

THE LEEUWIN GROUP

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PROPOSED NATIONAL HERITAGE LISTING FOR 'THE KWONGKAN (SOUTHWEST AUSTRALIA)'

Executive Summary

The Kwongkan (Southwest Australia) extends from Shark Bay in the north to the western end of Great Australian Bight in the southeast and encloses a region of exceptional global biodiversity, which is under threat. With at least 8379 vascular plant species, 47% of which are endemic to the region; 230 bird species, 13 endemic; 230 reptile species, 54 endemic; 32 frog species, 27 endemic and 77 mammals, 16 also endemic, The Kwongkan strongly qualifies as one of the world's 35 biodiversity hotspots that are now threatened by exceptional loss of habitat. The Kwongkan has been nurtured and maintained over millennia by the Indigenous inhabitants, who depended on its richness for their survival but, since the arrival of Europeans, their custodianship has lapsed and been largely supplanted by agriculture and other developments. The Leeuwin Group is nominating all National Parks and Class A Nature Reserves within The Kwongkan for inclusion in the National Heritage List because of their outstanding heritage value to the nation. The proposed listing does not include private lands nor areas subject to mining, agriculture or forestry and will thus not impact on any current or proposed economic activity in the area. National Heritage listing will provide additional protection for, and raise the status of, The Kwongkan's National Parks and Class A Nature Reserves and their plants and animals.

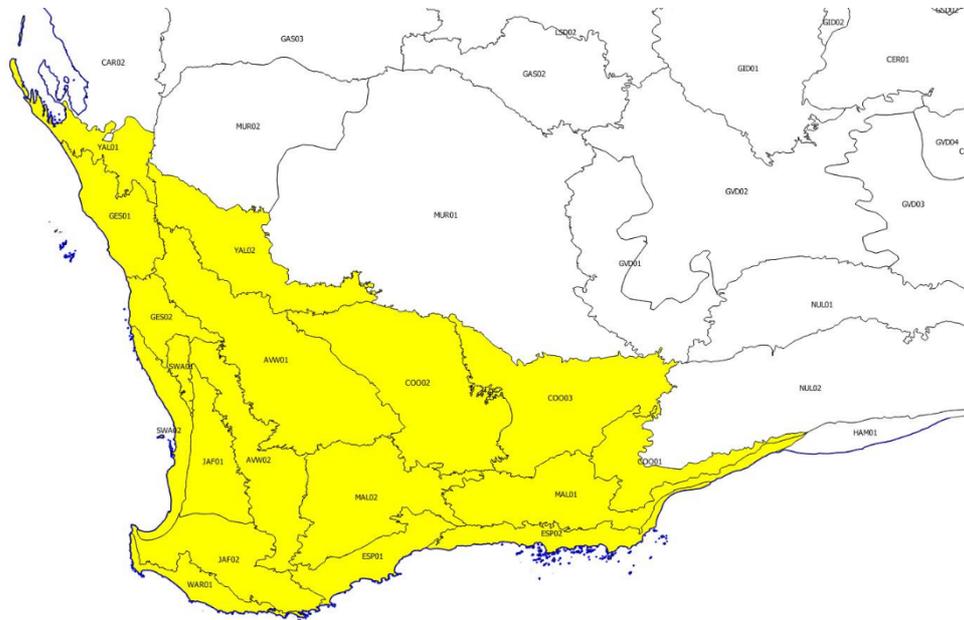
A global biodiversity hotspot

Southwest Australia is a global biodiversity hotspot. It was one of 25 in the world when the concept was proposed by Norman Myers (Myers 1988, 1990). The concept was further developed in partnership with Conservation International in 1999 in the book *Hotspots: Earth's biologically richest and most endangered terrestrial ecoregions* (Mittermeier *et al.* 1999) and published in the world's most prestigious scientific journal, *Nature*, in 2000 (Myers *et al.* 2000). Southwest Australia was the only Australian hotspot proposed by Myers *et al.* (2000). Mittermeier *et al.* (2005) in the book *Hotspots revisited. Earth's biologically richest and most endangered terrestrial ecoregions* proposed an additional nine hotspots, taking the total according to Conservation International to 34. 'Forests of Eastern Australia' was proposed as an additional global hotspot in 2011 (Williams *et al.* 2011), bringing the number to 35. Very few of the global hotspots are in nations with developed economies.

Global biodiversity hotspots are areas featuring exceptional concentrations of endemic species and experiencing exceptional loss of habitat. Myers *et al.* (2000) stated 'By concentrating on areas where there is greatest need and where the payoff from safeguard measures would also be greatest, conservationists can engage in a systematic response to the challenge of large-scale extinctions ahead' (p. 853).

'Kwongkan' is a Noongar word for 'sand' or 'sandplain' (Hopper 2014). Botanists use it for 'sandplain vegetation', as it is on these most severely nutrient-impooverished soils that we find the greatest plant biodiversity in south-western Australia (Lambers 2014). We are using the term 'The Kwongkan' to include the whole of the southwest of Western Australia from the western edge of Shark Bay to near Eyre, east of Esperance (Figure 1) in a similar way to the use in South Africa of 'Fynbos' to cover a region. Although kwongkan (also spelled kwongan) has been used for some time as a descriptor for sandplain shrublands, we are using 'The Kwongkan' to also include other vegetation types, including woodlands and forests, in which shrublands are widely embedded.

1. The



Kwongkan (Southwest Australia), based on bioregional boundaries

The Kwongkan as defined here is larger than the Southwest Australian Global Biodiversity Hotspot of 357 500 km² of which 70% is cleared (Sloan *et al.* 2014), as it includes areas often known as the South West Interzone just inland of the South West Australian Floristic Region (Hopper and Gioia 2004). Many of the endemic plants and animals of the southwest of Australia extend into this area, which also includes the unique 'Great Western Woodlands' that is largely uncleared. The Kwongkan comprises about 490 000 km².

To qualify as a global biodiversity hotspot a place must have at least 1500 endemic vascular plants and have 30% or less remaining of its original natural vegetation. The Kwongkan has at least 8379 vascular plants (species + subspecies), 47% (3911) of which are endemic to the Southwest Australian Floristic Region as recently updated (Gioia and Hopper 2017). Within The Kwongkan, about 15% is within protected areas. However, in the extensively-cleared wheatbelt the proportion is much lower: the Avon Wheatbelt bioregion has only 2.8% in protected areas and not all are Class A reserves.

Australia was once part of the ancient continent Gondwana, which began to break up more than 150 million years ago. The region that supports The Kwongkan's unique wildlife formed when India broke away from the supercontinent around 120 million years ago. While there are some young coastal sands and sand dunes, much of southwest Australia has been largely geologically quiescent for tens of millions of years. The Kwongkan (South West Australia) is therefore an ancient landscape with a relatively stable climate. It has not seen glaciers or ice for more than 250 million years. This has allowed species to evolve without the major extinctions seen elsewhere in the world. The region is about the size of the United Kingdom, which has about 1500 species of vascular plants (all plants except ferns and mosses), only a few of which found nowhere else. Contrast that with Southwest Australia, which harbours an astonishing number of vascular plant species, five times more than the UK, with 47% of which are found nowhere else in the world. Among these unique species is *Cephalotus follicularis*, the Albany pitcher plant, a carnivorous species that belongs to its own family and is not at all related to other carnivorous pitchers. Another iconic endemic is *Kingia australis*, a single species in an Order found nowhere else (to put this in context, an Order is the same level of classification as all butterflies and moths).

Driven by the combination of soils with a very low and highly variable nutritional status and moisture-holding capacity and an oceanically-buffered climate that features extended summer drought in a mix of ancient and young landscapes, the flora and fauna of The Kwongkan have evolved to exhibit incredible biodiversity, endemism, special adaptations and inter-species interactions of a nature and to a degree that are unique in the world (Hopper 2009; Lambers *et al.* 2014; Groom and Lamont 2015; Hopper *et al.* 2016).

Although globally rich across the Southwest Australian Floristic Region, The Kwongkan includes three traditionally recognised centres of plant biodiversity (the Fitzgerald River, Stirling Range and Lesueur National Parks), as well as novel centres only documented recently (Gioia and Hopper 2017), including the eastern Swan Coastal Plain and hinterland, districts centred on Cordering, Rocky Gully, Boxwood Hills, many other remnants in the wheatbelt and, to a lesser extent, the 'Great Western Woodlands' east of the cleared areas. Endemic animals

are distributed throughout The Kwongkan, but most of those animals that are Gondwanan relicts exist only on the higher-rainfall south coast and extreme south-west corner of the State.

Flora of The Kwongkan (Southwest Australia)

The rich diversity of The Kwongkan flora is primarily among its angiosperms (Gioia and Hopper 2017), especially woody families, the top ten including: Myrtaceae (1436 species/subspecies), Fabaceae (1156), Proteaceae (914), Orchidaceae (422), Ericaceae (362), Asteraceae (330), Cyperaceae (262), Goodeniaceae (231), Stylidiaceae (227) and Malvaceae (196). The importance of woody taxa is evident also in the ten largest genera: *Acacia* (Fabaceae; 530 species/infraspecies), *Eucalyptus* (Myrtaceae; 380), *Grevillea* (Proteaceae; 252), *Stylidium* (Stylidiaceae; 218), *Leucopogon* (Ericaceae; 209), *Banksia* (Proteaceae; 207), *Melaleuca* (Myrtaceae; 194), *Caladenia* (Orchidaceae; 178) and *Eremophila* (Scrophulariaceae; 123). Of these genera, only the herbaceous Triggerplants (*Stylidium*) and the geophytic orchid genus *Caladenia* constitute non-woody plants.

Phylogenetically significant endemics confirmed in DNA sequence studies include one monocot order (Dasypogonales) containing the genera *Dasypogon*, *Baxteria*, *Kingia* and *Calectasia* (one species occurs in Victoria's Gariwerd National Park outside The Kwongkan), all in just one family (Dasypogonaceae). Based on the latest global arrangement published by the Angiosperm Phylogeny Group (2016) another three families are also endemic or largely so to The Kwongkan – Cephalotaceae (*Cephalotus*, the Albany pitcher plant), *Emblingia* (Emblingiaceae) in the Brassicales, and the Ecdeiocoleaceae (*Ecdeiocolea* and *Georgeantha*), sister to the grasses, Poaceae.

Additionally, there are several other distinctive clades, some previously regarded as endemic families, for which The Kwongkan is renowned, including: Haemodoraceae subfamily Conostylidoideae (kangaroo paws and their relatives *Anigozanthos*, *Macropidia*, *Conostylis*, *Blancoa*, *Phlebocarya*, *Tribonanthes*); *Hopkinsia* and *Lyginia* (Restionaceae, previously in Anarthriaceae); *Eremosyne* (Saxifragaceae, formerly Eremosynaceae); *Nuytsia* (Loranthaceae); *Pilostyles* (Apodathanaceae); *Macarthuria* (Macarthuraceae); *Borya* (Boryaceae); *Byblis* (Byblidaceae); *Gyrostemon* and *Tersonia* (Gyrostemonaceae); the LAD clade (*Lechenaultia*, *Anthotium*, *Dampiera*) of Goodeniaceae; genera of Pomaderreae (Rhamnaceae) such as *Granitites*, *Blackallia*, *Stenanthemum*, *Cryptandra*, *Spyridium*, *Trymalium*, *Pomaderris*, *Siegfriedia*; *Nitraria* (Nitrariaceae); *Ornduffia* (Menyanthaceae); the remarkable aquatic sisters to the water lilies (*Trithuria*, Hydatellaceae), misplaced as monocots until 2007; *Drakaea*, *Spiculaea* and *Paracaleana* (Orchidaceae); and *Spirogardnera*, *Choretrum* and *Leptomeria* (Amphorogynaceae). Similarly, significant clades within the ten largest genera listed above are endemic or nearly so to The Kwongkan.

Local and regional endemics constitute 6% and 22%, respectively, of 1422 species investigated from plant communities of the Fitzgerald District (Cowling *et al.* 1994). Endemics are over-represented in species-rich families such as Proteaceae, Myrtaceae, Fabaceae and Ericaceae, and under-represented in Asteraceae and Orchidaceae. Endemics are virtually absent from younger landscapes such as relatively fertile coastal calcareous sand dunes, but, as expected, they constitute up to 30% of kwongkan communities on highly infertile quartzites and siliceous sands in the hinterlands.

Biologically, the narrow-range endemics are equally likely to be shrubs or graminoids in Fitzgerald River National Park. Such shrubs are of medium height; with soil or canopy-stored seed dispersed either by wind, vertebrates, ants, or ballistically in roughly equal proportion; and with estimated medium (10–100 m) to short (<10 m) seed-dispersal distances. No local endemics are recorded among tall shrubs (>2 m) or among woody shrubs lacking seed storage [such as *Billardiera* (*Sollya*) *heterophylla*, Pittosporaceae].

Molecular phylogenetic studies (reviewed in Hopper *et al.* 2016) and the discovery of fossils of extant genera such as *Banksia* (Proteaceae; Carpenter *et al.* 2016) and *Agonis* (Myrtaceae) as old as the early- to mid-Tertiary indicate great antiquity and stability of some contemporary plant lineages. The Kwongkan's high-latitude Eocene floras were conspicuously rich in families such as the Myrtaceae and Proteaceae, suggesting that a long history of speciation and slow extinction rates underpin the species richness of the flora (Hopper and Gioia 2004). Similar to contemporary kwongkan vegetation, the proportional representation of taxa in these Eocene communities varied over relatively short distances. Perhaps low dispersal capabilities of many components of The Kwongkan flora also have significant antiquity (Hopper and Gioia 2004; Hopper 2009).

Changes wrought on the The Kwongkan following European colonisation have profoundly altered most of its vegetation. The region now has more species of threatened plants than other Australian States and most countries of the world. Conservation issues include massive habitat loss and fragmentation, root-rot disease (*Phytophthora*) impacting 2500 species, displacement by ca. 1000 invasive weeds, and rising saline groundwater tables threatening 470 taxa. Climate change may also be looming as a concern, although the resilience of the flora thus far to a drop in rainfall since the mid-1970s and rising temperatures (see below) is noteworthy. Simple climatic envelope models predicting massive and rapid extinctions, although newsworthy, do not match observations. Much more experimental work on climatic thresholds is needed, as well as inclusion in predictive climate change models of microrefugia for which The Kwongkan is well known (Hopper and Gioia 2004).

There are also significant taxonomic impediments impacting on conservation efforts, associated with exceptional periods of collection and discovery recently unfolding. Gioia and Hopper (2017) documented an increase of 33% or 98 204 collections added to those in the Western Australian Herbarium and 744 (10%) additional taxa over the 11 year period from 2004-2015. Many more taxa remain to be described, and threatened taxa may be overlooked or not recognised depending on the species concept and taxonomic philosophy adopted (e.g., Hookerian taxonomic species based on herbarium studies versus Darwinian biological species based on multiple lines of field and experimental evidence bearing upon reproductive isolation in addition to morphological and geographical pattern).

Biological studies of threatened plants are slowly accruing, and unexpected discoveries in studies of taxa in The Kwongkan continue to surprise the botanical world (Lambers 2014; Hopper *et al.* 2016). Four examples are root adaptations to mine or scavenge phosphorus from infertile soils, the stimulus to seed germination provided by trace chemicals in smoke, the unusually high prevalence of pollination by birds, and non-flying mammals such as the marsupial *nyuarilpiiranqar* (noolbenger, Honey Possum (*Tarsipes rostratus*); Bradshaw 2014), and the remarkable biology of the long-misunderstood genus of small grass-like herbs of ephemeral pools and gnammas, *Trithuria*.

The Kwongkan's threatened endemic taxa (Hopper *et al.* 1990; Brown *et al.* 1998) are mostly woody perennials, one third of which are short-lived disturbance opportunists and obligate seeders after fire (e.g., species of *Acacia* and *Grevillea*). Perennial herbs feature prominently among the remaining threatened taxa, with orchids constituting more than half of these. Spring flowering occurs in two thirds of the threatened taxa, and 40% have flowers likely to be pollinated by birds and/or mammals (Hopper *et al.* 1990). This is almost three times the proportion (15%) of The Kwongkan's flora at large that is vertebrate pollinated.

Fauna of The Kwongkan (Southwest Australia)

The identification of The Kwongkan (Southwest Australia) as a global biodiversity hotspot was based on the extraordinary diversity and endemism of the vascular plants, although the region is also recognised for some of the largest and most significant temperate heathlands (kwongkan) and woodlands anywhere on the planet. Data on the fauna, however, did not contribute substantially to the identification of hotspots. Until recently, there was no comprehensive overview of the diversity and endemism of The Kwongkan's fauna. This was rectified by Rix *et al.* (2015), who analysed available datasets and reported on the biogeography and speciation of the terrestrial fauna, described levels of endemism and discussed the origin of the southwest's fauna.

Rix *et al.* (2015) concluded that the terrestrial and freshwater fauna of The Kwongkan includes a diverse range of taxa belonging to at least nine phyla: Annelida, Arthropoda, Chordata, Mollusca, Nematoda, Onychophora, Platyhelminthes, Rotifera and Tardigrada, of which Arthropoda, Chordata and Mollusca are the most conspicuous. Among vertebrates of the phylum Chordata, which are the best documented, there are c. 500 species.

The mammal fauna once comprised 77¹ species, 16 of them endemic to the region. Of these, 23 species no longer occur in the region and eight are extinct. Endemic species include the Honey Possum *Tarsipes rostratus*, which is classified in its own monotypic family. Some mammals, such as the Woylie *Bettongia penicillata*, Numbat (*Myrmecobius fasciatus*) and Chuditch (*Dasyurus geoffroii*), became 'new endemics', having disappeared from

1 Numbers of species and endemics provided here may differ a little from those in Rix *et al.* (2015), because the inland boundary of 'The Kwongkan' differs from that of their south-western land division of Western Australia and because of new data.

much of their former range, but persisted within The Kwongkan. Three other Australian species, once with widespread mainland distributions, survived only on Bernier and Dorre Islands, Shark Bay, at the northern end of The Kwongkan: Banded Hare-wallaby (*Lagostrophus fasciatus*), Western Barred Bandicoot (*Perameles bougainville*) and Djoongari or Shark Bay Mouse (*Pseudomys fieldi*). As well as the Honey Possum, the Quokka (*Setonix brachyurus*) is endemic at the generic level.

Of the more than 230 species of birds, 13 are endemic, including the threatened Noisy Scrub-bird, (*Atrichornis clamosus*), and two species of white-tailed black-cockatoos: Carnaby's (*Calyptorhynchus latirostris*) and Baudin's (*C. baudinii*). Other endemics include Red-capped Parrot (*Purpureicephalus spurius*), White-breasted Robin (*Quoyornis georgianus*) (both endemic genera), the critically endangered Western Ground Parrot (*Pezoporus flaviventris*), Red-eared Firetail (*Stagonopleura oculata*) and Red-winged Fairy-wren (*Malurus elegans*). There are also several endemic subspecies including the Forest Red-tailed Black-cockatoo (*C. magnificus naso*). Honeyeaters are diverse and often abundant in The Kwongkan and are important pollinators of many of the endemic plants.

Reptiles of The Kwongkan are exceptionally diverse. Bush *et al.* (2007), who documented a slightly larger area than The Kwongkan, list 230 species and subspecies: three species of freshwater turtles, 36 of geckoes, 19 of legless lizards, 28 of dragon lizards, 8 of goannas (monitors), 93 of skinks, 8 of blind snakes, four of pythons and 31 of elapid snakes. Endemism is high, with at least 54 species occurring nowhere else (Rix *et al.* 2015). Of particular note is the critically-endangered Western Swamp Tortoise (*Pseudemydura umbrina*), which represents a monotypic genus and subfamily of side-necked turtles of Gondwanan origin. Also notable among the reptiles are the legless lizards (Pygopodidae), almost all of which are restricted to Australia; one genus (*Pletholax*) and several species being endemic to The Kwongkan, and the number of fossorial (sand-swimming) species occurring in the sandplains.

Frogs, while not diverse, show a very high degree of endemism, with 27 of the 32 species occurring nowhere else (Rix *et al.* 2015). They include highly-specialised species such as the Sunset Frog (*Spicospina flammocaerulea*), the Turtle Frog (*Myobatrachus gouldii*), and other specialised burrowing species such as *Arenophryne rotunda* and *A. xyphorhyncha*. There are many cases among vertebrates where genera with species in southeast Australia and southwest Australia have more species in The Kwongkan; an example is the frog genus *Geocrinia*, with five of the seven species in the high-rainfall extreme southwest, some with very small geographic ranges. The White-bellied Frog (*Geocrinia alba*) has an extremely limited distribution over no more than 130 km² with an area of occupancy of less than 2.5 km² in the Margaret River region, and is listed as Critically Endangered. There are only 15 known subpopulations, comprising about 2230 adults of the closely-related Vulnerable Orange-bellied Frog (*G. vitellina*), which is confined to a 6.3 km² area located along six creeklines that drain into the Blackwood River. The species has an area of occupancy of only 8 ha (Department of Parks and Wildlife 2014).

The freshwater fish fauna is not diverse; however, of the 10 species that occur in the southwest, eight are endemic. One very unusual species is the Salamanderfish (*Lepidogalaxias salamandroides* an endemic monotypic genus and family), which can aestivate during summer (Pusey 1989), as can the Black-striped Minnow (*Galaxiella nigrostriata*). Both species are threatened by the drying climate (Ogston *et al.* 2016).

Most invertebrate groups are poorly documented. However, for those that are relatively well-known, it is clear that in many groups there is both high species diversity and high endemism, including orthopteroid insects (cockroaches, earwigs, praying mantises, crickets, grasshoppers, stick insects, etc.), mygalomorph spiders, harvestmen, bothriembryontid snails, onychophorans (velvet worms), millipedes and some other groups (Rix *et al.* 2015). Some examples follow.

Mygalomorph spiders (trapdoor and funnel-web spiders) are an ancient group of spiders that are very diverse and with very high endemism in The Kwongkan (Main 1957). Amazingly, in a tiny reserve near the wheatbelt town of Durokoppin, 23 species of mygalomorphs from six different families occur in an area of only 0.25 km². Barbara York Main, who has long studied these spiders, explains the richness as the consequence of ancient relictual taxa occurring coincidentally with later-derived species (Main 1996, 1987). The newly-described mygalomorph spider genus *Bertmainus* comprises seven species restricted to the wetter southwest corner of The Kwongkan (Harvey *et al.* 2015). An isolated population of the 'type race' of a Kwongkan trapdoor spider, *Aganippe raphiduca*, is found on the steep southeast-facing cliff of Mount Eliza in the Perth CBD, in matriarchal clusters, often spread over a large area where more than 160 individuals can be found in 400 m². This habitat is also home to a relictual population of the land snail *Bothriembryon indutus* with Gondwanan affinities (Main and Main 1991). Snails of the genus *Bothriembryon* are found only in Australia, where they constitute a remarkable element

of the fauna in the southwest of Western Australia. Approximately 90% of the species occur in The Kwongkan, all belonging to the family Bulimulidae, which is very diverse in South America and also found in Central America, New Zealand and islands of the western Pacific, but not in Africa or Asia.

The three species in the harvestman genus *Karripurcellia* are endemic to a small area of the Warren bioregion surrounding Pemberton (Giribet 2003). The closest relatives of *Karripurcellia* are found in New Zealand.

Six native millipede orders are present in southwest Australia with 87 species in five families and 14 genera. Moir *et al.* (2009) showed that the region of highest endemism is the eastern Stirling Range; other hotspots of millipede endemism are Cape Le Grand, Cape Arid, Walpole and the Porongurup Range. Millipedes of the genus *Antichiropus* have clearly undergone a major endemic radiation throughout the region, with over 150 species known (Rix *et al.* 2015)

A survey of the terrestrial invertebrates of the South Coast Natural Resource Management (NRM) region (Framenau *et al.* 2008) revealed 176 species in 65 genera, with many short-range endemics including velvet worms (100% of species), bugs (83%), millipedes (80%), araneomorph spiders (70%) and mygalomorph spiders (63%). Although short-range endemic invertebrate species were found along the whole South Coast NRM region, the areas of highest concentration of species occur in karri *Eucalyptus diversicolor* forest, isolated granite outcrops and on mountain peaks.

Hundreds of species of native bees have been documented, with more species being discovered. The family Colletidae is especially diverse in The Kwongkan with a number of endemic generic-level groups. An outstanding colletid that was named and described in 2012 is the Megamouth Bee (*Leioproctus muelleri*). Discovered only two years earlier in an outlying suburb of Perth, the species is remarkable for the massive head and jaws of the males, which fight for control of active nest burrows. Bizarrely, females excavate their burrows in claypans that are under water during winter and spring. Many solitary bees exhibit strong plant preferences and they provide vital pollination services to their host plants (Phillips *et al.* 2010; Houston 2014). Many remarkable cases of specialisation have been found among the bees of The Kwongkan: notable examples are the smoke-bush bees (*Leioproctus conospermi* species group) that mimic the hoary flowers they visit, the One-sided Bottlebrush Bee (*Euhesma tubulifera*) that has a unique 'drinking straw', and the oil-ingesting bees (*Euhesma morrisoni* species group) associated with feather-flowers *Verticordia* species.

Most species of jewel beetles (family Buprestidae) in The Kwongkan belong to the genera *Temognatha*, *Castiarina* (Barker 2006) and *Melobasis*. Adult jewel beetles feed on the nectar of native flowering plants during the day, and can be seen in their thousands at particular times of certain years. Very little is known of the larval stage of most species other than that they bore into native plants. As many are large and spectacularly coloured, they are prized by collectors and have been gazetted as specially-protected fauna in Western Australia since 1978, and cannot be legally collected without a scientific permit.

Looking much like dung-beetles, the earth-borer beetles are prodigious burrowers with powerfully-developed forelegs. Their diggings are a conspicuous feature of sandplains in The Kwongkan. Unlike dung beetles, adult earth-borers feed on fruiting bodies of underground fungi (native truffles), while the larvae appear to subsist on very little at all (maybe soil bacteria or humus). By dispersing the spores of mycorrhizal fungi (those that form symbiotic associations with plant roots), the beetles may play an important role in maintaining the health of The Kwongkan flora. About 60 species of butterflies occur in The Kwongkan as well as 24 species of sun-moths; 35 species of butterflies and five of sun-moths have been recorded in urban vegetation remnants in the Perth metropolitan area (Williams 2009)

A comprehensive survey of aquatic invertebrates in the wheatbelt (excluding the higher-rainfall southwest corner of The Kwongkan) revealed nearly 1000 species with a little over 200 of these being endemic. Many of the endemic species occupy naturally-saline habitats, but freshwater habitats (many of which have degraded or are under threat) are important (Pinder *et al.* 2004). The same survey revealed 774 species within 39 families of ground-dwelling araneomorph spiders (Harvey *et al.* 2004), with a high degree of endemism; included were 121 species of salticid spiders, with a high proportion of apparently localised and endemic species (Guthrie *et al.* 2004) and 117 species of zodariid spiders, with many short-range endemic species (Durrant 2004).

The wetter southwest corner harbours numerous endemic aquatic invertebrates, many with Gondwanan affinities. For example, the freshwater crayfish genus *Engaewa* comprising five species is endemic (Horwitz and Adams 2000), and all species are short-range endemics; three species are highly localised, with one, *E. pseudoreducta*, known only from a single swampy headwater that is severely modified (Harvey 2002).

Threatened and rare species

Mostly because of the extensive clearing for agriculture, but also because of other threats such as plant disease caused by the water mould *Phytophthora cinnamomi* and other *Phytophthora* species, and by weeds (Coates *et al.* 2014), The Kwongkan includes many threatened and rare species of plants. The most recent official Western Australian list includes 164 plant taxa as Critically Endangered, 123 as Endangered and 138 as Vulnerable. Fifteen plant taxa are listed as Extinct. The vast majority of these listed plants occur in The Kwongkan (Hopper *et al.* 1990).

Many animal species are also listed as threatened in Western Australia: 49 as Critically Endangered, 47 as Endangered and 149 as Vulnerable. As with plants, the majority occur in The Kwongkan; however, because of the widespread nature of some threats, such as predation by introduced Red Foxes and feral Cats, a higher proportion of listed animals compared with plants occurs outside The Kwongkan.

As well as the official lists of threatened species, the Department of Parks and Wildlife maintains lists of 'priority flora' and 'priority fauna'. These are taxa that are possibly threatened that do not meet adequacy of survey criteria, or are otherwise data deficient. Currently there are several thousand such taxa; most occur in The Kwongkan.

A non-statutory process has been in place to list Threatened Ecological Communities; however, the *Biodiversity Conservation Act 2016* provides for statutory listing, but this is yet to occur. As at October 2016, there were 102 unofficially listed Threatened Ecological Communities, all but 16 of these are located in The Kwongkan. In addition, at November 2016, more than 400 Priority Ecological Communities had been identified, of which about 140 are within The Kwongkan. A few of these are listed under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999*.

Cultural heritage

Over the 50 000 years of their occupation of The Kwongkan (Allen and O'Connell 2014), the Noongar and adjacent Nhandu, Yamaji, Wongi and Nadju people developed understandings of and cultures relating to The Kwongkan that have few recorded parallels elsewhere in the world. The nearest analogous extant cultures are South Africa's Khoisan. Moreover, as evidence increasingly points to the origin of our own species in small climatic refuges along the southern coastlines of South Africa some 200 000 years ago (Marean *et al.* 2010), the importance of understanding and conserving Aboriginal lifeways associated with The Kwongkan has a personal relevance to each and every one of us alive today (Hopper *et al.* 2016).

The Noongar nation comprises a rich diversity of dialect groups, bands and clans (Figure 2) covering most of the geographical extent of The Kwongkan.

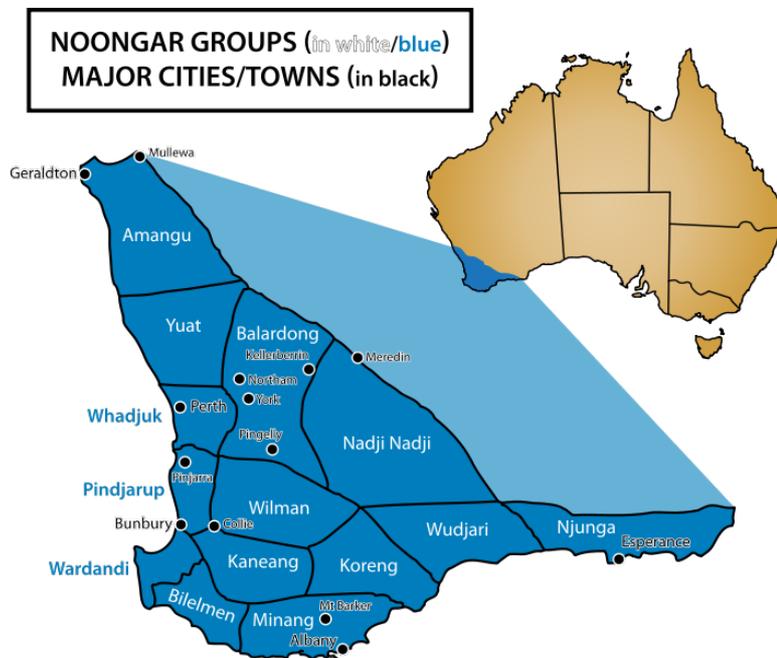


Figure 2. Map of Noongar dialect groups in southwest Australia, based on Tindale's (1974) classification (from <http://whadjukwalkingtrails.org.au/noongar-information/>)

The word 'kwongkan' is of Noongar origin, from *k/quayar* = sand or sandy, ... *ang* = from, of, and *k/qaan* = to be clear, light, bright, enspirited (von Brandenstein 1988; Hopper 2014). Kwongkan is therefore loosely translated as meaning sandplain, or open vegetation where the sun hits the sand, or where the sand becomes clear and enspirited. The word was widely applied across Noongar *boodja* (country), as well as by some clans of the adjacent Wongi and Nadju people who lived in the Great Western Woodlands (Figure 3).

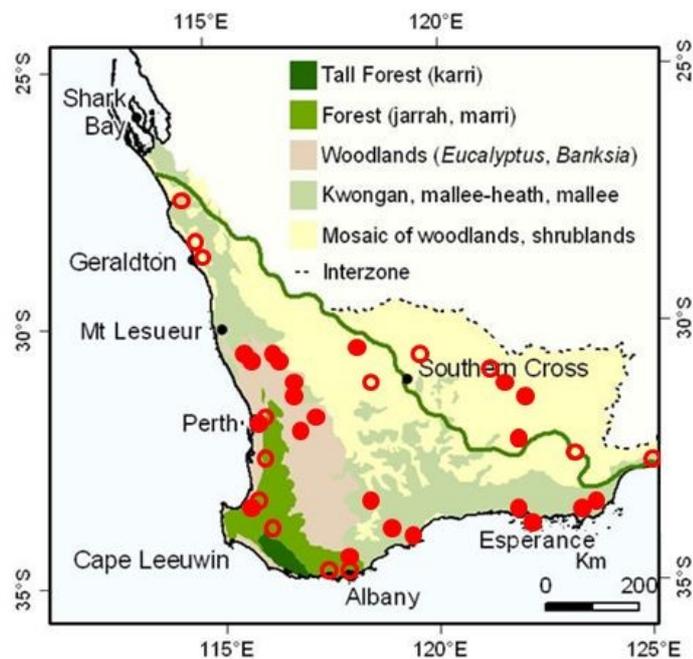


Figure 3. Places where the term 'kwongkan' or similar was recorded in Aboriginal dialects (red dots) or another word for sandplain heath was applied (red circles). Base map is derived from John Beard's (pers. comm. 1978) vegetation mapping. From Hopper (2014).

Noongar people traditionally traversed country on a six-season cycle for various reasons, sacred and profane (Robertson *et al.* 2016), in a similar manner to that described and mapped for the Spinifex people of the Great Victoria Desert (Cane 2002). Archaeological survey and Noongar oral tradition indicate that preferential camping was and is undertaken during the six seasons for sites on relatively young landforms, close to freshwater,

with fertile soils supporting abundant game and staple plants such as geophytes. Kwongkan sites were and are visited for special resources such as acquiring the nutritious underground structures of youaq (*Platysace maxwellii*), mearn (*Haemodorum spicatum*) and kwerding (*H. discolor*). Mining of rock (e.g., dolerite, quartz) for toolmaking occurred on granite outcrops, which also offered slabs of sheet rock suitable for constructing karda mia (lizard traps), a unique Noongar invention (Murray 2015).

Integral to travelling across country is the day by day, moment by moment celebration and connection with ancestral spirits, invoked through the use of language and human movement. Every place, process, animal, plant and star or constellation has its own stories, song, dance and artwork (Noel Nannup, pers. comm. 2015). The enspirited world of Noongar culture revolves around three central elements – boodja (country), moort (family) and katadjin (knowledge), which provide a cosmology that embraces personal responsibilities and lifeways honoured by all (Collard and Harben 2010).

The elevated uplands of kwongkan sandplain, laterite gravel and granite outcrops are especially important for ceremonies, public and secret. The initiation of young men and women traditionally followed song-lines across country which are still known and utilised (e.g., Nannup 2008; Nannup Karda 2006). One such beedawang (initiation journey) starts in Perth and travels eastward to Yorkrakine Rock, where the ancestral spirit women first stood up after the great spirit snake (Waarkarl) had created the landforms and waterholes of Noongar territory.

The songline then follows salt lake systems and granite outcrops to the southeast ending up at Kaatakitch (Wave Rock near Hyden), where Noongar people first became real and significant events relating to ancestral spirits unfolded, embracing connections to boodja and the sky (e.g., where spirit woman trampolined into the night like a spear and became the Milky Way – Nannup Karda 2006). Language and lore were transferred to Noongars, and the importance of knowledge of country was everywhere reinforced as initiates and their elders returned to Perth. Thus, regular connection with significant kwongkan landforms such as granite outcrops and lateritic hills in these travels is central to Noongar cosmology. These landforms are truly sacred, equivalent to churches and mosques for monotheistic religions.

Noongars also maintained intimate understandings of animals and plants of The Kwongkan (e.g. Abbott 2009; Hopper and Lambers 2014). Their system of totemism (von Brandenstein 1977) ensured responsibilities for caring for species, involving totemic rites, changing food prohibitions through life, and the incorporation of totems as guiding representations for marriage moieties (sometimes referred to as skin groups). For example, most Noongars were assigned to two primary marriage divisions – wardang (Australian raven) or manitch (White Corella). A wardang man could only marry a manitch woman and vice versa. Within each of the primary moieties, further subdivisions relating to animals or plants refined the system of permissible marriages. Totems were also assigned to individuals, at birth, through membership of families, clans and bands, and through personal choice.

Perhaps the most significant persisting source of information about Noongar connections to The Kwongkan is in their languages – names for places (Collard *et al.* 2015), animals and plants, and especially words for the proper (and inappropriate) interactions with the lived enspirited world (von Brandenstein 1988). Like most Aboriginal languages, Noongar is rich in verbs and relatively poor in nouns compared with English. Life was lived and involved doing, interacting with ancestral spirits and their living representatives, much more than objectifying, and Noongar languages reflect this world view.

Consider, for example, two names recorded for one of The Kwongkan's most distinctive eucalypts - *E. macrocarpa*. This is a sprawling to upright sinuous-trunked mallee or muert, long-lived and multistemmed due to resprouting from a woody underground lignotuber. It has very large broad white leaves, disc-like to pyramidal woody nuts and the largest flowers known in the genus, each with hundreds of bright red stamens. Early colonists travelling with Noongar guides east of Perth wrote the name of *E. macrocarpa* as mottlecah or balwonga (Moore 1884). Modern linguists, however, clarified that 'mottlecah' should read as the word 'martilgarang' (Douglas 1974), which translates literally as hand-leaf-anger/passion/rage/scorn. It is perhaps best paraphrased as meaning the angry-spirited eucalypt with hand-sized leaves. Seeing this muert appear in low kwongkan heath as a mass of large white leaves with big blood-red flowers, especially at night, undoubtedly set Noongar hearts pumping, as the colour white is associated with death and dead people. Modern Balardong Noongar elders have given the name of the eucalypt as 'maragah' or similar (M. Griffiths, pers. comm. 2007), which appears to be simply a contraction of martilgarang.

Balwonga is such a different word to martilgarang, literally meaning don't!/leave it!/finish with! - speak. Probably, when asked 'what is that distinctive plant?' by Moore (1884), Noongar guides simply said 'do not touch

or speak to it', concerned that the angry-spirited eucalypt would wrought harm on their small party for such disrespect.

The richness of Noongar place names (Collard *et al.* 2015) similarly embraces respect for, and seamless interaction with, the spirit world. Moreover, the view that language was given to people through ancestral country speaking to them is evident to Noongars (Nannup Karda 2006; Robertson *et al.* 2016). Consider, for example, two of the largest granite outcrops of The Kwongkan found in Peak Charles National Park – Peak Charles and Peak Eleanora – to the northwest of Esperance. These were named by Surveyor General John Septimus Roe in 1842 for the then Governor of the Swan River Colony Charles Fitzgerald and his wife Eleanora. Unbeknown to Roe, Noongars had long ago named the peaks Kardutyaanap, from kord = spouse/ partner, koodjal = two, tyaa = mouth, ..anj.. = was, and ..ap = related to, having become. This might be paraphrased as two talking ancestral spouses. The fact that Roe named the two granite peaks for a married couple is, to Noongars, no coincidence. Kwongkan country was speaking to him, and he was receptive to its teaching.

The eloquence of Noongar word-smithing, perhaps not unexpected given 50 000 years of occupation of The Kwongkan, is also seen in animal names and descriptions of burnt country. Consider, for example, the name given to The Kwongkan's most iconic mammal, the Honey Possum (*Tarsipes rostratus*). Recorded by colonial collectors and ethnologists as ngulbungur (Moore 1884) or ngoolboongoor (Grey 1840), subsequently Anglicised to noolbenger, today's linguists render the animal's name as nyuarilypiiranqar, translated as nyuarilyu = narrow/tight, piiran... = squeeze, and q/kaar = plural suffix. Hence a meaning is 'the one which squeezes itself tight (into blossoms)' (von Brandenstein 1988), allusions beautifully capturing the foraging behaviour of this slender-snouted nectarivore.

Noongars applied fire to The Kwongkan in sophisticated ways, requiring a more refined language for such activity than English provides. Country and various stages in the burning cycle are named firstly bokyt – covered in vegetation yet to be burnt - from boka, the kangaroo skin covering or cloak used for warmth in winter (Moore 1884). Then there is narrik (dry country ready to burn), narrow (to burn slightly), naariny, naarinj (burning), naaranany (keep burning), nappal (burned ground over which fire has passed), and kundyl (young grass coming up after fire).

Noongar uses and stories of prominent plants of The Kwongkan are summarised by Hopper and Lambers (2014), who include accounts of the distinctive Christmas tree moodgar (*Nuytsia floribunda*), the diversely useful grasstrees balga (*Xanthorrhoea preissii*) and paalaq (*X. platyphylla*), mearn and allies with red edible bulbs (*Haemodorum* spp.), the delectable native potato youaq and its relatives (*Platysace* spp.), and the toxic but detoxifiable red-coated seeds (pauyin) of the palm-like cycad djirjii (*Macrozamia* spp.). Noongar names for kwongkan birds, many of them strikingly onomatopoeic, are treated by Abbott (2009).

Accounts of other Kwongkan Aboriginal groups bordering Noongar territory reveal glimpses of similar lifeways, albeit with their own languages, stories and connections with the spirit world (e.g., Oldfield's (1985) account of Nhanda people in the Kalbarri National Park region). Of especial interest in the Great Western Woodlands kwongkan context are papers on Nadju culture and language (von Brandenstein 1980; Prober *et al.* 2013, 2016).

As occurred elsewhere in Australia, Noongar contact with European explorers and settlers is a tale of decimation, disease, displacement from land and waters, cultural suppression, stolen children, and successive failures and rare successes in social integration. These issues remain of great concern to this day. Yet Noongars survive and their cultures remain vibrant and increasingly celebrated. Noongar authors are now telling their own stories, including the remarkable convergence of traditional wisdom with the recent discoveries of western scientific research concerning The Kwongkan and its origins (Robertson *et al.* 2016). Many beautifully illustrated bilingual books by Noongar authors and artists are now available in which kwongkan features prominently (e.g., Kickett 1995; Nannup Karda 2006; Knapp 2011).

The Kwongkan features a rich and diverse settlement history through to contemporary times. Bunbury (2016) provides a recent treatment, focussing on land use and understanding. The South West Native Title Settlement was concluded between the Noongar people and the Western Australian government in June 2016. The earliest possible commencement of the Settlement is proposed for mid-2017 with the establishment of the Noongar Boodja Trust, followed by the appointment of the six Noongar Regional Corporations. Under the agreement, cooperative and joint management arrangements will be put in place for the conservation estate in

the south west. Public access to national parks and nature reserves is not affected. Further information can be found at <https://www.dpc.wa.gov.au/lantu/south-west-native-title-settlement/Pages/default.aspx>.

Recently, the Federal Court found that the settlement could not be registered because some Aboriginal 'named applicants' refused to sign the agreement. The Western Australian government has stated that it is working to ensure that the agreement proceeds.

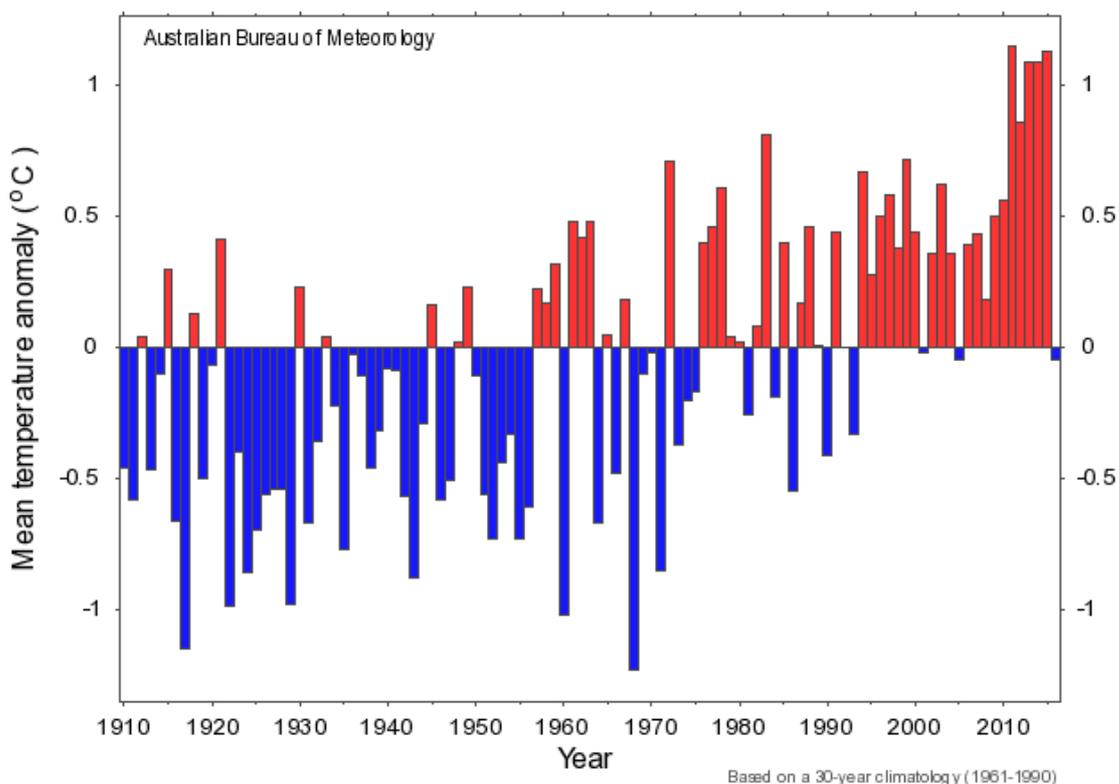
Climate change

The changing climate of the southwest has been well documented, in part through the research efforts of the Indian Ocean Climate Initiative, a collaboration formed in 1997, of the State, the Bureau of Meteorology and CSIRO (<http://www.ioici.org.au/>). This has documented the general warming and drying of the region, and linked these changes to the intensification and poleward movement of the mid latitude high pressure belt, a phenomenon now observed around the southern hemisphere and believed to be related to the global warming trend. How these change will likely progress through the rest of this century has been examined as part of the Australian Government's study of National Resource Management regions, Climate Change in Australia, (<https://www.climatechangeinaustralia.gov.au/en/publications-library/technical-report/>) and in particular for the southern and southwest regions by Hope *et al.* (2015).

The impost of a changing climate on fauna and flora is complex, relating to the range of potential climatic characteristics such as rainfall, runoff, temperature, extreme events (daily, seasonal and inter-annual variations, storms), evaporation, cloudiness, humidity and sea level, all interacting with the likewise complex and dynamic nature of ecosystems. As a result, existing knowledge will rarely provide reliable predictive power in terms of anticipating impacts on individual or groups of species. Often the impost will be only apparent after the fact. This is perhaps one of the main reasons why mitigative action on climate change is so important; the likely, long-term commitment, yet poorly defined consequences for natural ecosystems.

Annual mean temperature anomaly - Southwestern Australia (1910-2016)

Figure



http://www.bom.gov.au/climate/change/#tabs=Tracker&tracker=timeseries&tQ=graph%3Dmean%26area%3Dswaus%26season%3D0112%26ave_yr%3D0

The Kwongkan has experienced climatic drying since the mid-1970s (Ogton *et al.* 2016), with the total rainfall declining by 10 to 50 mm per decade (~16% overall reduction), causing annual stream flows to decline by

~50% (Petrone *et al.* 2010). Mean annual air temperature has also increased between 0.10 and 0.30 °C per decade over that period (Figure 4), resulting in faster rates of evaporation from surface waters (<http://www.bom.gov.au/climate/change/>). The drying climate and increasing temperatures have greatly affected runoff with an amplified effect on wetlands, stream and stream-flows. For example, the flow into Perth dams has declined from an average of 338 GL/yr during 1911-1974 to 177 GL/yr in 1975-2000, to 93 GL/yr in 2001-2005 and to 66 GL/yr in 2006-2012 (Figure 5, Water Services Association of Australia 2013). Similar effects on rivers, streams and wetlands are widespread in The Kwongkan.

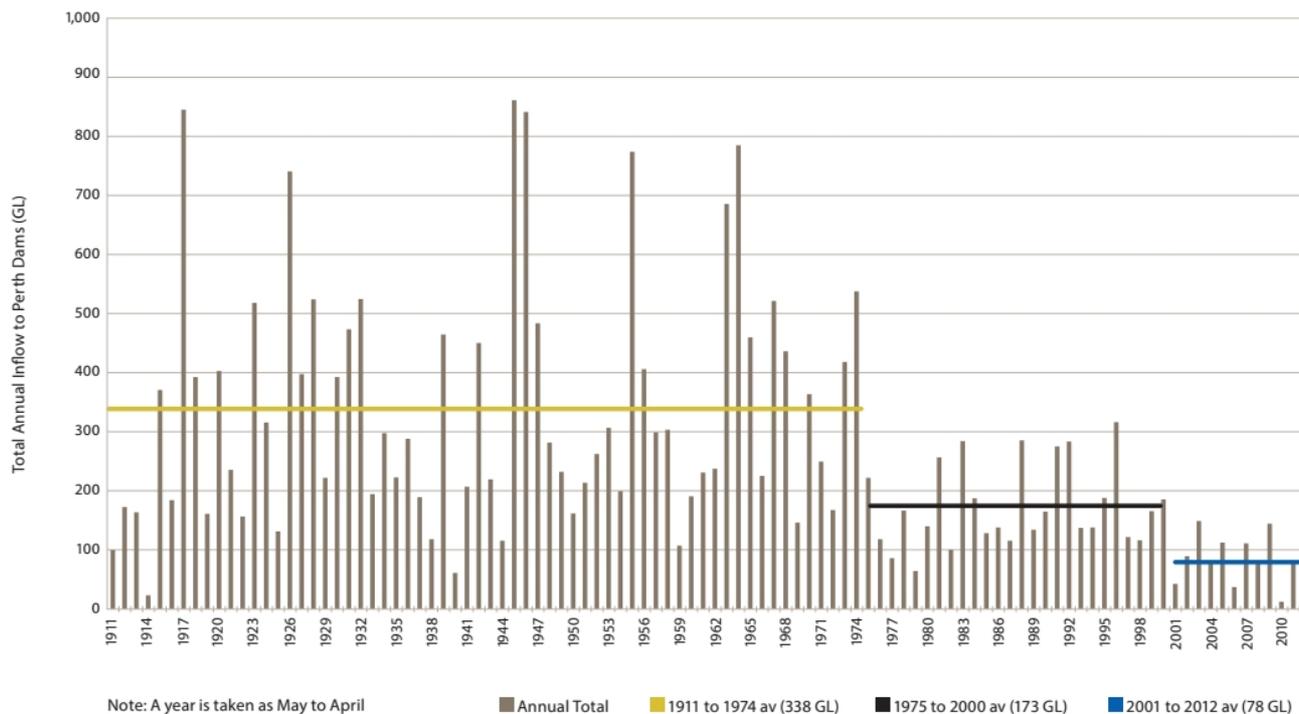


Figure 5. Total annual streamflow into Perth dams (GL); from WSAA (2013)

The Western Ringtail Possum (*Pseudocheirus occidentalis*), recently declared as critically endangered, is one species being affected by climate change as it requires high nutritional-quality food, mainly leaves from myrtaceous trees such as the WA Peppermint (*Agonis flexuosa*), to be able to breed and raise young successfully. In low rainfall years, poor-quality forage has significantly affected recruitment, a threat on top of others such as land clearing for urban development, and predation by feral Cats and Red Foxes (Department of Parks and Wildlife 2014; unpublished information provided to the WA Threatened Species Scientific Committee 2016).

Projections of climate change for the region indicate a further reduction (up to 20%) in mean annual rainfall and further warming (0.5 to 1.3 °C) by 2030 (Suppiah *et al.* 2007). Moreover, large reductions in fresh groundwater levels (>10 m in some areas) are also projected to occur (Barron *et al.* 2012). These changes have affected and will affect the biota, making the protection and management of the remaining vegetated parts of The Kwongkan even more important.

National Heritage listing

The areas proposed by The Leeuwin Group (www.TheLeeuwinGroup.org.au) for inscription on the National Heritage List are restricted to those treasured remnants that are currently included in National Parks and Class A Nature Reserves scattered across the former range of these vegetation types, where the highest level of protection (National Park or Class A Reserve) has been provided via legislation and where Western Australian Parliamentary approval is required before any development, including mining, can occur. These areas are listed in Appendix 1, which includes 1362 separate reserve numbers with a total area of 5 854 274 ha. Note that some National Parks and Class A Nature Reserves include more than one reserve number, so the total number of separate parcels of land is less than 1362. While some of the nominated reserves are relatively small, it is well

documented that even very small remnant bush areas in The Kwongkan can be of very high biodiversity conservation value (e.g., Kitchener *et al.* 1980).

The opportunity exists to add privately-owned land, where the owner wants their remnant bushland included, as well as reserves vested in other authorities.

Western Australia has a long history of declaring National Parks and Nature Reserves and that initiative should be recognised. In The Kwongkan (Southwest Australia) there are 79 named National Parks (as well as four small unnamed ones), 867 named Class A Nature Reserves and 907 unnamed Class A Nature Reserves.

The Leeuwin Group proposes that these parts of The Kwongkan be nominated for National Heritage and, if successful, consideration be given at a later date to nomination as a World Heritage Property. Our proposal is aimed at enhancing national and international recognition of the biodiversity and tourism values of The Kwongkan as well as enhancing the conservation of The Kwongkan's biodiversity. It is designed so that listing does not conflict with existing industries, including mining, agriculture and forestry. As the coverage of this proposal is confined to existing National Parks and Class A Nature Reserves, it will have no impact on privately-owned farming land or mining tenements.

Inscription of The Kwongkan as a site (or sites) on the national and, possibly, subsequently on the World Heritage List, would help preserve the existing significant remnants of the previously vast, biodiverse Kwongkan, and focus attention on the unique, fascinating and invaluable features of this region that will make it a high priority for sustainable management, tourism and scientific research.

While the majority of The Kwongkan has been cleared for agriculture or otherwise alienated, some of the remnants that are the subject of this proposal are small, isolated and fragmented and a number of plant and animal species have been rendered extinct within the region, two of the features of The Kwongkan that make it unique act to allow key features of the ecosystem to be conserved, even in quite small areas. The high degree of endemism and many species with naturally-small distributions (often known as 'short-range endemics') in the flora and fauna of The Kwongkan means that, with appropriate protection and management, species have persisted and can continue to persist in low numbers in small areas.

Currently, there are seven Western Australian terrestrial natural areas on Australia's National Heritage List: Lesueur National Park, Porongurup National Park, Purnululu National Park, The Ningaloo Coast, Shark Bay, Stirling Range National Park and The West Kimberley. The Dampier Archipelago (including Burrup Peninsula) is listed primarily due to its rock art. Lesueur National Park, Porongurup National Park and Stirling Range National Park lie within this proposal. Kings Park is also on the national heritage list.

Currently there are 10 Australian terrestrial natural areas inscribed on the World Heritage List; those outside Western Australia are: Wet Tropics of Queensland, Tasmanian Wilderness, Kakadu National Park, Fraser Island, Macquarie Island, Greater Blue Mountains area, Tasmanian Wilderness and Gondwana Rainforests of Australia. The last of these comprises some eight main properties and about 20 lesser reserves spread from south-eastern Qld to the central coast of NSW, so our proposal of listing reserves within a larger area is not without precedent. Three areas in Western Australia are inscribed on the World Heritage List for their natural values: Purnululu National Park, Ningaloo Coast and Shark Bay. The 'Universal Values' of The Kwongkan are at least the equal of any of these. The only World Heritage Property within The Kwongkan is a part of Shark Bay.

National Heritage listed places are protected by Australian Government laws and special agreements with state and territory governments and with Indigenous and private owners. Places on the list are protected under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act), which requires that approval be obtained before any action takes place that could have a significant impact on the national heritage values of a listed place. This provides a level of protection similar to that provided under Western Australian legislation.

Nominations must set out the qualities or values of the place that makes it outstanding to the nation by indicating how the place meets one or more of the nine heritage criteria. The Leeuwin Group firmly believes that the areas to be included in our nomination would meet several of these criteria, especially noting that some southwest national parks are already listed. Nominations are assessed by the Australian Heritage Council (AHC), comprising seven people appointed by the Commonwealth Minister for the Environment, with the decision whether to list being made by the Minister. The AHC has published guidelines for the assessment of places for the national heritage list.

Of the nine criteria, it is our view that the elements of The Kwongkan that we propose to nominate would meet at least four:

- I. the place has outstanding heritage value to the nation because of the place's importance in the course, or pattern, of Australia's natural or cultural history
- II. the place has outstanding heritage value to the nation because of the place's possession of uncommon, rare or endangered aspects of Australia's natural or cultural history
- III. the place has outstanding heritage value to the nation because of the place's potential to yield information that will contribute to an understanding of Australia's natural or cultural history
- IV. the place has outstanding heritage value to the nation because of the place's importance in demonstrating the principal characteristics of:
 - i. a class of Australia's natural or cultural places; or
 - ii. a class of Australia's natural or cultural environments.

The Leeuwin Group is nominating all National Parks and Class A Nature Reserves within 'The Kwongkan (Southwest Australia)' for inclusion in the National Heritage List. A substantial number of relevant groups and individuals have already indicated to support a proposal for heritage listing and indicated willingness to contribute to its preparation. Amongst the groups indicating (preliminary) support are WA Conservation Council, WWF-Australia, the WA Wildflower Society, and several WA Naturalists Clubs. Clearly, the widest support possible is desirable with a particular emphasis on community organisations based in The Kwongkan region.

As the proposed listing does not include private land or areas subject to mining, agriculture or forestry, there will be no impact on current or proposed economic activity. We anticipate that if and when The Kwongkan receives World Heritage listing, there will be a significant increase in international tourism, if this fact is appropriately used in marketing, as has happened for the Greater Blue Mountains World Heritage listed site.

Conclusion

The recognition of the values of The Kwongkan (Southwest Australia) that would come from inscription of its National Parks and Class A Nature Reserves on the National, and possibly subsequently the World Heritage List, would encourage Western Australians to take a greater interest in the southwest of their State and its conservation. The small size and scattered nature of many of the publicly-owned reserves that are covered under this proposal mean that local communities could make a significant contribution to the preservation and management of reserves in their immediate vicinity, and benefit from tourism if marketed in the right manner. National and international recognition that would come from National Heritage Listing can be expected to greatly increase the number of visitors wanting to visit the area to view and learn about its biodiversity.

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Appendix 1. List of all National Parks and Class A Nature Reserves in ‘The Kwongkan (Southwest Australia)’.

See attached file National Parks & Class A Nature Reserves_area in The Kwongkan