THE RELATIONSHIP BETWEEN MANGROVE AND SALTMARSH COMMUNITIES IN THE SYDNEY REGION

Meredith L. Mitchell* & Paul Adam

School of Biological Science
University of New South Wales
PO Box 1
Kensington NSW 2033

*Current address: Rutherglen Research Institute
Chiltern Valley Rd
Rutherglen Victoria 3685

INTRODUCTION

Coastal saltmarshes around the world are characterised by belts of vegetation parallel to the shore. The species and communities which define the zones vary geographically such that it is claimed that a particular zonation pattern is a feature of a broad geographical region (Chapman 1974). It has been suggested that the zonation pattern repeats in space the course of succession over time. The most seaward zone occupies the lowest elevation on the shore and is vegetated by pioneer species. As sediment accretes the marsh surface is raised, and thus experiences fewer tidal inundations. The changed physical environment is conducive to the invasion of species which replace the pioneers. However, conditions to seaward are now appropriate for colonisation so that the pioneer species move seaward. With further sedimentation the pioneer zone continues to migrate seaward (see Fig. 1) until a balance between accretion and erosive forces is reached and extension ceases.

The seral interpretation of saltmarsh zonation was championed by Chapman (1974) and has been widely accepted as a textbook example of the relationship between spatial and temporal patterns of vegetation. There have been studies in various parts of the world which have confirmed the dynamic nature of saltmarsh vegetation and have demonstrated that some of the patterns inferred from spatial patterns arise in the course of succession. However, as Beeftink (1977) emphasised, even in well studied areas such as northern Europe there are relatively few long term studies of succession and published succession diagrams have many speculative elements. Despite the apparent logic of most such diagrams present day zonation does not necessarily represent former successional changes nor provide a guide to future changes. One example which clearly demonstrates this is provided by *Spartina anglica*, the grass which now dominates the lowest marshes in much of northern Europe (and also marshes in Tasmania and New Zealand). *S. anglica* is presumed to be of recent hybrid origin and first appeared towards the end of the last century. Where *S. anglica* has invaded, or been planted, in front of existing marshes there is sharply delineated zonation between *Spartina* dominated communities and the communities at higher elevations. *S. anglica* did not play any part in the genesis of those communities occurring in the zones above it, and the future course of succession from *Spartina* is still uncertain.

In New South Wales (as elsewhere in Australia) saltmarsh characteristically occurs at higher elevations than mangroves and it is not surprising that it has been suggested that in the course of succession mangrove is replaced by saltmarsh. Under the influence of the American ecologist Clements succession was regarded as one of the most important unifying themes in ecology from the 1920's onwards. The striking mangrove/saltmarsh zonation was an obvious candidate for successional interpretation, which was provided by Pidgeon (1940 - see Fig. 2).

Pidgeon (1940) proposed that mudflats around Sydney were colonised by mangroves (*Avicennia marina*); as sediment accretes mangroves move further into the estuary and on the landward side mangroves are replaced by saltmarsh species. Pidgeon's succession diagram was based on observations of zonation, with no additional support from historical or other studies. Most textbook successions (for example those on glacial moraines or sand dunes) involve increasing structural complexity of the vegetation (from mosses and lichens, through herbs to shrubs and then trees). The succession postulated by Pidgeon (1940) is unusual in that it involves replacement of trees by herbs, but this aspect of the proposal has not previously been subject to comment. Pidgeon (1940) did not identify any change in environmental conditions which might confer a competitive advantage on herbs over trees.

Pidgeon's succession diagram should be regarded as a plausible hypothesis, amenable to testing, but not as a definitive statement. Unfortunately it has been accepted uncritically and has been given as an example of succession in textbooks (see for example Carey 1944); it has become part of the basic biological dogma instilled into generations of senior school students.

Kratchovil, Hannon & Clarke (1973) suggested that Pidgeon's model of succession could not be supported but unfortunately did not provide evidence to support their view.

In this paper we discuss a number of lines of evidence which argue against any general acceptance of Pidgeon's hypothesis.

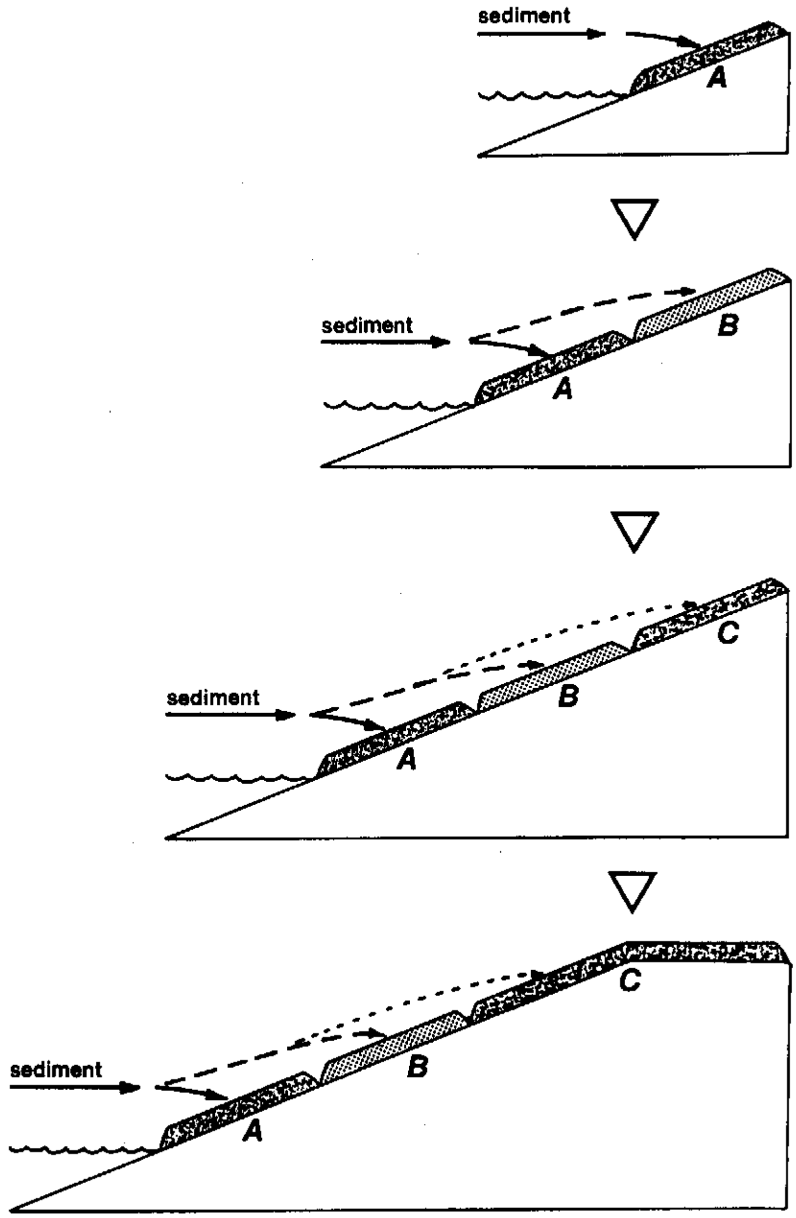


Figure 1. Schematic representation of the classic saltmarsh succession with tideborne sedimentary input. On a stable coast the marsh surface cannot reach an elevation greater than that of the highest tide, so that the old marsh surface becomes level, while continued accretion permits the seaward extension of the pioneer zone (A = pioneer species, B = midmarsh species, C = high marsh species).

PREDICTIONS FROM THE MODEL

A number of testable predictions can be proposed on the basis of the successional interpretation of mangrove/saltmarsh zonation.

Clearly if the model is of general applicability the observable zonation patterns at a number of sites should match that in Figure 2.

Over a period of time the zonation pattern would be expected to advance seaward; new areas would be colonised by mangroves and the original upper part of the mangrove zone would be replaced by saltmarsh. As a further consequence we might expect to find some evidence of former mangroves in the sediment underneath present saltmarsh. (Figure 3). *Avicennia marina* wood has an easily recognisable wood structure, and even relatively small fragments could yield identifiable sections.

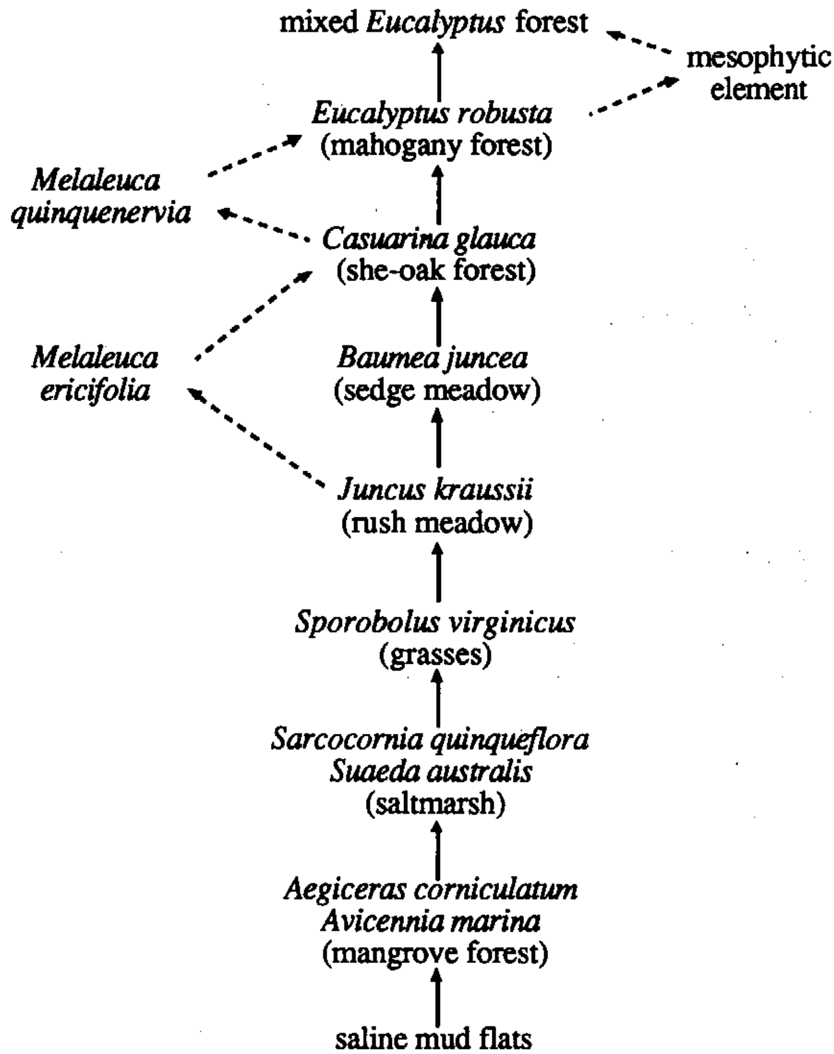


Figure 2. The succession model proposed by Pidgeon (1940). Nomenclature has been amended.

The basic model of intertidal succession is driven by sedimentation so that the rate of change in the vegetation will be a function of the sedimentation rate. If this rate is low then the change in vegetation may be correspondingly slow. In the absence of data on sedimentation, evidence of little change in vegetation boundaries over historic time would not count against the hypothesis. However, invasion of saltmarsh by mangroves would be incompatible with the succession model.

If new areas of intertidal sediment become available for colonisation the model would predict initial invasion by mangroves followed in time by replacement by saltmarsh.

EVIDENCE

We are not aware of any long term mapped permanent quadrats which could be used to monitor changes in intertidal wetlands in New South Wales by direct observations. In the absence of such data we have used as a proxy aerial photographs to map the position of vegetation zone boundaries at various times since the 1930's for a number of sites in the Georges River - Botany Bay estuary system (Fig. 4).

During this time seaward extension of mangroves has occurred at several locations - this expansion is especially evident at the top of Salt Pan Creek. Similar extensions of mangroves has been recorded in the Parramatta and Lane Cove Rivers (Thorogood 1985, McLoughlin 1985, 1987). This spread has been directly onto mudflat and has not involved a saltmarsh stage.

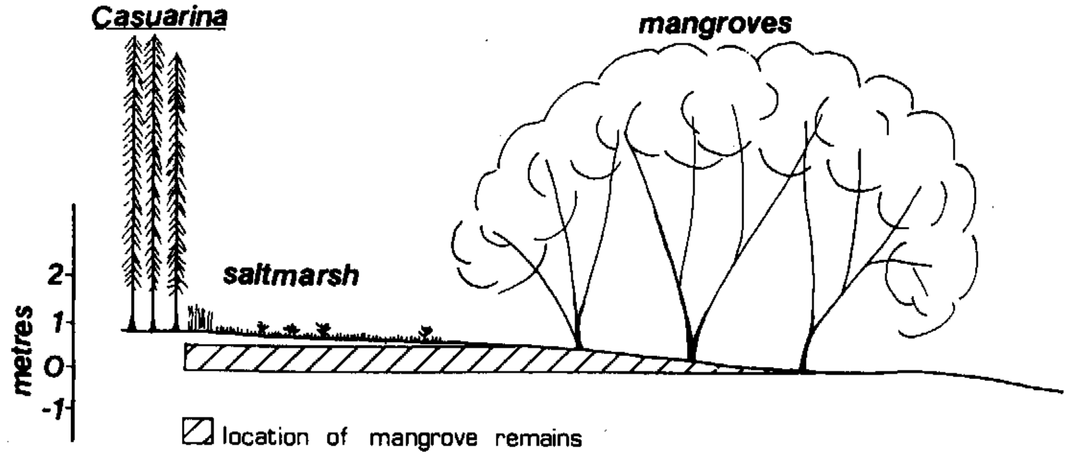


Figure 3. Predicted location of mangrove remains in sediment below saltmarsh. Elevation in metres above Australian Height Datum (AHD).

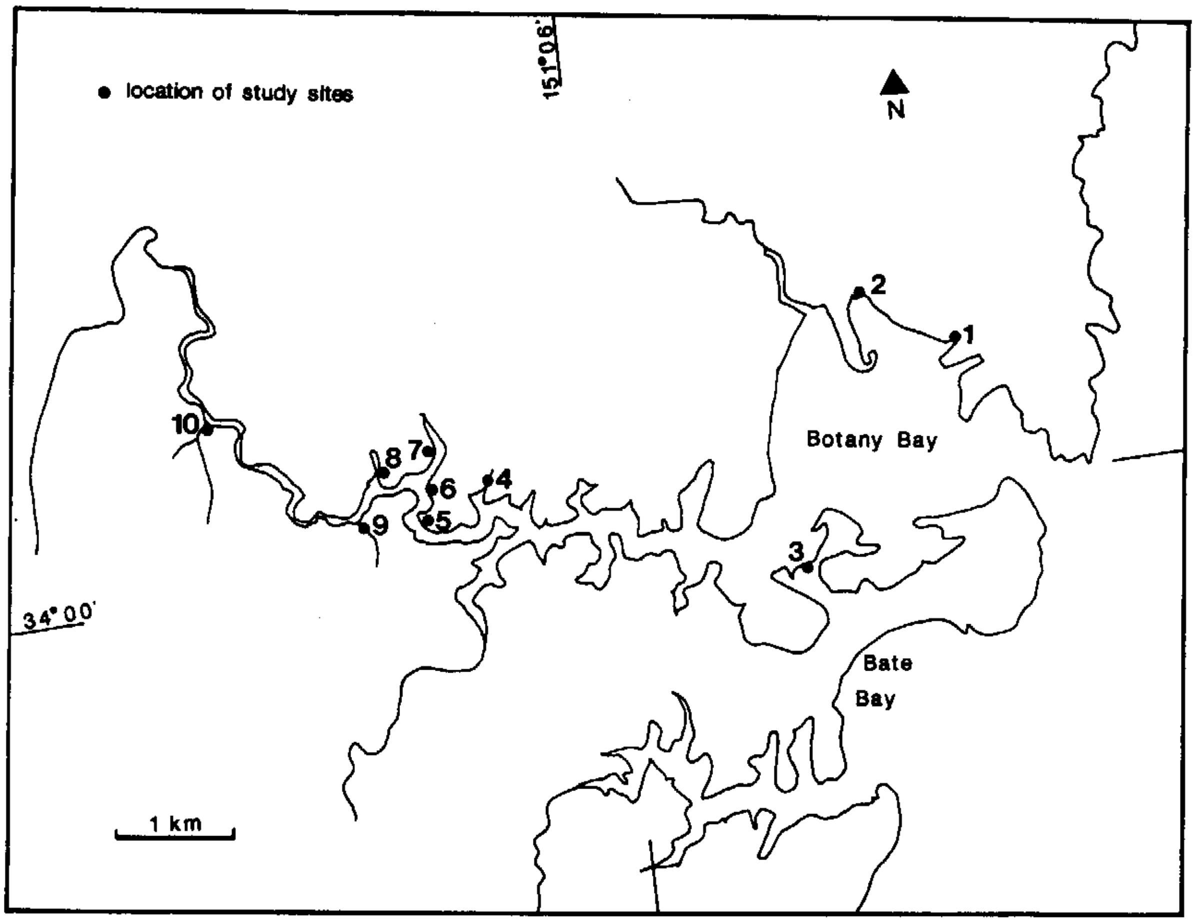


Figure 4. Location of study sites in Botany Bay and along Georges River. 1: Penrhyn Rd, 2: MSB Hydraulics Laboratory, 3: Towra Point, 4: Lime Kiln Bay, 5: Moon Bay, 6: opposite Alfords Point, 7: Salt Pan Ck, 8: Little Salt Pan Ck, 9: Mill Ck, 10: Williams Ck.

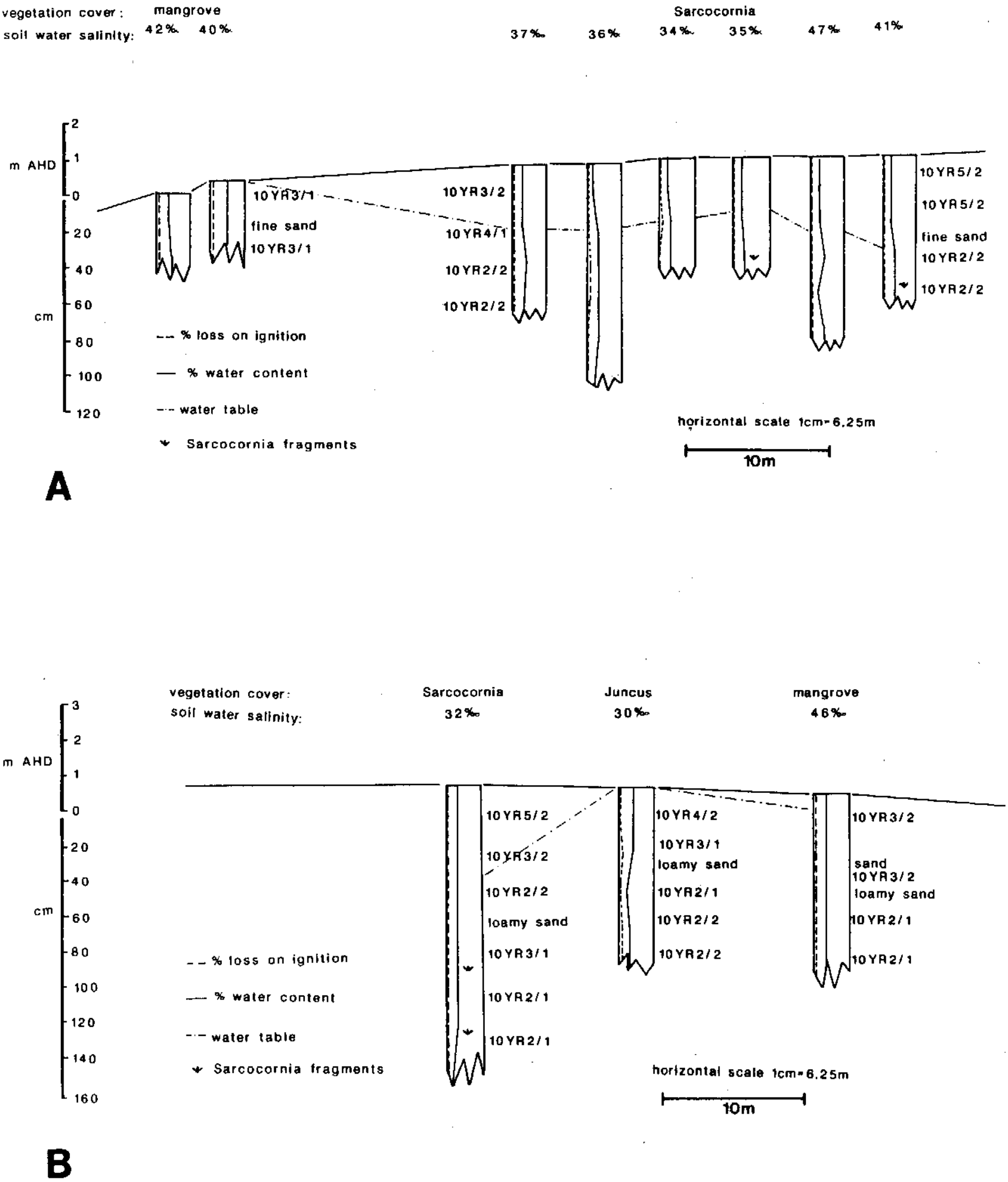


Figure 5. Examples of core data for transects. Note that there is no increase in organic matter with depth below saltmarsh as would be expected if the succession model were true. Colour indications (10YR5/2 etc.) are from the Munsell colour chart. A: Towra Point. B: Mill Creek.

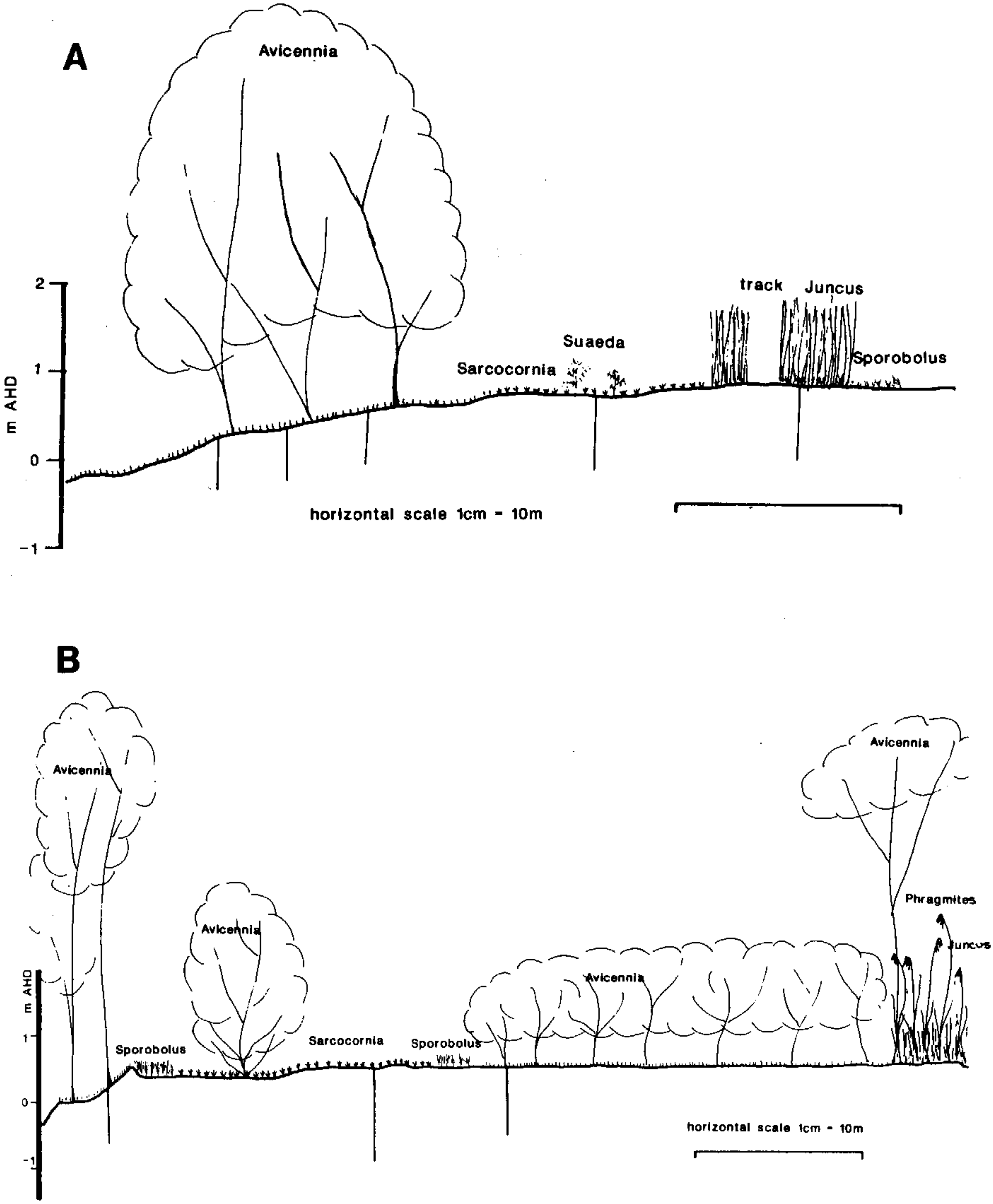


Figure 6. Zonation diagrams for selected transects. Vertical lines indicate position of stratigraphic samples. Scale bar indicates 50m. A: Towra Point. B: Moon Bay.

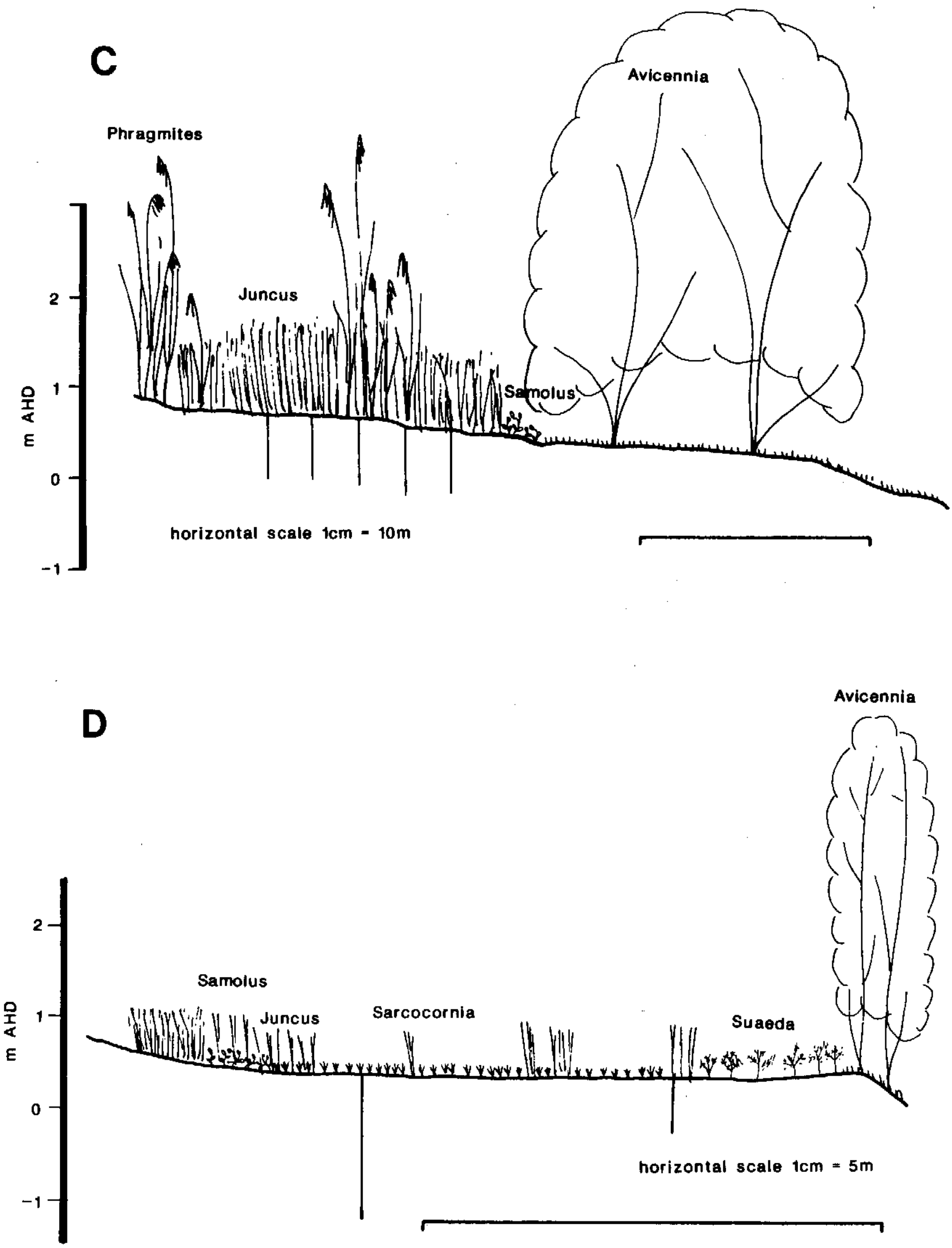
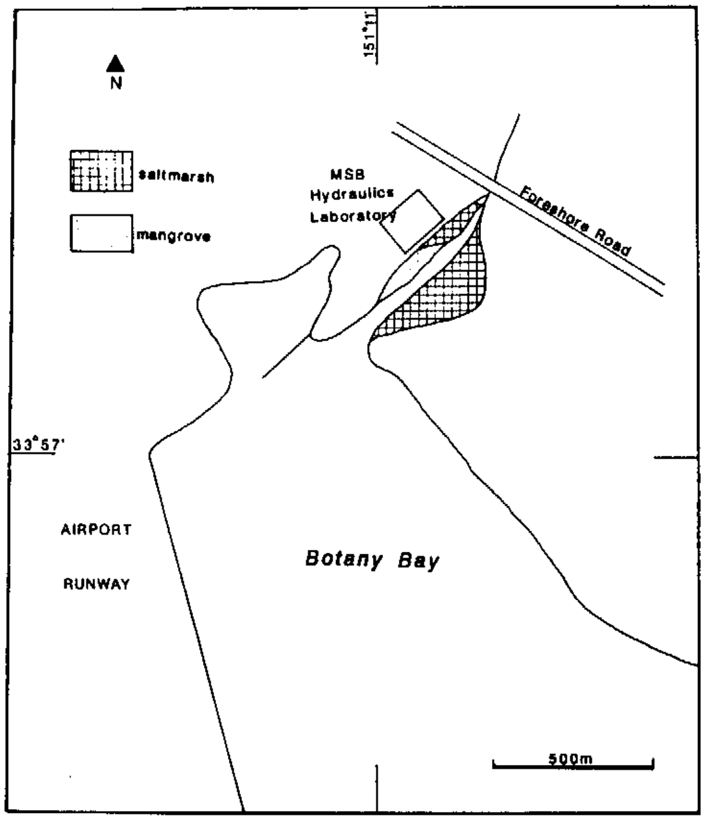


Figure 6 (cont'd). C: Little Salt Pan Creek. D: Mill Creek.



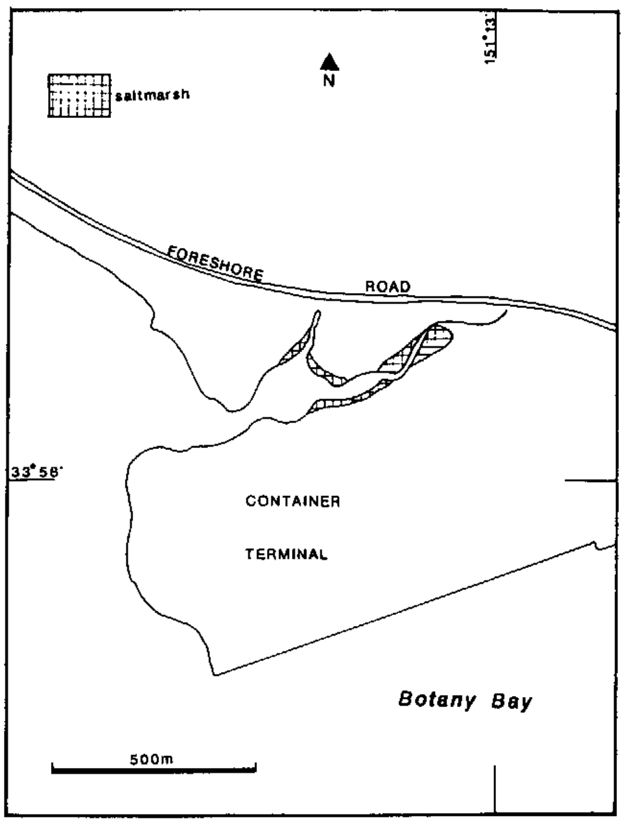


Figure 7. Newly developing saltmarshes, northern shore of Botany Bay.

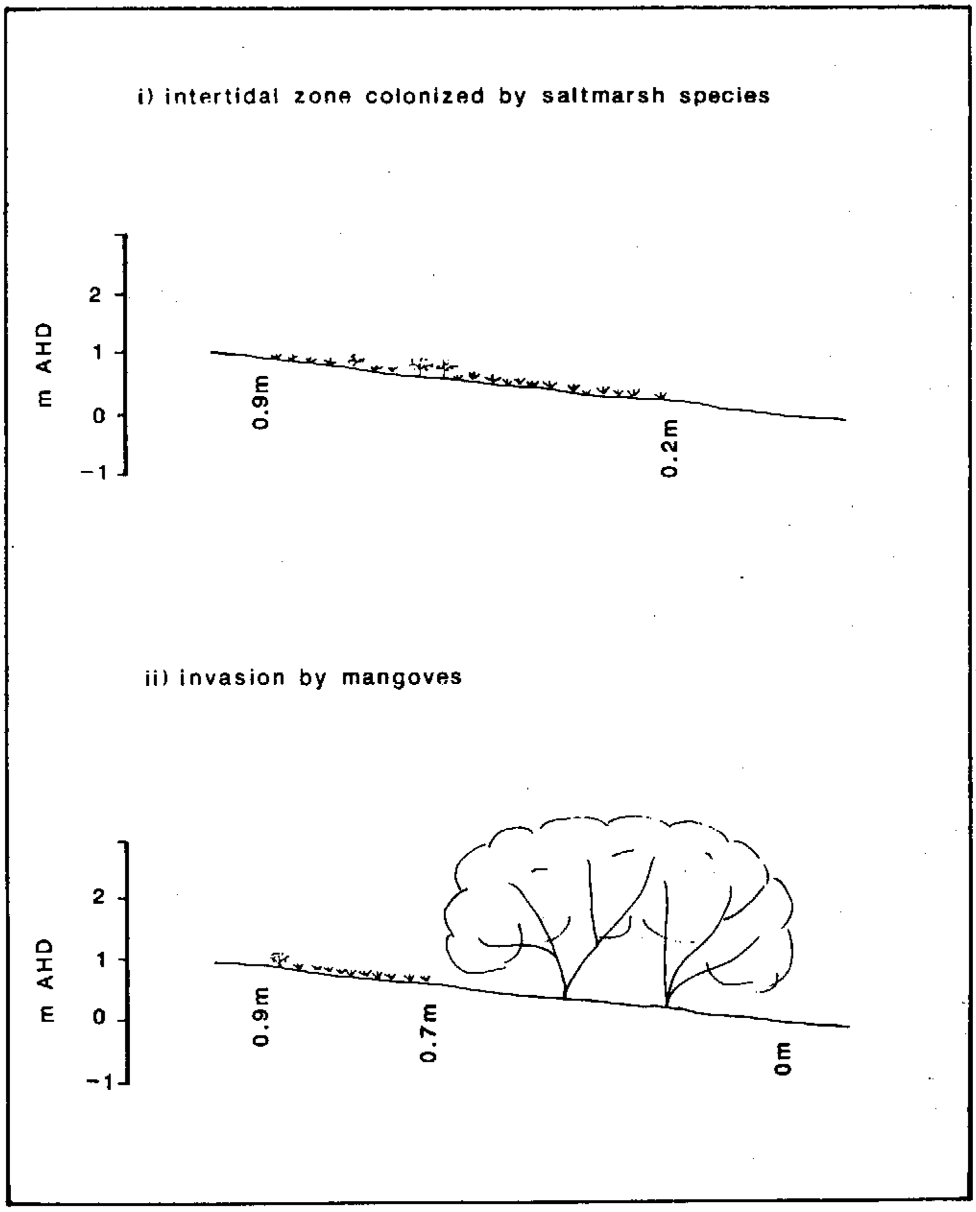


Figure 8. Proposed model of succession on saline mudflats in the Sydney Region.

The major increase in mangrove area has been by encroachment into saltmarsh which has occurred at Towra Point (Mitchell & Adam 1989) and at Lime Kiln Bay and Mill Creek in the Georges River and at Cabbage Tree Basin in Port Hacking.

Bore holes were augered at intervals along transects through saltmarsh and mangroves at various locations. In no case did the stratigraphy provide any indication of the previous occurrence of mangroves at sites now supporting saltmarsh (Fig. 5).

Our observations at various sites indicate that as a summary of the species zonation in intertidal wetlands Pidgeon's diagram is a synoptic overview but the full suite of possible zones is not encountered at every site (Fig. 6).

New sites for the development of intertidal wetland are rare. However, the development of Port Botany and the reshaping of the northern foreshore of Botany Bay in the late 1970's provided two sites for colonisation, one close to the MSB Hydraulics Laboratory at the junction of General Holmes Drive and Foreshore Road and the other close to Port Botany at Penrhyn Road (Fig. 7). The developing vegetation at these sites was studied by Wilson (1984) and we have added to his observations. The initial colonists at these sites were not mangroves, as would be predicted by Pidgeon (1940), but saltmarsh species with only a few scattered mangrove seedlings. The elevation range of these saltmarshes extends much farther downwards in the intertidal zone than does the saltmarsh at Towra Point on the southern side of Botany Bay, where the saltmarsh occurs above mangroves.

DISCUSSION

We have been unable to find evidence which would support the seral interpretation of the saltmarsh/mangrove zonation. On the other hand the invasion of saltmarsh by mangroves and the pattern of development at the two sites in northern Botany Bay are directly contrary to prediction based on Pidgeon's (1940) model. Although we cannot deny the possibility that at some sites the classic model may apply we would argue that it can no longer be accepted as a generalised statement about the development of intertidal wetlands.

Based largely on the observations of the northern Botany Bay sites we would suggest an alternative hypothesis to explain the mangrove/saltmarsh zonation (Fig. 8). Initial invasion of intertidal mudflats is primarily by saltmarsh species; subsequently the lower part of the saltmarsh is invade by mangroves. The question then arises as to why, if mangroves replace saltmarsh in the lower intertidal, they do not spread upwards and replace all the saltmarsh. This we cannot answer, although the evidence of continuing invasion of saltmarsh by mangroves (Mitchell & Adam 1989) suggests that the mangrove/saltmarsh boundary is not a stable one.

It seems probable that if the proposed third runway at Sydney airport is built the developing wetland near the MSB Hydraulics Laboratory will be destroyed. The development of the wetland at Penrhyn Road should be monitored to test our hypothesis for the development of the mangrove/saltmarsh zonation.

ACKNOWLEDGEMENTS

We thank Captain O'Keefe, Harbour Master of the Port of Botany Bay for permission to carry out fieldwork on the saltmarshes in northern Botany Bay and the Director, National Parks and Wildlife Service for the issue of a permit to work at Towra Point and along the Georges River. Alaric Fisher and Stephan Williams assisted with fieldwork and Alaric Fisher prepared the manuscript for publication.

REFERENCES

Beeftink, W.G. (1977). The coastal saltmarshes of western and northern Europe: an ecological and phytosociological approach. In Chapman, V.J. (ed.), *Wet Coastal Ecosystems*. Elsevier, Amsterdam. pp. 109-155.

Carey, G. (1944). *Botany by Observation. A Textbook for Australian Schools.* Angus & Robertson, Sydney.

Chapman, V.J. (1974). *Salt Marshes and Salt Deserts of the World. 2nd ed.* Cramer, Lehre.

Kratochvil, M., Hannon, N.J. & Clarke, L.D. (1973). Mangrove swamp and saltmarsh communities in southern Australia. *Proceedings of the Linnean Society of NSW* 97: 262-276.

McLoughlin, L. (1985). *The Middle Lane Cove River: a History and a Future.* CEUS Monograph 1. Centre for Environmental and Urban Studies, Macquarie University.

McLoughlin , L. (1987). Mangroves and grass swamps: changes in the shoreline vegetation of the middle Lane Cove River, Sydney, 1780's - 1880's. *Wetlands (Australia)* 7: 13-24.

Mitchell, M.L. & Adam , P. (1989). The decline of saltmarsh in Botany Bay. *Wetlands (Australia)* 8(2): 55-60.

Pidgeon, I.M. (1940). The ecology of the central coast of New South Wales III. Types of primary succession. *Proceedings of the Linnean Society of NSW* 65: 221-249.

Thorogood, C.A. (1985). Changes in the distribution of mangroves in the Port Jackson - Parramatta River estuary from 1930 to 1985. *Wetlands (Australia)* 5: 91-96

Wilson, N.C. (1984). *The Plant Communities of the Saltmarshes of the Sydney Region.* Unpublished honours thesis, School of Botany, University of NSW.