

Estuarine wetlands distribution along the Parramatta River, Sydney, 1788–1940: implications for planning and conservation

Lynette C. McLoughlin

McLoughlin, L.C. (Graduate School of the Environment, Macquarie University, NSW Australia, 2109) 2000. *Estuarine wetlands distribution along the Parramatta River, Sydney, 1788–1940: implications for planning and conservation*. *Cunninghamia* 6(3): 579–610. This study examined a variety of written, cartographic and pictorial historical materials to document the extent and distribution of inter-tidal wetlands and riparian vegetation along the Parramatta River and its bays from 1788 (first settlement in Port Jackson) to c. 1940 (when documentation by aerial photographs commenced). Although data available do not permit detailed quantitative analysis, and no single source is definitive, in total they yield a more detailed picture has hitherto been available. These historical sources indicate that in the 19th century extensive mudflats and saltmarsh communities dominated the inter-tidal zone, with mangroves more limited to creek fringes and some patches in bays for much of the period. In the upper river from Subiaco Creek to Parramatta, there is no evidence for the presence of mangroves until the 1870s. Following settlement and increased sedimentation, inter-tidal mudflats expanded, mangroves colonised up river and out onto mudflats in bays in the latter part of the 19th century, followed by expansion into saltmarsh in the 20th century.

This study demonstrates that some of the assumptions regarding the former extent of mangroves on which recent studies and foreshore plans are based are inappropriate. The historical data, combined with subsequent aerial photographic data, provides an enlarged database that needs to be taken into account in the formulation of conservation management plans and restoration strategies.

Keywords: foreshore vegetation, mangrove colonisation, saltmarsh, reclamation, revegetation, wetland zonation, wetland conservation, Australia, Sydney Harbour

Introduction

Over much of the period from European settlement in 1788, Sydney Harbour and Parramatta River were viewed from a utilitarian perspective. However, from the 1970s, as waterfront industries and port activities relocated and shipbuilding declined, changes in land use led to a greater appreciation of the waterways' aesthetic and recreational values. With the Clean Waters Act in 1970 and early measures to improve the river's water quality, interest in the ecological values of the Parramatta River and its foreshores also emerged. The National Trust of Australia (NSW) published *Parameters for the River* (Lynch et al. 1976) to stimulate such interest in improving degraded aspects of the river: its foreshores, landscapes, remnant vegetation, habitats and fauna.

Improvement has included protection and conservation of a number of vegetation remnants, particularly wetlands, while the restoration of indigenous vegetation along foreshores has been included in many planning documents of the 1980s and 1990s. However, wetlands restoration requires an understanding of their former distribution and composition, as do policies and decisions for foreshore vegetation management. Studies have used aerial photographs to document former wetland communities on the Parramatta River and to trace changes in their distribution (Thorogood 1985, DEP 1986b, Moss 1987, Clarke & Benson 1988; Burchett & Pulkownik 1996), but the earliest aerial photographs date from the 1930s and there has been very little work in tracing other, earlier, sources.

This paper examines the source material and evidence available to determine the extent and distribution of inter-tidal wetlands and shoreline vegetation along the Parramatta River arm of the Sydney Harbour system from time of European settlement in 1788, up to 1940. The evidence consists of written descriptions, pictorial evidence such as paintings, drawings and photographs, and cartographic evidence in maps and plans. Each is by nature fragmentary and incomplete in coverage but in total yields a more detailed picture than the assumptions and unsourced statements on which the understandings of recent studies are built. While the primary goal is to shed light on the foreshores at the time of European settlement, this paper will also consider the changes that occurred up to 1940. Implications of a longer-term historical view for planning and conservation are considered following analysis of the historical data.

Study area

Parramatta River commences a short distance up the Sydney Harbour system from Sydney Cove, extending from its junction with the Lane Cove River at Greenwich/Balmain to the weir at Parramatta (see Fig. 1 for all cited locations). The river lies along the southern edge of the Hornsby Plateau, massive vertically jointed Hawkesbury sandstone capped with Wianamatta Group shales, in which the river's northern tributaries have cut deep steep-sided valleys. Sandstone is the surface geology along much of the northern shores of the river and outliers of the sandstone plateau occur on the southern side of the river in decreasing prominence from Balmain to Uhrs Point. On this south side of the river the sandstone is broken by large embayments, where tributary creeks draining catchments substantially of shale built larger patches of alluvium and inter-tidal mudflats.

From Homebush Bay upstream the geology changes dramatically on the southern side. Here the catchment consists entirely of Wianamatta shales, which have a low resistance to denudation processes and result in subdued terrain. High levels of sediment stripped from the shales produced large deposits of alluvium along the river and its tributaries between Homebush Bay and Clay Cliff Creek, and associated inter-tidal mudflats, particularly from Homebush Bay to Duck River.

Much of the shoreline has been disturbed by clearing and reclamation but patches of wetland can be found in a number of locations, notably Homebush Bay, Newington, Duck River, Majors and Yaralla Bays on the south side, and Meadowbank and Ermington on the north (Register of the National Estate n.d. a–g). These wetlands are

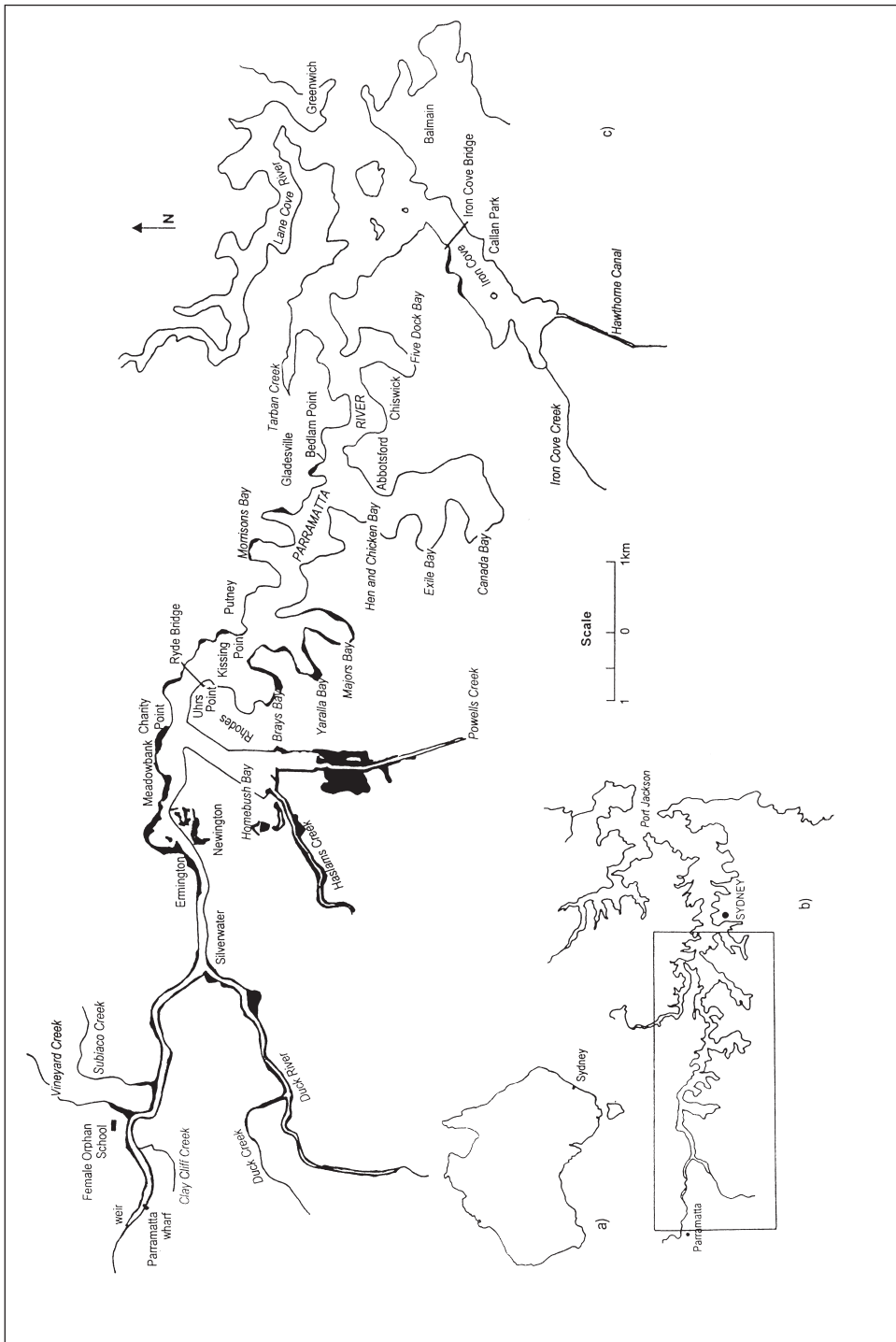


Fig. 1. The Study Area (a) geographic location; (b) the Sydney Harbour system; (c) Parramatta River from Greenwich/Balmain to the weir at Parramatta including: ■ mangrove distribution in the 1990s (from NSW Land Information Centre 1994 aerial photograph series with some later ground confirmation).

predominantly mangroves and mudflats with some small areas of saltmarsh at Homebush Bay and Newington and casuarinas at Newington. There is also a mangrove fringe along many sections of the river above Homebush Bay as far as Parramatta.

Existing reconstructions and perceptions of former wetland distribution

Reconstruction of the historical distribution of Parramatta River inter-tidal wetlands and shoreline vegetation has relied largely on three elements: aerial photographs series dating from the 1930s, ecological inference from present distribution patterns, and some key assumptions which have been repeated through a variety of studies of the past twenty years.

Two of the most pervasive of these assumptions are that the river was lined with mangroves to the limit of tidal influence at Parramatta (except perhaps for rocky headlands) prior to the impact of European development, and that present areas of mangroves are therefore small remnants of this former extent. This gained currency with Lynch et al.'s (1976) statement that 'the mangrove community is recorded to have once extended in a continuous strip for at least 60 kilometres up Parramatta River and in its bays stretching southwards.' This 'recorded' observation is unsourced and undated but forms part of Lynch et al.'s description of the river's former wetlands and foreshore vegetation. The mid-channel length of the Parramatta River is 19 km from the weir at Parramatta to Greenwich. The description, not located by this study, clearly refers to a shoreline distance, but along which parts of the river, whether confined only to the bays on the southern side and whether based on the 1788 shoreline or at some later stage, is not clear. Yet in many subsequent studies of the river and its vegetation, this unsourced description has been reproduced as the only 'evidence' for the river's pre-1940s foreshore vegetation (SPCC 1979, Department of Environment and Planning (DEP) 1986a, 1986c, Moss 1987, Latham 1988, MacDonald 1990, EDAW & Environmental Partnership 1996). Only one of these (DEP 1986a) noted that the original statement was unsourced.

Perceptions of the historical extent of saltmarsh vary. Saltmarsh is taken to include rush, sedge and reed communities as well as herbs and grasses, as defined by Adam et al. (1988) and all rarely distinguished separately in historical sources. According to Hamilton (1919) large areas of saltpan mudflats were also once found in or adjacent to saltmarsh areas above regular high tide. Clarke and Hannon (1967) analysed the geomorphic factors affecting development of halophytic vegetation in other estuaries in the Sydney region. They concluded that the small size and rugged sandstone geology of these catchments produced little run-off and low sediment yields, thus limiting areas for the development of saltmarsh. This has also been applied to the Parramatta River (Lynch et al. 1976, EDAW and Environmental Partnership 1997), despite a quite different geology on the southern shores and in the upper reaches, with the conclusion that saltmarsh existed there also only as a narrow band behind the mangrove zone (DEP 1986c). Clarke and Benson (1988), using historical evidence, note that saltmarsh was extensive at Homebush Bay but few other studies discuss the former extent of saltmarsh. General terms, such as 'extensive wetlands' or 'extensive mangroves and saltmarsh' are more common descriptions (Karskens 1986, Benson and Howell 1990, Connell Wagner 1995, Register of the National Estate n.d., a-g).

There is also limited consideration of the extent of inter-tidal mudflats. A 1975 study notes (unsourced), that the heads of bays such as Iron Cove, Hen and Chicken, Yaralla, Majors and Homebush 'originally had extensive mudflats' (University of Sydney 1975) but above Homebush Bay the areas filled behind the seawalls were 'previously (intertidal) mangrove swamps'. The most consistent recognition of the presence and extent of mudflats is for Homebush Bay where they were 'extensive' and bordered by mangroves and saltmarsh (Benson & Howell 1990, Webster & Kachka 1992, Olympic Coordination Authority 1997).

These perceptions of former wetland distribution have been reinforced by ecological inference from current distribution, as in the description of the river at Parramatta at the time of first settlement: 'there would have been mangroves, *Avicennia marina*, below Church Street' (Benson & Howell 1990). They are also reinforced by concepts of wetland spatial zonation and temporal succession first described for the Sydney district by Hamilton (1919) and Collins (1921) and later detailed in a model of primary succession in wetlands of the NSW central coast by Pidgeon (1940). This model describes successive zones from the water's edge of mangroves, which colonise mudflats as soon as they reach above low-tide level, saltmarsh, rushes and sedges, and finally casuarinas and melaleucas. Clarke and Hannon (1967, 1969, 1970, 1971) described similar zonation in several study sites to the north and south of Sydney. Thus the 'natural' or historical pattern of wetland vegetation along the Parramatta River foreshores from the water is consistently taken to be the successive zones of Pigeon's (1940) model (Karsens 1986, DEP 1986c, Benson & Howell 1990, NSW Property Services Group 1992, Kachka 1993, EDAW and Environmental Partnership 1997).

Whilst this pattern can be found in many places along the NSW coast (Adam et al. 1988), it is not universal. Clarke and Hannon (1967) found distinct patterns of zonation in some localities around Sydney but no discernible pattern in others. Kratochvil et al. (1973) mapped wetland communities at Smiths Creek, a tributary of Broken Bay, which displayed great variation in species associations and community patterning with all three major community types, mangroves, saltmarsh and casuarinas along the water's edge. Extensive saltmarshes not associated with mangroves have been found fringing the southern part of Wallis Lake, near Forster on the NSW north coast (Adam et al. 1988). Maps of the distribution of mangroves and saltmarsh on the Parramatta River for 1945–53 (Moss 1987) show saltmarsh along the water's edge without a mangrove fringe in a number of locations from Homebush Bay upstream, as do Clarke and Benson's (1988) map of Homebush Bay for 1931. In examining the temporal aspects of Pidgeon's model using several lines of evidence, Mitchell and Adam (1989a) could not find evidence to support Pidgeon's model of saltmarsh succeeding mangroves in the Georges River and Botany Bay system.

There are limited studies for the period prior to the 1930s. Hamilton's (1919) study of mangroves and saltmarshes of the Sydney District, included specific examples from the Parramatta River such as in Iron Cove, Hen and Chicken Bay, Homebush Bay and Duck River, but there is little indication of the distribution and areal extent of these communities in these locations. Benson and Howell (1990) refer to limited primary source material in describing the foreshore wetlands of the Parramatta River as part of

a wider study of Sydney's former vegetation. Clarke and Benson (1988), in discussing 200 years of change at Homebush Bay, used descriptions of 1843 and 1919 and mapped 40 years of change from the aerial photos 1930–1970. However, they did not consider the impact of dredging activity from 1905–1917 (McLoughlin in press) in shaping Wentworth Bay and the intertidal zone of Wentworth Point.

Materials and methods

A broad array of materials and sources was searched for evidence on the nature of the foreshores and foreshore vegetation of the Parramatta River before 1940: written material (Table 1), pictorial material in paintings and drawings and photographs (Table 2), and cartographic evidence in maps, charts and plans (Table 3).

Items discussed below are referenced to the tables thus: (table no: item no).

The cartographic evidence of the late 19th century was determined to be particularly useful and the data from a series of plans was used to compile a single map of the distribution and extent of mudflats, mangroves and saltmarsh in the 1880s–90s.

Evidence formats — discussion

Written material describing the European settlement of Sydney, its environment and the native people over its first ten years from 1788 is relatively abundant. After this, material on the immediate environment of Sydney is limited until the 1820s when travellers began to arrive and record their experiences for publication in Europe. However, soils and farming land were of more immediate interest to the settlers and description of wetlands and foreshore vegetation is less frequently found.

Of the pictorial material available, Sydney's early landscape paintings and drawings provide a far more accurate portrayal of the nature of the landscape and its vegetation than traditional critical comment has acknowledged (McLoughlin 1999). They can thus be a valuable source of evidence, either in the absence of any other evidence, or to assist in substantiating material from other sources. However, production primarily as artworks for exhibition or commercial publication, rather than simple landscape records, may affect their credibility, particularly if they are the only source of evidence or if they conflict with other sources. From the 1870s black and white photographs also become available.

Several key locations or views were favoured by painters and photographers and these appear repeatedly through the period, providing some indications of change. At Parramatta one such location was in the vicinity of the wharf looking downstream around the bend in the river, often as far as the Female Orphan School perched high above the river. As a major feature in a commanding position, the Orphan School was frequently painted in its surrounding landscape and it was also used as a point from which take views. Further downstream, homes and other buildings (signs of development and progress) on the northern bank were also favoured subjects. These included 'Vineyard', later 'Subiaco' (between Vineyard and Subiaco Creeks), the home and brewery of James Squires (Putney), 'Cleves' (Putney), and the Asylum (Gladesville).

Table 1. Description of the Foreshore Vegetation of the Parramatta River, 1788–1933.

Observation	Location	Year	Observer and Source
1 ...about 4 mile higher than where the ships lay, the country was open and improved the farther we went up & in most places not any underwood, grass very long.	Upper harbour	1788	Lt. William Bradley, Bradley 1969, p. 75
2 ...along the bank the grass was tolerably rich and succulent, and in height nearly up to the middle, interspersed with a plant much resembling the indigo.	Above Duck River	1788	Surgeon John White, White 1962, p. 127
3 The banks of it were now pleasant, the trees immensely large, and at a considerable distance from each other; and the land around us flat and rather low, but well covered in the kind of grass just mentioned.	Above Clay Cliff Creek	1788	Surgeon John White, White 1962, p. 128
4 About two miles below this settlement, the harbour becomes quite narrow, being not more than ten or twelve yards across, and the banks are about six feet high: here the country has the appearance of a park. In rowing up this branch, we saw a flock of about thirty kangaroos or paderong, but they were only visible during their leaps, as the long grass hid them from our view...	3–4 km down-stream from Parramatta	1790	Lt. Phillip Gidley King, King 1968, p. 402
5 Went into the SW branch, found it terminate in snug Coves, surrounded with Mangroves, rather shoal water.	harbour	1788	Lt. William Bradley, Bradley 1969, p. 76
6 Those coves above where the ships lay were surrounded by Mangroves & had Mud flats at the bottom...	Upper harbour	1788	Lt. William Bradley, Bradley 1969, p. 79
7 For it is strikingly singular that three such noble harbours as Botany Bay, Port Jackson and Broken Bay, alike end in shallows and swamps filled with mangroves.	harbour	1792	Lt. Watkin Tench, Tench 1961, p. 64
8 Description of romantic scenery along the river which included mangrove avenues and picturesque rocks	Parramatta River	1793	Thomas Watling, artist Watling 1979, p. 23–24
9 On a shooting expedition to 'the Flats': We landed on some low land or swamp, every step we took was up to our ankles in water...we walked in this manner for some hours seeing amazing quantities of ducks &c...after walking some hours we came to a brush which with the greatest difficulty we got through...but also up to our ankles in mud every step...	Homebush Bay	1793	Richard Atkins, Judge-Advocate, Atkins 1791–1810, p. 120–21
10 I had hardly touched ground when I found two tetragonias and various other oraches, all edible ...Then I saw a lythrum, the three geraniums already mentioned, three new species of lobelia, the mangrove, three banksias, the casuarina and many other plants.	S shore about 1/2 way to Parramatta	1793	Luis Nee, naturalist, Cavanilles 1990, p. 155
12 Discussion of usefulness for boat timbers of mangrove which grows in the upper end of the Coves and swamps.	harbour	1794	Daniel Paine, Paine 1983, p. 38
14 Reports on supply of fine timber and charcoal from a Government farm at Long Bottom (now Canada Bay), as well as Mangroves used for the Stone masons and cutters mallets.	Hen and Chicken Bay	1819	Major George Druitt, Ritchie 1971, p. 6
15 Report on possible crossings of the Parramatta River mentioning the different Mangrove Swamps on the West Side of Hen and Chicken Bay.	H. & C. Bay	1828	Major Thomas Mitchell, Mitchell 1828
16 Description of the Great North Road passing Hen and Chicken Bay: Its shores are low with mangrove flats.	H. & C. Bay	1832	James Raymond, Raymond 1966, p. 75

Observation	Location	Year	Observer and Source
17 <i>One portion of our land at Homebush consisted of salt-water marshes, covered in high tides and producing immense quantities of samphire. ...the mangrove grew very luxuriantly on the brink of the salt-water all along the embankments (of drains cut through the marshes)...these belts of green skirting the water were of great value in our view, and the sailing boats which passed daily up the creek glancing behind and between the groups of mangroves...</i>	Homebush Bay, between Powells & Haslems Cks	1843	Louisa Meredith, Meredith 1973, p. 155
18 <i>...beautiful bays branch off to each side: the water-worn sandstone rock is covered with gnarled gum and grass trees (lower reaches)... further up, the river, becoming more narrow, winds a good deal, and here and there are to be seen neat cottages, or elegant villas, the gardens and orangeries sometimes extending to the waterside.</i>	Parramatta River	1850	John Henderson, Henderson 1851, p. 103
19 <i>There are two species belonging to the Corolliflorae which abound on the banks of the Parramatta River (Aegeciras fragrans and Avicennia tomentosa). ...Near these may be seen Myrsine variabilis.</i>	Parramatta River	1859	William Woolls, Woolls 1867 p. 6
20 <i>Iron Cove Creek runs south-west out of Long Cove, with mud flats and mangroves along one shore, and around the next point (Rodd Point), Iron Cove, a little semi-circular bay, also lined with mangroves at its head.</i>	Iron Cove	1898	McLaurin & Hunt, McLaurin & Hunt, p. 60
21 <i>Two branches of Powells Creek cross the 'marsh' near Concord West railway station: banks of the shallow waterways are lined with Mangroves which display a graduated reduction in development as the channels merge into the plain.</i>	Homebush Bay	1919	A.A. Hamilton, Hamilton 1919
22 <i>...the heads of the bays are more or less like Iron Cove, all mangrove swamps, and there are possibilities of reclamation and of conversion into useful areas, Canada Bay, Exile Bay, Majors Bay, Yaralla Bay.</i>	Lower river, southern bays	1933	Chairman, Reclamation Trust of NSW, Maritime Services Co-ordination Board 1933

Table 2. Paintings, drawings and photographs of the Parramatta River.

No	Year	Creator	Title	Format	Location	Picture Location
1	1788	William Bradley	<i>A View in upper part of Port Jackson; when the fish was shot.</i>	watercolour	Difficult to locate	William Bradley (1960) opp p. 120
2	1798	unknown	<i>Captain Waterhouse's house, Sidney, Vineyard, about 1798</i>	watercolour	East side Vineyard Creek	ML SSV1B/PARR/6
3	1807	Attributed to G.W. Evans	Parramatta	watercolour	From Parramatta wharf looking downstream	ML SV1B/PARR/9, McCormick (1987) Pl. 132
4	1809	Unknown	<i>The landing place at Parramatta Port Jackson</i>	watercolour	From Parramatta wharf looking downstream	ML PXD388 Vol. 3 f.5, McCormick (1987) Pl. 133
5	1824-25	Joseph Lycett	<i>Kissing Point, NSW</i>	aquatint	From Uhrs Pt. downstream across Rocky Point on S, Kissing Pt. on N	Lycett (1825)

No	Year	Creator	Title	Format	Location	Picture Location
6	1824 -25	Joseph Lycett	<i>View of the Female Orphan School</i>	aquatint	From south bank slightly upstream (position of James Ruse Drive)	Lycett (1825)
7	1824 -25	Joseph Lycett	<i>View of a Residence near Parramatta the property of John McArthur Esq.</i>	aquatint	From the Orphan School looking SW across river to Elizabeth Farm	Lycett (1825)
8	1825	Augustus Earle	<i>The Female Orphan School, P'matta, NSW</i>	watercolour	Looking downstream past Orphan School on high bank.	NLA Image 08144, Collison (1986) p. 8
9	1825	Augustus Earle	<i>A View in Parramatta, NSW</i>	watercolour	Looking downstream from near wharf.	Views N.S. Wales ML ZPX D265
10	1835	T. Godfrey	<i>The Orphan School, Parramatta NSW</i>	drawing	From directly across river	ML, Collison (1986) p. 1
11	1835	Robert Russell	<i>Parramatta, 5th Dec 1835</i>	watercolour	Looking downstream from near wharf	NLA Image 8789
12	c. 1837	Conrad Martens	<i>Parramatta River</i>	painting	View upstream to Parramatta from Orphan School	Art Gallery of NSW
13	1838	Conrad Martens	<i>Parramatta</i>	painting	View upstream to Parramatta from Orphan School	Parramatta City Council (1950) p. 9
14	1838	Conrad Martens	<i>(View of Parramatta)</i>	watercolour	View upstream to Parramatta from Orphan School	ML ZDLPg 15, Ellis (1994) p. 152
15	1840	Unknown	<i>Orphan School Reach</i>	sepia ink drawing	Looking directly upstream past Orphan School from downstream on water	de Falbe (1988) p. 19
16	1840	Unknown	<i>Red Bank and Farm</i>	pencil drawing	From N bank across to mouth of Clay Cliff Creek	de Falbe (1988) p. 19
17	1840	Attributed to F. Montague	<i>Female Orphan School, Parramatta</i>	painting	Looking across river and downstream from S bank	Collison (1986) p. 11
18	1840	Henry C. Allport	<i>Cleves</i>	ink & watercolour	Northern shores at Putney from S shore, east side of Uhrs Point.	<i>Sketches in Sydney</i> ML ZPXD 86 f.17
19	1840	Henry C. Allport	<i>Cleves - Parramatta River</i>	ink	Northern shores at Putney from S shore, east side of Uhrs Point f.31	<i>Sketches in Sydney ...</i> ML ZPXD 86
20	1847	Unknown	<i>Parramatta NSW</i>	watercolour	Looking down stream from near wharf	ML ZDL PXX39 f.14

No	Year	Creator	Title	Format	Location	Picture Location
21	1850s	Unknown	<i>Byrnes Bros' flour mill and the George St. Barracks in the 1850s</i>	?	Looking down stream from near windmill	Parramatta City Council (1950) p. 13.
22	1858	Henry G. Lloyd	<i>Parramatta, NSW</i>	watercolour	Looking up-stream from S bank near present Alfred Street	<i>Sketches of N.S. Wales</i>
23	1860	C.F. Terry	<i>Tarban Point</i>	lithograph	Looking up Parramatta River at mouth of Tarban Creek	NLA Image. 9146, Terry 1860
24	1860	C.F. Terry	<i>Lunatic Asylum</i>	lithograph	From south side on Great North Road, Concord, across to Gladesville	NLA Image 9145, Terry 1860
25	1860	C.F. Terry	<i>From Kissing Point</i>	lithograph	From Top Ryde across River to Uhrs Point, Brays Bay, Homebush Bay	NLA Image 9147, Terry 1860
26	1860	C.F. Terry	<i>Subiaco c. 1860</i>	lithograph	From S bank across River to Rydalmere.	NLA 9148, Terry 1860
27	1860	C.F. Terry	<i>Parramatta</i>	lithograph	Parramatta River,	NLA 9149, Terry 1860
28	1867	G.P. Slade	<i>Parramatta River</i>	watercolour	-	NLA Image 7643
29	1870	GPO	<i>Subiaco, Parramatta River, near Parramatta</i>	B&W photo	From directly across river on Grand Ave.	ML GPO1: 06145
30	1870	GPO	<i>Byrnes' Mill on Parramatta River in the 1870s</i>	B&W photo	From the Orphan School fence looking upstream to Parramatta	ML GPO1: 06146
31	1870s ?	GPO	<i>Protestant Orphan School, Parramatta</i>	B&W photo	From across river downstream	ML GPO1: 06139
32	1870s	GPO	<i>View of Protestant Orphan School</i>	B&W photo	From directly across the river	ML GPO1: 06131,
33	1880	Gibbs Shallard & Co.	<i>Parramatta River near Ryde</i>	B&W photo	From Top Ryde across river to Uhrs Point Brays Bay Homebush Bay	Gibbs, Shallard & Co. (1880)
34	1880s	W. Clarsen	<i>Iron Cove</i>	lithograph	Looking across Rodd Island	NLA Image 20600
35	1881	?	<i>Iron Cove, 1881</i>	B&W photo	?	ML Small Picture File
36	1890	John Paine	<i>Iron Cove</i>	B&W photo	From Birkenhead Pt across bridge to Callan Park	MM 82\039\697
37	1892	Dept. of Public Works	<i>View at Long Cove, suction dredge at work reclaiming land</i>	B&W photo	Iron Cove	Public Works Dept. 1892 p. 139

No	Year	Creator	Title	Format	Location	Picture Location
38	1892	Dept. of Public Works	<i>View at Long Cove showing canal, floating and shore discharge pipes</i>	B&W photo	Iron Cove Hawthorne Canal	Public Works Dept. 1892 p. 141
39	1914	GPO	<i>Parramatta River view</i>	B&W photo	Possibly from Meadowbank Park (Ryde Bridge) upstream across Wentworth Pt.	ML GPO1: 17488
40	1914	GPO	<i>Parramatta River views: from Abbotsford</i>	B&W photo	Possibly at Quarantine Reserve on Hen & Chicken Bay	ML GPO1: 17483
41	1914	GPO	<i>Parramatta River view</i>	B&W photo	Possibly in a bay on the northern shores	ML GPO1: 17482
42	1927	Concord Council	<i>The swampy nature of the ground around Exile Bay before reclamation</i>	B&W photo	Part of Hen & Chicken Bay, Parramatta River	Coupe (1983) p. 170.
43	1928	Melvin C. Kent	<i>Homebush Bay</i>	B&W oblique aerial photo	Across Ryde Bridge, full view of Homebush Bay	ML GPO1: 24964
44	1928	Melvin C. Kent	<i>Parramatta River west of Ryde Railway Bridge</i>	B&W oblique aerial photo	From above river near Putney, across Ryde Bridge & Homebush Bay	ML GPO1: 24971
45	1928	SHT	<i>Parramatta River at Camellia, looking east</i>	B&W oblique aerial photo	-	ML GPO1: 24975
46	1930s	-	<i>Looking west over Parramatta</i>	B&W oblique aerial photo	From downstream of wharf	MM 83\066\0359b
47	1932	Sydney Mail	<i>A Swamp calling for Reclamation</i>	B&W photo	Across the head of Canada Bay from the southwest	Official Consultative Committee (1932) p. 33
48	1930s	-	<i>Looking east over Concord Golf Course</i>	B&W oblique aerial photo	Across golf course and head of Majors Bay now Majors Bay Reserve	MM 83\066\0504
49	1936	MWS&DB	<i>18" Submain crossing Major's Bay to P.S. No. 90 Concord.</i>	B&W photo	From west shore south of the main, east across head of Bay	Sydney Water Archives
50	1936	MWS&DB	<i>18" Submain crossing Major's Bay to P.S. No. 90 Concord.</i>	B&W photo	From grounds of 'Yaralla' north of the main looking south-east	Sydney Water Archives

Notes to Table 2.

GPO = Government Printing Office, ML = Mitchell Library, State Library of New South Wales, MM = Macleay Museum, University of Sydney, NLA = National Library of Australia, MWS&DB = Metropolitan Water Sewerage & Drainage Board, SHT = Sydney Harbour Trust

Mitchell Library GPO images and National Library images can be viewed online via the respective library websites.

Table 3. Maps, Charts and Plans of the Parramatta River.

No	Date	Title	Creator	Location/ Coverage	Source/Plan No.
1	1789	<i>Chart of the Coast between Botany Bay and Broken Bay</i>	John Hunter	Includes Hawkesbury Parramatta & Georges Rivers	Hunter (1968), opp. 160
2	1789	<i>Port Jackson, Chart 6</i>	William Bradley	Port Jackson, Middle Harbour, Lane Cove River, Parramatta River	Bradley (1969)
3	1789	<i>The Channel to Rose Hill, Chart 11</i>	William Bradley	Parramatta River, Homebush Bay, Duck R., Haslems Ck., Powells Ck.	Bradley (1969)
4	1828, Dec.	<i>Sketch of Part of the Parramatta River Showing the proposed Situations for a Punt near Kissing Point.</i>	T. Mitchell H.F. White, Darcy	Parramatta River, Hen & Chicken Bay, Brays Bay, Majors Bay	SR Map 3221 SR Map 3222 SR Map 3223
5	1833, June	<i>Sketch of the Parramatta River near Redbank</i>	Thomas Mitchell	Parramatta River, Rydalmere	CP NLD P.843a, SR Map 4903
6	1833, Dec.	<i>Survey of part of the Parramatta River</i>	Mathew Felton	Parramatta River, Rydalmere, Camellia	CP NLD P.843, SR Map 4902
7	1840	<i>Map of Port Jackson and the Parramatta River NSW</i>	Brownrigg & Meadows	Parramatta River, Homebush Bay, Duck River, Parramatta	ML ZM3811.15/ 1840/1
8	1842	<i>Plan of a Site for a Village at Longbottom</i>	Galloway	Hen & Chicken Bay, Parramatta R.	SR Map 3381
9	1845	<i>Proposed Road in Parish of Hunters Hill</i>	J.J. Galloway	Parramatta River	ML ZM3811. 1423/1845/1
10	1856	<i>Sketch shewing the unoccupied Land at Longbottom</i>	- -	Hen & Chicken Bay, Homebush Bay, Parramatta River, Longbottom	LA V & P 1863-64 (5), p. 668
11	1857	<i>Plan of 22 Villa Sites on the Three Brothers Point opposite Five Dock, Parramatta River.</i>	E.J.H. Knapp	Parramatta River, Henly	ML ZM2811. 1421/1857/1
12	1867	<i>Survey of Mr B.C. Rodd's Water Frontage, Iron Cove</i>	W. Orr	Iron Cove, Rodd Point, Fivedock	CP C935-690
13	1867, Sept.	<i>Survey of Mr B.C. Rodd's Water Frontage to Hen & Chicken Bay in connection with his application to be allowed to reclaim.</i>	W. Orr	Hen & Chicken Bay, Parramatta River	CP C965-690
14	1881	<i>Permanent Harbour Survey Long Cove etc</i>	J. Deering	Iron Cove, Parramatta River	CP 105-574
15	?	<i>Tracing showing part of the Water Frontage of Hen & Chicken Bay at Longbottom, Parish of Concord, County of Cumberland</i>	-	Hen & Chicken Bay, Canada Bay	CP 141-574
16	1883?	<i>Plan showing the foreshores at Fivedock Bay, Parramatta River, Parish of Concord, County of Cumberland</i>	-	Parramatta River, Five Dock Bay, Chiswick	CP 196-574

No	Date	Title	Creator	Location/ Coverage	Source/Plan No.
17	1883, Aug.	<i>Tracing shewing High Water Mark Chiswick Estate, Fivedock Bay, Parramatta River, Parish of Concord, County of Cumberland</i>	John Deering	Parramatta River, Five Dock Bay Chiswick	CP 197-574
18	1884, Nov.	<i>Plan showing Portions of River Frontage and Mortlake Road, Parish of Concord, County of Cumberland</i>	William L. King	Parramatta River, Mortlake, Majors Bay	CP 174-574 (C39-440)
19	1888, Aug.	<i>Part of Hen & Chickens Bay, Parish of Concord, County of Cumberland, shewing Positions of High and Low Water Marks and Frontage Detail</i>	Walter Mills	Hen & Chicken Bay, Canada Bay	CP 71-440
20	1888 Oct.	<i>Plan shewing survey of Mean High, and Low Water Marks on the western side of Hen & Chicken Bay, Parish of Concord, County of Cumberland</i>	George Knibbs	Hen & Chicken Bay, Exile Bay, France Bay, Cabarita	CP 72-440
21	1891	<i>Parramatta River from Homebush Bay to Queens Wharf, Parramatta — Compiled</i>	-	Homebush Bay, Parramatta River	CP 567-3000
22	1892	<i>Port Jackson Harbour Frontage from Bedlam Wharf to Gladesville Wharf</i>	Francis J. Gregson	Parramatta River, Looking Glass Bay	CP 209-574
23	1892, May	<i>Plan showing an area proposed to be dedicated as a reserve in connection with the Yaralla Hospital, Parish of Concord, County of Cumberland</i>	Walter Mills	Brays Bay	CP 656-3000
24	1892	<i>Port Jackson Harbour Frontage Gladesville to Parramatta</i>	V. Stephen	Parramatta River, Glades & Morrisons Bays	CP 207-574
25	1893	<i>Mean High Water Mark Parramatta and Duck Rivers</i>	V. Stephen	Parramatta River, Duck River, Homebush Bay	CP 230-574
26	1893	<i>Plan of Homebush Bay</i>	-	Homebush Bay, Parramatta River	CP 2977-3000
27	1926, June	<i>Proposed Reclamation Iron Creek Bay, Long Cove</i>	-	Iron Creek, Iron Cove	SHT file 32/6782 (SR 13/13878)
28	1919	<i>Soundings, Newington Wharf to Parramatta Tramway Wharf</i>	-	Parramatta River from Duck River downstream	SHT file 32/2796 (SR 13/13860)
29	1925	<i>Newington Wharf to Silverwater Wharf, Parramatta River</i>	G. Hart	Parramatta River from Duck River downstream	SHT file 32/2796 (SR 13/13860)
30	1930	<i>Hydrographic Survey, Broadoaks Estate, Parramatta River</i>	G. Hart	30 & 31 together cover approx. 1 km downstream from Duck River	348 ^s & 375 ^s in SHT file 31/6911 (SR 13/13864)

Table 3. cont.

No	Date	Title	Creator	Location/ Coverage	Source/Plan No.
31	1931	<i>Hydrographic Survey, Parramatta River</i>	G. Hart	30 & 31 together cover approx. 1 km downstream from Duck River	348 ^s & 375 ^s in SHT file 31/6911 (SR 13/13864)
32	1938	<i>Plan showing Hydrographic Survey between Charles St. Parramatta and Duck River, Parramatta River</i>	MSB	Parramatta River	Sydney Ports Authority, Roll 25 Sh 1
33	1939	<i>Duck River, Granville</i>	Dorman	Duck River, Parramatta River, Redbank	CP 12044-3000

Notes: SR = State Records of New South Wales, CP = Crown Plan, ML = Mitchell Library, State Library of New South Wales, LA V & P = Legislative Assembly (of NSW) *Votes and Proceedings*, SHT = Sydney Harbour Trust, MSB = Maritime Services Board of NSW.

Original Crown Plans are held by the Department of Land and Water Conservation (unless shown as SR Map), microfilm copies by the Registrar-General's Office.

Early pictures of the lower portions of the river and its bays are limited. Artists focussed on the main settlements and their settings — Sydney Cove and the surrounding harbour, and Parramatta. Up to the 1870s images are predominantly of the upper river, after the 1880s they are predominantly of the lower river.

Presence or absence of mangroves, specifically the Grey Mangrove, *Avicennia marina* (L.) Blanco, which forms pure stands, is the most easily identified feature of foreshore wetland vegetation in pictures. Not only is their location on the edge of the water a key indicator, but mangroves have a distinct dense rounded canopy which generally reaches ground/water level on the outer edges of a line or cluster of the trees. Eucalypts and casuarinas (specifically Swamp Oak, *Casuarina glauca*) also have distinctive forms, but different from mangroves. Low green areas are more problematic and may be saltmarsh or cleared grassed areas above high tide. Mudflats may be shown, but their absence may simply mean the picture depicts high tide.

Maps and plans can provide detailed and accurate information on the former distribution and extent of wetlands, especially larger scale survey plans. Maps of the Parramatta River commence with the charts drawn up by officers of the First Fleet, notably John Hunter and William Bradley. After Bradley, little of the inter-tidal zone of the Parramatta River was mapped until 1828 when a portion of the river between Brays Bay and Abbotsford was surveyed to fix a suitable crossing point (3:4). Prior to the 1860s, minimal vegetation, soils and topographic information was marked on surveys or on portion plans (surveys of individual parcels of land to be alienated from the Crown by grant or sale) but in 1864 Crown surveyors were directed to include this information (Jeans 1978). Surveys taken later in the 19th century can thus provide a detailed snapshot of a period 40–50 years prior to aerial photographs.

The most significant cartographic evidence of the former extent of mudflats, mangroves and saltmarsh in the Parramatta River derive from a series of surveys of the 1880s and 1890s (3:14–26). As dredging and the demand for reclamation of mudflats gathered pace (McLoughlin in press), there was a need to survey the harbour

foreshores to establish the line of high and low water marks and limit lines for reclamation. Plans 14, 22, 24 and 25 were part of this effort and were produced at large scale (one chain to the inch, 1: 792, or two chains to the inch, 1: 1584), on a series of large sheets. There is complete and detailed mapping of the northern foreshores from Bedlam Point (Gladesville) to Parramatta wharf and on the southern shores from Rhodes to Parramatta Wharf. On the south side downstream from Rhodes, with the exception of Iron Cove, surveys accessed for this paper are at similar scales but are less complete and evidence relies more on the inclusion of vegetation and other foreshore detail on waterfront property or other surveys (3:15–20).

Results

Lower River to Uhrs Point

From written descriptions it is evident that mangroves formed at least a part of the foreshore vegetation of the lower Parramatta River at the time of European settlement but it is not clear how extensive they were. Many references are general, or are not accompanied by precise location information. The earliest descriptions, from Bradley (1969), Tench (1961) and Paine (1983) (1:5, 6, 7, 12) indicate mangroves were clustered in coves at the heads of the bays on the southern shores. These bays were described as terminating or ending in 'snug coves' or shallows filled with mangroves. At that time bays were more indented than they are now, with a series of coves or minor embayments at tributary creeks (now walled and filled creating smoothly curved shoreline profiles). As the first surveys of the harbour were done from the water, the area of mangroves behind the shoreline fringe is not indicated. A description of the harbour 'ending' in 'shallows and swamps filled with mangroves (1:7) has been applied to upper river (Clarke & Benson 1988), but is more likely to describe the river at Homebush Bay. It is clear from a number of accounts (Bradley 1969, Phillip 1978, Paine 1983) that 'the Flats', the extensive intertidal mudflats and limited channels upstream from Uhrs Point (Fig. 2), were regarded as the head of the harbour.

The earliest painting of the lower river is by Bradley in 1788 (2:1), predominantly of rocky shoreline, but in the curves of two bays, or coves, bands of brighter green along the shoreline are likely to represent belts of mangroves. Although downstream from Uhrs Point, it is difficult to identify just where this picture is located, particularly given Bradley's tendency to exaggerate the vertical scale in rocks and cliffs, but it confirms his description of coves terminating in mangroves.

There are conflicting accounts of vegetation at the spot where two convicts cutting rushes (for roof thatching) were killed by Aborigines 'up the harbour', i.e. upstream from Sydney Cove, in 1788 (Hunter 1968, Tench 1961, Bradley 1969, White 1962, and Worgan 1978). A few miles by boat away from the settlement (Worgan 1978), in the 'southwest arm' (Bradley 1969), they were variously said to be found dead in the rushes or one or both in mangroves, but this incident indicates both mangroves and rushes (or reeds) were present, probably at the waters edge accessed by boat. An expedition by naturalist Luis Nee also indicates some variety in vegetation found on,

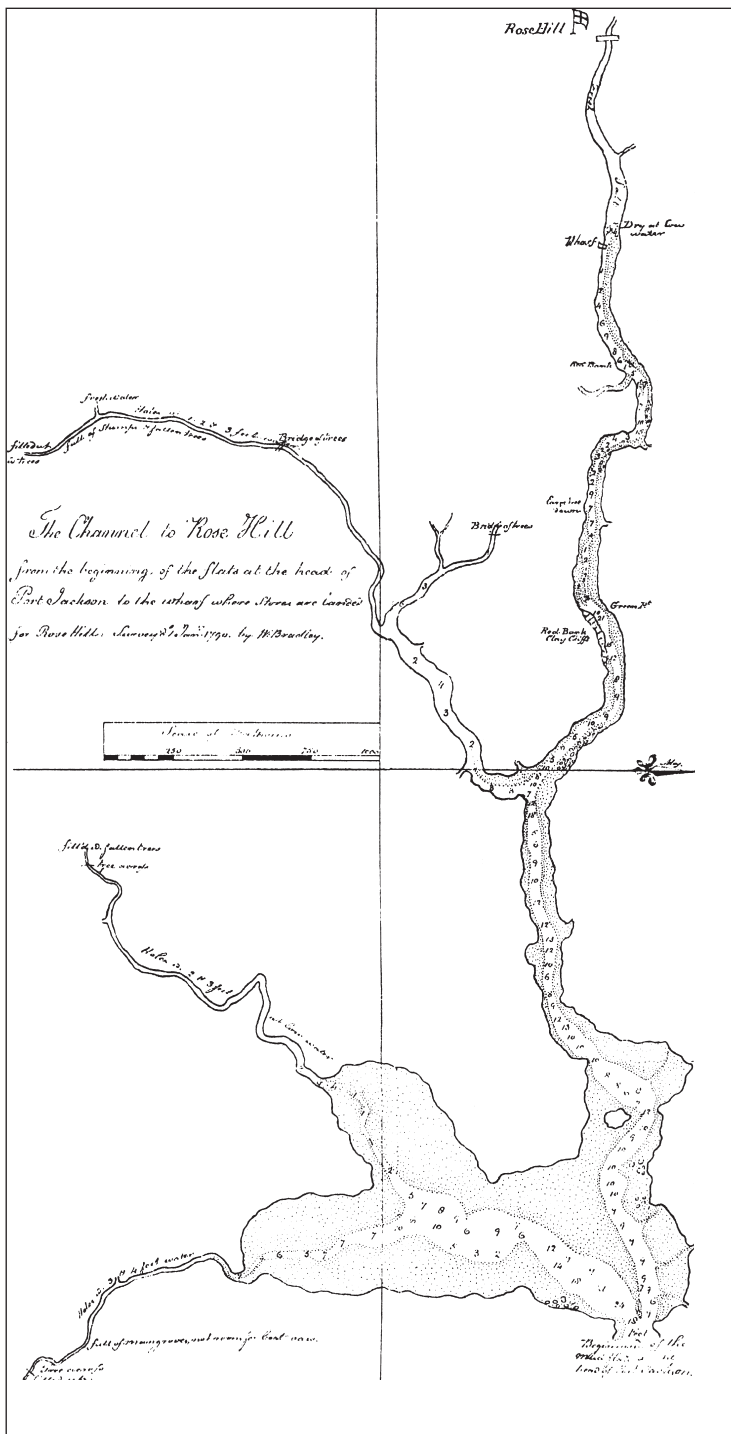


Fig. 2. William Bradley, A Voyage to New South Wales 1786–1792, Chart 11 ‘The Channel to Rose Hill from the beginning of the flats at the head of Port Jackson to the wharf where the stores are landed for Rose Hill’. Homebush Bay, Duck River and Upper Parramatta River to Parramatta (Rosehill) wharf. (Mitchell Library, State Library of New South Wales)

or near, the water's edge, including the wetland species mangrove, casuarina and tetragonia (1:10).

In the 1820s and 1830s there is consistent evidence for the presence of patches of mangroves in Hen and Chicken Bay, both written (1:14–16) and in plans. Three versions of the 1828 survey of the river between Brays Bay and Abbotsford to fix a suitable crossing point (3:4) show patches of mangroves in Majors and Yaralla Bays and in two coves in the south and east parts of the head of Hen and Chicken Bay. The consistent orientation of the mangrove patches to the south and south-east of the bays and coves is striking, as are the presence of large inter-tidal zones not covered by mangroves. While the compiled map of the 1880s–90s surveys (Fig. 3a) is incomplete in its coverage of the shoreline, it confirms the patchiness of mangrove presence, their orientation to the southeast corners of the coves and the presence of large areas of inter-tidal mudflats in the southern bays of the lower river. By the 1930s, there were still large areas of saltmarsh and saltpan above normal high tide in Canada Bay (Longbottom) at the head of Hen and Chicken Bay (2:47) in the areas shown on Fig. 3a.

By 1927 a solid band of mangroves with an area of saltmarsh on the landward side was photographed in Exile Bay (part of Hen and Chicken Bay), prior to reclamation in the 1930s to create Edwards Park (2:42). In Majors Bay oblique angle aerial photographs of the 1920s show a large patch of mangroves is present covering most of the area to become Majors Bay Reserve (2:48). Ground photographs in 1936 (2:49–50) show most of these mangroves had been cut but were recolonising.

In Iron Cove an 1890 photo of Iron Cove Bridge from the north-east (2:36) includes the area of Callan Park which was to be reclaimed in 1893–94 (Public Works Department, 1893). Mangroves are not visible in this area in this photograph and the 1881 survey indicates the area was mudflats (Fig. 3a). Images of other parts of Iron Cove show the foreshores as cleared or open and grassy to the water's edge with scattered eucalypts and casuarinas (2:34, 35, 37). At the head of the bay change can be traced from 1881, when no mangroves are shown in Iron Creek (3:14, Fig. 3a). By 1898 mangroves are described as present on one bank (1:20) and by 1926 a large stand occupies half of the 1881 mudflats (3:27).

Further up river, Joseph Lycett's 1820s view of both banks from the vicinity of the present Ryde Bridge (2:5) gives no indication of mangroves, even around those points on the south side, now lined by this species. By the 1890s (Fig. 3a) the steeper rocky northern shores of the river had several generally very small patches of mangroves on mixed mud and sandy flats which were accumulating in bays and on parts of the shoreline. Hamilton (1919) notes saltmarsh fronted by a sandy shore at Meadowbank.

Brays Bay appears in 2:25 and 33, These broad views lack detail but it is still apparent that the part of Brays Bay within the view carries few if any mangroves, nor does the long foreshore of the Rhodes peninsula. Hamilton (1919) describes *Acacia falcata* lining the banks of Brays Bay and also notes the presence of a *Casuarina glauca* forest.

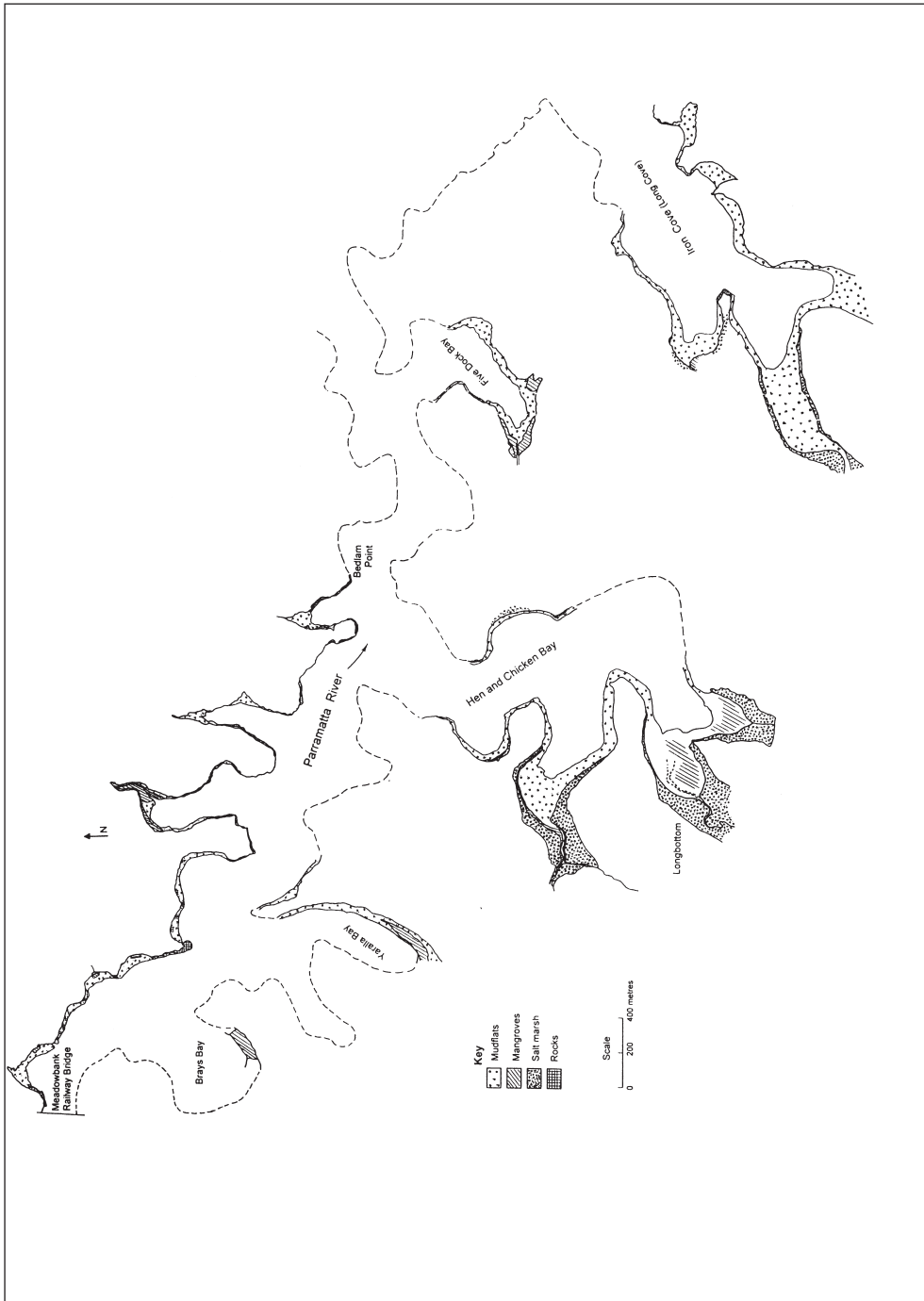


Fig. 3a. Composite map of wetlands of the Parramatta River in the 1880s and 1890s: Iron Cove to Meadowbank Railway Bridge, Charity Point. Compiled from Plans 14–20, 22–24 (Table 2). Some vegetation detail from Plan 12 also included. Dashed line indicates parts of shoreline for which no plan found showing wetlands in this period. Lack of a solid line boundary to wetlands reflects lack of a boundary on some plans where the inter-tidal zone was shown as context for the main purpose of the plan and their full extent was not surveyed.

Homebush Bay to Duck River

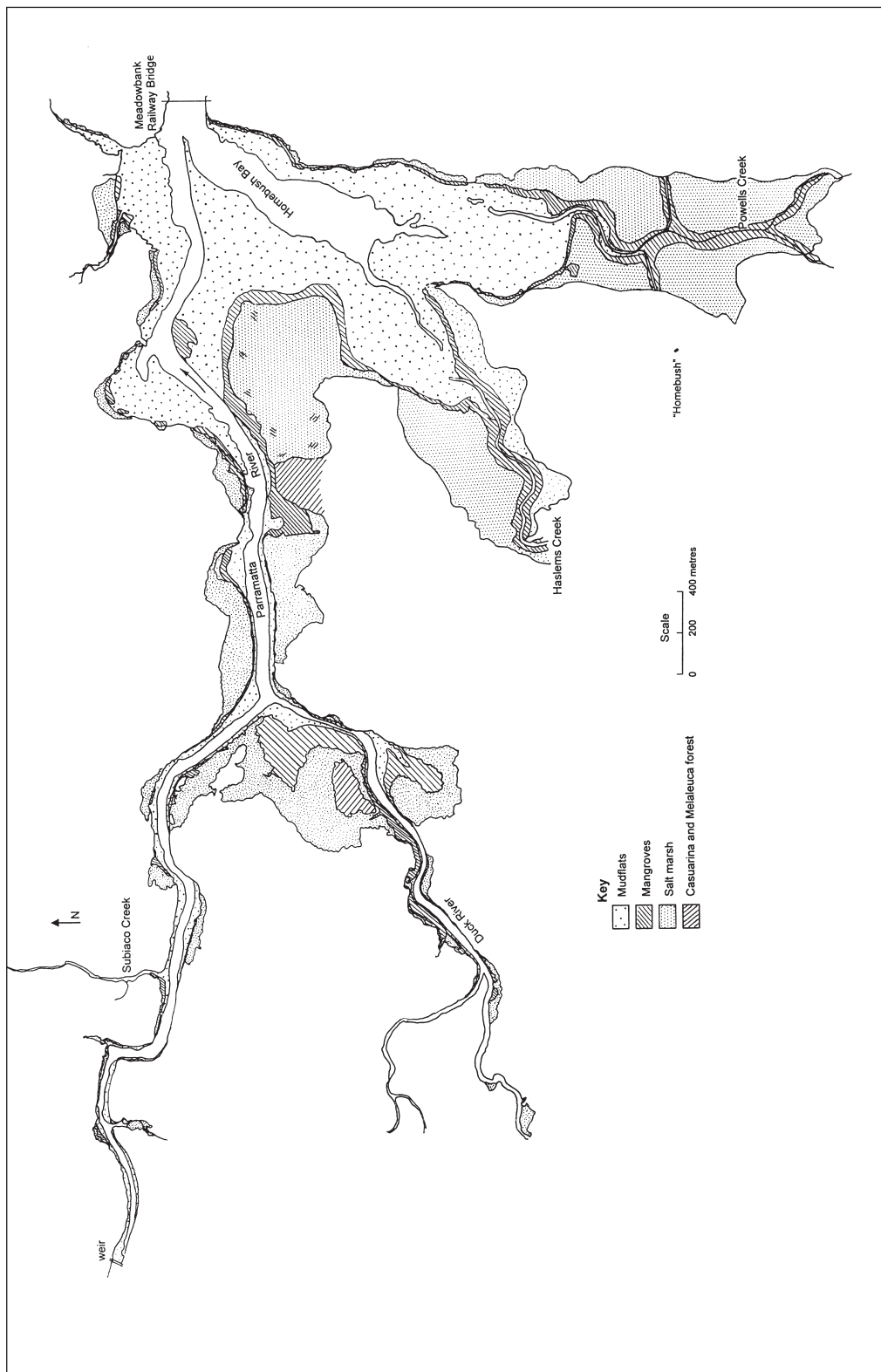
On Bradley's 1789 chart from Charity Point to Parramatta (3: 3, Fig. 2) both Homebush Bay and the river upstream are shown as predominantly consisting of inter-tidal areas cut by narrow navigable channels generally 2–3m deep. The 'Flats' could have been mudflats or saltmarsh but the stippled area on Bradleys chart did not carry mangroves — a mangrove island mentioned in his journal is delimited separately. 100 years later, a map compiled in 1891 (3:21) confirmed much of the topographic detail of Bradley's chart. Bradley's stippled areas were in fact extensive areas of mudflats and were still mudflats in 1891 (Fig. 3b) although the mudflats at the mouths of Haslams and Powells Creeks had prograded 190 m out into the Bay, presumably as a result of a century of clearing in the catchment and accelerated siltation.

In 1793 Atkins (1:9) appears to have spent hours tramping across saltmarsh at Homebush Bay before trying to get through a mangrove or casuarina/melaleuca thicket. Louisa Meredith (1:17) describes mangroves along the creeks and embankments of drains cut through the saltmarsh of Homebush Bay by the 1840s but on Powells Creek mangroves appear to have been discontinuous and there is no reference to large clusters of mangroves at Homebush Bay. Hamilton similarly describes mangroves lining channels at Homebush Bay in 1919 (1:21).

Confirming aspects of these earlier accounts, the plans of the 1890s (Fig. 3b) provide evidence of very extensive saltmarshes and mudflats from Homebush Bay to Duck River. Although there were several large patches of mangroves on Duck River and at Newington, mangroves were mainly restricted to fringes, generally narrow or in patches. There were also some large stands of *Casuarina* and *Melaleuca* forest. Both mangroves and casuarinas were found in small patches through the saltmarsh east of Newington.

Comparison of Fig. 3b with Clarke and Benson's (1988) maps from aerial photographs demonstrate the distribution of mangroves and saltmarsh on Haslams and Powells Creeks changed little between 1890 and 1930 except for the drainage channels east of the 'Homebush' residence, which no longer appear to be present in 1930. However there are dramatic changes in the wetlands of Wentworth Point on the western side of the bay with most of the former mudflat colonised by both saltmarsh and mangroves. Construction of seawalls in the early 1890s along the western shore of the bay and around the point, followed by dredging and reclamation 1905–1917, substantially altered the topography and inter-tidal zone of the enclosed area. Pumping dredged sediment onto this area, or diverting sediment deposition, may have enabled the expansion of mangroves and saltmarsh apparent by 1930 by sufficiently raising the level of parts of this inter-tidal mudflat. From the 1940s the area of saltmarsh and mangroves progressively declined as the major reclamation project of 1948–61 shaped the present form of Homebush Bay.

Seawalls were extended further upstream to Duck River on the south side by 1913 (Sydney Harbour Trust 1931). Surveys in the kilometre stretch downstream of Duck River between 1919 and 1931 (3:28–31) show a few patches of expanding mangroves on the south side as prograding mudflats are colonised.



There are few images of Homebush Bay, either paintings or photographs prior to the 1940s. In similar views across Rhodes peninsula and Homebush Bay from the high ridge above the river at Ryde in an 1860 painting (2:25) and an 1880 photograph (2:33) a dark band of mangroves is obvious along the shoreline of Homebush Bay, particularly in the 1880 photograph. Oblique angle aerial photographs of the river in the 1920s show extensive patches of mangroves in Homebush Bay and mangrove fringes along sections of the river banks upstream, although by no means continuous (2:43–46).

Upper Parramatta River above Duck River

In the narrow Upper Parramatta River, early descriptions give no hint of mangroves or other wetland vegetation, but rather of open banks and long grass (1:1–4). It would also not seem possible to see the houses and features mentioned by travellers as visible on a trip up the river in a small boat, if the river was lined with mangroves. These writers included Lt. King in 1790 (1:4), Peter Cunningham in the 1820s (1966) and John Henderson in the 1850s. The latter's description of the Parramatta River (1:18) contrasts markedly to his description of the Hunter estuary up river from Newcastle (150 km north of Sydney) where it begins to narrow and wind, 'the mangroves lining it to within the water's edge'.

Of 28 pictures (Table 2) created prior to 1870, 20 are of the river upstream from Subiaco Creek, Rydalmere. Only one shows vegetation that might be mangroves. Instead the banks are open to the water's edge with scattered or clumped eucalypts, casuarinas and other shrubs and small trees, or they are low cliffed banks about 2 m high (Fig. 4a) as King (1:4) described, in marked contrast to this stretch of river today (Fig. 4b).

The single painting (2:4) which possibly shows mangroves is so open to question that it cannot be taken as evidence without corroboration. Dated two years later than the very similar No. 3, small shrubs appear near the water on a bend on the northern bank downstream from Parramatta wharf. These shrubs are not present in No. 3 and could represent newly established mangrove seedlings. However, McCormick (1987) points out that other discrepancies between views 3 and 4 suggest that No. 4 was drawn from an 'earlier indistinct sketch'. In addition the shrubs are at some distance and not clearly depicted as in the intertidal zone, nor even on the water's edge. All other pictures of the same bend in the river have no mangroves present.

The pictures of and from, the Female Orphan School comprise the most consistent series anywhere on the river, depicting changes through to the 1870s. From the earliest views after its completion in 1818 the steep slope to the river in front of the school is open and grassed. But along the water's edge a narrow flat supports a continuous

Fig. 3b. Composite map of wetlands of the Parramatta River in the 1880s and 1890s: Homebush Bay to Parramatta wharf. Sources: Plan 21 (Table 2) — detail for much of Homebush Bay and for mudflats on most of map, Plan 25 — most of the saltmarsh and mangrove distribution, except west and south of Homebush Bay. Dated 1891 and 1893, the vegetation distribution on these two plans has a high level of agreement, except south of Haslams Creek where the zone beyond the mangroves is shown as 'salt swamp' on Plan 25, 'clay flat with mangroves in patches' on Plan 21. Density of shading for this area lies between mudflat and saltmarsh due to this discrepancy in the sources.

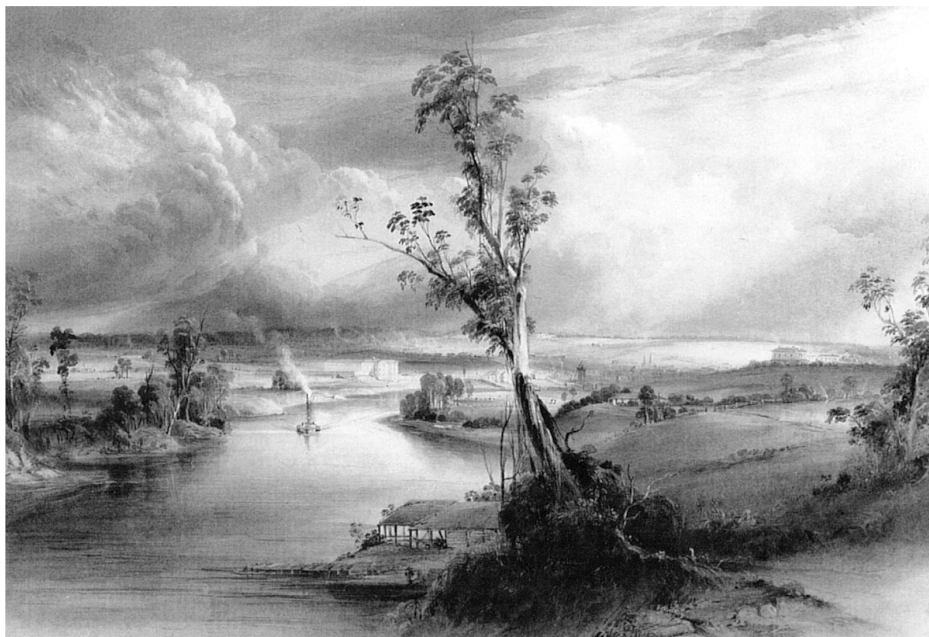


Fig. 4a. Parramatta c. 1837, Conrad Martens (The Clyde Bank Collection, Sydney). View upstream to Parramatta from Vineyard Creek. James Ruse Drive now crosses just beyond the boatshed on the water's edge. The entrance to Clay Cliff Creek, which winds up past Elizabeth Farm, is visible at left.



Fig. 4b. Parramatta River, 1999. View upstream from James Ruse Drive bridge over the river, of the same stretch of river as depicted in Fig. 4a. The entrance to Clay Cliff Creek is visible on the left.



Fig. 5a. View of the Female Orphan School, Joseph Lycett, 1824 (Lycett 1824–5, Mitchell Library, State Library of New South Wales). Despite Lycett’s stylised portrayal of landscape and vegetation, this image, along with others of both banks of this stretch of river listed in Table 2 (Nos 6–8, 10, 12–17) depicts a shoreline vegetation of a diversity of eucalypt, casuarina and shrub species.

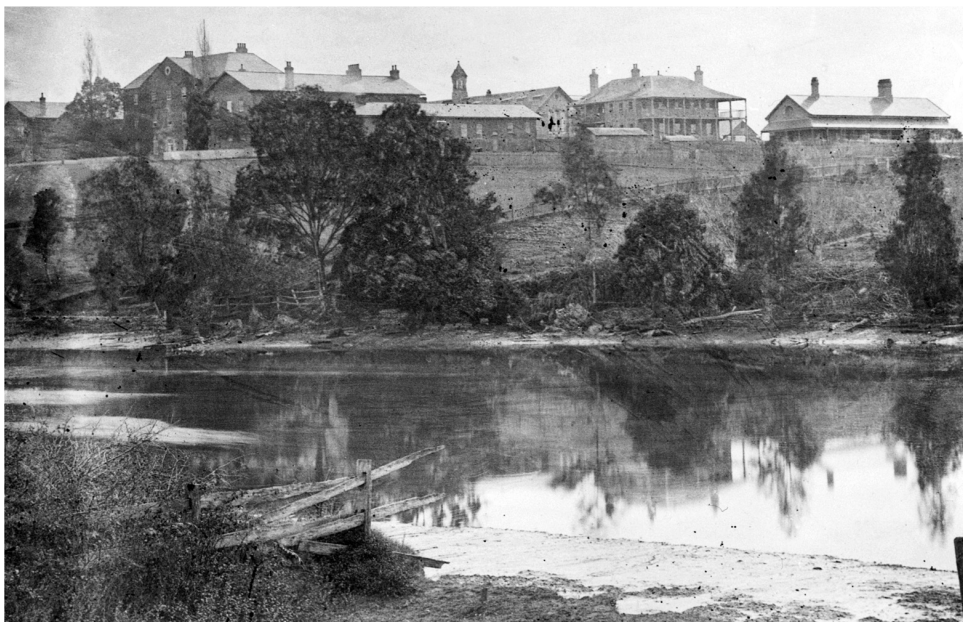


Fig. 5b. View of Protestant Orphan School, 1870s (Mitchell Library, State Library of New South Wales, GPO 1-06131). A young mangrove grows on the accreting mud along the foreshore in front of the Orphan School. This shoreline now has a complete fringe of tall mangroves. The Orphan School boatshed (in Fig. 4a) and elements of the former foreshore vegetation survive behind this fringe.

fringe of eucalypts, casuarinas and shrub species (Fig. 5a). Later pictures variously show the fringe as clumps and scattered trees (2:8, 10, 17) or relatively unbroken (2:15, 32). By about 1850, accumulation of sediment along the banks is obvious (2:17, 31) and in the 1870s an early photograph clearly shows a single young mangrove in the intertidal zone in front of the band of eucalypts and other terrestrial species (2:32, Fig. 5b). Today elements of the former waterfront fringe of terrestrial species still stand behind a tall belt of mangroves.

Discussion

Vegetation at the time of settlement

The combined written, pictorial and cartographic evidence builds a substantial, although incomplete, picture of the foreshores of the Parramatta River in the early years of settlement. Along the northern sandstone shoreline from Greenwich to Charity Point (and on the sandstone parts of the southern shores) rock outcrops and platforms were interspersed with sandy beaches (3:11, Campbell 1919, Cunningham 1966), backed by *Casuarina glauca* and moderate to steep slopes of sandstone eucalypt woodland. In the small narrow bayheads tributary creeks had built pockets of alluvium, beaches, limited mudflats and small areas of saltmarsh, reeds and rushes but few, if any, mangroves. On the south side from Balmain to Uhrs Point in the coves around the large embayments draining a largely shale catchment, were significant areas of intertidal mudflats and of low-lying alluvium covered in saltmarsh communities. There were patches of mangroves, particularly in the southeast of the coves and/or fringing the creeks but they did not form a consistent outer zone to saltmarsh.

From Homebush Bay upstream past Duck River erosion of the Wianamatta Shale had created broad areas of low-lying land, much of which flooded on spring high tides, and, like the southern bays downstream, large areas of inter-tidal mudflats not colonised by either mangroves or saltmarsh. Vegetation on the low-lying alluvium was dominated by extensive saltmarsh communities. Mangroves were present, at least along the Homebush Bay tributaries and on an island surrounded by mudflats (now part of the shoreline upstream of Wentworth Point) but there is insufficient evidence to determine their distribution at this time as far as Subiaco Creek. On slightly higher parts of the alluvium were groves of 'casuarina' and 'melaleuca scrub'.

Upstream from Subiaco Creek there is no evidence of mangroves in the early years of the colony. Here evidence indicates open eucalypt woodland with grassed understorey and well-spaced trees on raised alluvial banks, or mixed casuarina and eucalypt woodland with shrub understorey closer to the water's edge. Colonisation by mangroves appears to have begun in this part of the river in the latter part of the 19th century.

Post-settlement changes

Settlement along the river commenced at Parramatta in November 1788, Impacts included increased sedimentation, increased turbidity and changes in water quality with increased nutrient loading and other forms of pollution. As these accelerated, the wetland systems responded. Mudflats expanded in bays and along the margins of the river and by the late 19th century, mudflats were a dominant component of the intertidal zone (Figs 3a and 3b), along with saltmarsh.

Mangroves colonised upstream along shoreline not previously colonised, out onto mudflats and landwards into saltmarsh. There is evidence of mangroves beginning to appear in the upper river in the 1870s (Fig. 5b) and by the 1890s significant patches were established upstream from Duck River (Fig. 3b). By the 1930s mangroves in the southern bays were being targeted by local councils for reclamation (1:22). The Reclamation Act 1930 set up mechanisms by which reclamation could be approved, funded and the resulting land legally disposed. Recording of subsequent reclamation thus often describes areas reclaimed as mangrove swamps but the inference that mangroves were the pre-European vegetation, which remained intact until they were destroyed by reclamation, is a simplistic view of post-1788 impacts on these wetland systems. Using aerial photographs, Thorogood (1985) demonstrated that expansion of total mangrove area in Port Jackson-Parramatta River continued up until the 1950s with a 20% increase from 1930 to 1951, despite reclamations during this period.

Figs 3a and 3b show wetland vegetation 40–50 years earlier than previous mapping based on aerial photographs from the 1930s–40s. Whilst this cartographic evidence of wetland distribution is the most concrete and detailed available to date for the period prior to the 1930s, it represents only a snapshot in a possibly very dynamic system. However, there is some evidence, for example comparison of Figs 2 and 3b, that change in wetlands over the first 70–100 years may have occurred mainly as expansion of mudflats. Mangroves then expanded first onto mudflats and up river from the latter part of the 19th century (Fig. 3b) and into saltmarsh in the 20th century.

Although reclamation has been considered largely responsible for losses of extensive areas of wetland vegetation in most of the bays along the river (Lynch et al. 1976, Forbes and Shillington, 1987), comparison of Figs 3a and b with modern maps reveals that in many places the modern seawalled shoreline closely mirrors the low tide edge of the mudflats of the 1880s–90s. Areas filled were predominantly mudflats in the earlier reclamations of the late 19th and early 20th centuries. Later reclamations from the 1930s, such as at Hen and Chicken Bay, Homebush Bay and Duck River, affected large areas of saltmarsh. Mangroves were also affected but at least some of the mangroves destroyed during reclamation were of recent origin.

The mangrove referred to previously in this paper is the Grey Mangrove, *Avicennia marina*. *Aegiceras corniculatum* (Forsk.) Vierh., the River Mangrove was identified as abundant 'on the banks of the Parramatta River' in 1859 by William Woolls (1:19). However, of 25 specimens of *Aegiceras corniculatum* held by the National Herbarium of NSW, collected in the Sydney region from Broken Bay/Hawkesbury River to Port Hacking between 1887 and 1996, none are from the Parramatta River. Likewise, of

seven specimens held by the Royal Botanic Gardens, Kew, England, collected in the same region from 1862–1984, none are from the Parramatta River (R. Chinnock, Australian Botanical Liaison Officer, Kew, pers. comm., 17 Sept. 1999). Both collections include a specimen collected in 1802–05 by Robert Brown from 'Port Jackson', at that time a general term for the entire Sydney settlement.

Only one of the studies or listings reviewed for this paper lists *Aegiceras* as present in the 20th century (Clarke & Benson 1988). Benson (pers. comm., 24 June 1999) states he saw one plant at Bicentennial Park, Homebush Bay which was later destroyed by boardwalk construction. It was not found by later Homebush Bay studies (Webster & Kachka 1992, Kachka 1993, M. Burchett, UTS Sydney, pers. comm. 26 July 1999) but has recently been located in a small cluster at Bicentennial Park (Swapan Paul, Scientific Officer, pers. comm. 4 Feb. 2000) and at Duck River (P. Adam, pers. comm. July 2000). Although not common, River Mangrove is specifically listed for nearby estuaries, Brisbane Water, Hawkesbury River, Pittwater, Botany Bay, Georges River and Port Hacking (West et al. 1985) and for Lane Cove River (Lane Cove Council 1998).

Mangroves, among other inter-tidal vegetation, were burnt for barilla, an alkaline ash used for soap manufacture in Australia from 1810 to about 1850. However, although there is evidence of harvesting mangroves at Hen and Chicken Bay for timber in the early 19th century (1:14), there is no evidence for other harvesting in the Parramatta River. Most of the soap factories were at Botany Bay (Bird 1981) and harvesting may have been focussed there. Harvesting is unlikely to have affected later distribution as *Avicennia marina* colonises and regenerates strongly in the Parramatta River (Clarke & Benson 1988).

Lack of available inter-tidal mudflats is unlikely to account for the apparent mangrove distribution at the time of European settlement, given the extent of open mudflats at Homebush Bay, for example, at this time. However, sedimentation along the banks of the upper river may have contributed to their expansion there by the late 19th–early 20th century. Increased nutrients from the effects of settlement: clearing, agriculture, domestic animals and urbanisation, may also have rendered some inter-tidal areas more suitable for mangrove colonisation than they had been prior to settlement (Saintilan & Williams 1999). Other changes in conditions possibly influencing the relative distribution of mangroves and saltmarsh in this system are a reduction in the freshwater component of the river towards Parramatta with the construction of the first weir there in 1857 (SMEC 1976) and reduced salinity in saltmarshes due to increased precipitation on the east coast of Australia since 1945 (Saintilan & Williams 1999).

Planning and conservation

Studies using the earliest aerial photographs as the primary information for the 'former extent' of wetland vegetation of the Parramatta River, may be fundamentally flawed if this is taken to represent distribution earlier than the 1930s–40s, given 140 years of change in the river system to that time. Planning studies which produce development controls or recommendations for enhancement of foreshore areas and

restoration of 'natural' vegetation communities based on a datum point in the 1940s may likewise suffer from erroneous assumptions.

The availability of aerial photographs, Lynch et al's (1976) unsourced statement and ecological inference regarding the historical distribution and nature of wetland systems of the Parramatta River have had a significant influence on foreshore planning and restoration activity. Mudflats, or gaps in the mangrove belt along the shoreline have been taken to mean that mangroves have been destroyed. New mangrove growth has been taken to indicate 'regenerating' mangroves (Register of the National Estate n.d. c, e, DEP 1986b, 1986c, Powell 1987, Gutteridge, Haskins & Davey 1991) and bare mudflats and gaps have been recommended for revegetation or regeneration with mangroves to restore the 'natural' foreshore vegetation (SPCC et al. 1983, DEP 1986d, Moss 1987, Clouston 1995, Pittendrigh, Shrinkfield, Bruce 1996, EDAW and Environmental Partnership 1997).

This examination of the available historical evidence indicates assumptions that Grey Mangrove, *Avicennia marina*, was a dominant component of the pre-settlement Parramatta River wetlands are not well-founded. Saltmarsh, including reed and rush communities, appears to have been more extensive and these communities have suffered the most severe reductions in area as a result of settlement (Thorogood 1985, Burchett & Pulkownik 1996). The casuarina/ melaleuca associations, although formerly perhaps less extensive than saltmarsh, have also become rare. By contrast mangroves expanded significantly onto rapidly expanding mudflats in the bays and up river from approximately the 1870s to the 1950s and into saltmarsh, at least from the 1930s (Clarke & Benson 1988), until reclamation impacted their area. A similar pattern of expansion has been described for the Lane Cove River (McLoughlin 1987).

Williams and Watford (1997) found expansion along the shoreline, downslope and upslope occurred from existing mangrove stands in Berowra and Marramarra Creeks, tributaries of the Hawkesbury River, between 1941 and 1992. Mangrove extension into saltmarsh in the Sydney region in the 20th century has also been noted in Botany Bay (Mitchell & Adam 1989), Hawkesbury River (Saintilan 1997), and the Hunter River (Buckney 1987). Further afield, studies using aerial photographs are demonstrating mangrove transgression in many coastal estuaries of south-eastern Australia over the last 50 years, but not in every estuary or in all creeks within an estuary (Saintilan & Williams 1999). However, discussion of the mechanisms causing mangrove expansion into saltmarsh is hampered by the relatively short time frame of the aerial photographs available.

Saltmarsh has been demonstrated to be important as bird habitat in the Hunter estuary (Buckney 1987) and Homebush Bay (Straw 1996) and mudflats in Homebush Bay and Hen and Chicken Bay (Taylor & Hutchings 1996). In the Parramatta River large numbers of ducks and other waterbirds were noted in the Homebush Bay/Newington area, where there were large areas of saltmarsh and mudflats, by Richard Atkins in the 1790s and Campbell (1919) and Garling (1924) in the 1850s. The listing of Parramatta River wetlands on the Register of the National Estate (n.d., a–g)) includes their important role as habitat for migratory birds covered under international agreements.

Clarke and Benson (1988) and Burchett and Pulkownik (1996) noted the significant loss of saltmarsh at Homebush Bay and Adam (1996) of saltmarsh in the Sydney region. Saintilan and Williams (1999) note its significant loss in other estuaries of the east coast. Recent conservation and rehabilitation work in the Homebush Bay and nearby Newington wetlands associated with the Olympic Games site, has focussed on monitoring and methods for saltmarsh re-establishment (Burchett & Pulkownik 1996), and Leichhardt Council (1999) has undertaken a small saltmarsh revegetation program at its Federal Park in Annandale. Elsewhere there has been little recognition of losses in saltmarsh along the river, and there is still little consideration or effort given to the replacement/replanting of saltmarsh, rush and reed communities while the focus remains on mangroves or while the perception that saltmarsh only existed in narrow bands behind mangroves persists (DEP 1986c). The more recent foreshores improvement plan for Duck River (EDAW 1997), which considers re-establishment of salt marshes as 'an appropriate conservation priority', is an exception.

Ongoing loss of saltmarsh also has significant implications for management of mangrove seedling invasion of the existing small saltmarsh zones in heavily impacted areas such as the Parramatta River. In many parts of Sydney *Pittosporum undulatum*, a species native to wetter bushland environments, is regularly culled from dry sclerophyll areas where absence of fire allows its invasion and expansion, threatening the viability of those communities. Should mangroves be similarly culled where they invade saltmarsh, under what conditions and in which areas?

This paper has brought together a variety of historical evidence to shed light on the nature of wetland distribution on the Parramatta River at the time of European settlement and subsequent changes up to the 1930s when aerial photography provides more consistent data. The study illustrates the importance of both location specific studies and the role of historical evidence in reconstructing the former distribution of vegetation to provide a firmer basis for conservation (Lunt 1998), management and, if appropriate, restoration.

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