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Re-imagining Sydney's freshwater wetlands through historical ecology

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ABSTRACT

Australian conservation targets commonly focus on preserving a vaguely defined ecological baseline, often conceptualised as a pre-European, 'natural' state. For instance, environmental legislation protects 'Endangered Ecological Communities' (EECs), which purportedly represent remnants of naturally occurring biota. However, EECs are often classified without long-term data, making it unclear as to whether the community being protected is indeed 'natural'. In this essay, we use history, ecology, and geography to map the long-term socio-environmental evolution of Sydney's freshwater wetland EECs, which were once key features of Australia's biggest city. Our data show that today's remnant wetlands are different from those of the early 1800s, highlighting how quickly landscapes can be misremembered. We encourage a reimagining of these wetlands not as snapshots of the past, but as human-impacted places with educational, ecological and historical importance. Our work emphasises the relevance of long-term, cross-disciplinary data for effective conservation, while highlighting limitations in post-colonial land management.


KEYWORDS

environmental history; legal geography; palynology; palaeoecology; GIS; urban planning; blue-green grid; Eastern Suburbs *Banksia* Scrub; Sydney Freshwater Wetlands; Botany Sands Aquifer

Introduction

The densification of cities places immense pressure on remnant green and blue spaces, which must simultaneously function as recreational respites, biodiversity reserves, pollutant filters, and heat and flood mitigators (e.g. Haaland & van den Bosch, 2015). In responding to these challenges, urban designers, conservation scientists, and environmental policy makers must decide how to best safeguard and enhance the socioecological functioning of urban refugia, while considering the evolving needs and desires of a diverse range of residents (Aronson et al., 2017; Cimon-Morin & Poulin, 2018). A means of striking this balance is the protection or restoration of a systems' 'natural'¹, ecological functioning. This approach rests on the assumption that 'natural' functions will, among other benefits, buffer against the acute impacts of climate change borne

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by cities, enhance educational and recreational utility, and promote the protection of biodiversity (Oke et al., 2021; Xie & Bulkeley, 2020). Additionally, the (re)establishment of past biotypes as part of this approach can build a sense of urban identity and human connection to the land and its history and, in so doing, cultivate care for place in the broader community (Mosler, 2019; Pickett et al., 2011 and references therein).

In Australia—an ancient cultural land only recently subjected to British or ‘European’ land management—there is a strong focus on conserving remnants of both ecologically and culturally significant Indigenous landscapes and historical early-British colonial landscapes (GANSW & NSW DPE, 2017; The City of Melbourne, 2017). These remnants may be the only surviving examples of once extensive ecosystems in otherwise heavily modified settings. Protection of these landscapes is facilitated by multi-layered, multi-jurisdictional legislative frameworks. For example, ‘naturally occurring’ vulnerable, threatened, or endangered ecological communities are listed in Australian law, including the Environmental Protection and Biodiversity Conservation Act 1999 (Cth) (EPBC Act) at a national scale and, in the State of New South Wales, under State legislation (e.g. the Biodiversity Conservation Act 2016 (NSW) (BC Act)). Historically and culturally significant places are listed, inter alia, on National and State heritage lists. The act of listing for protection has the potential effect of conceptually ‘freezing’ landscapes in a particular, normatively defined state. This can potentially deny change, providing little space for ecological processes such as succession, migration and evolution. We argue that this peculiar lens is problematic if a more thorough accounting of the past is considered.

The unceded lands of the Gadigal and Dharawal people have been progressively incorporated into metropolitan Sydney since British colonisation began with the arrival of the First Fleet in 1788 CE. These lands are now almost completely overprinted with layers of tar, concrete and glass. Last remnants of the pre- and early- British landscape are thus highly prized. Several of these places are legally protected as important ecological communities and historic sites, and are tightly interwoven into urban planning policy for the city. For example, the Eastern Suburbs *Banksia* Scrub, an Endangered Ecological Community within southern Sydney, has been the subject of contestation regarding its protection in a recent NSW Land and Environment court case (see Carr, 2023).

Remnants of inner Sydney’s once interconnected system of freshwater wetlands are particularly important, due to their high ecological and historical value. These once-extensive wetlands historically drained south from just beyond the southern boundary of the central business district (CBD) to Gamay (Botany Bay) in a series of ponds and channels. Their spatial orientation is tightly coupled to the hydrogeology of the region i.e. the presence of a 183 km², thick layer of saturated aeolian quartz sand called the Botany Sands Aquifer (Ackworth & Jankowski, 1993) which once permitted the formation of extensive standing water bodies. The catchment boundaries of the Botany Sands Aquifer are shown in Figure 1. Today, there are two protected ‘remnant’ freshwater wetlands in an otherwise highly urbanised landscape, Lachlan Swamp and the Botany Wetlands.

The ~1.5 ha Lachlan Swamp (as named by British colonisers), located at the northern margin of the Botany Sands Aquifer (Figure 1), is currently protected within Sydney City’s largest park, the Centennial Parklands, and managed by the Centennial Park and Moore Park Trust (constituted under section 6 of the *Centennial Park and Moore Park Trust Act 1983* (NSW) (CPMPT Act)). In 2020, the NSW State government created a Greater Sydney Parks Consolidated Board (under the auspices of the *Greater Sydney Parklands Trust Act 2022* (NSW)), and amalgamated key parklands across the Sydney region, including Centennial Park. The Centennial Park and Moore Park Trust continues and is now overseen by the Greater Sydney Parks Consolidated Board.

The vegetation protected within Lachlan Swamp is classified as ‘Coastal Swamp Sclerophyll Forest of South-eastern Australia’ (Figure 1)—a predominantly native assemblage that was assessed for listing as a Threatened Ecological Community (TEC) under the EPBC Act (DAWE, 2021). As of 8 December 2021, the Coastal Swamp Sclerophyll Forest of NSW and southeast Queensland has been listed as ‘endangered’ under the Federal EPBC Act. Additionally, the

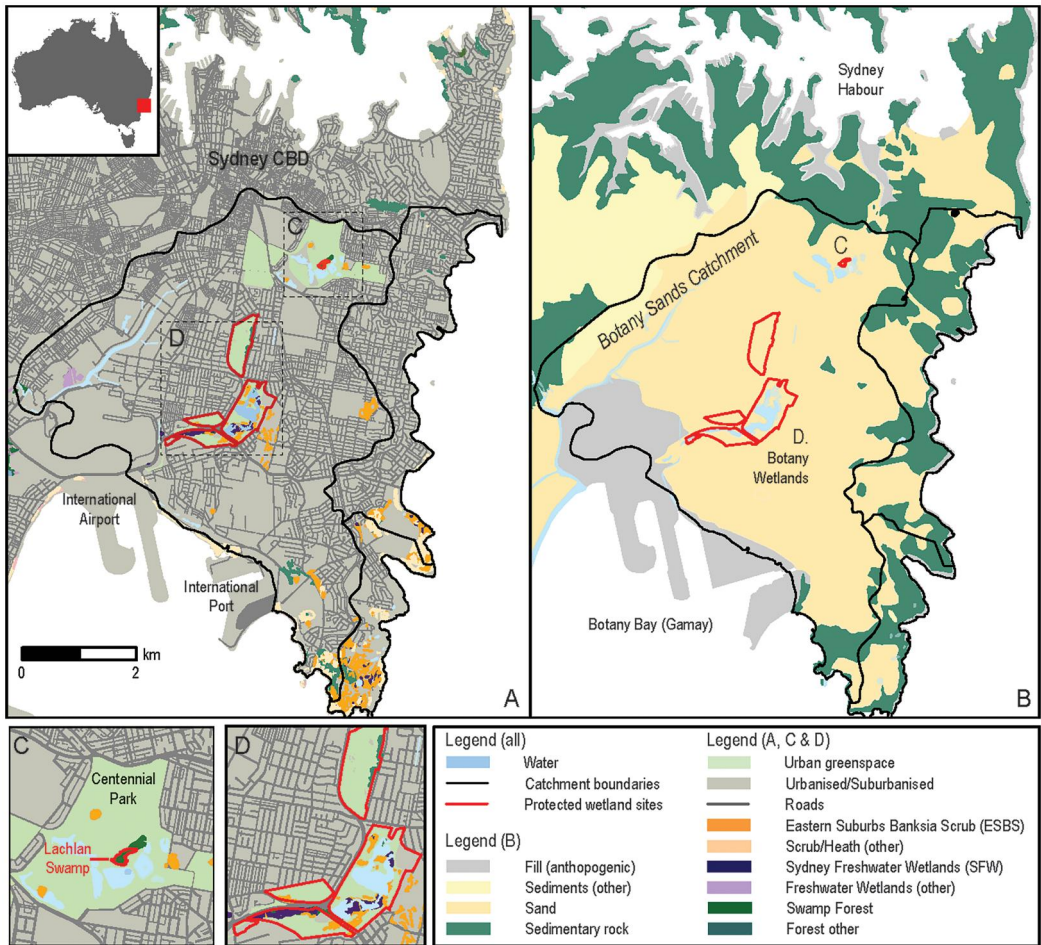


Figure 1. (A) Map of southern Sydney showing urban areas (grey), streets (dark grey) (SGNSW & DPIE, 2016) and remnant (including native) greenspaces (coloured) (NSW Department of Planning, 2013). (B) Surface geology of the same region (Geoscience Australia, 2012). Black line delimits the catchment boundary of the Botany Sands Aquifer determined from digitisation and analysis of NSW Department of Lands (1894) – see [Supplementary Information](#). Red lines show the boundaries of protected remnant wetland sites: (C) The Lachlan Swamp and (D) Botany Wetlands.

dominant terrestrial and wetland vegetation at the Lachlan Swamp (*Melaleuca quinquenervia* [Broad-leaved Paperbark], *Casuarina glauca* [Swamp Oak], *Callistemon salignus* [Crimson Bottlebrush], *Gahnia sieberiana* [Saw Sedge]) is compositionally consistent with indicator species listed for the ‘Sydney Freshwater Wetlands in the Sydney Basin Bioregion’. These freshwater wetlands are listed as an Endangered Ecological Community (EEC) (BC Act) and are noted as being particularly extensive ‘in the Sydney Eastern Suburbs ... with occurrences reported at the Lachlan Swamps, Centennial Park and Botany Swamps (Wetlands)’ (NSW Threatened Species Scientific Committee, 2011). In fact, the Lachlan Swamp Reserve, and the Mill Stream section of the Botany Water Reserves (discussed below) are considered the ‘main surviving examples’ of this community (Benson & Howell, 1994).

The conservation significance of the flora in the Lachlan Swamp Reserve is implicitly and explicitly conveyed to the user through boardwalks, fencing and signage that encourages users to protect the significant native vegetation. In addition to its ecological significance, the site is also considered to be historically important as it was colonial Sydney’s second official town water supply between 1820 to 1859 (Ashton, Blackmore, & Scorrano, 2014) (Figure 2).



Figure 2. Lachlan Swamp Reserve looking into the Coastal Swamp Sclerophyll Forest. The wetland fringing vegetation is dominated by *Gahnia sieberiana* (sedges) while the dominant canopy tree is *Melaleuca quinquenervia* (broad-leaved paperbark).

The second remnant – the Botany Water Reserves, or Botany Wetlands – is a 4.5 km long stretch of 11 interlinked freshwater marshes, ponds and weirs, located downstream of Centennial Park. It is managed by Sydney Water, local councils (Bayside and Randwick City Councils) and, further downstream, the Commonwealth government. Sydney Water leases much of the land to three golf clubs, the Lakes, Bonnie Doon and East Lakes. The land is managed under a Plan of Management (2018 to 2028) that sets ‘the directions and priorities for on-ground works and management actions’ (Sydney Water, 2018, p. 4). Like the Lachlan Swamp, the wetlands of the Reserve have colonial historical significance, serving as the city’s third official water supply in the second half of the 19th century. This has resulted in the sites being listed on the NSW Heritage Register (No. 01317) (pursuant to Part 3 A of the *Heritage Act 1977* (NSW)).

The ecological significance of the Botany Wetlands which, like the Lachlan Swamp remnant, are thought to protect important native ecological communities, is evidenced by: 1) being included on the Commonwealth’s Inventory of Important Wetlands (reference number NSW073) (Environment Australia, 2001), and; 2) the vegetation being classified into two EECs, including Sydney Freshwater Wetlands and the Eastern Suburb *Banksia* Scrub – the latter of which is listed both under the EPBC Act and the BC Act as ‘Critically Endangered’ (Figure 3).

Reconnecting and improving public access to the former aquatic (blue) and green spaces that once connected the Lachlan Swamps and Botany Wetlands is one of the centre pieces of the State Government’s ‘Blue Green Grid’² open space policy for Central Sydney (GANSW & NSW DPE, 2017). This plan aims to take advantage of the unique, sandy geomorphology of the Botany Sands Aquifer and draw on significant remnant natural wetlands and drainage corridors to provide connected public pathways linking Centennial Park in the north to Gamay in the south (Bayside Council, 2020; GANSW & NSW DPE, 2017). Importantly, a focus of these plans is protecting, restoring, and connecting the indigenous vegetation of the sites, including the freshwater wetlands and *Banksia* scrub, and where possible, returning some of the critical ecological functions afforded by these ecosystems. However, objectives to conserve or recreate versions of the past landscapes are compromised by a lack of information about the past extent, composition, and disturbance



Figure 3. Botany Wetlands – view of Pond 3, looking west. The pond vegetation is part of the Sydney Freshwater Wetlands, while the vegetation in the back left quadrant is Eastern Suburbs *Banksia* Scrub.

regimes of the Indigenous and early-British wetland ecosystems. This is recognised in the environmental planning policy developed for the region. Key threats include a lack of knowledge on the past spatial distribution of the communities, the unclear impacts of altered hydrological, climatic, and fire regimes, and the influence of toxic and organic pollutant loading, which can variably cause some species to survive and/or thrive above others (NSW Department of Environment & Conservation, 2004; NSW Office of Environment & Heritage, 2020). Past studies show the important influence of some of these atmospheric and hydrological threats (including elevated CO₂, temperature, and draining for agriculture) on the structural and ecological functioning of wetlands, including woody plant encroachment, over relatively short timeframes (e.g. Johnston, Slavich, & Hirst, 2003; Saintilan & Rogers, 2015).

This essay explores the holistic socio-environmental history of southern Sydney's freshwater wetlands and produces a robust spatiotemporal narrative about their development and eco-hydrological change since the time of British settlement in Sydney in 1788 CE. We do this through the multi-disciplinary lens of historical ecology—a practical framework for understanding relationships between physical geographies and human culture in the past, present and future (Crumley, Kolen, de Kleijn, & van Manen, 2017). This framework is particularly useful for exploring multiple-use, heavily modified sites such as urban green spaces (Crumley, 2017) where the structure, function and dynamics of ecosystems that, if not completely lost, are often heavily obscured by people and are contested (Beller et al., 2017). While the advantages of historical ecology for identifying ecological baselines and exploring interacting drivers of landscape change though multidisciplinary are many, its application in an Australian context is still rare (Beller, McClenachan, Zavaleta, & Larsen, 2020).

Here, we visualise the historical ecology of southern Sydney's freshwater wetlands through the creation of historical environmental maps that incorporate quantitative palaeoecological point data (Hamilton & Penny, 2015) and novel analysis of qualitative historical hydrological, floral and faunal data (see [Supplementary Information](#) for methodology). To do so, we first explore the total area and extent of the Indigenous and early-British wetlands across the Botany Sands Aquifer to determine how representative wetlands were of southern Sydney in the past. Secondly, we reconstruct the composition and structure of the wetland vegetation, assess consistency across space, and compare visions of the early- and pre-British flora with contemporary ecological communities protected at the sites. Finally, we review historical data that sheds light on the shifting use, regulation, and attitudes towards the wetlands by British colonists through time. This environmental and social landscape context is then used to examine how our contemporary memories of, and regulatory approaches to the last remnants of the wetlands have taken shape.

Ecological evolution of southern Sydney's wetlands

1788 to 1860 CE

The earliest available hydrological historic data from southern Sydney (listed in the Supplementary Text) indicate that the wetlands were a dominant feature of the early 19th-century landscape. Alone, the inundated soils within the Botany Sands Aquifer catchment and adjacent catchment region to the west covered approximately 11.3 km², a measurement that likely excludes adjacent portions of the ground described as 'in a very moist state' (1833/1834) (SMH, 1885a) and saturated to the point that walking across the surface required 'plunging knee deep' into the ground (1788) (Phillip, 2015) (Figure 4).

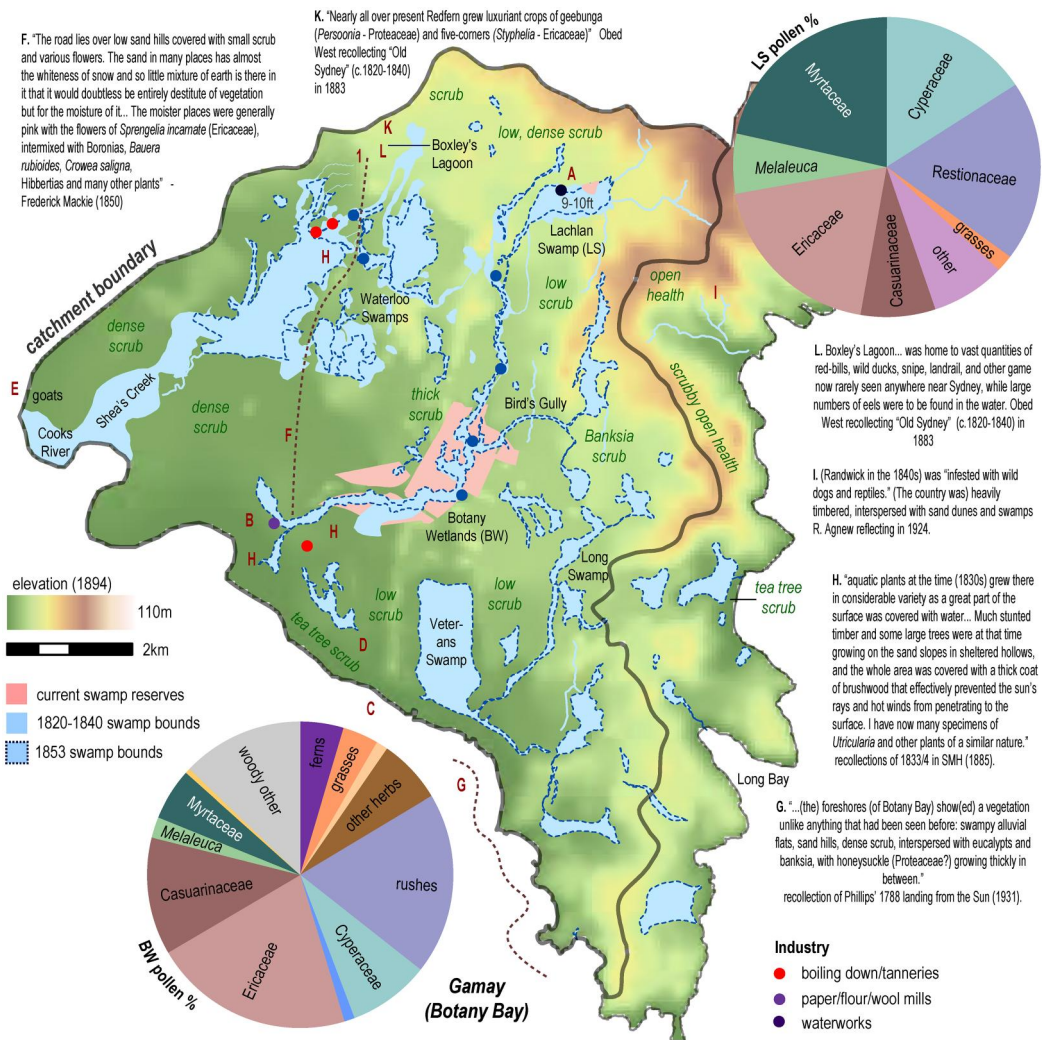


Figure 4. Early British-period historical map of southern Sydney showing wetland boundaries (1820–1853) (blue polygons) and historically reconstructed vegetation/fauna (1788–1860) (annotations). The pie charts show the early- to mid-19th century vegetation composition of the Lachlan Swamp [LS] (adapted from pollen data presented in Hamilton & Penny, 2015) and Botany Wetlands [BW] (unpublished data provided by Dan Penny). Letters A to E correspond to sketches and paintings shown in Figure 5. Base map shows the geomorphology of the site at 1894 reconstructed from NSW Department of Lands (1894). The coloured points show the locations of water intensive/ polluting industries established in the area, and the pink polygons show the extant location of the Lachlan Swamp and Botany Wetlands.

Historical recollections from 1833 and 1834 of wetland and aquatic plants growing in both the Botany Wetlands and Waterloo Swamps (the latter of which is located towards the northern boundary of the catchment, and drains southwest), shed light on the early 19th century Sydney Freshwater Wetland EEC. These recollections refer to a diverse flora comprising ‘many specimens of *Utricularia*’ (carnivorous bladderworts) (SMH, 1885a p8). Pond margins and the saturated swampy soils proximal to the wetlands are also described in the historical record as being very diverse and made up of high, coarse rushes (Restionaceae) (Tench, 1793), *Sprengelia incarnate* Sm. (Ericaceae), *Bauera rubioides* Andrews, (Cunoniaceae), *Crowea saligna* Andrews and *Boronia* spp. Sm. (Rutaceae), and *Hibbertia* spp. Andrews (Dilleniaceae) (Mackie (1850) in Benson & Howell, 1995). Functionally, these woody heathland plants played a crucial role in sheltering ‘barren’ aquifer sands from the sun and wind (SMH, 1885a p8). These descriptions complement scientific interpretations of the swampland flora reconstructed from fossil pollen grains preserved in sediments laid down in the Lachlan Swamp and Botany Wetlands during the late 18th and early 19th century. The pollen data indicate that wetland vegetation included rushes (Restionaceae) and, to a lesser extent, sedges (Cyperaceae) and that the surrounding region was dominated by Ericaceous, heathy taxa (Hamilton & Penny, 2015; unpublished data provided by Dan Penny).

The ‘barren’ sand hills and slopes interspersed between the early 19th century wetlands are consistently described as vegetated with ‘scrub’, ‘brushwood... (and) stunted timber...’ (SMH, 1885a p8), suggesting the widespread presence of a low, woody plant community. These descriptions are mirrored in the early sketches and paintings of the region (Figure 5A–E), which indicate that the Botany Sands Aquifer catchment supported a low and open vegetation structure. This assemblage is structurally compatible with the Eastern Suburbs *Banksia* Scrub EEC, though detailed compositional descriptions of the scrubland in the historical record are rare. However, references to *Banksia* spp., other Proteaceae (e.g. *Persoonia*), Ericaceae (e.g. *Styphelia*) and Myrtaceae taxa exist (SMH, 1883 p5; The Sun, 1931 p7), and it is expected that this community merged with the Ericaceous-Rutaceous swamp-heath communities described adjacent to the mires.

Perhaps the most prominent feature of the early-British period flora of the region, particularly in comparison to what is being protected at the Lachlan Swamp remnant today, is the absence of any significant wooded or forested patches in the vegetation descriptions, maps, or images. Most notably, there is no description of the contemporary Lachlan Swamp dominant—the broad-leaved paperbark (*Melaleuca quinquenervia*)—in the historical record. Again, this observation is supported by pollen data from Lachlan Swamp, which suggests that *Melaleuca* taxa only comprised a small component of the local site vegetation in the 18th and early 19th century (see Figure 4). Similarly, it is only a minor feature of the pollen record from the Botany Wetlands prior to the 1870s (Figure 4). Rare trees that did grow in the vicinity of the Lachlan Swamp during this period were from the Casuarinaceae family (probably *Casuarina glauca*) and *Leptospermum* genus. Rare, large blackbutts (*Eucalyptus pilularis*), and coastal tea trees (*Leptospermum laevigatum*) are noted in the historical record as growing locally in regions supporting better soils (SMH, 1883) (Figure 6).

Data on wetland fauna in the early-19th century are uncommon. However, recollections of Redfern in ‘Old Sydney’ (c.1820-1840) by Obed West—resident of Barcom Glen (within today’s suburb of Darlington) and local historian—describe the local wetlands as supporting a large number of red-bills, wild ducks, snipe, landrail and ‘other game now rarely seen anywhere near Sydney’ (SMH, 1883, p5). Additionally, an early (1840) description of Randwick refers to the region around Lachlan Swamp ‘as infested with reptiles and wild dogs’ (Agnew, 1924 p4). These wild dogs presumably refer to dingoes, given Obed West’s recollection that ‘the head of the (Glenmore) swamp’, within today’s Paddington, ‘was a great resort for dingoes’ (SMH, 1882 p9).

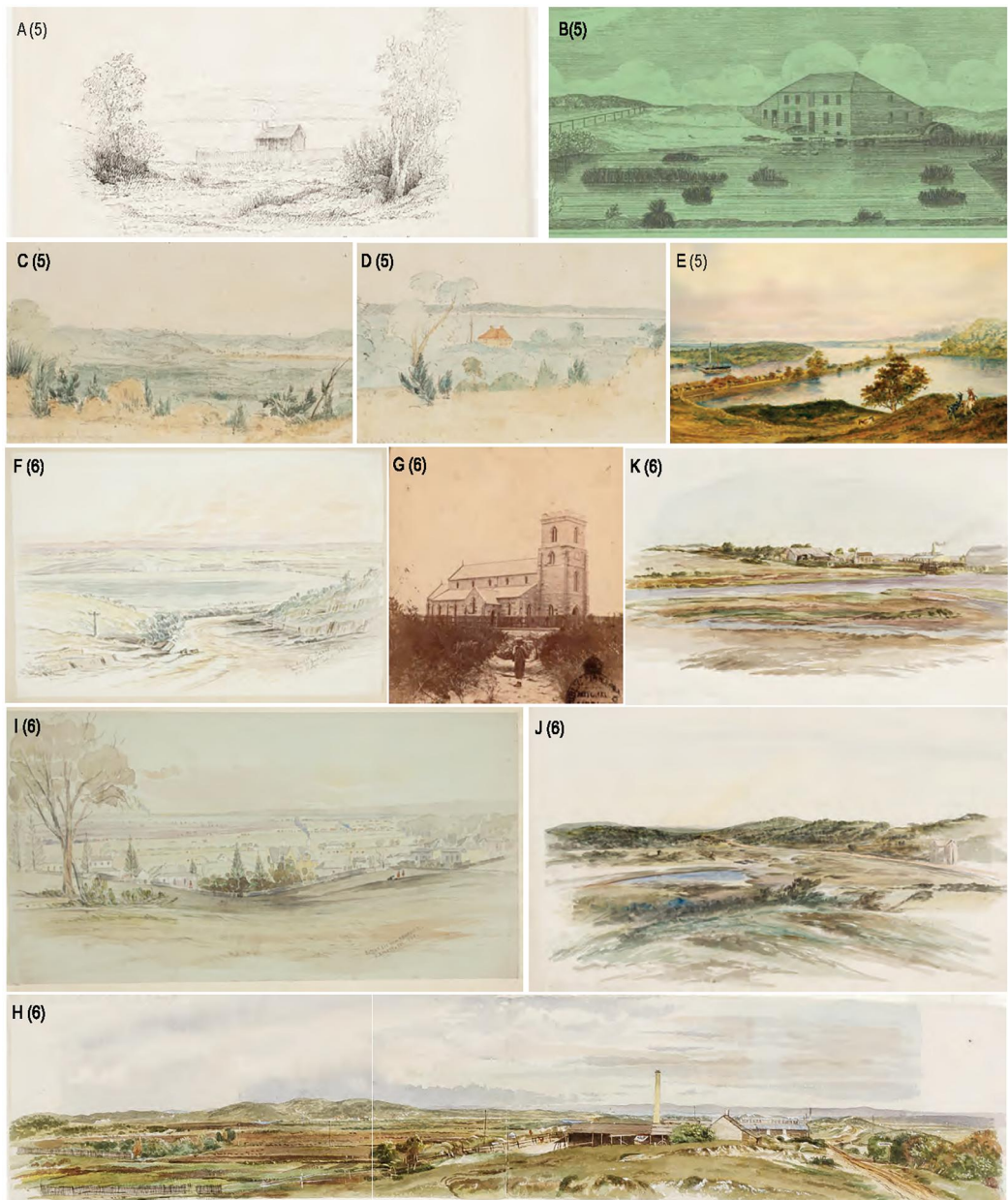


Figure 5. Drawings, paintings, and photographs of southern Sydney in the 19th century. These images highlight the broad continuity of open, scrubby vegetation across the region. Approximate locations for each picture are shown on Figure 5(A–E) and Figure 7(F–H). Figures are sourced from the State Library of NSW with collection details included in the [Supplementary Information](#).

1860 To 1930 CE

By the mid- to late- 19th century, the extent of the wetlands had markedly decreased. Analysis of historical maps from this period (spanning 1871 to 1936 CE – see [Supplementary Information](#) for methods) indicate that the wetlands covered an area of approximately 7.1 km², around 62% of their early-19th century extent (see [Figure 7](#)). In addition to this shrinkage, historical notes describe the significant compaction and hardening of once saturated, soft, sandy soils that were present in the late 18th and early 19th century.



Figure 6. *Melaleuca quinquenervia* or the broad-leaved paperbark (left front) which dominates the Lachlan Swamp site today is notably absent from the 19th century landscape of southern Sydney.

The changing distribution and composition of the wetland vegetation is linked to changes in the exposed Botany Sands Aquifer soils, over extraction of water, the construction of dams and weirs, and trampling by hoofed animals. Recollections published in 1885 explain that clearance and the increased incidence or intensity of dry season fires, potentially related to removal of Indigenous land-use practices, resulted in the destruction of protective brushwood cover ‘opening the way for parching winds ... and sun to dry the ground’ (SMH, 1885a p8). This reinforcing feedback appears to have transformed the aquatic and waterlogged flora of the wetlands, including the disappearance of *Utricularia* (SMH, 1885a), and the reduction in diversity of in-wetland and surrounding swamp heath vegetation (Gibbs, 1981; SMH, 1885a). Additionally, the partial replacement of rushes on the wetland margins (probably *Eleocharis sphacelata* R.Br. dominant – a perennial aquatic) with more sedges (probably *Gahnia* spp. – a seasonally submerged wetland land plant) and grasses (reflecting a combination of dryland and wetland taxa) from the Lachlan Swamp and Botany Wetland pollen records supports the interpretation of the wetlands drying and shrinking from the mid-19th century.

However, clear reference is made to the resilience of certain wetland taxa. For instance, deliberate attempts to ‘exterminate’ the ‘reeds, rushes, &c.’ that were ‘choking the swamps’ in the late 19th century were described as ‘useless’ (Australian Town & Country Journal, 1885 p1), clearly suggesting the persistence of some local wetland plants. There is also evidence that the broader, terrestrial landscape exhibited a degree of structural and compositional resilience across the 19th and early 20th century. Pollen data indicate the persistence of *Allocasuarina/Casuarina*, as well as several heathland plants from the *Banksia* genus (Botany Wetlands) and Ericaceae family (Lachlan Swamp and Botany Wetlands) into the 20th century, though there is a notable decline in their abundance in association with the construction of dams and weirs in the 1860s, and the

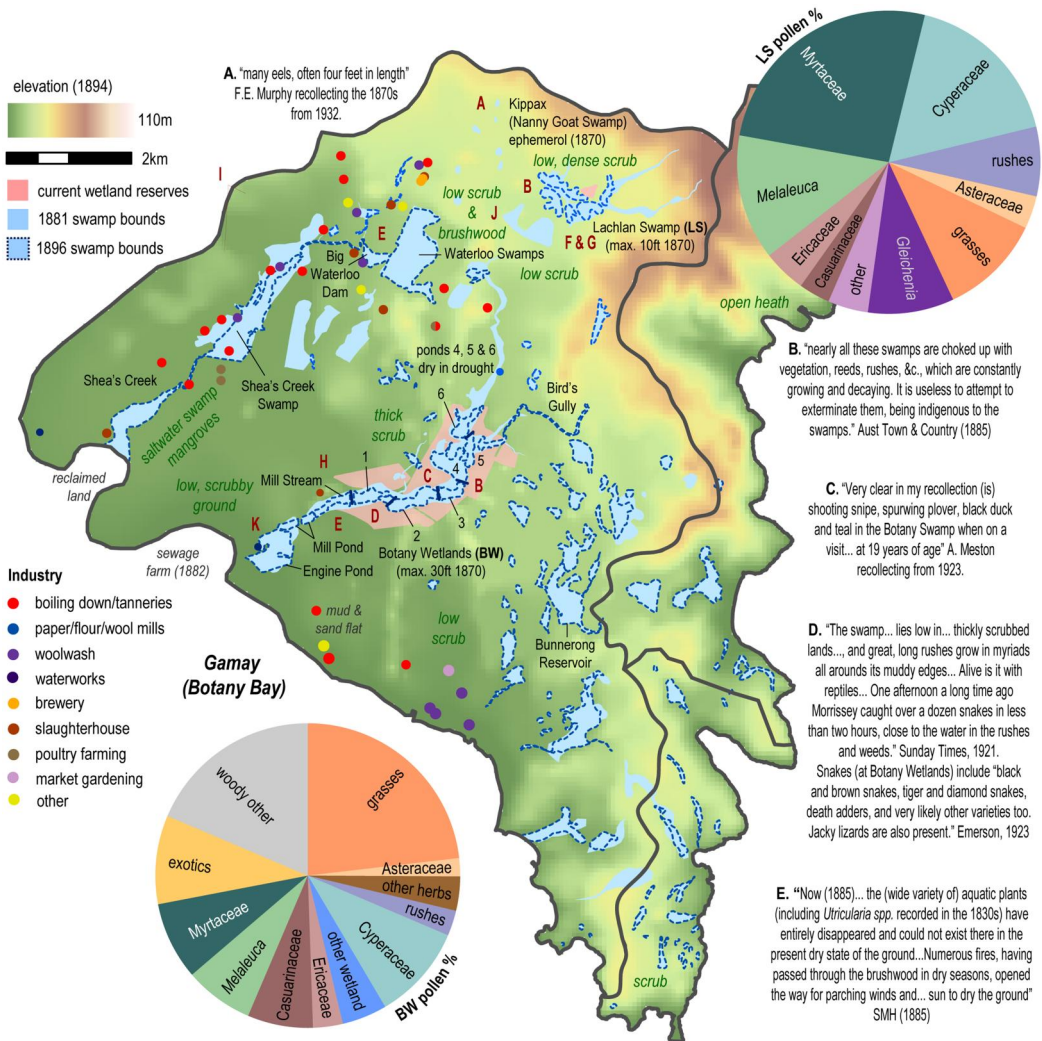


Figure 7. Late 19th and early 20th century historical map of southern Sydney showing wetland boundaries (1871–1936) (blue polygons) and historically reconstructed vegetation/fauna (1860–1930) (annotations). The pie chart shows the vegetation composition of the Lachlan Swamp [LS] and Botany Wetlands [BW] over the same period (adapted from pollen data presented in Hamilton & Penny, 2015 and unpublished data provided by Dan Penny). Letters F to H correspond to graphics shown in Figure 5. Base map shows the geomorphology of the site at 1894 reconstructed from NSW Department of Lands (1894). The coloured points show the locations of water intensive/ polluting industries established in the area, and the pink polygons show the extant location of the Lachlan Swamp and Botany Wetlands.

conversion of the Lachlan Water Reserve into Centennial Parklands in the 1880s (Hamilton & Penny, 2015; unpublished data provided by Dan Penny). The persistence of a broadly open flora across the catchment during the late 19th century is supported by paintings and photographs showing a treeless landscape (Figure 5F–H), as well as written records and maps indicating the wide-scale presence of ‘scrubby’ land (Figure 7).

Hydro-social evolution of wetland (mis)management and (mis)remembrance

The physical manifestation of waterscapes and how they are managed is, despite being considered a scientific endeavour, strongly contingent on shifting values and cultural norms

(Coyne, Zurita, Reid, & Prodanovic, 2020). The importance of the material-social dynamics embedded within waterscapes has been recognised through the notion of a 'hydro-social' cycle (Swyngedouw, 2009). Separating the study of waterscapes into physical and social or human silos has long been considered an inappropriate binary (see also Linton & Budds, 2014). In this essay, we pay attention to the hydro-social context of these wetlands as places that are co-constructed by both physical and social (especially regulatory) forces. We argue that the hydro-social framing collapses artificial binaries in the study of complex wetlands ecosystems in a similar vein to the approach adopted by Coyne et al. (2020) who critically analyse the historical evolution of the Georges River catchment in Sydney. Unpacking shifting values in the management of waterscapes sheds light on how they take on their contemporary form. This is particularly the case for ecosystems like the Sydney's freshwater wetlands which represent multiple-use urban landscapes and, in several places, public lands (Crumley, 2017). Thus, tracing the changing interactions between these wetlands and people through time is critical for understanding their contemporaneous physical geography, management, and public perception.

Indigenous histories held by local Dharawal and Cadigal people as well as the early British written records indicate that the natural resources of the wetland and surrounding lands have long been used for multiple purposes, including for hunting, medicinal, provisional and ceremonial purposes (Attenbrow, 2002, unpublished data provided by Shane Ingrey). Archaeological evidence show that Aboriginal people have been using the wetlands for at least 8500 years in and around Randwick (Godden Mackay Heritage Consultants Pty Ltd & Austral Archaeology Pty Ltd, 1997), and for at least 6000 years around Shea's Creek – the latter of which was determined from radiocarbon dating of a butchered dugong skeleton (Haworth, Baker, & Flood, 2004). This long connection between people and lands subject to long droughts and deluge have meant that Australian Aboriginal communities have developed strong knowledge systems around the sustainable management of ground and surface water for utilitarian, cultural and spiritual purposes (Moggridge, Betteridge, & Thompson, 2019).

Evidence for the continual use of these wetlands has, in large part, been lost due to the colonial use of shell middens to make limestone and through urbanisation. Nevertheless, Aboriginal people continued, and continue to use these areas for survival and for economic gain (Irish, 2017). For instance, in the mid-1800s, Mahroot, an Aboriginal man from Gamay, lived at the Botany Aboriginal Camp at the Mill Stream (southwest end of the Botany Wetland Reserve) and ran fishing and hunting tours around Gamay and the surrounding wetlands (Goodall, 2008). After he passed away, another Dharawal man, Jemmy Malone took over as a fishing guide around Gamay living at the Botany and San Souci Aboriginal camps (Irish, 2017).

Wetland vegetation, although modified, still holds a significance to local Aboriginal people. The cultural uses and preparation of the plants within the regional landscape show a longtime continual connection. For instance, the grass tree (*Xanthorrhoea* spp.), depicted growing in early colonial paintings and sketches along the waterways, is a multi-use plant used to construct fishing spears – a practice continued today within the La Perouse Aboriginal community. Similarly, other food and medicinal plants have long been used and are still used today. These include Ericaceaeous five corners (*Styphelia triflora*), geebung (*Persoonia pinifolia*), native sarsaparilla (*Smilax glycyphylla*), mat rush (*Lomandra longifolia*) and multi-use heath and swamp plants such as the coastal wattle (*Acacia sophorae*), swamp oak (*Casuarina glauca*), and coastal tea tree (*Leptospermum laevigatum*). Because wetland and heathland habitats attracted birds, reptiles and small mammals, the waterways were prime hunting grounds. The fossil pollen record from the Lachlan Swamp indicates that Indigenous management before 1788 CE supported a hydrologically and floristically stable wet heath system over at least the previous 2000 years (Hamilton & Penny, 2015).

Social attitudes towards the wetlands, which were 'managed' by the British colonial authorities solely for their perceived utility (or lack thereof), were erratic across the late 18th to early 20th century, presenting an apparently stark contrast to Indigenous land-use. An early colonial

disdain for the 'unhealthy' landscape of southern Sydney, combined with the perceived low utility of the 'boggy' soils, meant that the sodden sands supported by the Botany Sands Aquifer were largely unregulated. This enabled shrewd entrepreneurs to establish uncontrolled, water-intensive, often polluting industry along the wetlands. Within the Lachlan Swamp to Botany Wetlands (central) drainage course, Daniel Cooper and Solomon Levey established Lachlan Mill in 1820 CE for flour, wool (1827 CE) and later paper (1830 CE) milling. Progressing south, Clarkson (c. 1819 CE), Winder's and Lord's (1815 CE) Wool Mills were built next to the Botany wetlands, and dams for these mills were constructed between 1810 and 1820 CE. In the west, several boiling down works, tanneries, flour and wool mills emerged on the once-extensive Waterloo Swamps, which drain to the southwest along Shea's Creek (Figure 5). Though relatively sparse, effluent produced from these industries, particularly the animal processing works (boiling down factories, tanneries, glue factories, soup works and fellmongeries) probably began to load the wetlands with chemical and organic pollutants.

The regulatory approach to the central drainage line between the Lachlan and Botany Swamps began to change between the 1820s and 1850s when droughts, mismanagement of the current water supply (the Tank Stream), and a growing population demanded the procurement of a new water source for the British colony at Sydney (NSW Committee on the Tunnel, 1837). Protected water reserves were established first at the Lachlan Swamp (1827–1887 CE) and then at Botany Wetlands from the 1850s (Sydney Water, 2018) in response to this need. Though this did result in over extraction and hydrological manipulation through the constructions of dams, weirs and drains (Hector, 2011; Sydney Water, 2018), the protection of these sites for their utilitarian value appears to have limited the expansion of polluting industries along the central swamp line relative to the other wetlands in the catchment. For instance, wetlands within this chain, notably Botany Wetlands Ponds 4, 5 and 6 (locations on Figure 6), were, in 1874, described as 'bright and beautiful' due to their geomorphic setting in 'a valley bounded by low hills, nearly in their original state, and covered in ... scrub growing in almost pure sand, which forms an admirable filter bed' (Norton, 1874). Nonetheless, by the 1870s, the Lachlan Swamp and downstream ponds of the Botany Wetlands were described as loaded with 'nitrates ... and organic matter' (SMH, 1874 p2). One of the sources of pollution was the dumping of human excrement, sometimes one to two feet deep within the Lachlan Swamp watershed, including 'upon the hills in Moore park' and within '800 to 900 yards' of the Botany Waterworks (Daily Telegraph, 1886 p5; Goulburn Herald & Chronicle, 1875 p4). An interview with a night cart contractor noted that there were about '40 carts discharging upon the very margin of the swamps from which the Botany Dams are supplied', a process linked to outbreaks of typhoid fever in Paddington and Marrickville (Daily Telegraph, 1886 p5). Other pollution sources noted within the watershed included washing linen in the creek, runoff from cultivated land and the establishment of market gardens (noted at the Engine Pond), and contamination from stable yards, humans and dogs near the Randwick racecourse (Daily Telegraph, 1886; Norton, 1874).

The chain of wetlands to the west and east of the central Lachlan Swamp-to-Botany Wetlands flow path, which were not protected as water sources and thus overlooked by British regulatory authorities until the late 1800s, fared even worse than the central drainage-line. A Royal Commission into Noxious and Offensive Trades, appointed in 1882 CE, provides a rich description of the hydrologically altered, highly polluted wetlands, and strongly indicates that, by late 19th century, the sites were irreversibly altered from their late 18th century low nutrient state (New South Wales Noxious & Offensive Trades Inquiry Commission, 1883). An explosion of hyper-polluting, animal processing industries and associated storage dams, the establishment of market gardens, and nightsoil dumping occurred at the head of the western swamp chain between the mid- and late 19th century (contrast industry points concentrated around Waterloo Swamps between Figure 4 and Figure 7). This ultimately resulted in the transformation of 'soft, fresh' water observed in the 1820s into 'filthy' water bodies emanating a stench described as 'abominable' and 'something fearful' (New South Wales Noxious & Offensive Trades Inquiry

Commission, 1883 p144). Because industry was largely concentrated upstream, the entire western chain of wetlands became biochemically and hydrologically degraded (New South Wales Noxious & Offensive Trades Inquiry Commission, 1883).

Market gardens were an important industry within the eastern wetland chain and along the north shore of Gamay, where the ground was naturally more fertile (New South Wales Noxious & Offensive Trades Inquiry Commission, 1883). These gardens had two major impacts on swamp hydrology and chemistry. First, several formerly expansive swamps, including Veterans Swamp—a large wetland located within the southern part of the catchment on the north shore of Gamay—appears to have completely disappeared as a result of draining, tilling and mining for peat (contrast [Figure 4](#) and [7](#)) (works alluded to in SMH, [1885b](#), [1885c](#); SMH, [1885d](#)). Second, the gardens were fertilised with manure, bone refuse and offal (often containing hydatid cysts) from nearby animal processing industries, which were sometimes mixed with ferns and sand and dumped into drainage ditches (SMH, [1885b](#), [1885c](#)). This rendered the swamp water ‘dangerous’, ‘totally unfit for consumption’ (SMH, [1885b](#) p5; [1885c](#) p13), and ‘emanating a horrible smell’ (New South Wales Noxious & Offensive Trades Inquiry Commission, 1883 p523).

The pollution and drainage of the wetlands in the 19th and early 20th century, laid strong foundations for positively reinforced feedback loops of overprinting, infilling, redirecting and polluting the hydroscaapes in the mid- to late-20th century. Justification for this is articulated by Butlin ([1976](#)), who states in the context of the Port Botany development that:

The attitude of some environmental impact statement has been that, because the standards of the physical environment are poor, the introduction of “new” (developments) would not make matters different... This attitude obviously ignores the possibility of an alternative attitude: that an environment that is at present poor may claim high priority for improvement. (p. 73)

We see this play out time and time again at the different wetland sites. Perhaps most notably is the fate of Veterans Swamp. Today, this swamp is buried beneath Botany Industrial Park—a chemical manufacture site established in 1942. The site is infamous for playing host to one of the worst contamination incidents in Australian history, where the poor regulation of toxic chemical manufacturing over decades resulted in the intrusion of a diffuse, $\sim 2\text{km}^2$, extremely toxic groundwater plume into the Botany Sands Aquifer (Prior & Partridge, [2010](#)).

Out of the mire: working towards conservation of holistic hydro-socio-ecologies

Our synergetic reconstruction of changes in the ecological, social and industrial fabric of southern Sydney’s freshwater wetlands reveals the influence of culture and approaches to land custodianship (or lack thereof) in shaping our conceptions of more-than-human places. In doing so, historical ecology reveals itself as a powerful, yet underutilised tool for revealing and healing flaws in our understandings of place. This has implications for measuring how accurately we are meeting ‘conservation targets, for the pragmatic re-evaluation of the usefulness of these targets in the first place, and for empowering specialists and non-specialists alike to better understand their local hydro-socio-ecologies. Equally, close and critical attention to the complex regulatory structures that have evolved over time and presently act to enable and disable certain actions, reveals how the materialities of landscape—including EECs and TECs—are produced and maintained.

At its most basic level, our reconstruction shows that what is being protected in law and subordinate policy as a pre-British ‘natural’ plant community within urban Sydney is an imagined, 20th-century version of the Indigenous wetland flora. This offers practical lessons for landscape management. As discussed at the top of this essay, the protection of pre-European benchmark ecological communities is a common and persistent theme of Australian environmental legislation and policy at national, state, and local scales. Similar approaches are also used in other modern settler colonial states, including North America, where legal frameworks such as the

United States *Wilderness Act* (1964) strive to protect places allegedly ‘untrammeled by man’ (section 2c). These approaches are increasingly critiqued as blinkered, Eurocentric and colonial, particularly when they do not incorporate the agency of Indigenous societies in shaping dynamic pre-colonial ecologies (see Fletcher, Hamilton, Dressler, & Palmer, 2021). Our failure to accurately remember even static versions of past physical landscapes, let alone understand their range of human-induced variability, signals the importance of long-term environmental data and adaptive governance structures for crafting meaningful land management targets centred on the conservation or restoration of a past version of an ecosystem. This applies not only southern Sydney’s freshwater wetlands, but to listed TECs and EECs elsewhere.

At a deeper level, our work raises the questions of whether ‘natural’ benchmarks are pragmatic for ecosystem conservation, particularly within urban or other highly modified settings. This is brought into focus when ecological reconstruction is paired with its socio-cultural context. In the case of Sydney’s freshwater wetlands, we observe ecologies subject to 200 years of Western revulsion, destruction, exploitation, incremental loss, disconnection and fragmentation, both drained and used as a drain with resultant pollution, before being prioritised for protection (BC Act, EPBC Act) and reconnection (GANSW & NSW DPE, 2017). These socio-cultural pressures correspond to the transformation of rush-fringed, *Utricularia* wetlands and low, open Ericaceous heathlands and *Banksia* scrub into sedge (*Gahnia*)- and coral fern (*Gleichenia*)-fringed *Melaleuca quinquenervia* swamplands that sit constrained within a heavily urbanised landscape. The former community includes plants that thrive in nutrient-poor, and often saturated sands, while the dominant plants within the latter thrive in nutrient-rich soils and tolerate drying (see Hamilton & Penny, 2015). Practical recreation of the pre-urban wetlands, if even plausible at a large scale, would require significant cost and time, and the establishment of nutrient-free buffer zones around the sites (Figure 8).

A strong case could be made for using a fine-scale liveability framework that accounts for socio-cultural legacies to make decisions about the future management of remnant freshwater wetlands. A liveability lens has already been developed at a coarse scale for hydrosapes in the Sydney Metropolitan region (Birtles et al., 2013). It is envisioned that using an expanded version of this framework that incorporates Indigenous Research Methodologies (IRMs) for framing cultural water values (Moggridge, Thompson, & Radoll, 2022) could promote integrated conservation approaches that centre on key issues facing Australia’s cities e.g. maintaining and promoting extant urban biodiversity, mitigation of flood and heat risk, promotion of equitable access to green-blue spaces, and facilitating learning about, and connection to country. In some cases, this may encourage land managers to selectively mimic the composition or community



Figure 8. Southern Sydney’s wetlands once supported low, open heathlands that thrive in nutrient poor, sandy soils, somewhat comparable to the swamp-heathlands present today within Gamay Botany National Park. Restoring this ecological community within the well-fertilised golf-courses and parkland lawns surrounding the Lachlan Swamp and Botany Wetlands would be a logistical and costly management challenge.

structure of past ecosystems to promote specific functional or cultural characteristics, such as to promote urban biodiversity or to reconnect otherwise disjunct patches of important native flora. In other cases, a modified or hybridised wetland ecosystem may be more functionally, recreationally, or educationally desirable. In both cases, the inclusion of Indigenous knowledge and decision making would have the powerful impact of reminding us that, despite urbanisation, warfare, and disease, Aboriginal people in Sydney have maintained strong connections to the local landscape (Irish, 2017). This would, we hope, reverse the erasure of Indigenous histories within the colonial period and highlight the largely overlooked fact that Indigenous knowledge, stories, and people are still here, are dynamic, and have a critical role to play in land management decisions. The legacy of environmental mismanagement and mis-remembrance that is so clearly encapsulated by the un-restored, un-‘natural’ swamps presents a tangible place for truth-telling about the past, and for re-imagining contemporary landscapes.

We end this essay with the hope that it will inspire environmental practitioners and communities to better understand the evolution of their local socio-ecologies. While a deep time approach has long been understood as crucial for understanding and managing ecosystems within palaeoecology (e.g. Froyd & Willis, 2008; Hamilton & Penny, 2015; Seddon et al., 2014; Willis & Birks, 2006), it is still poorly applied and used in practice. This theory-practice disjunct may relate to the time and cost constraints of palynology (i.e. the dominant mode of ecological reconstruction based on the analysis of fossil pollen), its bias towards single site applications, and/or issues with cross-disciplinary translation. An additional impediment is the constrictive effect of law and policy, which embodies and enforces one specific environmental narrative, effectively ‘freezing’ landscapes in a normatively defined condition that may have no historical analogue and may not serve the needs of cities into the future. Our work here shows that, within the right setting, a complementary geohistorical approach can offer quickly accessible and cost-effective insights into past landscape histories across space. In the context of Sydney’s freshwater wetlands, oral histories and easily accessible historical data reveal the presence of consistently open heathlands across space and showcase the dominance of these ecosystems in the landscape prior to the mid-19th century. Yet, as our work shows, these past sites appear largely forgotten or misremembered. We hope that this essay empowers people to learn about and connect to landscape histories, and that it encourages a healthy dose of scepticism about dominant narratives around past places.

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Notes

1. We use quotation marks around the word natural in acknowledgement of the fact that that many Australian landscapes that are unthinkingly described as ‘natural’ have been long-managed and shaped by Indigenous and local peoples.
2. Blue-Green grids are ‘corridors of open space and water bodies that enhance human wellbeing, biodiversity, and ecological resilience’ (GANSW & NSW DPE, 2017)

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