A Hidden Cultural Landscape: Colonial Sydney's Plant Microfossil Record

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Organic-rich sediments, including buried soil material, usually preserve diverse assemblages of fossil pollen, spores and other microscopic plant remains. Archaeological sites in Sydney are no exception and such microfossils form a natural archive of plants growing on, or in the general vicinity of, the excavated area. The majority reflect native plants, in particular trees such as eucalypts and casuarinas, or introduced species such as northern hemisphere pines and dandelions which also produce and disperse pollen in large numbers. Pollen and spores of introduced ornamental and horticultural plants, including garden bean and pea, are preserved sporadically and in much lower numbers. Nonetheless the combined data provide an additional means of tracing changes in the vernacular landscape and of changing community attitudes to both the domestic and natural environment in colonial Sydney.

'The answer lies in the soil'
BBC Radio Program

Until relatively recently, historical archaeology in Australia was concerned primarily with material culture. Following seminal works such as the *Making of the English Landscape* by Professor W. G. Hoskins, there has been a growing appreciation that past human activity and human attitudes also are archived in more subtle fashion, including by the landscape itself. For example, Taylor argues that cultural or vernacular landscapes are 'an imprint of human history [and] the richest historical record we possess [which] if read aright...reveals something of the achievements and values of our predecessors'.[2]

If correct - and there is little reason to challenge the thrust of the above claims - then a full understanding of present-day Australia involves not only an analysis of Aboriginal and European history but also of the cultural landscape in which their material relics are 'embedded'.[3]

Fossil pollen and spore records of past vegetation (palynology) are one of the keys to unlocking this 'hidden' landscape' and cultural deposits in Europe and North America have been routinely analysed for plant microfossils as well as for charcoal and human artefacts since the 1920s.[4] Extreme examples of cultural deposits which have been found useful in historical archaeology are fossilised faeces (coprolites), used to reconstruct diets,[5] and a sunken eighteenth-century merchant ship.[6]

In Australia prehistoric deposits have been routinely pollen analysed since the late 1960s but the use of the technique was not formally investigated for use in *historical* archaeology in Australia until the late 1980s.[7] Reasons include the excellent documentary records for many sites[8] and the not unreasonable suspicion that pollen and spores did not survive in Australian soils due to repeated wetting and drying cycles.[9]

The latter assumption is now known to be incorrect, chiefly due to Dr. Edward Higginbotham who incorporated the first systematic pollen analyses of buried soils into an archaeological study. This was of the colonial Water Police Court, Phillip Street, built in the 1850s on the former grounds of First Government House (c. 1788-1850) overlooking Sydney Cove.[10] Although no evidence of edible horticultural species was found, other fossil pollen and spores provided the first evidence of native plants and introduced weeds occupying the grounds following the building of the present vice-regal residence (Second Government House) on Bennelong Point in the 1840s.[11-12] Deeper samples lacked European pollen indicators and were suggested to pre-date European settlement of Australia in 1788.

The study was a timely one given the extent to which Sydney has, and continues to be, reshaped by the construction of high-rise buildings on sites which preserve evidence of the colonial and, less often, prehistoric periods. In almost all cases the only historic relics that are preserved *in situ* or reconstructed in alternative contexts are the larger scale architectural remains. Other cultural evidence not salvaged at the time of the archaeological excavation is obliterated by heavy machinery.

An example is the Angel Place archaeological site between lower Pitt and George Streets (Plates 1-2). Here salvage excavations uncovered sections of the 1860s oviform brick drain enclosing Sydney's first water supply, the Tank Stream, an unrecorded 1840s sandstone embankment, and soils dating to the earliest colonial period which overlay a sand with Aboriginal tools.[13-15] Even more surprisingly given 200 years of intense disturbance of the lower Tank Stream Valley, an approximately 17 000 year old palaeochannel of the Tank Stream (Plate 3) was found preserved below the Sydney General Post Office (G.P.O.) several hundred metres to the south.[16-19] Sections of the brick drain and sandstone wall have been preserved at Angel Place, entombed in concrete.

Since 1987, some 25 historical archaeological sites in Sydney City and surrounding suburbs have been found to preserve fossil pollen and spore assemblages (palynofloras). These palynofloras represent plants whose presence will have seemed unimportant last century. The same plants now can be seen to mirror not only landuse but also the attitudes of the citizenry to their domestic surroundings and to the diminishing areas of native bushland as Sydney acquired its suburban character in the nineteenth century.

This paper presents an overview of the palynological database. Because of the highly varied nature of the archaeological contexts and the uncertain age of many cultural deposits, it is premature to compare the individual pollen sequences too closely. Exceptions can be found for almost all generalisations. Nevertheless the case remains that fossil pollen, spores and other plant microfossils such as soil organic matter, charcoal and plant silica cells (phytoliths) provide one of the best natural archives of how the vernacular landscape evolved in colonial Sydney.[20,21]

CONSTRAINTS AND OPPORTUNITIES

Fossil pollen and spores (miospores) are direct, albeit partial, evidence of past floras with some indication of abundance. Accordingly, all pollen-based reconstructions of past floras,

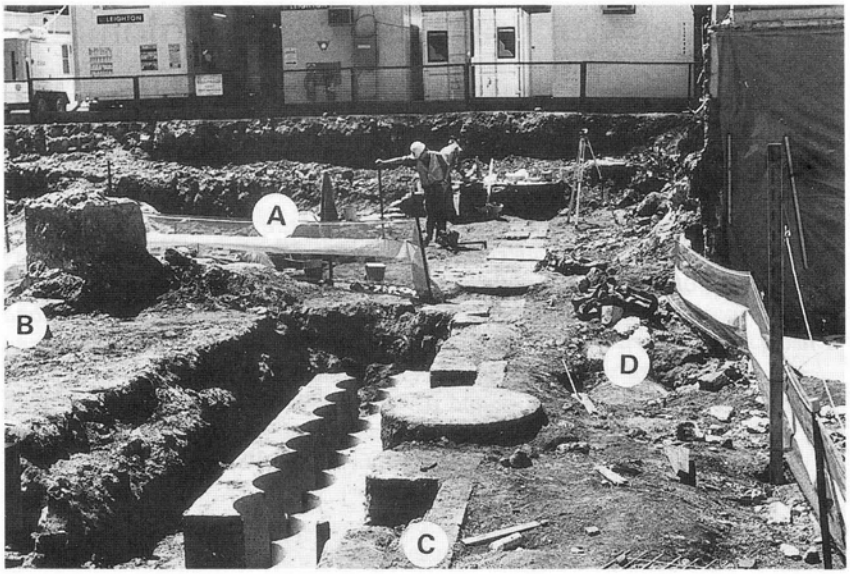

Plate 1: Angel Place archaeological site showing the location of early colonial architectural remains and associated cultural deposits. A -Trial Trench 1 (see Plate 2). B - possible Late Pleistocene soil preserved near the concrete foundations of the 1890s Palings Building; C - top of an unrecorded (1840s) embankment wall bordering the Tank Stream. The wall is made of carefully dressed (ashlar) sandstone blocks and evidently once demarcated the rear boundary of a property extending from George Street onto the Tank Stream. D - top of 1860s brick oviform drain enclosing the Tank Stream. This section was the longest surviving stretch of the drain recorded to date (photograph by M.K. Macphail 1997).

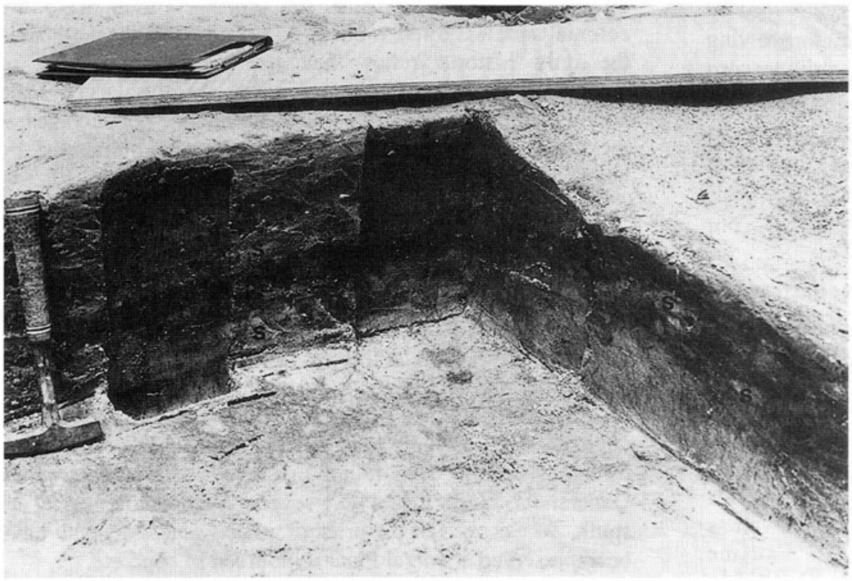

Plate 2: Trial Trench 1, Angel Place archaeological site, showing a distinctive dark grey silt (paleosol?) separating an charcoal-rich sand containing early colonial-period artefacts and a lower (?) Holocene sand sheet which preserved Aboriginal stone tools. The absence of exotic pollen types other than two grains of Liguliflorae point to the dark grey silt being deposited within the first years of European settlement at Sydney Cove (photograph by M.K. Macphail 1997).

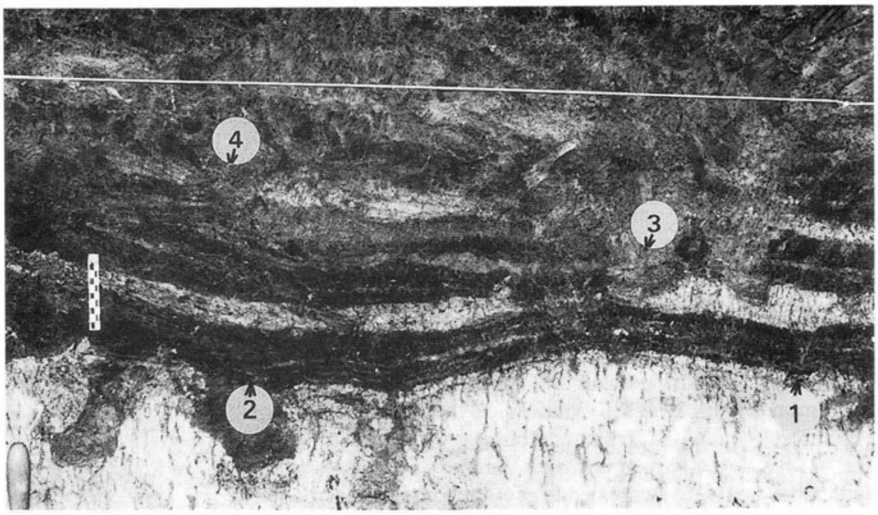

Plate 3: Sydney G.P.O. archaeological site showing parallel multiple (tram-track) charcoal laminae at the base of a c.17 000 year old palaeochannel of the Tank Stream. These beds appear to have been deposited horizontally under water but have been distorted by the weight of the overlying Late Pleistocene slope deposits and younger strata (photograph by T. Lowe 1997).

vegetation and past environments are interpretations circumscribed both by factors intrinsic to the plants themselves, and conditions during and subsequent to deposition of the fossil pollen or spores. In an archaeological context (archaeopalynology), the more important constraints are:

Taxonomic resolution

Many fossil miospores can be identified to the generic or family level only. Examples are the crucifer (Brassicaceae = Cruciferae), daisy/daisy-bush (Asteraceae = Compositae), grass (Poaceae = Gramineae) and saltbush (Amaranthaceae-Chenopodiaceae) families. These families include introduced (exotic) species, some of which are edible and/or ornamental, as well as native species. In certain cases, a particular type can be confidently related to an exotic rather than a native species because of its more specialised morphology. For example, Poaceae pollen with thick walls and diameter greater than 50-60 microns (μ) almost certainly represent edible (cereal) species such as wheat, oats or barley. Pollen grains which have very pronounced (high) spines are rare amongst the native species within the Asteraceae subfamily Tubuliflorae in the Sydney flora, and fossil specimens are more likely than not to have been produced by introduced species.

In other instances, different ecological preferences allow exotic species to be distinguished from native species at particular sites. An important example is the Asteraceae subfamily Liguliflorae due to the preference of the European dandelion (*Taraxacum officinale*) for clay soils in contrast to the only native species producing this distinctive pollen type which are restricted to dune sands (*Sonchus meglocarpus*) or higher elevations (*Microseris lanceolata*). A fourth possible but unlikely source of the same pollen type is introduced Endive (*Chicorium*).

Representivity

Different plants differ markedly in the amount of pollen (angiosperms, gymnosperms) or spores (ferns, fern allies, liverworts mosses, fungi and algae) they produce and the distance these are dispersed into the surrounding landscape by wind, water or animals (including humans).

Studies of the modern pollen rain in Australia have confirmed that the overwhelming majority of sclerophyll shrubs, herbs and cryptogams (ferns, fern allies, liverworts, mosses) in the Sydney flora are severely *under-represented.* That is, their pollen or spores are never found in large numbers unless the source(s) grew on, or upstream of the site. In an archaeological context, it is always possible that the source plants were carried onto archaeological sites. Examples are discarded cut flowers and (if flowering) branches used as kindling or (casuarina) in the manufacture of shingles for roofing.

A small number of genera are *well-* or *over-represented* in that they produce abundant amounts of pollen or spores and disperse these very widely into the surrounding landscape (long distance transport). In this instance it is difficult to determine whether low to moderate numbers of their fossil pollen or spores represent a few local plants or more extensive stands growing at a greater distance from the site unless other evidence for a local origin is present. The latter might include leaves, anthers or clumps of immature pollen. The class includes wind-pollinated trees such as the River- and Swamp-oaks and their shrub relatives (*Allocasuarina/Casuarina*) and the northern hemisphere pines (*Pinus*) and firs (*Abies*). A few insect-pollinated native trees such as eucalypts (*Eucalyptus*) are also well-represented due to their dominance of forests around Sydney. Shrubs, herbs and ferns falling into the same category include the Broom-heath (*Monotoca*), Native Hops (*Dodonaea*), raspwort (*Gonocarpus*), most species within the saltbush and grass families, and two tree ferns (*Cyathea, Dicksonia*).

Extreme cases of long distance pollen transport include *Nothofagus moorei* (sourced from cool temperate rainforest on the New England Plateau) and Gyrostemonaceae, sourced from semi-arid shrublands west of the Blue Mountains). Conversely many wind-pollinated herbs disperse relatively little pollen, e.g. sedges (Cyperaceae) and wire-rushes (Restionaceae).

The representivity of many of the native plants in the Sydney flora and elsewhere has been established by a program of pollen-trapping and analysis of surface samples.[22-23] Many of the 'agricultural weed' taxa denoting an European presence in Australia are the same used to detect Neolithic agriculture in North-West Europe and a sizeable body of literature exists on the morphology and dispersal of their pollen.[24] Important conclusion are (a) that cereal species and associated low-growing weeds produce and/or disperse relatively few pollen grains, and (b) cereal pollen are mostly dispersed by cutting and transportation of sheaves, not by wind dispersal from standing crops.[25-26] O'Rourke and Lebowitz have concluded that much of the pollen accumulating within houses (up to 5.5 million grains/g house dust) in Arizona was carried in on the feet and bodies of people and pets.[27]

No similar studies exist in Australia and those exotic plants which disperse pollen in large amounts have had to be identified empirically. Introduced species and genera that appear to be well-represented include northern hemisphere pines, European dandelions (Liguliflorae), docks (*Rumex*), and Wire-weed (*Polygonum aviculare*). Cereal pollen values seldom exceed 2 percent except in cesspit samples.

Depositional environment

In contrast to twentieth-century buildings whose basement floors and foundations extend deep into bedrock, many nineteenth-century constructions tended to be built on sites that had been levelled by infilling.[28] This infill entombed the pre-existing landscape and any associated cultural deposits. An example is the 1850s landscape preserved *in situ* under sandstone rubble used to level the Phillip Street Water Police Court on eastern Circular Quay.[29] Equally importantly, water leaking from old sewer or storm water drains appears to create ideal (water-logged) conditions for the long-term preservation of plant microfossils, which in turn reflect local environments and hint at social attitudes prevailing when the source plants were alive.

Fossil palynofloras preserved on such sites are an amalgam of pollen and spores shed from plants growing on/around that site (local pollen influx) and pollen and spores from well-represented plants growing further away from the site (extra-local to regional pollen influx). The relative proportions of each 'class' depended on the extent to which the local pollen influx dilutes the regional pollen rain, i.e. whether the local vegetation is dominated by species which produce/disperse abundant pollen or spores.

In the case of under-represented species, even trace occurrences of their pollen or spores are good evidence that the source plant(s) grew locally. The absence of the same pollen or spore types is *not* reliable evidence that the source plant(s) did not grow elsewhere in the vicinity. For well-represented species, it can be difficult to distinguish between a few individuals growing locally and dominance of the regional vegetation by the same plant(s). An extreme case is that of devegetated sites since these continue to accumulate miospores from the regional pollen rain, in particular of well-represented plants such as *Allocasuarina/Casuarina*. This in turn may give the misleading impression that trees once surrounded the site.

Soil – a special depositional environment

Many samples submitted for palynological analysis come from soil profiles or from deposits which have been subjected to pedogenic processes since burial.[30]

Although the more organic-rich horizons are a suitable medium for the long-term preservation of plant microfossils, soils *per se* present a number of problems not found in wholly waterlogged or desiccated deposits. These include the possible movement of fossil pollen, spores and phytoliths within the soil profile and the related difficulty of determining the age of the assemblages at each level:

1. Most miospores, charcoal particles and phytoliths are sufficiently small (c. 8-100 μ) to be translocated downwards into the soil profile (illuviation and/or fluid transportation in pores). Burrowing animals such as worms may bring older material to the surface or take younger material down the profile. Both processes (bioturbation) can result in mixed age assemblages.

2. Because of differences in chemistry and surface areas, soil organic matter (including miospores) differ markedly in their resistance to physical attrition or chemical dissolution. Partial or complete destruction of the more fragile types results in fossil assemblages being dominated by robust pollen types, such as *Allocasuarina/Casuarina*, *Eucalyptus* and *Pinus* which can be easily identified even when badly corroded or crumpled.

For these reasons, the soils that are likely to be most informative in archaeopalynology are those which come from under impervious material such as clay, stone flags or brick paving, and, equally important to avoid contamination by modern pollen and spores, which were sampled when first exposed by excavation.

Age control

Documentary evidence supported by material artefacts provides a broad time framework for dating and correlating the palynological evidence. Conversely, because exotic plants were introduced sequentially into the Sydney region, their pollen and spores potentially provide a broad-brush method of dating the associated archaeological features. In practice relatively few taxa have been found to be useful as chronostratigraphic evidence[31] because (a) many commonly occurring taxa were established as early as 1788,[32-33] (b) the date of introduction is unknown, or (c) the pollen types are

Table 1a: Archaeological Sites, Sydney City

LOCALITY	ARCHAEOLOGICAL CONTEXT	APPROX. AGE RANGE	SAMPLE TYPE	NO. OF SAMPLES	REFERENCE
ANGEL PLACE	1. Floodplain bordering Tank Stream	before 1788	soil	1	Macphail 1997a
	2. Buried top soil along Tank Steam	1788-1830s	soil	4	Macphail 1997b
	3. Oviform drain over Tank Stream	1860s	silt	2	Macphail 1998a
CAMPBELL & PITT STREETS	1. Post-packing	before 1830	soil	1	Macphail 1997c
	2. Filled-in well	late 19th. c.	silt	2	
	3. Disturbed soil profile	late 19th. c.	soil	1	
G.J. COLES SITE 400 GEORGE ST.	1. Remnant soil?, upper Tank Stream	before 1788	sapropel	1	Macphail 1996b
CUMBERLAND/ GLOUCESTER ST, THE ROCKS	1. Remnant top soil	before 1810	soil	1	Macphail 1995
	2. Yard	before 1820	soil	2	
	3. Filled in ditch	1810-1820	soil	1	
	3. Yard	1820-1830	silt	2	
	4. Filled-in well	1820-1830, 1850s	silt	3	
	5. Bakery yard	1840-1860	soil	1	
	6. Cesspit	after 1865	soil	1	
	7. Terrace sub-floor deposit	1880-1890	soil	1	
FAMILY COURT, SITE, GOULBURN & CASTLEREAGH ST.	1. Soil profile (NW corner of site)	early 1800s?	soil	6	Macphail 1990b
	2. Soil profile (SW corner of site)	early 1800s?	soil	6	
	3. Cesspit	1830s	soil	2	
	4. Soil below brick pavement	1830s	soil	1	
	5. Filled-in well	1840s	organic mud	1	
SYDNEY G.P.O. SITE	1. Palaeochannel of Tank Stream	Late Pleistocene	silts & clays	20	Macphail 1996a
	2. Slope deposit	Late Pleistocene	charcoal loam	2	Macphail 1998b
	3. Cobble yard	before 1880	silt	7	Macphail 1998c
HAYMARKET SITE (PADDY'S MARKET)	1. Remnant top soil	before 1780s?	soil	1	Macphail 1991
	2. Leveling & fill material	before 1860s	soil	4	
	3. Yard	1840-1860	soil	2	
	4. Terrace sub-floor deposit	after 1860	soil	6	
	5. Occupation deposits	1860-1910	soil	2	
	6. Demolition rubble	after 1860	silt	1	
	7. Wood dump	1880-1890	peat	1	
	8. Infill in pipe trench	after 1890?	soil	1	
MILLERS POINT	1. Cultivated soil under terrace house 155 Kent St.	before 1840	soil	1	Macphail 1997e
	2. Soil infilling rock crevice, under house, Merriman St.	before 1830	soil	2	Macphail 1994b
MACQUARIE PLACE	1. Backfill in foundation trench	before 1810	soil	7	Macphail 1989
	2. Mud mortar	before 1810	mud mortar	1	
PHILLIP ST. WATER POLICE COURT	1. Top soil buried under rock infill	before 1851	soil	12	Macphail 1987

Table 1b: Archaeological Sites, Sydney Suburbs (inner suburbs)

LOCALITY	ARCHAEOLOGICAL CONTEXT	APPROX. AGE RANGE	SAMPLE TYPE	NO. OF SAMPLES	REFERENCE
BROADWAY GRACE BROS. SITE	1. Tannery	before 1885	soil	2	Macphail 1996d
CHIPPENDALE 2-18 LEVY ST	1. Artificial pond	1846-1877	soil & silts	5	Macphail 1997f
DICKSON'S MILL LITTLE PIER ST, DARLING HARBOUR	1. Below flaggings, flour mill	before 1813?	soil	1	Macphail 1992
	2. Reclamation fill	before 1813?	silt	1	
	3. Rubbish dump, flour mill	before 1842	soil	1	
	4. Saw-mill yard	before 1842	soil	1	
	5. Vacant allotment	before 1885	soil	1	
	6. Foreshore muds	< 1813-1900	mud	10	
PYRMONT CSR SITE	1. Terrace (sub-floor of ?parlour)	after 1860	soil	2	Macphail 1997i
	2. Terrace (sub-floor of kitchen)	after 1860	soil	2	
RANDWICK CHILDREN'S ASYLUM	1. Child's grave	1863-1891	silt	1	Macphail 1997h
SURRY HILLS 20 ALBION ST	1. Brick Kiln	1830s	soot	2	Macphail 1997c
	2. Rubbish pit at rear of tenement	after 1850	soil	1	
SURRY HILLS 188 GOULBURN ST	1. Yard at rear of terrace	early 1800s?	Remnant Top soil	1	Macphail 1997g
SURRY HILLS 130-132 PELICAN ST	1. Rear yard of terrace house	late 1800s	soil	2	Macphail 1997g
SURRY HILLS 20 POPLAR ST	1. Abandoned terrace house	1920s?	soil	1	Macphail 1997
ULTIMO MARY-ANN ST.	1. Colonial Estate (early occupation)	before 1860?	soil	4	Macphail 1994
	2. Colonial Estate (late vacant phase)	1860-1880	soil	5	

seldom if ever found in cultural deposits.

Nevertheless in some archaeological contexts, e.g. buried soil material, the presence of exotic pollen types can be the only evidence for distinguishing sediments which have accumulated since European settlement. Of particular value are the exotic pollen types that are transported long distance by wind, e.g. *Pinus*, or 'weed' species which have become widely naturalised because of their ability to colonise waste ground and exposed mineral soils and out-compete native species on sites fertilised by ash and other rubbish. Examples include the European dandelions, docks and plantains (*Plantago coronopus*, *P. lanceolata*), and unidentified cereal types (Poaceae > 50μ diameter).

PALYNOLOGICAL DATABASE

Historical sites and archaeological contexts for which some palynological data are available are presented in Table 1. The majority are located either in the Sydney Central Business District between Circular Quay and Central Railway (Table 1a) or surrounding inner suburbs such as Glebe, Pyrmont, Surry Hills and Ultimo (Table 1b). A smaller group is clustered around the equally early settlements of Parramatta and Richmond on the Cumberland Plain west of the CBD (Fig. 1).

In most instances the fossiliferous sediments are organic loams within, or surrounding, the foundations of colonial period buildings which range in age from the 1790s to the 1920s, and in social status from convict huts to the G.P.O., the 'heart' of colonial Sydney. In many cases the cultural deposit may be no more than dust which has filtered through into the sub-floor cavity or rubbish accumulating in back yards. Less commonly found contexts include grave-fill, mud used as mortar in brick walls and sediment infilling cesspits, rubbish pits, drains, wells and ponds.

Pollen preserved in the lower (A_2, B) horizons of soils are an unreliable guide to the colonial period vegetation since what little pollen are preserved almost certainly have been translocated downwards from the surface over time. Similarly bioturbation, whether by tillage or burrowing animals such as worms, appears to accentuate the oxidation of the soil organic matter content, including the fossil pollen and spore content. Pollen and spores preserved in garden contexts almost always represent plants colonising the site following its abandonment as a garden or field. Soils used as post-packing or accumulating below the drip-line of roofs are often characterised by frequent liverwort spores.[34-36]

Arguably the most culturally informative deposits analysed to date are stratified deposits infilling cesspits, wells and ponds since the sediments can preserve a continuous record of horticultural and ornamental plants over time. One of the two fossil pollen records of the garden pea (*Pisum sativum*) in an archaeological deposit comes from a pond at Chippendale[37] and the most detailed fossil record of an orchard species, the lemon (*Citrus limon*), comes from an 1840s waterhole at Parramatta.[38] Reinforcing the wider scientific value of such sites are spores preserved in an 1830-1880s waterhole at Richmond which demonstrate that a rare aquatic plant (*Isoetes drummondii*) formerly extended north of its present limits on the Southern Highlands.[39]

Table 1c: Archaeological Sites, Sydney (Parramatta-Richmond districts)

LOCALITY	ARCHAEOLOGICAL CONTEXT	APPROX. AGE RANGE	SAMPLE TYPE	NO. OF SAMPLES	REFERENCE
AIRD ST, PARRAMATTA	1. Town allotment (commencement)	1810 to 1836	post packing	9	Macphail 1993
	2. Town allotment (early occupation)	1836 to 1858	dam infill	4	
	3. Town allotment (late occupation)	after 1858	garden soil	4	
41-53 GEORGE ST, PARRAMATTA	1. Convict huts	1790s	post packing	2	Macphail 1997d
	2. Repairs to convict huts	Pre-1823	post packing	3	
	3. Buried soil	1830-1840	top soil	1	
PROSPECT COUNTY COUNCIL CAR PARK, SMITH & GEORGE STS, PARRAMATTA	1. Convict huts	1790-1820	Post-packing	6	Macphail 1989
	2. Buried soil beside bottle dump	after 1829	Alluvium	8	
	3. Buried soil profile along channel	before 1840	cultivated soils	8	
RICHMOND	1. Artificial water-hole	<1842-1890s	silts and clays	11	Macphail 1996c

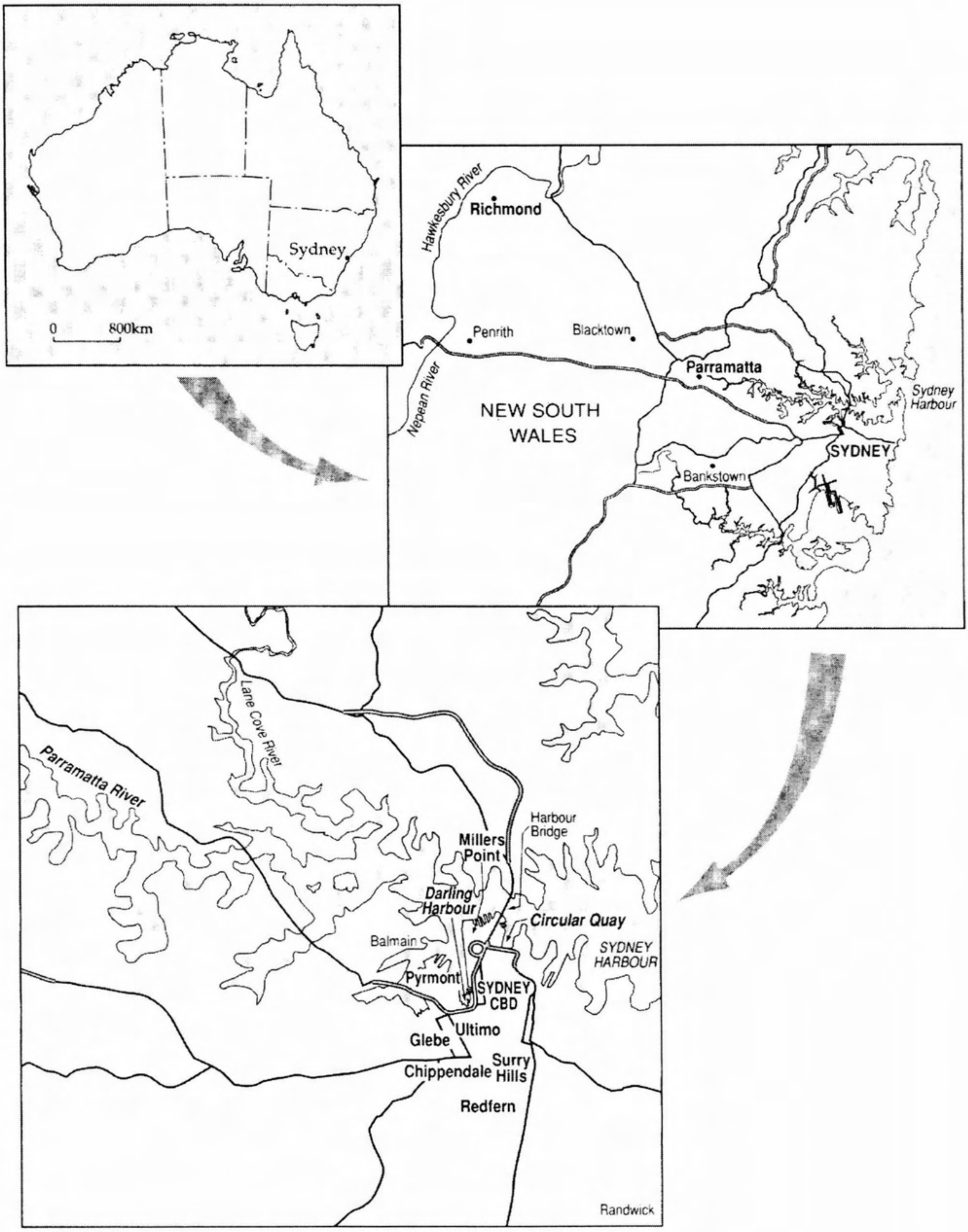

Fig. 1: Locality map of Cumberland Plain with Sydney City inset.

Table 2a: Definite exotic taxa

TAXON	COMMON NAME(S)	SHOWY FLOWERS?	REPRESENTATION ON ARCH. SITES
trees & shrubs			
Abies-type	Fir	no	rare
Arecaceae	Palms	yes	rare
Anacardiaceae cf *Schinus*	Pepper-tree	no	rare
Archontophoenix-type	Bangalow Palm	yes	rare
Cassinia aculeata-type	Chinese-bush	no	rare
Chaenomeles-type	Japonica	yes	rare
Citrus limon-type	Lemon	no	rare
Fragaria-type	Strawberry	no	rare
Ipomoea-type	Morning Glory	yes	rare
Lauraceae cf *Connamomum*	Cf. Camphor Laurel	no	rare
Ligustrum	Privet	yes	rare
Lycopodium cernum-type	(tropical) Club-moss	no	rare
Merremia-type	Convolvulus	yes	rare
Pandorea pandoreana	Potato Vine	no	rare
Papaver	Poppy	yes	rare
Pinus	Radiata Pine, Pine	no	frequent
Prunus	includes Almond, Cherry, Plum	yes	rare
Telopea	Waratah	Yes	rare
herbs			
Cannibis sativa	Cannibis	no	rare
Liguliflorae	Dandelion	yes	frequent
Lilium regale-type	Regal Lily	yes	rare
Medicago	Medic	no	rare
Phaesolus sativum	Garden Bean	yes	rare
Pisum sativum	Garden Pean	yes	rare
Poaceae (>> 50 μ diameter)	Cereal-grasses	no	uncommon
Polygonum aviculare	Wire-weed	no	uncommon
Rubus-type	Blackberry, Bramble	yes	rare
Silene	Silene	no	rare
Trifolium	Clover	no	rare
Verbena bonariensis	Purple Top	no	rare

Table 2b: Probable exotic taxa (includes native species introduced into Sydney)

TAXON	COMMON NAME(S)	SHOWY FLOWERS?	REPRESENTATION ON ARCH. SITES
trees & shrubs			
Araucaria	Hoop Pine, Norfolk Pine	no	rare
Austrobuxus	Sea-box	no	rare
Celtis	Celtis	no	rare
Cupressaceae	Cypress, Macrocarpa, Port Jackson Pine	no	rare
Gyrostemonaceae	none known	no	rare
Helicia-type	(unidentified Proteaceae)	?	rare
Malvaceae	Mallow family	yes	rare
Nothofagus moorei	Antarctic Beech	no	rare
Podocarpus	(pine)	no	rare
herbs			
Apiaceae	Umbellifers (includes edible spp.)	yes	rare
Brassicaceae	Cruficers (includes edible spp)	no	frequent
Chenopodiaceae	Salt-bush, Amaranth (incl. edible spp.)	no	common
Elodea/Lemna	(water plants)	no	rare
Euphorbia peplus-type	Milk-weed	no	rare
Geranium	Geranium	yes	rare
Pelargonium	Pelargonium	yes	rare
Poaceae (< 50 μ diameter)	Grass (includes lawn and pasture spp.)	no	common
Polygonum persicaria-type	Knotweeds	no	rare
Ranunculus	Butter-cup	yes	rare
Rumex	Dock	no	uncommon
Stellaria	Chickweed, Starwort	no	rare
Tubuliflorae (high spine type)	Daisies, Daisy-bush (includes Thistles)	yes	rare
ferns & fern allies			
Cyathea	Rough Tree-fern	(foliage)	rare
Dicksonia	Smooth Tree-fern	(foliage)	rare
Isoetes drummondii	Quillwort	-	rare
Pteridium	Bracken, Common Bracken	-	rare
Pteris	Jungle Brake, Tender Brake	(foliage)	rare

DIVERSITY AND DOMINANCE

Some 135 distinctive pollen and spore types (miospores) have been recorded to date in historical archaeological sites in the Sydney region (Table 2a-c).

The overwhelming majority (Table 2c) represent native plants that were widespread to common in the Sydney flora and which range in stature from potentially tall trees such as eucalypts (*Eucalyptus*) and River-oak (*Casuarina*) to mosses and single-celled algae.[40] Because organic deposits tend to accumulate in shaded or moist areas, many palynofloras also include low to significant numbers of spores produced by ferns and fern allies. Many native trees, shrubs and ferns possess 'showy' flowers and/or foliage and have been used for decorative purposes since the early colonial period.

On present indications, both historic and prehistoric palynofloras will be dominated by the same small group of pollen types: *Allocasuarina-Casuarina* (Casuarinaceae), eucalypts and related Myrtaceae belonging to the *Angophora-Eucalyptus gummifera*-type (Bloodwood) group, and 'native' Poaceae, usually with significant (>1-5%) numbers of *Gonocarpus* pollen and an unidentified trilete spore.

Pollen and spore types that represent known (= definite) or suspected (= probable) exotic taxa are usually much less frequent and some have been recorded only on one to two site. Examples (Table 2a) include the highly distinctive pollen produced by the garden bean (*Phaesolus sativum*), garden pea (*Pisum sativum*), poppy (*Papaver* sp.) and Regal-lily (*Lilium regale*). A subgroup of the definite exotic class are non-local native plants which have been planted as garden ornamentals, e.g. Hoop and Norfolk Pines (*Araucaria* spp.), and tree-ferns (*Cyathea*, *Dicksonia*). For example, early colonial sketches show a Norfolk Pine (*Araucaria heterophylla*) and tree ferns growing in the grounds of First Government House before 1802 and 1828 respectively.[41]

The most widespread example of the probable exotic class are the Chenopodiaceae (and its close relatives the Amaranthaceae), native and introduced species of which occupy similar habitats such as waste ground. At some sites, e.g. the Prospect County Council Site, at the corner of Smith and George Streets, Parramatta, it is possible that the chenopod count represents the edible Fat Hen (*Chenopodium album*).[42] Similarly the Brassicaceae count at this site may represent edible species such as the turnip (*Brassica campestris*) or mustards (*B. hirta*, *B. juncea*) since the fossil palynofloras include a specimen of garden bean (*Phaesolus sativum*).

Table 2c: Native trees & shrubs (common names after Fairley & Moore 1995)

TAXON	COMMON NAME(S)	SHOWY FLOWERS?	REPRESENTATION ON ARCH. SITES
Trees & shrubs			
Acacia baueri	(wattle)	yes	rare
Acacia spp.	Wattles	yes	uncommon
Allocasuarina/Casuarina	River-oak, Swamp-oak, She-oak	no	abundant
Amperea xiphoclada	Broom Spurge	no	rare
Banksia marginata-type	includes Silver Banksia	yes	rare
Banksia robur-type	includes Swamp Banksia	yes	rare
Banksia serrata-type	includes Old Man Banksia	yes	uncommon
Banksia spp.	Native Honey-suckles	yes	uncommon
Beyeria viscosa	Pinkwood	no	rare
Bursaria spinosa	Blackthorn, Boxthorn	No	rare
Callicoma	Black Wattle	yes	rare
Cissus-type	Native Grape, Water Vine	no	rare
Clematis	Old Man's beard	yes	rare
Conospermum tenuifolium	Smokebush	yes	rare
Dodonaea ericifolia-type	Native Hops	no	uncommon
Dodonaea triquetra-type	Native Hop	no	uncommon
Epacridaceae (T-types)	Native heath	some	rare
Eucalyptus/Angophora	Eucalypts, Native Apples	yes	abundant
Exocarpus	Native Cherry	(fruit)	rare
Fabaceae	Pea-flowers	yes	rare
Goodenia-type	Goodenia	yes	uncommon
Heritieria-type	Blackbean	yes	rare
Hibbertia	Guinea Flower	yes	rare
Leptospermoidae	includes Bottle-brush, Ti-tree	yes	uncommon
Leptospermum	Ti-tree	yes	rare
Lomatia	Crinkle Bush	yes	rare
Loranthaceae	Mistletoe	no	rare
Melaleuca-type	Paper-barks and some Bottle-brushes	yes	uncommon
Micrantheum	(Micrantheum)	yes	rare
Monotoca	Broom-heath	no	common
Muehlenbeckia	Lignum	no	rare
Myrtaceae	includes Lily-pilly, Myrtle, Water-gums	yes	uncommon
Persoonia juniperina-type	Geebung	yes	uncommon
Petrophile	Conesticks	yes	rare
Pimelea	Rice-flowers	yes	uncommon
Polygalaceae	Matchheads/Milkworts	yes	rare
Ricinocarpos	Wedding Bush	yes	rare
Rutaceae	includes Boronias	yes	rare
Sprengelia incanata-type	Pink Swamp Heath	no	uncommon
Symphionema paludosa	Swamp Symphionema	yes	rare
Villarsia exalta	Yellow Marsh Flower	yes	rare
Xanthorrhoea	Black-boys	yes	rare
Xylomelum pyriforme	Woody Pear	yes	rare

Table 2c (cont.): Native herbs, fern, fern allies, liverworts and mosses

TAXON	COMMON NAME(S)	SHOWY FLOWERS?	REPRESENTATION ON ARCH. SITES
Herbs			
Arthropodium-type	Pale Vanilla Lily	yes	rare
Baumea	Twig-rush	no	rare
Brassicaceae	Crucifers	some	frequent
Burchardia-type	Milkmaids	yes	rare
Caryophyllaceae	Caryophs	(some)	rare
Cyperaceae	Sedges	no	frequent
Drosera	Sundews	no	rare
Galium	Bed-straw	no	rare
Gonocarpus	Raspworts	no	common
Liliaceae	Lillies	(some)	uncommon
Nertera	(nertera)	no	rare
Opercularia-type	Stickweed	no	rare
Orchidaceae	Orchids	yes	rare
Plantago	Native Plantain	no	rare
Potamogeton	(water weed)	no	rare
Restionaceae	Cord Rushes, Wire-rushes	no	uncommon
Typha	Bull-rush	yes	rare
Ferns and fern allies			
Calochlaena	Rainbow Fern	(foliage)	frequent
Davallia-typ	Hare's Foot Fern	(foliage)	rare
Gleicheniaceae	Coral Fern, Divaricating Fern	(foliage)	frequent
Grammitis	Finger Fern	-	rare
Histeopteris incisa	Bat's-wing Fern	(foliage)	rare
Lycopodium deuterodensum	Bushy Club-moss	(foliage)	rare
Lycopodium laterale	Slender Club-moss	(foliage)	rare
Microsorium	Fragrant Fern, Kangaroo Fern	(foliage)	rare
Selaginella uliginosa	Swamp Selaginella	-	uncommon
Schizaea-type	Comb Fern	-	rare
Sphagnum	Sphagnum-moss	-	rare
Unidentified monolete types	includes the Fish-bone ferns	(foliage)	rare
Unidentified trilete types	includes most filmy ferns	(foliage)	common
Liverworts & mosses			
Cingulatisporites bifurcatus	Liverwort (Anthocerotae)	-	uncommon
Rudolphisporis rudolphi	Liverwort (Ricciaceae)	-	rare
Algae			
Botryococcus	(green alga found in brackish water)	-	uncommon
Operculodinium	(marine alga)	-	rare
Pediastrum	(green alga found in freshwater)	-	rare
Spiniferites	(marine alga)	-	rare
Zygnemales	(soil algae)	-	frequent

CASE STUDIES

Five case studies illustrating the value of archaeopalynology in a range of historical contexts are summarised below. With the exception of the Phillip Street Water Police Court site and Cumberland/Gloucester Street site, the Rocks, to date none of the data have been formally published elsewhere.[43-44]

With rare exceptions, only 1-2 samples from the one archaeological context on a given site were made available for pollen analysis. Full site and other details are available from the excavation authorities or author. Relative pollen abundance values in Tables 3-6 and Figure 4 are expressed as a percentage of the total identifiable spore and pollen count, with values less than 1 percent (trace) given as +. An asterisk indicates definite exotic taxa (*). Taxa that are likely to include both native and exotic species, or which are unlikely to have been part of the pre-European flora in the inner Sydney district (probable exotics) because of their modern distribution are indicated by a hash (#).[45]

A selection of the more distinctive pollen and spore types is illustrated in Plates 4-6. Benson and Howell's reconstruction of the likely pattern of the vegetation occupying Sydney city in 1788 (Fig. 3) and other localities in the greater Sydney metropolitan area provide a benchmark for assessing changes associated with European settlement.[46]

Millers Point

Redevelopment of the Rocks has exposed the remains of a number of small houses built between 1820 and 1850 (Fig. 2). Two sites which provide evidence of cultivation and the survival of native species on the eastern side of Darling Harbour into the early to middle colonial period, occur at 30 Merriman Street and 155 Kent Street, Millers Point.[47-48] At the former site, soil preserved in bedrock crevices below the foundations of an 1820s timber cottage was suspected to preserve evidence of flour-milling activity on Millers Point.[49-50] The Kent Street site preserved evidence of tillage in the form of hoe marks in a soil buried in the small rear yard of a nineteenth-century terrace house built after c. 1840.[51]

Topographic and archaeological setting

Both sites are located on the northwest-facing slope of the sandstone ridge separating Darling Harbour and Sydney Cove. The ridge (Observatory Hill) and foreshore (Millers Point) have been extensively modified for residential and industrial purposes since the early nineteenth century but, originally, would have been a series of structural benches eroded into horizontally bedded Hawkesbury Sandstone. This geology is characterised by small springs, leading to the accumulation of organic soils around areas of saturated soil and seepages.

Plant communities in similar environments elsewhere in Sydney indicate that the pre-European settlement vegetation

was dry sclerophyll woodland dominated by eucalypts (*Eucalyptus pilularis*, *E. gummifera*, *E. piperita*) and a Native Apple (*Angophora costata*).[52] This type of woodland is relatively open and usually is characterised by a grassy understorey. Moist rock surfaces and soaks will have supported fernland and drought-intolerant herbs.

Sketches from Observatory Hill by J. S. Prout and J. Rae published in 1842 illustrate the complexity of the cultural landscape in the early 1840s.[53] Amongst the more significant features depicted are: (a) substantial areas of unfenced and fenced open ground used as rough pasture for grazing livestock, including goats, on and below Observatory Hill; and (b) rows of small conjoined cottages, built c. 1820 along the major thoroughfares, interspersed with more substantial buildings including warehouses and taverns. Since the area included docks (a berthed ship is illustrated) it is reasonable to presume horses were stabled on Millers Point. Local milling of grain however had ceased and a windmill built c. 1802 on the Point was in ruins.[54]

Results (Table 3)

The three samples analysed yielded moderate numbers of well-preserved pollen and spores in a matrix of humified organic matter and finely dispersed charcoal particles. The presence of definite exotic types including *Pinus* (Merriman Street) and a cereal confirm that both soils post-date European settlement. Four distinct groups of plants representing different habitats are present.

The first group consists of well-represented plants which disperse large amounts of pollen over long distances, making it difficult to determine whether moderate pollen values reflect a few specimens growing near the site or rather larger but distant stands. Examples are *Eucalyptus* (up to 45%) and *Allocasuarina/Casuarina* (up to 22%), native Poaceae (up to 17%) and *Gonocarpus* (up to 5%). Only two species of the last genus occur in Sydney: G. *teucrioides*, which is found in open forest, scrub and heath, and *G. micranthus*, which is common on wet ground. Pollen of well-represented shrubs species such as *Monotoca* and *Dodonaea* may come from distant sources (Kent Street) or represent descendants of the pre-European heath vegetation (Merriman Street).

The eucalypt pollen count includes a high proportion of small/immature and aggregated grains indicating a local source. Since it is improbable tree-sized eucalypts survived on Observatory Hill or Millers Point in the 1840s, at least part of the count may have come from flowering branches used as firewood. The *Allocasuarina/Casuarina* count is more likely to reflect distant forest whilst *Gonocarpus* values are typical of local plants and imply damp conditions. Native Poaceae pollen are distinctly less common at Kent Street than Merriman Street (8% vs. 11-17%), consistent with the increasing urbanisation of Millers Point between 1820-1840.

The second group comprises ferns and fern allies whose spores are seldom dispersed far from the source plants except by running water (unlikely in this context). Records include *Histiopteris incisa*, a common pioneer species in burnt wet forests, and *Calochlaena dubia* which is able to grow on moist rocky outcrops (natural or created by quarrying). Both ferns, and *Selaginella uliginosa*, typically occupy wet soils/sites that are not subjected to frequent disturbance or trampling. The only

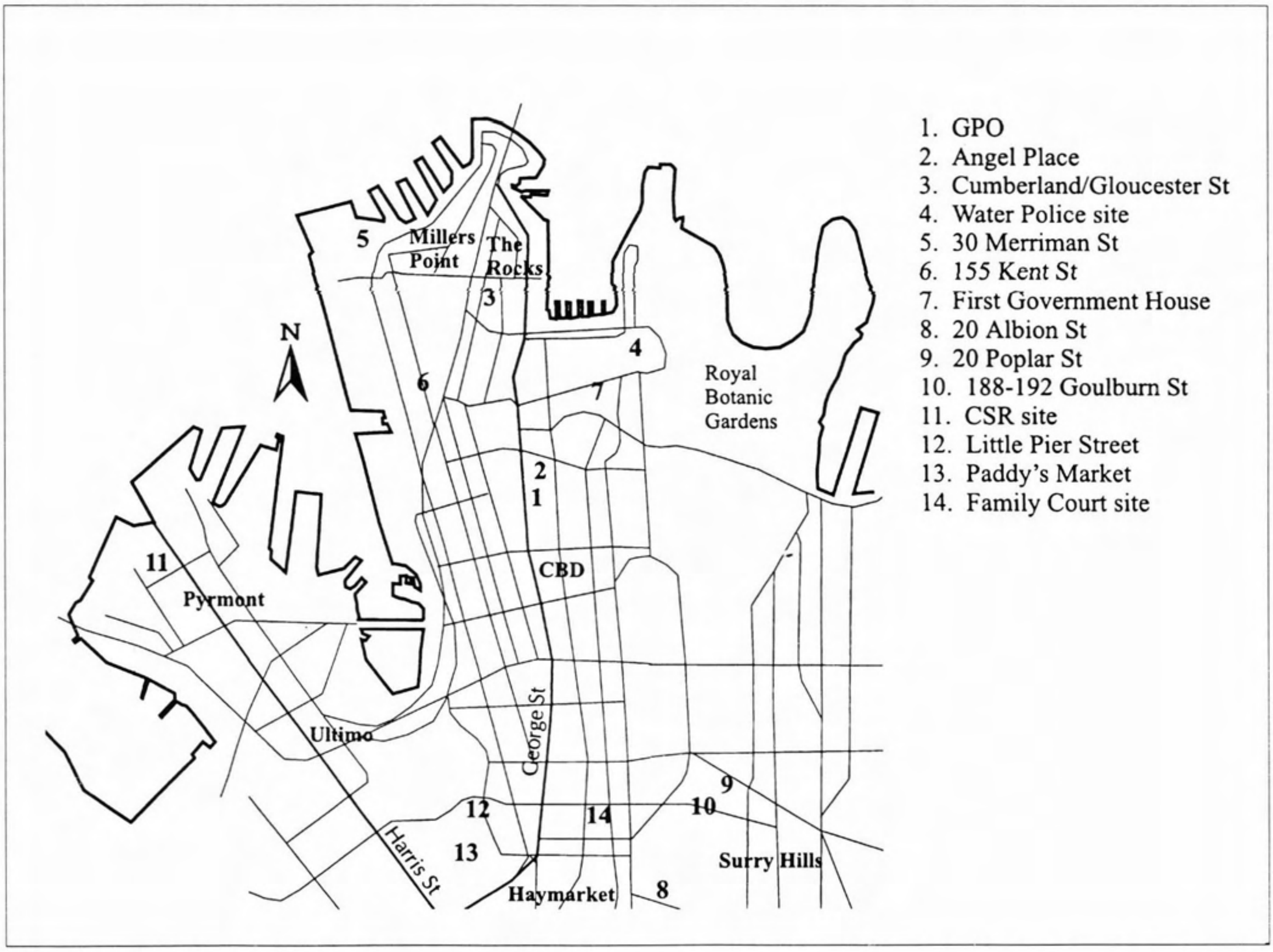

Fig. 2: Location map of Sydney City sites.

type common on both sites is an unidentified trilete ground fern (up to 13%) which may or may not represent a mesophytic species.

Significant numbers of *Histiopteris* (2%), *Calochlaena* (1%) and *Selaginella uliginosa* (1%) spores are unequivocal evidence that the cultivated soil at Kent Street was moist or that fern fronds had been used as a fertiliser. If the former, then source of the *Gonocarpus* pollen count almost certainly was locally growing *G. micranthus*. Sedges (1%) are equally typical of wet conditions.

The third group consists of definite and probable introduced herbs that are characteristic of open grassy areas. Pollen values demonstrate that at least one agricultural weed taxon was established on both sites, *viz*. Liguliflorae (up to 3%). The relatively high cereal pollen count at Merriman Street suggests that the soil remnant accumulated whilst the windmill on Millers Point was in operation. Conversely the lower count (1%) at Kent Street is more likely to represent naturalised plants. Self-sown cereals would be consistent with stabling of horses on Millers Point or the spillage of grain during transport.

Polygonum aviculare, represented by trace pollen values only at Kent Street, was growing in the Rocks district before 1810.[55] Other possible exotic weeds include Brassicaceae and Chenopodiaceae. Values as high as 4 percent (Merriman Street) almost certainly represents an introduced species growing on the site since the local geomorphology is against the development of saltmarsh along the foreshore. Chenopods and crucifers were to become widespread to common on waste ground in Sydney by the 1840s.

The fourth group, recorded only at Kent Street, consists of rare, usually crumpled grains that are likely to represent horticultural and ornamental species. The latter include an Anacardiaceae, possibly the Pepper-tree *Schinus molle* which has been widely planted as a street-tree due to its tolerance of drought and pollution. The former includes a Rosaceae pollen type which closely resembles *Fragaria* (Strawberry).

The combined pollen data point to the survival of some native shrub and herbs on Millers Point into mid colonial times as well as the widespread naturalisation of species associated with European agriculture. At Kent Street, the tilled soil appears to have been fertilised by domestic ash. However it is not clear whether the weed and fern community was established on the site before or after cultivation. If the former, then it is more likely that the hoe marks represent clearing of an overgrown area which was then cultivated (for strawberries?). If the latter, the fossil palynofloras mostly will represent weeds invading a former garden.

Dickson's Mill, Little Pier Street, Darling Harbour

Sometime before c. 1831, the first steam engine was imported into Sydney to replace aging windmills used to process the Colony's grain. Documentary evidence indicates this engine was housed in Dickson's Mill built on the southeastern shoreline of Darling Harbour (formerly Cockle Bay) although some uncertainty exists whether the stone building, the foundations of which were buried under Little Pier Street, was erected in 1813 or 1831 (Fig. 2).[56]

Techniques used to resolve this question included comparing fossil pollen and spores preserved in the Mill Complex after c. 1830 with palynofloras preserved in (a) the earliest phase of reclamation fill on the site (pre-1813?) and (b) estuarine mud deposited in front of the nineteenth-century sea wall over the same general period.[57] The latter were sampled using a drilling rig capable of extracting large (15 cm) diameter

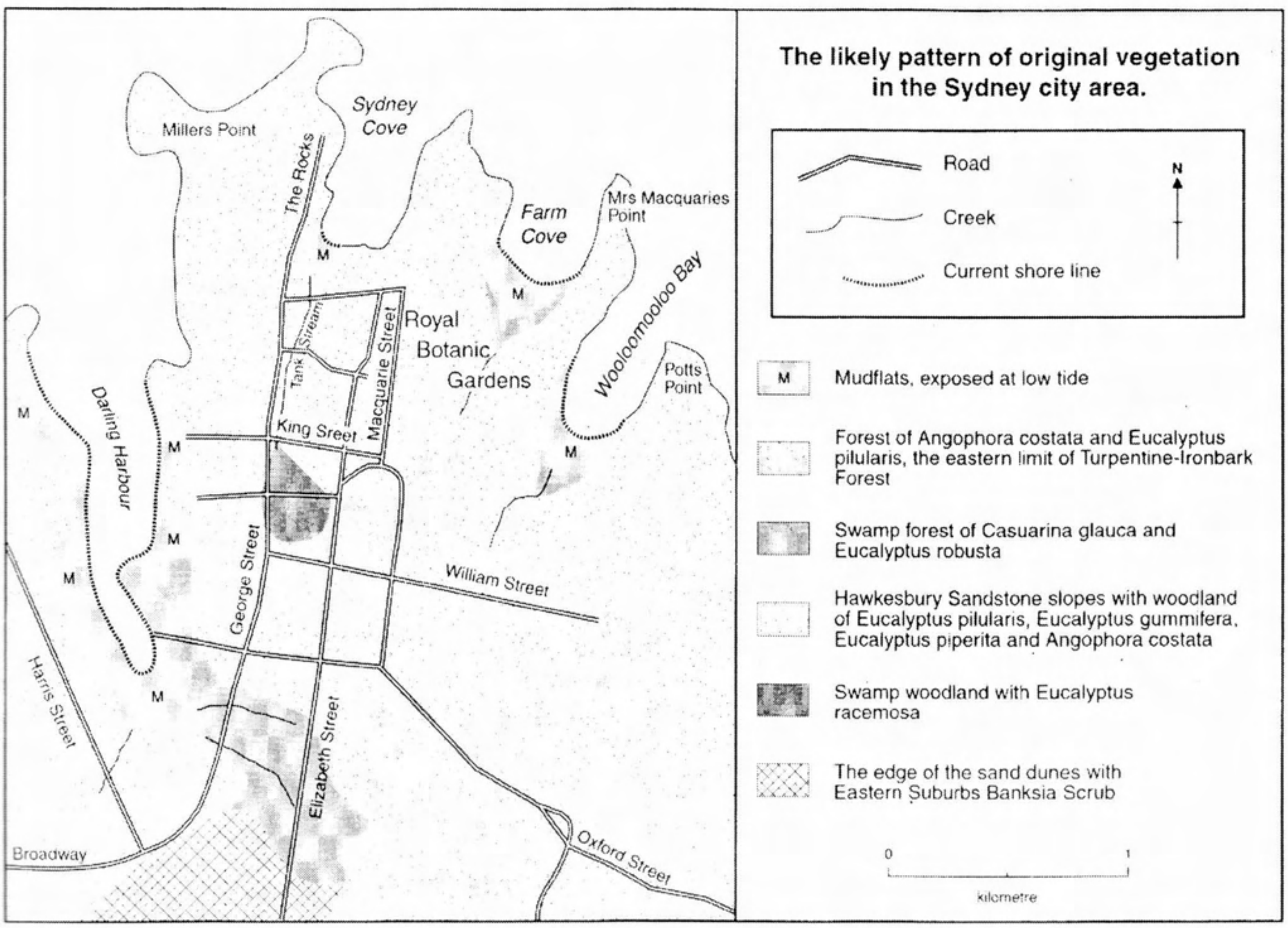

Fig. 3: The likely pattern of the pre-1788 vegetation in Sydney City (from Benson & Howell 1990).

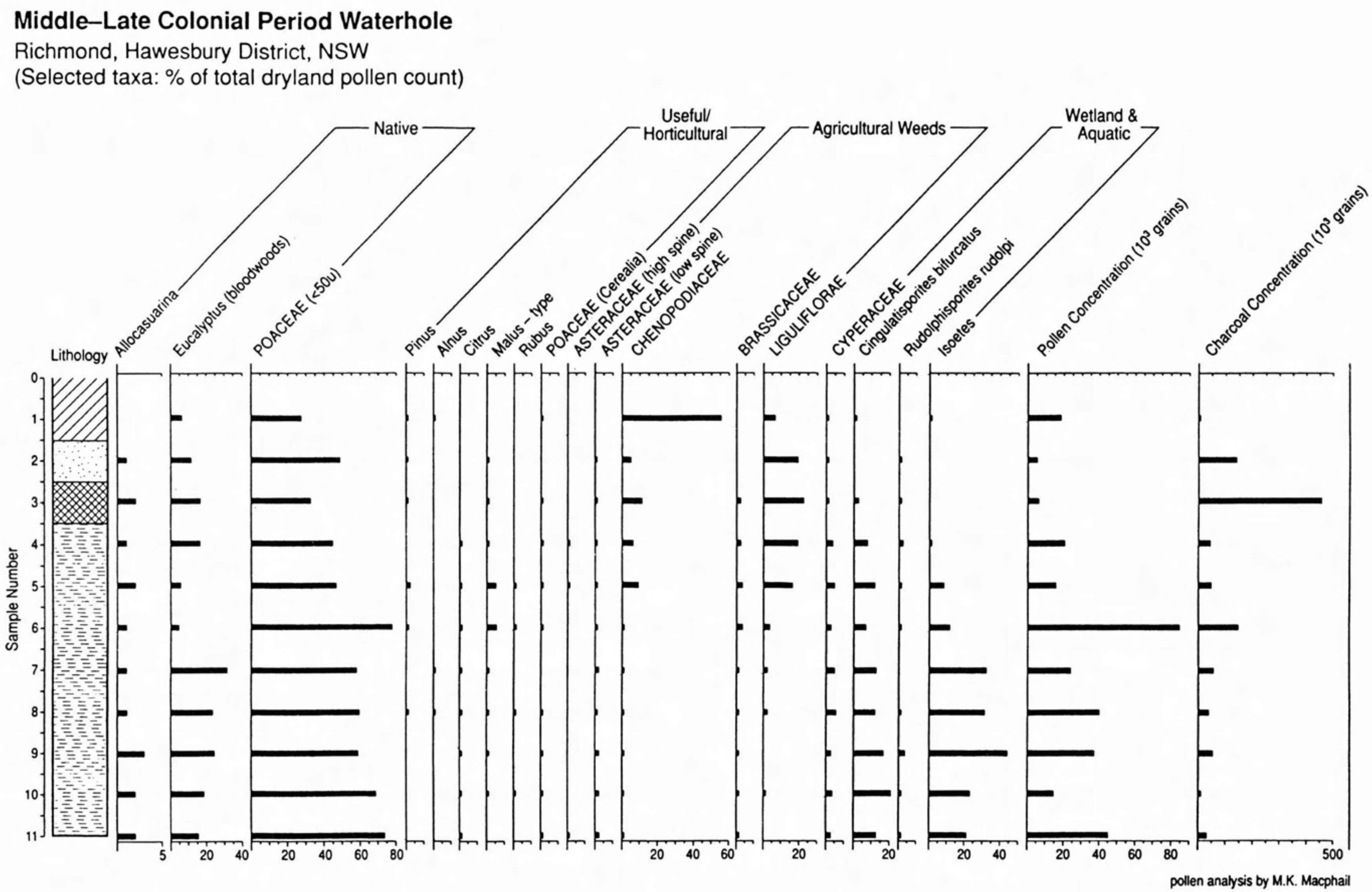

Fig. 4: Pollen diagram showing trends in the relative abundance of selected fossil spores and pollen, 1840s waterhole, Richmond.

Table 3: Relative abundance data, archaeological sites, Millers Point

TAXON	MERRIMAN ST.	KENT ST.
Trees & shrubs		
Allocasuarina/ Casuarina	6-22%	16%
Anacardiaceae cf. *Schinus#*	-	+
Banksia marginata-type	-	+
Banksia serrata-type	+	-
Dodonaea ericifolia-type	+	+
Dodonaea triquetra-type	+	+
Eucalyptus/Angophora	22-37%	45%
Helicia-type	-	+
Hibbertia	-	+
Leptospermum	+	+
Monotoca	12-13%	+
*Pinus**	+	-
Podocarpus#	+	-
Shrubs/herbs		
Asteraceae low spine	trace to 2%	+
Asteraceae high spine#	+	
Chenopodiaceae#	1-4%	+
Fabaceae #	-	+
Unidentified tricolpates#	-	+
Unidentified tricolporates#	-	2%
Herbs		
Brassicaceae#	+	+
Burchardia-type	+	+
Clematis	+	-
Cyperaceae	-	1%
Gonocarpus	1-2%	5
Liguliflorae#	+	3
Poaceae (cereals)*	trace to 4%	1%
Poaceae (native)	11-17%	8%
*Polygonum aviculare**	-	+
Rosaceae cf. *Fragaria**	-	
Tree-ferns and ferns		
Calochlaena	+	1%
Cyathea#	+	+
Davallia-Microsorium	+	+
Gleicheniaceae	-	+
Histiopteris	-	2%
Unidentified monoletes	-	+
Unidentified triletes	6-11%	13%
Fern Allies		
Selaginella uliginosa	+	1%
POLLEN SUM	273, 294	336

conventional cores. A key assumption, which is difficult to test using the available data, is that the estuarine muds have not been intensively bioturbated, i.e. European indicators such as cereal pollen are *in situ* as well as being sourced from the Mill.

Topographic and archaeological setting

Prior to European settlement, foreshore communities on Cockle Bay included *Casuarina glauca* (Swamp-oak) woodland and, less certain, mangrove communities dominated by *Avicennia maritima* woodland and Chenopodiaceae salt marsh. Sandstone slopes to the rear supported dry sclerophyll (*Eucalyptus*) forest with a grassy understorey.[58] A watercolour depicting the view across Darling Harbour c. 1819 shows fenced allotments, some with houses, lining the eastern foreshore. A felled tree is being cut up for firewood whilst sheep and cattle graze a grassy common traversed by a dirt road.[59] Pyrmont peninsula, which forms the western side of Darling Harbour, remained covered with woodland down to the foreshore.

A slightly later (1820) view shows an estuarine wetland fringing the head of Darling Harbour and a number of (indistinct) buildings at the approximate location of the Mill.[60] The archaeological sequence at Dicksons Mill reflects the reclamation of the foreshore in Cockle Bay and the succession of industrial purposes to which the Mill buildings have been put since the 1840s. These include the manufacture of soap and candles (1842-1868), galvanising (1868-1885) and warehousing (1886-1914). After standing vacant for 17 years the building was demolished in 1932.

Results (Table 4)

All samples yielded well-preserved pollen and spores in a matrix of humified organic matter and finely dispersed charcoal particles. Probable and definite exotic types include Brassicaceae, *Cassinia arcuata*-type (Chinese-bush), cereals, *Dicksonia*, Liguliflorae, Malvaceae (mallow family), *Medicago*, *Pinus*, *Rumex*, *Silene* and *Trifolium*. Saltwater indicators, including marine dinoflagellates, foraminifera and mangrove pollen (*Avicennia maritima*), confirm that the Mill complex was built on land reclaimed from Darling Harbour. The high diversity of native taxa (> 65 genera) indicate that much of the pollen was sourced from plant communities lining the head of Darling Harbour and streams draining the Brickfield (now Broadway-Haymarket) area.

The upward decline in *Allocasuarina/Casuarina* percentages in the estuarine core is linked with a marked increase in the native Poaceae count. Although *Eucalyptus* values show little change, both trends are likely to represent the progressive destruction of the local sclerophyll woodlands and forests when the larger early colonial estates at Glebe and Ultimo were subdivided for small holdings after c. 1830, then medium to high-density residential dwellings after c. 1850.[61] The apparent increase in *Avicennia* almost certainly reflects erosion following the subdivision, leading to an expansion of mudflats at the head of the Harbour. Mangrove populations appear to have collapsed (Samples 5-6) as estuarine habitat within Darling Harbour continued to degrade.[62]

If correct, then the sediment containing the earliest significant values of cereal pollen (Sample 8) will have been deposited well before c. 1830. The corollary is that the stone building housing the steam engine also was in existence by this time. A similar line of reasoning, based on the high *Allocasuarina/Casuarina* value in Sample 4, suggests that the earliest phase of reclamation was undertaken before 1830 or that the sediments used for the infill were of this general age. Significant values of cereal pollen in the highest sample of estuarine mud analysed (Sample 5) are suggested to have been derived from populations naturalised after c. 1830.

Numbers of cereal pollen recovered from red clay infilling joints in the stone floor of the engine room (Sample 3) are too sparse to correlate the deposit with milling of grain. The sample is presumed to reflect the period when the Mill was used for the manufacture of soap and candles. The marked increase in Chenopodiaceae pollen, associated with significant to high numbers of *Pinus* pollen (Sample 2) and *Polygonum aviculare* and an unidentified tricolporate type (Sample 1), suggest these soils accumulated during the late nineteenth-century period when the area had degenerated into slumland.

2-18 Levy Street, Chippendale

Sydney's inner suburbs are in the process of being refurbished for high-density housing, in particular larger blocks formerly

Table 4: Relative abundance of selected taxa, Dickson's Mill, Little Pier St., Darling Harbour

Archaeological Context	Mill Complex			Reclam.	Estuarine Core				
SAMPLE No.	1	2	3	4	5	6	7	8	9
Height above high water mark>	+1.99 m	+1.22 m	+1.20 m	+1.10 m	-0.33 m	-0.38 m	-0.48 m	-0.58 m	-0.68 m
Definite & probable # exotics									
Brassicaceae#	-	+	+	+	+	+	+	+	-
Caesalpinaceae	-	-	-	-	-	+	-	-	-
Cereals (Poaceae > 50 μ)	+	+	+	-	2%	+	+	2%	+
Cassinia arcuata-type	+	+	+	-	-	-		-	-
Chenopodiaceae#	5%	4%	1%	+	1%	1%	1%	1%	2%
Cupressaceae#	-	-	-	-	+	-	+	-	-
Cyathea#	-	+	+	-	+	-		+	+
Dicksonia#	-	-	-	-	-	-	+	-	-
Liguliflorae#	2%	2%	+	+	-	+	+	+	-
Malvaceae#	-	-	-	-	-	-	-	+	-
Medicago & *Trifolium* spp.	1%	+	+	-	4%	+	+	+	-
Pinus	+	1%	-	-	+	+	+	+	-
Plantago lanceolata-type	-	+	-	-	+	+	-	-	-
Polygonum aviculare	4%	+	+	-	+	+	-	+	-
Rumex#	-	+	-	-	+	-	+	-	-
Stellaria#	1%	-	-	-	+	-	-	-	-
Unidentified tricolporates#	53%	+	+	+	6%	1%	+	+	-
Native species									
Allocasuarina/Casuarina	2%	22%	39%	46%	27%	28%	39%	50%	55%
Amperea xiphoclada	-	-	2%	-	-	1%	+	+	+
Asteraceae low spine	5%	4%	+	+	2%	2%	2%	2%	2%
Cyperaceae	+	2%	1%	4%	+	2%	1%	+	+
Eucalyptus	6%	9%	8%	38%	12%	15%	12%	18%	15%
Gonocarpus	-	3%	4%	2%	2%	1%	3%	2%	4%
Monotoca	-	-	+	-	+	1%	+	+	+
Poaceae (< 50 μ)	13%	37%	33%	3%	36%	38%	23%	7%	3%
Restionaceae	+	2%	+	-	+	2%	2%	+	+
Trilete ferns & fern allies	+	8%	8%	5%	4%	3%	8%	11%	12%
Saltwater taxa									
Avicennia maritima	-	-	-	+	+	+	3%	+	1%
Foraminifera	-	-	-	+	-	-	+	+	-
Marine dinoflagellates	-	-	-	-	+	+	+	+	+

Sample 1: Soil on vacant allotment between late? nineteenth-century buildings.
Sample 2: Soil accumulating in Mill yard (pre 1842?)
Sample 3: Clay infilling joints in sandstone floor of Mill's engine room
Sample 4: Earliest phase of reclamation (pre 1830?)
Samples 5-9: Core drilled through late reclamation fill into buried estuarine muds deposited against the eastern seawall of the Mill site.

occupied by now defunct light to heavy industries. These factories had displaced middle to late nineteenth-century terrace houses built on holdings cut from large early nineteenth-century estates. Examples include the Glebe Estate granted to the Colony's first chaplain in 1790 (subdivided in 1843), the 1500 acre Ultimo Estate granted to Surgeon John Harris in 1806 (subdivided in 1859) and Chippendale Estate (subdivided in the 1870s).

In many cases, earlier cultural deposits have been preserved within the foundations of the terrace houses buried under the factory floors. A typical example is 2-18 Levy Street, Chippendale where relict soils preserve pollen of plants growing in a plant nursery excised from the Chippendale Estate prior to formal subdivision of the whole estate for residential housing in 1877.[63]

Topographic and archaeological setting

Levy Street is located on the southwest facing slopes of a shallow valley formerly drained by a freshwater creek (Blackwattle Creek) flowing from swampy ground (now occupied by Victoria Park and Sydney University) into Blackwattle Bay via Blackwattle Swamp (now infilled as Wentworth Park). The valley sides have been graded and levelled but originally would have consisted of a series of structural benches eroded into horizontally bedded Wianamatta Shale. These iron-rich shales break down to form infertile clays, utilised in brick manufacture during the early colonial period.

Plant communities in similar environments elsewhere in Sydney indicate that the pre-European settlement vegetation will have been Turpentine-Ironbark forest dominated by trees of Turpentine (*Syncarpia glomulifera*), *Eucalyptus globoidea*, *E. resinifera* and *E. paniculata*. The shrub-dominated subcanopy will have included *Acacia* spp., *Dodonaea triquetra*, *Pittosporum undulatum* and *Polyscias sambucifolia*.[64] This type of dry sclerophyll forest is relatively dense and, now, lacks the grassy ground cover found in lower/more open forests and woodlands nearer to Sydney Cove. Early accounts emphasise the general infertility of, and the density of the native scrub growing on the clay/ironstone soils[65]. Lower/wet areas along creeks and around Blackwattle Swamp supported wetlands dominated by Cyperaceae, *Melaleuca* (paperbark), *Leptospermum*, *Viminaria* (Native Broom) as well as *Callicoma serratifolia* (Blackwattle). *Casuarina glauca* and *Eucalyptus robusta* (Swamp Mahogany) grew around the shoreline in Blackwattle Bay.

The Chippendale Estate, which fronts onto Blackwattle Creek, originally comprised a 95 acre holding granted to William Chippendale in 1819. Sometime before 1838, a two acre portion was excised and sold to one Charles Lyons who established and operated a plant nursery (Lyons' Garden) on his allotment up to c. 1846. Amongst the constructions shown on the Bill of Sale was a large rectangular pond on the eastern (Blackwattle Creek) half of the property. In common with the rest of Chippendale's Estate, Lyons' Garden was sub-divided for high-density terrace housing in the 1870s-1890s. These dwellings were demolished during or shortly after World War I and a factory built across the general area of the Lyons' pond (Levy Street).

Relict soils surviving below the factory floor are believed to relate to Lyons' occupancy of the site.[66] If correct, the site would provide an unusually good opportunity to compare the

documentary evidence for horticulture in the area[67] with actual microfossil evidence for plants growing on the site.[68]

Results (Table 5)
Nineteenth-century cultural deposits preserved at Levy Street were sampled by boreholes drilled above the estimated location of the 'rectangular pond'. Pollen of aquatic plants such as *Lemna* (duckweed) and the high organic nature of the sediments confirm that these boreholes had intersected a shallow, formerly swampy depression, consistent with a pond or waterhole.

In such contexts, sample depth is a reliable guide to relative age. The upward fining (sand to clay) then coarsening (clay to silt) lithology is typical of a waterhole or pond which initially had silted up by natural processes rather than deliberate infilling. The same trend is evident in the pollen data, which show freely floating and rooted aquatics such as *Lemna*, Restionaceae (wire-rushes) and *Typha* (bull-rushes) being replaced by native Poaceae (up to 71%).

The absence of Cunoniaceae pollen and low values of *Allocasuarina/Casuarina* indicate that Blackwattle and Swamp-oak stands growing around at the head of Blackwattle Bay had already been destroyed (for firewood and building purposes?). *Eucalyptus* and other native shrubs seemed to have survived in the area. Both observations and significant (1-4%) amounts of cereal pollen are consistent with a 'middle' colonial period date.

There is no pollen evidence that fruit trees or edible berry species grew on the site despite ponds and other waterholes being a favoured locality for planting drought-intolerant citrus species such as lemons at Parramatta and Richmond.[69-70]

Unless edible plant or ornamental species are represented amongst the unidentified pollen types, it is improbable that the palynosequence covers the period during which Lyons' Garden was actively used as a plant nursery. Nevertheless the data provide hints of horticulture, e.g. in trace records of *Sphagnum* (Peat-moss) which is widely used in plant propagation, and *Lycopodium laterale* (Slender Club-moss) which thrives in damp conditions created by routine watering.

Conversely the pollen data are emphatic that a wide range of European weeds and other opportunist plants had invaded the grassy sward (lawn) around the pond. Amongst these are cereals, dandelions, docks, Purple Top (*Verbena bonariensis*), *Silene*, Wire-weed, and unidentified but probably introduced members of the Fabaceae, Lauraceae and Vitaceae families. Tree ferns (*Cyathea, Dicksonia*) were being grown elsewhere in the district.

The combined sedimentary and fossil pollen evidence point to the samples representing an 'interregnum' between the sale of Lyons Garden in 1846 and its formal subdivision for residential housing in 1877. During this 'abandonment' phase, the 'pond' silted up and the site as a whole remained weed-infested open grassland, possibly used as a paddock.

41-53 George Street, Parramatta

Parramatta is the second oldest European settlement in Australia and its first country town.[71] Its location on poorly-draining alluvium and relative freedom from high-rise developments has allowed the foundations of convict huts, some constructed as early as 1790, to survive below more recent commercial buildings lining George Street and other early roads such as Smith Street (Fig. 1). Cultural sediments and soils associated with the convict huts *potentially* preserve evidence of the first successful agricultural developments in Australia, including wheat, barley, maize and tobacco, as well as subsistence gardening by convicts. At the other end of the

Table 5: Relative abundance data (woody taxa), 2-18 Levy Street, Chippendale.

SAMPLE No. (Borehole No)	1 (#1)	2 (#2)	3 (#3.2)	4 (#4)
DEPTH BELOW ST. LEVEL	0.70-0.90 m	0.90-1.17 m	1.52-1.55 m	1.55-1.60 m
SEDIMENTOLOGY	mottled silt	mottled silt	organic clay	sandy loam
Trees & shrubs				
Abies-type*	-	-	-	+
Acacia	-	+	-	~1%
Allocasuarina/Casuarina	6%	7%	6%	15%
Arecaceae*	-	?	-	-
Banksia serrata-type	-	-	+	+
Banksia spp.	+	+	-	+
Cupressaceae-Taxodiaceae#	-	-	+	-
Dodonaea ericifolia-type	+	+	-	+
Dodonaea triquetra-type	+	+	-	-
Epacridaceae T-types	+	-	+	-
Eucalyptus/Angophora	13%	27%	26%	40%
Grevillea/Hakea	-	+	-	-
Hibbertia	-	+	-	-
Lauraceae cf *Cinnamomum**	-	+	-	+
*Ligustrum**	-	+	+	+
Monotoca	+	2%	+	+
Persoonia juniperina-type	-	+	+	-
Pimelea	-	+	-	+
*Pinus**	+	-	-	-
Sprengelia incarnata-type	-	+	-	-
Unidentified Myrtaceae	+	+	1%	1%
Shrubs/herbs				
Asteraceae High spine*	+	1%	1%	-
Asteraceae Low spine	+	+	+	+
Amperea xiphoclada	-	-	-	-
Chenopodiaceae#	+	2%	+	+
Fabaceae spp.#	2%	1%	2%	+
Malvaceae#	-	-	-	-
Mutisia-type*	-	-	-	-
*Pisum sativum**	-	-	-	+
Vitaceae cf *Cissus*	+	-	-	-
Unidentified tricolpates#	+	+	+	+
Unidentified tricolporates#	2%	3%	4%	8%

Table 5 (cont.): Relative abundance data (herbs, ferns, fern allies, bryophytes & algae).

SAMPLE No. (Borehole No.). DEPTH BELOW ST. LEVEL	1 (#1) 0.70-0.90 m	2 (#2) 0.90-1.17 m	3 (#3.2) 1.52-1.55 m	4 (#4) 1.55-1.60,
Herbs				
Apiaceae#	+		+	-
Brassicaceae#	-	+	1%	-
Burchardia-type	-		-	-
Cereals (> 50 μ)*	3%	1%	2%	+
Cyperaceae	+	1%	4%	6%
cf *Euphorbia peplus**	-	+	-	-
Gonocarpus	+	+	+	2%
Liguliflorae#	+	+	+	2%
Liliaceae	+		-	-
Poaceae (< 50 μ)	71%	49%	41%	20%
Plantago lanceolata-type*	+	+	1%	-
*Polygonum aviculare**	+	+	+	+
Polygonum persicaria-type#.	-	-	+	-
Restionaceae	+	+	1%	2%
Rumex#	+	1%	5%	3%
*Silene**	-	-	-	-
Sparganiaceae-Typhaceae	-	-	1%	2%
Stellaria#	-	+	-	-
*Verbena bonariensis**	+	-	-	-
Tree-ferns and ferns				
Calochlaena	+	+	+	+
Cyathea#	-	+	+	-
Davallia-Microsorium	-	+	-	-
Dicksonia#	-	-	+	+
Gleicheniaceae	+	+	-	1%
Histiopteris	+	+	+	+
Lemna	-	-	2%	-
Schizaea-type	-	+	-	+
Unidentified Monoletes	+	1%	+	+
Unidentified Triletes	+	1%	2%	2%
Fern Allies				
Lycopodium laterale	-	+	-	-
Selaginella uliginosa	+	+	+	+
Sphagnum	-	-	(+)[1]	-
Liverworts & Algae				
Cingulatisporites bifurcatus	+	+	+	+
Desmidaceae	-	+	-	-
POLLEN SUM	350	419	437	327

[1] Found at a similar depth in another borehole (#3).

social scale were formal gardens surrounding Old Government House, established on Rose Hill overlooking the township.

Excavations at 41-53 George Street uncovered the remains of a several convict huts, as well as evidence of repairs and additions to these huts, dating to between 1790 and c. 1820.[72] Sediments found to preserve fossil pollen and spores included soil used to pack posts supporting the huts and the A_2 horizon of a buried soil dated to between 1830-1840.[73] Pollen data from equally early equivalent archaeological contexts (post-packing/post-pipe and buried soils) are available for nearby sites at the corner of Smith and George Streets (Prospect County Council car park site) and Aird Street.[74-75]

Topographic and archaeological setting

Colonial-period Parramatta was largely built on alluvial terraces and river flats close to the tidal (and initially navigable) limits on the upper reaches of the Parramatta River. Archival and borelog evidence indicate that the pre-settlement topography of the lower (Holocene) terraces was highly irregular due to the prevalence of levee bank remnants (mounds) and back-swamp hollows, some of which held permanent freshwater in the 1790s.[76]

Prior to European settlement, woodlands of tall Grey Box (*Eucalyptus moluccana*) and Forest Red Gum (*Eucalyptus tereticornis*) with an open grassy understorey covered these terraces.[77] Mangroves (*Avicennia marina*) are likely to have colonised the river margins up to the tidal limit (approximately below Church Street) whilst the Common Reed (*Phragmites australis*), paperbarks (*Melaleuca linariifolia*) and Rough-barked Apples (*Angophora floribunda*) occupied wetter and drier areas on the adjacent flats respectively.

Clearing of the alluvial flats began in 1789, and levelling of the same terrain was initiated in June 1790 with the construction of the first planned road in Australia. This road (George Street) extended some two km from the landing place on the Parramatta River to the vice-regal residence located on Rose Hill. When first planned, George Street was intended to be about 200 ft (61 m) wide and lined by huts placed some 100 feet (30 m) apart to reduce the risk of fire. Each hut was to be about 25 ft long and capable of holding up to ten persons.[78] By November 1790, some 32 of these 'wattle and daub' two-room huts had been completed, as had two more substantial buildings - a storehouse and barracks built close to the wharf.

Clearing and cultivation of the land at Parramatta was carried out by convict gangs between 1789-1791.[79] The first crops included wheat, barley, oats and maize, planted on ground broken up by hoe and fertilised by the ashes of burnt native vegetation. In 1789 a wheat field occupied part of the projected route of George Street whilst by late 1790 maize was being grown in a garden surrounding the Marine's barracks. Tobacco, vines, apples and turnips (?) were being grown by December 1791 and, although issued with flour and salt meat, many of the convicts also grew their own vegetables. A market for the sale of grain, fish, poultry and livestock was established in 1792.[80]

Up to c. 1820, the population of Parramatta reputedly exceeded that of Sydney Town and it had a well-deserved

Table 6a: Archaeological context and lithology, 41-53 George St., Parramatta

No.	CONTEXT	SITE	AGE RANGE	SEDIMENTOLOGY
1	Post-packing	Convict hut	1790+	Red-brown mottled sandy silt; charcoal smears
2	Post-packing	Convict hut	pre 1823 repairs to 1790 hut	Red-brown mottled sandy silt; charcoal smears
3	Post-packing	Convict hut	1790+	Yellow-brown mottled clay-silt; charcoal
4	Post-packing	Convict hut	pre 1823 repairs to 1790 hut	Red-brown mottled sandy silt; charcoal smears
5	Post-packing	Convict hut	pre 1823 repairs to 1790 hut	Red-brown mottled sandy silt; charcoal smears
6	Buried soil	A2 horizon	top soil modified *c.* 1830s-1840s	Dark grey loam; red clay aggregates, charcoal

TABLE 6b: Relative abundance of fossil pollen & spores, 41-53 George St., Parramatta

TAXON	SAMPLE No.					
	1	2	3	4	5	6
Trees & shrubs						
Allocasuarina/Casuarina	18%	8%	9%	6%	5%	4%
Eucalyptus/Angophora	35%	37%	59%	60%	44%	39%
Monotoca	-	-	-	-	+	-
Unidentified Myrtaceae		+	-	-	-	+
Shrubs/herbs						
Asteraceae low spine	-	2%	2%	-	-	+
Chenopodiaceae#	-	-	+	+	+	+
Unidentified tricolpates#	-	3%	-	-	+	-
Unidentified tricolporates#	+-	+	+	+	+	+
Herbs						
Apiaceae#	-	+		-	-	-
Brassicaceae#	-	2%	-	-	-	+
Burchardia-type	-	+	-	-	-	-
Cyperaceae	-	+	-	-	-	-
Gonocarpus	-	+	-	-	-	-
Liguliflorae#	+	6%	2%	+	+	14%
cf *Medicago**	-	+	-	-	-	-
Poaceae (> 50 μ)*	-	-	-	-	-	+
Poaceae (< 50 μ)	5%	5%	3%	7%	6%	12%
Rumex#	-	-	+	-	+	-
Stellaria#	-	-	-	-	-	+
Tree-ferns and ferns						
Culcita dubia-type	5%	+	2%	+	+	1%
Schizaea-type	-	+	-	-	-	-
Unidentified Monoletes	-	-	+	-	+	-
Unidentified Triletes	-	+	3%	-	5%	2%
Fern Allies						
Selaginella uliginosa	-	+	-	-	-	-
Liverworts & Algae						
Cingulatisporites cf *bifurcatus*	30%	19%	18%	18%	23%	15%
Rudolphisporis rudolphi	5%	6%	3%	6%	11%	5%
POLLEN SUM	44	124	128		102	186
POLLEN CONCENTRATION	no data	11	2	7	54	155

Table 6c: Trends in relative abundance of selected taxa c. 1790-1890, Parramatta.

SITE:	PROSPECT C.C. CAR PARK	41-53 GEORGE ST.	AIRD ST.
REFERENCE:	Macphail (1990)	Macphail (1997)	Macphail (1993)
AGE (No. of Samples):	1790-1815? (7 samples)	1830s-1840s (1 sample)	1858-1895 (1 sample)
Allocasuarina/Casuarina	4-10%	4%	36%
Eucalyptus	67-88%	39%	12%
Chenopodiaceae#	+	+	26%
Native Poaceae (< 50 μ)	2-11%	12%	3%
*Pinus**	absent to 1%	-	6%
Cereal grasses (> 50 μ)*	absent to 1%	+	-
Liguliflorae#	trace to 11%	14%	2%

reputation for innovation. For example the first Agricultural Society in Australia was founded at Parramatta in July 1822 and in the following year, a piece of ground on the north side of the river was made available as an experimental garden in which new varieties of horticultural and ornamental plants could be trialed. By 1828, the principal streets had been macadamised. By the late 1830s George Street 'could boast some very handsome dwellings and a few splendid inns'. Elsewhere the town was 'extending on every side with surprising activity; new and reputable dwelling houses were springing up in all directions and the value of town allotments was daily increasing' according to a newspaper report in 1837.[81]

Results (Table 6 a-c)
Both the post-packing and buried soil samples yielded abundant strongly humified plant detritus (rotten wood?) and fungal spores, mixed with variable amounts of disseminated charcoal fragments and low numbers of poorly preserved fossil pollen and spores. The presence of Liguliflorae pollen (up to 14% in the buried soil) confirm that the samples post-date European settlement whilst the absence of *Pinus* is consistent with the early rather than later decades of the nineteenth century.

All samples yielded essentially the same palynofloras, dominated by *Eucalyptus* (35-60%), *Allocasuarina*/*Casuarina* (5-18%), native Poaceae (3-7%) and two liverwort spores (up to 15%). The genera producing the spores have not been precisely identified and the types are cited under their formal fossil species names, *Cingulatisporites bifurcatus*, *Cingulatisporites*. sp. cf *C. bifurcatus* (18-30%), and *Rudolphisporis rudolphi* (3-11%). The only other taxa that are frequently recorded in individual samples are Liguliflorae, *Calochlaena dubia* and a second, but unidentified, trilete fern (up to 5%). Pollen of sclerophyll shrubs are absent except for trace records of *Monotoca*.

Pollen of definite vegetable genera such as *Pisum* are absent but it is possible that pollen of Apiaceae, Brassicaceae and Chenopodiaceae pollen represents introduced/edible cultivars such as celery, turnips and Fat-hen respectively. The only (trace) record of cereal pollen comes from the Sample 6, a remnant topsoil which had been modified between c. 1830-1840.

The absence of cereal pollen in the post-packing samples is surprising, given documentary evidence for crops growing on the area traversed by George Street prior to 1790 and elsewhere at Parramatta up to c. 1820. Alternative explanations are: (1) that the samples are closer to c. 1823 than to 1790 in age; and (2) that the plant fossil content consist of little more than pollen incorporated in the soil at the time the hut-posts were erected (native taxa) and the miospores of plants such as dandelions and liverworts which subsequently colonised bare ground along the outside walls. Dandelions and liverworts are pioneer plants, which flourish after wildfires, and (liverworts) require damp conditions to sporulate. Water dripping from eaves onto mineral soils fertilised by burning off of the pre-existing plant cover, or subsequently by ash from domestic fireplaces, would create an ideal habitat for both taxa.

The *Eucalyptus* and native Poaceae pollen counts are suggested to represent grassy woodland existing on the site prior to clearing in the 1790s. Whether tall trees were left standing, e.g. for shade, is unclear since the count consists mostly of small (immature?) and fused grains that equally well could represent fire-wood. A comparison with other sites (Table 6c) shows the expected progressive decline in *Eucalyptus* populations at Parramatta throughout the early decades of the nineteenth century and concomitant increase in grassland.

Apart from Sample 1 (18%), *Allocasuarina*/*Casuarina* pollen values are low relative to sites of comparable age in Sydney, i.e. the source (River-oak?) did not grow locally during the time represented by Samples 2-6. Nevertheless evidence that *Allocasuarina* and/or *Casuarina* once grew on the alluvial flats traversed by George Street is provided by high (65%) values preserved at the base of an alluvial sequence excavated on the nearby Prospect County Council Car Park site.[82] Similar reasoning implies that the convict hut represented by Sample 1 was amongst the earliest to be built on George Street and that timber-sized casuarinas were amongst the first trees to be cleared or exploited, e.g. for roofing shingles, during the founding of Parramatta.

1840s Artificial Waterhole, East Market Street, Richmond

The first permanent European settlements on the Cumberland Plain west of Sydney were placed on high level terraces away from riverbanks because of periodic massive floods. This in turn necessitated the construction of dams and other smaller artificial waterholes away from the river. Because these waterholes were a valuable community asset, their positions were usually marked on early nineteenth-century maps.

One waterhole, shown on an 1841 map, has been found buried under late nineteenth- and twentieth-century deposits on the western boundary of a large vacant allotment bounded by East Market, Lennox, Paget and March Streets at Richmond on the upper Hawkesbury River (Fig. 1). Like comparable basins elsewhere, this waterhole had become infilled not only with sediments washing in from the surrounding paddock but also by thrown rocks and domestic rubbish such as bottles. Because of waterlogging, the (now destroyed) infill constituted a remarkably well-preserved archive of rural attitudes and activities in the middle-late decades of last century.[83]

Topographic and archaeological setting
Richmond is situated about 15 m above normal river level on the floodplain on the right bank of the Hawkesbury River, in a district characterised by high alluvial levee banks, abandoned river channels or 'backswamps' and suites of river terraces of Holocene to Pleistocene age. Before European settlement in c. 1790, most of the alluvial land was forested with eucalypts up to 30 m tall, principally *Eucalyptus saligna* on the most recent floodplain soils and *E. tereticornis* mixed with *Angophora subvelutina* and *Melaleuca* spp. on older soils. Benson and Howell suggest that the understorey of the river flat forests was a discontinuous shrub layer of *Bursaria spinosa*, with native grasses (*Aristida*, *Eragrostis*) on well-drained sites away from the river.[84] The levee banks supported much more dense undergrowth, including shrubs, vines (*Smilax*?), nettles (*Urtica*), cutting grass (*Gahnia*) and tall graminoids (*Lomandra*).

When first settled, Richmond was close to the upper tidal limit on the Hawkesbury River but above the region influenced by saltwater. Clearing of the river flat forests has caused silting of the river which in turn aggravated the impact of frequent floods.[85] For example ten floods are recorded between 1799-1819 (one reaching 17 m above normal river level) and 15 between 1857-1879, including the all-time record flood of 1867 when East Market Street was submerged. Two major and 13 minor floods between 1870-1880 caused extensive bank erosion, further widening and shoaling the river by up to 2 m by 1876. Many of the more severe floods were preceded by unusually dry years, e.g. the major 1830 flood followed three consecutive years of drought.

Early colonial-period records show that the chief crops grown in the district were wheat and maize. Limited areas were planted to vegetables such as cabbages, potatoes, pumpkins and water melons but fruit trees such as peaches, apples and figs were little planted.[86] Most of the farms were unfenced since, apart from riding horses, the only animals kept as stock were

Table 7: Sedimentology and inferred age of samples, Richmond waterhole.

Sample	Unit	Depth	Lithology	Inferred Age	Interpretation
1	A	-0.25m	black clay	20th century	O/A_1 horizon of modern soil
2	B	-0.36 m	yellow & red sands	c. 1890	Builders' sand
3	B	-0.46 m	dark brown clay (charcoal)	c. 1890	hearth at base of sand (Unit B)
4	C	-0.53 m	light grey clay	1860s-1880s	Low water level facies (pond silted up)
5	C	-0.65 m	medium grey clay	1860s-1880s	Low water level facies
6	C	-0.80 m	massive grey clay	1860s-1880s	High water level (flood?) facies
7	C	-0.87 m	white clay	1867?	Flood deposit?
8	C	-1.00 m	mottled/turbated grey clay	1830s-1860s	Low water level facies (drought?)
9	C	-1.10 m	massive olive-grey clay	1830s-1860s	High water level facies
10	C	-1.20 m	laminated/mottled clay	1830s-1860s.	High water level facies
11	C	-1.24 m	olive-grey sandy clay	early 1830s?	High water level facies

pigs. Following the 1850s gold rush, horse breeding became an important industry until superseded by the railway. Wheat growing was phased out in the 1870s and the main agricultural products grown up to c. 1900 were maize, lucerne, hay, oranges, melons and pumpkins. Since then, dairying and market gardening have been the principal industries.

Construction of the waterhole implies that the allotment was used for grazing stock (pigs?) before 1841 but it is uncertain if the occupants of the allotment followed subsequent agricultural trends in the district. Dumping of builders' sand indicates that formal farming activities had ceased by 1890. Old fence lines behind the 1880s to 1950s cottages lining the four boundary streets suggests that the allotment became a *de facto* internal 'common' during the twentieth century. At the time of excavation the site of the waterhole was marked by a shallow depression within grassland invaded by dandelions, thistles, and docks. Local plantings included fruit trees such as lemon and mulberry (*Morus nigra*, *M. rubra*), Camphor Laurel (*Cinnamomum camphora*), senna (*Cassia* sp.), privet (*Ligustrum*) and bottlebrush (*Callistemon*).

Sediments infilling the waterhole were exposed by mechanically excavating a trench aligned approximately north to south across its probable centre on 31 July 1996. At this point, the feature is a shallow, saucer-shaped depression about 14 m long and greater than 1.5 m deep at the depocentre. The profile implies that the waterhole was dug in an existing depression, probably a shallow palaeochannel, using a horse-drawn drag-board. The site was levelled by sand and rubble during the late nineteenth century. Anecdotal evidence suggests the sand comes from the site of the Hawkesbury Agricultural College, built c. 1890.

Sediments exposed in the north wall of the trench indicate that four lithostratigraphic units are present, each separated by a subhorizontal to irregular unconformity surface (Table 7). In order of increasing depth from the surface, these units are: (a) a 20-30 cm thick black clay, interpreted as the O/A_1 horizons of the modern soil (Unit A); (b) a 10-35 cm thick sequence of red and yellow medium fine sands (Unit B); (c) a stacked sequence of laminated to massive, light grey to dark olive grey, clays (Unit C); and (d) undisturbed mottled to pallid sandy clay (Unit D), interpreted as Pleistocene? alluvium.

Foreset bedding, minor channelling and strong colour contrasts indicate that Unit B is builders' sand, spread by barrow. Except towards the centre of the trench, where there is a thin/laterally discontinuous charcoal-rich clay, interpreted as a European hearth, the sand unit lies on top of Unit C. Individual strata within Unit C range in thickness from < 10 cm to > 60 cm. Mottled and turbated (trampled?) horizons are suggested to represent periods of very low water, i.e. drought years, whilst massive or laminated beds are presumed to represent deposition during periods of relatively high water levels within the waterhole. Pebbles, broken bottles and blue and white Victorian pottery shards are scattered throughout the infill.

Age Control and sampling

When the waterhole was dug is unknown but, logically, the need for such an infrastructure is most likely to have arisen when the allotment was first subdivided or following a prolonged drought in the decade(s) before 1841. If the latter then the most probable *maximum* age of the clay infill is before 1830s when the district - on average one of the driest areas of the Cumberland Plains - was subjected to three years of severe drought. It seems improbable that the insecure existence led by the early colonial residents of Richmond would have warranted the construction of private or communal dams prior to c. 1825.[87] For example, in 1824 local landholders were granted small allotments within the Richmond township for the express purposes of erecting houses out of the reach of floodwater.[88]

Pottery and glass inclusions in the clay infill confirm that the site was an open waterhole during the mid-late nineteenth century. Artefacts of the same general age occur in building rubble exposed below the modern soil elsewhere in the vicinity of waterhole. The *minimum* age of sediments infilling the waterhole is c. 1890, based on anecdotal evidence (sand unit) and the completion of a reticulated water supply to the township.

Representative samples of all major and most minor lithological units observed in the trench wall were taken at three vertical profiles (sections) between the southern end and apparent depocentre of the waterhole (depths measured below a horizontal tape aligned along the top of the trench). Trends in the relative abundance of the more common native and introduced species are graphed in Fig. 4.

Results (Fig. 4)

The sample of Pleistocene? alluvium (Unit D) was barren whilst a sample collected from the edge of clay infill (top of Unit C) yielded very low numbers of eucalypt pollen and liverwort spores only - evidence that the clay infill had been exposed for some years prior to burial of the waterhole site by sand (Unit B). All other samples yielded abundant fossil pollen and spores in a matrix of finely disseminated charcoal and humified plant fragments. Amongst the former were large numbers of microspores produced by a Quillwort, *Isoetes drummondii* (Plate 4). The record is botanically important since this rare aquatic species does not now occur in the Sydney Basin flora and the nearest known population is at about 700 m elevation at Goulburn on the Southern Tablelands. How this Quillwort came to be established in the waterhole is unknown. Alternative suggestions are (1) that the Quillwort was growing in palaeochannels in the Richmond district before c. 1840 but had became extinct prior to the first comprehensive floral surveys were made, or (2) the species was introduced into the pond from spores carried down from the tablelands by stock or (less likely) water-birds.[89] The species occurs naturally at low elevations on the Fleurieu Peninsula in South Australia and also in southwest Western Australia, suggesting that *Isoetes drummondii*'s modern distribution is influenced by factors other than mild temperatures.

Pollen of introduced European weeds, e.g. *Plantago lanceolata*-type and *Polygonum aviculare*, and horticultural genera, e.g. cereals and *Citrus*, confirm that clays infilling the waterhole were deposited since European settlement at Richmond. Significantly, the highest relative abundance (1%) of cereal pollen occurs close to the base of the clay infill unit (Sample 10). The high relative abundance of native Poaceae relative to *Eucalyptus* and *Allocasuarina/Casuarina* is consistent with excavation of the waterhole in the 1820-1830s when much of the native forest and scrub cover had been cleared from the Richmond district.

Native Poaceae (up to 77%) associated with frequent to common *Eucalyptus*, *Allocasuarina/Casuarina* and spores of an unidentified liverwort (*Cingulatisporites bifurcatus*) and *Isoetes* dominate palynofloras recovered from the clay infill. The former (*C. bifurcatus*) is likely to represent a liverwort species growing on the exposed clay margins of the waterhole. *Isoetes* is an obligate aquatic and indicates relatively clear-water conditions. All show an overall decrease in relative abundance up section, consistent with increasing utilisation of the allotment for agricultural purposes. Silting-up of the waterhole almost certainly had caused the local? extinction of *Isoetes* before sand was dumped over the site: The collapse of *Cingulatisporites bifurcatus* reflects the changed edaphic conditions.

The ecologically complementary (reverse) trend is displayed by the increase in definite/probable exotic weeds such as Brassicaceae, Chenopodiaceae, Liguliflorae and *Rumex*. For example Liguliflorae values increase to 19 percent at the top of the clay infill, and reach a maximum of 21-22 percent in Unit B. The same upward-increase is displayed by many of the rare probable exotic taxa whose precise affinities are unknown, e.g. Convolvulaceae, Malvaceae and a number of indeterminate Fabaceae types. Two exotic *Polygonum* species were part of the local weed flora during the life of the waterhole, as were *Plantago lanceolata*-type (plantain) and *Stellaria* (Chickweed/Starwort). The paucity of agricultural weed species below sample 5 is significant as the observation is difficult to explain unless a dense grass cover was maintained around the waterhole. A corollary is that the site was not intensively grazed by herbivores.

Pollen of 'useful' exotics planted for windbreaks and shade trees, e.g. northern hemisphere pines (*Pinus*) and alder (*Alnus*) first occur part way up the clay unit (above Sample 9) with the highest value (2%) of pine occurring near the top of the infill (Sample 5). Horticultural species occur in low to trace amounts in most of the samples. The most common of the 'rare' type is *Citrus* pollen which occur only in the clay infill. The type includes definite specimens of the lemon (*C. limon*), and possibly a cultivar of the orange (*C. sinensis*). Other fruit plants represented by pollen are *Prunus*, *Rubus* (berry) and probably *Malus* (apple). Pollen values are too low to confirm that an orchard had been planted close to the waterhole but are unequivocal evidence for fruit-trees on the allotment up to c. 1890.

Trends observed in palynofloras from the hearth and builders' sand 'peak' in the overlying black clay. For example, the highest values of chenopods (56%) and lowest values of eucalypts (6%), native grasses (27%) and charcoal particles are recorded in Sample 1. The virtual absence of Liguliflorae pollen is surprising given the abundance of Dandelions on the site at present. Chenopodiaceae tend to be most prominent on mineral or salt-affected soils, suggesting that the palynofloras may have accumulated at a time when the ground cover across the site was sparse (summer drought?).

CONCLUSIONS

The five case studies illustrate the point made at the beginning that, at present, few unambiguous conclusions can be drawn using fossil pollen and spores preserved in colonial-period sites. Nevertheless the success of palynology in reconstructing terrestrial environments around the world on longer time scales (10^3-10^7 years) suggests that it will be possible to see 'wood' through the 'trees'. The following generalisations, supported by examples drawn from the full colonial palynological dataset, are presented as working hypotheses - to be tested in future Australian historical archaeological research.

On present indications, the only cultural sediments found in archaeological sites that are *not* likely to preserve fossil spores and pollen are freely-draining silts and sands, or silts and clays which have been subjected to high temperatures or exposed to subaerial weathering for long periods of time. The diversity of fossiliferous sediments makes it difficult to predict what will or will not be preserved in given cultural deposits. For example, *Citrus* pollen has been found in detritus accumulating in a colonial wood yard on the Haymarket Site, Darling Harbour.[90]

The same point is illustrated by the occurrence of cysts of marine algae (dinoflagellates) in the sub-floor deposit of an 1860s terrace house on the same (Haymarket) site. Possible explanations are that mud carried in from Darling Harbour had filtered through the floorboards, or more speculatively, that the algae come from the remains of a fish meal eaten during construction or occupation of the house (by a fisherman?). Dinoflagellates preserved in silt at 16-18 Smith Street, Parramatta, suggest that landfill dumped on this site included material dredged from the Parramatta River.[91]

Not all the fossil pollen data exhibit a particularly close match with documentary or archaeological evidence. Possible explanations are the low taxonomic resolution, poor representivity and over-representation of long distance transported pollen types when the local pollen influx is low or negligible, biased preservation or mixing of different age assemblages. Examples include:

1 Cabbage Tree Palm (*Livingstona australis*). Stands of this 'rainforest' palm growing along the lower-middle reaches of the Tank Stream Valley were used to make the first convict huts in 1788.[92] Its pollen type is moderately distinctive but fossil specimens have not been found to date in any archaeological site along lower and middle George Street even although these appear to preserve soils dating to the first decades of the Colony.[93-95] The same applied to pollen of the Norfolk Island Pine, planted in the grounds of First Government House before 1802 and also along lower George Street before 1820.[96]

2 Blackwattle (*Callicoma serrata*) was sufficiently common in the Glebe district to give its name both to one of the bays and a major creek. Its pollen is absent in relic soils near the head of Blackwattle Creek [97] but occur in imported (?) clay loam at 188-192 Goulburn Street, Surry Hills.[98]

3 Formal plantings on the Governor's Domain (now Royal Botanic Gardens) since c. 1812 include numerous trees which are long-lived and likely to produce/disperse distinctive pollen types.[99] Reasons why such pollen types are not recorded in adjacent archaeological sites are difficult to explain.

Elsewhere however the evidence is more emphatic that intensive cultivation destroys much or all pollen evidence of edible herbs and ornamental shrubs although pollen of *in situ* trees occasionally are preserved. An example of the latter occurs at Parramatta where soil from a garden adjoining an 1830s house preserved abundant *Pinus* and Chenopodiaceae.[100] Apart from trace records of Liliaceae and Polygalaceae, which

might represent exotic species, other pollen consisted of native types that are difficult to accept as being planted in a formal garden context, e.g. a cone-stick (*Isopogon*) and coral fern (Gleicheniaceae). Such cultivation is less likely to destroy phytoliths which may become concentrated in the A_2 horizon.[101]

Other general observations can be made that may help advance (or circumscribe) the application of pollen analysis in colonial contexts are:

A In spite of the relatively pervious texture of cultural deposits, fossil pollen and spores does not appear to be translocated downwards through the profile into 'older' deposits. A predictable exception is a grave dug into sand in the Destitute Children's Asylum Cemetery at Randwick.[102]

B The European dandelion (*Taraxacum officinale*) appears to have become widespread in the Sydney district within the first few years of European settlement. The same may be true for Wire-weed, plantain and dock.

The data are more clear-cut that *Pinus* was brought into the colony somewhat later (post 1812?) although the precise date remains unknown. Cereals are a special case since the earliest unequivocal fossil record of the pollen type is in a pre-1810 deposit at Cumberland/Gloucester Street, the Rocks.[103] On present indications, cereal grasses became widely naturalised after c. 1830 due to the expansion of a transport system centred on the horse.

Notwithstanding this, caution should be exercised when using negative evidence, e.g. the absence of exotic pollen types, to identify sediments or soils that pre-dates European settlement. Reasons include the time taken for many introduced species to become naturalised or soil had been brought in from univaded bushland. A possible example occurs at 188-192 Goulburn Street, Surry Hills.[104]

C The majority of palynofloras will be dominated by *Allocasuarina/Casuarina*, *Eucalyptus* and/or native Poaceae,and often include trace amounts of *Banksia*, *Dodonaea*, *Monotoca* and *Gonocarpus* pollen, irrespective of the age of the deposit or whether or not the source(s) grew locally.

Apparently reliable indications that a source grew on or close to the deposit are clumps of immature grains (including whole anthers). Confirmation is provided by *in situ* stumps, preserved on an 1820s site, Goulburn and Castlereagh Street.[105] On the majority of younger, i.e. post-1830 to 1840s, 'inner city' sites, the high relative abundance of eucalypt and casuarina pollen is better explained by an absence of local plants, or that flowering branches had been brought onto the site for firewood or (casuarina?) roofing shingles.

D The combined fossil data confirm a widespread expansion of grasses at the expense of native trees and shrubs during the nineteenth century but also demonstrate the survival of a significant number of native plants in the inner suburbs. For example banksia, Broom-heath, geebungs (*Persoonia*) and ti-trees appear to have been able to regenerate in the densely settled Rocks area up to the 1880s, possibly because of opportunities created by quarrying.[106] Industrial areas such as the Colonial Sugar Refinery site on Pyrmont peninsula provided equally good refugia into the twentieth century and the same may be true of inner city parks.[107]

E Many of the native shrubs represented by fossil pollen in cultural deposits have 'showy flowers' well-suited for household decoration. Some produce edible fruits, e.g. the Narrow-leaf Geebung (*Persoonia linearis*) although it is premature to interpret (trace) fossil records of *Persoonia* pollen as evidence that native foods were used to supplement European diets.

Alternative explanations are that the pollen types represent remnant native vegetation on the site or (preferred) that they come from the discarded wildflowers taken home as decoration. Sites where the latter is probable are Parramatta where Waratah (*Telopea*) pollen was recovered in soil packed around the timber supports of a convict hut[108] and Haymarket where pollen of the Swamp Symphionema (*Symphionema paludosa*) occur in the foundations of an 1860s terrace house.[109]

If correct, then lower socio-economic groups were using native plants for decorative purposes well before the second half of the nineteenth century – the time when Benson and Howell propose that the disappearance of much of the remaining bushland and an increase use of designs centred around bush plants led to an increasing awareness of the Sydney flora throughout the general population.[110]

F In other instances, the transhumance of stock is more likely to be responsible for the pollen records. A convincing example are pollen of the Chinese-bush (*Cassinia arcuata*-type) at the Haymarket Site since the species is naturally restricted to the southwest slopes of N.S.W.[111]

G Palynofloras recovered from the sites of former gardens are dominated by opportunist herbs, in particular grass, clovers, plantains and native or introduced chenopods, crucifers, dandelions and docks. There can be little doubt that the assemblages represent weed communities invading the disused gardens. A reasonable corollary is that tillage *ipso facto* destroys whatever pollen have been shed by cultivated plants. At present it is unclear if ornamental plants produce distinctive phytoliths (which should survive cultivation).

Conversely, pollen of some identified and unidentified horticultural and ornamental species are preserved in permanently waterlogged sediments accumulating in wells and ponds. For example fossil pollen of the garden pea has only been recovered at two sites, silts infilling an 1840s pond at Chippendale[112] and an 1810-1820s well on the Cumberland/Gloucester Street site, the Rocks.[113] The latter deposit also preserved fossil pollen of a bedstraw (*Galium*), *Citrus*, and an unidentified member of the rose (Rosaceae) family. Fossil pollen of the garden bean was found in mud infilling an 1850s well at Cumberland Street. Documentary evidence confirms horticultural activity on both sites.

H Intensive urbanisation of the inner city suburbs during the middle to late decades of the nineteenth century accentuated the spread of opportunist shrubs and herbs, which require disturbed and/or fertile soils. Contributing to this has been the widespread? practice of disposing of household waste, including ash and putrescible matter, in the rear yard. For example, palynofloras recovered from a rubbish pit at the rear of an 1850s terrace house at 20 Albion, Surry Hills are dominated by distinctive spores of an unidentified fungus.[114] Cesspit deposits are dominated by cereal pollen and an unidentified sporomorph that may be the egg cases of a gut parasite.[115]

I There is no compelling evidence for the deliberate planting of exotic or native trees or shrubs in the back yards of inner Sydney terrace houses during the mid-late nineteenth century. Whether the impression of unkempt conditions is valid or an artefact of the destruction of pollen in cultivated contexts is unclear. What is certain is that moist conditions created by quarrying, poor drainage,

rising damp and shading in densely populated areas created idea conditions for the survival, if not expansion, of drought-sensitive herbs, ferns and fern allies.[116]

Species identified to date which appear to have thrived include a raspwort (*Gonocarpus micranthus*?), Bat's Wing-fern, coral-ferns (Gleicheniaceae), Rainbow Fern and Swamp Selaginella. Less commonly found are spores of a brake (*Pteris*) and several species of club-moss (Lycopodiaceae) and the pollen of a sundew (*Drosera*), sedges and wire-rushes.

THE FUTURE

Taylor's claim that the cultural landscape reveals the attitudes and achievements of our forebears may be true at the geographic scale but the prospect is rather more blurred from the individual archaeological site.[117] For example many distinctive fossil pollen types remain unidentified although it is reasonable to presume that these represent exotic rather than native plants. Assigning a high social 'value' to a plant is no guarantee that its pollen or spores will be preserved in a cultural deposit. Nor is it likely that cultural responses to home maintenance will have been any less heterogeneous in the past than today. What then are the future prospects for palynology in historical archaeology in Australia? Two observations are:

1 Archaeopalynology is still in the 'descriptive' phase of development. Modeling, even for phenomena that are highly visible in the fossil record such as the spread of exotic species whose time of introduction is known, will require analysis of many more sites and much tighter dating of the cultural deposits.[118-119]

   Cereals within inner Sydney are an obvious example because of the hypothesized relationship with a horse-based transport system. There would appear to be no lack of suitable sites or sediments. Extending pollen reference collections to include distinctive exotic taxa, and incorporating analyses of phytoliths, will improve the taxonomic basis for interpreting the evolving colonial landscape.[120]

2 Although the geographic coverage is adequate, cultural deposits on the majority of sites represent only isolated points in time. The most complete 'continuous sequence' analysed to date - the Cumberland Street site which covers the period from c. 1805 to 1900 - is synthesised from 12 samples representing ten different archaeological contexts. Sites which once preserved relatively continuous pollen records for last century include the artificial waterholes at Parramatta and Richmond (now wholly destroyed by redevelopment of the sites) and geotechnical cores of the estuarine muds drilled as part of redevelopment of Darling Harbour (discarded in the 1980s).

One surviving, cored, but as yet incompletely analysed organic deposit, which potentially preserves a cultural record from before European Settlement up to the early twentieth century, is preserved under Redfern Oval.[121] Heightening the cultural value of the site is its use by Aboriginal people for feasting and ritual warfare into the nineteenth century.[122]

Carney has noted that the question of slums is regularly raised in excavations across Sydney and posed the question 'are slums identifiable in the content (type) of artefacts, quantity of artefacts or both?'[123] His suggested criteria include diet (argued to be the one of the most archaeological observable markers of culture) and physical evidence of over-crowding. The assumption here is that documenting the 'what, how and by whom' will reveal answers to culturally deeper questions of 'why'.

Parallel agendas can be developed using palaeobotanical evidence. For example, was the widespread use of terrace backyards for rubbish disposal in the middle-late nineteenth century due to social necessity (lack of a municipal rubbish collection system) or a manifestation of wider social attitudes in inner Sydney? The (apparent) absence of backyard gardens may have had dietary (and health) ramifications or merely be a consequence of a thriving market economy that made home gardening unnecessary?

Bryant and Holloway have noted that pollen studies of archaeological sites have become the 'norm rather than the exception' in Europe and North America.[124] A hopeful sign that Australia will share in the same 'bright future' is the current willingness of the heritage consultancies responsible for excavating colonial Sydney to use palynology as a valid tool in archaeological research.

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NOTES

1 Hoskins 1955.
2 Taylor 1992:2.
3 Lowenthal 1975:2.
4 Bryant and Holloway 1996.
5 Sobolik 1996.
6 Weinstein 1996.
7 E.g. Pearson 1988.
8 Cf. Connah 1988:1-5.
9 Cf. Litchfield.
10 Higginbotham *et al.* 1987.
11 Macphail 1987.
12 Macphail *et al.* 1987.
13 Macphail 1997a.
14 Macphail 1997b.
15 Macphail 1998a.
16 Macphail 1996a.
17 Macphail 1996b.
18 Macphail 1998b.
19 Macphail 1998c.
20 Lentfer and Boyd 1997.
21 References in Rapp and Mulholland 1992.
22 References in Kershaw *et al.* 1994.
23 References in Kershaw and Bulman 1994.
24 See Moore, Webb and Collinson 1991.
25 Vuorela 1973.
26 Behre 1981.
27 O'Rourke and Lebowitz 1984.

28 Cf. Macphail 1996b.
29 Higginbotham *et al.* 1987.
30 Johnson 1990.
31 Macphail 1997c.
32 Bligh 1980.
33 Gilbert 1986.
34 Macphail 1990a.
35 Macphail 1993.
36 Macphail 1997d.
37 Macphail 1997e.
38 Macphail 1993.
39 Macphail 1996c.
40 Benson and Howell 1990.
41 References in Macphail 1987.
42 Macphail 1990a.
43 Macphail *et al.* 1987.
44 Godden Mackay Pty Ltd.
45 Fairley and Moore 1995.
46 Benson and Howell 1990.
47 Macphail 1994.
48 Macphail 1997e.
49 Carney 1993.
50 Carney 1996.
51 M. Casey pers. comm.
52 Benson and Howell 1990.
53 See Macphail 1994.
54 See deVries Evans 1987.
55 Macphail 1995.
56 Wilson and Steele 1992.
57 Macphail 1992.
58 Benson and Howell 1990.
59 McCormick 1987.
60 McCormick 1987.
61 G. Wilson pers. comm.
62 Benson and Howell 1990.
63 M. Casey pers. comm.
64 Benson and Howell 1990.
65 Cunningham 1827.
66 M. Casey pers. comm.
67 Raymond 1832.
68 Macphail 1997f.
69 Macphail 1993.
70 Macphail 1996c.
71 Jarvis 1960.
72 M. Carney pers. comm.
73 Macphail 1997d.
74 Macphail 1990a.
75 Macphail 1993.
76 Lawrie 1982.
77 Benson and Howell 1990.
78 Jervis 1961.
79 Tench 1793.
80 Jervis 1961.
81 Jervis 1961.
82 Macphail 1990a.
83 Macphail 1996c.
84 Benson and Howell 1990.
85 Bowd 1982:15-22.
86 Bowd 1982:191-193.
87 Benson and Howell 1990.
88 Raymond 1832.
89 M. K. Macphail and E. A. Higginbotham in preparation.
90 Macphail 1991.
91 Macphail 1999.
92 Benson and Howell 1990.
93 Macphail 1989.
94 Macphail 1996a.
95 Macphail 1998a.
96 Marriot 1988.
97 Macphail 1996d.
98 Macphail 1997g.
99 Gilbert 1986.
100 Macphail 1993.
101 Boyd *et al.* 1998.
102 Macphail 1997h.
103 Macphail 1995.
104 Macphail 1997g.
105 Macphail 1990.
106 Macphail 1995.
107 Macphail 1997i.
108 Macphail 1990a.
109 Macphail 1991.
110 Benson and Howell 1990.
111 Macphail 1991.
112 Macphail 1997e.
113 Macphail 1995.
114 Macphail 1997c.
115 Macphail 1990b.
116 Fitzgerald 1987.
117 Taylor 1992.
118 Hobbs and Hopkins 1990.
119 Brown and Carter 1998.
120 Lentfer and Boyd 1996.
121 M. K. Macphail and R. Lawrie unpublished data.
122 Marriott 1988.
123 Carney 1997.
124 Bryant and Holloway 1996:913.

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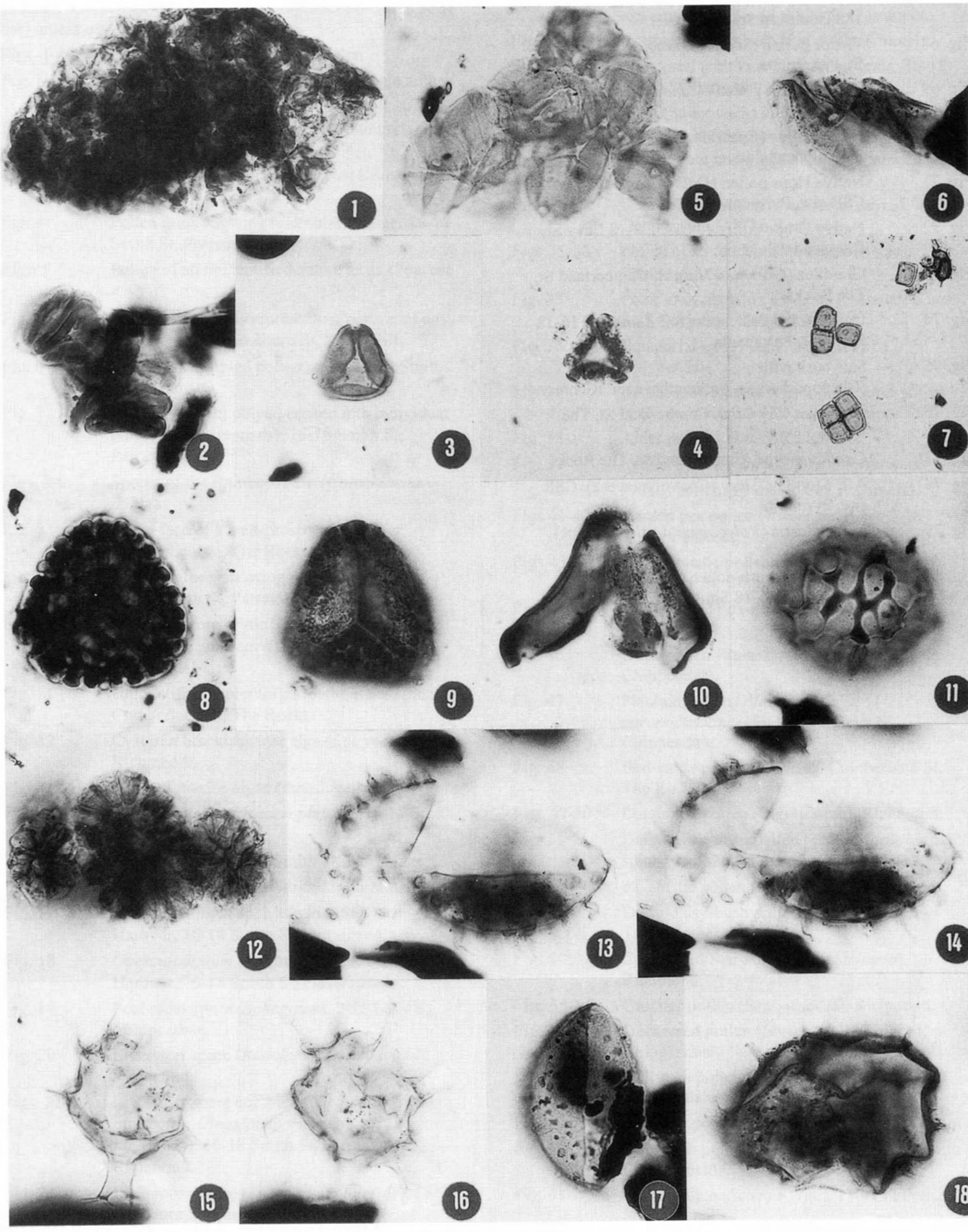
APPENDIX 1

Photomicrographs of commonly occurring and archaeologically significant fossil pollen and spores recovered from historical archaeological sites in Sydney City and surrounding suburbs. All photomicrographs x788 magnification (50 μ scale bar) unless otherwise stated.

Figs. 1-4	*Eucalyptus gummifera*-type pollen
Fig. 1	Fused pollen mass representing a single anther sac. x250. 16-18 Smith St, Parramatta
Fig. 2	Tetrad of mature pollen grains. Cumberland St, The Rocks.
Fig. 3	Well preserved pollen grain. 16-18 Smith St, Parramatta.
Fig. 4	Pollen grain showing microbial etching. 16-18 Smith St, Parramatta.
Figs. 5-6	Pollen of an unidentified native grass (Poaceae < 50 μ).
Fig. 5	Fused pollen mass representing portion of an anther sac. 188 Goulburn St, Surry Hills.
Fig. 6	Torn and crumpled pollen grain. 16-18 Smith St, Parramatta.
Fig. 7	Wattle (*Acacia*) polyad broken into individual pollen grains (monads). 16-18 Smith St, Parramatta.
Figs. 8-9	Spores of the Rainbow Fern (*Calochlaena dubia*).
Fig. 8	Distal face of a well-preserved spore. Cumberland St, The Rocks.
Fig. 9	Proximal face, showing microbial decay. 16-18 Smith St, Parramatta.
Fig. 10	Decayed spore of the Soft Tree-fern (*Dicksonia antarctica*). 16-18 Smith St, Parramatta.
Fig. 11	Unidentified sporomorph found in cess pits. Cumberland St, The Rocks.
Fig. 12	Cyst of a brackishwater alga (*Botryococcus*). Richmond.
Figs. 13-18	Cysts of marine algae (dinoflagellates).
Figs. 13-14	*Lingulodinium machaerophorum*. 16-18 Smith St, Parramatta.
Fig. 15	*Spiniferites* sp. 16-18 Smith St, Parramatta.
Fig. 16	*Spiniferites* sp. 16-18 Smith St, Parramatta.
Fig. 17	*Operculodinium* sp. Little Pier St, Darling Harbour, 16-18 Smith St, Parramatta.
Fig. 18	*Operculodinium* sp. Little Pier St, Darling Harbour, 16-18 Smith St, Parramatta
Fig. 19	Peat-moss spore (*Sphagnum*). 2-18 Levy St, Chippendale.
Fig. 20	Liverwort spore (*Rudolphisporis rudolphi*). Richmond.
Figs. 21-23	Liverwort spore complex (*Cingulatisporites bifurcatus*, *Cingulatisporites* spp. cf. *C. bifurcatus*). 16-18 Smith St, Parramatta, Richmond.
Fig. 24	Club-moss spore (*Lycopodium laterale*). 188 Goulburn St, Surry Hills.
Figs 25-26	Quillwort spore (*Isoetes drumondii*). Richmond.
Fig. 27	Selaginella spore (*Selaginella uliginosa*). 2-18 Levy St, Chippendale.
Fig. 28	Coral Fern spore (Gleicheniaceae). 2-18 Levy St, Chippendale.
Fig. 29	Kangaroo Fern spore (*Microsorium*-type). Richmond.
Fig. 30	Celery-top Pine pollen (*Phyllocladus aspleniifolius*). 16-18 Smith St, Parramatta.
Figs 31-33	Northern hemisphere pine pollen (*Pinus*).
Fig. 31	Equatorial (side) view of pollen grain. 16-18 Smith St, Parramatta.
Fig. 32	Polar (underneath) view showing sacci. 16-18 Smith St, Parramatta.
Fig. 33	Pollen grain undergoing fragmentation. Richmond.
Fig. 34	Garden bean pollen (*Phaesolus sativa*). Cumberland St, The Rocks.
Figs 35-36	Pollen of an unidentified cereal species (Poaceae > 50 μ)
Fig. 35	Polar view showing annulate (collared) pore. 2-18 Levy St, Chippendale.
Fig. 36	Equatorial (side) view. 2-18 Levy St, Chippendale.
Fig. 37	Lauraceae pollen cf. Camphor Laurel pollen (*Cinnamomum*). 2-18 Levy St, Chippendale.
Fig. 38	Alder pollen (*Alnus*). Richmond.
Fig. 39	Lemon pollen (*Citrus limon*). Richmond.
Fig. 40	Prunus pollen (*Prunus*-type). Richmond.
Figs 41-42	Garden pea pollen (*Pisum sativum*). 2-18 Levy St, Chippendale.
Figs 43-44	Clover/medic pollen (*Trifolium/Medicago*). 2-18 Levy St, Chippendale.
Fig. 45	Unidentified pea-flower pollen (Fabaceae). Richmond.
Fig. 46	Dock pollen (*Rumex*). 2-18 Levy St, Chippendale.
Fig. 47	Plantain pollen (*Plantago coronopus/lanceolata*). 2-18 Levy St, Chippendale.
Fig. 48	Bed-straw pollen (*Galium*). Cumberland St, The Rocks.
Figs 49-50	Dandelion pollen (Liguliflorae). Richmond.
Fig. 51	Daisy/daisy-bush pollen (Tubuliflorae high spine type). 2-18 Levy St, Chippendale.
Fig. 52	cf. Thistle pollen (*Bidens*-type). Richmond.
Fig. 53	Daisy/daisy-bush pollen (Asteraceae Tubuliflorae). Richmond.
Fig. 54	Chickweed/Starwort pollen (*Stellaria*). Richmond.
Figs 55-56	Crucifer pollen (Brassicaceae). Richmond.
Fig. 57	Duckweed pollen (*Lemna*). 2-18 Levy St, Chippendale.
Fig. 58	Bull-rush pollen (*Typha*). 2-18 Levy St, Chippendale.
Fig. 59	Sun-dew pollen (*Drosera*). CSR site, Pyrmont.
Fig. 60	Wire-rush pollen (Restionaceae). 16-18 Smith St, Parramatta.
Fig. 61	Sedge pollen (*Scirpus*-type). 130-132 Pelican St, Surry Hills.
Fig. 62	Unidentified lily pollen (Liliaceae-Iridaceae). Richmond.
Fig. 63	Flax Lily pollen (*Dianella*). Cumberland St, The Rocks.

Fig. 64	Native grass pollen (Poaceae < 50 μ). 2-18 Levy St, Chippendale.
Fig. 65	Wattle polyad (*Acacia*). 16-18 Smith St, Parramatta.
Figs 66-67	River-oak/She-oak (*Allocasuarina/Casuarina*). 188 Goulburn St, Surry Hills.
Fig. 68	Ti-tree pollen (*Leptospermum*). 16-18 Smith St, Parramatta.
Fig. 69	Broom-heath pollen (*Monotoca*). CSR site, Pyrmont.
Fig. 70	Heath pollen (Epacridaceae T-type). 2-18 Levy St, Chippendale.
Fig. 71	Native Hops pollen (*Dodonaea triquetra*). CSR site, Pyrmont.
Fig. 72	Native Grape pollen (*Cissus*). 2-18 Levy St, Chippendale.
Fig. 73	Grevillea (*Grevillea/Hakea*). Cumberland St, The Rocks.
Fig. 74	Unidentified Proteaceae (cf. *Lomatia*). 16-18 Smith St, Parramatta.
Fig. 75	Salt-bush pollen (Chenopodiaceae-Amaranthaceae). Richmond.
Fig. 76	Clematis (*Clematis*). Cumberland St, The Rocks.
Fig. 77	*Canthium*-type. Cumberland St, The Rocks.
Fig. 78	Aff. Morning Glory (Convolvulaceae). CSR site, Pyrmont.
Fig. 79	cf. Persicaria (*Polygonum persicaria*-type). Richmond.
Fig. 80	Daisy/daisy-bush pollen (Tubuliflorae low spine type). 16-18 Smith St, Parramatta.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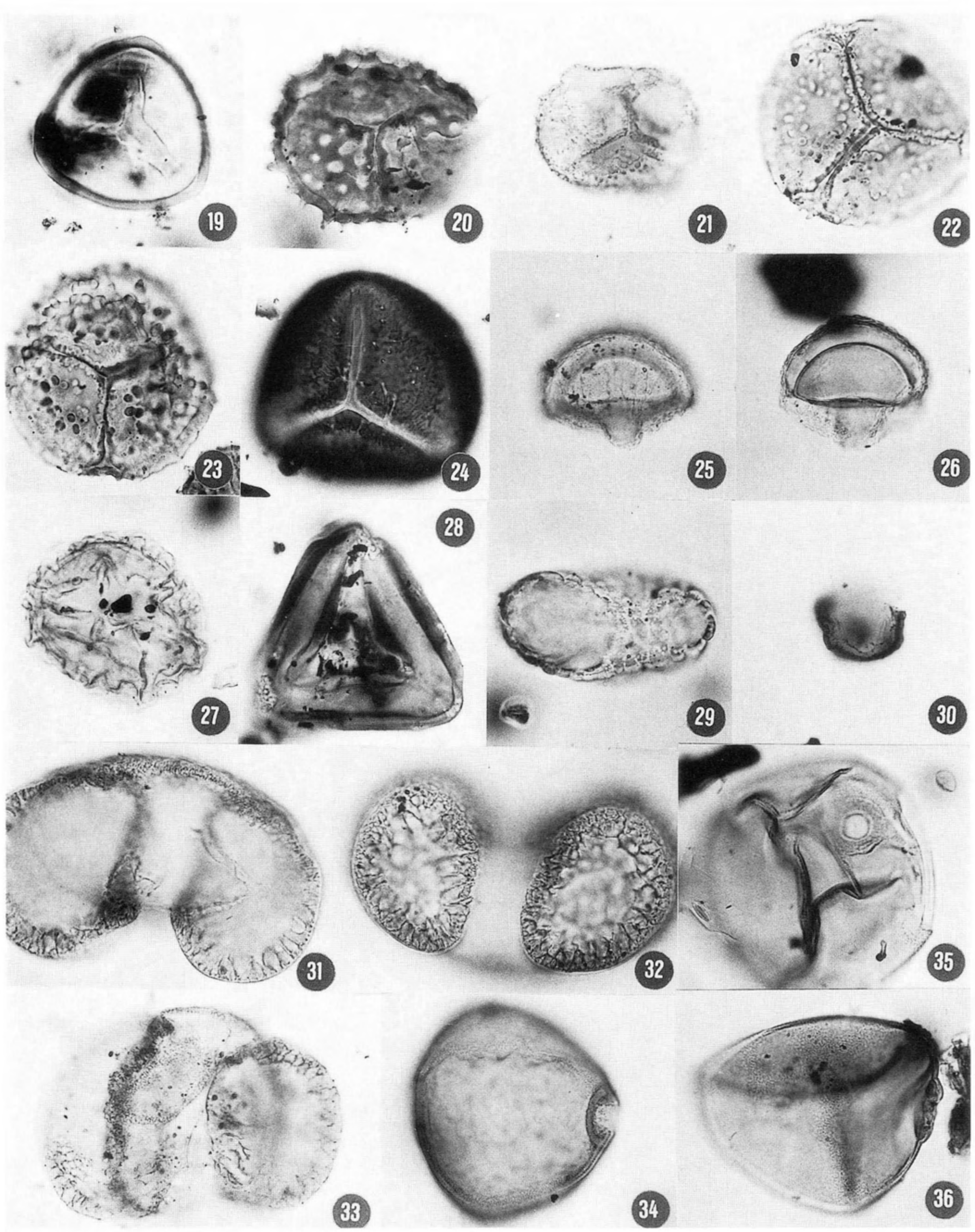
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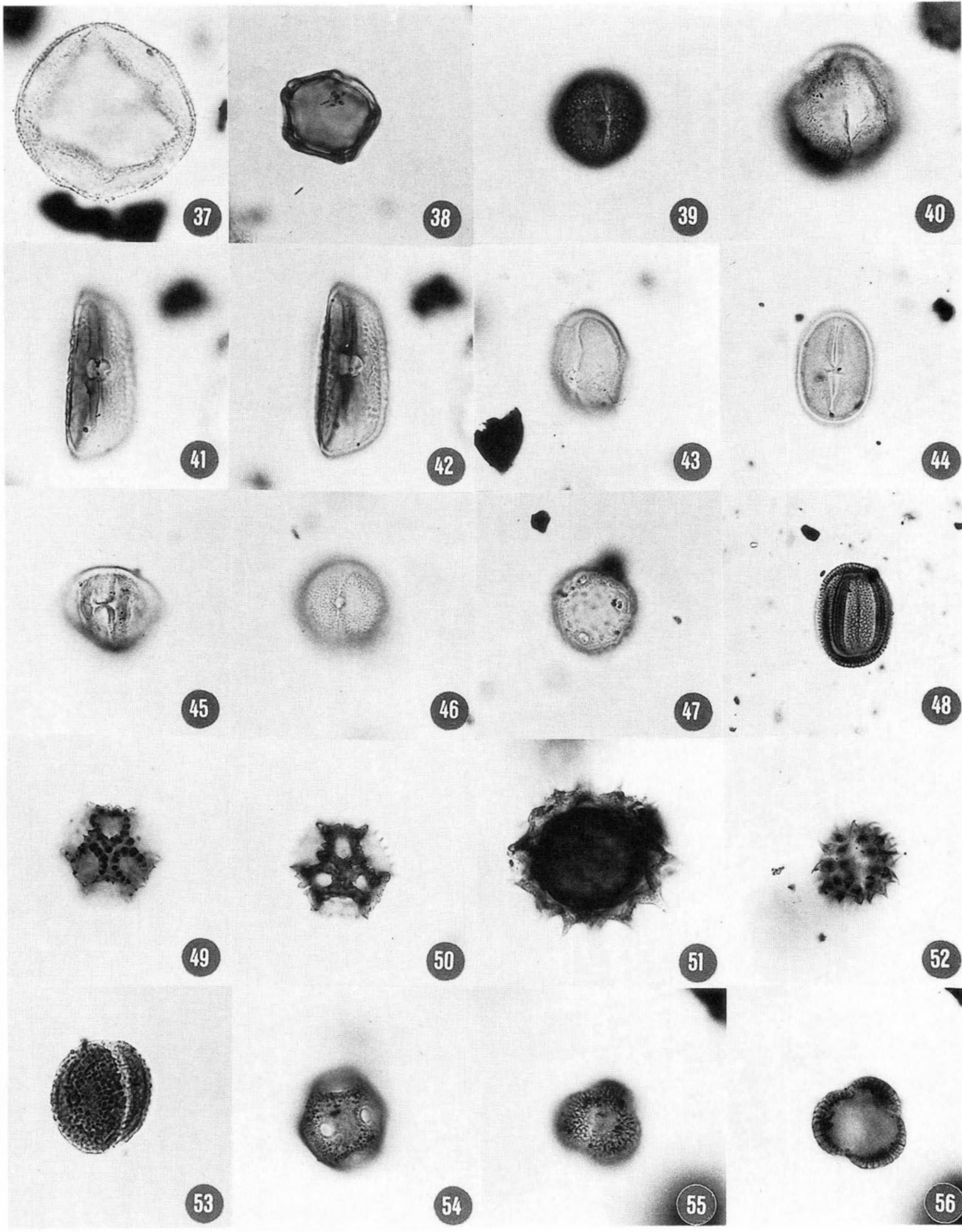
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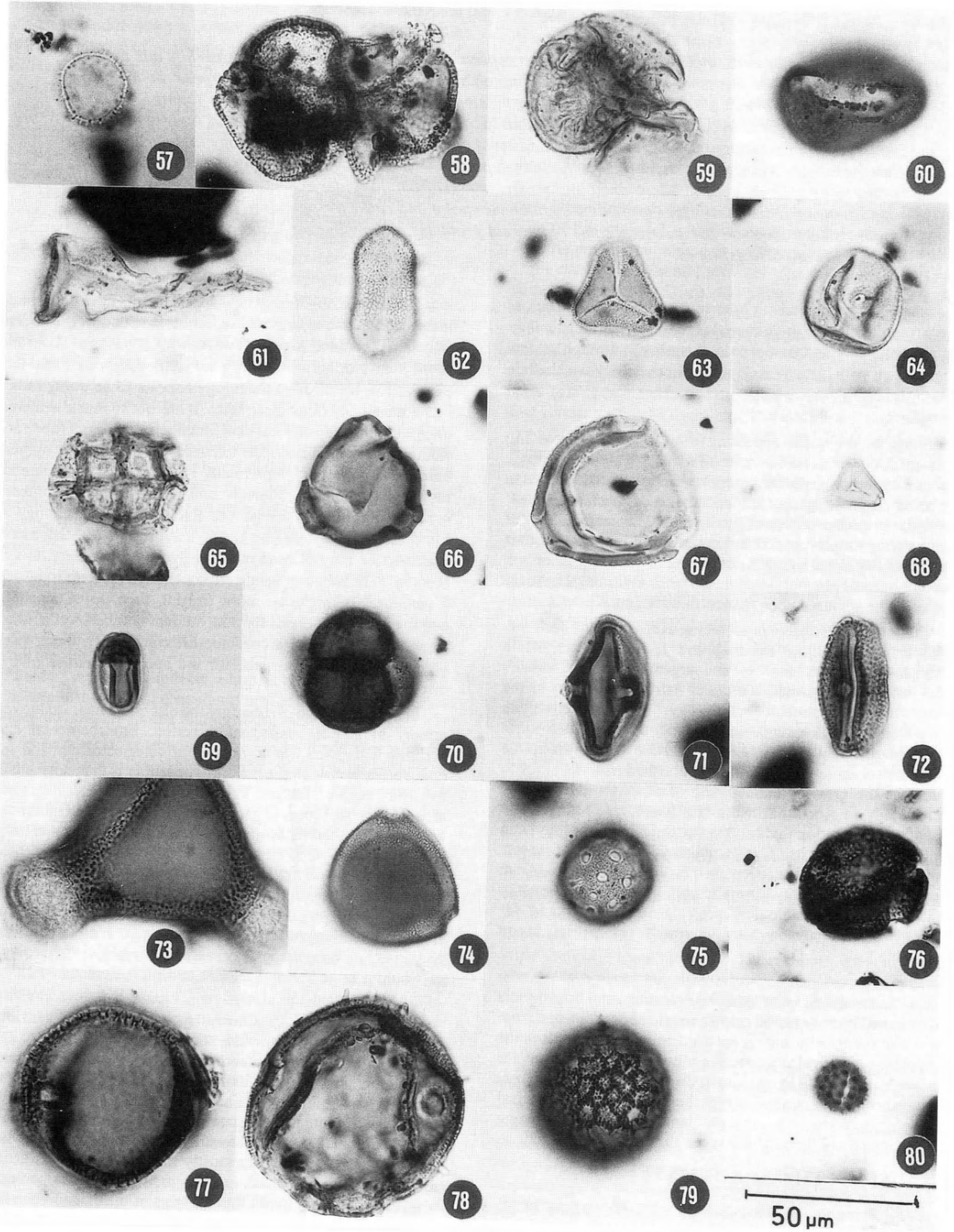
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