A SHORT HISTORY

OF A SUB-TROPICAL FRESHWATER WETLAND:

A PALAEO-ENVIRONMENTAL PERSPECTIVE

Wetland Condition 2023 and 2024

Great Barrier Reef Catchment Wetland Monitoring Program

July 2025

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July 2025

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Table of contents

Tables

Figures

Plates

Executive summary

In April 2023 a sediment core[1] of approximately 25 cm in length was taken from an ephemeral sub-tropical wetland (site that temporarily holds water following substantial rains or flooding but dries out between events) near the Connors River in Central North Queensland. The core comprised layers of fine sediments with noticeable amounts of plant roots and other visible organic material. In the upper half of the core the roots and other organic material are larger and the sediments are a light grey/brown in colour. From the mid-point of the core the sediments become a darker grey/black in colour, and the organic material is more broken down in size/structure.

These 25cm of layered sediments were deposited over the last 2000 years, based on a radiocarbon date from the base of the core. Aside from radiocarbon dating, charcoal and pollen studies were undertaken. Charcoal is produced and incorporated into sediments from the burning of vegetation in the immediate vicinity of a site (larger pieces) or in the region (smaller pieces). Pollen is produced by the plants within a wetland and surrounding landscape. It is incorporated into sediments largely through being transported by the wind or water runoff. By examining the changes in pollen quantities from older to younger sediments, it is possible to identify which plant groups were becoming more, or less common in the landscape.

In the case of this core, we know that the oldest sample studied (23 cm depth) represents the conditions of the site approximately 2000 years ago. Likewise, the uppermost sample (0 cm depth), represents the conditions of the site in the relatively recent past. The ages of the middle samples (5, 10 and 15 cm depth) are less certain due to the lack of associated radiocarbon dates. However, based on changes in pollen and charcoal it is probable that the sediments from at least 10 cm in depth were deposited post-European arrival in the region. This time across Australia saw marked increases in rates of erosion and sediment deposition associated with land clearing and changes in land use. Confirmation of this would however require additional dating work to be done.

Fire history

In the two deepest and oldest samples and based on based on comparison with the amounts of charcoal found in the youngest/uppermost sample, there is evidence that there was a somewhat greater amount of fire occurring in the broader region than has been occurring in the recent past. At a depth of 10 cm, there seems to be a slight increase in local fires compared to older samples. However, on a regional scale, there was significantly more fire. Following the peak in fires at 10 cm depth, both regional and local fires appear to have decreased, with a notable reduction in local fires compared to earlier periods.

A potential explanation of these changes in fire in the landscape is that the lower sample/s are showing the use of fire for land management purposes by local indigenous groups, or alternatively, fires associated with an enhanced El Nino-Southern Oscillation at this time driving wet/dry conditions. The significant increase in fires observed at 10 cm depth is likely linked to the use of fire for land clearing during development. This spike is also associated with an increase in herbivore-associated dung-fungi which supports this suggestion. This is then followed by a shift towards more fire suppression.

[1] A sediment core is a tube of sediment extracted from the bottom of a waterbody. It is a type of sample that captures the sediment layers with depth while preserving the sequence in which the sediment settled over time. Sediment cores provide glimpses into Earth's climate and environment through time

Vegetation history

All the samples analysed for pollen from this core yielded abundant amounts of reasonably preserved pollen. The area around this site has been an open woodland with Acacia and Eucalypt trees, with an understory of sedges, for at least the last 2000 years. This conclusion is based on the dominance of sedge pollen in all the samples, along with an array of pollen from various trees, shrubs and non-woody plants. Compared to the most recent sample, the oldest sample suggests that the herbaceous understory was more diverse 2000 years ago. There was less sedge pollen and more pollen from other herbaceous plants, such as daisies. Due to the very low relative abundances of all non-sedge taxa, any other changes in the vegetation are ambiguous. However, in the middle samples it does appear that overall amount of tree pollen does diminish slightly, before increasing again in the uppermost sample. This sample also sees the herbaceous vegetation becoming somewhat more diverse than in the middle samples.

Introduction

This study is one of seven palaeo-environmental wetland studies being undertaken in the Fitzroy Basin, four of which are in the Isaacs catchment. The study is being undertaken as part of the Paddock to Reef Monitoring, Modelling and Reporting program's wetland condition monitoring.

Palaeo-environmental studies show that wetlands are dynamic and change significantly over long time periods. These studies help us understand environmental changes and longer-term environmental variability from both natural processes and human influences. Combined with modern ecology and historical records this information can be used to guide wetland restoration and management.

This report presents the findings of the palaeo-environmental investigation carried out on a sediment core collected from the wetland.

Figure 1: extracting the sediment core

Study site and methods

The study core (Fig 3) was collected from the wetland (Fig 2) using a percussion corer (Fig 1) in April 2023. The dry conditions combined with the high proportion of fibrous (plant) material in the sediments, meant that the corer was only capable of penetrating to a depth of 25 cm. The core from this drive was recovered and has been analysed by the Queensland Department of the Environment, Tourism, Science and Innovation and the University of Queensland via radiocarbon dating, palynological (pollen) analysis and charcoal analysis.

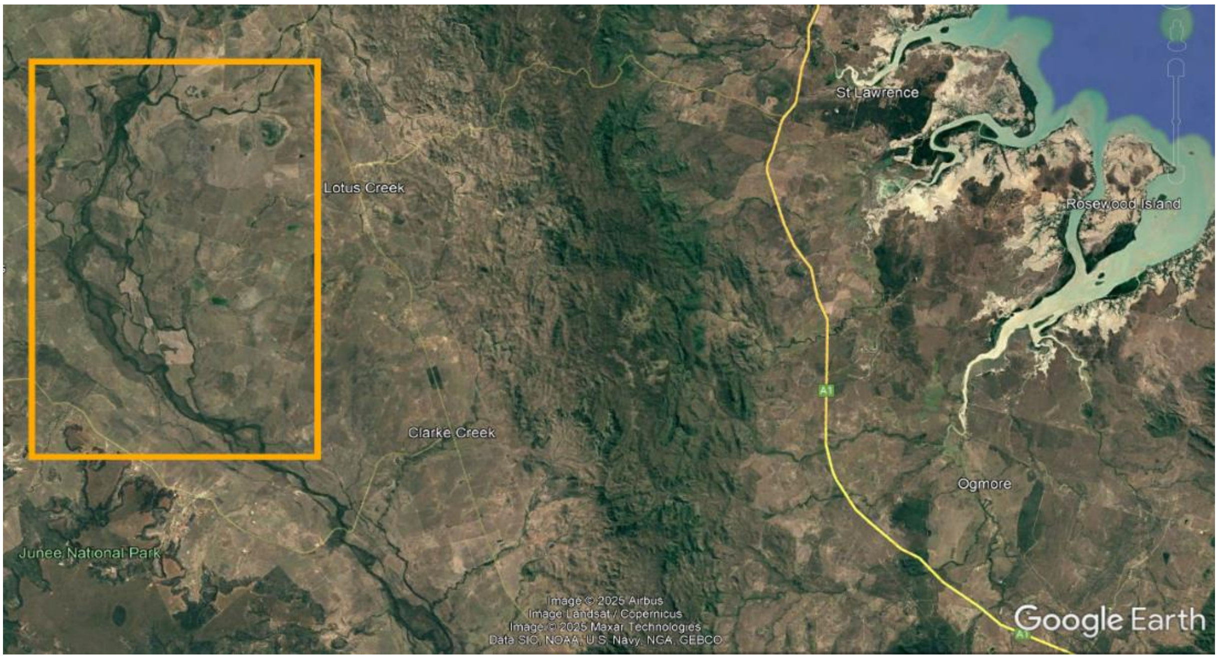


Figure 2: Map of region showing approximate location of the core site (above). The exact location is confidential. Image taken from Google Earth.

Core Dating

To constrain the age of the cored sequence, a bulk organic sediment sample was taken from the base of the core (at the 21-23cm depth) and sent to SBS Beta for radiocarbon dating.

Pollen and Charcoal analysis

Between 7 and 23 grams of sediment was used for palynological/charcoal analysis for each of the 5 samples analysed (Table 1). They were processed using the method (utilising sodium polytungstate heavy liquid with a specific gravity of 2.0) described in Wheeler et al. **(2021)**. Each sample was counted for pollen, carbonised particles (particles less than <125 microns, which provides insight into regional fire regimes) and *Sporormiella* (a dung fungus associated with herbivores, such as cattle, sheep, kangaroos, wallabies, and pademelons) at 400 times resolution using a compound light microscope and at least 200 pollen grains were counted from each slide. All samples contained fossil pollen and micro-charcoal (particles <125 microns). A pollen diagram was then produced using the Tilia computer program.

Figure 3: The wetland core post splitting.

After the pollen and spores are identified and counted, a method called CONISS (Constrained Incremental Sums of Squares), was used to sort the sediment layers into zones. This method groups together layers that have similar characteristics and keeps the layers in the order they were deposited over time. This classification analysis of the raw pollen data was undertaken to compare the degree of similarity of the sample compositions based on differences in pollen abundances and which is shown as a dendrogram (a tree diagram showing relationships) on the classification diagram (Grimm,1987).

During the processing of the samples of pollen and microcharcoal, the fraction of the material when sieved greater than 125 microns was put aside for microcharcoal analysis. This material had 5% hydrogen peroxide added and was left overnight. The hydrogen peroxide acted to break down and lighten the organic material in this size fraction that was not carbonised, while leaving the carbonised material unaffected. Once this had happened, the samples were poured into Petrie dishes and carbonised particles of greater than 125 microns were counted at 10 times resolution using a binocular microscope.

Table 3: list of samples and sample weights.

Sample (cm)	Weight (g)
0	23
5	7.4
10	7
15	9.5
23	12

Results

Core description

The wetland core (Fig 1) is approximately 25 cm in length and is relatively homogenous in nature. Throughout the length of the core the dominant sediment type is a silty clay, with a relatively high amount of fibrous organic material (mostly roots) incorporated. These roots are most abundant, larger and structurally coherent in the upper half of the core, but are present in the lower half, though reduced in number, size and structural integrity. The other notable change in the core is a transition from a slightly lighter grey/brown colour in the upper part (5YR 3/2 to 11cm in depth) to a darker colour below (5YR 2.5/1 from 11 to 25 cm in depth). The core was pulled out for study in April of 2025, and had dried somewhat since it was originally recovered, which is the most likely explanation for the texture of the core when photographed.

Chronology

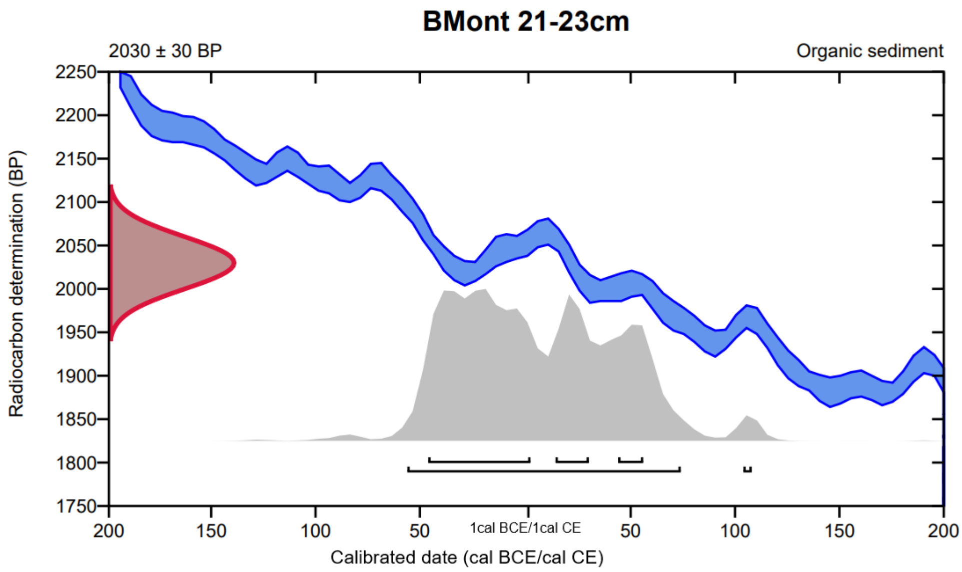


Figure 4: Radiocarbon calibration plot.

On analysing the radiocarbon sample from the core (~22cm depth), SBS Beta found that the material had a conventional radiocarbon age of 2030 ± 30 BP (vertical axis of Fig 4), which when calibrated against the southern hemisphere calibration curve SHCal20 (Hogg et al., 2020), gave a calendar age of between 58 BCE to 74 CE with 94.8% certainty using OXCal v4.4 (Bronk Ramsey, 2009) (horizontal axis of Figure 4).

Explanatory notes

Radiocarbon dating works by measuring how much carbon-14 (14C) remains in organic material. Carbon-14, a naturally occurring radioactive isotope of carbon that decays over time. This decay is used to determine the age of organic materials, as the amount of 14C in their remains decreases. The 'conventional radiocarbon determination' gives the age of the sample in years 'Before Present', where the present is defined as 1950, which is when the first radiocarbon dates were published. For the base sample, this age determination is shown in the red in Figure 4. This determination does then need to be calibrated to actual calendar year equivalents as the starting amount of 14C available to organisms to incorporate into their tissues has varied slightly through time. This is done via comparison of the 'raw' results to calibration curves (in blue in Fig 4), which have been created by measuring the amount of 14C found in tree-rings of known ages. These calibrated ages then give the most likely calendar year range the sample dates to (in grey in Fig 4).

Results

All 5 samples taken from the sediment core proved to contain countable numbers of pollen, dung fungi, and both micro- and macro-charcoal (Table 2). Despite the sampling site being an ephemeral wetland, i.e. not one with permanent standing water which is typically where the best pollen preservation occurs, there were a reasonable number of identifiable grains found from each sample. These assemblages of pollen grains were however of rather mixed preservation quality with many grains having degraded beyond recognisability, or only identifiable to a family level. To accurately describe past vegetation, pollen samples typically need to contain at least 200 to 500 grains, depending on the method used and the characteristics of the site.

Table 2 lists the sample depths, as well as how many microcharcoal, macro-charcoal or dung fungi spores were recovered per gram of sample material. Microcharcoal and dung fungi spores were counted from the pollen slides, while macro-charcoal was counted in a Petrie dish from the greater than 125-micron size fraction, processed separately.

Table 4: Counts of pollen, charcoal and fungi for the 5 samples.

Sample (cm)	Pollen counted	Macrocharcoal/gram	Microcharcoal/gram	Dung fungi/gram
0	~295	13	186,689	27
5	~326	909	810,253	29
10	~423	2,774	1,879,868	37
15	~484	1,617	480,125	26
23	~256	1,094	202,243	15

The relative abundances of the plant taxa identified in each of the samples are plotted in the pollen diagram (see Figure 5, page 15), showing how the overall composition of the assemblages has changed through time, with the oldest samples at the base of the core and the youngest at the top of the core. Based on the basal radiocarbon date, we know that the entire cored sequence of sediments has been deposited at the site over the last approximately 2000 years.

The pollen assemblages are all overwhelmingly dominated by pollen produced by the Cyperaceae (sedges). In the lowermost sample (23cm), pollen from the Cyperaceae makes up a quarter of the total pollen assemblage before increasing to roughly half of each of the younger samples. Of the remaining taxa identified in these samples the only other taxa that ever comprise 10% or more of a given sample's pollen are the Asteraceae (daisies) (5-17%), Restionaceae (rushes) (3-10%) and Poaceae (grasses) (8-12%). Taxa that have a maximum relative abundance of between 4-10% in at least one sample are Myrtaceae (3-6% of Eucalypts and Melaleuca combined) and Macaranga (0-7%). All others are present only in trace amounts.

Interpretation and discussion

How to interpret pollen and charcoal data (Palynology)

Pollen assemblages reflect the plants that were growing in the vicinity of the site that the samples were taken from at the time the sediments were being deposited. Due to the often-slow rate of sediment deposition, any given pollen assemblage recovered in the lab often represents the pollen that was collected at a site over several years. Further, the absolute amounts of pollen from any given taxon (a group with shared characteristics) in a pollen assemblage may be an over, or under representation of how abundant that taxon was as a plant in the surrounding area. This difference in plant vs pollen assemblages is due to several factors, including:

- Pollination mode: plants that are wind pollinated tend to produce significant amounts of pollen out into the environment and hence are often over-represented in pollen assemblages. Conversely, plants that have very specific animal pollinators may be much more conservative with their pollen production and have a lower probability of being preserved in sediments.
- Plant growth habit and distance from depositional site: plants that make up the tallest component of a vegetation community will more readily have their pollen picked up in the wind or by water and therefore can be over-represented in pollen assemblages, while those that have less exposed growth positions are likely to be underrepresented. Equally, plants that are growing in the immediate vicinity of the depositional site are going to make up most of the pollen assemblage, while only trace amounts of pollen from more distant plant communities are likely to appear in assemblages.
- Pollen morphology: in situations where pollen is damaged prior to being deposited, pollen types with thick walls and/or ornamentation are much more likely to remain recognisable compared to pollen with thinner walls and less distinctive features.

Because of these factors, when looking at pollen data, rather than focusing on how much pollen of each type is found in a single sample, we instead look at how the relative amounts of each pollen type change through several samples. This tells us if the plant type the pollen comes from was becoming more, or less, common at different points in time.

Calculated as number/gram, the microcharcoal, macro-charcoal and dung fungi also tell us about the environment at the time they were deposited. Microcharcoal comprises the pieces of carbonised material with angular edges less than 125 microns in size. Due to their small size this microcharcoal can be carried long distances by the wind and is therefore interpreted as a regional fire signal. Macro-charcoal with a size of 125 microns and greater, is less readily transported, and therefore is an indication of how much fire was occurring in the near surroundings of the sample site. Dung fungi as counted here are spores produced by fungi that are found in association with herbivore dung and therefore give an indication of what volume of herbivores was present around the site through time.

What do the results mean?

The coring locality today is an ephemeral wetland, and based on the consistent sedimentology of the core, combined with the relatively minor changes seen in the pollen assemblages, this is likely to have been the case for the entire time covered by the cored interval.

23 cm sample – approximately 2000 years ago

As this sample is taken from the same interval as the radiocarbon sample, we can be confident that the pollen assemblage extracted from this interval represents the plants that were growing at or nearby the site approximately 2000 years ago. Based on the classification analysis run on the pollen assemblages from the core (CONISS column in the Figure 5 pollen diagram on page 15), this is the assemblage that is most different from any of the overlying samples. Notably, this sample sees the pollen of the Cyperaceae (sedges) at their lowest relative abundance of the entire sequence, comprising just 25% of the total pollen assemblage. The Cyperaceae (sedges) are plotted here amongst the aquatic taxa due to many species from the family preferring wetter conditions, however, several species from the family such as *Cyperus difformis* do grow in either seasonally wet, or grassland environments. Other common components of the assemblage are pollen from the Asteraceae (daisies), Poaceae (grasses) and Restionaceae (rushes). The remainder of the pollen assemblage is comprised of pollen from a wide range of plant types present each at levels less than 5% of the total assemblage each, including Acacias (2.9%) and Eucalypts (3.3%).

Based on this pollen assemblage, the plant community growing around the coring site 2000 years ago most likely consisted of an open Acacia and Eucalypt woodland with a sedge-dominated understory. While Acacia pollen does only make up just under 3% of the total assemblage, it likely represents a serious underrepresentation of the amount of Acacia growing in the environment as Acacia pollen is fragile and readily becomes unrecognisable.

The sedge dominated understory would also have contained other herbaceous plants including but not limited to members of the Asteraceae, Poaceae, Convolvulaceae (morning glories), and Restionaceae. Either as part of the woodland or growing nearby in denser forest stands were trees and shrubs that included members of the Arecaceae (palms), Rubiaceae (gardenia), Celtis (nettle trees), Melaleucas and Pandanus (screw pines).

Fires both in the immediate vicinity of the site and the region were also part of the landscape, if we assume the uppermost sample's values are indicative of 'today's/the immediate past', then fires may have been somewhat more common than seen at the site today.

15 cm sample

From this point onwards, determining what time-period a particular sample represents in the 2000-year window becomes less certain as no radiocarbon dates were obtained for this part of the sediment core. Additional dating of material from other parts of the core would enable more definitive interpretation.

Based on the results, at the time this sample was deposited, we see the Cyperaceae become an even more dominant part of the assemblages reaching 50% of the total pollen assemblage. Pollen from other herbaceous plants such as the Restionaceae, Poaceae and especially the Asteraceae does decrease in relative abundance. Given the very low starting abundances of the other taxa, the significance of variations on the order of ≤1-3% relative abundance is unclear. However, of the tree and shrub taxa one likely significant change is the marked increase in the relative abundance of pollen from the *Macaranga* from 0.4 to 6%. Plants from this genus are often pioneer species recolonising areas cleared through some form of disturbance. This may have been associated with the slightly increased amounts of both local and regional fire occurring at the time, or potentially large cyclone events.

10, 5 and 0 cm samples

The pollen assemblages from these three samples do change slightly in the relative abundances of pollen from specific families from sample to sample, but overall, the differences between the assemblages are minor. Some of the more notable changes are a dropping down of the relative abundance of *Macranga* pollen in these samples compared to the 15 cm sample and a minor peak in Restionaceae and Pteridophyte (ferns and allies) abundance in the 10 cm sample. By the 0 cm sample, the Asteraceae and Rubiaceae are starting to get closer to their previous abundances in the lowermost sample, as are the Acacia, which did decline slightly in the 15 and 5 cm samples. Through this interval we also see a slight increasing trend in the abundance of *Casuarina* pollen, as well as pollen from the Urticaceae (nettles). Note that the increase seen in Asteraceae pollen seen in the 0 cm sample may potentially be due in part to an increase in the pollen of the invasive Parthenium weed which has been invading native and managed Australian grasslands for almost 40 years (Belgeri et al., 2020).

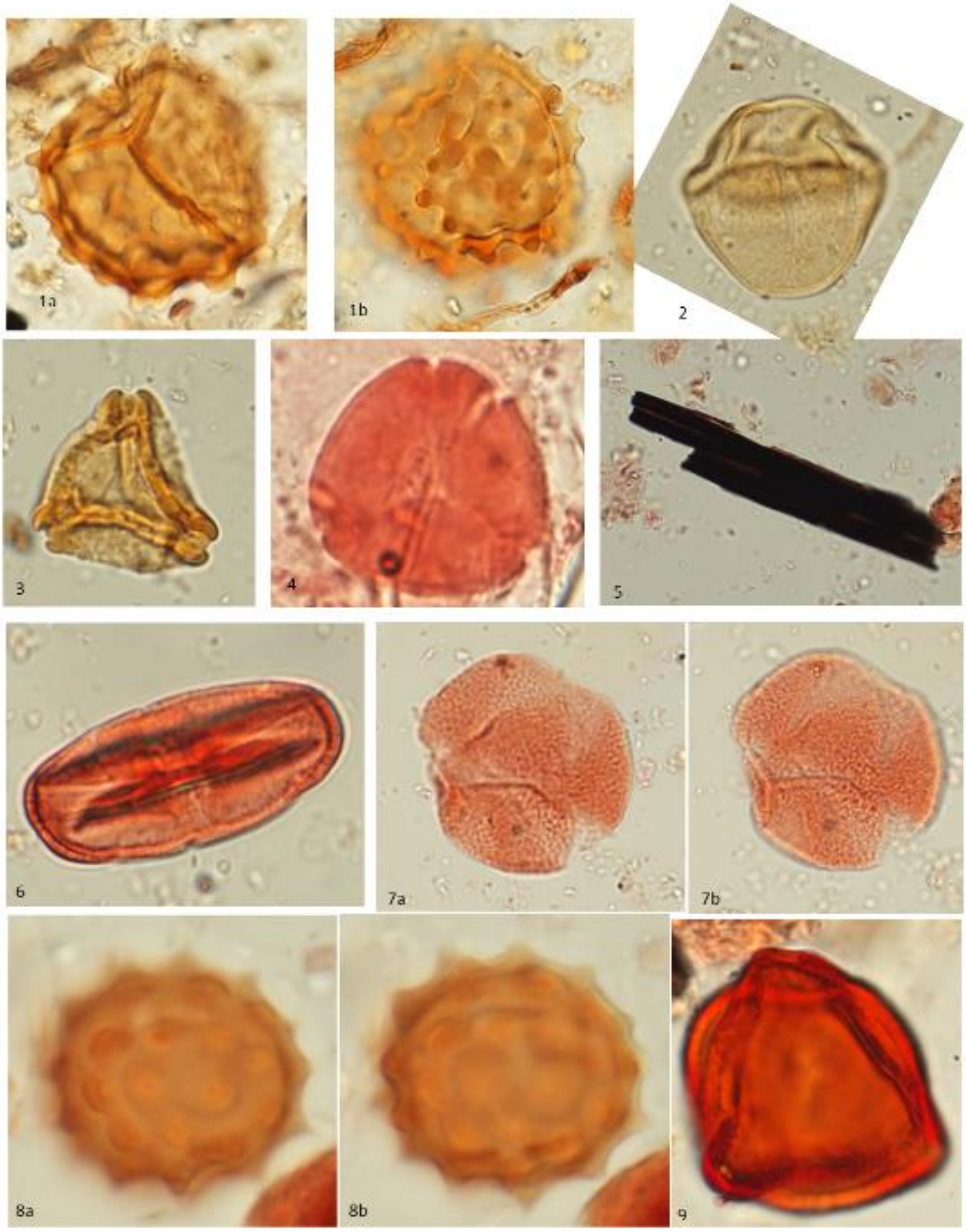
The 10 cm sample was taken just above the point where the core transitions from a darker to a lighter grey. This sample also shows a marked increase in both micro- and macro-charcoal as well as dung fungi, all of which have their highest abundances of compared to the samples. All these values do then drop off in the 5 cm and especially the 0 cm samples.

The marked increase in microcharcoal, macro-charcoal and dung fungi seen in the 10 cm sample is a pattern that has elsewhere been linked with European use of fire for the purpose of land clearing. This pattern can however also be linked to changing natural or indigenous land management practices associated with shifts in climate. Without additional radiocarbon dating, in this instance the pattern cannot be definitively explained. The fact that the spikes in charcoal are associated with increases in dung fungi (a marker of roughly the volume of herbivores in an area), does somewhat support the contention that these samples are post-contact in age. As such the decline in both micro and macro-charcoal seen in the 5 and 0 cm samples would then be associated with a transition to a more fire-suppressing land management regime. The uneven rate of sediment deposition at the site would imply it is in accordance with changes observed elsewhere in Australia (Wasson et al., 1996), where sedimentation rates post-European arrival show significant increases.

Conclusions

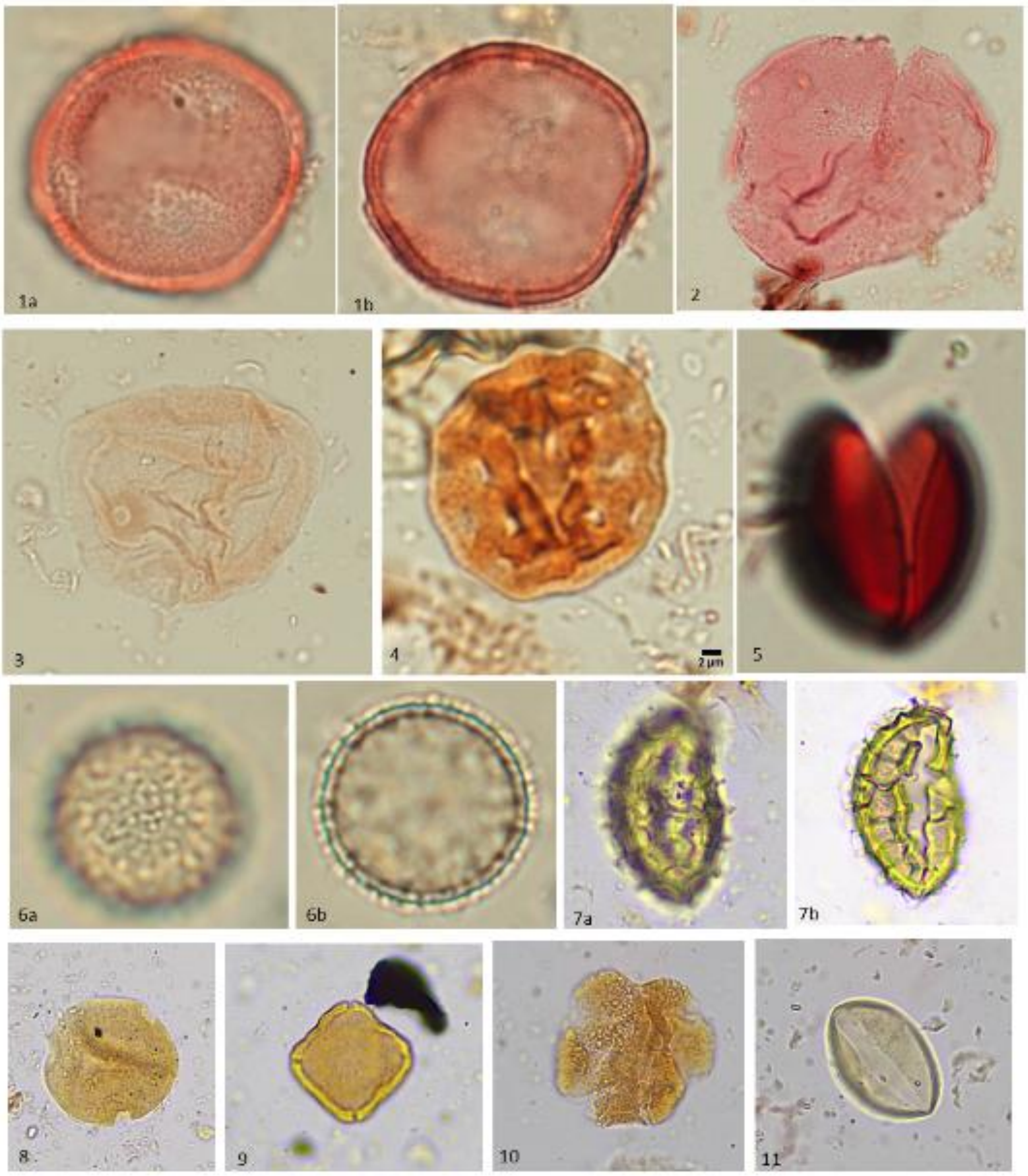
This sub-topical wetland sediment core covers approximately the last 2000 years of the site's history. The charcoal data does show that there have been some significant changes in the area's fire regime, shifting from moderate to high, then down to low fire occurrence. However, based on the pollen data it does appear that the site's vegetation has been relatively resilient in the face of these changes and has remained a relatively open and diverse woodland with sedgy understory.

Plate 1



1. Lycopodiaceae; 2. Rubiaceae; 3 & 4. Myrtaceae; 5. Microcharcoal; 6. Apiaceae; 7. Lamiaceae; 8. Asteraceae—spinose sculpture; 9. *Casuarina*

Plate 2



1 & 2. Cyperaceae; 2. Poaceae; 3 & 4. Amaranthaceae; 5. Dung fungi; 6. *Pandanus*; 7. Liliaceae; 8. *Celtis*; 9. *Myriophyllum;* 10. Lamiaceae; 11.Arecaceae

<u>Pollen diagram for the wetland sediment core.</u>

Columns to the left of the 'Pollen sum' show the relative abundances of individual taxa, grouped into their likely ecological assemblages. Those with a solid fill colour are showing their actual relative abundance, those with a dotted fill have had their relative abundance exaggerated x5 for visibility, and the remainder are shown via a dot indicating which samples they were recorded in. The pollen sum shows the changing relative proportions of the broad vegetation groups through the core with the 'aquatic' and Pteridophytes taxa plotted outside the pollen sum. The columns for microcharcoal, macro-charcoal and dung fungi are plotted to show how much of each component was present per/gram of sample. The final column on the right shows a stratigraphically constrained indicator of which samples are the most alike or unalike. Starting from the right-hand side of the column, this shows that here the lowermost sample has the least in common with all other samples, followed by the uppermost sample and so on.

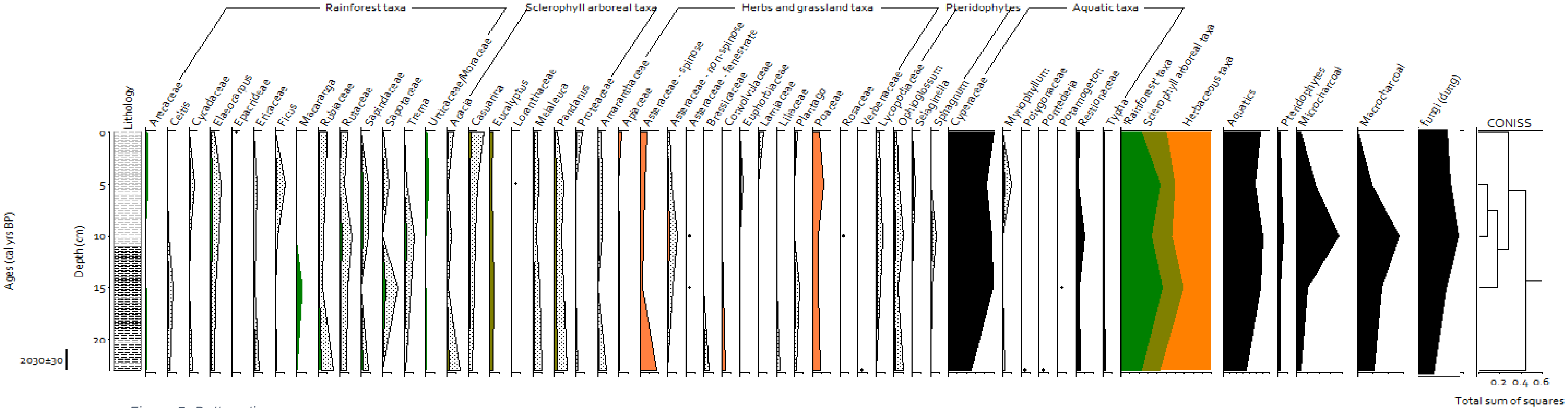


Figure 5: Pollen diagram

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