2022 LINNEAN SOCIETY OF NSW NATURAL HISTORY FIELD SYMPOSIUM

Natural History of the Northeastern Sydney Basin

Covering Geology, Geomorphology, Soils, Flora, Fauna and Aboriginal Cultural Occupation

With a special focus on the proposed Ku-ring-gai GeoRegion

17th November (presentations) & 18th November (field excursion)

Program, Abstracts and Field Guide

2022 LINNEAN SOCIETY OF NSW NATURAL HISTORY FIELD SYMPOSIUM

Natural History of the Northeastern Sydney Basin

Since 2010 the Linnean Society of New South Wales has been active in organising field symposia highlighting aspects of natural history in the Port Macquarie area (2010), Royal National Park (2012), Jenolan Caves (2013), Belubula Valley (2015), Snowy Mountains (2017), the Warrumbungles (2018), and most recently the Blue Mountains World Heritage Area (2019). Originally planned for November 2021 but rescheduled to 2022 due to the Covid-19 pandemic, this year's symposium focuses on the region bounded by Sydney Harbour to the south and the Hunter River in the north, with the coastline to the east, and extending west to the boundary of Yengo National Park. Much of this area lies within the distinctive lower Triassic Hawkesbury Sandstone outcrop with its spectacular geomorphology and characteristic floral communities. The symposium will take a similar format to those held previously, with presentation of 16 scientific papers on 17th November focusing on current research into the geology and geodiversity, flora and fauna, and Aboriginal occupation of the northeastern Sydney Basin region. This will include a themed session devoted to the Ku-ring-gai GeoRegion. The field excursion on 18th November will explore the Ku-ring-gai Chase National Park and the Ku-ring-gai Wildflower Garden in northern Sydney.

THE LINNEAN SOCIETY OF NEW SOUTH WALES

Founded 1874
Incorporated 1884

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The society exists to promote the cultivation and study of the science of natural history in all branches. The Society awards research grants each year in the fields of Life Sciences (the Joyce Vickery Scientific Research Fund) and Earth Sciences (the Betty Mayne Scientific Research Fund), as well as the William Macleay Scientific Research Fund for Microbiology. The Society offers annually a Linnean Macleay Fellowship for research, and publishes the *Proceedings*. It holds field excursions and scientific meetings including the biennial Sir William Macleay Memorial Lecture delivered by a person eminent in some branch of natural science.

Membership enquiries should be addressed in the first instance to the Secretary. Candidates for election to the Society must be recommended by two members. Membership fees and application form are available from our web site.

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Front cover: Tessellated sandstone pavement adjacent to head of Elvina Track in Ku-ring-gai Chase National Park (photo: Ian Percival)
Compiled and edited by Ian Percival and Bruce Welch

PROGRAM OF PRESENTATIONS – THURSDAY NOVEMBER 17

8.30 – 9 am	***Registration in Boronia/Waratah conference room, Hornsby RSL Club***
9 am	**Welcome and Acknowledgement of Country**
9.10 am	**The age and origin of the Hawkesbury River of southeast Australia (Stephen Gale)**
9.30 am	***Genoplesium baueri*, a floral gem of the Sydney Basin (Wendy Grimm)**
9.50 am	**Club and Coral Fungi: Diversity, Distribution and DNA (Michael Gillings)**
10.10 am	**Fungal Biodiversity of the Lane Cove Valley (Vanessa McPherson)**
10.30 – 11	***morning tea***
11 am	**Vegetation patterns associated with volcanic dykes at West Head and Govett Ridge in Ku-Ring-Gai Chase National Park (Jonathan Sanders)**
11.20 am	**Last Glacial Maximum landscapes and vegetation on the continental shelf coastal plain off Sydney, and impacts of its subsequent loss, as indicated by plant species distributions and disjunctions (Doug Benson)**
11.40 am	**The Sydney Basin's expression of the worst mass extinction in Earth history: A song of slime and fire (Chris Mays)**
12.00– 1.15	***lunch***
Afternoon session on the Ku-ring-gai GeoRegion	
1.15 pm	**Initiating the Ku-ring-gai GeoRegion Project (Ursula Bonzol)**
1.30 pm	**The Ku-ring-gai GeoRegion of the Sydney Basin (John Martyn)**
2 pm	**The Hornsby Diatreme: centrepiece of the new Hornsby Park (Ian Percival)**
2.20 pm	**Droning on: Application of a UAV to interpretation of the coastal cliffs in the Ku-ring-gai GeoRegion (Peter Mitchell)**
2.50 pm	**Soil landscapes of the Ku-ring-gai GeoRegion and their contribution to a revised pedology (Peter Mitchell)**
3.10 – 3.40	***afternoon tea***
3.40 pm	**Fauna of the Ku-ring-gai GeoRegion (Jayden Walsh)**
4 pm	**Connection to Country - Aboriginal Sites of the Ku-ring-gai GeoRegion (Bob Conroy)**
4.20 pm	**Geotrail Development within the Ku-ring-gai GeoRegion (David Robson)**
4.40 pm	**The Ku-ring-gai GeoRegion and the National Geotourism Strategy (Angus M Robinson)**
5 pm	**close**

ABSTRACTS OF PRESENTATIONS (in order of placement on program)

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The age and origin of the Hawkesbury River of southeast Australia

S.J. Gale

Department of Archaeology, The University of Sydney, Sydney, New South Wales 2006

The Hawkesbury River and its tributaries are amongst the largest of the systems draining the eastern seaboard of Australia. Although its modern vagaries have been endlessly studied, the age and origins of the river have largely escaped the attention of researchers, with only a handful of fragments available from which to construct its history.

We know, for example, that an early incarnation of the river flowed across the northern part of the Cumberland Basin, where it deposited a train of coarse fluvial sediments known as the Rickabys Creek Gravel. We know too that this river pre-dated the uplift of the Blue Mountains Plateau and the Hornsby Plateau, and thus that it preceded the formation of the Cumberland Basin. It is also possible that the river pre-dates the downwarping of the east Australian margin, an episode that seems to have begun in the Eocene.

In more recent times, the path of the river across the Cumberland Basin has shifted north, a move that may have taken place sometime in the mid-Cenozoic. From this time onwards, the depositional record of the river is better preserved, at least in its middle reaches upstream of Sackville Gorge, where there is superfluous capacity to accommodate its depositional products. By contrast, in the bedrock-confined valley downstream, the story is rather different. Here there is limited accommodation space and successive floods tend to flush these channels clear of earlier deposits, leaving a record only of more recent and lower magnitude events.

Yet many questions remain unanswered. Does the Maroota Sand, which lies on the Hornsby Plateau 200 m above the modern course of the river, represent the original course of the river? What is the origin of the great right-angled bend in the river's course at Wiseman's Ferry? And did headward erosion along the lower Hawkesbury capture the Parramatta River, diverting the waters of the Warragamba–Nepean north to transform the drainage system into its modern form?

Genoplesium baueri, a floral gem of the Sydney Basin

Wendy A Grimm

Australian Plants Society North Shore Group

Genoplesium baueri is a binomial plant name in the system of taxonomy devised by Carl Linnaeus. It is the scientific name given by Robert Brown to an orchid collected in Port Jackson and is the type species of the genus *Genoplesium*. Brown's description published in 1810 relied heavily on drawings by the botanical illustrator Ferdinand Bauer, another member of the expedition with Matthew Flinders, and who Brown acknowledged in his choice of species epithet.

Genoplesium baueri is an endangered terrestrial orchid endemic to the central and south coast and tableland botanical regions of the Sydney Basin, NSW.

Many species of Australian terrestrial orchids are difficult to detect due to their small size and often cryptic colouring. Populations of *Genoplesium baueri* were thought not to flower on an annual basis. In an ongoing study (2009-22) restricted to the North-eastern Sydney Basin part of its range, *G. baueri* populations have been shown to emerge and flower annually, but the timing of emergence of plants from their underground tubers varied by as much as three months from year to year.

Aspects of the life history documented during this study included collection of voucher specimens of the pollinator, a chloropid fly, for the Australian Museum. Weekly observations of each emergent plant in each major population revealed elements of natural history that were characteristic of the species. Ratios of flowering plants to apparently dormant, but actually developing, tubers and protocorms were estimated at several sites. Digital imaging augmented field observations of plant size, flower and fruit counts and flowering period. *G. baueri* is a distinctive species, so identification at the species level can be made by an experienced observer from images of a plant in flower.

The presence in 2003 of one population near Mount Colah had been recorded with National Parks staff. During the period of this study an additional seven or eight new sites, with a total of ten subsites, were recognised. Most sites were in or adjacent to Ku-ring-gai Chase or Garigal National Parks. The annual plant count across all northern sites studied, gradually increased from 46 plants in 2009 to more than 500 flowering plants in 2020. Record rainfall and restrictions to travel between suburbs in the three years to 2022 have meant that plant counts may have been underestimated in the 2020-2022 flowering seasons.

This multi-year research was made easier by the proximity of native bushland within National Parks, Crown Land, nature reserves and corridors to a large city like Sydney, which has botanical and educational facilities and also people appreciative of their natural environment.

Club and Coral Fungi: Diversity, Distribution and DNA

Michael Gillings[1,2] *and Vanessa McPherson*[1]

[1] School of Natural Sciences, Macquarie University

[2] ARC Centre of Excellence in Synthetic Biology, Macquarie University

The Kingdom Fungi are central players in the ecology and biogeochemistry of terrestrial ecosystems. Despite this importance, the diversity, distribution and abundance of fungal species are poorly known. There are two ways to approach fungal identification. Traditionally, people have used culturing of fungi or surveys of above-ground fruiting bodies. More recently, DNA-based methods have been used to directly detect fungal species in soil. However, a compromise approach combines field surveys with 'DNA-barcoding'. This allows us to identify fungal fruiting bodies, initially to the genus level, and potentially to species level if the species has previously been formally described and then characterized using DNA. We have used this combination approach to identify club and coral fungi in the Lane Cove Valley.

Our survey took place over a period of two years, and comprised more than 200 collection trips. We collected almost 1200 specimens, and identified these to Genus using a combination of DNA barcoding and morphology. The majority of specimens did not match any sequences in GenBank at more than 95% similarity, meaning that many of these fungi are either poorly represented in DNA databases, or are potentially novel species.

Our study is far from complete, but we can already report some general observations. Many species in the Lane Cove Valley are undescribed, with up to 30% - 40% of specimens being potentially new species. Club and coral fungi are not distributed evenly through the valley. These types of fungi are mainly found along creek lines, particularly those dominated by coachwood gallery rainforest. Our observations suggest that the sides of creeks where sewer lines have been laid host lower fungal diversity and abundance than their corresponding sewer-free creek-sides. Creeks with no sewer lines are often rich in fungal species.

In less disturbed areas of bushland, we have documented significant fungal hotspots. In these areas, there is elevated fungal diversity and abundance. There are three outstanding locations for fungal diversity in the Upper Lane Cove Valley. These are Rofe Park/Sheldon Forest, Browns Field, and Coups Creek. All these areas are sheltered valleys that face southwest, and all are likely to be nutrient-rich. We think these locations contain important remnant populations of native fungi that are worthy of conservation, similar to Lane Cove Bushland Park, a reserve dedicated to the conservation of endangered waxcap fungi. Notably, these areas are not within the boundaries of the National Park.

Management and conservation of our natural bushland needs to incorporate knowledge of fungal diversity in addition to the diversity of plants and animals.

Fungal Biodiversity of the Lane Cove Valley

Vanessa McPherson[1] *and Michael Gillings*[1,2]

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Fungi are poorly known. Of the estimated 3 to 8 million species in existence, only about 120,000 species ever have been named and described. This accounts for only 2% to 5% of the estimated total. The proportion of Australian fungi that are formally named is likely to be even lower than this, because the Australian biota contains many endemic species. Since many of our plants and animals are found nowhere else, Australian fungi are probably also unique.

There are a number of reasons that fungi are under-described. First, fungi spend most of their lives existing as mycelial networks, hidden underground. Second, when we do see fungi, they are the above ground reproductive structures (mushrooms, toadstools, etc). These are mostly small and ephemeral. And, these fruiting bodies often do not have many consistent, distinguishing characteristics.

Despite our lack of knowledge of fungal diversity, we do know that they perform essential functions in ecosystems. They have various roles, including as pathogens (causing disease to plants or animals), saprotrophs (breaking down dead animal and plant material), and mutualists (supporting the growth of plants). Almost all land plants form beneficial associations with fungi, as mycorrhizae ('fungus root'), so conservation of plant communities must also include conservation of their fungal partners.

We have been conducting surveys of fungal diversity in the Lane Cove Valley, and here we present a selection of both common and rare species. Many of the fungi we have found appear to be undescribed. These unusual fungi often occur in small patches of relatively pristine bushland. The formal process of naming these new species will take many years, but understanding fungal biodiversity is just as important as understanding plant and animal diversity if we are to successfully monitor and manage natural ecosystems.

Vegetation patterns associated with volcanic dykes at West Head and Govett Ridge in Ku-Ring-Gai Chase National Park

Jonathan Sanders

Burrawang Environmental Services, 29 Park Rd Cowan NSW 2081

There are a significant number of volcanic intrusions into the sedimentary strata of the Sydney Basin. Some of these form large features in the landscape, often with their own micro-climates (e.g. Mt Tomah, Mt Monundilla) while others are more localised features (e.g. Peats Crater, Hornsby Quarry). Basaltic dykes which run through the sedimentary landscape, sometimes for kilometres, tend to conform to the general surrounding topography. This makes them a useful subject for ecological study, as the vegetation on the adjoining sedimentary and volcanic soils is subject to the same general landform, aspect and climate.

The dyke which runs from Campbells Crater on Govett Ridge, east to West Head was surveyed for vegetation differences. The vegetation associated with the dyke at West Head has previously been described in a number of publications. The survey found that some species had strong preference for the basalt-derived soils, while others didn't grow on the dyke despite being abundant on the adjoining sandstone. Further investigation covered the possible reasons underlying these differences, including seed transport, soil differences and factors affecting germination. At West Head, a diverse forest with rainforest elements grows on the dyke. A detailed survey of soils and vegetation at West Head found that the differences between the vegetation structure on basalt and sandstone-derived soils was not as great as has generally been described, and that some previous studies have inaccurately described the underlying soil boundary on the basis of the overlying vegetation. Some of the interesting issues arising from the disjunct species distributions associated with these volcanic features are also briefly discussed.

Last Glacial Maximum landscapes and vegetation on the continental shelf coastal plain off Sydney, and impacts of its subsequent loss, as indicated by plant species distributions and disjunctions

Doug Benson

Honorary Research Associate, Australian Institute of Botanical Science, Royal Botanic Gardens and Domain Trust, Mrs Macquaries Rd Sydney 2000

At about 28 000 – 18 000 years BP, the height of the Last Glacial Maximum (LGM), sea level dropped to its lowest level, up to 120 m lower than currently, revealing off Sydney, a rocky sandstone coastline, about 8-15 km beyond the present Sydney sandstone foreshores, interrupted by estuarine deposits associated with saltmarsh, rather than mangroves. Behind the foreshores a landscape of infertile sand dunes, with outcrops of sandstone, shale and other bedrock was revealed.

The vegetation of the LGM sandplain is likely to have been similar to the current sand-based north coast wallum Myall Lakes vegetation, where extensive Pleistocene and Holocene landscapes have fortuitously survived. Various wallum species associated with Pleistocene sands reach their southern limits near Sydney. On the higher rainfall coast, short-lived Ruderal /fire sensitive shrub species (longevity 5-50 years) are likely to have been important components while clay soils on shale and volcanic outcrops are likely to have had low heath vegetation.

From 14 000 years BP temperature increased considerably (approx. 4°C), initially continuing relatively dry, but with warmer, wetter conditions peaking about 6 000 years BP. With increasing temperature, rainfall and CO_2, likely Holocene coastal landscape scenarios include southward and inland migrations of coastal competitors (fast-growing eucalypts and other Myrtaceae); local expansion and limited northward movement of Temperate mesic species from LGM gully refugia; and animal assisted distance-dispersal of northern (Tropical) rainforest species.

By about 7000 years BP rising sea level had pushed the coast back to its current extent, albeit with a slight 1 m Mid Holocene highstand, flooding the coastal plain, pushing back saltmarsh and reducing saltmarsh richness, and allowing northern mangroves to invade. Coastal populations of some poorly-dispersing species became isolated, others were dispersed by birds to new habitats. The importance of the extent and loss of the coastal plain has had an important impact on current species distributions, connections and disjunctions that has been largely overlooked.

The Sydney Basin's expression of the worst mass extinction in Earth history: A song of slime and fire

Chris Mays[1], *Vivi Vajda*[2], *Tracy D. Frank*[3], *Christopher R. Fielding*[3], *Robert S. Nicoll*[4], *Sam M. Slater*[2], *Stephen McLoughlin*[2]

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Most mass extinction events have been linked to rapid warming, driven by massive injections of greenhouse gas from volcanic eruptions. The most devastating extinction event in Earth history, the end-Permian event (c. 252.2 million years ago), was no exception, and provides the endmember for our emerging model of global mass extinctions. Oceanic fossil records of the end-Permian event indicate several warming-related extinction drivers that are becoming increasingly common today (e.g., acidification, algal blooms, lethal temperatures, coral bleaching). However, the intermediate causes between warming and continental (land and freshwater) mass extinction have remained poorly understood. Our recent findings from the world-class rock successions of the Sydney Basin indicate that rapid climate warming led to an increased frequency of wildfires, which in turn, was a likely trigger for a cascade of biodiversity loss and ecosystem collapse across the Gondwana supercontinent. Back then, as today, wildfires can cause widespread forest habitat destruction, and this deforestation leads to soil loss and enhanced nutrient into freshwater bodies, promoting toxic algal blooms. Our fossil, rock and chemical data reveal extreme bloom events following Permian forest ecosystem collapse. These microbe communities proliferated in lowland fresh and brackish waterbodies, with algal concentrations typical of modern bloom events. During the following 3 million years, algae and bacteria thrived within short-lived, poorly-oxygenated, and likely toxic lakes and rivers, inhibiting the recovery of freshwater ecosystems for hundreds of millennia. Given that the present rate of warming is likely faster now than during the end-Permian event, such mass extinctions of the past provide timely lessons about the chain of causation between global climate change and biodiversity loss. Lastly, we recommend that the outcrop expressions of the end-Permian event along the northern Sydney Basin coast become recognized as sites of geoheritage significance on state, national and global scales, and welcome a discussion on the best avenue to achieve this.

Initiating the Ku-ring-gai GeoRegion Project

Ursula Bonzol[1]

[1]Friends of Ku-ring-gai Environment Inc

Friends of Ku-ring-gai Environment Inc (FOKE) is a community group dedicated to protecting and conserving the built and natural environment of Ku-ring-gai. This Ku-ring-gai GeoRegion project was initiated three years ago with the objective of making a positive contribution to conservation based in and around Ku-ring-gai Chase National Park. Though the area has long had a strong tradition in conservation activism, there was a need to build conservation understanding and support among our growing population.

This proposal aims to build on the existing recognised values of the area, especially its biodiversity, natural and cultural heritage (particularly Aboriginal), and to highlight its foundation of nationally and internationally significant geology and geomorphology that has resulted in the development of these unique traits. The plan is to re-invigorate and highlight the area's importance with the unifying aspects of a GeoRegion via the establishment of geosites and geotrails linking the various features and aspects of the area.

The Ku-ring-gai GeoRegion embraces the Ku-ring-gai Chase National Park, the Northern Beaches coastline, Muogamarra Nature Reserve and the eastern section of the Berowra Valley National Park. This is a complex project needing extensive consultation with local Aboriginal and other community groups, State Government agencies and three LGAs. To date a comprehensive natural heritage document has been prepared to assist in promoting the significance of the area. Having received endorsement from the Geological Survey of NSW that no known impediments exist, subsequent presentations to the relevant local Councils, National Parks and Wildlife Service, and local Members of Parliament who include the Minister for the Environment and the Minister for Planning and Public Spaces, have all received strong support to proceed and offers of assistance.

The initial aim is for the development for Geotrails across the designated area, as the basis to seek State approval of the area as a GeoRegion and ultimately nomination as an Aspiring UNESCO Global Geopark. This would complement the Blue Mountains WHA and Australia's first national park, the National Heritage-listed Royal National Park – together these three outstanding landscapes showcase for the world and Sydney residents, our unique natural and cultural heritage.

The Ku-ring-gai GeoRegion of the Sydney Basin

Dr John Martyn

Consultant Geologist, Turramurra NSW 2074

In understanding the Ku-ring-gai GeoRegion it's important to consider the depositional position of the Permo-Triassic Sydney Basin which lay around 5 to 10 degrees south of where Macquarie Island sits today. Widespread glaciation of its continental hinterland was a big part of its Permian history. The abundant ice-rafted glacial dropstones of the South Coast Permian are part of this story, and redbeds like the Triassic Bald Hill Claystone clearly had a different origin to the hot desert setting of Triassic redbeds. Our Permian coal measures were compacted from peat laid down in boreal rather than tropical swamp forests.

The Sydney Basin evolved as the foreland basin of an alpine mountain front, deepening sharply against the rising New England Fold Belt to the north, like the trough in front of an ocean swell, with its sediments fanning out and flattening to the south-west and south over the worn-down Lower Palaeozoic basement rocks of the Lachlan Fold Belt. It captured a strong influx of sediment from the rising fold belt. In Late Permian to Early Triassic times, volcanoes of shoshonitic composition lay to the east, pouring in lava flows and flooding in debris that locally put a strong imprint on the sediments.

A big event locked into basin history was the end-Permian global extinction event at 252 million years. Triggered by massive eruptions in far-away Siberia it changed the climatic conditions, profoundly reset the vegetation and terminated coal seam formation.

The Ku-ring-gai GeoRegion draws on all these influences. The classic geology of the Narrabeen Group along the Northern Beaches coastline features rocks like Bald Hill Claystone that formed from the in-situ weathering of riverine debris washed in from the shoshonitic volcanic ranges. The Newport Formation of coastal cliffs like Avalon and Bungan Head carries conglomerate bands sourced almost certainly from several hundred kilometres to the north, in an active mountain belt in what is now New England.

The thick quartz lithic sandstones and interlayered laminites today support endangered littoral rainforest and the beautiful Pittwater Spotted Gum Forest of the Pittwater shoreline, both floral highlights of the GeoRegion. The 230-metre thick, quartz-rich Hawkesbury Sandstone that overlies the Newport Formation and underpins the extensive tablelands of Ku-ring-gai Chase, is the braid plain deposit of a massive river system, with distant catchments extending to what is now Antarctica. Its preserved ancient land surface is florally rich and diverse, ranging from woodlands and shrublands to upland swamps. Ku-ring-gai Chase's drowned valley coastline is a classic of its type and a local scenic wonderland.

The Sydney Basin became land in the Jurassic during which a brief interval of alkali basalt igneous activity introduced dykes and triggered diatreme formation.

The Hornsby Diatreme: centrepiece of the new Hornsby Park

Ian G. Percival

Honorary Research Associate, Geological Survey of New South Wales

The Hornsby Diatreme, the best preserved and most readily accessible of more than 95 such features of Jurassic age intruding Triassic and Permian strata of the Sydney Basin, is spectacularly revealed in cross section in the new Hornsby Park. A diatreme is a vertical pipe-like volcanic feature that intruded country rock in the subsurface (in this case the Hawkesbury Sandstone that forms the Hornsby Plateau) and exploded at the surface due to release of pressure. Unlike a normal volcano, no lava was erupted; the mechanism driving the upward movement of pulverised rock is superheated steam, formed by reaction of hot magma at depth with groundwater such as the water table or a lake. The fragmented rock fell back into the surface crater forming distinctive dish-shaped beds in the upper part of the diatreme (as exposed in the former quarry). A diverse suite of rock types has been recognised, reflecting those strata intersected by the rising column of steam and rock as well as basaltic magma fragments formed at depth in the lowermost part of the diatreme pipe. The breccia includes sandstone, shale, coal (from Permian seams), accretionary lapilli (interpreted as concentrically laminated pea-size pebbles formed by volcanic 'ash' interacting with rainfall) together with rare xenoliths (fragments of rock from lower in the crust, in particular igneous rocks including granite, gabbro and peridotite). Sandstone forming the boundary walls of the diatreme shows almost no effects of heat and pressure, indicating that the volcanic event, although rapid and violent, was of relatively low temperature compared with normal volcanic eruptions.

The dish-like structure was only exposed during quarrying operations in the 1960s to 1980s, which explains why the brecciated rocks infilling the diatreme were not heavily weathered as is the case with almost all contemporaneous diatremes. During the active quarrying phase, the diatreme was visited and studied by geologists, research scientists and university students. A report to the NSW Heritage Commission in 1980 established its State significance. Its national significance as a geological heritage site was recognised by listing on the Register of the National Estate in the 1980s. However, after the protection afforded by that listing was removed when the Register closed in 2007, the importance of the site was overlooked in planning decisions at local and state level. This became evident when the disused quarry was selected to hold the spoil excavated from the North Connex tunnel project, which threatened the integrity of the cross section by infilling the quarry void to a level that would have covered the dish-shaped layers of the diatreme. Fortunately a concerted effort by members of the Geological Society of Australia, who provided submissions to the Northern Sydney Planning Panel, managed to ensure that the fill level would be lowered so that the diatreme structure would remain largely visible. Hornsby Council, who is responsible for redeveloping the former quarry site as a public recreation space, also became informed of the scientific and educational aspects of the diatreme, which is now believed to be one of the best examples of this type of rare geological feature in the world. As a result the eastern face of the former quarry that exposes the cross section of the diatreme will become the centrepiece of the new Hornsby Park and the opportunity for close-up inspections of the layers will again be possible.

Droning on: Application of a UAV to interpretation of the coastal cliffs in the Ku-ring-gai GeoRegion

John Illingsworth[1] *and Dr Peter Mitchell*[2]

[1] Alumnus Macquarie University, Pittwater Pathways

[2] Retired (previously Macquarie University, School of Earth Sciences)

Over the last decade or so small drones (unmanned aerial vehicles or UAV) fitted with high definition video cameras have become cheap enough for almost anyone wanting a different view of their world to access one. They are now widely used by film producers, estate agents, government agencies, surf lifesavers, and numerous consultants engaged in site surveys. Along with the digital imagery, computer programs capable of handling very large data sets have been developed and it is a relatively easy task to produce digital elevation models and 3-D photogrammetric models of features.

One of us (JI) has been flying a drone for the production of short video clips dealing with environmental issues on the northern beaches and PM has been involved in the geomorphic interpretation of drone data collected by others over Aboriginal sites on Cape York, the Hunter Valley, and the Woronora Plateau.

For geologists wishing to view coastal cliffs and headlands we believe that a drone is an ideal platform giving easier and safer access. Conventional air photos and satellite imagery do not provide a useful view of these near vertical features and quite often the cliffs are in deep shadow when the camera or satellite is overhead. In many places cliff faces are inaccessible to all but dedicated (or insane) rock climbers and geologists are challenged when trying to delineate rock formations which they can only see from a foreshortened view on the shore platform or a rocking boat.

To date we have flown all of the GeoRegion coast north of Long Reef and placed it in the public domain as an archival record. This is accessible by searching Pittwater Pathways. Our first imagery immediately revealed lithological and structural details that have been overlooked by previous workers and it showed that there were a far greater number of recent large rockfalls than were assessed by Kotze (1987).

This presentation will illustrate the imagery, reveal some of the geological detail, and make an assessment of rockfall frequency and magnitude on one short section from Narrabeen Head to Warriewood Beach. Ideas for using drone imagery for communication about geosites will also be presented.

Soil landscapes of the Ku-ring-gai GeoRegion and their contribution to a revised pedology

Dr Peter Mitchell

Retired (previously Macquarie University, School of Earth Sciences)

There have been several soil-landscape surveys and numerous detailed soil studies of the Ku-ring-gai GeoRegion since the first reports in the 1950s. In the three decades from 1970 much of this research was undertaken by students, staff, and graduates of Macquarie University under the guidance of Prof T.R. Paton in the School of Earth Sciences.

When first opened, Macquarie University allowed students to construct their own majors by combining courses from related disciplines. This objective of cross-fertilization was grand, but the reality did not always work as many academics remained old school disciples. Students, however, did take up the options and several subject groupings became more popular than expected. One of these was soil science (pedology) which contributed to majors in environmental science, and resources and environmental management.

The soil courses were field based and undergraduates were required to undertake project work. As many students lived in the GeoRegion they scoured the bushland and new suburbs to locate field sites, several of which were later investigated for Honours and Post-Graduate theses.

Three topics were particularly popular: the genesis of texture contrast soils (Duplex profiles), the nature and distribution of previously unknown podsols in the sandstone country, and studies on laterite.

All of this work broke new ground and contributed to a number of papers and a text book by Paton, Humphreys, and Mitchell (1995). According to one reviewer (Schaetzl 2000), the book was a 'must read' that would 'Shock the World' and in 2000 it became the first overseas recipient of the G.K. Gilbert Award for Excellence in Geomorphic Research from the Association of American Geographers.

These studies in the Ku-ring-gai GeoRegion not only shocked the world in a modest way but led directly to a new approach to soil landscape mapping by the NSW Soil Conservation Service and have subsequently made important contributions to improved understanding of open archaeological sites right across Australia.

This paper will outline the ideas that challenged pedology and illustrate how the GeoRegion was involved.

Fauna of the Ku-ring-gai GeoRegion

Jayden Walsh

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The Ku-ring-gai GeoRegion displays a true melting pot of fauna. Largely thanks to complex geology, topography and favourable climate, an impressive diversity of plants and vegetation communities has evolved. Thus, many species approach their distributional limits. The endangered Southern Brown Bandicoot can be found on West Head Road where it is present at its Northern limit. Similarly, if you were to peer deep into caves and crevices characteristic of the GeoRegion, during winter you might find a Brown Tree Snake deep in brumation, very close to its southern limit. Further, the hot westerly winds that sometimes greet the coast in Spring bring a plethora of inland displaced birds seeking resources, such as White-browed and Masked Woodswallows, Brown and Rufous Songlarks and Red-capped Robins. Following strong southerlies in winter, Long Reef and Bangalley Headland offer great vantage points to watch passing seabirds; from the savage, penguin-eating Northern Giant-Petrel, to the delicate Fairy Prion, to the Wandering Albatross with the world's largest wingspan.

Wildlife within Australia is very much condition dependent whereby species align their behaviour with the constant boom and bust of resources. Some species within the GeoRegion such as the Dainty Tree Frog are only active following the heaviest downpour after a prolonged period of dryness, and therefore only call on a handful of nights every year, making them notoriously difficult to survey.

There are few places within Australia where such diversity and species richness is as evident as in the GeoRegion, rivalling the likes of Kakadu National Park. Internationally recognised for its impressive wildlife watching opportunities, the GeoRegion doesn't fail to deliver. With over 300 bird species recorded in this relatively small area it is home to some impressively rare and diverse species. The Black Bittern, Australian Masked Owl, Chestnut-rumped Heathwren, Lewin's Rail, Little Eagle and Little Penguin all have strongholds within this area.

On a typically hot November night, encounters with 10 amphibian species including the vulnerable sandstone specialists the Giant Burrowing Frog and Red-crowned Toadlet are likely. On a 20+ degree warm night the fastest striking snake in the world, the Common Death Adder, can be found searching for a mate. The Bandy Bandy is frequently encountered in Heathlands and Woodlands within the area. On the warmest of nights, there's a chance of coming across reptiles like the Eastern Water Skink, Copper-tailed Skink, Red-bellied Black Snake, Tiger Snake, and even the Eastern Brown Snake, active at night. The mammalian fauna is equally as impressive, having personally recorded Southern Brown Bandicoot, Yellow-footed Antechinus, Common Dunnart, New Holland Mouse, Little Red Flying Fox, Swamp Rat, Rakali, Broad-toed Feathertail Glider, Spot-tailed Quoll, and the notoriously elusive Eastern Pygmy Possum.

Connection to Country - Aboriginal Sites of the Ku-ring-gai GeoRegion

Bob Conroy

Retired (formerly NSW National Parks & Wildlife Service)

For at least the last 6,000 years and perhaps for more than 15-20,000 years, Aboriginal people have maintained, and continue to maintain, a strong association with the landscapes of the Ku-ring-gai GeoRegion. The plateaus, ridges, drowned river valleys and coastal landscapes of the GeoRegion also maintain an extraordinary record of Aboriginal heritage over this time, a period during which Aboriginal people have been witness to dramatic changes in climate, to sea levels and to the associated shoreline and estuarine interface.

Evidence of human occupation and use of the area over several millennia survives with more than 1,400 recorded Aboriginal sites, represented by occupational deposits including middens and artefact scatters, rock art in shelters, art on sandstone rock platforms. Other site types include burials, stone arrangements, modified trees and grinding grooves. Often a combination of different site types exist as a recorded site and therefore a total of some 1,800 Aboriginal site type locations have been recorded within the GeoRegion.

There is a relationship between the various site types and landscape features. Rock engravings in the GeoRegion occur within defined average elevation ranges. Most rock engraving sites have either a westerly or northerly aspect, often with commanding views across the Hornsby Plateau. Engravings are usually found on large, flat and smooth rock outcrops on Hawkesbury Sandstone interfluves, usually on the shoulders of the higher peaks, but also on seepage zones of terraced upper slopes in association with grinding grooves and 'engineered' waterholes. Sites including large numbers of motifs are often found in association with unusually shaped sandstone features such as natural waterholes or gnammas, on tessellated sandstone and some in association with stone arrangements. Vertical or near vertical engravings are much less common and are often found in association with open middens near the shoreline. Shelters with art (pictographs), middens and artefacts are often associated with shallow overhangs under terraced rock platforms, at the bottom of fall faces and under large sandstone rock falls on colluvial foot slopes at elevations suggesting that a very large number of shelters would have been inundated by sea level rise over the last 20,000 years.

Art in shelters consists of either stencilled, painted or printed figures in a mixture of ochre, water and animal fat or drawn in charcoal, often on vertical and smooth panels within a shallow weathered shelter. Two excavated shelters in the GeoRegion provide an excellent record of occupation and use of the area over the last 4,000 years with evidence of cultural tradition, seasonal use patterns, food resources, tool use and local fauna extinctions. Other Aboriginal sites include grinding grooves, stone arrangements, burials, modified trees and occupation sites. No systematic archaeological survey has been carried out in the region and it is likely that there are many more sites in the area that are yet to be recorded.

Geotrail Development within the Ku-ring-gai GeoRegion

David Robson

Chair, Geotourism Standing Committee, Geological Society of Australia

Geotrail development within the Ku-ring-gai GeoRegion will foster tourism on the geology and landscapes which shape the character of the region. It will showcase accessible and well-known "visitor friendly" geological locations, and many unique landscapes for tourists to enjoy. The target audience is the public looking to enrich their visits to the region. This can be done in a fun and educational way to create an early interest in geology for school children and their parents. It will attract not only residents but more visitors to the region leading to a higher level of tourism spend.

Geotrails offer the advantages of:

- relating directly to the tourism experience of a journey linking destinations;
- having universal appeal, and do not compete with or impact on land management/access issues; and
- are relatively easy to establish and represent a very cost effective means of enhancing regional development.

Geotrails should:

- be constructed around routes currently used by tourists i.e., they should form logical journeys linking accommodation destinations;
- meld the geological heritage features of a region with a cohesive story; and
- incorporate the biodiversity and cultural components (including mining heritage) of the region through which the geotrail traverses.

As a group, we have identified, documented and are now in the process of managing geotrails covering an area from the NSW coast through the Ku-ring-gai National Park, including Long Reef to Barrenjoey, Ku-ring-gai Chase National Park, Muogamarra Nature Reserve, northern Garigal National Park and eastern Berowra Valley National Park.

Currently we have identified over 50 sites very worthy of visitation. Publically accessible and safe sites are the priority. The Geological Society of Australia (GSA) has proposed a quick field method for identifying geosites/geotrails. Subsequent detailed assessment would follow for our selected geosites for geotrail development. Other geosites might be identified as of sensitive cultural/geoheritage significance and are not developed for our geotrails.

The Ku-ring-gai GeoRegion and the National Geotourism Strategy

Angus M Robinson

Coordinator, National Geotourism Strategy, Australian Geoscience Council Inc

The Australian Geoscience Council Inc (AGC) is the Peak Council of geoscientists in Australia. It represents eight major Australian geoscientific societies with a combined membership of over 8,000 geoscientists.

In April 2021, the AGC launched a National Geotourism Strategy that is being designed to support the orderly development of major geotourism projects and activities in line with overseas trends and domestic regional development imperatives. The AGC sees the articulation of a strategy with a staged and incremental approach as being essential to ultimately gain government endorsement at all levels.

The AGC understands that geotourism adds considerable content value to traditional nature-based tourism (the primary motivator of travel to Australia) as well as cultural tourism, inclusive of Aboriginal tourism, thus completing the holistic embrace of 'A' (abiotic – landscape and geology) plus 'B' (biotic – flora and fauna) plus 'C' (culture) aspects. In essence, in Australia, geotourism has been defined as 'tourism which focuses on an area's geology and landscape as the basis for providing visitor engagement, learning and enjoyment'.

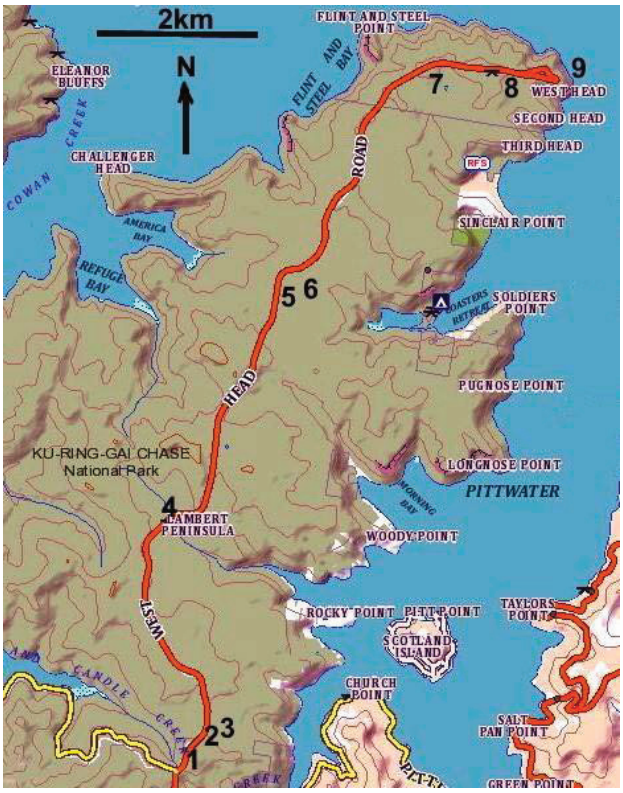
Following consultation with key government geoscience agencies in recent years, the AGC believes that the establishment of a national set of administrative procedures is necessary to provide for the orderly development of major geotourism projects such as geoparks, regional geotrails and geoparks, both state based and potential Aspiring UNESCO Global Geoparks.

It has now been recommended that any geopark proponent should, in the early stages of project conceptualisation, adopt a nomenclature which removes reference to the word 'geopark' and focus instead on communicating the concept of a GeoRegion. This approach offers the opportunity for proponents using the language of GeoRegions to explore various alternative options for geotourism development, including a strong focus on the establishment of geotrails between sites of geological merit as interpretive sites, including robust geoheritage sites, some of which may already have been established as geological 'monuments' or recognised in state or national geoheritage registers.

From an UNESCO evaluation perspective, this approach also serves to establish a status of a 'defacto' geopark. Once a GeoRegion has been identified, then a full audit of natural and cultural heritage attributes in the region as well as early discussions with state/territory based Geological Surveys, Planning and Environment agencies, and any other state/territory government agencies responsible for land and resource management can be undertaken. Two GeoRegion projects are now being developed as pilots under the auspices of the NGS with long-term aspirations of being supported by their respective State Governments and of being nominated as Aspiring UNESCO Global Geoparks.

EXCURSION GUIDE FRIDAY NOVEMBER 18, 2022

The field trip commences at Hornsby Railway Station (bus zone on west side, Station Street off Peats Ferry Rd) at 8.30 am on Friday November 18, and proceeds via Mona Vale Road, McCarrs Creek Road and West Head Rd to West Head in Ku-ring-gai Chase National Park. First stop will be at West Head lookout to view Pittwater, the entrance to Broken Bay, and the Palm Beach-Barrenjoey Headland tombolo. There will be a brief diversion to the interpretation centre near West Head. The second main stop will be at the head of the Elvina Track for a short walk to inspect a spectacular exposure of a tessellated sandstone pavement, Aboriginal carvings, and a heathland plant community. We plan to arrive around 12.30 pm at the Ku-ring-gai Wildflower Garden, off Mona Vale Rd at North St Ives, for a picnic lunch (please supply your own food) and a bush walk (choice of a shorter one with level gradient, or one of greater length along a paved track with one hilly section). We then proceed through North Turramurra along Bobbin Head Road to Bobbin Head. From the carpark we will walk along the Mangrove Boardwalk to examine that plant community and the associated brackish water biota on the rising tide. Afterwards an Aboriginal rock carving site at Mt Ku-ring-gai will be visited before returning to Hornsby Station by 5.30 pm.



Map of the proposed West Head geotrail on the Lambert Peninsula in Ku-ring-gai Chase National Park (from Robson in Conroy et al. 2022). Locality 9 on this map is the West Head Lookout (Stop 1 on the excursion); Locality 7 is a road cutting exposing the weathered dolerite intrusion and associated dyke that trends east-west parallel to the final section of the road to the lookout. Locality 3 is the tessellated sandstone pavement with Aboriginal rock engravings near the head of the Elvina Track (Stop 2 of the excursion).

STOP 1 – WEST HEAD, LAMBERT PENINSULA, KU-RING-GAI CHASE NP

West Head provides panoramic views over Broken Bay and Lion Island to the north, and across Pittwater to Barrenjoey Headland to the east. It is an outstanding viewpoint from which to observe and interpret the effects of sea-level rise in the Holocene, which drowned the entrance of the Hawkesbury River as well as the river valley leading into Pittwater from the south and originally exiting to the Tasman Sea through what is now Palm Beach.

West Head is predominantly composed of resistant Hawkesbury Sandstone of Early Triassic age. This nutrient-poor substrate supports a dry schlerophyll forest community dominated by *Angophora costata* that has been much modified in the immediate vicinity of the lookout by clearing and bushfire.

The resistant rocks forming Barrenjoey Headland are sandstones of the Newport Formation, which is the upper unit of the Narrabeen Group that directly underlies the Hawkesbury Sandstone. These rocks are also of Early Triassic age. The headland is tied to the Northern Beaches Peninsula by a low sandy isthmus known as a tombolo.

Since the Last Glacial Maximum (LGM) about 28 000–18 000 years ago, sea level has risen up to 120 m as the climate warmed, reaching its current level about 8 000–6 000 years ago. According to Martyn (in Conroy et al. 2022), the ‘Pittwater River’ originally flowed north and then east to the sea in a bedrock valley 75 m beneath the Palm Beach barrier. It was blocked to the north by a sandstone ridge that joined West Head and Barrenjoey. As sea level rose to an elevation about 30 m below today’s level, the river overtopped the sandstone ridge that joined West Head and Barrenjoey and then flowed north directly to the Hawkesbury River. This allowed the Palm Beach barrier to close and form today’s landscape.

View from West Head across Pittwater (in foreground) to Palm Beach, a tombolo (sandy isthmus) tying the former island of Barrenjoey Headland to the Northern Beaches Peninsula. Tasman Sea visible on horizon (photo: Ian Percival).

Barrenjoey Headland and Lighthouse - geology dominated by thick Newport Formation sandstones of the Narrabeen Group capped by Hawkesbury Sandstone (photo: John Martyn), from Martyn in Conroy et al. (2022).

Lush forest and rainforest over thickened dolerite dyke, West Head, Ku-ring-gai Chase National Park (photo: John Martyn), from Martyn in Conroy et al. (2022).

A weathered volcanic intrusion of doleritic composition, several tens of metres wide, is exposed in cuttings and adjacent to the road about 1.5 km west of the lookout. Mineral nutrient (mainly iron) leaches from the volcanic rock, which is more susceptible to chemical weathering than is the quartz-rich Hawkesbury Sandstone it intrudes, to support a diverse

forest comprising grey ironbark (*Eucalyptus paniculata*), turpentine (*Syncarpia glomulifera*) and large-fruited red mahogany (*Eucalyptus scias*) in the overstorey, and a mesic or littoral rainforest understorey dominated by cabbage tree palms (*Livistona australis*) and burrawang (*Macrozamia communis*) (Martyn in Conroy et al. 2022). The age of the dolerite intrusion is unclear, but Martyn (2018) suggests that it is related to the widespread diatreme activity in the Sydney Basin which elsewhere has been dated as Jurassic.

STOP 2 – TESSELLATED SANDSTONE PAVEMENT AT HEAD OF ELVINA TRAIL, LAMBERT PENINSULA, KU-RING-GAI CHASE NATIONAL PARK

Tessellated sandstone pavement adjacent to head of Elvina Track in Ku-ring-gai Chase National Park (photo: Ian Percival)

From the carpark at the Elvina Trailhead, we will walk about 200 m along a formed track on mostly level to gently sloping ground to what is the largest expanse of tessellated sandstone pavement known in the Sydney Basin (and certainly the most accessible and spectacular). The pavement consists of Hawkesbury Sandstone, as seen at West Head, but here it has developed a striking irregular polygonal surface. This phenomenon was described by Branagan (1968) who speculated that the formation of the polygons might be metamorphic in origin although no local heat source was known in the immediate vicinity and no recrystallisation of quartz grains was observed in thin sections of the sandstone. Neither do the polygons represent preserved mud cracks, as the depositional environment of the Hawkesbury Sandstone was a fast-flowing riverine setting developing characteristic large cross-beds, rather than the quiet water intertidal environment necessary to form mud cracks. The origin of the polygons is more plausibly a result of weathering involving casehardening of the surficial layers, given that the depressions separating the polygons are only tens of cms deep (Martyn in Conroy et al. 2022). Other weathering features present include potholes and long runnels or grooves.

Aboriginal engravings are numerous at this site (which is on Garigal land), and include a large emu, several wallabies, a very large whale, fish, a goanna, a brushtail possum and numerous decorated shields. The mythical figure of Daramulan is shown in profile with one leg and with an animal-shaped body or head.

Not all weathering features at this site are polygonal – some are more rectangular in outline (photo: Ian Percival).

Moss island developed on sandstone pavement, supporting Short Leaf Heath Myrtle (*Baeckea brevifolia*) (photo: Ian Percival).

To get to and from the tessellated pavement, we walk through a coastal heathland community in which the Coral Heath (*Epacris microphylla*) is particularly prominent. Other shrubs present include the Grey Spider Flower (*Grevillea buxifolia*) and Pink Spider Flower (*Grevillea sericea*), and the Parrot Pea (*Dillwynia elegans*), also popularly called Eggs & Bacon. Soils are generally very thin above the sandstone pavement, and water retention is assisted by mossy islands on which the Short Leaf Heath Myrtle (*Baeckea brevifolia*) grows, standing out with its distinctive red colour. Martyn (2018, p.106) also notes the presence of the Tiny Sun Orchid (*Thelymitra carnea*) on these moss islands.

STOP 3 – KU-RING-GAI WILDFLOWER GARDEN, RICHMOND AVE OFF MONA VALE ROAD, ST IVES

This will be our lunch stop, with the opportunity to walk one of the several trails in the Garden of various durations and difficulties. The Visitor Centre (which also has a café and gift shop) generally has a display of cut foliage and flowers of named native plants that are in bloom, allowing visitors to readily identify plants that they observe on the trails.

Suggested walks (minimum times indicated) – see map on inside back cover:

Solander Trail (distance 2 km, 45–60 mins round trip): sealed throughout with some steep sections, passes through Hawkesbury Sandstone terrain with good examples of cross-bedding. Highly biodiverse native flora of dry schlerophyll forest and scrubby shrubs, varying with topography.

Banks Track and Boardwalk (distance 300 m, 10 mins): links the picnic ground behind Caley's Pavilion with Lambert's Clearing, passing through an upland swamp on a boardwalk. Good place to spot Lace Monitors (goannas) and other reptiles, and small birds. Wallabies are often observed eating the grass at Lamberts Clearing. Then take the **Caley Track** (distance 200 m, 5 mins) merging with the **Bentham Track** (distance 300 m, 15 mins) to walk to Cunningham's Rest through Banksia heathland on rocky terrain. Proceed along road south to Visitor Centre for a well-earned ice cream.

Senses Track (distance 500 m, 15 mins): fully sealed and generally flat, with self-guided signage, this track starts and finishes near the Visitor Centre. This area is underlain by shale rather than sandstone, supporting an open woodland habitat.

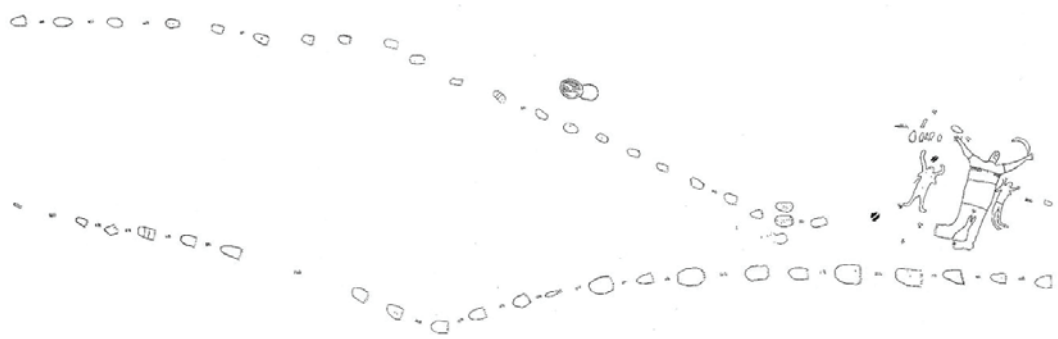
STOP 4 – MANGROVE BOARDWALK OF GIBBERAGONG TRACK, COCKLE CREEK AT BOBBIN HEAD, KU-RING-GAI CHASE NP

We will be visiting this initial section of the Gibberagong Track on the rising tide, well-timed to spot invertebrates (crabs, gastropods etc) in the muddy substrate among the air-breathing roots of the Grey Mangrove (*Avicennia marina*) that form a largely monofloral community growing in brackish water along the banks of Cockle Creek. For birdwatchers, wading birds such as herons, spoonbills and ibises are likely to be feeding, with the possibility of glimpsing an azure kingfisher. A little further along the track beyond the boardwalk (we won't have time to go very far) there are plentiful Grass Trees (*Xanthorrea*), Old Man Banksia (*Banksia serrata*) and Scribbly Gum (*Eucalyptus haemastoma*) growing in nutrient-poor thin soils on Hawkesbury Sandstone.

View from Gibberagong Track of Cockle Creek, showing Grey Mangroves bordering the creek and Grass Tree (in foreground) growing on Hawkesbury Sandstone.

STOP 5 – ABORIGINAL ENGRAVINGS, MT KU-RING-GAI ABORIGINAL AREA

An Aboriginal Area is a site which is managed as a protected area by the NPWS under the National Parks and Wildlife Act 1974. The Mt Ku-ring-gai Aboriginal Area protects an outstanding set of Aboriginal engravings. McCarthy (1959) considered this site to be an important ritual group of engravings reflecting images of Daramulan with his two wives and other figures including a very large number (45) of mundoes or footprints. However, the figure probably depicts Baiame, a culture hero, together with female figures and various other motifs including a basket, fish, animal tracks, and the mundoes which are engraved over some 200 m along a narrow rock ledge (Conroy in Conroy et al. 2022).



McCarthy's (1959) recording of the Mt. Ku-ring-gai engraving site (Conroy, in Conroy et al. 2022)

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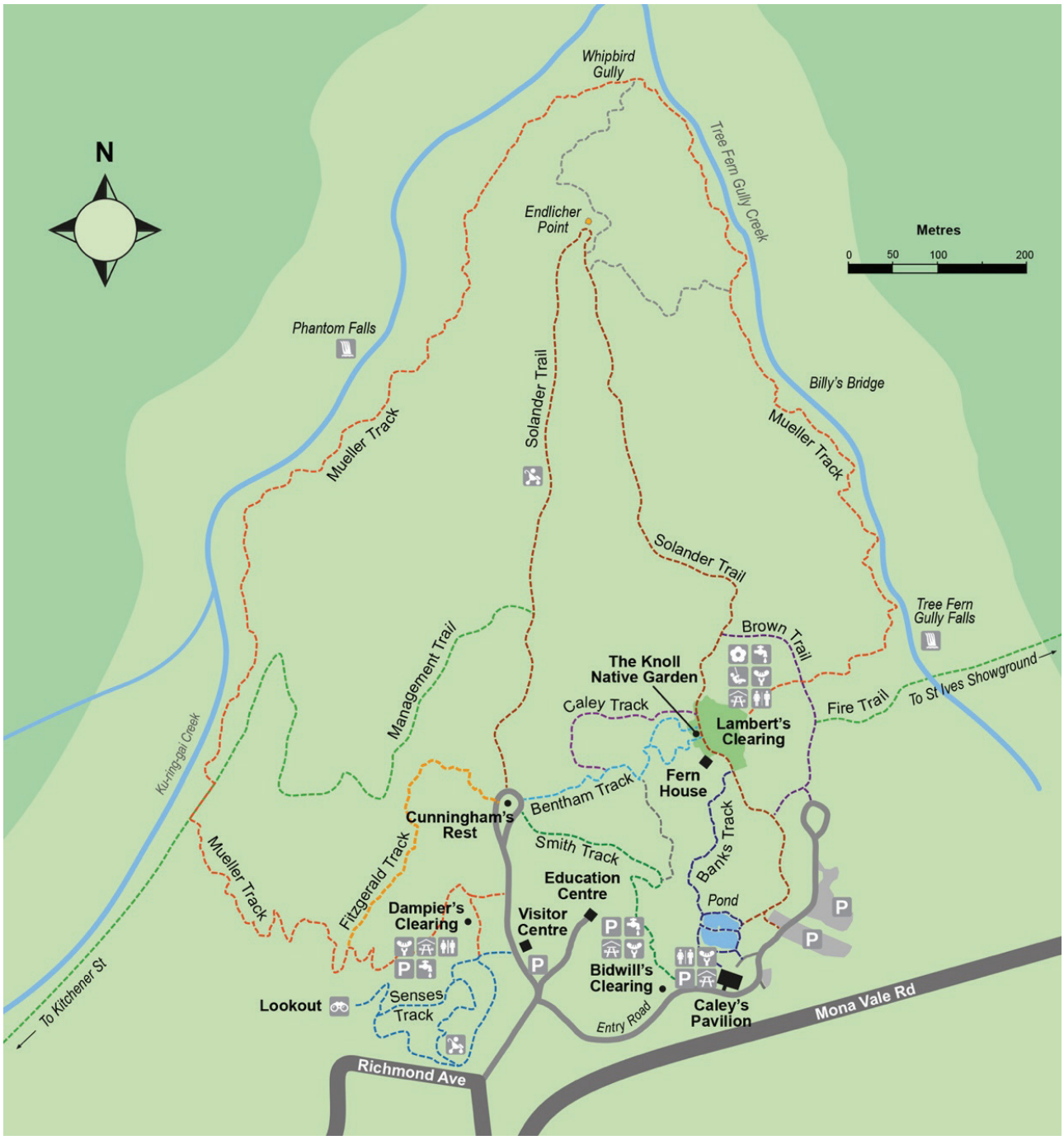
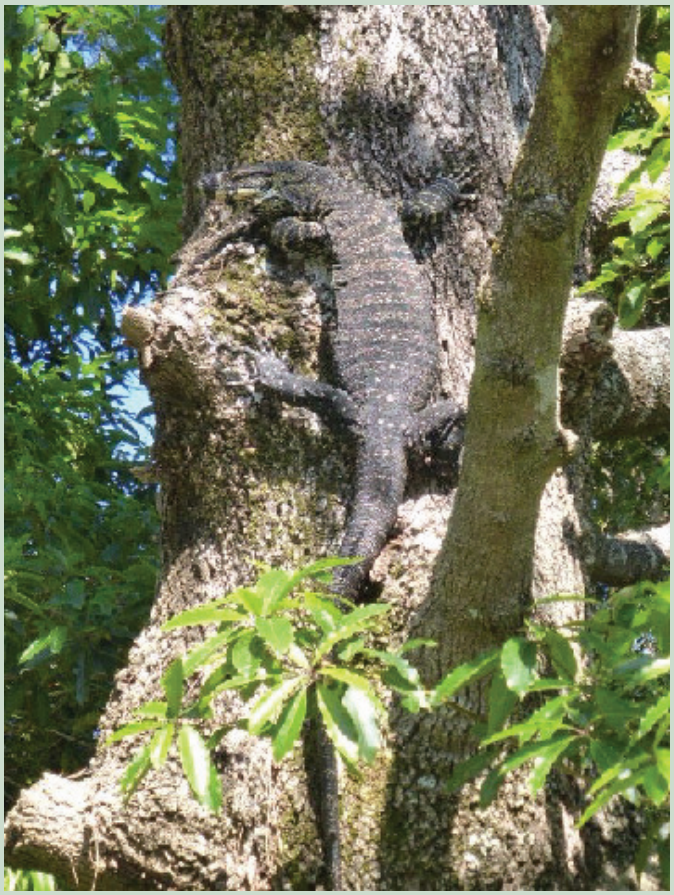


Map of Ku-ring-gai Wildflower Garden, showing facilities and walking trails (from website https://www.krg.nsw.gov.au/Things-to-do/Ku-ring-gai-Wildflower-Garden)

Ku-ring-gai Wildflower Garden is located at 420 Mona Vale Road, St Ives (in northern Sydney), with entry off Richmond Avenue. There is plenty of onsite parking in close proximity to the Visitor Centre, and Caley's Pavilion.
If travelling by public transport, alight at the nearby bus stop on Mona Vale Road.

Entry to the Wildflower Garden is free, 8am – 5pm daily *(except New Year's Day, Good Friday, Christmas Day and Boxing Day)*. Entry to the Visitor Centre and Wildflower Nursery is free, 9am – 4pm Monday to Friday & 10am – 4pm weekends and public holidays *(except New Year's Day, Good Friday, Christmas Day and Boxing Day)*.



Selection of animals and plants found at Ku-ring-gai Wildflower Garden:
Top row: Lace Monitor *Varanus varius*;
Middle row: (left) Mountain Devil *Lambertia formosa*, (right) Crimson Bottle Brush *Callistemon citrinus* (also known as *Melaleuca citrina*);
Bottom row: Flannel Flower *Actinotus helianthi*
(Photos: Ian Percival).

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