Patterns in Nature

We see patterns in landscapes, but do plants and animals see the same patterns? To manage for conservation, we need to adopt an organism-centred perspective of environmental patterns. Contemporary biological surveys aim to quantify these relationships. One such survey, of the Carnarvon Basin, has recently been undertaken by the Department of Conservation and Land Management, the Western Australian Museum and the University of Western Australia.

Compiled by
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from contributions made by members of the survey team

The Carnarvon Basin extends from near Cape Range in the Exmouth area, south to the Murchison River and inland to the Kennedy Range. It is one of the major sedimentary basins of Western Australia and has a geological history spanning much of the last 450 million years. Because of its geographical position, the basin is influenced by both the winter rainfall of the south-west and the summer rainfall of the north. The region has an arid to semi-arid climate, with a mean annual rainfall as low as 200 millimetres in places. Severe droughts are prominent elements of the climate.

Low, open woodlands of *Acacia* species, such as snakewood and bowgada, with an understorey of shrubs, such as poverty bush (*Eremophila*), cassias (*Senna*) and saltbush, occur on the extensive plains dominating the basin. Shrubs and hummocks of spinifex grass grow on the low sand ridges that are scattered across these plains. In northern parts, the plains grade into red sand dune fields, supporting spinifex and mulga communities that are reminiscent of Australia's red centre. In the south, the plains support *Eucalyptus-Callitris* woodlands, with mallee, *Banksia* or *Actinostrobus* scrubs and heaths on greyish and yellow sand dunes. Low-lying areas, such as the fringes of Lake MacLeod and the coastal flats, support rich samphire communities. Extensive areas of coastal limestone, partially mantled by pale yellow to grey sands, support low heaths with emergent

thickets of *Banksia* and mallees, such as illyarrie. A particularly impressive feature of the area to the south of Shark Bay is the Zuytdorp Cliffs, which are topped with windblown, almost prostrate shrubland.

Previous page: Satellite image of the lower reaches of the Gascoyne River, showing the outflow of sediment after Cyclone Bobby.
Photo – DOLA WA, SPOT © CNES (1995) – SPOT Imaging Services, Sydney.

Above: An undescribed species of *Eremophila*, confined to the Shark Bay Heritage Area.
Photo – Greg Keighery/CALM

Below: This aerial view of the Gascoyne River shows the characteristic wide, sandy bed typical of Carnarvon Basin rivers.
Photo – Marie Lochman

Below right: The recent record of a kultarr in the Carnarvon Basin represents a major range extension for the animal.
Photo – Babs & Bert Wells/CALM

EARLY EXPLORATIONS

The first recorded landing by a European in Western Australia was at Cape Inscription, at the northern end of Dirk Hartog Island, in Shark Bay, where Dirk Hartog landed in 1616. Hartog and the other early Dutch sailors made only passing reference to natural history observations they may have made. On the other hand, William Dampier, who explored the Shark Bay islands in 1699, compiled some of the earliest botanical collections by Europeans in Australia. These are still preserved in the herbarium at Cambridge University. He illustrated four birds he saw in the Shark Bay area (red-necked avocet, pied oystercatcher, bridled tern and common noddy) in his book *Voyage to New Holland*. Important plant collections were also made by the French, during voyages in the early 1800s, and by several English expeditions (sea and land) in the mid to late 1800s. The German expedition led by Michaelsen and Hartmeyer in the early 1900s produced significant collections of invertebrates. Numerous studies have been made since the mid-1900s, but these have all been opportunistic collections or observations, or have been confined to a relatively narrow range of animals or plants.

Exploration of the interior for agricultural and development reasons began in 1839, when George Grey explored the coast in the vicinity of the Gascoyne River and present day Carnarvon.

Francis Thomas Gregory explored the

Gascoyne, Lyons and Murchison Rivers in 1858, and pastoral settlement followed soon after.

THE SURVEY

Our knowledge of the patterns of distribution of native species across the study area was still fragmentary in 1993, and strongly biased towards birds and large plants in the vicinity of main roads. The data gleaned from localised studies, and from opportunistic collections held by institutions such as the Western Australian Museum and CALM's WA Herbarium, while significant, were insufficient for sound management of the native plants and animals of the region. Also, while we knew of ecosystems and ecological communities that were not represented in the area's conservation reserve network, there was no satisfactory basis for planning a representative, yet cost-effective reserve system.

Against this background, the Australian Nature Conservation Agency (ANCA), CALM, the WA Museum and the University of Western Australia (UWA) began a systematic ecological survey of the region in 1994, as part of the National Reserve System Co-operative Program. The study area extends from Lake MacLeod to the Murchison River. We included landscapes south of the Carnarvon Basin to learn more about the complex biological boundary with the wetter areas to the south.

Such a survey is a difficult and time-consuming task—the ecological systems are complex and the study area is about the size of Tasmania. To provide a perspective on the geographical patterns in biodiversity, we sampled the plants, mammals, birds, reptiles, amphibians and terrestrial invertebrates at 60 'dry-land' quadrats, and aquatic invertebrates at 60 'aquatic' quadrats, all carefully chosen to provide a cross-section of the region's environments.

Field work for the project has involved almost 30 people, including zoologists, botanists, a soil scientist and a geomorphologist. Field work is now mostly complete, and will be finished this summer. Because the region is so poorly known biologically, many of the plant and animal species have been difficult to identify—a process that is still continuing. Next, we face the challenging task of analysing and interpreting the data so it can be used to understand biogeographical patterns in the study area, and to make recommendations for management. Even though there is still a lot of work to be done, much interesting information has already come to light.

LANDFORMS

The Carnarvon Basin is generally a region of low relief, although erosional upland regions do occur in the eastern parts. It is drained by a number of large ephemeral rivers, which carry large volumes of bed load sediment. Extensive alluvial deposition has occurred in the lower reaches of the Wooramel and Gascoyne rivers, where large deltaic complexes have formed at their coastal margins.

Other processes have modified the contemporary geomorphology of the region. Deep weathering during the last 50 million years has led to the formation of silcretes and laterites, which have provided a strong control on the contemporary geomorphology of the region. Extensive dune fields attest to the extreme arid climates the region has experienced in the last few hundred thousand years. Small anticlinal ridge structures near the coast indicate recent tectonic activity that probably persists today.

The coastal regions of the Carnarvon Basin also bear a strong imprint of the changes of sea level that have occurred during the present Ice Age. The remains of coral reefs, beaches and coastal dune fields, formed during periods of higher sea levels in the past, can be seen throughout much of the region. Shark Bay and Lake MacLeod are the result of unique combinations of these geomorphological processes and changes in sea level.

PLANTS

More than 1 200 species of flowering plant are known from the Carnarvon Basin. The area is a major biogeographical change-over zone between the south-western and

Above: The odd-clawed scorpion is a common nocturnal hunter of the region.
Photo – Douglas Elford/WA Museum

Left: CALM senior technical officer Bill Muir sifting small burrowing lizards and insects from sand that was in the bottom of a pit trap.
Photo – Jiri Lochman

Left: Low shrublands of *Acacia drepanophylla* with a carpet of yellow pompom heads (*Cephalipterum drummondii*) following the exceptional rains of 1992.
Photo – Greg Keighery/CALM

desert plants. This change is especially notable between Zuytdorp and Shark Bay (see *LANDSCOPE*, Summer 1993–94).

During the course of the survey, we discovered a number of new species, including a flying duck orchid, a pigface and a one-sided bottlebrush. Taxonomic work on the collections will also result in names for several new species of coppercups (*Pileanthus* spp.) from the area. Very large range extensions were recorded for a variety of plants, especially in the wetlands—the most impressive to date being for an *Eremophila* at Shark Bay, previously thought to be confined to Cape Range.

Flora lists for most of the major conservation reserves are being compiled to help assess the conservation status of the plant species of the study area. Some plant species previously thought to be confined to Shark Bay were found further afield—the daisy *Sondottia glabrata* and *Trachymene elachocarpa* near Cape Cuvier, and the yellow-leaf newcastelia (*Newcastelia chrysophylla*), north-east of Kalbarri National Park. These species, along with more than 80 other perennial plants, are still only known from the study area. Other examples include two undescribed species of poverty bush, in Zuytdorp National Park, together with Shark Bay mallee (*Eucalyptus roycei*) and *Halgania littoralis*, which are also Shark Bay endemics.

INVERTEBRATES

This was the first systematic collection of terrestrial invertebrates on a large scale to be carried out in the region. Twelve months of collecting produced thousands of specimens. The sorting of this material is under way at the WA Museum, where the larger invertebrates—spiders, scorpions, centipedes and beetles—are being separated for further analysis. Some smaller invertebrates will then be isolated using microscopes. So far, more than 33 orders of terrestrial invertebrates have been collected. Identification of many species will be extremely difficult, and we estimate that more than half of the invertebrates collected will represent undescribed species, never before collected by scientific surveys.

However, previous work on the larger centipedes has enabled us to identify collections to species level. Of these, *Ethmostigmus curtipes* and *Arthrorhabdus paucispinus* have had their known ranges extended westward.

Scorpions are also relatively well studied. An interesting find was the long-tailed scorpion (*Urodacus megamasticus*), which until now, had only been known from a few museum specimens from the central interior of WA. This is a significant range extension for the species. We also now know that they are probably only active for a short time during summer (maybe explaining why so few specimens had been collected previously!). Many other scorpions were collected, including the odd-clawed scorpion (*Urodacus hartmeyeri*), a common inhabitant of these areas.

Spiders were widespread in the study area and are an important part of invertebrate fauna in the region. The huntsman spider *Pediana tenuis* was found at night, climbing on tree trunks near the ground—this record extended its known range westward. Many species of trapdoor spider were collected, and sandgropers (*Cylindracheta* sp.) were unearthed at several sites.

The aquatic invertebrates were also diverse, with more than 20 orders of insects, crustaceans and other microscopic organisms occurring at many sites. At the species level, the diversity is higher; for example, up to 10 species of ostracod, many of which are undescribed, occur in claypans and rock pools. Ostracods, sometimes called seed-shrimps or shell-shrimps, are an order of microscopic crustaceans with a thin bivalved carapace, that mostly feed on organic matter from the bed of the pool or claypan. They vary between a half and three millimetres in length. Other groups still have to be identified to species level.

Above: The sandhill frog is restricted to dunefields of the basin. It can often be seen abundantly on tracks and dunes in the Shark Bay area after rain and dew.
Photo – Jiri Lochman

Right: CALM zoologist Norm McKenzie looking for wildlife among the spinifex and other vegetation on the Kennedy Range.
Photo – Jiri Lochman

REPTILES AND AMPHIBIANS

The complex mosaic of soils and vegetation types found in the Carnarvon Basin plays host to an exceptionally rich and diverse population of reptiles. More than 120 species were recorded during the survey. Around the Shark Bay region, reptiles typical of south-western, northern and inland desert habitats live in close proximity to each other, giving a total regional diversity as high as any area of equal size in Australia.

Especially complex reptile assemblages were found within the thick litter beds that accumulate beneath dense stands of *Acacia* across the region. Searching in these habitats revealed several dozen species of lizard and small snake, including as many as 10 species of burrowing and sand-swimming skinks of the genus *Lerista*.

Sampling also resulted in extensions to the known ranges of several reptile species, including two skinks, *Ctenotus calurus* and *C. rufescens*, found at Mardathuna and the Kennedy Range. The nearest they were known from previously was in the Exmouth region.

Frogs are less diverse in these relatively dry habitats. However, a heavy fall of cyclonic rain during the course of the second field trip brought out large numbers of several species. One of these was the sandhill frog (*Arenophryne rotunda*) of the Shark Bay region. This species is one of the most arid-adapted frogs in the world. It becomes active after heavy rain, but its eggs are laid in moist sand and develop directly into froglets without any free-swimming tadpole stage.

Right: White mangroves (*Avicennia marina*) line the western shore of Lake MacLeod, in the northern part of the survey area. This is one of the few occurrences of mangroves inland from the coast.
Photo – Greg Keighery/CALM

Because reptiles have low mobility, their distribution is more closely determined by aspects of the physical environment (such as soil type) than are more mobile groups, such as birds. This characteristic, together with the relatively high numbers of reptile species in the Carnarvon Basin, means that we expect reptiles to show patterns of distribution at a relatively fine scale, thereby giving us an insight into detailed biogeographic patterns. To take full advantage of this high biogeographical resolution, special effort is being put into 'fine-tuning' the classification of this group of animals prior to the final analysis. So far, the survey has found at least six undescribed species of reptile, some of which are probably not found outside the Carnarvon Basin. Many of these additional species have probably evolved only recently (in geological terms), possibly in response to environmental change over the last million years or so.

BIRDS

More than 120 species of terrestrial birds were recorded during the first (spring 1994) sampling session. The sites supporting the greatest numbers of bird species were along the major river systems—the Gascoyne and Wooramel. These included species such as the red-browed pardalote, which is restricted to riverine and similar habitats, and the chiming wedgebill and little crow, which are widespread throughout the study area. The river systems also provide nest sites for a number of species, particularly parrots, which nest in the hollow limbs of river gums.

Letter-winged kites normally breed in the Lake Eyre basin, following rodent plagues associated with prolonged good seasons, then disperse. Our records represented the first from the study area for about 100 years.

A number of uncommon or rare species occur in the study area, but the most interesting of these is the thick-billed grasswren (see *LANDSCOPE*, Summer 1991–92). This species was formerly widespread across arid parts of southern Australia, but is now restricted to less than five per cent of its former range. Shark Bay is one of its remaining strongholds, and we found it on most of our sampling sites there, as well as on Woodleigh Station east of Shark Bay.

Fifty-five species of waterbird were recorded during the first aquatic survey in spring 1994. This included counts of

30 000 migratory waders and other waterbirds on Lake MacLeod, and 1 300 waterbirds on a large birrida at the northern end of Peron Peninsula. Both areas are important waterbird habitats. The numbers of waterbirds on river pools and other claypans were comparatively low, but up to a dozen species occurred at some sites.

MAMMALS

We recorded twenty-eight species of native mammal and nine species of introduced mammal in the study area. Of the native mammals, 10 were recorded in the region for the first time, although the kultarr (*Antechinomys laniger*) and mulgara (*Dasycercus cristicauda*) were already known from sub-fossil bones deposited long ago in caves and hollow trees by predators such as owls. Alex Baynes of the WA Museum has found that these deposits also include bones of a further 18 native mammals, comprising three wallabies, five bandicoots, four carnivorous marsupials (dasyurids) and six rodents, that appear to have become extinct in the region since European settlement. Fortunately, five of these species survive on islands in Shark Bay.

Despite the extinctions, the area is still rich in small native insectivores. We captured 10 species of dasyurid marsupial in the pit traps, and recorded eight species of small bat. Bats were identified from recordings of the high frequency sonar calls they use to locate their prey. The other extant native mammal species comprise four native rodents, three kangaroos, the honey possum (in the extreme south of the study area), echidna and dingo. The nine introduced mammals ranged in size from house mice to camels.

PRELIMINARY IMPRESSIONS

Results to date show that plant and animal species are not uniformly distributed across the study area. There is a north-south change from tropical arid species (Torresian crow, little red kaluta and the lizard *Ctenotus saxatilis*) to temperate species (western yellow robin, honey possum and south-western spiny-tailed gecko). Also, at more local scales, certain species associate with sands, like the flat-bellied lerista (*Lerista planiventralis*), spotted sand-dragon (*Ctenophorus maculatus*), rufous-crowned emu-wren and lesser hairy-footed dunnart (*Sminthopsis youngsoni*). Others, such as

A new species of flying duck orchid (*Paracaleana* sp.) discovered on Nerren Nerren Station during the survey.
Photo – Greg Keighery/CALM

the cinnamon quail-thrush and kultarr (*Antechinomys laniger*), prefer heavier soils, while a few, including djoorri or common rock rat (*Zyzomys argurus*), long-tailed dunnart (*Sminthopsis longicaudata*), ring-tailed bicycle-dragon (*Ctenophorus caudicinctus*) and spotted dtella (*Gehyra punctata*), are confined to rocky outcrops. Although the different groups of organisms show similar geographic patterns at broad scales, their ecological responses to landscape mosaics at more local scales are visibly different. The significance of these differences will be quantified during the analysis phase of the study.

CONCLUSIONS

The region has supported a pastoral industry for a century, and been invaded by pervasive pests such as buffel grass, rabbits, goats and foxes. Many native species have declined or become extinct, although some persist on adjacent islands. The survey data-base will provide managers with a scientific basis for conservation decisions relating to land-use and land-care in the future—both on conservation reserves and on other land. It provides much useful information on the biodiversity of the region, including knowledge of the ecological communities that are centres of endemism. Equally, it provides information on the conservation status of the region's indigenous species, gaps in the region's reserve network, distribution of a wide range of introduced and feral species (such as weeds and feral predators and herbivores), a basis for searching for additional populations of rare species and a regional framework for future environmental impact assessments.

Such detailed data on the distribution of each species in relation to the region's physical environments, provide the first explicit basis for designing a cost-efficient reserve network and for assessing conservation priorities in the region.

There are several conservation reserves in the study area, the major ones being Francois Peron National Park, Kennedy Range National Park, Toolonga Nature Reserve and Zuytdorp National Park (which will be extended to include the present Cooloomia Nature Reserve).

However, while including important and interesting ecological communities and rare or unusual species, these reserves are all at the margins of the study area. They do not include some of the major ecological communities (and therefore significant aspects of the biodiversity) of the region. In particular, the floodplains of the Wooramel and Gascoyne Rivers, and the extensive snakewood-bowgada communities on the undulating plains are not represented in the conservation reserve system. There are also other, less widespread—but nevertheless important and interesting—ecological communities that are not in the reserve system. These include the mallee scrubs in the southern part of the study area and the samphire communities around Lake MacLeod. In addition, many interesting species occur outside the conservation reserve system. A future challenge will be to ensure the conservation of these species and communities.

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Visitors can walk in the treetops along a series of walkways, platforms and stairways at the new Forest Heritage Centre in Dwellingup. (See page 10.)

A major survey of the Carnarvon Basin has recently been completed by staff from CALM, the WA Museum and the University of WA. What did they find? (See page 15.)

LANDSCOPE

VOLUME ELEVEN No. 2 SUMMER ISSUE 1995–96

It was a very good year in the Wildflower State. Find out just how good in our story on page 38.

Australia has its own families of songbirds that are very different from their European namesakes. See 'True Blue Birds' on page 45.

Quokkas were once widespread on WA's mainland, but the most visible populations are now found on just two islands. 'Where Have All the Quokkas Gone?' (See page 49.)

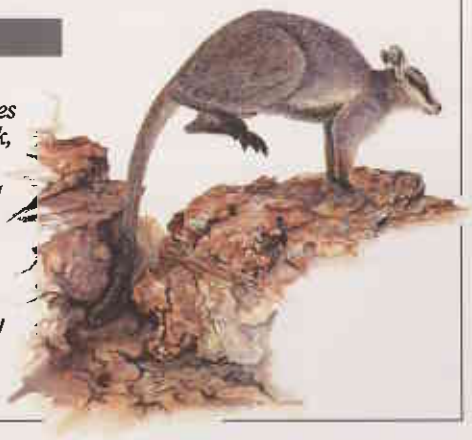
FEATURES

REGULARS

COVER

Western black-footed rock-wallabies are on the increase in Yardie Creek, thanks to a CALM fox-baiting program. Their numbers are being monitored by local tour operators Neil and Rhonda McGregor. See our story on page 36.

Illustration by Philippa Nikulinsky



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Colour Separation by Prepress Services
Printed in Western Australia by Lamb Print

Pubished by Dr S Shea, Executive Director
Department of Conservation and Land Management,
50 Hayman Road, Como, Western Australia 6152.