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From Ancient to Modern: The History of Human Fire Management in Australia's Tropical Savannas

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The paper "Late Pleistocene emergence of an anthropogenic fire regime in Australia's tropical savannahs" was published in the journal Nature Geoscience on January 10, 2024, by authors Michael l. Bird, Michael Brand, Rainy Comley, et al., from the Australian Research Council Centre of Excellence for Australian Biodiversity and Heritage, Wollongong, Australia, among other institutions. The study investigates the transformation of natural fire regimes into anthropogenic ones within Australia's tropical savannahs over the last 150 000 years. Utilizing a continuous lacustrine record, the research establishes with high statistical certainty that a pivotal change occurred around 11 000 years ago, transitioning from less frequent, more intense fires to more frequent, less intense ones. This shift marks the influence of Indigenous fire management practices on the landscape, emphasizing human agency in modifying fire regimes throughout the Holocene.

1 Experimental Data Analysis

Key findings are supported by several data types, including the accumulation rates of micro-$_{char}$coal and stable polycyclic aromatic hydrocarbon, grass pollen percentages, and carbon isotope compositions. These metrics collectively provide evidence for the timing and nature of changes in fire regimes. Notably, the study presents:

An increase in micro-$_{char}$coal particle accumulation rate (PAR_{char}) during wetter periods, indicating higher fire incidence.

The mass accumulation rate (MAR) of stable polycyclic aromatic carbon ($_{SPAC}$) highlights variations in fire intensity across different climatic stages.

Shifts in the tree-grass balance, inferred from changes in the percentage of C_4 pollen, suggest alterations in savannah vegetation in response to changing rainfall patterns and fire management.

Figure 1 depicts the modern coastline of Australia, as well as the topography during the lowest sea levels of the Last Glacial Maximum, indicated by the solid white line on the landmass. Part "a" of the image shows the modern vegetation, while part "b" is a satellite image of the specific study site. Additional locations mentioned in the text include Girraween Lagoon, Madjedbebe, and Lynch's Crater. The modern southern limit of the savannah biome is represented by a dashed white line, suggesting a historical expansion of this biome beyond its present boundaries. The data for this map is provided by Google and Maxar Technologies.

Figure 2 presents a 150,000-year record of environmental changes at Girraween Lagoon. Part a shows the variation in total organic carbon content (TOC, right y-axis) and distance to the coast (left y-axis) over time. Part b represents PARchar (right y-axis) and MARspac (left y-axis) on a logarithmic scale. Part c depicts the percentage of grass pollen out of the total dryland pollen (left y-axis) and δ13C values of SPAC (right y-axis). The alternating background colors denote the approximate durations of Marine Isotope Stages (MIS), with peaks of MIS 5 substages also marked (a-e). Peaks in wet-season insolation at 15° S are indicated by vertical red dotted lines at 136, 114, 92, 70, 45, 19, and ~0 ka (0 ka not displayed; insolation curves can be found in Supplementary Figure 2).

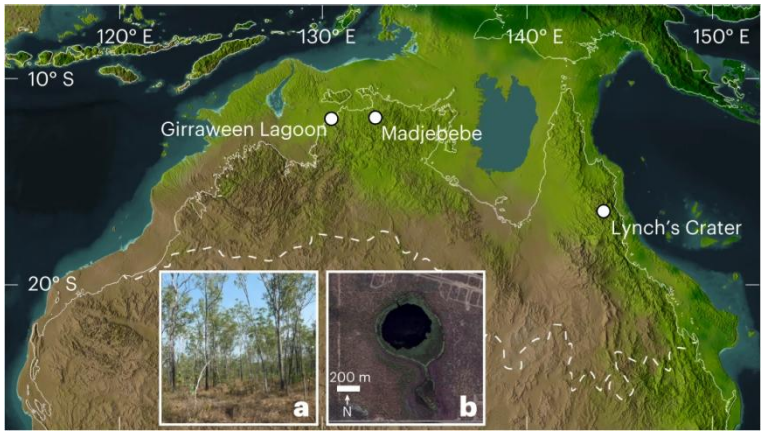

Figure 1 Location of Girraween Lagoon

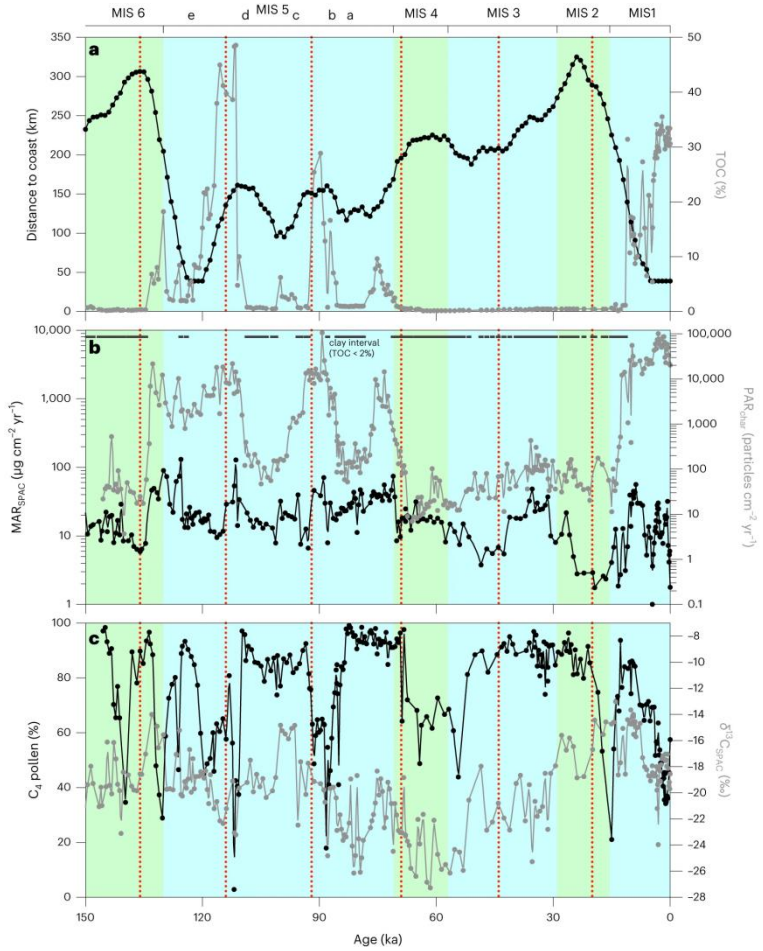

Figure 2 150 ka record of environmental change at Girraween Lagoon

Figure 3 illustrates the relationships between fire regimes and vegetation indices at Girraween Lagoon. In part a, a more pronounced positive correlation between MARSPAC and PARCHAR is hypothesized for the pre-human natural fire regime compared to the anthropogenic fire regime with lower-intensity fires. Part b shows the relation between the percentage of C4 pollen and δ13CSPAC, where a stronger positive correlation is expected during the anthropogenic fire regime's lower-intensity fires than in the natural fire regime. These correlations apply only when TOC is greater than 5.1%, with the proposed division between natural and anthropogenic periods at 30 ka. The red dashed lines represent the best-fit relationships with uncertainty for the natural fire regime, while the solid blue lines represent those for the anthropogenic fire regimes, with all relationships for the samples detailed in Supplementary Figure 1.

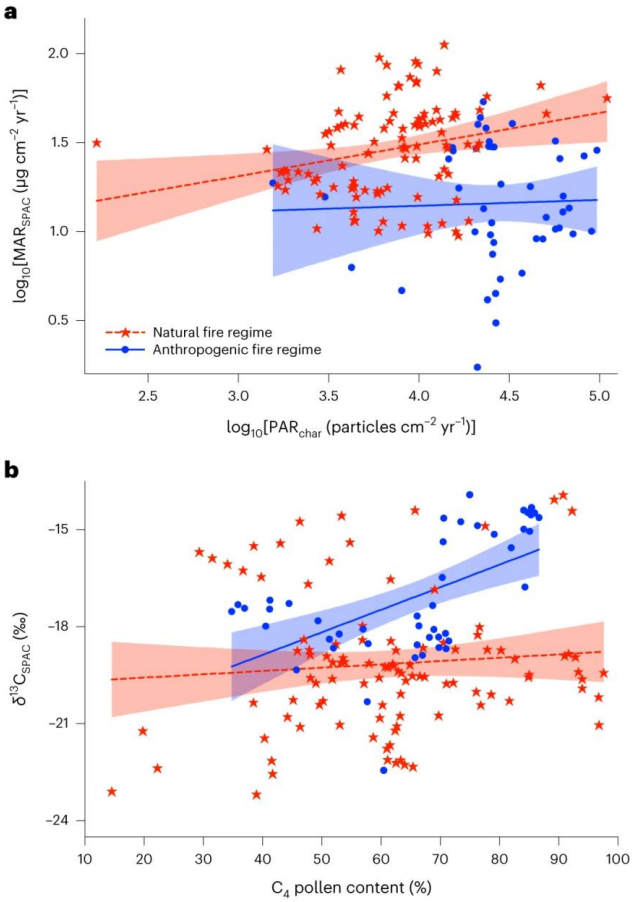

Figure 3 Relationships between fire and vegetation indices at Girraween lagoon

Figure 4 shows histograms of Spearman's correlation coefficient for the relationship between fire and vegetation indices at Girraween Lagoon. Panel a illustrates the resampled relationship between MARSPAC and PARCHAR under the natural fire regime (>30 ka; red bars) relative to the observed Spearman's ρ for the anthropogenic fire regime (<30 ka; blue vertical dashed line). Panel b does the same for the relationship between the percentage of C4 pollen and δ13CSPAC. The relationships apply only to samples with TOC greater than 5.1%. The probabilities of these results occurring by chance are 0.007 1 for panel a and less than 0.000 2 for panel b, given the threshold combination. The grey shaded regions indicate a ρ less than 0.05. On both panels, the x-axes show the binned value of ρ for the relationship under the natural fire regime across all iterations, while the solid black lines represent the Gaussian probability density function of each histogram.

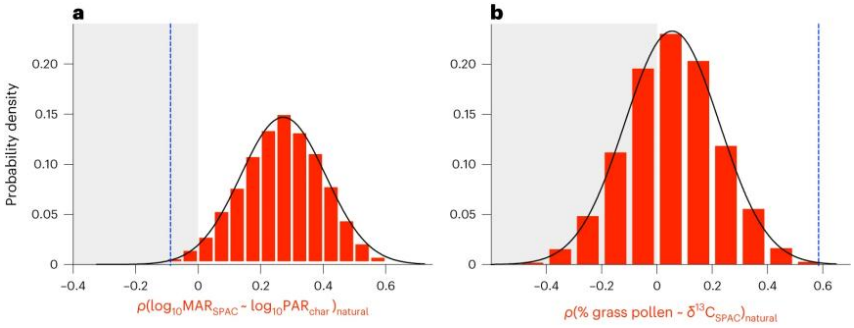

Figure 4 Histograms of Spearman's correlation coefficient for fire and vegetation indices at Girraween lagoon

Figure 5 demonstrates the sensitivity of the hypotheses regarding fire and vegetation indices at Girraween Lagoon. Panel a displays the sensitivity to variations in the TOC threshold with a constant temporal split at 30 ka. Panel b shows sensitivity to changes in the temporal split that defines the transition from natural to anthropogenic fire regimes, with a constant TOC threshold of greater than 2%. The green dashed line indicates the probability that

the Spearman's ρ relationship between MARSPAC and PARCHAR is stronger under the natural fire regime compared to the anthropogenic one. The solid black line indicates the probability that the relationship between the percentage of C4 pollen and δ13CSPAC is stronger under the anthropogenic regime. Both outcomes of the hypothesis tests are insensitive to changes in either the TOC threshold when it's over 2% or temporal splits that are older than 10 ka. Details on the methodological approach can be found in the Methods section of the study.

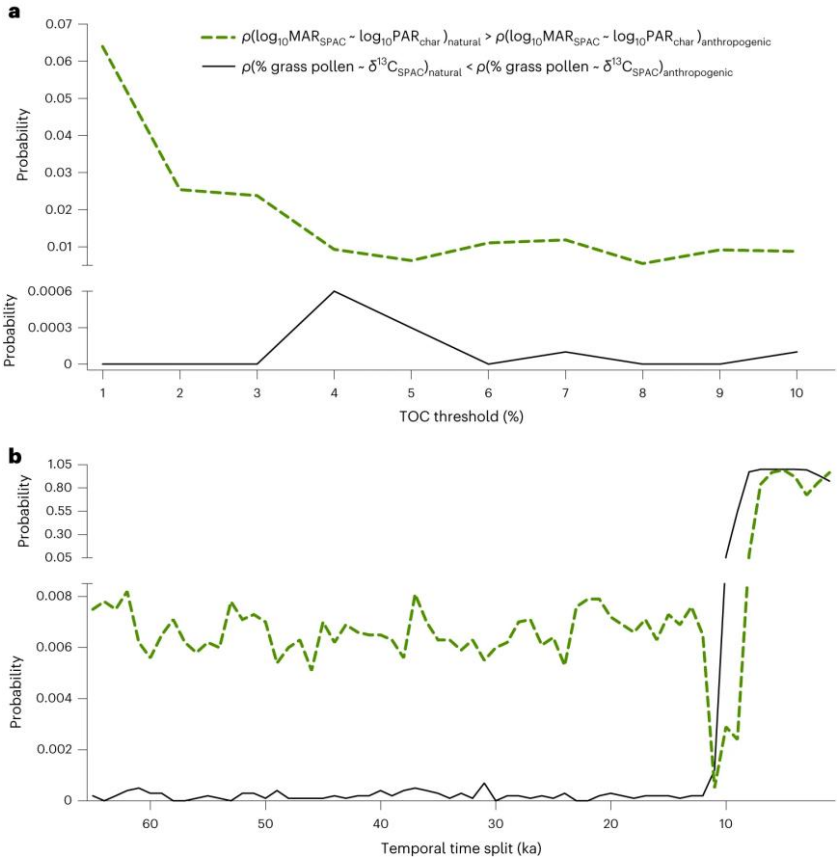

Figure 5 Sensitivity of hypothesis to fire and vegetation indices at Girraween lagoon

2 Analysis of Research Findings

The transition to an anthropogenic fire regime at least 11 000 years ago reflects Indigenous peoples' sophisticated land management strategies, significantly predating European arrival. This study underscores the long-standing human influence on fire regimes and challenges previous assumptions regarding the natural state of Australia's fire-prone landscapes.

3 Evaluation of the Research

This research stands out for its rigorous methodological approach, combining palaeoenvironmental proxies with statistical analyses to decipher long-term fire regime shifts. Its findings contribute significantly to our understanding of human-environment interactions, highlighting the role of Indigenous land management in shaping current biodiversity and ecosystem function. The study's limitations include the inherent challenges of distinguishing anthropogenic from climatic impacts on prehistoric fire regimes, a common hurdle in palaeoenvironmental research.

4 Conclusions

The study convincingly demonstrates that the alteration of natural fire regimes to anthropogenic ones in Australia's tropical savannahs was a gradual process influenced significantly by Indigenous fire management practices starting from at least the early Holocene. This work adds a crucial chapter to the narrative of human impact on the environment, offering insights into sustainable land management practices that could inform current fire management strategies.

5 Access the Full Text

Bird, M.I., Brand, M., Comley, R. et al. Late Pleistocene emergence of an anthropogenic fire regime in Australia's tropical savannahs. Nat. Geosci. 17, 233-240 (2024). https://doi.org/10.1038/s41561-024-01388-3.

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