An ecological community is defined by the Commonwealth's *Endangered Species Protection Act* (1992) as:

> an integrated assemblage of native species that inhabits a particular area in nature.

Use of the term ecological community sidesteps debate about the nature of communities by providing a specific definition for communities represented as geographical units. The term provides a useful communication tool, particularly for the purposes of land-use planning.

### *2.5 Legislative requirements*

As discussed above, the *Endangered Species Protection Act* provides a definition of an ecological community. Current legislation in some Australian States also provides for listing of threatened ecological communities (Victoria's *Flora and Fauna Guarantee Act* 1988; the New South Wales *Threatened Species Conservation Act* 1995; the Australian Capital Territory's *Nature Conservation Act*, 1980). Western Australian legislation (*Wildlife Conservation Act* 1950) does not provide for listing of threatened communities at present. However, the Department of Conservation and Land Management maintains a non-statutory database of threatened ecological communities.

Although the *National Strategy for the Conservation of Australia's Biological Diversity* recommends a combination of species and ecosystem approaches to nature conservation, threatened ecosystems are not explicitly provided for in current legislation. However, listing of threatened ecological communities (TECs) effectively acts to conserve whole ecosystems, since abiotic factors are used to define the habitats of those communities.

### *2.6 Definitions for this project*

The above review has indicated that *ecosystems* and *ecological communities* are appropriate basic units for planning a comprehensive, adequate and representative protected area system for nature conservation. The issue then becomes one of

defining ecosystems and ecological communities in such a way that they can become operational.

For the purposes of this project, we propose to use vegetation types, identified and mapped at the association level, as surrogates for ecosystems. Each vegetation polygon will be taken to be a separate ecosystem, with polygons of the same vegetation association being the same ecosystem type.

Where additional environmental information is available, the ecosystems defined on the basis of vegetation only will be spatially refined and further defined in terms of those environmental factors.

Where particular ecosystems have been identified and mapped through some process other than vegetation mapping, those ecosystems will be incorporated into the database.

We will also incorporate data on ecological communities, which define assemblages of organisms at a range of scales, where those ecological communities have some geographical dimensions (ie they can be mapped). For the purposes of this project, we will accept nominations of ecological communities that satisfy the guidelines developed by the Endangered Species Scientific Subcommittee (1995) for threatened ecological communities. These guidelines include criteria that must be met in order to clearly define an ecological community:

- the name of the ecological community (if any) must be generally accepted by the scientific community and/or publicly recognised, and should include references to community structure or community substrate, abiotic components, or dominant taxa.
- the description of the ecological community must distinguish it from other ecological communities
- the classification of the ecological community must be conventionally accepted.

In addition, the location and boundaries of each ecological community must be defined at a level of accuracy appropriate for mapping and inclusion in the GIS database.

The resulting database of ecosystems and ecological communities will include:

- a brief description of each ecosystem and ecological community;
- a review of the current conservation status of each ecosystem and ecological community; and
- a review of the threats to each ecosystem and ecological community.

The list of ecosystems and ecological communities produced through this project should be regarded as provisional, and the database will be structured to allow for the incorporation of additional examples as data permit.

## 3. Sources of data for the project

### *3.1 Vegetation associations*

This project will use the vegetation types, originally mapped by J S Beard at a scale of 1:250,000 and at the level of vegetation association, as surrogates for the ecosystems in Western Australia. Data will be drawn from the digital vegetation database developed by Hopkins *et al.* (1996). This vegetation database covers the whole of Western Australia.

In parts of the State where there are consistent map coverages of relevant environmental data such as geology, soils, water catchment boundaries, these data will be used to refine the ecosystems defined on vegetation alone. For example, it is expected that the very large polygons of eucalypt woodlands extending from the eastern margins of the jarrah forest into the goldfields will be subdivided into eucalypt woodland on each of a variety of substrate types.

### *3.2 Other ecosystems*

Using vegetation associations mapped at a consistent scale to represent ecosystems may conceal ecosystems of a smaller scale that are useful at the level of regional or local planning. The consultative process will identify other ecosystems, including those based on other groups of biota, such as invertebrates and microbes, which can then be incorporated into the spatial database. Criteria will be developed for ecosystem nominations, based on the criteria of the Endangered Species Scientific Subcommittee (1995) for threatened ecological communities. Other ecosystem may include cave systems, groundwater systems and mound springs.

### *3.3 Threatened ecological communities database*

The Threatened Ecological Communities (TEC) database is maintained by the Department of Conservation and Land Management's Threatened Species and Communities Unit. The database contains information about ecological communities in Western Australia and their conservation status. Each of the ecological communities that have been nominated for consideration as a threatened ecological community will be considered for incorporation into the database established for this project.

### *3.4 Community input*

There will be extensive community consultation during this project, including the scientific community, Aboriginal communities, members of local natural history organisations, Landcare groups and individuals. Nominations for ecosystems and ecological communities will be actively sought over the period of the project

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