

Palynology techniques: A useful tool for Integrated Catchment Management.

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ABSTRACT: *Stratigraphic and pollen studies can extend and complete contemporary environmental information required for Integrated Catchment Management. In Australia, post-European sediments are easily identified by the presence of introduced pollen. Yarra River pollen data verify stratigraphic analyses that indicate the lower reaches of the river act as a sediment sink. The Latrobe River and Lake Wellington pollen studies give data on floodplain and lake sediment deposition, storage and pollution transport. Historical vegetation responses to land-use change are also apparent and management implications are discussed.*

1. INTRODUCTION

Integrated Catchment Management utilises data from many sources to consider sediment mitigation, nutrient transport and pollution problems within catchment systems. Prediction is a major component of these management strategies that often incorporate a "return to natural systems" component. These natural systems operate over time scales beyond those generally considered by land managers. Effective Integrated Catchment Management needs a long term historical component to augment contemporary monitoring programs (Grayson et al., 1994 and Clark and Wasson, 1988).

Instrumental data is broadly based and only of general use for current specific catchment management problems. The introduction of European grazing, agriculture, industry and urbanisation had a rapid and extensive impact on the Australian landscape disrupting Aboriginal land-use practices and altering established fire regimes. Many of these changes were not recorded and as a result historical accounts of the impact of settlement are sparse, incomplete, short and Eurocentric. To resolve modern environmental resource issues concerning vegetation, soil and land-use interactions with increased accuracy, additional techniques such as fossil pollen and stratigraphic analysis techniques are required to augment the contemporary historical and instrumental record (Clark, 1986; Gell et al., 1994).

In Australia, the presence in the stratigraphic record of pollen from introduced plants such as *Pinus*, *Salix*, *Plantago* and *Rumex* indicates the beginning of European settlement. This boundary enables comparisons to be made between the pre-settlement landscape and the effects of European land-use. Recent pollen studies have begun to consider the environmental issues of sedimentation, erosion,

hydrologic and vegetation changes related to European impact (Clark, 1986; Reid, 1989; Gell et al., 1993; Rutherford and Kenyon, in prep.).

This paper shows that fossil pollen analysis is a powerful tool that can be incorporated into Integrated Catchment Management studies. The specific objectives of this paper are to demonstrate: 1) the presence of pollen from introduced plant taxa provides a chrono-stratigraphic marker that delineates pre- and post-European sediments and vegetation thus providing a precise relative dating tool for sediments; 2) pollen assemblages within sediments give information on the patterns and extent of sedimentation and sediment source areas within the catchment and 3) pollen analysis provides a complete extended historical record of vegetation changes and responses to land-use and urban development.

Two examples are used to illustrate these assertions. The first is a combined study from the lower Yarra River and its delta, in the Melbourne urban area. The second is a combined study of sediments from the Latrobe River and Lake Wellington, Victoria. These studies give preliminary results of work-in-progress.

2. SITE DESCRIPTIONS

The lower Yarra River study area extends from Dights Falls to the city of Melbourne. Downstream of the city the river is bordered by a delta that extends into Hobson's Bay (Fig. 1). For the lower reaches of the river few surveys are available (Brizga et al., 1995). Historical and modern vegetation data for the delta and Melbourne area are incomplete and contain little specific local information (Anthony, 1994). Since European settlement extensive alterations to the river channel, floodplain, and the natural habitat of the delta have been numerous. These include draining and infilling of wetlands, dredging, widening and changing the course of the river and levelling hills and coastal sand dunes (Anthony, 1994; Brizga et al., 1995).

The Latrobe River in Gippsland, Victoria, drains a catchment of approximately 5,200 km² before emptying into Lake Wellington (Fig. 2). The lower reaches of the Latrobe River are highly disturbed, having been subjected to extensive channelisation strategies that included clearing of riparian vegetation, river de-snagging, artificial meander cut-offs and more recently, reinstatement of meander cut-offs (Reinfelds et al., 1995). Overburden from brown coal mining has in the past, been sluiced into the river and historical accounts attest to the

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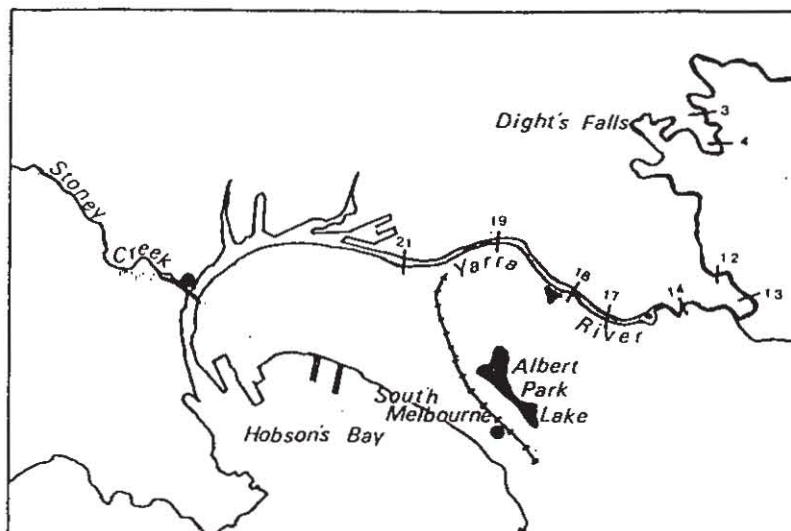


Figure 1. Map of the lower reaches of the Yarra River, Stoney Creek and South Melbourne. Numbers indicate river reaches from which cores were obtained for pollen analysis.

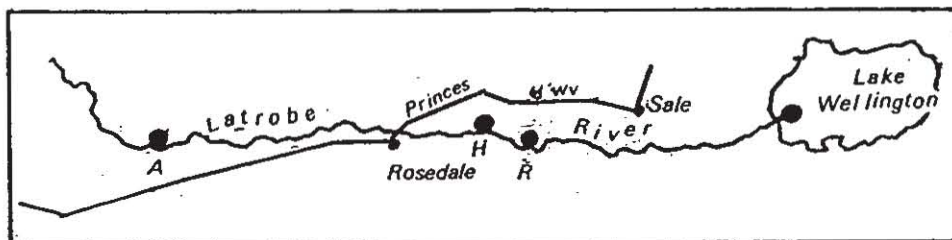


Figure 2. Map of the lower Latrobe River and Lake Wellington showing river and lake core sites. Core sites are A - Archibald's cutoff; H - Holey Plains and R - Robertson's cutoff.

accumulation of coal in the river bed (Erskine et al., 1990; Reinfelds et al., 1995).

3. METHODS

Several sites along the lower Yarra River and its delta were probed to determine sediment depths and locate suitable coring sites (Fig. 1). The Stony Creek Backwash core was taken using a D-section corer (Anthony, 1994). Cores at all other sites were obtained by hammering a 50 mm PVC tube into the sediments (Gippel et al., 1994; Brizga et al., 1995). All cores were sealed, labelled and sampled in the laboratory for pollen after core stratigraphies were recorded.

Samples chosen for pollen analysis were based on the occurrence of major stratigraphic changes and the absence of European artefacts in the sediments. The two delta cores were sampled at more frequent intervals (fine resolution) to provide a continuous chronological record of local vegetation change. The surface of each core was clean and 1 cm thick slices were cut at selected depths. From these slices 1-3 cm³ samples were taken and prepared for pollen according to the methods of Faegri and Iversen (1975). Pollen preparations were stored in a known volume of silicon oil. Aliquots were placed on microscope slides, covered and sealed. Wherever possible, a pollen sum of 100 dryland pollen grains were counted for each sample at x400 magnification

using a binocular microscope. Relative percentages of the pollen sum were then calculated for each taxon.

Pollen types identified were grouped into the following vegetation communities indicative of important environmental conditions: Exotic taxa; wet sclerophyll taxa that also include riparian vegetation elements; tree ferns; coastal taxa and pollen from Tertiary age brown coal deposits.

4. SEDIMENTS

4.1 Lower Yarra River

The objectives of these two studies were to: 1) describe the location and age of sediment deposits in the river channel, identify likely sediment sources, and to examine the implications of sediment processes for waterway management (Brizga et al., 1995); and 2) identify the vegetation communities and provide a history of environmental change relevant to park management and revegetation programs (Anthony, 1994).

For detailed descriptions of all cores see Anthony (1994) and Brizga et al (1995). Pollen data from nine riverbed cores shows that brown fluvial deposits in the Yarra River cores are modern while mottled clays and grey estuarine sediments are pre-European (Table 1). The grey clays at South Melbourne are similar to the grey Yarra River clays.

However, pre-European brown fluvial sediments were identified at Stony Creek (Anthony, 1994). Sediment colour and texture are therefore not definitive indicators for identifying pre- and post-European deposits. Determination of the time of deposition can be verified using pollen analysis techniques. Sediment depth increases in the downstream reaches where channel modifications and dredging have occurred in the estuary.

Sample Site	Depth	Sediment	Exotic Pollen
Stony Creek	70 cm	silt & sand	PRESENT
	150 cm	clay & silt	ABSENT
South Melbourne	7 cm	grey clay	PRESENT
	16 cm	organic clay	ABSENT
21	285 cm	fine silt	PRESENT
19	95 cm	sandy clay	PRESENT
19	101 cm	grey clay	ABSENT
18	130 cm	fluvial silt	PRESENT
18	140 cm	estuarine clay	ABSENT
17	#115 cm	mud & sand	ABSENT
14	140 cm	sandy clay	ABSENT
13	50 cm	sand & clay	PRESENT
13	#60 cm	mottled clay	ABSENT
12	80 cm	fluvial clay	PRESENT
12	#115 cm	mottled clay	ABSENT
4	62 cm	silt & sand	PRESENT
3	30 cm	silt & sand	PRESENT

Table 1. Shows the presence or absence of introduced pollen grains and sediment type in selected Yarra River samples. # denote samples with no or very little pollen present.

4.2 Lower Latrobe River

Cores from three floodplain billabong sites along the lower Latrobe River were obtained to investigate whether the infilling sediments provide a record of coal pollution in the river as suggested by the historical accounts, and to identify changes in the character of flood-load sediments resulting from European settlement (Reinfelds, in prep.). The management authority responsible for the Latrobe River and Lake Wellington (Gippsland Water) were concerned that sedimentation rates in Lake Wellington had increased sixfold as a result of the extensive European impacts on the Latrobe River catchment and channel (Craigie et al., 1991). This second study aimed to provide data from the Latrobe River delta to determine the importance of bedload sediment delivery and change in sedimentation rates for Lake Wellington to help improve water quality management targets (Grayson et al., (1994).

At Archibald's cutoff in the upper reaches of the study area a change from silt-clay to sand dominated sediments is associated with the appearance of pollen from introduced and Tertiary age taxa at a depth of 106 cm in the core (Table 2). Although substantial erosion in the river was documented

from historical data (Reinfelds et al., 1995), pollen analyses enabled the onset of European settlement to be associated with the switch from silt-clay to sand dominated flood-load sediments. Pollen analyses downstream at Robertson's cutoff reveal that black coloured sediment strata are indeed contaminated with coal as they contain a large proportion of Tertiary age pollen (Table 2) which can only originate from the Latrobe Valley brown coal deposits. Sediments from other strata in Robertson's cutoff contain no Tertiary pollen (Table 2). Although pollen analysis has proved extremely useful to determine the nature of the contaminants causing the black staining of sediment strata, further research is necessary to investigate whether the coal can be attributed to sluicing of mining overburden into the river or, whether it is a 'natural' phenomenon associated with channel incision into riverbed coal seams resulting from the emplacement of artificial meander cut-offs (Reinfelds et al., 1995; Reinfelds in review).

	Depth (cm)	96	160	270	274
ROBERTSON'S CUT-OFF	Eucalyptus	14	17	37	17
	Wet forests	14	27	19	18
	Exotics	4	3	4	1
	Grasses	4	0	6	14
	Tertiary	17	17	0	0
HOLEY PLAINS	Depth (cm)	206	211	279	
	Eucalyptus	29	34	30	
	Wet forests	11	7	20	
	Exotics	4	0	0	
	Grasses	26	15	11	
	Tertiary	5	9	1	
ARCHIBALD'S CUTOFF	Depth (cm)	43	82	106	213
	Eucalyptus	15	22	38	53
	Wet forests	6	5	37	13
	Exotics	2	6	1	0
	Grasses	34	7	1	1
	Tertiary	12	8	3	0

Table 2. Latrobe River Billabong sites. Pollen assemblages expressed as percentages of the pollen sum at selected depths from three sites along the Latrobe River.

Pollen analyses of samples from seven cores located in the Lake Wellington Latrobe River delta indicate the sediment deposition rate has increased only twofold to 1 mm/year since European settlement (Grayson et al., 1994), and not sixfold as had been originally suggested. Post-European sediments entering Lake Wellington contain more fine sand and silt than pre-European sediments and these are sufficiently fine to carry large nutrient loads into Lake Wellington, with phosphorus loads increasing fourfold since European settlement (Grayson et al., 1994). The increase in Tertiary age pollen in the modern lake sediments is another indicator that pollution is being transported in fine sediments by the river and deposited in Lake Wellington.

5. VEGETATION

As well as illustrating the usefulness of pollen in determining modern sedimentation deposition patterns, pollen data also show major changes between the pre- and post- European vegetation along both the Yarra and Latrobe Rivers despite the coarse sampling strategy. The finer sampling regime used at South Melbourne shows progressive changes over time in more detail. Post- European pollen spectra provide an indication of land-use changes within both catchments.

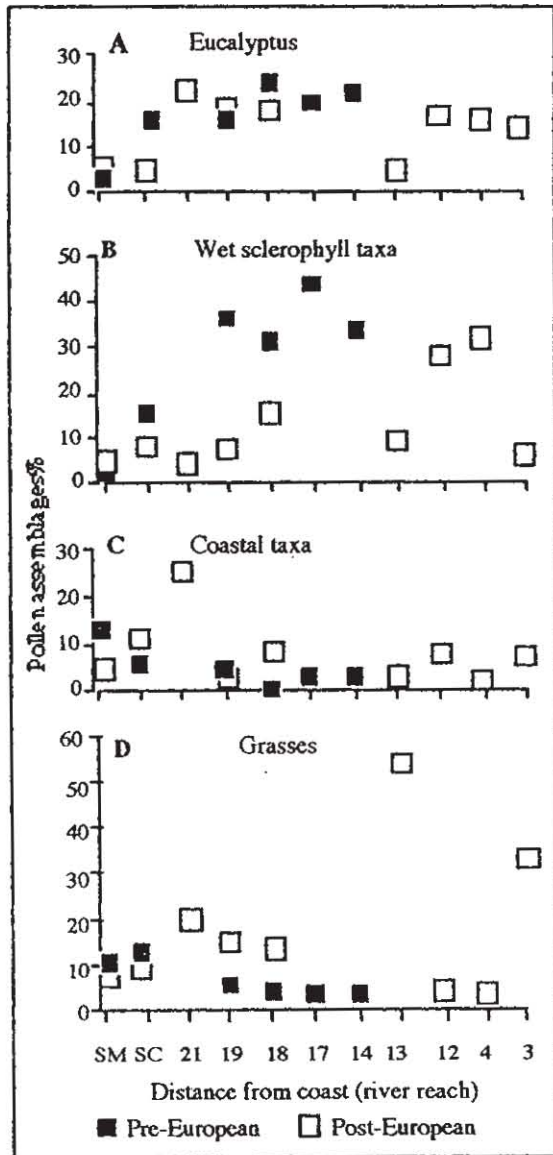


Figure 3. Vegetation communities identified in the pollen assemblages from Yarra River and delta cores (Fig 1) showing major vegetation changes along the river since European settlement. SM - South Melbourne; SC - Stony Creek Backwash.

Early vegetation records for Melbourne describe coastal grassy shrublands and wetlands with open *Eucalyptus* woodlands along the floodplain. These environments are reflected in the pre-European pollen data (Fig. 3). Since European settlement the

pollen data mirror vegetation changes associated with urban development in the Melbourne region and Yarra catchment (Kenyon, 1995). All Yarra river sites (Fig. 3) generally record increases in grasses, but *Eucalyptus* increases only near the delta. The high grass values in reaches 3 and 12 reflect in-river stands of the common reed, *Phragmites*. The increased wet sclerophyll component include tree ferns and Myrtle Beech (*Nothofagus cunninghamii*) (Kenyon, unpubl. data) indicating increased sediment transport and its deposition at these sites from the upper catchment region, possibly a result of land-use changes. Riparian vegetation also includes wet sclerophyll components and the decline, downstream may reflect local riverbank clearance. *Allocasuarina* is commonly used in revegetation programs. This is seen in the record as an increase in the coastal elements of which *Allocasuarina* is a component.

The fine resolution study at South Melbourne (Fig.4) gives a continuous record of change. Pollen from pre-European sediments (Aboriginal phase) showed an open grass and shrub community dominated by Lamiaceae (*Westringia*) and *Pomaderris* consistent with the early historical records (Hannaford, 1856). The pollen representation changed significantly during Early European settlement. Used extensively for grazing, the local coastal open woodland became a closed shrubland of *Pomaderris*. With urbanisation and massive vegetation clearance an open simple community of weeds, grasses and herbs developed. A decline in exotic pollen and an increase in native species due to garden plantings and revegetation of parklands is indicative of the current Revegetation Phase. At Stony Creek Anthony (1994) has described an increase in *Allocasuarina* pollen and a decline in exotic pollen in the upper section of the core reflecting revegetation programs begun in the 1980's. High *Allocasuarina* values were not seen in the pre-European sediments at Stony Creek.

The lower floodplain of the Latrobe River was initially settled because of its fine grazing qualities. A more detailed study of the pollen record from Lake Wellington (Fig. 5) shows decreases in *Eucalyptus* and increases in grasses associated with the development of grazing pasture. These changes have been progressive since settlement began in the region. Increases in Tertiary age pollen from brown coal pollution is also evident. *Ruppia*, a salt tolerant species, was present in the lake pollen spectra (Kenyon, unpubl.data). Its presence can probably be associated with the artificial opening of the Gippsland Lakes to the sea.

6. MANAGEMENT IMPLICATIONS

The two case studies presented here illustrate that pollen analysis is an extremely useful technique for Integrated Catchment Management that can supplement historical data and contemporary

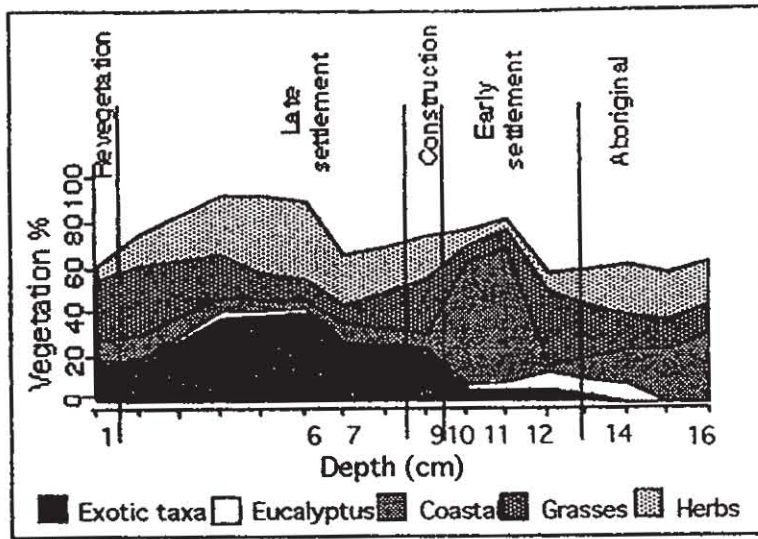


Figure 4. Pollen diagram from South Melbourne illustrating changes in vegetation communities through time in response to land-use changes.

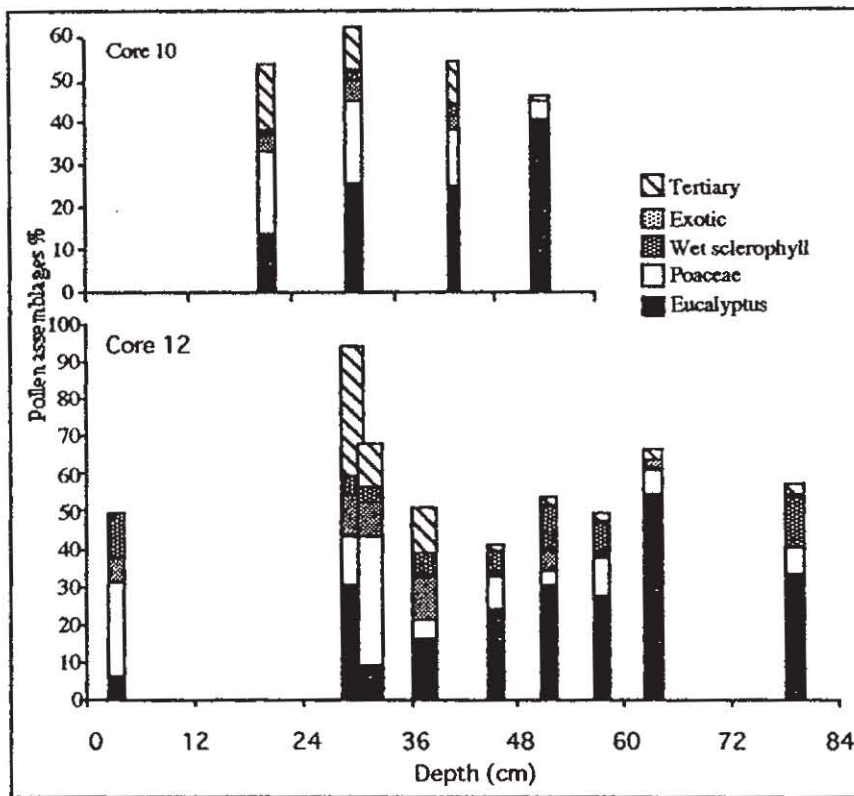


Figure 5. Histograms of 2 cores from the Latrobe River delta, Lake Wellington illustrating the general trends over time in selected pollen assemblages.

monitoring programs. It also provides a relative dating tool marking the post-European contact in the stratigraphic record enabling identification of historical changes in catchment and riparian vegetation responses to land-use. Comparison of the pre-European and post-European stratigraphic record provides baseline data with which to assess sedimentological and hydrological changes in rivers following European settlement.

The Yarra catchment pollen study was integrated into a multi-disciplinary study incorporating geomorphological, hydrological and historical data. The pollen record has helped provide a better understanding of the processes affecting sediment transport and deposition processes within the river channel from which a management plan for the lower reaches of the Yarra River is currently being

developed. Vegetation changes over time provide important insights into local historical and ecological processes in the area that can be used as a guide for better resource allocation for catchment and riparian managers when planning revegetation projects.

From the lower Latrobe River it has been determined that the coarse sediments eroded from the river channel are being deposited in the Latrobe River floodplain. The deposition of fine sediments in Lake Wellington is not as great as previously believed and need not be a management priority (Grayson et al., 1994). The fine sediments entering the lake however, carry large nutrient loads and coal pollution. The presence of Tertiary pollen in the sediments has been used to identify coal pollution and transport since European settlement. With regard to the Lake Wellington management study, pollen analysis in conjunction with stratigraphic analysis was instrumental in shifting the management focus from sediment mitigation to nutrient mitigation (Grayson et al., 1994).

7. REFERENCES

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