Received: 18 September 2023 | Revised: 25 March 2024 | Accepted: 19 May 2024

DOI: 10.1111/1745-5871.12658

ORIGINAL ARTICLE

Geographical Research WILEY

Reconciling 22,000 years of landscape openness in a renowned wilderness

Michael-Shawn Fletcher[1] | **Anthony Romano**[1] | **Agathe Lisé-Pronovost**[1] | **Michela Mariani**[2] | **William Henriquez**[1] | **Patricia Gadd**[3] | **Hendrik Heijnis**[3] | **Dominic Hodgson**[4] | **Maarten Blaauw**[5] | **Andry Sculthorpe**[6]

[1]School of Geography, Earth and Atmospheric Sciences, University of Melbourne, Melbourne, Victoria, Australia

[2]School of Geography, University of Nottingham, Nottinghamshire, UK

[3]Australian Nuclear Science and Technology Organisation, Lucas Heights, New South Wales, Australia

[4]British Antarctic Survey, Cambridge, Cambridgeshire, UK

[5]Queen's University Belfast, Belfast, UK

[6]Tasmanian Aboriginal Centre, Hobart, Tasmania, Australia

Correspondence
Michael-Shawn Fletcher, School of Geography, Earth and Atmospheric Sciences, University of Melbourne, Melbourne, Victoria, Australia.
Email: michael.fletcher@unimelb.edu.au

Funding information
Australian Research Council, Grant/Award Numbers: IN170100062, IN210100055

Abstract
Here, we explore the profound impact of the Tasmanian Aboriginal (Palawa) people on Tasmanian landscapes by examining a 22,000-year record of landscape change from Lake Selina in western Tasmania, Australia. We analysed a sediment core for palaeoecological proxies, namely, pollen (vegetation), charcoal (fire), and geochemical data (landscape weathering). This study reveals that the contemporary landscape is a product of Palawa people's intentional and strategic fire management practices characterised by fire-dependent buttongrass moorland and the absence of climax rainforest. Specifically, our data show that rainforest failed to re-establish a dominance at Lake Selina following the end of the Last Glacial Maximum, as temperature and moisture increased as a result of Palawa cultural fire for at least 18,000 years. This finding challenges the long-held notion that Tasmania's wilderness is a product of the absence of human activity. Rather, archaeological sites across western and central Tasmania demonstrate long term presence, with some of the highest artefact and faunal bone densities in the world. The study contributes to the recognition of Tasmania's west as a cultural landscape shaped by generations of Aboriginal care for Country and fire practices.

KEYWORDS
Aboriginal Australia, cultural burning, cultural landscape, fire, Tasmania, wilderness

1 | INTRODUCTION

Humans have modified most of the Earth's surface for more than 12,000 years (Ellis et al., 2021). One of people's characteristic influences through most of that time has been to promote landscape openness to allow easier travel (Oetelaar & Meyer, 2006; Rantanen et al., 2021), sustain economic practices (dependent on grazing animals and agriculture), and enable a range of other pragmatic, economic, and spiritual purposes (Larson et al., 2021; Mercuri et al., 2012). While their influence over terrestrial landscapes has been profound (Ellis et al., 2021), there has been little recognition of the role of Indigenous peoples (such as Aboriginal Australians, First Nations peoples of North America, and Indígena peoples of South America) in creating, shaping, and maintaining vegetation landscapes (Adams & Mulligan, 2012; Fletcher, Hamilton, et al., 2021). Until recent decades, the dominant narrative in Australian discourse about Aboriginal people and their influence over the Australian landscape has framed Aboriginal people as "parasites on nature" who "had little, if any, effect on vegetation" (Elkin, 1933, p. 154; Horton, 1982). Such tropes have led to the pervasive fallacy that Australia was primarily a wilderness (Origin. Old English *wildēornes* "land inhabited only by wild animals," from *wild dēor* "wild deer" + -ness).

The Oxford English Dictionary (2023) defines wilderness as "A wild or uncultivated region or tract of land, uninhabited, or inhabited only by wild animals; 'a tract of solitude and savageness'." Wilderness has come to represent idealised landscapes managed as ecologically intact areas of high-value for biodiversity, aesthetics, and uniqueness that are free from human disturbance (Dowie, 2011; Fletcher, Hamilton, et al., 2021; Guernsey, 2016; Nash, 2014). The notion of wilderness thus underpins the myth that Australia (among other regions) was an unoccupied land belonging to no one, providing the basis on which the British legalised their theft of land from Aboriginal people (Langton, 1996; Suchet, 2002).

Resistance to using the word "wilderness" to describe Country in Australia by Aboriginal people is not new (Langton, 1996), with decades of Indigenous scholarship arguing that "conceptions of wilderness and conservation are yet another form of paternalism and dispossession" (Bayet, 1994, p. 27). Tropes and myths such as "intelligent parasites" (Elkin, 1933, p. 154) and "wilderness" continue to underpin contemporary attitudes towards the influence of Aboriginal people on the Australian landscape (Horton, 2000; Mooney et al., 2011; Watson et al., 2018; Williams et al., 2015). It also underpins the ethos behind the management of Australian National Parks and reserves that overwhelmingly seeks to protect "ecologically intact" (that is, wilderness) landscapes from human pressures through the exclusion or minimisation of human influence (see NSW Department of Planning and Environment, 2018; Parliament of South Australia, 2002; Parliament of Victoria, 2021; Tasmania Parks and Wildlife Service, 2021).

Running counter to this misanthropic attitude about the role of people in the care and management of Australian landscapes is the wealth of evidence demonstrating that Aboriginal approaches to caring for and managing Country has had—and continues to have—a profound influence over Australian landscapes (such as Adeleye, Haberle, Connor, et al., 2021; Adeleye, Haberle, Ondei, et al., 2022; R. B. Bird, D. W. Bird, Fernandez, et al., 2018; Bowman, 1998). Indeed, Aboriginal care and management are often integral to the maintenance of biodiversity and ecosystem health in Australia (D. W. Bird et al., 2016; R. B. Bird, D. W. Bird, Codding, et al., 2008; R. B. Bird & Nimmo, 2018; Fletcher & Thomas, 2010a, 2010b; Gott, 2005; Mariani et al., 2017, 2021; Trauernicht et al., 2015).

Globally, Indigenous cared for and managed lands are often viewed and managed as 'pristine' wilderness areas (Bloom & Deur, 2021; Eichler & Baumeister, 2021; Goyes & South, 2019). This paradigm devalues the roles Indigenous people have in creating and maintaining the health of their land and promotes inappropriate land management approaches that threaten the cultural and curated ecological integrity of biocultural landscapes (Sandlos & Keeling, 2016; Spence, 1999; Urzedo & Chatterjee, 2021; Youdelis et al., 2021).

Key insights
A 22,000-year sediment core from Lake Selina, in western Tasmania, Australia, was analysed using three palaeoecological proxies. Results show that the contemporary landscape is a result of intentional and strategic fire management by Palawa people (Tasmanian Aboriginal people). The findings highlight the effects of Palawa care for Country and challenge ideas about wilderness as areas free from human impact/disturbance. The study confirms that western Tasmania is a culturally significant and created landscape shaped by generations of Aboriginal Care for Country practices.

Understanding the long-term evolution of landscapes and documenting how people both shape and are shaped by our world is vital if we are to promote and maintain healthy environments and healthy people into the future (Garnett et al., 2009; Townsend et al., 2009). The demise of biodiversity and degraded ecological conditions (Artelle et al., 2019; Loring & Moola, 2020; Moola & Roth, 2019) result from the denial, eviction, and exclusion of people from their territories and landscapes in places denoted and renowned as "wilderness" under the guise of "conservation" (Brockington & Igoe, 2006; Koot & Büscher, 2019; Langton, 2003; Poirier & Ostergren, 2002; Watson et al., 2018; Watson & Venter, 2021). While there are growing attempts to redefine "wilderness" to include people (see Bartel et al., 2020), such attempts are rarely, if ever, led by Indigenous scholars. Indeed, Indigenous people "contest the idea that any place, land, sea or sky, can be undisturbed wilderness; everywhere has a story and a cultural context" (Collins & Thompson, 2020, p. 87) and its continued use to describe Indigenous lands amounts to an erasure of their culture and humanity (Fletcher, Hamilton, et al., 2021). Instead of continuing to deny Indigenous people their agency and knowledge of caring for and conserving their territories, governments and government departments, conservation and restoration organisations, and members of the public, must empower, support, and recognise the multifaceted connections that Indgenous and local peoples have to place, their role in biodiversity promotion and conservation, and their knowledge of ecology (Dawson et al., 2021; Simpson, 2004). Critically assessing and scientifically testing myths and tropes that govern how we engage with the world, such as wilderness and *Terra Nullius*, is one way to dispel such perceptions and return agency to whom it has been denied.

The Tasmanian Wilderness World Heritage Area (TWWHA) is recognised as an Aboriginal cultural landscape (DPIPWE, 2016; McCormack, 2022; Tebrakunna Country & Lee, 2019). It contains the oldest archaeological sites in Tasmania (see Cosgrove, Allen, et al., 1990, 2014, for further detail) where people have cared for Country and lived for over 40,000 years (Fletcher & Thomas, 2010a, 2010b). With the British Invasion (~1803 common era [CE]) came the attempted genocide of Palawa (Tasmanian Aboriginal people) (Breen, 2011; Madley, 2008; Ryan, 2010), cessation of Palawa lifeways, and imposition of new land uses and practices, such as agriculture, mining, and logging (Department of the Environment and Heritage, 2007; Mendel, 2003; Mosley, 2003; Quarmby, 2006).

Conservationism of the late 19th and early 20th centuries, heralded as an antidote to the detrimental environmental impacts of modernity (Domínguez & Luoma, 2020; Watson et al., 2018), recognised this landscape for its ecological and scenic values. Then, in 1982, the Tasmanian "wilderness" gained international recognition when it was inscribed as a UNESCO World Heritage site for its outstanding universal value, including Gondwanan flora, unique ecosystems, and Indigenous cultural heritage, with efforts directed to preserving its biodiversity and wilderness characteristics (Department of the Environment and Heritage, 2007; DPIPWE, 2016). However, the TWWHA still faces numerous threats such as catastrophic wildfire, anthropogenic climate change, and resource extraction (DPIPWE, 2021; Love et al., 2017; Styger, Brown, et al., 2010, Styger, Marsden-Smedley, et al., 2018).

Tasmania is known as Lutruwita by Palawa people who have lived on this cool temperate continental island continuously for at least 40,000 years (Cosgrove, Allen 1999; Cosgrove, Pike-Tay, et al., 2014). Palawa, like all Aboriginal people in Australia, have a deep and sophisticated relationship with fire (Gammage, 2008). Fire is used in a range of ways for ceremonial, spiritual, and economic purposes. The deliberate application of fire to the land is known as cultural burning (Victorian & Traditional Owner Cultural Fire Knowledge Group, 2019), and millennia of this practice have had a profound influence over the vegetation and landscape (Fletcher, Hall, & Alexandra, 2021; Fletcher, Romano, et al., 2021; Fletcher & Thomas, 2010a, 2010b; Mariani et al., 2017, 2021; Romano & Fletcher, 2018). The cessation and suppression of cultural burning following the British invasion of Australia have led to an increase in woody plants at the expense of grasslands and other treeless vegetation (Fletcher, Hall, & Alexandra, 2021; Fletcher, Romano, et al., 2021; Mariani et al., 2017, 2021). This change has been accompanied by an increase in forest and shrub fires that have become hotter and more destructive over recent decades (Fletcher, Romano, et al., 2021).

The underlying principle of applying fire to the land is one that exploits what is classically referred to in western science as vegetation succession (Folke et al., 2004; Scheffer et al., 2012; Scheffer & Carpenter, 2003; van Andel et al., 1993). By adopting specific fire return intervals within a vegetation system, it is possible to hold vegetation in a desired state along its successional pathway (Fletcher et al., 2020). Working systematically across a landscape, exploiting natural features such as topography and watercourses, Aboriginal people create and maintain spatially heterogeneous and biodiverse landscapes with fire via the promotion of various vegetation stages along the successional pathway in close juxtaposition across their Country (D. W. Bird et al., 2016; R. B. Bird, D. W. Bird, Fernandez, et al., 2018; R. B. Bird & D. W. Bird, 2021; Trauernicht et al., 2015). These cared for and managed landscapes are more diverse and productive than unmanaged and neglected land, and they also carry a lower risk of catastrophic fire (R. B. Bird, Codding, et al., 2012). The net effect of this style of fire practice (that is, care and management) is to produce less woody and more open landscapes to enhance grazing and increase food resources (for example, Cosgrove, Allen 1999; Fletcher, Hall, & Alexandra, 2021) that carry more biodiversity than areas in which "natural" forces dictate the vegetation and fire regime (R. B. Bird, D. W. Bird, Codding, et al., 2008; D. W. Bird, 2016; R. B. Bird, D. W Bird, Fernandez, et al., 2018; Kelly et al., 2020).

In the TWWHA, the modern vegetation landscape has long been regarded as a paradox (Brown & Podger, 1982). Where ecologists expected rainforest, there is instead a treeless fire-adapted vegetation type: buttongrass moorland. Rainfall is high in every month, and the climate is hostile to fire (Bowman & Jackson, 1981), yet the landscape comprises a fine-scale mosaic of fire-dependent treeless plant communities interspersed with fire-sensitive rainforest (Kitchener & Harris, 2013). Rainforest is almost always restricted to areas protected from fire by topography and aspect (Wood, Murphy, & Bowman, 2011). The keystone plant in the buttongrass moorland, *Gymnoschoenus sphaerocephalus*, burns even at high leaf moisture content; that is, it is highly flammable (Marsden-Smedley & Catchpole, 1995). Prior to human arrival during past interglacial periods resembling that of today's climate, fossil records show that fire sensitive rainforest grew in places where buttongrass is now found (Colhoun et al., 1999; Colhoun & van der Geer, 1988; Fletcher & Thomas, 2010b). Thus, in what is a perennially wet and cold landscape suited for rainforest growth, the dominance of highly flammable

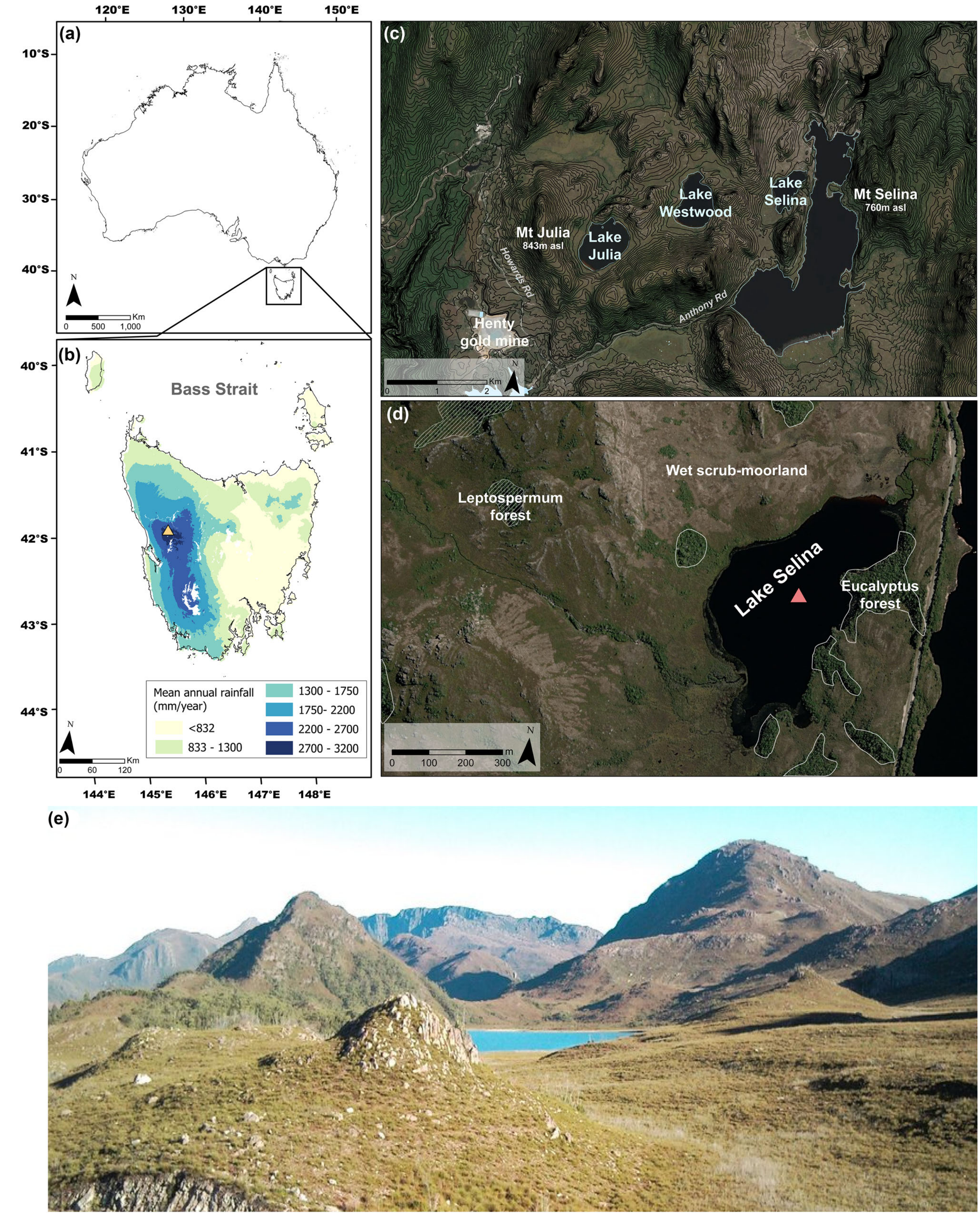

FIGURE 1 (a) Map of Australia, black square indicates Tasmania; (b) Tasmania overlain by average annual rainfall isohyets showing the orographic rainfall gradient across the island and location of Lake Selina (yellow triangle) in the wettest zone (Land Tasmania, 2022); (c) satellite image of the surrounding region of Lake Selina with 10 m contours (Land Tasmania, 2022); (d) satellite image of Lake Selina with the coring site in the approximate centre (red triangle) and the distribution of wet scrub-moorland, eucalyptus, and leptospermum forests outlined from TASVEG 4.0 (Land Tasmania, 2022); (e) Lake Selina and the surrounding landscape depicting contemporary moorland vegetation (credit: Michael-Shawn Fletcher). Maps throughout this publication were created using ArcGIS® Pro software by Esri.

treeless buttongrass moorland is a cultural artefact of Palawa management and care of their Country with fire (Fletcher & Thomas, 2010b).

Here, using a 22,000-year record of landscape change, we seek to understand the long-term legacy of human activity proximal to one of the most emblematic "wilderness" areas in Australia, the TWWHA, a United Nations Educational, Scientific and Cultural Organization (UNESCO) World Heritage Area. We present a well-dated and fine-scale record of changes in vegetation (pollen), fire (charcoal), and landscape weathering (geochemistry) in sediments from Lake Selina on the West Coast Range of Tasmania (Figure 1). Temperature depression and low atmospheric CO_2 when Palawa arrived in Tasmania during the Last Glacial Period (between ~115,000 and 11,700 years ago) inhibited tree establishment and promoted grassland habitats where forests had dominated during the previous warm interglacial period (Colhoun & Shimeld, 2012; Fletcher & Thomas, 2010b). Palawa exploited the dominance by open grassy habitats and developed an economy based around seasonal exploitation of inland grasslands in which wallaby and wombat were farmed using grassland fire management (Cosgrove, Pike-Tay et al., 2014; Cosgrove & Pike-Tay, 2004; Pike-Tay et al., 2008; Roberts et al., 2019).

The end of the Last Glacial Maximum (LGM) saw a rapid return to a warm interglacial climate. All prior glacial to interglacial climate shifts over the previous several hundred millennia, in the absence of people, saw a replacement of glacial grasslands by rainforest (Colhoun et al., 1999; Colhoun & van der Geer, 1988; Cooley et al., 2024). However, the most recent human-inhabited glacial–interglacial transition was characterised by the expansion of treeless fire-promoted buttongrass moorland in areas rainforest had previously expanded in to (Fletcher & Thomas, 2010b; Mariani et al., 2017). This difference between the human inhabited and uninhabited response of the landscape to glacial and interglacial climates was empirically demonstrated by Fletcher and Thomas (2010b), prompting them to contend that the modern-day dominance of treeless fire-promoted vegetation in western Tasmania is a cultural artefact, not a wilderness, produced by systematic care and management with fire by Palawa people since their arrival circa 40,000 years ago.

An over-reliance on data from bogs and swamps (Macphail, 2010) is the only substantive critique of the hypothesis of Fletcher and Thomas (2010b)—that the dominance of fire promoted moorland and the failure of rainforest to re-establish after the LGM across western Tasmania is the result of Palawa cultural fire preventing forest expansion. Macphail (2010) correctly cites a predominance of data from such sites in the Fletcher and Thomas (2010b) study. This site type can suffer from hyper-localised pollen signals, which can obscure or suppress regional (landscape-scale) signals, thus limiting the ability to apply the findings at the landscape-scale. Lake-based records, on the other hand, record regional information on past vegetation and environmental change and represent an important source of data for understanding how broader landscapes evolve through time unencumbered by local-scale influences (Sugita, 2007a). While Fletcher and Thomas (2010b) do use lake data in their analysis, there is a lack of continuous fine-scale lake sediment records that span the period from the LGM through to the present that allow an understanding of how the western Tasmanian landscape evolved through this period under Palawa care and management (Henríquez et al., 2023). Here, we seek to test the hypothesis put forward by Fletcher and Thomas (2010b) using the sediments contained within Lake Selina, a permanent lake located on the West Coast Range of western Tasmania (Figure 1d), in a vegetation landscape virtually identical to much of the TWWHA (situated less than 5 kilometres west of the UNESCO TWWHA boundary).

Previous pollen analyses of Lake Selina sediment indicate that prior to human arrival, the site was occupied by fire-sensitive rainforest during the last phase of climate similar to that of today, the Last Interglacial Period (Colhoun et al., 1999). In contrast, fire-dependent buttongrass moorland dominates the surrounding landscape today (Figure 1e). The analysis by Colhoun et al. (1999) is hampered by poor age control and breaks in the sediment sequence after the end of the LGM, prohibiting an assessment of how the current human occupied interglacial compares to the previous unoccupied interglacial period. We have addressed this oversight by re-coring the site to understand how the vegetation of the West Coast Range region evolved with people through the LGM, the Last Glacial–Interglacial Transition (LGIT), and the Holocene (the current interglacial). Understanding the long-term evolution of what is paradoxically renowned as both a cultural landscape and a wilderness is of profound importance for the development of appropriate and sustainable care and management for this globally unique landscape (Manzano et al., 2020; UNESCO, 2024).

2 | REGIONAL SETTING

2.1 | Geography, climate, and vegetation

Tasmania is a cool temperate island separated from the south-east coast of mainland Australia by a ~220 km wide and shallow sea (the Bass Strait). The island is bisected by a northwest-southeast trending mountain range (Figure 1). This range divides Tasmania in to two distinct bioclimatic zones: a hyper-humid west (precipitation >2,000 mm/year) and a sub-humid east (precipitation <600 mm/year). The mid-latitude westerly winds are driven over the central ranges, producing a steep orographic precipitation gradient (Figure 1b) (Sturman & Tapper, 1996). Tasmania's west has a maritime climate with cool temperatures and high rainfall (>2,000 mm/year) (Figure 1b). Less than 30 km separates the ocean from some of the wettest mountain ranges of western Tasmania (the West Coast Range), and the distinct high rainfall and high humidity climatic zone extends for a distance <100 km from the coast at its widest point (Bennett et al., 2012). The mountainous topography is cloaked in organic rich soils (peat), which is underlain by quartzite and quarzitic conglomerate and is dominated by treeless fire-adapted vegetation (buttongrass moorland) (Kitchener & Harris, 2013). Buttongrass moorland occurs and dominates in areas of high fire frequency (<20 years interval) that are both well and poorly drained (Balmer & Storey, 2010; Wood & Bowman, 2012; Wood, Hua, & Bowman, 2011). Where fire occurs, fire adapted taxa expand to the detriment of fire-sensitive rainforest taxa, including buttongrass moorland (Bowman & Jackson, 1981). Cool temperate rainforest in this region is restricted to fire-protected areas (Wood, Murphy, & Bowman, 2011). The east of Tasmania is comparatively drier (<600 mm/year) (Figure 1b) with higher variations in temperature, mineral soils, and a vegetation dominated by Eucalypt woodlands and grasslands (Kitchener & Harris, 2013).

Ecologically, the entire western half of Tasmania has a climate that can support cool temperate rainforest on any type of soil below the altitudinal timberline (<900 m asl) (Brown, 1999). Instead, rainforest only occupies 19.5% of western Tasmania, reflecting a failure of this vegetation type to capture its potential climatic range (Fletcher & Thomas, 2010b; Wood & Bowman, 2012) (rainforest value derived from TASVEG 4.0 vector data, clipped to "rainforest," analysed in ArcGIS® Pro, data from Land Tasmania, 2022).

Rainforest can take on a range of structural forms, from low and tangled rainforest on nutrient poor and waterlogged soils to tall and comparatively open rainforest on nutrient rich and well drained soils. Rainforests are dominated by long-lived and slow growing trees that can tolerate shading in the light-competitive forest canopy. Tree species diversity is low, with *Nothofagus cunninghamii* (Myrtle Beech) being a ubiquitous dominant in combination with *Phyllocladus aspleniifolius* (Celery-Top Pine), *Eucryphia lucida* (Leatherwood), and *Atherosperma moschatum* (Sassafras), with *Lagarostrobos franklinii* (Huon Pine) mostly restricted to major river courses and a range of other small trees and shrubs occurring throughout the region (Jackson, 1968; Jarman & Brown, 1983; Kitchener & Harris, 2013). *N. cunninghamii* (Hook.f.) Oerst. (Nothofagaceae) is used here for consistency with the fossil record (sensu Hill et al., 2015) rather than using the new botanical classification: *Lophozonia cunninghamii*.

The lowland of western Tasmania is dominated (56.2%) by treeless, fire-adapted buttongrass moorland (Brown, 1990; Brown, 1999; Kitchener & Harris, 2013). Moorland ecosystems occupy sites of lower soil fertility in areas that range from perennially damp and poorly-drained through to well drained slopes and hillsides. Buttongrass moorlands are more floristically diverse than rainforest and contain a diverse range of species that include members of the sedge family (Cyperaceae), including *Gymnoschoenus sphaerocephalus* (buttongrass), the wire-sedges (Restionaceae), and a number of shrub species (such as *Epacris* spp., *Sprengelia* spp., *Monotoca* spp., *Melaleuca* spp., *Leptospermum* spp., *Baeckea* spp., and *Banksia* spp.) (Brown, 1990; Brown, 1999; Jarman & Brown, 1983; Kitchener & Harris, 2013). The remaining vegetation of western Tasmania is comprised of Eucalypt-forest and other tree and shrub communities that represent stages that punctuate the fire-mediated spectrum between buttongrass moorland and Eucalypt/rainforest, depending on drainage (Wood & Bowman, 2012).

3 | LAKE SELINA

Lake Selina (41°52′41″S, 145°36′34″E) is a shallow natural lake (190 m^2, ~5 m deep), 516 m above sea level (asl) located in the West Coast Range of Tasmania, Australia (Figures 1d,e). While there is no permanent inflow or outflow, an ephemeral creek connects Lake Westwood (380 m^2, 605 m asl, ~1 km west) by flowing into Lake Selina. The local geology is low fertility quartzites and quartzite pebbles and cobbles, with some highly mineralised volcanic outcrops (Bradley, 1954). These mineralised deposits were the focus of mining activities and include the adjacent Mount Selina (~1 km east) that was prospected for lead, silver, and zinc (Figure 1c). Lake Selina receives rain on >200 days per year, receiving a mean annual rainfall of 3,109 mm. The mean maximum annual temperature is 9.2°C and determined by the nearest meteorological station at Mount Read (41.84°S, 145.54°E, 1,120 m asl) (Bureau of Meteorology, 2024). The local vegetation is dominated by buttongrass moorland (species include *Leptospermum* spp., *Melaleuca* spp., *Bauera rubioides*, *Monotoca submutica, Sprengelia incarnata*, and the sedge *Gymnoschoenus sphaerocephalus*). Along the eastern shores of Lake Selina are stands of wet eucalypt forest comprising of *Leptospermum nitidum* under a Eucalypt canopy (*Eucalyptus nitida*), with other trees and shrubs (such as *Melaleuca* spp., *Acacia* spp., *Allocasuarina* spp., *Ghania grandis*, and *Pteridium esculentum* understory) (Figure 1d).

4 | METHODS

4.1 | Coring, sampling, and chronology

Lake Selina was cored in November 2014 using two types of piston corers (Bolivia and Nesje-piston corers) from a floating platform from the approximate centre of the lake (Figure 1d) (Axelsson & Håkanson, 1978; Continental Scientific Drilling Facility, 2023; Nesje, 1992). This paper focuses on the Bolivia core TAS1402LA (0–84 cm), and all subsequent methods will refer those performed on this core (see Lisé-Pronovost et al., 2021, for the full TAS1402 cores 270 ka [ka = thousand years] chronostratigraphy and preliminary geochemical analysis of all cores). Sediment cores were transported to the University of Melbourne and split using a GEOTEK core splitter (Geotek, 2022). One half was used for geochemical scanning and archiving, and the other half was subsampled at 0.25-cm intervals for multi-proxy analyses. We employ the chronology developed by Lisé-Pronovost et al. (2021), which is based on 10 radiocarbon dates for the studied core TAS1402LA.

4.2 | Geochemical analysis

Geochemical analysis provides important information regarding landscape processes and cycles such as catchment erosion, the development of soils and weathering horizons, and terrestrial habitat change (Croudace & Rothwell, 2015; Gadd et al., 2015; Leys et al., 2016). Non-destructive geochemical data were obtained using an Itrax X-Ray fluorescence (XRF) core scanner at the Australian Nuclear Science and Technology Organisation at a resolution of 0.2 mm using a molybdenum (Mo) target tube set at 30 kV and 55 mA with a dwell time of 10s. Only a subset of XRF data is used in this study. We use incoherent/coherent ratio (inc/coh) as a proxy for sediment organic content (Fletcher et al., 2014, 2018; Rousseau et al., 2020; Woodward & Gadd, 2019), and lead (Pb), potassium (K), and silica (Si) as proxies for weathering/exposure of bedrock in the lake catchment (Beck et al., 2020; Eusterhues et al., 2002; Fletcher et al., 2014; Marynowski et al., 2012).

4.3 | Pollen analysis and vegetation threshold estimates

Sub-samples of 0.5 cm^3 were taken across the 85 cm core with a total of 101 samples analysed for pollen analysis using standard methods and a base sum of 300 terrestrial pollen grains. Stratigraphically constrained cluster analysis (CONISS) (Grimm, 1987) was performed in Tilia *v. 3.0.1* (Grimm, 2004) and used to produce a dendrogram to assist zonation of the terrestrial pollen data. Significant zones were identified using a broken stick model (Bennett, 1996) in the package rioja *v.09-15.1* (Juggins, 2016) in R *v.4.2.3* (R Development Core Team, 2022). Microscopic charcoal particles were counted during pollen identification. Accumulation rates for pollen (PAR = grains cm^{-2} $year^{-1}$), algae, and microscopic charcoal were calculated using a *Lycopodium* spp. spike and the age-depth model (Fletcher et al., 2014; Knight et al., 2021, 2022; Seppä et al., 2009). Terrestrial PAR have demonstrated to be a reliable proxy for reconstructing terrestrial plant biomass (Knight et al., 2021, 2022; Seppä et al., 2009).

Interpretation of pollen data is subject to issues of representation due to variations in pollen production and dispersal among plants (Fletcher & Thomas, 2007; Mariani et al., 2017; Prentice, 1985). In Western Tasmania, Fletcher and Thomas (2007) demonstrated that arboreal pollen taxa were typically over-represented in the modern pollen rain, while non-forest taxa were typically under-represented. Reconstructing regional vegetation coverage is possible using developed simulation models such as REVEALS (Regional Estimates of VEgetation Abundance from Large Sites), which primarily requires large lakes for reconstruction (>50–100 ha; Lake Selina surface area is ∼18.5 ha), and LOVE (LOcal Vegetation Estimates), which requires a prior knowledge on the regional plant abundance (among other parameters not met for this study) (Mariani et al., 2017; Sugita, 2007a, 2007b).

Here, pollen percentage threshold values were calculated as an indication of regional vegetation presence in lieu of applying REVEALS/LOVE models (Lisitsyna et al., 2011). The use of threshold values is a powerful means of objectively interpreting vegetation from pollen data (Hicks, 2006; McLachlan & Clark, 2004). We use the data generated by the analysis of Fletcher and Thomas (2007), surface "modern" pollen data from Surrey Hills (Fletcher, Hall, & Alexandra, 2021), Vale Of Belvoir Conservation Area (Fletcher et al., in press), Liawenee Moor (Thomas & Hope, 1994), and data from the Southeast Australian *Pollen* Database (SEAPD: D'Costa & Kershaw, 1997; Kershaw et al., 1994). They enable us to calculate threshold pollen values for rainforest, moorland, and grassland (here, the threshold is the mean pollen value required to indicate extantrainforest, moorland, or grassland relative to modern pollen-vegetation relationships) (sensu Fletcher et al., 2015; Stahle et al., 2017). In this study, we applied a standard approach to the threshold calculations (sensu Fletcher et al., 2015; Lisitsyna et al., 2011; Stahle et al., 2017). Key pollen taxa pollen percents were summed and grouped according to modern affinities. Those affinities are "Rainforest taxa," "Grassland taxa," and "Moorland taxa" (specifically buttongrass moorland; Table 1). The

TABLE 1 Taxa included in each modern affinity: "rainforest taxa," "grassland taxa," and "moorland taxa" for the threshold calculation

Group	Taxa included
Rainforest	*Anodopetalum*/*Eucryphia* spp. *Anopterus glandulosus* *Eucryphia* spp./*Bauera rubiodes* *Lagarostrobos franklinii* *Microcachrys tetragona* *Nothofagus cunninghamii* *Nothofagus gunnii* *Pherosphaera hookeriana* *Phyllocladus aspleniifolius* *Podocarpus lawrencei* *Pomaderris* spp. Proteaceae cf. Agastachys *Tetracarpaea* spp.
Moorland	*Bauera rubioides* Ericaceae *Gymnoschoenus sphaerocephalus* *Melaleuca* spp. *Monotoca* spp. *Sprengelia* spp.
Grassland	Poaceae

Note: Deciding which taxa to include was derived from Kitchener and Harris (2013).

mean, standard deviation, and absolute minimum values of those affinities were calculated as thresholds.

4.4 | Macroscopic charcoal

A sub-sample of 1.25 cm^3 was taken every 0.25 cm across the 85 cm sediment core for macroscopic charcoal analysis following standard protocols (Whitlock & Larsen, 2001). Samples were digested in Sodium hypochlorite (bleach, NaClO), sieved using 125 and 250 μm diameter mesh, and counted under a microscope. Macroscopic counts are presented as charcoal accumulation rates (CHAR = particles cm^{-2} $year^{-1}$).

5 | RESULTS

5.1 | Geochemical analysis

Selected elemental data obtained by the ITRAX analysis revealed peaks of lead (Pb), silicon (Si), and potassium (K) prior to the onset of the LGIT (~17,800 calendar years before present; 17.8 ka cal·year·BP). After that, they all decrease and remain low to the present (Figure 2). Incoherent/coherent ratio (INC/COH) sharply increases after ~17.8 ka cal·year·BP and remains constant until another slight increase from ~0.9 ka cal·year·BP (Figure 2).

5.2 | Pollen analysis and vegetation threshold estimates

We observed four significant CONISS zones from the percent terrestrial pollen taxa: Zone 1 (85–73 cm; ~21.6–15.5 ka cal·year·BP), Zone 2 (73–48 cm; ~15.5–11.2 ka cal·year·BP), Zone 3 (48–22.25 cm; ~11.2–6 ka cal·year·BP), and Zone 4 (22.25–0 cm; ~6 ka cal·year·BP–present) (Figure 3). Maximum pollen, spore, and non-pollen palynomorphs values are presented in parentheses unless stated otherwise.

Zone 1 is dominated aquatically by the fern taxon *Isoëtes* spp. (42.95%) and cold-dry climate indicating taxa, Poaceae (27.9%), Apiaceae (14%), and Asteraceae (21.2%). Cupressaceae (12.8%) peaks at the LGIT (red dotted line in Figure 3), while other montane rainforest taxa, *Nothofagus gunnii* (13.7%) and *Pherosphera hookeriana* (9.3%), increase and peak after the LGIT. *N. gunnii* (Hook.f.) Oerst. (Nothofagaceae) is used here for consistency with the fossil record (sensu Hill et al., 2015) rather than using the new botanical classification: *Fuscospora gunnii*. Here, after the LGIT (17.8 ka cal·year·BP), there are also increases in the aquatic algal taxon *Botryococcus* spp., temperate rainforest taxa: *N. cunninghamii* (6.2%) and *Phyllocladus aspleniifolius* (12.9%), *Eucalyptus* spp. (8.6%), and Ericaceae (5.9%) with decreasing trends in cold-dry climate and montane rainforest taxa (Figure 3).

Zone 2 is dominated by temperate rainforest taxa, *Bauera rubioides* (29.9%), *N. cunninghamii* (20.8%), and *P. aspleniifolius* (21%). Sclerophyllous taxa *Eucalyptus* spp. (19.3%) and *Pomaderris apetala* (9.1%) peak throughout this zone; Proteaceae (0.3%) appears in this zone. Aquatic taxon *Isoëtes* spp. (38.4%) has a decreasing trend to the end of this zone (~11.2 ka cal·year·BP) while *Botryococcus* spp. remains present throughout the zone. The ascomycetous fungi Xylariaceae appears and peaks throughout this zone. Moorland taxa *Leptospermum*/*Baekea* spp. (10.6%), Ericaceae (5.8%), and *G. sphaerocephalus* (5%) increase in this zone while montane rainforest and cold climate taxa decrease. Microscopic charcoal increases and peaks throughout this zone (Figure 3).

Zone 3 is marked by a decrease in *P. aspleniifolius* (7.5%), a decreasing trend in *B. rubioides* (min. 1.7%), apart from a peak ~8 ka cal·year·BP (29.3%) and an increasing trend in *N. cunninghamii* (24.3%). The temperate rainforest taxon *Anodopetalum*/*Eucryphia* spp. appears in this zone (3%). *Sprengelia* spp. (21.9%) dominates the moorland taxa during this zone while Ericaceae (10.8%), *Monotoca* spp. (6.8%), and *Melaleuca* spp. (4.7%) increase, and *Leptospermum*/*Baekea* spp. (9.2%) has a decreasing trend (Figure 3). Sclerophyllous forest taxa *Eucalyptus* spp. (14.2%) and

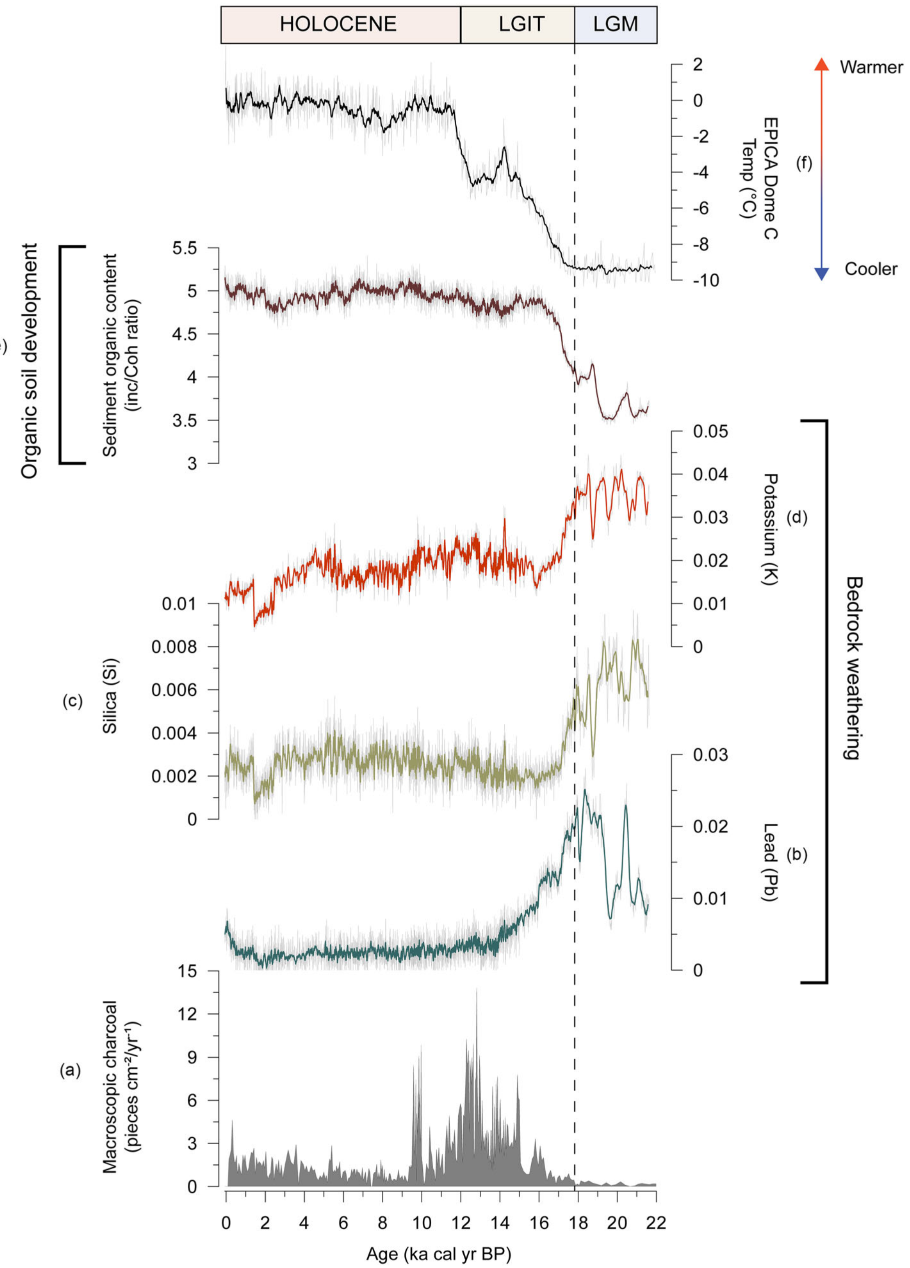

FIGURE 2 Selected sedimentary elemental data obtained with ITRAX analysis and macroscopic charcoal results from Lake Selina (core TAS1402LA). Dashed line indicates the end of the Last Glacial Maximum (LGM) and the onset of the LGIT at 17.8ka cal. yr. BP (Moreno et al., 2015). (a) Macroscopic charcoal (pieces cm^{-2}/year^{-1}); (b) lead (Pb) (dark green); (c) silica (Si) (light green); (d) potassium (K) (orange); (e) incoherent/coherent ratio (dark brown) (INC/COH); and (f) Antarctic temperature reconstruction (°C) from EPICA Dome C (Antarctica, 75.1°S 123.4°E) (Jouzel et al., 2007) data downloaded from National Centres for Environmental Information, NCEI (2023). All ITRAX data are fitted with a weighted average (window = 9). For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.

P. apetala (5.5%) decrease; however, Proteaceae (3.4%) increases. There is a near disappearance of *Isoëtes* spp. (5.8%; min. 0.2%), while *Botryococcus* spp. has an increasing trend in this zone with a peak at ~9.5 ka cal·year·BP; Xylariaceae has a general decreasing trend (Figure 3).

Zone 4 is denoted by increases (after decreasing trends in Zone 3) of temperate rainforest taxa: *Anodopetalum*/*Eucryphia* spp. (9.4%), *B. rubioides* (23.7%), *N. cunninghamii* (30.1%), and *P. aspleniifolius* (10.4%). While *Eucalyptus* spp. (18.5%) increases, *P. apetala* (4.1%) decreases; Proteaceae remains constant (3.4%) in this zone. *Sprengelia* spp. decreases (13.8%) throughout this zone; however, other moorland taxa increase: *Leptospermum*/*Baekea* spp. (11.7%) and Ericaceae (10.4%); *Monotoca* spp. (5.9%) and *G. sphaerocephalus* (3.4%) remain constant (Figure 3). Asteraceae (8.2%) and Poaceae (6.7%) increase towards the top of this zone. *Isoëtes* spp. remains low (2.9%) while *Botryococcus* spp. and Xylariaceae have similar increasing trends throughout the zone with peaks ~0.7 ka cal·year·BP. Microscopic charcoal also has an increasing trend to a peak ~0.7 ka cal·year·BP, decreasing thereafter (Figure 3).

Our vegetation threshold analysis demonstrates the transition to local moorland vegetation was permanent post-Last Glacial Maximum (LGM) (Figure 4a). During the LGM (~22–17.8

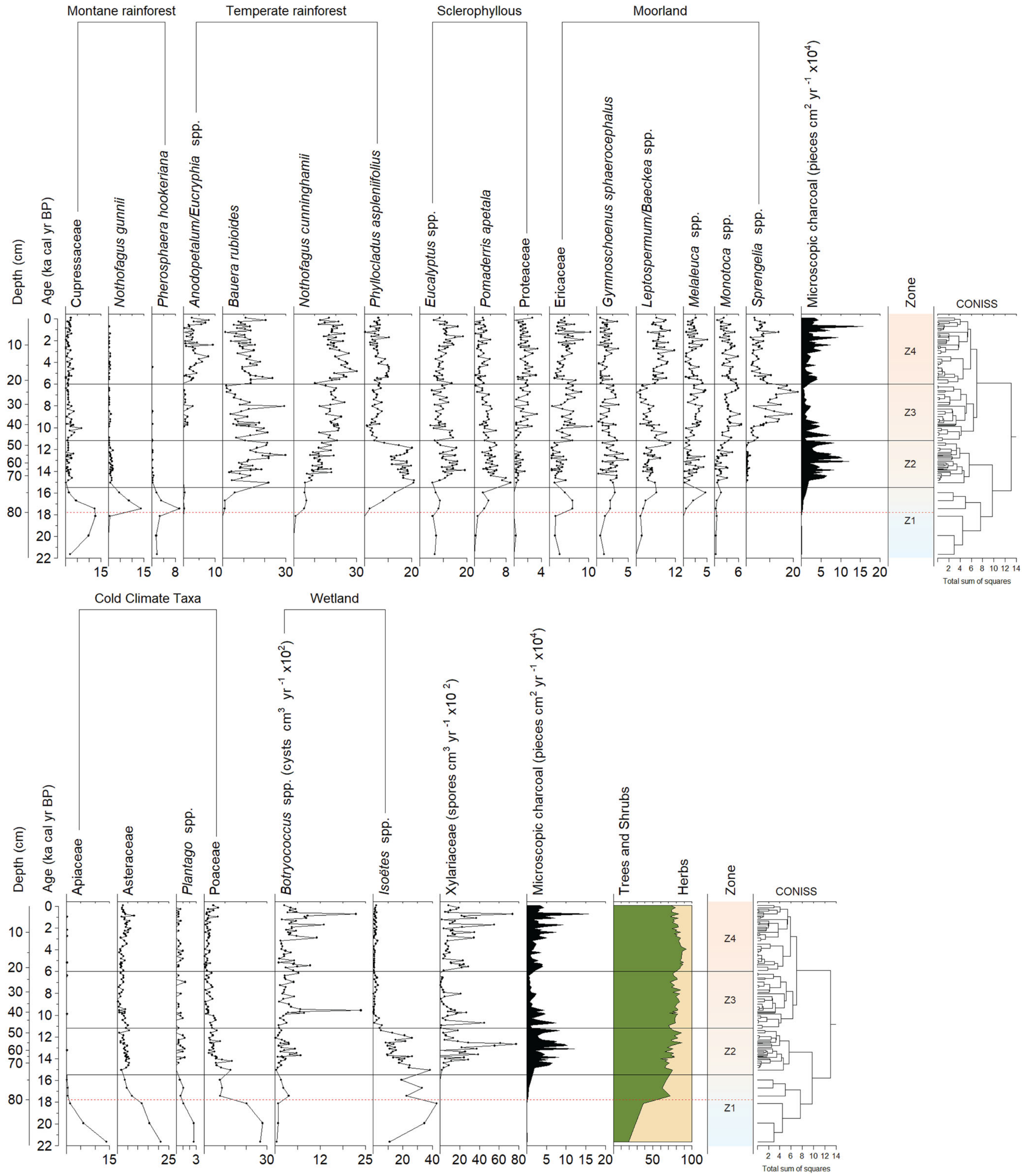

FIGURE 3 Lake Selina summary pollen diagram by depth (cm) and age (ka cal·year·BP) including microscopic charcoal accumulation calculated by known inputs of exotic lycopodium spores. Four significant zones were determined using CONISS on the terrestrial pollen data. Red line indicates LGIT at 17.8 ka (Moreno et al., 2015). Terrestrial pollen abundance was summed into two groups: trees and shrubs (green) and herbs (tan). Shading over the zones denotes the temperature transition from the LGIT to the Holocene. Note the changes in x-scale (%). For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.

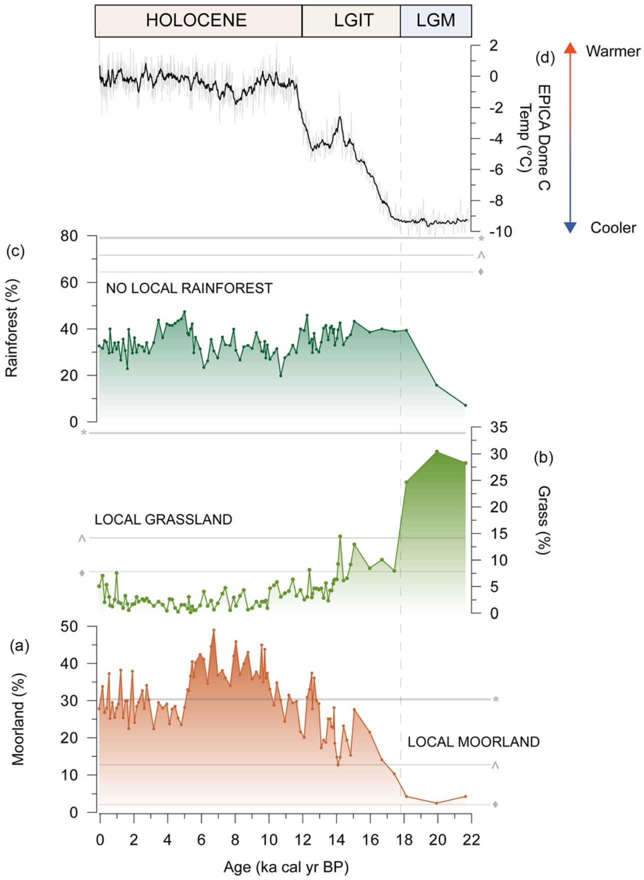

FIGURE 4 Results of vegetation threshold estimates and grouped pollen percentages (%). (a) Moorland (%) (orange); (b) grass (Poaceae, %) (light green); (c) rainforest (%) (dark green) and; (d) Antarctic temperature reconstruction (°C) from EPICA Dome C (75.1°S 123.4°E) (Jouzel et al., 2007) data downloaded from National Centres for Environmental Information, NCEI (2023), fitted with a weighted average in black (window width = 9). Vertical dashed line indicates the onset of the LGIT at 17.8 ka cal·year·BP (Moreno et al., 2015). Horizontal solid lines (light grey) indicate various threshold measures: *average pollen values of which extant vegetation groups can be inferred; ^the standard deviation of pollen values of which extant vegetation groups can be inferred; ♦minimum pollen values of which extant vegetation groups can be inferred (sensu Fletcher & Thomas, 2007; Stahle et al., 2017). For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.

ka cal·year·BP), grassland (Poaceae) dominates the local vegetation surrounding Lake Selina, which exceeds the threshold that indicates grassland conditions (Figure 4b: the minimum and standard deviation values). Post-LGM (~17.8 ka cal·year·BP) moorland vegetation exceeds the threshold above which values indicate extant moorland and remain so through to present day, with a particularly large peak between ~10 and 5 ka cal·year·BP (Figure 4a). At no stage throughout the record (~22 ka cal·year·BP record) does rainforest pollen content exceed the threshold above which values indicate a dominance of rainforest at Lake Selina, albeit some local patches (Figure 4c).

5.3 | Macro and microscopic charcoal

Macroscopic charcoal values were generally low between ~22.0–17.8 ka cal·year·BP (Figure 2). From ~16.3 ka cal·year·BP, macroscopic charcoal increases with a large and sustained increase with oscillations until ~12.2 ka cal·year·BP where a decreasing trend starts, reaching its highest peak at ~12.8 ka cal·year·BP (Figure 2). This was followed by a sustained decrease in macroscopic charcoal between ~12.4 and 10.0 ka cal·year·BP, interrupted by an abrupt increase between ~10.0–9.5 ka cal·year·BP (Figure 2). From ~9.5 ka cal·year·BP, macroscopic charcoal remains relatively low with a steadily increasing trend from ~4.5 ka cal·year·BP, with a peak at ~0.3 ka cal·year·BP, decreasing thereafter (Figure 2).

Microscopic charcoal shows very low values between ~22.0 and 17.8 ka cal·year·BP, followed by a sustained increase between ~17.8 and 11.2 ka cal·year·BP (Figure 3).

6 | DISCUSSION

6.1 | Landscape openness for 22,000 years

The most prominent feature of our data is the persistence of open buttongrass moorland surrounding Lake Selina for the entirety of the last ~22,000 years (Figure 5). The pollen data clearly record the response of different plant taxa to the climatic changes the occurred following the end of the Last Ice Age (LGM, ~17.8 ka cal·year·BP) through the Last Glacial–Interglacial Transition (LGIT) to the Holocene. Estimates of average annual temperature change through this period are between 3°C and 4°C (4–9°C globally; EPICA Dome C record) below the present average annual temperature on the west coast of Tasmania (Fletcher & Thomas, 2010a), sufficient to raise the altitudinal tree line by ~900 m from near the modern-day coastline to where it resides today. An initial grass-dominated landscape is indicated by the pollen percents, which exceed the extant grassland pollen threshold (Figure 5g) and is consistent with all glacial-stage pollen sequences from western Tasmania (Colhoun, 2000; Henríquez et al., 2023).

Our geochemical and pollen data provide clear evidence that the Last Ice Age around Lake Selina was characterised by a sparse vegetation cover of grasses growing on exposed mineral soils. The high levels of lead input indicate that there was sufficient moisture and exposed bedrock to allow the weathering and

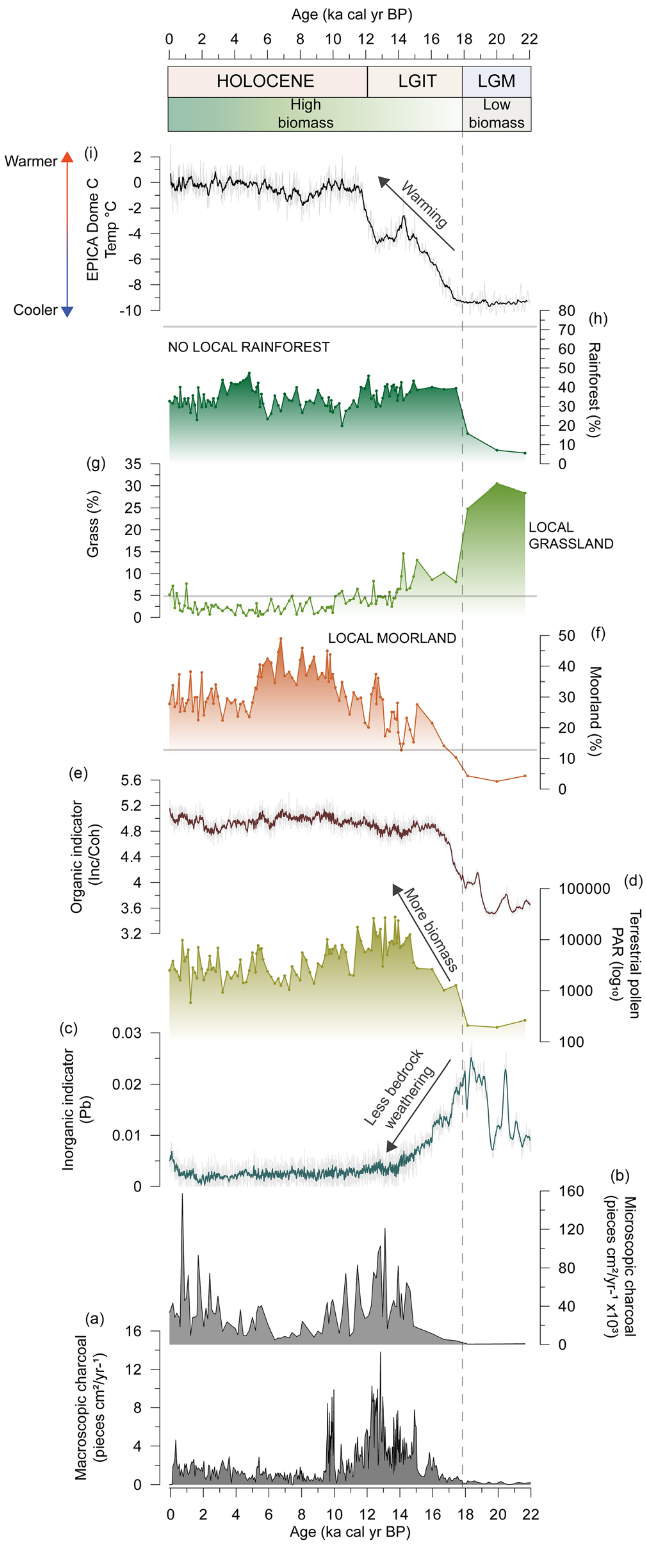

FIGURE 5 Summary plot of Lake Selina data (from core TAS1402LA): (a) macroscopic charcoal accumulation rate (macroscopic CHAR, pieces $cm^{-2}/year^{-1}$); (b) microscopic charcoal accumulation rate (calculated by known inputs of exotic lycopodium spores) (microscopic CHAR, pieces $cm^{-2}/year^{-1}$); (c) inorganic indicator—lead (Pb) (grey), fitted with a weighted average in dark green (window width = 9); (d) terrestrial pollen accumulation rates (calculated by known inputs of exotic lycopodium spores) (olive green) on a log_{10} scale to highlight the trend; (e) organic indicator—INC/COH ratio (grey), fitted with a weighted average in dark brown (window width = 9); (f) moorland (%) (orange), with the standard deviation threshold above which extant moorland can be inferred (light grey solid line); (g) grass (%) (light green), with the standard deviation threshold above which extant grassland can be inferred (light grey solid line); (h) rainforest (%) (dark green), with the standard deviation threshold above which extant rainforest can be inferred (light grey solid line); (i) Antarctic temperature reconstruction (°C) from EPICA Dome C (75.1°S 123.4°E) (Jouzel et al., 2007) data downloaded from National Centres for Environmental Information, NCEI (2023). Vertical dashed line indicates the onset of the LGIT at 17.8 ka cal·year·BP (Moreno et al., 2015). For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.

erosion of bedrock material into the lake (Figure 5). While Lake Selina is close to Palawa occupation sites through this time (within 40 km) (Cosgrove, 1999), it is likely that the main sites of seasonal hunting during the Last Ice Age and LGIT were located on relatively richer substrates elsewhere in the region that could support better grass cover, such as on the limestone bedrock near to many of the occupied caves (Cosgrove, 1999).

Pollen from lowland rainforest trees tends to track temperature change (increasing average temperatures) following the end of the Last Ice Age in our data (Figure 5 LGM to LGIT, ~17.8 ka cal·year·BP). The rapid increase in lowland rainforest trees at the beginning of the LGIT, however, could be reflecting an increase in available moisture (increased precipitation) at this time (Henríquez et al., 2023; Mackintosh et al., 2006). While lowland rainforest trees rapidly increase, they fail to reach levels that indicate a local presence of rainforest at or near the Lake Selina site (i.e., does not exceed the pollen threshold of substantial local rainforest presence) (Figure 5h). Rather, the charcoal evidence of burning, the expansion of buttongrass moorland, and the increase in biomass implied by the sharp increase in pollen accumulation rate after 18,000 years ago suggest an active effort by Palawa to maintain the open landscapes on which they depended on through this phase rainforest expansion driven by rapid climate change (Figure 5d,f). This finding further highlights the point that fire was an effective tool used by Palawa to halt the expansion of forest into their open grassy glacial environments (Figure 5). Increased vegetation productivity and biomass resulted in the spread of organic soils across the landscape, burying the mineral soils and bedrock and buffering them from weathering and erosion (Figure 5c,e).

In comparison with the LGIT, the onset of the relatively stable climate regime of the Holocene from 12,000 years ago to the present day was accompanied by persistent burning and the dominance of the landscape by buttongrass moorland (Figure 5f,i). This landscape stability through the Holocene is a feature of moorland vegetation across Tasmania (Bowman, Ondei, et al., 2023; Fletcher & Thomas, 2010b; Mariani et al., 2017). It reflects a combination of the persistent maintenance of open Country by Palawa (Fletcher & Thomas, 2010b), the inherent flammability of buttongrass moorland (Pyrke & Marsden-Smedley, 2005), and the ecophysiology of moorland vegetation that alters local-scale vegetation dynamics such that they inhibit forest encroachment (Adeleye, Haberle, Bowman, 2023; Fletcher et al., 2014).

6.2 | The impact of fire on vegetation succession

Contemporary studies highlight that while ignition sources tend to be human in this landscape (Bowman & Brown, 1986; Fletcher et al., 2014; Fletcher & Thomas, 2010b; Styger, Marsden-Smedley, et al., 2018), climate exerts a control over the long-term occurrence and extent of fire via its influence over fuel moisture (Mariani & Fletcher, 2016; Mariani & Fletcher, 2017). Disturbance, namely, fire in this landscape, acts to alter vegetation composition in favour of faster growing plants that have a poorer tolerance to shading, that is, that have a higher light requirement. Different fire return intervals can lock vegetation into different vegetation states in this landscape, which include rainforest, eucalypt-forest, shrubland/heathland, grassland, or buttongrass moorland (Wood & Bowman, 2012). The more frequent the fires, the less woody a vegetation state becomes. Exploitation of this virtually universal principle of decreasing woodiness and increasing grassiness, as fire becomes more frequent, is the underlying principle of most fire management strategies employed by Indigenous and local peoples across the earth for millennia (Archibald, 2016; Maezumi et al., 2018; McGlone, 2001; McWethy et al., 2010; Roos, Zedeño, et al., 2018; Roos, Swetnam et al., 2021).

6.3 | Deep time western Tasmania and the arrival of the Palawa

Tasmania is a mountainous continental island that is severed from mainland Australia during times of high global temperatures and resultant high global sea level. Numerous oscillations between cold glacial and warm interglacial climate regimes over the past two million years (the Quaternary geological period) act in combination with western Tasmania's complex and vertiginous topography, unique climate, and periodic isolation. They have forced vegetation to move upslope (in response to warming) and downslope (in response to cooling) repeatedly through this time. These and previous repeated shifts between cold and warm climates have essentially winnowed less adaptable plant species out of the western Tasmanian flora, leaving a comparatively depauperate set of resilient species relative to the diversity evident in previous geological periods (Hill & Read, 1984). Other long records of landscape change from western Tasmania reveal a switching between rainforest and grassland vegetation in response to cool glacial and warm interglacial climates, respectively (Colhoun, 2000; Colhoun & van der Geer, 1988). Importantly, evidence of fire is virtually absent in the fossil record during the rainforest dominated interglacial periods (Colhoun & van der Geer, 1988), consistent with the fire-sensitive nature of this vegetation. These large-scale switches in vegetation result from changes in temperature, rainfall, and atmospheric carbon dioxide concentration, driven by rhythmic changes in the Earth's orbit around the Sun and internal Earth system feedbacks that have resulted large-scale global changes.

Palawa people first arrived in Tasmania ~40,000 years ago from mainland Australia as sea level lowering drained the Bass Strait and exposed the Bassian Plain during the Last Glacial Cycle (Cosgrove, 1999). The landscape at that time was dominated by grassland and archaeological evidence indicates that the Palawa developed an economy that included the use of inland caves as dwellings for the autumn and summer harvesting of mammals in the west and southwest of what was then a peninsula of mainland Australia (Cosgrove, 1999). This seasonal economic strategy was employed for more than 20,000 years, from ~40,000 years ago through to the end of the Last Ice Age. Changing climate and vegetation following the end of the Last Ice Age and the onset of the current interglacial (the Holocene) saw a shift in the economic strategy of Palawa as the climate became hostile to the grasslands on which their seasonal inland economy was based (Cosgrove, 1999). Throughout the Quaternary (~2.58 million years ago to the present), fossil pollen records across western Tasmania consistently show rainforest returning after the termination of glacial periods—for example, throughout interglacial stages such as MIS5 (Colhoun, 2000; Colhoun et al., 1999; Colhoun & Shimeld, 2012; Colhoun & van der Geer, 1988). Critically, following the end of the LGM, fossil pollen records reveal a failure of rainforest to recapture the landscape (Fletcher & Thomas, 2007; Fletcher & Thomas, 2010a, 2010b). Instead, buttongrass moorland captures the landscape and fire becomes important for the first time in the Quaternary during the most recent (and current) full interglacial period known as the Holocene (Fletcher & Thomas, 2010a, 2010b). In contrast to previous interglacial periods, the Holocene is marked by a dominance of fire-adapted buttongrass moorland, as seen in the data presented here from Lake Selina (Figure 5), and widespread evidence for fire, underscoring the insight that this landscape is a cultural construct that is the product of cultural burning by Palawa, not a wilderness (Fletcher & Thomas, 2010b).

6.4 | The wilderness trope in western Tasmania

The notion of Tasmania's west being a cultural landscape lies in stark contrast to the wilderness moniker that defines attitudes and approaches to management of this region today. Rather than showcasing the power of Palawa care and management of this unique landscape, the TWWHA is commonly marketed as a wilderness (Milman, 2015; Tourism Industry Council Tasmania, 2019; Tourism Tasmania, 2022); one of the last remaining pristine places on Earth that has escaped the influence of people.

Here, our analyses of the pollen and charcoal records from Lake Selina have enabled us to revisit this concept of "wilderness" when applied to Tasmanian landscapes. Importantly, our data are from a lake basin and show that the landscape around Lake Selina has been actively managed since at least 18,000 years ago. The data are mirrored in a recent lake-based fine-scale analysis of 21,000 years of changes in vegetation and fire from Basin Lake on the southern end of the West Coast Range (15 km southwest of Lake Selina), which also demonstrates a failure of rainforest to capture the landscape in the current interglacial (Henríquez et al., 2023). More recently, Cooley et al. (2024) have shown that the shift from glacial to interglacial stage vegetation recorded at Lake Selina diverges from the vegetation shift recorded at Darwin Crater Palaeolake (a nearby location inside the TWWHA). There, prior to human arrival, rainforest taxa dominated the last interglacial period but were replaced by buttongrass moorland in the current interglacial—after people had arrived. Together, these lake-based studies allow us to reject the criticism levelled by Macphail (2010) based on site type influences. Doing so reaffirms Fletcher and Thomas' (2010b) assertion that the region represents an ancient cultural landscape. More importantly, collectively, these data allow us to reject the notion that this region is a wilderness and confirm it indeed represents a cultural landscape (Fletcher & Thomas, 2010b).

The results of this study have profound implications for Palawa people and for the long-term health of the TWWHA. The term wilderness is highly problematic (Fletcher, Hamilton, et al., 2021; Russell & Jambrecina, 2002). Central to the idea of wilderness is an absence of people (Oxford English Dictionary, 2023), a form of dispossession, the effect of which is to strip Indigenous and local peoples of their places in their lands and one that has been used to deny Indigenous and local people their rights to care for and make a living from their lands (Fletcher, Hamilton, et al., 2021; Koot & Büscher, 2019).

The wilderness trope underpinned the idea that Australia was an unoccupied land (later known as a *Terra Nullius*) used to legitimise the theft of lands from Aboriginal people (Chamarette, 2000). Under international and British law, there are four ways of acquiring land: (1) inheritance, (2) conquest, (3) purchase, or (4) occupation or settlement (Borch, 2001). Claiming new land by occupation and settlement requires that the land be unoccupied. In English common law, claiming land by conquest—a more realistic framing given that Aboriginal people fought fiercely for their land (Connor, 2002)—requires the adoption of local laws in the governing of the new land (Lange, 2009; Loughton, 2004)—something that has not happened in the Australian context and is unlikely to occur in the future (The Law Reform Commission, 2010). Thus, the myth of wilderness—that the land was the product of "natural" not human factors—substantiated the myth of Australia being unoccupied that legitimised the theft of the Australian continent from its original inhabitants (Langton, 1996; McNiven & Russell, 1995).

Recent threats to the TWWHA from catastrophic fire have thrust the management of this region under the spotlight (Figure 6). Triage in response to fires in 2013, 2016, and 2019 bushfires that either directly impacted or threatened the TWWHA have cost enormous sums of money, a large part of which is aimed principally at fire suppression and mitigation (Fletcher, Romano, et al., 2021; Rickards, 2016). These fires are viewed as the latest in a series climate-driven wildfires that are having an impact across southeast Australia, including Tasmania (Figure 6) (Byrne et al., 2021; Collins et al., 2021; Levin et al., 2021; van der Velde et al., 2021). Such events have also spurred a range of research efforts to understand the dynamics among climate, fire, and landscape ecology across the landscapes of TWWHA (Love et al., 2019; Tasmania Parks and Wildlife Service, 2021). The TWWHA landscape hosts the last remaining representatives of a number of fire sensitive plant species found nowhere else in the world, among them Pencil Pines (*Athrotaxis cupressoides*) and King Billy pines (*A. selaginoides*) that are either threatened or endangered (Bliss et al., 2021; Bowman, Bliss et al., 2019; Bowman, Rodriguez-Cubillo et al., 2021).

The framing of the current bushfire crisis through a solely climate lens and focusing on fire suppression

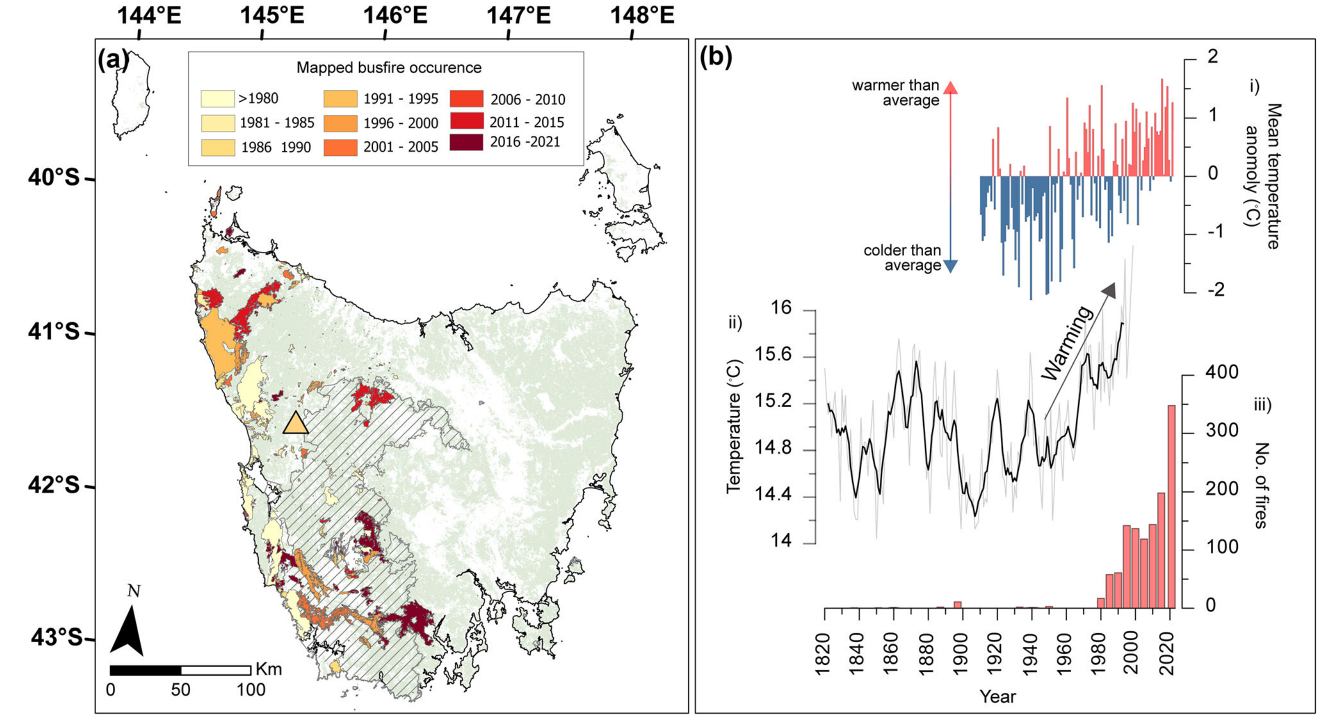

FIGURE 6 Bushfire data of Western Tasmania: (a) map of Tasmania with the location of Lake Selina denoted by yellow triangle. Tasmanian Wilderness World Heritage Area (TWWHA) (grey diagonal hatching) (Land Tasmania, 2022), forests of Tasmania (green) (Australian Bureau of Agricultural and Resource Economics and Sciences, 2018) and the location, area (ha) and occurrence of mapped bushfires across Western Tasmania binned into five-year bins (n.b., this dataset does not include planned burns) (Land Tasmania, 2022); (b-i) mean temperature anomaly for Tasmania (from 1910 CE to 2022 CE; n.b., temperatures are presented as anomalies or departures from the 1961–1990 average) (Bureau of Meteorology, 2024); blue shading represents temperatures cooler than average; red shading represents temperatures warm than average; (b-ii) temperature (°C) reconstruction of mean warm-season (November–April) temperatures from tree rings of *Lagarostrobos franklinii* (Huon Pine) at Mt. Read (grey) (1,123 m asl, 41.8°S 145.5°E; north west edge of the West Coast Range of Western Tasmania, ~6 km from Lake Selina) (data from Cook et al., 2000) with a weighted average (black) (window width = 9); (b-iii) a histogram of the number of fires in five-year bins across Western Tasmania (data from Land Tasmania, 2022, and historical [pre-1960s] data from Marsden-Smedley, 1998). For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.

and mitigation (McCormick, 2021), ignores the fact that Australian landscapes were substantially different under Aboriginal care (Fletcher, Hall, & Alexandra, 2021; Fletcher & Thomas, 2007; Laming et al., 2022; Romano & Fletcher, 2018). Empirical data such as that presented in this paper are required to challenge the harmful myths and tropes that underpin modern Australia's narrative about the continent, allowing more appropriate ways of engaging with and caring for Country. Other recent empirical data demonstrate that southeast Australian landscapes have become woodier and more flammable following the invasion by the British and the concomitant cessation and suppression of cultural burning (Mariani et al., 2021). For example, the removal of Palawa cultural burning has resulted in the replacement of Palawa grasslands by invading rainforest on the fertile soils of the northwest of Tasmania—a shift that is threatening grassland plant and animal species with extinction (Fletcher, Hall, & Alexandra, 2021). This expansion of rainforest precedes the first recorded evidence for catastrophic fires in northern Tasmania, suggesting a possible causal link between changing land care and management and catastrophic fires (Evans, 2013). Addressing the underlying drivers of the current fire crisis thus requires a reframing of our understanding of our relationship with Country.

Much of Australia's biodiversity depends on Aboriginal cultural burning (R. B. Bird & D. W. Bird, 2021; Greenwood et al., 2021; Kelly & Brotons, 2017), both because of the diversity that small-scale intimate application of fire promotes across a landscape and because low landscape fuel levels reduces the incidence and magnitude of large catastrophic bushfires (Fletcher, Romano, et al., 2021). Cultural burning must be viewed as more than a salve for the current fire problem. More than just an alternative version of hazard reduction burning, an approach that is centred solely on reducing the incidence of uncontrolled bushfires (Morgan et al., 2020). Cultural burning must be seen as a way of connecting with and conducting our relationship with Country, increasing biodiversity, landscape safety, and human health and wellbeing (Fatima et al., 2023; Green & Minchin, 2014; Townsend et al., 2009). Indeed, "Healthy Country, Healthy People" studies (Berry et al., 2010; Burgess et al., 2005; Garnett et al., 2009; Garnett & Sithole, 2008) have found an link between Aboriginal people involved in "caring for Country" practices—that is, cultural burning, connecting with Country—and a whole suite of health and wellbeing benefits (outlined in detail in Green & Minchin, 2014).

A barrier to the truth results from persistent use of "wilderness" in places such as the TWWHA, despite clear evidence of their having been cultural landscapes for at least 40,000 years as a direct result of Palawa cultural fire practices (Cooley et al., 2024; Fletcher et al., 2014; Fletcher, Hall, & Alexandra, 2021; Fletcher & Thomas, 2010b; Mariani et al., 2017). That outcome stymies efforts to reconcile modern Australia with its long-neglected obligations to care for Country. It prevents meaningful discourse about how we should engage with Country and about what Country needs. Efforts to include cultural burning into the management of the TWWHA (DPIPWE, 2016; Tasmania Parks and Wildlife Service, 2021) need to be backed by a concerted effort to orient policy, research, and the outward marketing of this unique and human-engineered cultural landscape to the public. The discourse must be based on truth, such as that presented here—that the landscape was created and maintained by Palawa with fire—and must include Palawa care and management at its core. To appropriately respect Palawa people and culture, there must also be a commitment to the principles of self-determination and community ownership of initiatives that involve practices such as cultural burning.

ACKNOWLEDGEMENTS

We thank the Australian Research Council for financial support for this research (IN170100062 and IN210100055). We also thank Kristen Beck, Alexa Benson, and William Rapuc for assistance in the field; Haidee Cadd for working on the sediment core in the laboratory and transport of the cores to the Australian Nuclear Science and Technology Organisation; and Joel Pedro for contributions to broader work that informed this study. We acknowledge the comments from anonymous reviewers of an earlier version of this manuscript that led to an improvement of the final paper. Open access publishing facilitated by The University of Melbourne, as part of the Wiley - The University of Melbourne agreement via the Council of Australian University Librarians.

CONFLICT OF INTEREST STATEMENT

All authors declare no conflict of interest.

DATA AVAILABILITY STATEMENT

Data will be made available upon request.

ETHICS STATEMENT

No ethics approval is associated with this original paper.

ORCID

Michael-Shawn Fletcher https://orcid.org/0000-0002-1854-5629
Anthony Romano https://orcid.org/0000-0002-1390-4311
Agathe Lisé-Pronovost https://orcid.org/0000-0002-7977-0512
Michela Mariani https://orcid.org/0000-0003-1996-3694
William Henriquez https://orcid.org/0009-0002-2209-5314
Patricia Gadd https://orcid.org/0000-0001-6725-1603
Hendrik Heijnis https://orcid.org/0000-0002-7601-3452
Dominic Hodgson https://orcid.org/0000-0002-3841-3746
Maarten Blaauw https://orcid.org/0000-0002-5680-1515

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How to cite this article: Fletcher, M.-S., Romano, A., Lisé-Pronovost, A., Mariani, M., Henriquez, W., Gadd, P., Heijnis, H., Hodgson, D., Blaauw, M., & Sculthorpe, A. (2024). Reconciling 22,000 years of landscape openness in a renowned wilderness. *Geographical Research*, 1–23. https://doi.org/10.1111/1745-5871.12658