

SUMMARY OF STATE HERITAGE PLACE

REGISTER ENTRY

Entry in the South Australian Heritage Register in accordance with the *Heritage Places Act 1993*

NAME: Nelly Creek Fossil Flora Complex **PLACE NO.:** 26546

ADDRESS: Arabana Country
South of Kati Thanda South (Lake Eyre South),
Oodnadatta Track, Callanna SA, 5733
CL6178/960, Outside of Hundreds

STATEMENT OF HERITAGE SIGNIFICANCE

The Nelly Creek Fossil Flora Complex comprises seven fossil sites containing numerous palaeobotanical fossils (leaves, wood and pollen) dating from the Eocene Epoch (~56–33 Million years ago (Ma)). The Nelly Creek site is considered to be Middle-Late Eocene in age and includes many mummified fossil leaf assemblages that are rarely found elsewhere in South Australia. The combination of mummified fossil leaves and its central Australian locality differentiates Nelly Creek from all other South Australian fossil sites.

The species preserved in the fossils at the site expand the known range of extinct and extant native plant species, with many not found anywhere else within the State. Additionally, the anatomy of the preserved flora differs greatly from those found at other South Australian fossil sites and appears to denote a transitional period in climate not shown in any other fossil assemblages in the State. As such, the place can be considered of State and National interest.

The Nelly Creek Fossil Flora Complex is also highly likely to yield information that will build knowledge of Eocene environments within South Australia, including climate change and the aridification of the State.

STATEMENT OF PALAEOLOGICAL DESIGNATION

Nelly Creek Fossil Flora Complex is a palaeochannel located south of Kati Thanda (Lake Eyre). It is a rare and outstanding Eocene Fossil Flora assemblage (~56-33 Ma) dating from the Middle-Late Eocene. Although the channel runs for over 13 km, the significant fossil localities are found within a ~7 km stretch as defined by the State Heritage Place boundary. Nelly Creek Fossil Flora Complex contains seven separate sites that have yielded examples of fossil flora in the form of leaves, pollen and wood.

The complex depicts a preserved environment in which the usual rainforest-like species found during the Eocene Epoch were being replaced by more dry-adapted plants. The fossil site provides a snapshot of the fluctuating Eocene climate that no other fossil flora sites captures within the State. The impressive preservation of the site also makes it an outstanding example of fossil flora within South Australia. The fossil plants are predominantly preserved as 'mummified' specimens in which the organic material of the leaf is preserved rather than replaced by rocks and minerals. This is an exceptionally unusual form of preservation, found in only one other fossil site in South Australia.

The site is also the type locality for at least six plant species, and is expected to yield more type specimens with further research. Examples of type specimens include *Dianellophyllum eocenicum* with features resembling those in the extant genus *Dianella* (flax lilies). Two other examples of *Dacrydium* (Conifers) were also identified from the site. These conifers are the earliest examples of the genus within South-Eastern to Central Australia, and the presence of these small-leaved plants further supports the theory of Nelly Creek's more dry-adapted vegetation.

Nelly Creek Fossil Flora Complex has the potential to reveal significant new information about South Australian plant species and climate change through further detailed research. Numerous palaeobotanists believe that the site has great research potential due to its unusual features. Designation of the fossil site will help to protect the site, enabling further research and increased understanding of the ancient fossil flora of South Australia.

The significant palaeontological features contained within the complex are:

- Seven Middle-Eocene fossil sites with abundant fossil flora
- Extremely well-preserved mummified and silicified fossil floras in the form of leaves, wood and pollen
- Type locality for at least six species of plants
- Eyre Formation directly overlying the Winton Formation, providing unique geological information
- An extensive assemblage that with further research can contribute to an understanding of the natural evolution of the State

RELEVANT CRITERIA (under section 16 of the Heritage Places Act 1993)

(b) it has rare, uncommon or endangered qualities that are of cultural significance

The cultural significance of the Nelly Creek Fossil Flora Complex lies in its scientific value, in particular through its remarkable fossil record, the types of fossils found in the complex, their age, the quality of preservation, and the species represented. The complex contains rare fossils that contribute to an understanding of the evolution of the State over a geological time period, including recording climate variance from the Middle Eocene to the present day.

Nelly Creek is one of 33 Eocene fossil sites identified in South Australia, of which only 13 have fossilised plants in varying states of preservation. Compared with the other Eocene fossil flora sites in South Australia, Nelly Creek Fossil Flora Complex has the highest level of preservation of fossil specimens. The Nelly Creek Fossil Flora Complex is one of only two South Australian fossil sites to contain mummified leaves. This form of preservation is both rare and scientifically important. Nelly Creek is also the type location for at least six fossil plant specimens, including two species of *Dacrydium*. The Nelly Creek Fossil Flora Complex possesses a number of rare qualities that are considered to be of scientific and cultural significance to South Australia.

(c) it may yield in formation that will contribute to an understanding of the State's history, including its natural history

The Nelly Creek Fossil Flora Complex has yielded many fossils in the past and is considered by palaeobotanists to be highly likely to continue to yield numerous fossils in the future. The mummified leaves present at Nelly Creek record plant families, genus and species. The specimens can provide vital information to help understand the climate, environment and ecological interactions that occurred from the Middle–Late Eocene, just prior to the beginning of the aridification of South Australia approximately 15Ma.

Nelly Creek's mummified fossils provide detailed and precise information about species through the quality of cuticle preservation. The site also contains abundant pollen fossils, enabling detailed reconstruction of the palaeoenvironment. The abundance and condition of the pollen enables the identification of the age, diversity and history of the site.

While some investigation and research has occurred at Nelly Creek, the site remains understudied. Thus far, 16 specimens have been positively identified at Nelly Creek, including at least six type specimens. Palaeobotanists anticipate the site is highly likely to yield many further examples.

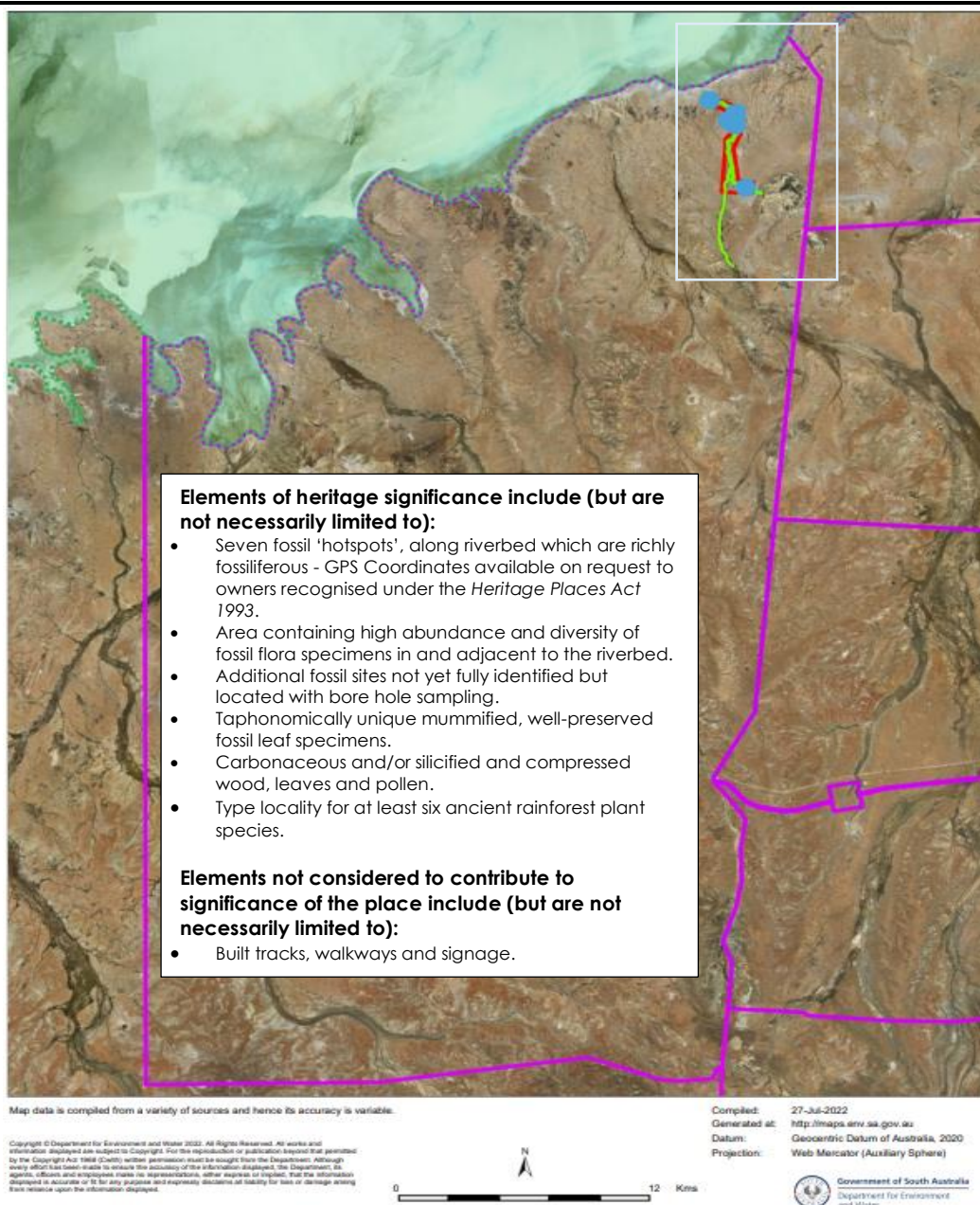
The fossils at Nelly Creek have an extremely high quality of preservation, with many remaining in excellent condition. Palaeobotanists also anticipate that Nelly Creek Fossil Flora Complex is highly likely to contain further high quality specimens in excellent condition. Consequently, the complex has high potential to yield information that will contribute to building our understanding of the vegetation, climate and environment of central South Australia. In particular, the site is likely to yield meaningful information about past environmental conditions and the impact of climate change on vegetation during the Eocene.

Nelly Creek Fossil Flora Complex is the only fossil assemblage to contain mummified and silicified specimens of Eocene age in central Australia. The geographical location is unique. This combined with the high quality of the fossil assemblage and high potential for research, means that Nelly Creek has and will continue to greatly contribute to our understanding of the State's natural history.

SITE PLAN - DETAIL

NAME: Nelly Creek Fossil Flora Complex

PLACE NO.: 26546



Nelly Creek Fossil Flora Complex, South of Kati Thanda South (Lake Eyre South), Oodnadatta Track, Callanna SA 5733. CL6178/960, Outside of Hundreds.

LEGEND

- Parcel boundaries (Indicates extent of Listing)
- Hotspot Areas
- Palaeochannel Watercourse
- Outline of Elements of Significance for State Heritage Place
- Area of interest depicted in subsequent Site Plan

N ↑

Summary of State Heritage Place: 26546

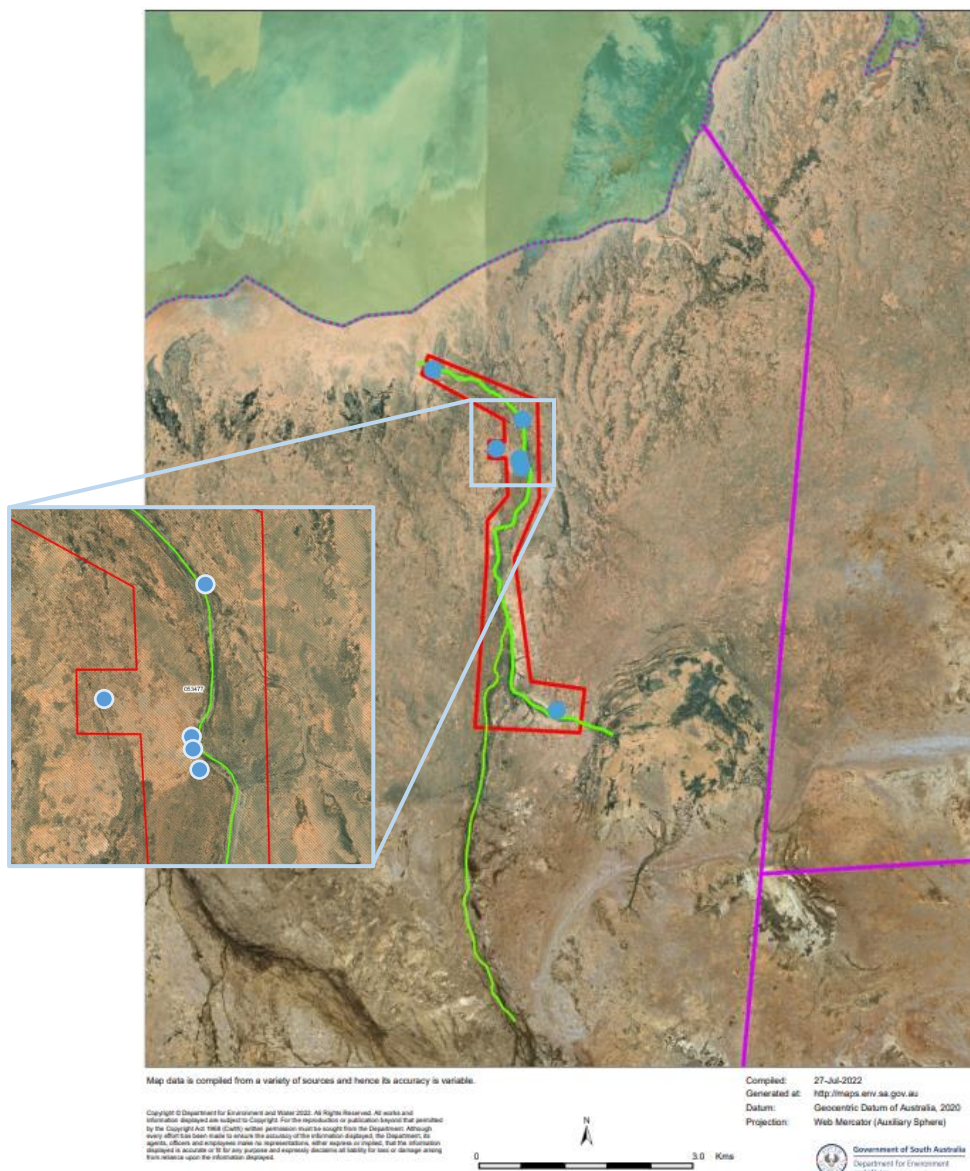
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Provisionally entered by the South Australian Heritage Council on 8 December 2022

Confirmed by the South Australian Heritage Council on 17 August 2023

SITE PLAN - DETAIL

NAME:	Nelly Creek Fossil Flora Complex	PLACE NO.:	26546
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**Nelly Creek Fossil Flora Complex, South of Kati Thanda South (Lake Eyre South),
Oodnadatta Track, Callanna SA 5733. CL6178/960, Outside of Hundreds.**

SHP Length: ~7km

Creek Length: Entire: ~13.5km, Within SHP: ~8.5km

LEGEND

- Parcel boundaries (Indicates extent of Listing)
- Hotspot Areas
- Palaeochannel Watercourse
- Outline of Elements of Significance for State Heritage Place

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COMMENTARY ON THE LISTING

Description and notes with respect to a place entered in the South Australian Heritage Register in accordance with the *Heritage Places Act 1993*

Physical Description

Nelly Creek Fossil Flora Complex is located approximately 55km North-West of Marree in central Australia.¹ The fossil assemblages begin just under 1km South of Kati Thanda South (Lake Eyre South) and continues for approximately seven kilometres along the width of the creek bed. At least one assemblage has been identified 400m west from a small bow in the palaeochannel.

The site is made up predominantly of clay, sands, silts and silcretes in which the compressed and mummified fossils are found. A number of nearby bore holes have also yielded fossilised material outside of the creek bed itself. The most notable fossil sites have been included within the proposed State Heritage Place.

Elements of Significance:

Elements of heritage significance include (but are not necessarily limited to):

- Seven fossil site 'hotspots' (identified on site plan) over seven km along a seasonal riverbed which is richly fossiliferous.
- Area containing high abundance and diversity of fossil flora specimens that are highly palaeontologically and scientifically significant.
- Additional fossil sites not yet fully identified but located with bore hole sampling.
- Taphonomically unique mummified, well-preserved fossil leaf specimens.
- Carbonaceous and/or silicified and compressed wood, leaves and pollen.
- Type locality for at least six ancient rainforest plant species.

Elements not considered to contribute to significance of the place include (but are not necessarily limited to):

- Built tracks, walkways and signage.

HISTORY

Geological Time (Dates approximate)

During the Jurassic, approximately ~199-145Ma, Australia began separating from Gondwana and started its northward movement towards the equator. Before this northward movement, the majority of the Australian continent experienced light summers and dark winters and was covered in vegetation comprised of large evergreen trees.²

Between ~150 and ~100 Ma the environment was largely fluvial (rivers) and/or lacustrine (lakes). However, from approximately 138-97.5Ma, Nelly Creek was under marine conditions. After this period, the seas regressed, allowing for the terrestrial environments seen today.

At ~70 Ma, the climate was believed to be uniformly humid. During the Palaeocene and Early-Eocene (~66- 50 Million years ago), the environment within central Australia was 'warm temperate with seasonally high precipitation'.³ Mean annual temperatures were 18-19 degrees Celsius and rainfall approximately 1400 mm/year. The temperature and rainfall levels created ideal conditions for rainforest plants to grow, and such vegetation is reflected in the fossil record.

During the Middle Eocene, the age of the fossil flora preserved at Nelly Creek (subject of this assessment), the area was believed to be a river channel. The fossils found at Nelly creek reveal that sclerophyllous forest (forest adapted to long periods of dryness and heat) and mesophyll vines (those more often found in a rainforest) dominated at this time. This mix of environments indicates that the area potentially had a dry season (Sclerophyllous) and semi-deciduous monsoon-like forests (Mesophyll).⁴ At this time, it is thought that the mean annual temperature was >20 degrees Celsius and the warm and strongly seasonal environment created distinct macroflora which are smaller than other Middle Eocene-aged floras.⁵

In central Australia, approximately ~60 Ma, there were believed to be large amounts of transient swamp-like land in the west and sandy alluvial fans common in the east. These would sporadically return until the Early Oligocene (~33 Ma).

By ~38 Ma (Middle Eocene), Tasmania and Antarctica finally separated, allowing the Antarctic Circumpolar current to form. The Antarctic Circumpolar current caused cooling throughout the Antarctic and Australia.

It was during these continental and climatic changes that the Nelly Creek Fossil Flora Complex was deposited with leaves that were then preserved in clay and mummified. Mummification requires unusual preservation conditions to occur and results in a high level of preservation of the leaf cuticle, allowing for detailed analysis of the fossil leaves at a higher resolution than those compressed in rock. Around the time of deposition at Nelly Creek, the prevailing environmental conditions were likely monsoonal in Central Australia⁶

Over time central Australia's lakes would periodically dry and return, allowing sporadic survival of rainforests until the Late Miocene. Open grasslands came to dominate, with rainforests standing only close to water sources as an annual dry period developed.⁷

By ~20 Ma, while the North of Australia remained monsoonal and rainforest-like, the rest of the continent became drier with duricrusted (a hard soil layer produced through evaporation of water and precipitation of minerals, common in arid areas)

ground surfaces common. At this point, lakes were still common in the Australian outback.

At ~10 Ma, central Australia became increasingly dry, nearing modern levels of aridity⁸. South Australia had moved south of the Tropic of Capricorn and within the latitudes that most often develop desert environments.

First Nations Interactions (overview)

The Arabana People have an ongoing association with Kati Thanda (Lake Eyre) and surrounding areas. In the mid-1800s, the Arabana People were recorded as living to the south and west of Kati Thanda (Lake Eyre) and may have camped at times near or at the Nelly Creek Fossil Flora Complex. At the time of this assessment, no sites of Aboriginal Heritage interest have yet been identified or recorded by the Arabana People in close proximity to the proposed Nelly Creek Fossil Flora Complex.

Scientific Investigation and Collecting

The site has a long history of scientific research. The first in-depth assessment of the fossil flora at Nelly Creek was conducted by Christophel *et al.* in 1992. The flora was dominated by an unidentified microphyllous flowering plant with unknown affinities and fossil records.⁹

Investigation of the fossil assemblage shows that the flora once living at Nelly Creek were well-adapted to drier environments. The preserved flora demonstrates evidence of sunken stomata (areas of the leaf that can absorb O₂ and CO₂ and moisture), thick cuticles (protective layers of the leaf), and very few examples of epiphyllous fungi which requires high amounts of moisture to thrive.¹⁰ All of these features are often associated with drier climatic conditions.

Numerous expeditions and six South Australian Resources Information Gateway (SARIG) collection expeditions have occurred since 1984, resulting in a body of research. A collection of fossils from the Nelly Creek Fossil Flora Complex is held in the Palaeobotany Collection, Botany Department, Adelaide University. Other collections are unknown.

Chronology

Year	Event
~56Ma	Beginning of the Eocene Epoch & Palaeocene-Eocene Thermal Maximum
~38Ma	Middle-Late Eocene (Age of Fossil Site and Deposition) – Antarctica separates from Australia, Monsoonal conditions are common in central Australia
~30Ma	Tectonics altering environmental factors within Australia as the continent moves northward
~15-5Ma	Beginning of Central Australia's aridification in earnest. Environment dried and plant assemblages changed greatly
Pre-1836	Aboriginal People operate trade routes throughout the area
Post 1836	European arrival in the area
~1860	Nearby Marree Township founded as Hergott Springs
1986	Area of fossil site discovered by Roger Callen
1992	First paper published on the fossil flora at Nelly Creek and the area is recognised as a site of great palaeontological interest
1980-Present	Subsequent explorations
1994	April. Recognised as a Geological Monument by the South Australian Division of the Geological Society of Australia
2006	Included as part of 12 sites in Australian Heritage Council's Australia's Fossil Heritage: A Catalogue of Important Australian Fossil Sites¹¹
2021	Included as priority for assessment in <i>Fossil Heritage Survey for South Australia</i> .

References

- Australian Heritage Council, The (2006), 'South Australia' in *Australia's Fossil Heritage: A Catalogue of important Australian fossil sites*, CSIRO Publishing, pp. 51-71.
- Christophel, DC (1994), 'The early Tertiary macrofloras of continental Australia', in Hill, RS (ed.) *History of the Australian Vegetation: Cretaceous to Recent*, Cambridge University Press, Cambridge.
- Christophel, DC, Scriven, LJ & Greenwood DR (1992), 'An Eocene megafossil flora from Nelly Creek. South Australia' *Transactions of the Royal Society of South Australia*, vol. 116, pp. 65-76.
- Conran, JG, Christophel, DC & Cunningham, L (2003), 'An Eocene monocotyledon from Nelly Creek, Central Australia, with affinities to Hemerocallidaceae (Lilianaes: Asparagales)', *Alcheringa*, Vol. 27, no. 2, pp. 107-115.
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- Greenwood, DR (1996) 'Eocene Monsoon Forests in Central Australia?', *Australian Systematic Botany*, Vol. 9, no. 2, pp. 95-112.
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- Wopfner, H, Callen, R, Harris & WK (1974) 'The lower tertiary Eyre formation of the Southwestern great Artesian basin', *Journal of the Geological Society of Australia*, Vol. 21, no. 1, pp.17-51.

SITE DETAILS

Nelly Creek Fossil Flora Complex

PLACE NO.: 26545

South of Kati Thanda South (Lake Eyre South), Oodnadatta Track, Callanna SA 5733.
CL6178/960, Outside of Hundreds.

DESCRIPTION OF PLACE:	Eocene age fossil flora complex consisting of seven sites containing mummified fossil leaves, abundant fossilised pollen spores and fossil wood. The fossils can be found within a mostly dried palaeochannel that can be seasonally wet. The rock found in the area is silcrete, clay, sand and silts.
REGISTER STATUS:	Provisional Entry: 8 Dec 2022 Confirmed: 17 August 2023 Designated: 17 August 2023
CURRENT USE:	Creek Bed
LOCAL GOVERNMENT AREA:	Out of Hundreds
LOCATION:	Town/Suburb: South of Kati Thanda South (Lake Eyre South) Title CL6178/960 Reference: D34847 A2 Plan No.: 34847
LAND DESCRIPTION:	Hundred: Out of Hundreds Encumbrance Native Title Holder: Arabana Aboriginal Corporation RNTBC (Determination Date: 22 May 2012) Miscellaneous Crown Lease: CL6178/960 - Arabana Aboriginal Corporation RNTBC

PHOTOS

Nelly Creek Fossil Flora Complex

PLACE NO.: 26545

Nelly Creek Fossil Flora, South of Kati Thanda South (Lake Eyre South), Oodnadatta Track, Callanna SA 5733. CL6178/960, Outside of Hundreds.



Fossil Logs at the Nelly Creek Fossil Flora Complex with Geologist Graham Krieg in background.

Source: Photo 047115, Neville Alley, 1999

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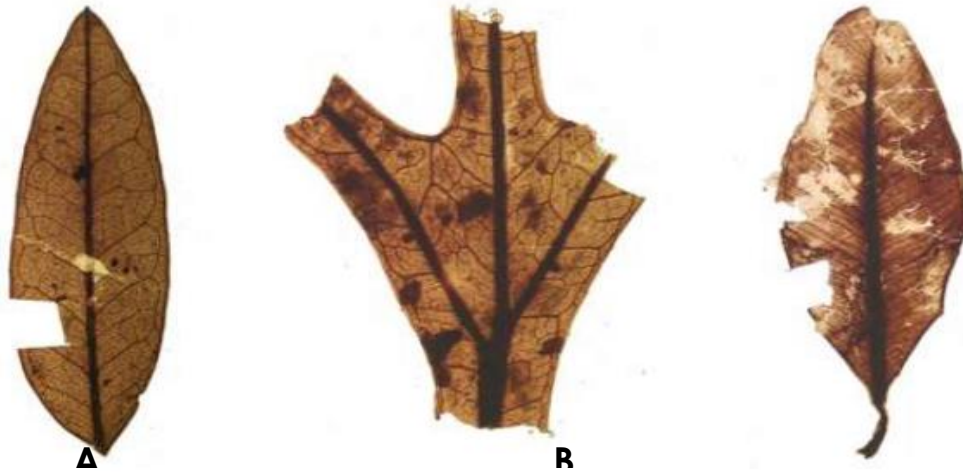
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PHOTOS

Nelly Creek Fossil Flora Complex

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Fossil Leaf specimens collected at the Nelly Creek Fossil Flora Complex locality

A, B, C – “Fossil leaves extracted from Eyre Formation in Nelly Creek”.

Source: Neville Alley 1999. A; Photo 047290 B; Photo 047288, C; Photo 047289

D – Carbonised leaf fossils in Eyre Formation, Nelly Creek.

Source: Callen, RA, 1986. Photo 039583.

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- ¹ Conran, JG, Christophel, DC & Cunningham, L (2003) 'An Eocene monocotyledon from Nelly Creek, Central Australia, with affinities to Hemerocallidaceae (Liliana: Asparagales)'.
² Hill, RS (2017) 'The Australian fossil plant record: an introduction', in Hill, RS (ed.) *History of the Australian vegetation: Cretaceous to recent*, Cambridge University Press, Cambridge.
³ Wopfner, H, Callen, R, Harris & WK (1974) 'The lower tertiary Eyre formation of the Southwestern great Artesian basin', *Journal of the Geological Society of Australia*, Vol. 21, no. 1, pp.17-51; Quilty, PG (1994) 'The background: 144 million years of Australian palaeoclimate and palaeogeography' in Hill, RS (ed.) *History of the Australian vegetation: Cretaceous to recent*, Cambridge University Press, Cambridge.
⁴ Greenwood, DR (1994) 'Palaeobotanical evidence for Tertiary climates' in Hill, RS (ed.) *History of the Australian vegetation: Cretaceous to recent*, Cambridge University Press, Cambridge.
⁵ Greenwood, DR (1994) 'Palaeobotanical evidence for Tertiary climates'; Macphail, MK, Alley, NF, Truswell, EM & Sluiter, IRK (1994) 'Early Tertiary vegetation: evidence from spores and pollen' in Hill, RS (ed.) *History of the Australian vegetation: Cretaceous to recent*, Cambridge University Press, Cambridge.
⁶ Alley, N Personal Communication (2022), Greenwood, DR (1996) 'Eocene Monsoon Forests in Central Australia?', *Australian Systematic Botany*, Vol. 9, no. 2, pp. 95-112.
⁷ Quilty, PG (1994) 'The background: 144 million years of Australian palaeoclimate and palaeogeography'.
⁸ Wilford, GE & Brown PJ (1994) 'Maps of late Mesozoic-Cenozoic Gondwana break-up: some palaeogeographical implications' in Hill, RS (ed.) *History of the Australian vegetation: Cretaceous to recent*, Cambridge University Press, Cambridge.
⁹ Christophel, DC (1994), 'The early Tertiary macrofloras of continental Australia', in Hill, RS (ed.) *History of the Australian Vegetation: Cretaceous to Recent*, Cambridge University Press, Cambridge.
¹⁰ Christophel, DC, Scriven, LJ & Greenwood DR (1992) 'An Eocene megafossil flora from Nelly Creek, South Australia'.
¹¹ Australian Heritage Council, The (2006), 'South Australia' in *Australia's Fossil Heritage: A Catalogue of important Australian fossil sites*, CSIRO Publishing, pp. 51-71.