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The support of the public is an essential component in any conservation or reserve management programme—but an informed, educated public is needed to ensure its continuing success.

This publication is designed as a medium by which the various organisations, individuals, and wildlife management personnel may be kept informed of the work being carried out by this department, of departmental policies and directions: and for promoting a better understanding and appreciation of Western Australian wildlife and the role it plays in maintaining a suitable environment in which man can live.

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WILLIAM C BROWN, Government Printer, Western Australia

COVER PHOTO

One of the most startling wildflowers to be encountered in Australia's dry inland, the Sturt Desert Pea *(Clianthus formosus)* was named after the explorer Charles Sturt. For more photographs of Western Australia's desert regions, see page 27. Photograph by Clifford Young.

BATS – A PART OF OUR HERITAGE

By N. L. McKenzie, Western Australian Wildlife Research Centre

▲ A typical insectivorous bat in flight. Gould's Wattled Bat *Chalinolobus gouldii* is one of about nine species of bat occuring in the south-west of Western Australia. Photo copyright A.G. Wells.

It is amazing how many people think of a bat only in terms of a furry thing that flies at night and spends the rest of its time hanging upside down in a cave somewhere. Legend also associates them with vampires and creepy-crawly things that get tangled in your hair.

In this abstract way, bats are much maligned whereas, in fact, they are mostly harmless little mammals so highly specialised that they were able to achieve mastery of the air long before prehistoric man walked upright.

Biologists include all bats in the taxonomic order Chiroptera which means hand-wing. But if you look more closely at the group a great array of differences between species becomes apparent. They range from species with bodies as large as a rabbit with a wing span of over a metre to those, smaller than a mouse, that have a wingspan about the size of a human hand.

In terms of species richness, bats are the second largest group of mammals; about 900 species are known worldwide. On warm, moonless summer evenings multitudes of bats can usually be seen coming to drink at farm dams. They are probably the most abundant group of mammals in the temperate and tropical zones of the world but few have colonised the sub-arctic and arctic regions (for reasons that will be discussed later) even though their ability to fly makes them one of the most mobile groups of animals on Earth. Aside from insects and birds they are the only animal group capable of sustained powered flight.

Bats are thought to have evolved about 50 million years ago, in tropical forests of the early Eocene, from a tree-dwelling insectivorous ancestor. The complex dentition of the more primitive groups of bats support this theory although species have since radiated into a wide variety of niches. Today, the Chiroptera includes species that feed on fruit, nectar, insects, arachnids, fish, crustacea, mammals, birds and reptiles. Such 'trophic' radiation has been associated with wide adaptation and specializations involving all aspects of bat physiology and anatomy.

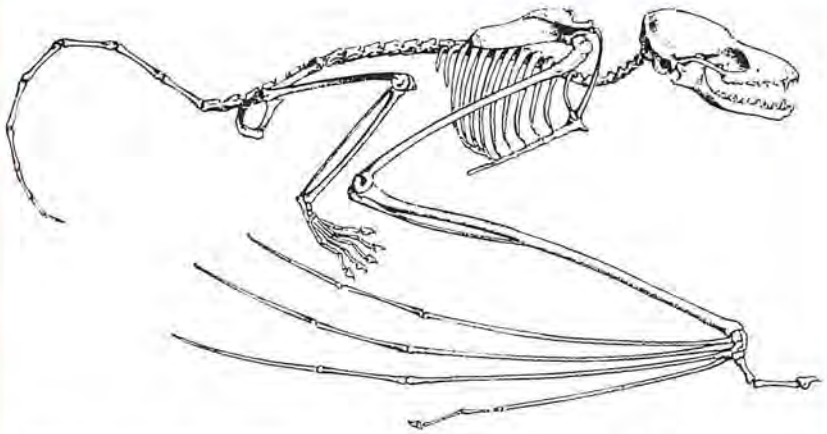
There was never really a first bat. It is just an arbitrarily defined section of the vast family tree stretching back in time to the first molecule of genetic material. Details of the evolution of bats are vague. Their very fragile bones do not fossilize well and, in any case, conditions in the tropical and sub-tropical areas where they are thought to have evolved are not favourable for fossilization. The very earliest fossil bats known (e.g. *Icaronycteris index* from lake sediments in Wyoming) had already evolved to almost their present state.

At that time the ancestors of modern horses were the size of dogs and humankind were just small monkeys "Bats were bats when men were lemuroids or less, and the family trees of the two groups...since dinosaur days, have grown tall side by side, in the same general ecological grove, to lofty branches of mammalian specialization: bats echo-locate and fly, men think and fly" (Jepsen).

Other animals have evolved flight; in vertebrate animals alone, flight was adopted as a means of locomotion wholly independently by reptiles, birds and bats. Although they all invented wings, the designs were different in each case. For bats, the anatomical and behavioural commitments associated with flight have cast them into a mould so alien to man's way that we have difficulty assigning them an anthropomorphic (man-like) image such as the cute and cuddly Koala Bear, Big Bird, Mickey Mouse and Donald Duck. Consider instead the leathery wings of the devil and Stoker's description of Dracula, climbing about on his castle wall "...but my feelings turned to repulsion and terror when I saw the whole man slowly emerge from the window and begin to crawl down the castle wall over that fearful abyss, face down with his cloak spreading out around him like great wings".

Bearing in mind that the vampire bats of Central America are also carriers of rabies, the Mayan worship of a blood-sucking god and the Aztec bat deities are hardly surprising. The European association of bats and supernatural happenings was transformed into a vampire craze in the 1730s after Cortes and his followers had discovered the vampire bat in the New World. A fragment of reality compounding superstition.

The Chiropteran way of life is committed to nocturnal activity, for only at night can their problems of moisture and temperature control be overcome. This strategy also determines their day-time refuges in the sombre depths of caves, hollow trees or dense foliage. They even feel different if touched; the oily skin of their wings is a prerequisite for temperature maintenance and moisture conservation in flight for these relatively small homeotherm animals that expose vast areas of skin to the air flow. Part of flying at night is the ability to see in the dark. In this regard, bats often have incredible sensory systems involving complex facial structures for sending and receiving high frequency sonar impulses. General ignorance of the factors which determine the behaviour and appearance of bats inevitably led humans to feelings of aversion and to dark superstitions.



Reconstruction of the skeleton, skull and teeth of *Icaronycteris index*, the earliest known fossil bat.

Bats are perhaps the most gregarious of all mammals. Single breeding colonies of the Bent-wing Bat *(Miniopterus schreibersii)* have been estimated at 44 000 individuals, but these are mere villages compared with the summer colonies of *Tadarida brasiliensis*, an American free-tailed bat known as the Guano Bat. An expanding cloud of *Tadarida brasiliensis*, 33 kilometres in diameter, was detected on radar in Texas, U.S.A. near Bracken Cave, a known breeding cave. In August up to forty million individuals occupy this cave. Camps of flying foxes in Australia comprise up to half a million individuals. In contrast, other species are near solitary, occuring in ones and twos in their roosts.

The Chiroptera fall in two natural sub-orders: the Microchiroptera, most of which are insectivorous, and the Megachiroptera or fruit bats, the larger of which are known as flying foxes.

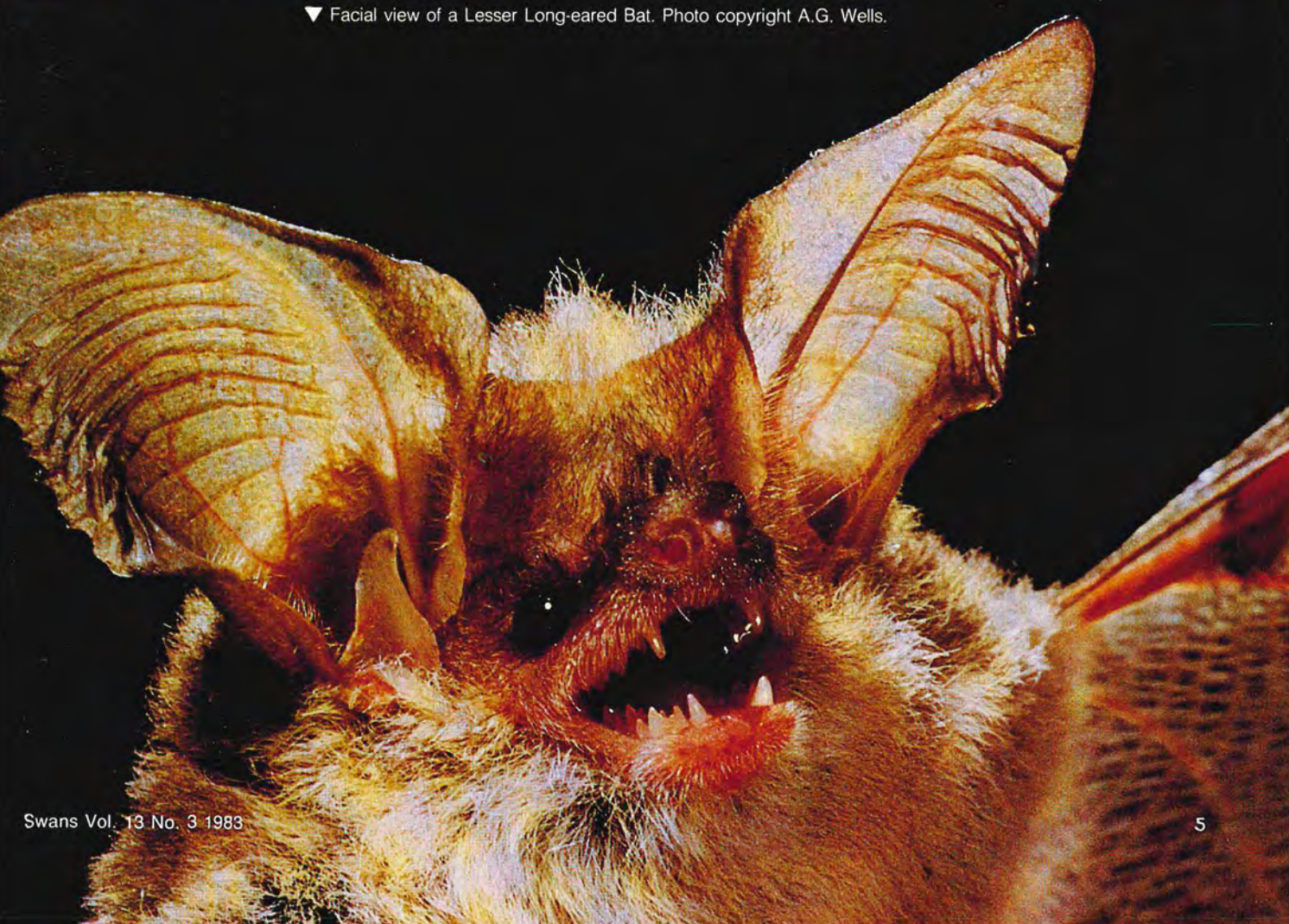
Megachiroptera

The Megachiroptera are generally larger in size and, with the exception of one genus which developed a form of its own, they do not use echo-location. Instead, their eyes are comparatively large and their skin incredibly tough so that collisions with vegetation seldom result in tears or impalement. They roost with their wings folded around them like a cloak.

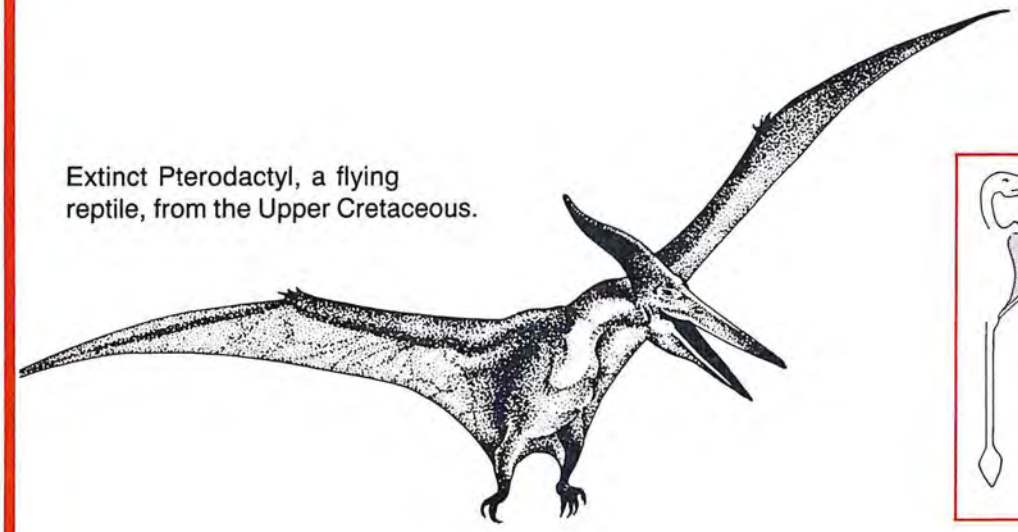
The larger fruit-eating members of the Megachiroptera can be very destructive, visiting domestic gardens and plantations up to 80 kilometres away in ravaging hordes, night after night. The CSIRO began a study of flying foxes as pests in Queensland and New South Wales in 1929. They found that broad scale control measures were economically impractical. Shooting, poison gas, explosives, flame guns and poisoning in orchards were all assessed as options. Flying foxes were shown to be mainly blossom feeders and not a serious menace to commercial fruit ventures although occasional large losses of soft fruit such as figs, peaches and especially mangoes were reported.

▲ Red Flying Fox. Photo copyright A.G. Wells.

▼ Facial view of a Lesser Long-eared Bat. Photo copyright A.G. Wells.

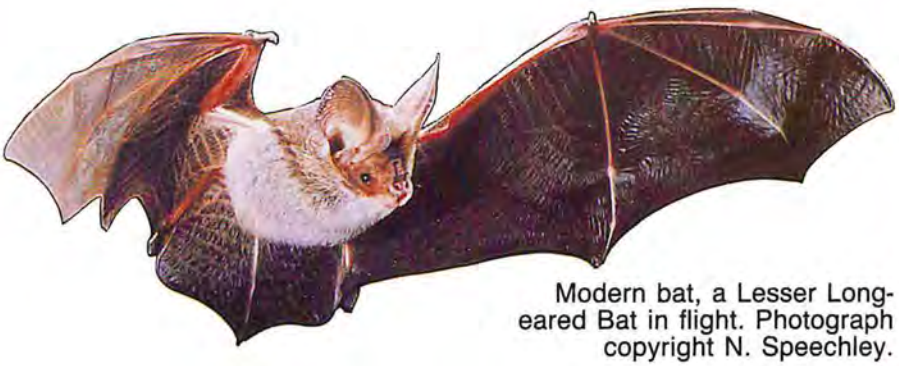


THE MECHANICS OF FLIGHT
— BIRDS, BATS AND REPTILES



Extinct Pterodactyl, a flying reptile, from the Upper Cretaceous.

Modern bird, Osprey in flight. Photograph copyright A.G. Wells.



Modern bat, a Lesser Long-eared Bat in flight. Photograph copyright N. Speechley.

There have been recent complaints about flying foxes damaging mango crops at Kununurra, Western Australia. This problem can be alleviated with sensible management. Commercially, mangoes are quickly perishable and generally have to be picked before they are ripe, that is, before they are acceptable to flying foxes. However, garden crops of mangoes that are left on the tree until they ripen invite a visit by flying foxes and are often laid waste. In Indonesia, garden trees are often completely encased in netting.

In some countries, flying foxes are considered food of great delicacy, but they need to be carefully prepared with spices and condiments because the skin and fur has a strong foxy odour.

▲ Common Sheath-tailed Bat roosting in a cave in the Todd Range, Gibson Desert. Photo N.L. McKenzie.

▼ Facial view of a Ghost Bat. Photo copyright A.G. Wells.

Microchiroptera

To achieve the perception required for flying at night, especially as this involves hunting insects and other small prey, the Microchiroptera have developed echo-location to a very high degree. This ability has given them an exclusive franchise on the nocturnal flying insect population, a resource universally abundant over land during warm seasons. Most of bat diversity has sprung from this enterprise. The variety of air spaces in which insects can be hunted at night entailed enormous potential for speciation (radiation) through wing design and other specializations that improved hunting efficiency.

There are high flying bats that harvest moths and beetles in the clear air-space over the vegetation canopy, species that hunt between the crowded trunks of forest trees and those that glean their prey from the bark and leaves of vegetation and the surface of the soil and water. Species of Microchiroptera have also specialized in hunting small vertebrates such as mice, lizards and even other bats. The large-footed species of the genus *Myotis* skim the surface of pools fishing with their hind feet.

Insectivorous bats are important as plant pollination agents and as voracious eaters of insects, many of which are pests of man and his crops. As an example, the Guano Bats are known to consume 6 600 tonnes of insects per year in the American state of Texas alone, about one gram per bat per night. In summer, this species is the sole vertebrate predator in Texas capable of limiting the number of night-flying insects.

Unfortunately, bat numbers are declining in several countries. Suggested causes for this decline include the destruction of breeding caves and widespread use of agricultural insecticides.

Orchids and Wasps

Text and photographs by Warren P. Stoutamire, Biology Department, University of Akron, Akron Ohio 44325, U.S.A.

To most of us the word 'flower' suggests certain attributes such as bright colour, fragrance and insects or birds searching for food. Western Australia is unusually rich in such flowers and we tend to be less aware of the duller colours and smaller size of those which attract less familiar insects or utilize wind for pollen transport. Many of the native terrestrial orchids are brightly coloured and often fragrant but others are dull in colour and odourless to man. Among the latter group are some with an unusual method of pollination: they attract male wasps by releasing chemical attractants simulating the sexual odour of female wasps.

Many insects utilize a chemical language conveying specific messages indicating warning, aggression, food, trail marking and sex. These substances are called pheromones and are specific for each insect species i.e. a compound utilized by one species is not detected by others. In Western Australia, flowers of some orchid species release sexual attractants for specific wasps. We do not know whether these attractants are identical to those of the target insect or merely induce similar behaviour. Flowers of these orchids chemically simulate female wasps, and searching males visiting the flowers transport pollen from one pseudo-female to another.

Orchids mimicking female wasps occur elsewhere, especially around the Mediterranean and in southern Europe, but they are best represented both in number of species and in floral diversity in southwestern Australia where about twenty-five species are known to occur. The Australian pheromone-utilizing orchids exploit three families of primitive wasps. The southwestern tongue orchid *Cryptostylis ovata* attracts male *Lissopimpla* wasps of the Ichneumonidae as do other *Cryptostylis* in the eastern states. The southwestern beard orchid *Calochilus robertsonii* is largely self pollinating, although Andrew Brown (W.A. Herbarium) has observed it attracting wasps, presumably of the family Scoliidae. This wasp family is exploited by eastern Australian *Calochilus* species. Most wasp-mimicking orchids of the southwest utilize male wasps of the family Tiphiidae, subfamily Thynninae. These sexually dimorphic insects have small wingless females superficially resembling ants and much larger winged males.

Wasp visits to Australian orchids were reported early in this century although the mechanism was not explained until Edith Coleman described male *Lissopimpla* wasps attempting to mate with flowers of several *Cryptostylis* species in a series of papers beginning in 1927. Since then, others have observed a variety of orchid species using sexual lures for wasps.

▼ Three male *Lissopimpla* wasps on the lip of *Cryptostylis ovata*.

Thynnid wasps are especially exploited by orchid flowers. In some species the flowers are the dimensions and general colour of female wasps but in others only generalized form and colour coupled with the appropriate attractant bring about pollination. The mating behaviour of these wasps lends itself to exploitation by the orchids. Wingless female thynnids perch on low vegetation and release pheromonal attractants into the airstream. Searching males follow the odour trail upwind to the source. At close range a wasp orientates visually to a female, picks her up, and carries her to a perch where she is simultaneously fed and fertilized. Some males offer material previously collected from flowers, while others carry the female to flowers where both feed while mating. The initial perching behaviour of an advertising female on low vegetation is simulated by orchids, where a decoy is placed at the end of a thin, flexible stem.

The chemical attractants are produced by specialized parts of the flowers and are specific for the target insect species. Attractants are produced by the sepal clubs of some spider orchids and by the head-like portion of a hammer orchid, but odour source has not been determined for most species. In the butterfly spider orchid of the southwest three sepal clubs with a combined length of 30-40mm produce the sex lure. A 2mm section of one of these clubs is sufficient to attract receptive male wasps.

Orchid attracted wasps search for females on the flower and in some cases attempt to pick up and mate with the pseudo-female. Orchid pollen adheres to the wasp during the visit and the insect transfers this to the stigma of another flower as it repeats its search for a female. The plant's reproductive cycle is completed by this subterfuge but the wasp gains nothing. In many nonsocial wasps such as these the males emerge before females. The orchids are assumed to exploit this difference in emergence time without seriously interfering with normal wasp reproduction. Such assumptions need investigation, however. We know surprisingly little of the biology of these insects.

▲ Male thynnid wasp alighted on decoy lip of an undescribed hammer orchid.

▼ Wasp has attempted to remove the decoy and has fallen into the stigma and anther.

This orchid-wasp association raises many questions about origin and evolution, about biochemistry of the attractants, about costs and benefits of the models and the mimics, and about the reasons for its extensive development in southern Australia but its virtual absence from most of the earth.

A New Reserve for the Mt Lesueur Area

Text by A.J.M. Hopkins, Western Australian Wildlife Research Centre. Photographs by Clifford Young.

In May last year, the Western Australian State Government announced a proposal to create a major new nature reserve in the area to the north of Jurien. It will be named the Mt Lesueur Nature Reserve and will be vested in the Western Australian Wildlife Authority. The announcement represents the culmination of attempts over the past 20 years to have this important area set aside for the conservation of flora and fauna.

The earliest proposals for the creation of the reserve came from the Western Australian sub-committee of the Australian Academy of Science Committee on National Parks. The sub-committee's recommendations that a reserve be created over the area were reiterated by the Conservation Through Reserves Committee in 1974 and subsequently endorsed by the Environmental Protection Authority (1976) and State Cabinet. However, until last year, no further action was taken because of the complexity of land use conflicts over the area.

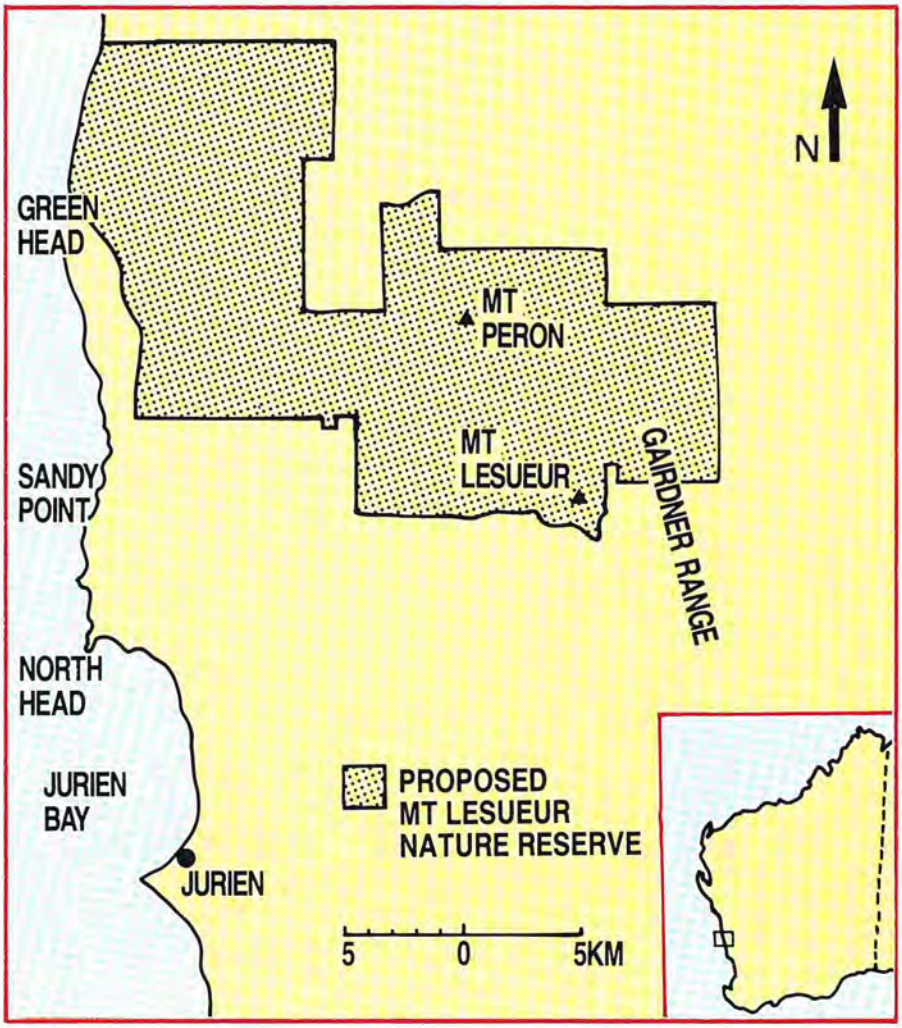
The Mt Lesueur – Cockleshell Gully area proposed for reservation includes one of the more interesting and spectacular parts of the landscape in the northern kwongan (the Irwin Botanical District). It is an area where the ancient sedimentary rocks have been broken up and distorted by a series of major faults with their surfaces partially lateritized. Patterns of drainage lines have further dissected the country. Mt Lesueur itself is the highest feature (313m elevation) of the area and this hill is a near circular mesa formed as a result of dissection and erosion and capped by hard laterite. As well, the area includes a fossil shore line equivalent to the Darling Scarp, a remnant from a time when the sea level was about 100m higher than at present. To the west are sand dunes and swamps similar to those of the Swan Coastal Plain near Perth.

The vegetation of the area is mainly kwongan or shrublands as is typical of much of the Northern sandplain region. These shrub communities are very rich in plant species, having up to 80 different species in a 100m^2 quadrat. Most of the shrubby species are less than 1m tall so the country has a very open appearance. Patches of mallee are common too. For example, Jarrah occurs as a shrub mallee only 1m tall on the southern slopes of Mt Lesueur. The occurrence of Jarrah at Mt Lesueur is of considerable scientific interest as it represents the extreme northern limit

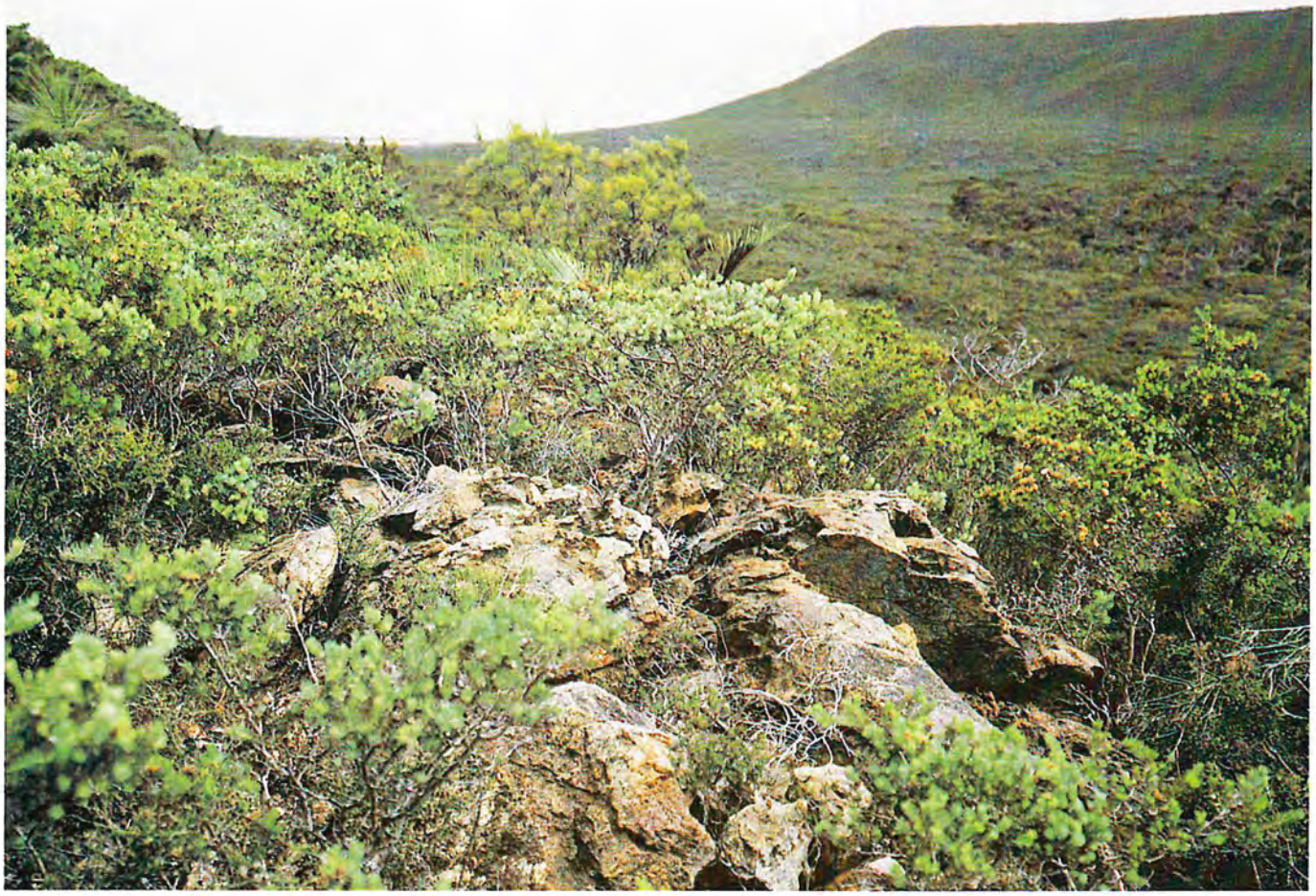
of its distribution and there is a gap of over 100km between this and the next stand of jarrah to the south. The proposed reserve features woodlands of several different types, mainly in the sandy valleys and drainage lines with heavier soils. Species of trees in the woodlands include *Eucalyptus accedens, E. calophylla, E. erythrocorys, E. haematoxylon, E. rudis, E. todtiana and E. wandoo, Banksia attenuata and B. menziesii.* The woodlands are important, particularly for tree-hole nesting birds such as cockatoos and corellas, because there are good stands of old trees together with some regeneration to maintain the supply of tree hollows, and there is also an abundance of food resources present (e.g. marri fruits and flowers of dryandra species).

The rich flora of the proposed reserve includes many species which are of special conservation interest. It is estimated that the total flora exceeds 600 species and of these 7 are gazetted rare and over 50 additional species have very restricted distributions being generally confined to the Jurien-Eneabba area. Mt Lesueur has been studied in detail and 286 species have been found on the top and slopes of the mesa. Twenty-three of the Mt Lesueur species are rare or restricted and a further 20 undescribed species are likely to be categorised similarly when the appropriate taxonomic research is undertaken. Twenty-six species are more generally confined to the wetter, forested region to the south as described for jarrah and the Mt Lesueur populations represent extreme outliers.

The presence of so many species of special interest in the Mt Lesueur–Cockleshell Gully area and their patterns of distribution provide evidence that the area has been a refuge where species have been able to persist while nearby populations became extinct as the climate became drier over the past 5 000 years. As well, the particular combination of climatic factors (including micro-



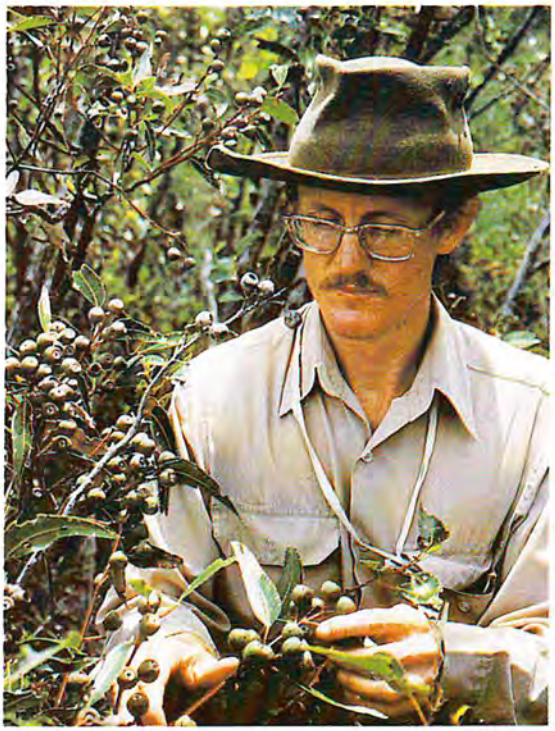
▼ *Calytrix tenuifolia.*



▲ A feature of the proposed reserve is a series of major fault lines that have broken up and distorted the underlying ancient sedimentary rocks. Mt Lesueur is in the background.

◀ *Pimelea* spp.

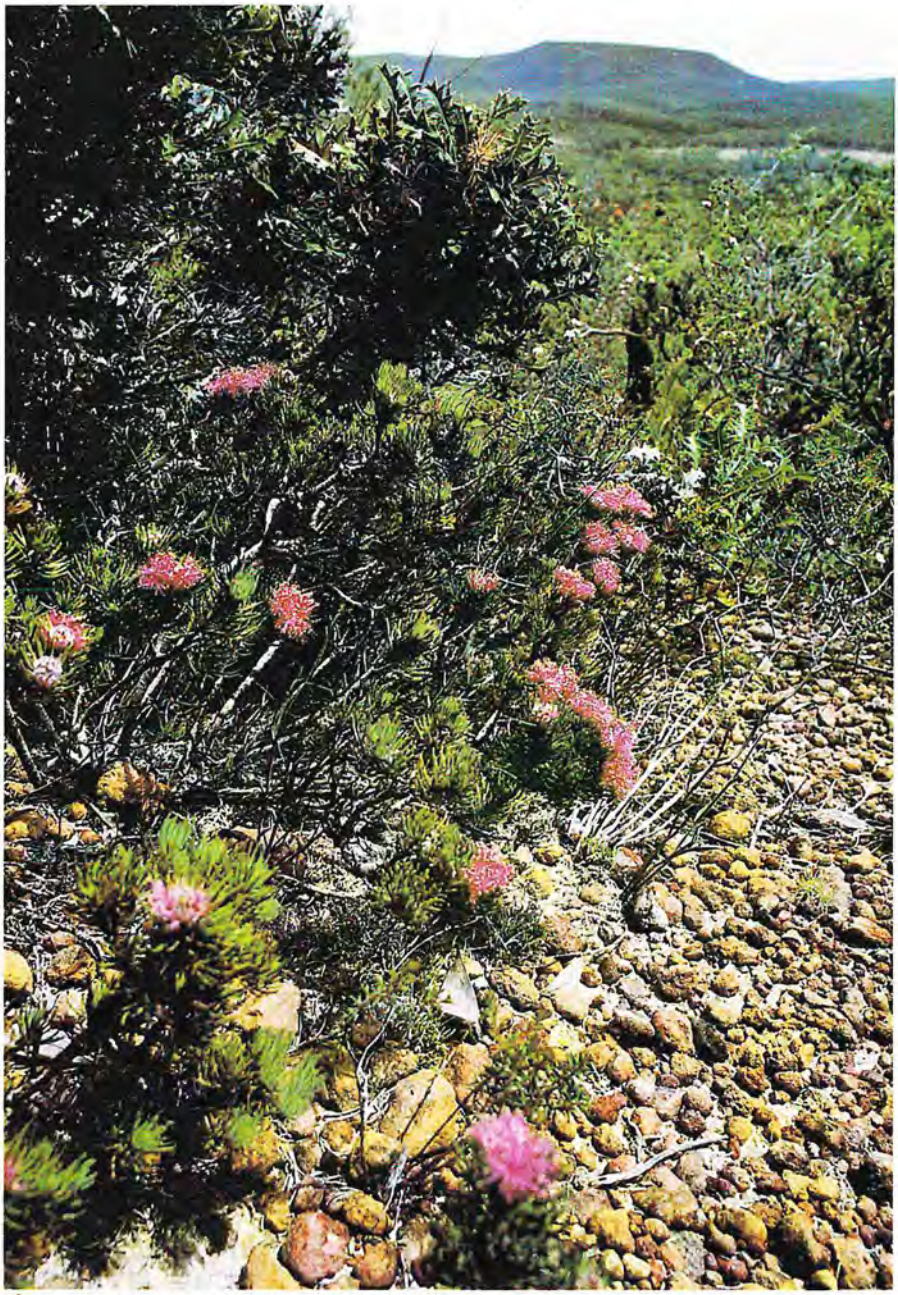
▼ The northern-most known population of Jarrah *Eucalyptus marginata* occurs around Mt Lesueur where it grows as a stunted mallee in contrast to the tall trees found further south.



climate) and the dissection of the terrain has facilitated speciation in plants so the area is indeed important for nature conservation.

The Western Australian Museum conducted a survey of the fauna of a portion of the proposed reserve in 1973-74 as part of its survey of some wheatbelt reserves. They found the area to be rich in birds (146 species), particularly in heath dwelling species, and in frogs and reptiles (48 species) with many species at the limit of their ranges. Only nine species of native mammals, including three species of Dunnarts *(Sminthopsis)* were reported whereas it was known from the study of owl pellets in a nearby cave that the mammal fauna has been much richer in the past few thousand few thousand years. Woylies *(Bettongia penicillata)* and several small species of native rodent were among those animals which had been present in the past. The changes probably result from the general decline in rainfall from the mid-Holocene, effects of sea-level change on habitat availability particularly for sand-dune dwelling species and, more recently, the impact of European colonization including changes in fire regime and the introduction of cats and foxes. From the mammal point of view, the proposed reserve is of value because it is one of the few places in Western Australia where the extant fauna can be compared with a recent fossil assemblage.

Once the reserve is declared, staff at the Western Australian Wildlife Research Centre will move quickly to complete survey work and then to draw up a management plan. The area has been considerably disturbed over the past 20 years due to the lack of management. Surveys for petroleum, coal and mineral sands have created a web of tracks, many of which have eroded badly. As well, adjacent farmers have been concerned about the lack of proper fire planning. It is to be hoped that these management issues can be resolved through the impending planning process with input from interested citizens and organisations.



▲ The pink flowers of *Melaleuca trichophylla* fill the foreground with Mt Lesueur in the distance.

▶ A massed display of *Verticordia acerosa*.

▼ Black Kangaroo Paw *Macropidia fuliginosa*.

Rare Flora of the Mount Lesueur Area

Text and photographs by Dr Stephen Hopper, Western Australian Wildlife Research Centre.

The Mt Lesueur region has much to offer to the botanical enthusiast. Covering its rugged plateau landscape is a heathland flora with one of the richest concentrations of rare wildflowers in Western Australia.

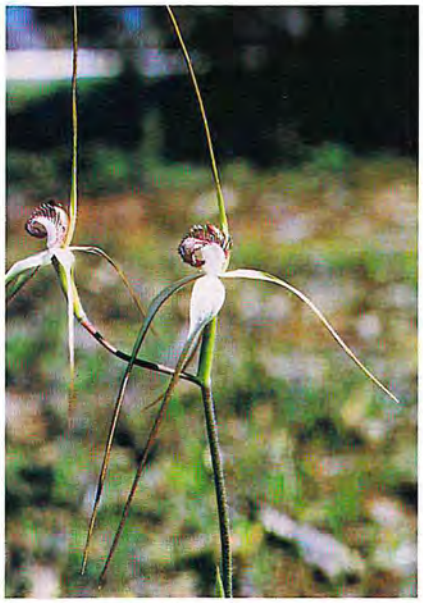
This is highlighted in the accompanying map, which shows the relative density of species of the Proteaceae (banksias, dryandras, grevilleas, hakeas, etc.) in south-western Australia. The Mt Lesueur region ranks alongside the Fitzgerald River National Park and the Darling Range, and is exceeded only by the Stirling Range, in the richness of species in this group of plants. The same applies about many other groups of plants.

It is little wonder that Mt Lesueur has captured the imagination of botanists ever since James Drummond first traversed its slopes in the 1850s. It certainly impressed C.A. Gardner who, in 1947, discussed the botanical virtues of the region in a paper given prominence as the first article in the inaugural issue of *The Western Australian Naturalist*. The first detailed study of the region's vegetation was undertaken by N.H. Speck as part of a Ph.D research project completed in 1958. Speck regarded the vegetation and flora so distinctive as to warrant recognition of the area as a new botanical district within the geographical subdivisions recognised for south-western Australia.

Subsequent research has indeed highlighted the rich complement of rare and geographically restricted species that makes the Mt Lesueur region's flora unique. A review of available information in 1981 by consultant botanist, E.A. Griffin, showed that 38 named and 24 unnamed species with a maximum geographical range of less than 160km occurred within the proposed Mt Lesueur Nature Reserve. These include three species gazetted as rare flora under the Wildlife Conservation Act – Lesueur Hakea *H. megalosperma*, Pine Banksia *B. tricuspis*, and Gairdner Range Starbush *Urocarpus phebalioides*. Several other plants among those recorded for the region are proposed for gazettal as rare once they have been formally named by botanists and field surveys of their distribution and abundance are complete.

There is every likelihood that further rare plants will be discovered near Mt Lesueur. For example, over the past two years, four more gazetted rare plants have been found (Boyagin Mallee *Eucalyptus exilis*, Fishbone Banksia *B.chamaephyton*, Leafy Stachystemon *S.axillaris* and

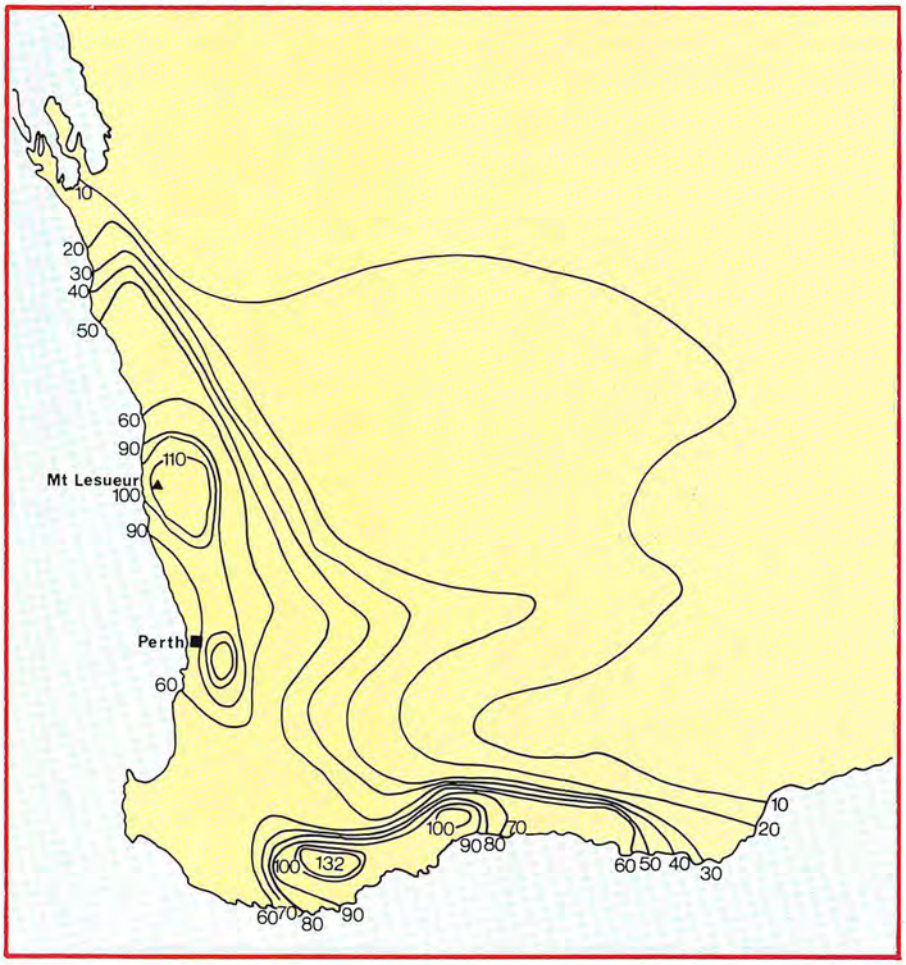
▼ Pine Banksia *Banksia tricuspis*. A gazetted rare shrub confined to the the immediate vicinity of Mt Lesueur. Its large inflorescences are up to 20cm long and appear in autumn-winter.



▲ White Spider Orchid *Caladenia longicauda*. The segments of this orchid commonly exceed 10cm in length, making it the largest representative of this family to be seen near Mt Lesueur.

▲ Winter Bell *Blancoa canescens*. The 3-4cm long flowers of this herb attract birds as pollinators. The species was illustrated by C.A. Gardner in a paper extolling the botanical virtues of the Mt Lesueur region. It was regarded by him as a rare species, but it is now known to be common in the northern sandplains.

▼ Isoflor map of the Proteaceae showing relative species richness for this plant family in south-western Australia. Each isoflor line encompasses areas having the number of species indicated. The map is based on data for 426 species compiled by N.H. Speck for his 1958 Ph.D thesis. Note the high concentration of species around Mt Lesueur.



▼ Black Gin *Kingia australis* with Mt Lesueur in the background. This location is the most northerly known for Kingia, as well as for Jarrah and Mountain Marri.

▲ *Eucalyptus suberea* growing on the slopes of Mt Lesueur. Only recently recognised as an undescribed species, this rare mallee is another relict, having no close relatives among eucalypts. Small populations of it are distributed along the breakaway systems near Mt Lesueur.

▼ *Eucalyptus lateritica* growing on Mt Michaud. This is a rare species soon to be named formally by botanists. It is confined to lateritic breakaway country between Mt Lesueur and Coomaloo Creek.

▲ Lesueur Hakea *Hakea megalosperma*. A very rare shrub confined to the Mt Lesueur region and south-east near Cataby. This species has no close relatives, presumably evolving in isolation for a long time and persisting in relict populations on high lateritic hills.

Star Orchid *Thelymitra fuscolutea* var. *stellata*), together with small populations of new unnamed species of eucalypt and a *Conostylis*. The discovery of Boyagin Mallee near Mt Lesueur extended the range of this species some 300 km northwards. Previously, it was only known from a few populations near Pingelly to the south-east of Perth. This remarkable disjunction in geographical distribution indicates the importance of Mt Lesueur as a refuge where previously widespread species have been able to persist during presumably adverse climatic changes.

Other species display the same pattern as Boyagin Mallee with small populations at Mt Lesueur well-removed from the main species' occurrence. These include such well known plants as Jarrah *Eucalyptus marginata*, Mountain Marri *E. haematoxylon* and Black Gin *Kingia australis*.

The aggregation of rare species, geographical outliers of widespread species, and a remarkably rich assemblage of plants in the small area surrounding Mt Lesueur makes the region exceptionally valuable for flora conservation.

Once created, the proposed Mt Lesueur Nature Reserve will rectify what has been an important deficiency in the State's network of nature reserves and national parks.

Farm Refuges for Native Waterfowl

Text and photographs by Clifford Young.

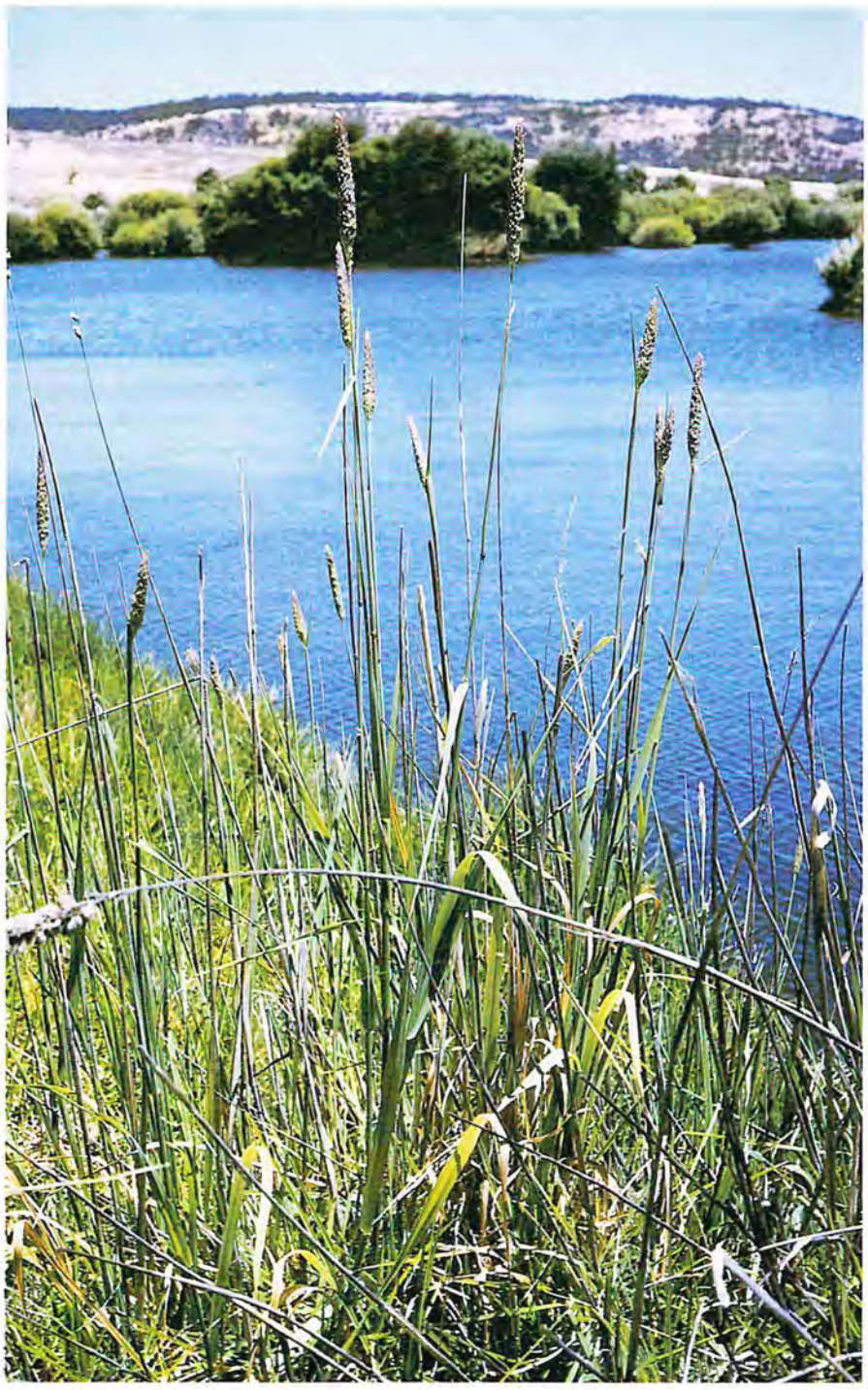
It is a complex world. In their natural state, all living things, from the tallest trees to the smallest animals and insects, live in a constantly changing state of interaction between one another. The process of life is never-ending but the changes take place slowly in accord with the gradual evolution of the physical world. That is, until man. Man with his mining, man with his agriculture. Within a few short lifetimes, the whole evolutionary timetable of the world has been thrown out of gear and with it the time necessary for the natural adaptation of the rest of the living kingdom.

Happily, many people have recognised the problems brought about by man's activities, particularly through land clearing and the accompanying destruction of habitat so vital to wildlife. Although farming and mining are necessary activities, much can be done to minimise or rehabilitate disturbed areas of wildlife habitat at relatively little cost.

A prime example of successfully combining farming with wildlife can be seen at 'GlenAvon', an historic property along the banks of the Avon River near Toodyay, Western Australia. Owned by the Masters family for several generations, the property has been developed to function efficiently and economically while at the same time providing useful habitat for birdlife, particularly waterfowl.

The key to the system on 'GlenAvon' is a pair of large water storage dams nestled within walking distance of the farm's residence, and fed by a series of diversion channels. Besides providing a more-than-adequate supply of good water for the farm's stock and, in the past, irrigation for lucerne, the dams are a haven for many species of waterfowl and other birds. The pleasure of being able to look out over the dams with their lush vegetation and plentiful birdlife, without so much as putting a foot outside the farmhouse door, is an added bonus.

In addition to running the farm, Jim Masters, an ardent birdwatcher, has kept careful note of the species frequenting the dams and over the years has recorded almost every



species of duck found in the south-west of the State. These have included Teal, Black Duck, White-eyed Duck, Maned Geese, Mountain Duck, Bluebill Duck, Musk Duck, Blue-wing Shoveller and even some Pink-eared Duck. Other waterbirds which have used the dams include Coots, Little Grebes, Blue Herons, White Egrets, White-necked Herons, yellow-billed Spoonbills and a variety of migrant waders. Fringing vegetation around the dams has also proved attractive to other forms of birdlife commonly including Magpies, Willy Wagtails, White-winged Trillers, Rufous Whistlers, Silvereyes, Magpie Larks, Western Warblers, Splendid Wrens, Reed Warblers and a few Little Grass Birds.

All very well and good you may be saying to yourself, but at the same time thinking you cannot afford to spend the time nor the money developing facilities for birds when you have a farm to run. Wrong. According to Jim Masters, the extra time and money required to make a dam, particularly a new dam, more attractive to wildlife is very small provided some thought is given to the problem beforehand. In fact, a better dam for all round farm use may result. The following information on farm dams and their modifications for waterfowl is based on information supplied by Jim Masters which, in turn, is based on practical knowledge and experience gained by him over a period of more than 20 years.

Dam Design

Before planning any dam there are several points to consider. Firstly, find out the annual average volume of water discharge from the farm's catchment and, secondly, the quality (i.e. salinity) of this water. However, be careful with the latter as sample average readings of salinity of inflow do not always give the full story. They need to be related to the volume of inflow as, for example, the salinity of surface discharge usually falls as the volumes increase after rain.

Having covered the above points you will have learned a great deal about water discharge for your own particular situation. Do not build any dam for water storage unless sufficient water of suitable quality (i.e. salinity under 800 parts per million for plants or under 2 000 parts per million for most stock animals) is available for 12 months of the year. Remember salinities may double over summer. The figures given above apply for agricultural use.

▲ Many dams dry out over a long summer but in the process can provide good feeding habitat for wading birds such as this Banded Stilt.

For wildlife refuge and breeding, or for flood control purposes, salinities may be double those given above, reaching as high as 8 000 parts per million in late autumn without causing too much harm. However, it should be noted that dams designed for this purpose with such high salinities must be provided with a bottom outlet for flushing whenever surplus water is available, and preferably at least once a year.

A general rule to follow is not to build the capacity of any dam to a volume greater than one quarter of the known average volume of discharge of its catchment. Experience, in the Avon valley at least, has shown a probability of completely filling the dam nine years out of ten on this basis. Do not try to be too greedy, it is self-defeating for your own ends as well as being detrimental to the whole environment.

Excavated Dams

A common design, the excavated tank dam more often than not has less effective water storage than the amount of earth removed. At best, only a 1:1 ratio can be achieved so the method is not very cost effective. If it is fenced off against stock, water must be pumped out into troughs, adding further to the cost of the operation. Such disabilities offer little economic incentive for farmers to develop them as wildlife refuges and shelter belts. They are also subject to frequent flood siltation and stock pollution.

Dammed Creeks

Dams in creeks and open valleys can be built with ratios of storage of water to earth moved of up to 3:1 on some sites. Although they can usually be provided with a bottom outlet quite cheaply, allowing fencing with an outside gravity-fed water supply, the general design allows little protection from flood siltation or pollution without elaborate and costly flood bypass systems. They are also very subject to increasing salinity from a general water table rise in the surrounding valley. Although they are a risky proposition for farm use, they can prove effective as wildlife refuges and breeding places for waterfowl having large areas of gently sloping margins with shallow water. Small islands for nesting can be easily provided and will provide some protection from ground predators such as cats and foxes.

Semi-turkey nest dams

These dams offer the same possibilities for wildlife as dammed creeks with the added benefit of allowing more control of water levels. Semi-turkey nest dams are placed outside of main valley situations and natural water discharge lines of large size. The general principle to recognise about these dams is the possibility of moving water around

An excellent example of a farm dam modified for waterfowl. The small islands are separated by deep water from each other and the dam banks, are well vegetated and have gently sloping margins to help waterfowl walk out of the water. This is 'GlenAvon' near Toodyay.

▲ Jim Masters at the controls of one of several simple diversion gates on his property which together control the quantity and quality of water flowing into the farm's dams. This particular gate, when closed, banks up the water level behind it and diverts it into the grill-covered dam inlet (see below). The gate is closed only after any salty surface water has been flushed through.

▼ The same diversion gate as above seen from 'upstream'. The dam intake on the extreme right carries good quality water to the dam. The natural watercourse carries saltier and surplus water under the railway to the left of the tree in the background.

▼ Another diversion gate higher up the watercourse on the same farm as above. Here, the creek is deeper and the water flow faster necessitating different engineering techniques. The planks above the creek are lowered via a crank (left) and the water diverted through the grill on the left to a diversion channel system which takes the water to the dam.

sloping ground away from direct discharge lines. In doing so you are keeping water as high as possible for as long as possible, thus providing height for water storage above natural ground surfaces. This in turn assists the provision of a bottom outlet back to the natural discharge lines. The dams can be placed in any man-made contour or grade-banks system or, by using small weirs in creeks, redirecting the water from natural discharge lines. For an average effective farm dam depth of three metres, even landscape with a fall of five metres in one kilometre has potential. These dams have many advantages including complete control of water intake (both quantity and quality). In turn, this means most siltation can be controlled thus giving the dam a greatly increased life span. Other benefits include virtual immunity from flood damage, more potential dam sites, low annual maintenance and, most importantly, a high ratio of water storage. Ratios of 12:1 and better have been achived for farm dams of this sort.

On 'GlenAvon', Jim Masters has built two semi-turkey nest dams, a large one and a smaller one, side by side. Both dams were constructed by pushing up turkey nest walls around an old swamp bed and in this way it was not necessary to lower the original bottom level. Natural bottom outlets were thus able to be employed for periodic drainage. Both dams are fed by a series of diversion channels moving water as necessary from a natural creek draining the farm's catchment. The whole system operates on a vertical head of about eight metres over a distance of approximately one kilometre, a situation few farms in the wheatbelt would not be able to duplicate.

The main dam was built 21 years ago as a source of good quality water for irrigation and has a surface area when full of about five hectares. Its maximum depth is four metres but throughout most the year the average maximum depth is about two metres. The adjoining dam is much smaller and considerably shallower. When full, the maximum depth is less than two metres and this dam usually dries

▲ Thickly vegetated island and dam margins protect earthworks from erosion and provide feed and cover for many species of waterfowl. Wherever possible, only local tree species have been planted.

▲ In a dam, shallow water is the most important source of food for waterbirds.

out over summer. Both dams have gently sloping margins, a feature which Jim Masters says is most important to waterfowl. In a dam, shallow water is the most important source of food for waterbirds. Light and warmth can penetrate shallow water, encouraging the growth of aquatic plants and insects which in turn are eaten by the birds. Shallow water will also support the growth of rushes and reeds which provide food, shelter and nesting sites for many species of waterfowl.

In practice, Jim has found that the most successful plant around dam perimeters has been kikuya grass. This grass is easy to establish and spreads rapidly around the dam banks providing a food source and essential protection against erosion. It has the added advantage of being tolerant of dry situations, such as the dam drying up over summer, for periods of up to 12 months. Lower down along the water's edge, cooch grass covers much of the dam's margins. This grass will tolerate short periods of complete immersion when dam levels are at their highest.

Where denser cover is required, Jim has allowed clumps of cumbungi and the imported African grass, Elephant grass, to take hold. Here however, Jim has warned that care needs to be taken, particularly with cumbungi, as the plant grows rapidly and can colonise all shallow margins of the dam in a very short time thereby crowding out other useful plants and creating a nuisance. Elephant grass is particularly well suited for planting on islands within the dam as it provides excellent shelter and nesting habitat.

Islands are very important to the successful establishment of wildlife on a farm dam. If properly orientated they provide shelter to ducks on windy days, the ducks and their young keeping close into the lee created by the islands to prevent being blown the length of the dam. They are

▼ When planning a dam to encourage waterfowl, islands should be orientated to provide shelter against the prevailing winds.

▲ Light and warmth can penetrate shallow water, encouraging the growth of aquatic plants and insects which, in turn, are eaten by waterfowl such as this Black Duck.

▼ A Little Grebe's nest made of floating vegetation and anchored in the lee of a small island on a modified farm dam. Nesting material for other species of waterfowl can include loose hay if there is insufficient natural vegetation.

also utilised as predator-free nesting sites. Some points to keep in mind when constructing islands include the need to provide gently sloping sides, both to allow the ducks to walk out of the water on to the islands and also to provide additional shallow feeding grounds, and to ensure there is deep water between the island and the shore to discourage potential land-based predators from making the trip. As with the dam edges, artificial islands should also be vegetated against erosion and to provide nesting cover, although for the latter use, Jim Masters has had some success by just providing small bales of hay for nesting purposes. Trees also provide welcome shade and resting and nesting sites for many species of birds and waterfowl. Generally, the best trees to grow are those that are found locally as these will most readily adapt, provided of course that they will tolerate moist conditions. On 'GlenAvon', most of the trees around the dams and on the islands are either floodgums or Melaleucas. Here again, some care is required not to plant trees too close to the dam walls as they may weaken the walls, nor to plant them too thickly around the whole dam as this would obstruct flight lanes to and from the water surface.

Many species of aquatic plants inlcuding algae and duckweed which provide food for waterfowl will probably colonise suitable farm dams naturally. At 'GlenAvon', the small islands have also been vegetated naturally, with the exception of their tree cover, by seeds floating across the water or being carried over by wildlife.

Although the modified dams at 'GlenAvon' have taken many years to take on their present appearance, Jim Masters says the time and effort involved was more than worthwhile. Not only has the value of his property increased as a result of the improved dams and diversion channel system, but the pleasure involved in watching the day-to-day and year-to-year activities of the birdlife attracted to the dams is immeasurable.

Further information and technical advice on modifying existing farm dams or designing new farm dams for the benefit of wildlife can be obtained from the Department of Fisheries and Wildlife. Contact Jim Lane or Grant Pearson at the Western Australian Wildlife Research Centre, Woodvale on (09) 405 1555.

Gull-billed Terns in the South-West

Text and photographs by Roger P. Jaensch, Field Officer, Royal Australiasian Ornithologists Union.

In the past, the Gull-billed Tern *Gelochelidon nilotica* has been regarded as a rare visitor to the South-West and Eucla Land Divisions. However, observers participating in the Royal Australasian Ornithologists Union's (RAOU) survey of waterbirds using south-western wetland nature reserves (vested in the Western Australian Wildlife Authority), have found the terns at a number of localities.

So far in the 1983-84 waterbird breeding season, Gull-billed Terns have been seen at several salty wheatbelt lakes and on the Coastal Plain. In addition, although there are no published records of the species breeding in the South-West Division, RAOU observers recently located a small breeding colony of the terns near Wongan Hills.

Background

Typically mid-way between the Crested Tern *Sterna bergii* and Common Tern *S. hirundo* in size, the Gull-billed Tern is readily recognised by its immaculate white plumage. It is in fact most similar to the Silver Gull *Larus novaehollandiae* in length and, as the name implies, it has a stouter bill than either Crested or Common Terns. Although breeding adults sport a long sleek black cap, immatures and non-breeding adults may have shadowy head markings or occasionally none at all. One of the most distinctive features of the Gull-billed Tern is its peculiar yelping calls, often written as "kuh-wuk, kuh-wuk".

Cosmopolitan in occurrence, Gull-billed Terns are rare visitors to Tasmania and New Zealand but are not uncommon on parts of the Australian mainland. Besides the endemic Australian subspecies *G. n. macrotarsa*, the grey-tailed migratory Asian subspecies *affinis* has occasionally been recorded in Australia, eg. in the north-western Kimberley.

The status of the Gull-billed Terns in Australia is not well understood, owing to their highly nomadic movements. Major breeding efforts seem to occur opportunistically in the inland, typically following floods, or after heavy downpours which fill shallow lakes. There is some evidence for regular movements to northern coasts in winter and southern coasts in summer. In considering regular haunts, Gull-billed Terns appear to be least common in the higher rainfall parts of southern Australia.

▲ Gull-billed Tern *Gelochelidon nilotica*.

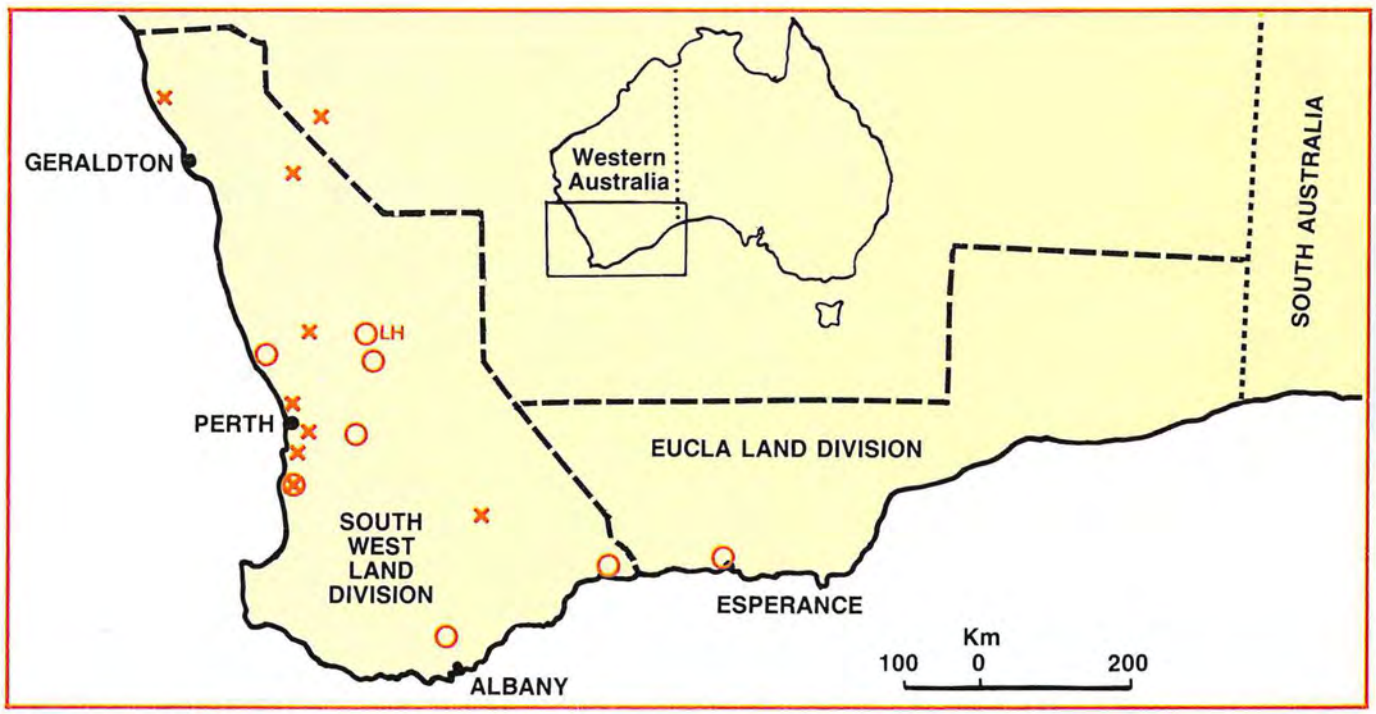
▼ A Gull-billed Tern's nest with eggs at Lake Hinds.

In Western Australia, the Gull-billed Tern is most common in the North-West, e.g. the Eighty Mile Beach and Roebuck Bay, but until 1953 it had never been seen in the South-West. During the 1950s, individuals and small flocks were seen at Hutt Lagoon; near Morawa, Moora and Wanneroo; at Lakes Forrestdale and Cooloongup; near Peel Inlet and at Lake Grace. Nesting has been observed near Pt. Cloates, Wooleen (in the Murchison), Lake Nabberu (north of Wiluna) and Yalgoo.

Records from the RAOU Waterbird Survey

Fieldwork for the RAOU's Atlas of Australian Birds (1977-81) resulted in South-West records of Gull-billed Terns from near the Stirling Ranges and Esperance. However, observers monitoring wetlands for the RAOU's Waterbird Usage Survey have since contributed quite a few reports of this species, some from 'new' localities.

Between June 1981 and May 1983, participants located Gull-billed Terns at six wetlands: Lakes Ninan and Hinds near Wongan Hills, Peel Inlet, and Warden, Windabout and Ewans Lakes near Esperance. Besides Peel Inlet, these are all essentially salt lakes, even though Lake Ninan has sometimes reached more than 2.0 metres in depth. In this period, the



▲ Locations of Gull-billed Tern sightings in the south of Western Australia. O indicates records by R.A.O.U. observers since 1977; X indicates earlier records. The only recorded nesting site of the Gull-billed Tern in the South West and Eucla Land Divisions is at Lake Hinds (LH).

▼ The Gull-billed Tern breeding colony at Lake Hinds.

▲ Chick and egg of the Gull-billed Tern.

maximum number of birds seen together at any one time was only two and most records were from August and September, with no evidence of breeding anywhere.

In the 1983-84 waterbird breeding season, water-levels in Walyormouring Lake (Goomalling Shire), the Beverley Lakes (Beverley/Brookton) and Jerdacuttup Lake (Ravensthorpe) reached peaks not seen for some years (0.9m, 1.92m and 0.98m respectively). These are all salty lakes with salinities in September 1983 of between 6.3 and 49.6 parts per thousand.

Gull-billed Terns were first detected at Walyormouring Lake on 13 October, when three birds were seen sitting on a small dry bar between a vast area of flooded samphire and open water. This bar and two nearby islands in deeper water may have been suitable nesting sites, but observers did not detect breeding evidence in subsequent visits to the lake. Four Gull-billed Terns were reported at Beverley Lakes on 10 October by J. Masters while a single bird was seen at Jerdacuttup Lake on 3 September by R. Schulz.

A team of observers from the Kwinana/Rockingham/Mandurah/Murray Branch of the W.A. Naturalists' Club censuses waterbirds on a monthly basis in the eastern Peel Inlet reserves. One of the team was with me on 17 November when a lone Gull-billed Tern was seen at the Harvey River delta. During a co-ordinated count three days later, members of the team saw seven Gull-billed Terns, the first for their study.

The only freshwater wetland which was found to support Gull-billed Terns was Karakin Lake near Lancelin. Five birds were seen at this shallow grassy lake on 29 October, 1983.

First Suspicions of Breeding

I first suspected that Gull-billed Terns were nesting near Wongan Hills in mid-September. During a brief visit to Lake Hinds at this time, I noticed three pairs of terns sitting on mud spits and samphire islets at the north end of the lake. I quickly inspected these possible nest sites but without luck. However, one pair of terns returned to circle over and 'bark' at me near one of the sites.

I decided to revisit Lake Hinds after hearing that a flock of 29 Gull-billed Terns had been encountered on 9 October by O. Mueller at a small lake in samphire flats a few kilometres south of Lake Hinds. Consequently, in the early morning of 28 October I began my search in the south-eastern part of Lake Hinds. Here, with the aid of a tripod-mounted spotting scope, I was able to see far enough to determine that Gull-billed Terns were probably not present on the eastern side of the lake.

The Breeding Colony

Having ruled out the eastern side of the lake, I then drove along a road with a view of the western side of the lake where I spied a fairly large samphire 'island' close to the lake shore. Again using the telescope, I saw white tern-sized birds sitting on the island and occasionally spreading their wings.

The approach to this area was through ice-cold shallows about 25cm deep. Bearing in mind the need to minimize disturbance to the birds if they were nesting, I identified and counted the birds (29 Gull-billed Terns) from a 'safe' distance, before moving quickly through the suspected nesting site.

As I approached the site, adult Gull-billed Terns flew around me, calling loudly as they did so and displaying the distinctive bright red colour inside their bills. This convinced me that nests were nearby. Moving along a dry mud bar (50m long) between flooded samphire and open, deeper water, I counted 21 nests at spacings of 1.5 to 2.5 metres over a distance of 20 metres. The nests were all bowls constructed of weeds and grass, up to ten cm high at the rims. They were as close as practical to the exposed 'beach' of the mud bar.

One nest contained one egg and one chick only a few days old, nine nests held one egg and eleven nests held two eggs. Markings on the eggs and chick seemed typical of some species of tern that I had encountered breeding in the past.

As I moved away from the site, adult birds quickly returned to their nests. The total of 21 nests implied a probable total of 42 adults involved in the colony so some birds must have been flying around the lake or elsewhere. As I reached my vehicle, a group of at least 12 birds casually flew low overhead, heading towards cropland. Having earlier seen one tern bring a grasshopper-like food item to the colony, I concluded that the Gull-billed Terns were feeding at least to some extent over dry land.

Dry land feeding is not unusual for this species in inland regions. At times I have even seen Gull-billed Terns hawking over stony gibber near shallow pools in desert country. Accordingly, the terns breeding at Lake Hinds may have been partly or even largely independent of the salty lake for their food supply. Salt lakes are possibly favoured by Gull-billed Terns as they are more likely to include bare islands for nesting and roosting than deeper, vegetated fresher lakes of the coastal regions.

Unfortunately I was unable to return to Lake Hinds to determine nesting success. However, the remoteness and poor access of the site should have precluded intereference by humans although strong winds and waves on the lake could have caused some trouble to eggs close to the lake-edge. Another danger the colony may have had to face as water levels fell was the possibility of foxes and other terrestrial predators wading out to the nesting site to attack eggs and chicks. I believe however, from first-hand experience with Gull-billed Terns caught in cannon-nets at Broome, that any foxes reaching the nesting site would have received savage treatment from the adult birds.

Conclusion

No doubt observers will continue to find Gull-billed Terns at more localities in the South-West. Although this species is probably one of many which erupt periodically into the South-West, any previous nesting at Lake Hinds or elsewhere could easily have been overlooked. Salt lakes are rarely visited by naturalists and if it were not for the Waterbird Survey, this 'new' colony might not have been discovered in 1983.

Furthermore, some waterbirds, e.g. the Sacred Ibis and Yellow-billed Spoonbill, are increasing in numbers in the South-West and now breed regularly in the region. With salinization and loss of vegetation in many lakes in the last 20 years (i.e. more habitat available), the Gull-billed Tern could well be following a similar pattern.

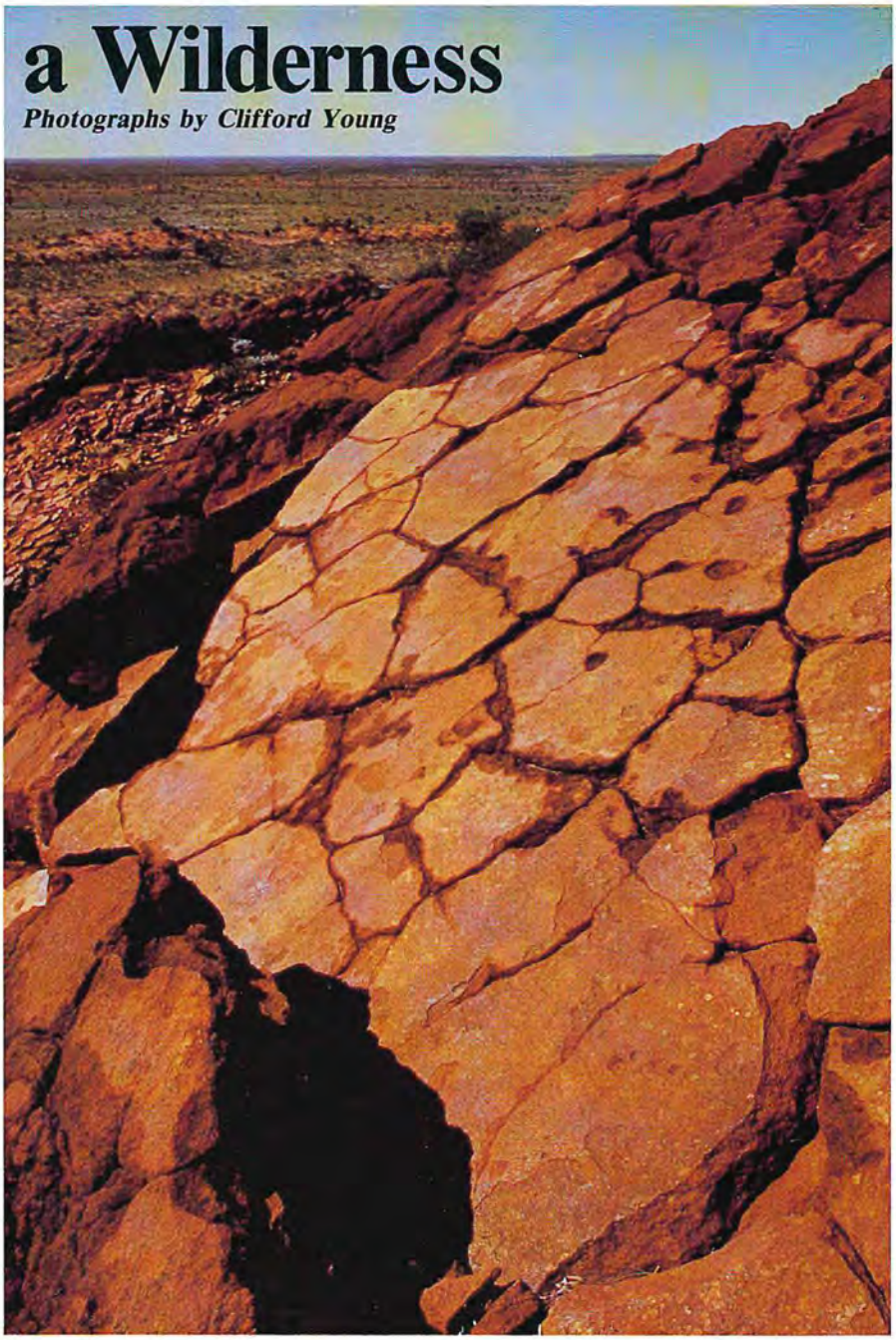
Pictures of a Wilderness

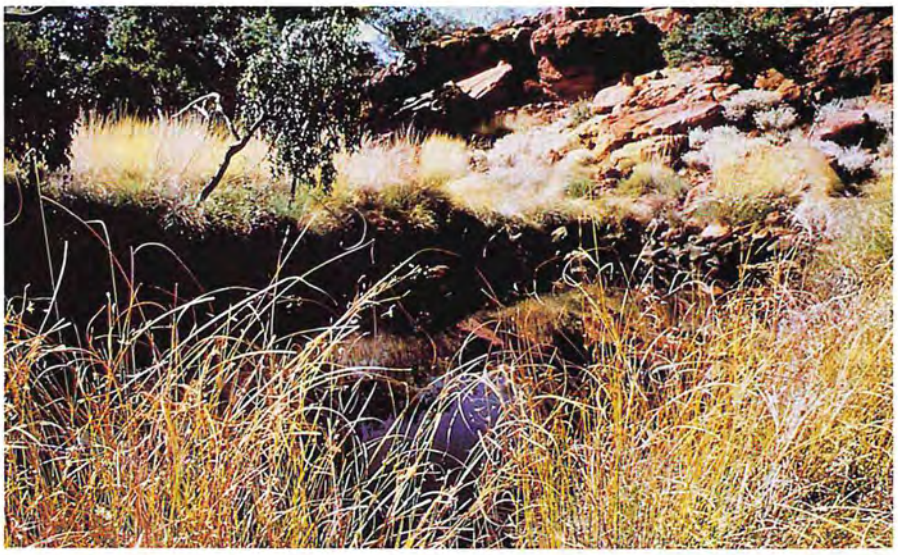
Photographs by Clifford Young

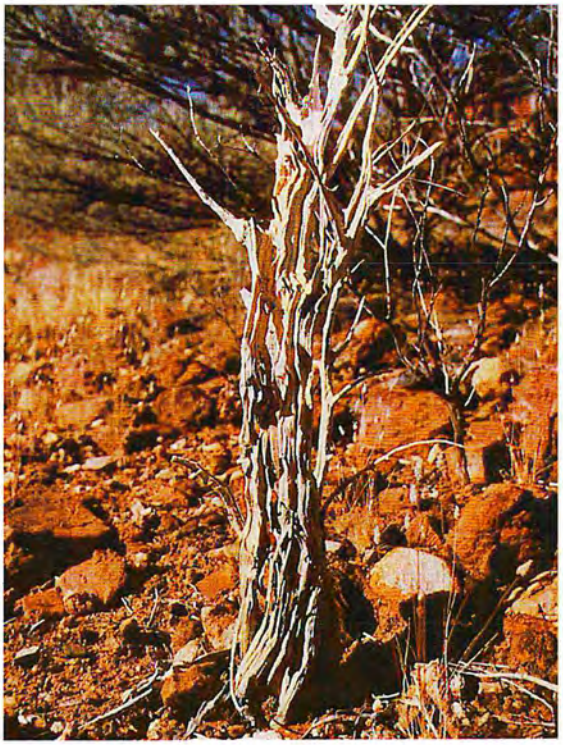
Much of Western Australia's interior is occupied by desert – the Great Sandy Desert, the Little Sandy Desert, the Great Victoria Desert and the Gibson Desert making up the bulk of the land under this heading. However, contrary to many people's impressions, these desert regions are not wholly monotonous stretches of spinifex and sand dunes.

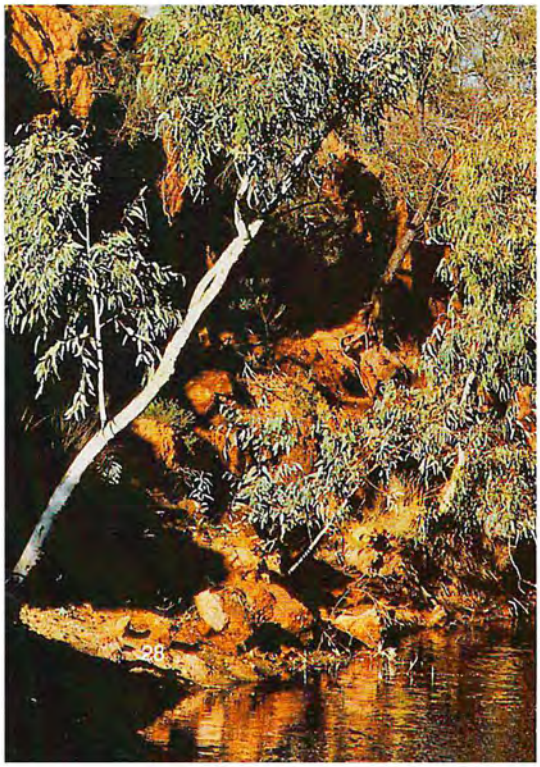
If nothing else, the desert is a land of contrast. Temperatures can sometimes range in the course of a single day from scorching heat to freezing cold. The landscape sweeps from rolling red sand dunes to abrupt breakaways of weathered rock, from dry and windswept salt lakes to lush pools of fresh water and from bare sand to carpets of magnificent wildflowers and stately trees.

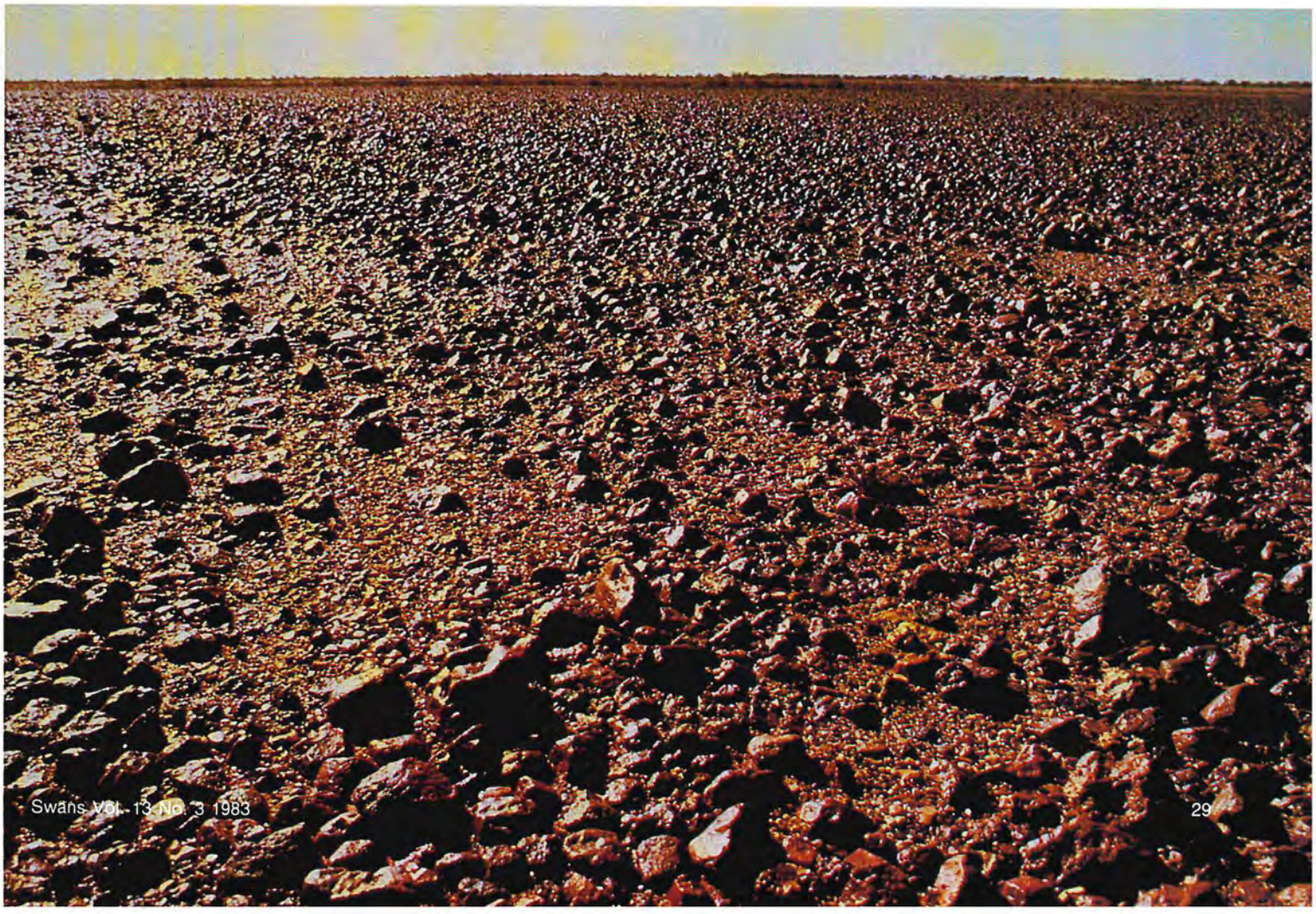
The desert is a land of many moods and faces, no single one of which portrays the 'real desert'. The following photographs were not selected to show any particular aspect of the desert regions except, perhaps, their changeable nature. Instead they form a small selection of images fleetingly seen during the course of several journeys to these regions over a couple of years.







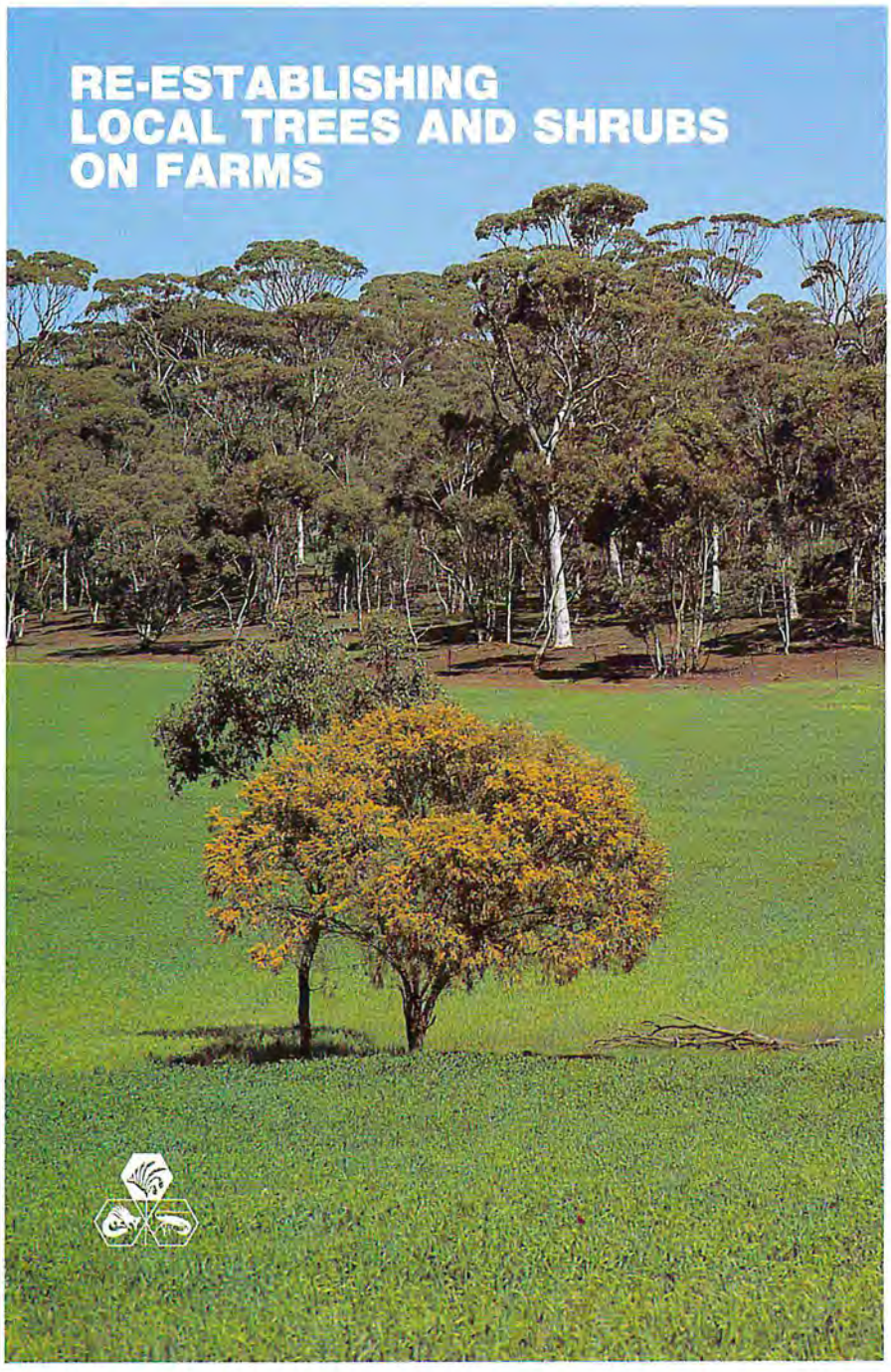




Farm Trees Booklet Available

The Department of Fisheries and Wildlife has recently produced a booklet on re-establishing local trees and shrubs on farms. It comes at a time of increased discussion on the value of trees. June 1982 to June 1983 was Australia's Year of the Tree, and this has now been extended into the Decade of the Tree.

This Department hopes to communicate to the public a lot more than the general belief that trees are beneficial. The booklet's introduction explains that the values of trees (or shrubs) are especially high when the trees and shrubs are **local** — species that grow on the site naturally, or grew there before it was cleared.



The rest of the booklet provides information to farmers on restoring local vegetation, either by encouraging the natural regeneration of existing remnants of bush or by planting local trees and shrubs. The booklet describes how to collect seeds from trees and shrubs in the area, how to plant the seeds, and how to care for and plant the seedlings.

Encouraging regeneration, or growing trees and shrubs through one's own efforts, is much more rewarding than buying plants from nurseries: it is a way of learning about the species that grow in the area and their ecology.

Copies of the booklet are available, free of charge, from:

Extension and Publicity Office,
Department of Fisheries
and Wildlife,
Perth,
Western Australia 6000.
(Telephone (09) 325 5988)

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WILDLIFE DISTRICTS IN WESTERN AUSTRALIA